Faculty of Geosciences
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Healthy Urban Living

Spatiotemporal Regressions to Explore Suicide Mortality in Germany

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1. Background

Suicide mortality is a public health concern in most developed countries [1]. In Germany suicide mortality declined from 1991 to 2006, but in 2007 this downward trend reversed. The reasons are poorly understood.

While a multitude factors play a role in explaining suicide mortality, the complexity of suicide epidemiology is increased by spatial and temporal variation in risk. Previous studies focused on spatial disparities for a single point in time by pooling data over years assuming invariable risk. However, incorporating spatiotemporal variability is crucial for valid statistical inference.

2. Aim

This study addressed this research gap and answered the following research questions:

- How does suicide risk develop in Germany in 2007–11 and which areas are under excessive risk?
- What area-level risk and protective factors are associated with suicide risk?

3. Study design and data

The study design is longitudinal. All annual suicide cases in Germany in 2007–11 were considered. Suicides (i.e. X60–X84) were extracted from the mortality database. As suicide is a rare event, annual data aggregated to districts (N=402) was obligatory.

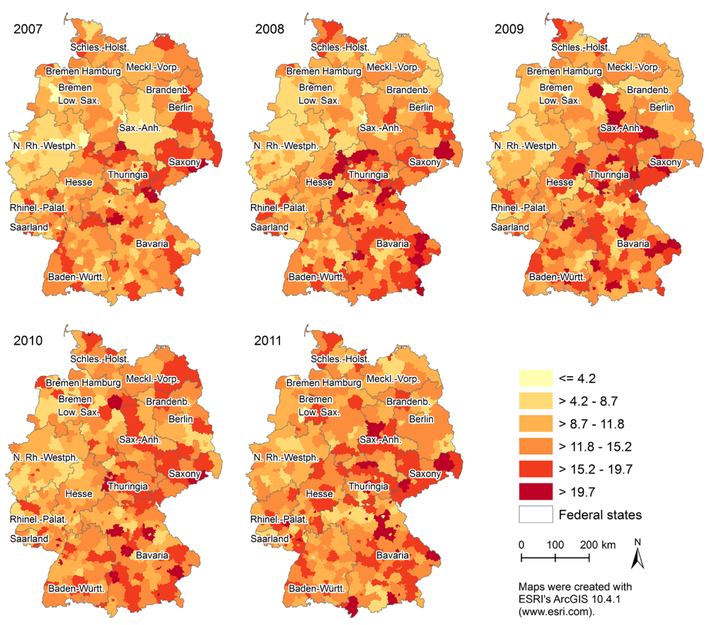

Figure 1: Suicide rates per 100,000 persons

The following area-level determinants were considered as time-varying covariates:

- Average annual income per person
- Annual unemployment rates
- Annual population densities

The following covariates were kept temporally constant:

- Depression prevalence
- Numbers of general practitioners per 100,000 persons
- Numbers of psychiatrists per 100,000 persons
- Numbers of psychotherapists per 100,000 persons

4. Methods

To identify risk and protective factors from 2007 to 2011 and to investigate spatiotemporal suicide risk, hierarchical Bayesian Poisson models were set up.

Let y_{it} be the observed suicide cases in area i (i=1,…,402) at time t (t=2007,…,2011), ρ_{it} denotes a rate, and E_{it} represent the expected number of cases. Then the implemented mode is expressed as:

$$y_{it} = \text{Poisson}(\lambda_{it}) \qquad \lambda_{it} = E_{it}\rho_{it} \qquad \log(\rho_{it}) = \eta_{it}$$

Model 1

Model 1 has a parametric linear time trend [2]:

$$\eta_{it} = \alpha + \beta_k x_{kt} + v_i + u_i + (\psi + \delta_i) \times t$$

where the intercept α represents the area-wide relative risk and β_k refers to the regression coefficient of covariate k. v_i is a spatially structured residual effect for each district modelled as intrinsic conditional autoregressive specification and an unstructured residual effect u_i models spatially uncorrelated extra variability provoked by unobserved aspatial variables and is assumed to follow a Gaussian distribution [3].

Model 2

Model 2 relaxes the linearity assumption of the temporal effect by means of a nonparametric dynamic time trend :

$$\eta_{it} = \alpha + \beta_k x_{kt} + v_i + u_i + \gamma_t + \phi_t$$

Here, the same parametrization applies as above except that γ_t now refers to a temporally structured effect modelled as second-order random walk and ϕ_t to a temporally unstructured effect. The temporally structured effect resembles the trend of adjacent districts.

In both models significantly associated linear covariates are replaced with second-order random walks to explore non-linear effects.

Bayesian inference was carried out with the integrated nested Laplace approximation [4]. For both models relative risk estimates were obtained together with the 95% credibility intervals (CI). A relative risk is significant if the 95% CI does not include one. The deviance information criterion (DIC) assessed the goodness-of-fit. Lower DIC values denote better models.

5. Results

A total of 48,570 suicides occurred in 2007–11, with a peak of 10,136 in 2011. The suicide rate showed a constant temporal increase from 11.4 deaths per 100,000 persons in 2007, to 12.6 deaths per 100,000 persons in 2011.

Model 1b with non-linear effects of the significant covarites performed best (i.e. lowest DIC score; Table 1) and is further discussed.

Table 1: Model performance

	DIC
Model 1 with linear effects	12,330
Model 1 with non-linear effects	12,324
Model 2	12,352

The nationwide temporal risk increased significantly over time, even after adjusting for confounders (Figure 2).

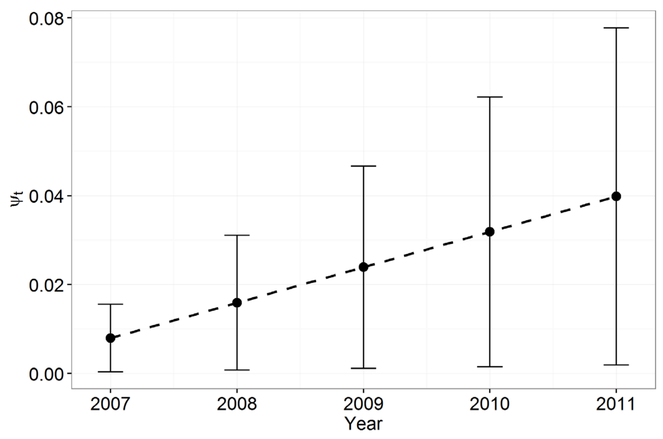

Figure 2: Temporal trend

District-specific trends deviating from the grand increase are shown in Figure 3 (left). Whereas a more distinct upward differential time trend appears in more central areas, districts such as Berlin show a less steep trend. A spatial pattern in the differential time effect is hardly recognizable.

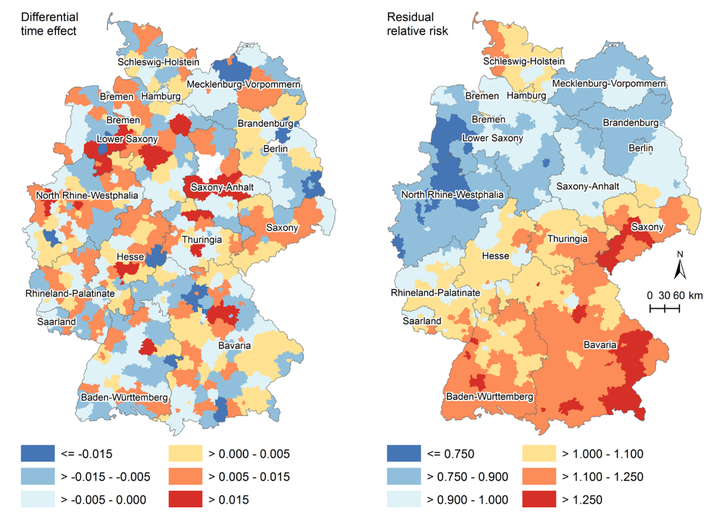

Figure 3: Differential time effect (left) and residual relative risk (right) per district

The residual relative risk for each district shows a distinct pattern (Figure 3 right). Southern districts have an elevated risk. The more central districts have a lower residual relative risk.

Income, unemployment rate and population density are important covariates (Figure 4).

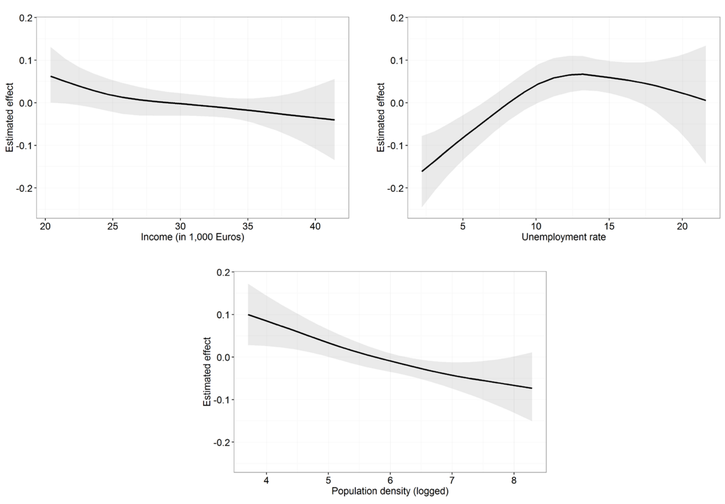

Figure 4: Non-linear effects of risk factors

6. Conclusions

This study examined space–time suicide mortality in Germany in 2007–11. Germany has experienced a significant upward trend in suicide risk. Some districts deviated substantially from this nationwide trend, facing pronounced risk over time. Striking patterns of elevated risk emerged in southern districts.

The findings challenge public health policies. While the significant time trend calls into question the effectiveness of the National Suicide Prevention Program, efforts to reduce the health burden of suicide (i.e. allocation of financial means, localized health policies) are advised to prioritize vulnerable areas of high spatiotemporal risk and prevent excess risk spilling over to adjacent areas.

References
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