Mapping of human health risks and of the uncertainty of the risk estimates

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- Standardised Morbidity Rate
- Car.normal model
- Case study for the Leipzig region
- Summary and conclusions

Characteristics of spatial risks

- Heterogeneous distribution of the population
  - ⇨ Population density
  - ⇨ Structure of the population
- Heterogeneity in the distribuion of the risk factors
- Spatial correlation

How to model spatial risks?

- Heterogeneous distribution of the population
- Heterogeneity in the distribuion of the risk factors
- Spatial correlation

→

- Including differences in population density
- Risk adjustment for exposures
- How to take the chance into account
- Estimation of location risk
- Comparing risks between several small areas

The relative health risk in small areas

Definition:

Ratio of health risk in one areal unit

to the health risk in the whole area

of interest

Standardised Morbidity rate – SMR

- Estimator: Standardized Morbidity Rate (SMR)

$$SMR_i = \frac{O_i}{e_i} = \frac{O_i}{n_i \, \overline{o}} = \hat{\theta}_i$$

- Observed cases → O_i
- Expected cases → e_i
- Tested probands → $\overline{o}$
- Estimated relative risk → $\hat{\theta}_i$

- Meaning of the values of relative risk:

  <1: low risk level

  =1: no significance

  >1: high risk level

Checklist of the modelling tasks

- ☑ Differences in the distribution of the population: is considered by the expected cases
- ☒ Further special attributes of spatial data: are not taken into account (e. g. spatial correlation)
- ☒ No observed cases in some areal units: SMR is a not satisfying estimator
- ☒ Confidence intervals: unrealistic
- ☒ Splitting of the spatial relative risk into area-specific location and influence risk: not possible

Car.normal model

$$O_{ij} \sim Poi(e_{ij}\,\theta_{ij})$$

$$\log(\theta_{ij}) = a_0 + a_1 x_{1j} + \ldots + b_i$$

$$e_{ij} = n_{ij}\,\bar{o}$$

$$a_0 \sim N(0, \sigma_0{}^2)$$

$$a_1 \sim N(0, \sigma_1{}^2)$$

$$b_i \sim Car.normal(neighbours, v^{-1})$$

$$v^{-1} \sim \Gamma(c, d)$$

$i = 1, 2, \ldots, 111$ area-specific

$j = 1, 2, \ldots$ exposure group

$\bar{\theta} = 1; \quad \bar{b_i} = 0$

a_i – regression parameter

e^{a_i} – relative exposure risk

a_0 – log(mean disease risk of area)

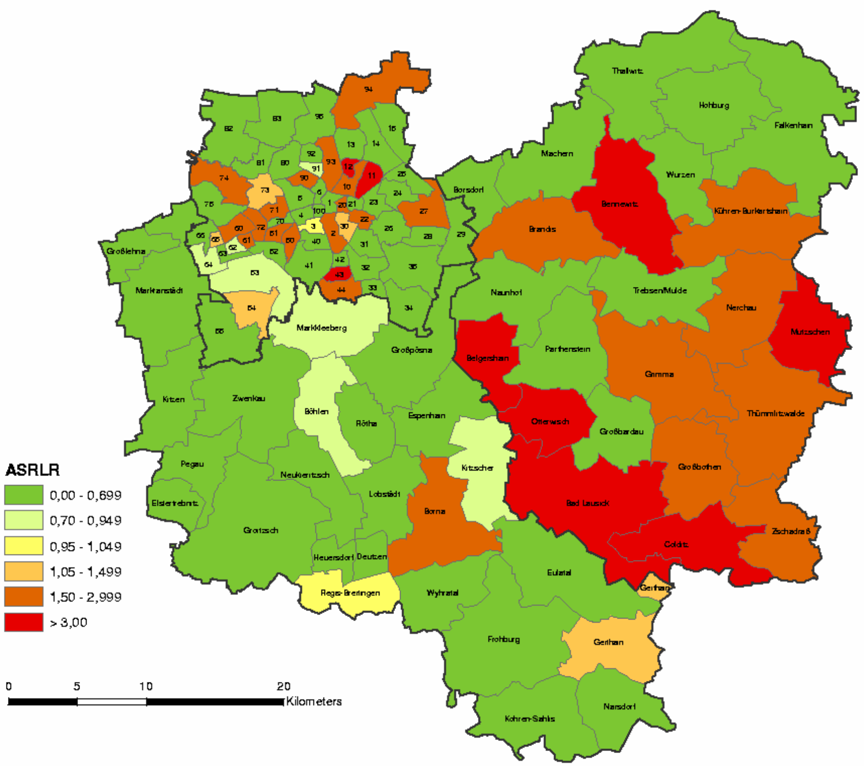
$$x_i = \begin{cases} 1, & \text{probands with exposure} \\ 0, & \text{probands without exposure} \end{cases}$$

Case study for the Leipzig region

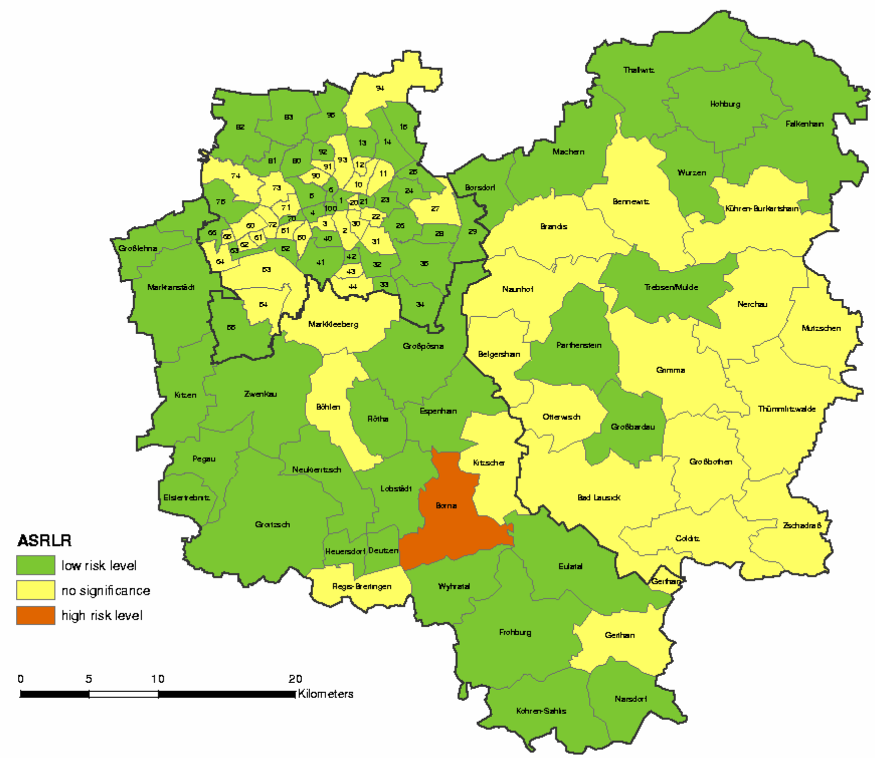
- Leipzig region: City Leipzig, two rural districts (Muldentalkreis, Leipziger Land)
- Spatial risk analysis for *Helicobacter pylori* (*H. pylory*) infection
- Data gathering ($N \approx 3800$) in 1998, 1999, 2006:
  - Infection status
  - Questionnaire about potential risk factors
  - Geographical coordinates of the residence
  - Data aggregation for administrative districts
- Assumed pathways for the *H. pylori* infection: faecal-oral, oral-oral, gastro-oral

Spatial risk estimation by SMR

Mean SMR for the *H. pylori* infection
(Leipzig, Leipziger Land, Muldentalkreis)



Significance of SMR for the *H. pylori* infection
(Leipzig, Leipziger Land, Muldentalkreis)
- 90% confidence intervals

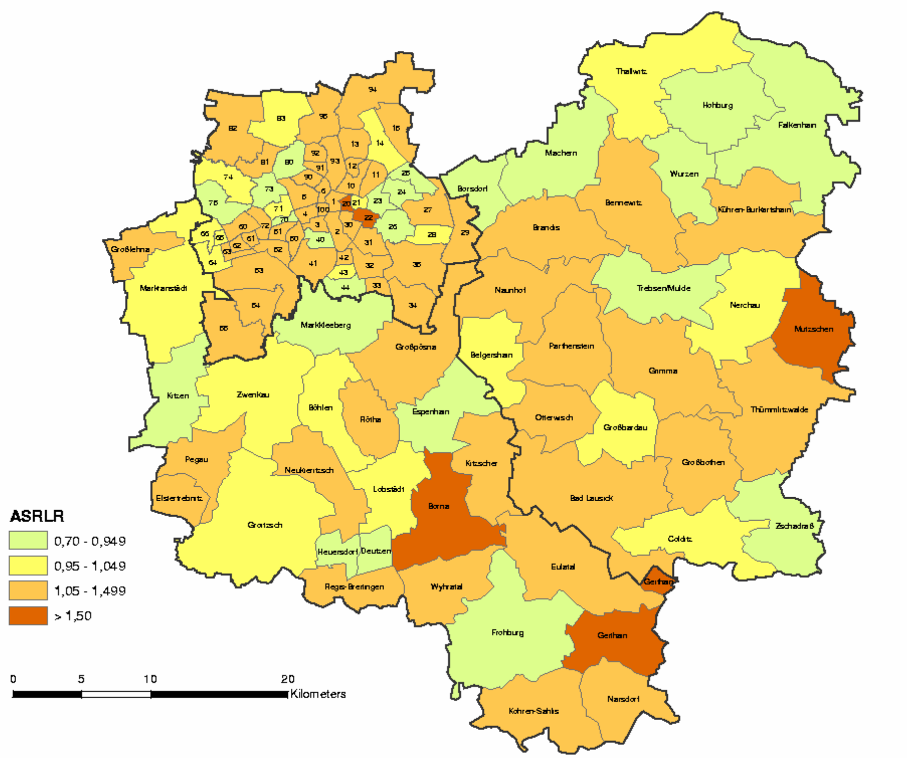


Spatial risk estimation by Car.normal model

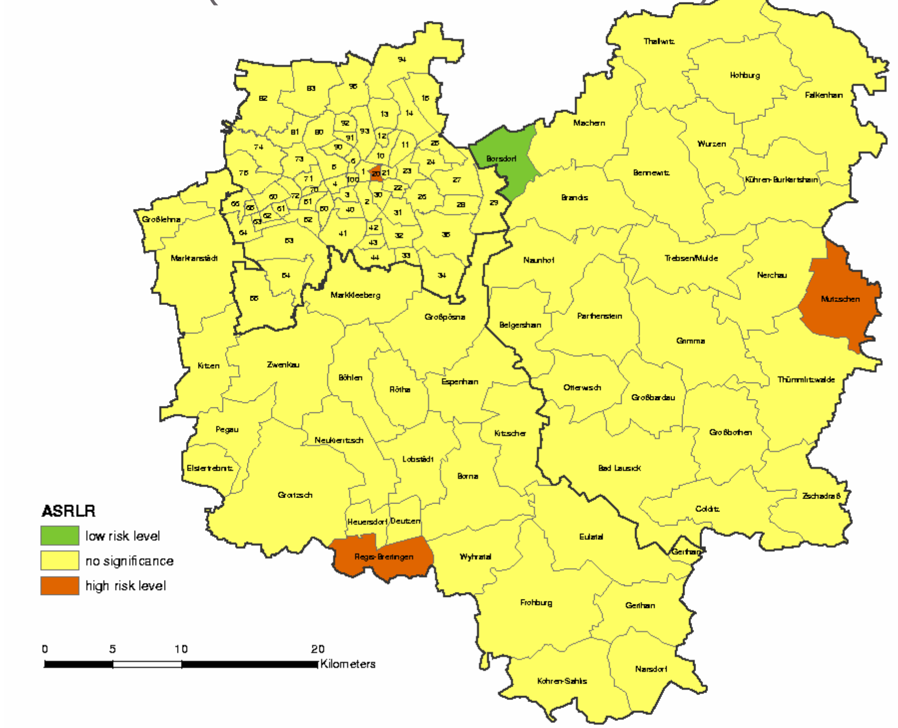
Adjusted for relative influence risk (RIR) of the child has travelled to Africa – AFR - and at least one of the parents is diseased with medical conditions of the intestinal tract - 1PSD

RIR- AFR: 1.18…1.83…2.42 **p-value**: 0.0000
-1PSD: 1.20…1.53…3.36 0.0000

Mean ASRLR for the *H. pylori* infection



Significance of ASRLR for the *H. pylori* infection (90% confidence intervals)



Conclusions

- CAR.normal model overcomes drawbacks of SMR
  - ✓ Consider special attributes
  - ✓ More realistic approach for no observed cases
  - ✓ Realistic confidence intervals
  - ✓ Splitting the total risk into local and influence risk
  - ✓ Advantages of Bayesian Methods

Further applications of the Car.normal model

- For human risk assessment and even more
- Other forms of data aggregation
- Environmental risk factors (e. g. air pollution)

Thanks for your attention