The effect of spatial resolution in disease mapping: A simulation study

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Background

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- Mapping of cancers
  - Allocating resources in prevention
  - Elucidating causes
- Childhood leukaemia: 5.4 per 100,000 person years
- Environmental risk factors
- Data availability in Switzerland
- Confidentiality issues
- Methods

Schweizer Kinderkrebsregister
Registre Suisse du Cancer de l'Enfant
Registro Svizzero dei Tumori Pediatrici
Swiss Childhood Cancer Registry

Previous studies

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- Areal data: Conditional Autoregressive (CAR) models
  - Besag *Ann Inst Statist Math* 1991
  - Faure et al. *European Journal of Cancer Prevention* 2009, Thompson et al. *Cancer Causes & Control* 2007, Manda et al. *Eur J Epidemiol* 2009.
- Precise data: Log Gaussian Cox process (LGCP)
  - Møller et al. *Scand J Stat* 1998
  - Cancer mapping: Lung cancer in Spain (Diggle et al. Stat Sci 2013), Colon and rectum in Minesota (Liang et al. Ann Appl Stat 2008)
  - none for childhood cancers.
- Simulation studies:
  - Lung and stomach cancer (Li et al. *J R Stat Soc C-Appl* 2012)
  - Syphilis (Li et al. *Methods in Medical Research* 2012)
  - LGCP outperforms CAR

Aim

- For rare cancers (for instance childhood leukamia) does LGCP provide additional benefits over CAR models on aggregated data in:
  - Quantifying the risk in space
  - Identifying high risk areas

Methods: Data Availability

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- Cases
  - Swiss Childhood Cancer Registry (SCCR)
  - >90% coverage since 1985
  - Precise location
- Population
  - Census (1990, 2000, 2010 onwards)
  - Precise location
- Geographical units in Switzerland
  - 26 Cantons
  - 2353 municipalities

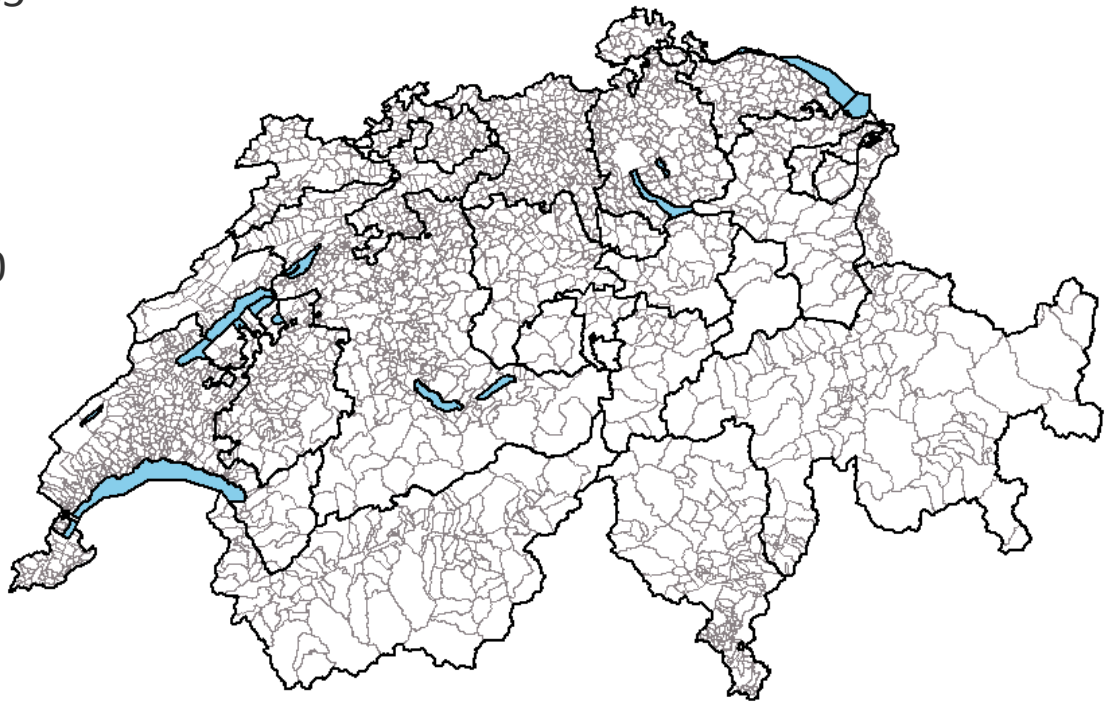


Figure. Geographical units in Switzerland

Methods: Data Simulation

- Canton of ZH (168 municipalities)
- 205,242 (15%) children
- Leukaemia incidence 1985-2015 (n = 334)
- Simulation scenarios
  - 3 high risk areas
  - 2 and 10-fold increase (constant)
  - Circles with 5km radius

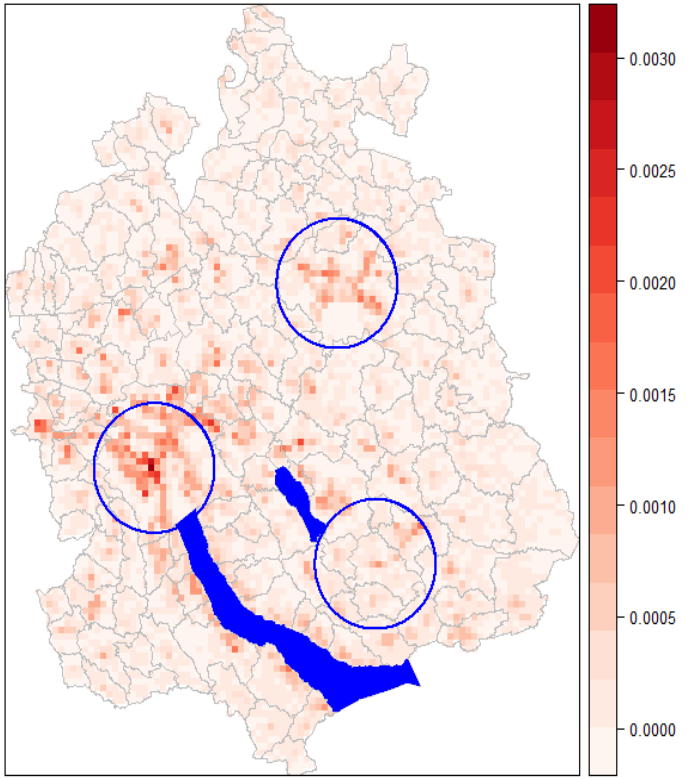
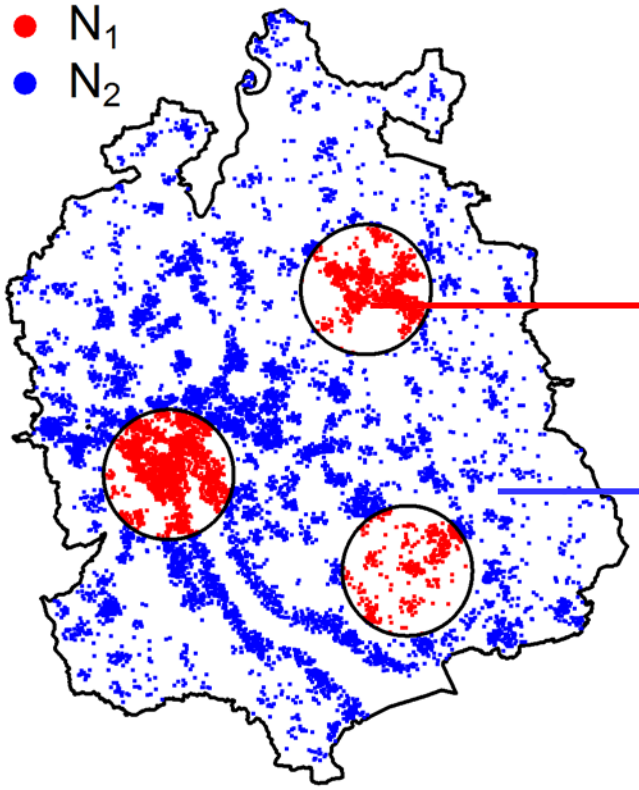


Figure. Population density

Methods: Data simulation



- Let n be the number of leukaemia cases
- N_1 be the number of residents inside the circle
- N_2 be the number of residents outside the circle
- $p = \frac{n}{c \times N_1 + N_2}$

$$X_1 \sim Binomial(c \times p, N_1)$$

$$X_2 \sim Binomial(p, N_2)$$

Methods: Model description

> CAR (BYM) model on municipalities

$$\log(Y_i) = \log(M_i) + \beta_0 + u_i + v_i \,,$$

$$u_{i|-i} \sim N\left(\frac{\sum w_{ij} u_j}{\sum w_{ij}}, \frac{\sigma_1^2}{\sum w_{ij}}\right), v_i \sim N(0, \sigma_2^2), \ \mathrm{i} = 1, \ldots, \mathrm{m}$$

> LGCP model

$$\mathrm{Y(s)} = \lambda(s)\exp\{\beta_0 + u(s)\}$$

$$u(s) \sim GRF(\mu, \kappa)\,, \kappa(|h|) = \sigma^2 \rho_\nu(|h|/\phi),\ \rho_\nu(\cdot) \text{ is Matérn}$$

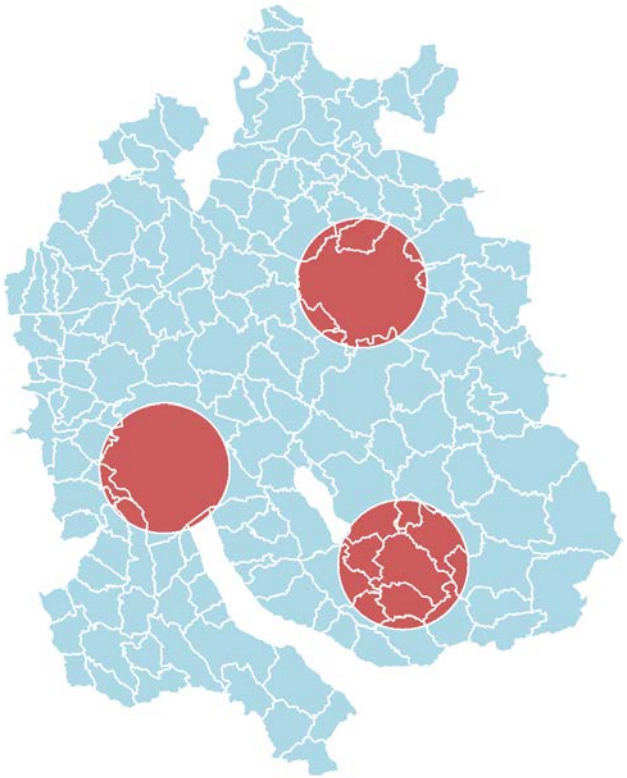
> Inference with Integrated Nested Laplace Approximation (INLA)

Simulation Metrics

- Root mean integrated square error (RMISE):

$$RMISE = \left\{ E\left[\int w(s) \left(\hat{R}(s) - R(s) \right)^2 ds \right] \right\}^{1/2}$$

  - $RMISE_1$ for w = 1
  - $RMISE_2$ for w population intensity weights



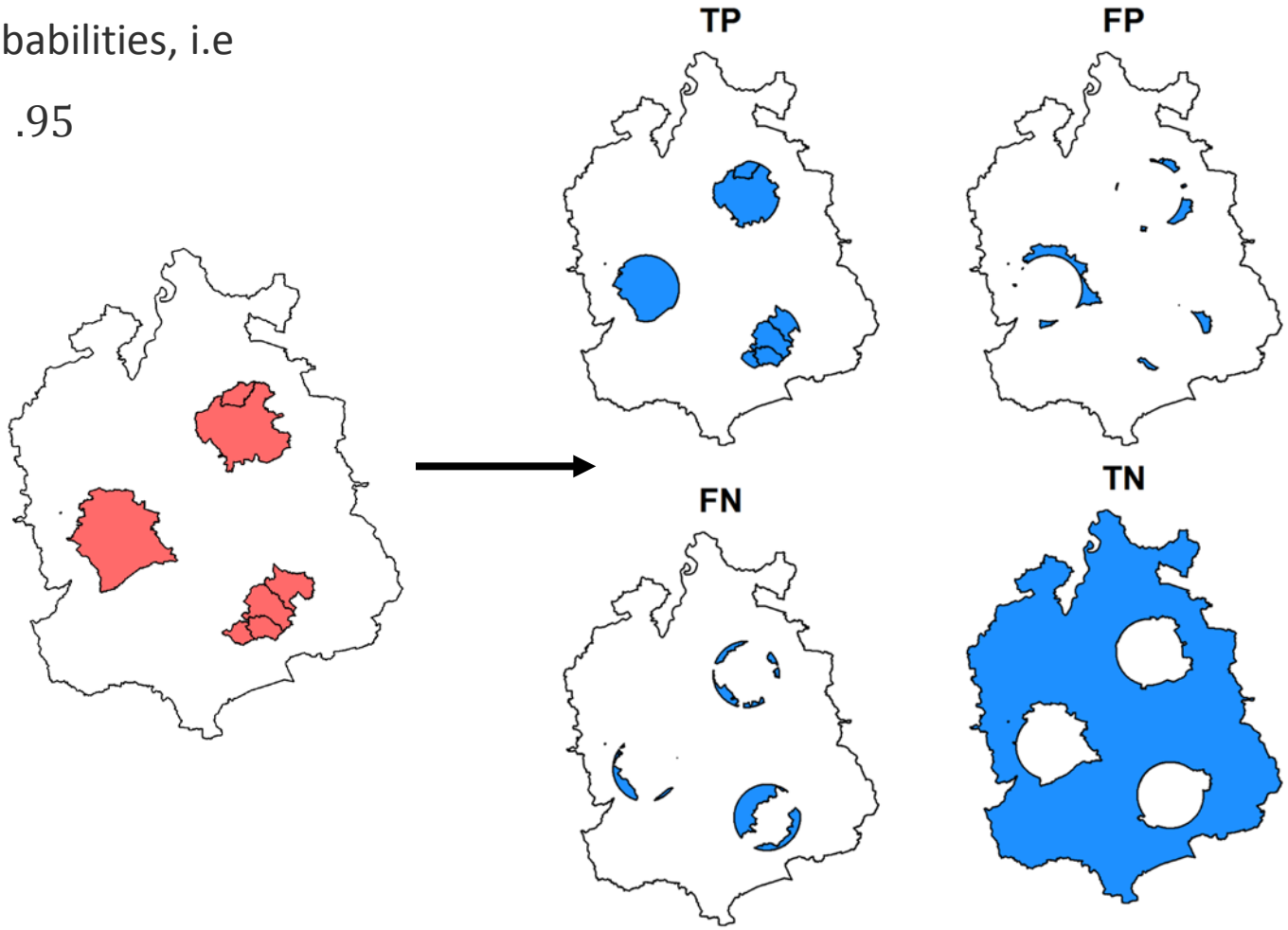
- Sensitivity and Specificity
  - Area based
  - Case based

Simulation Metrics: Sensitivity/Specificity

- Exceedance probabilities, i.e

  $\mathrm{pr}[u(s) > 0] > .95$

- Area based
- Case based



Simulation Metrics: Sensitivity/Specificity

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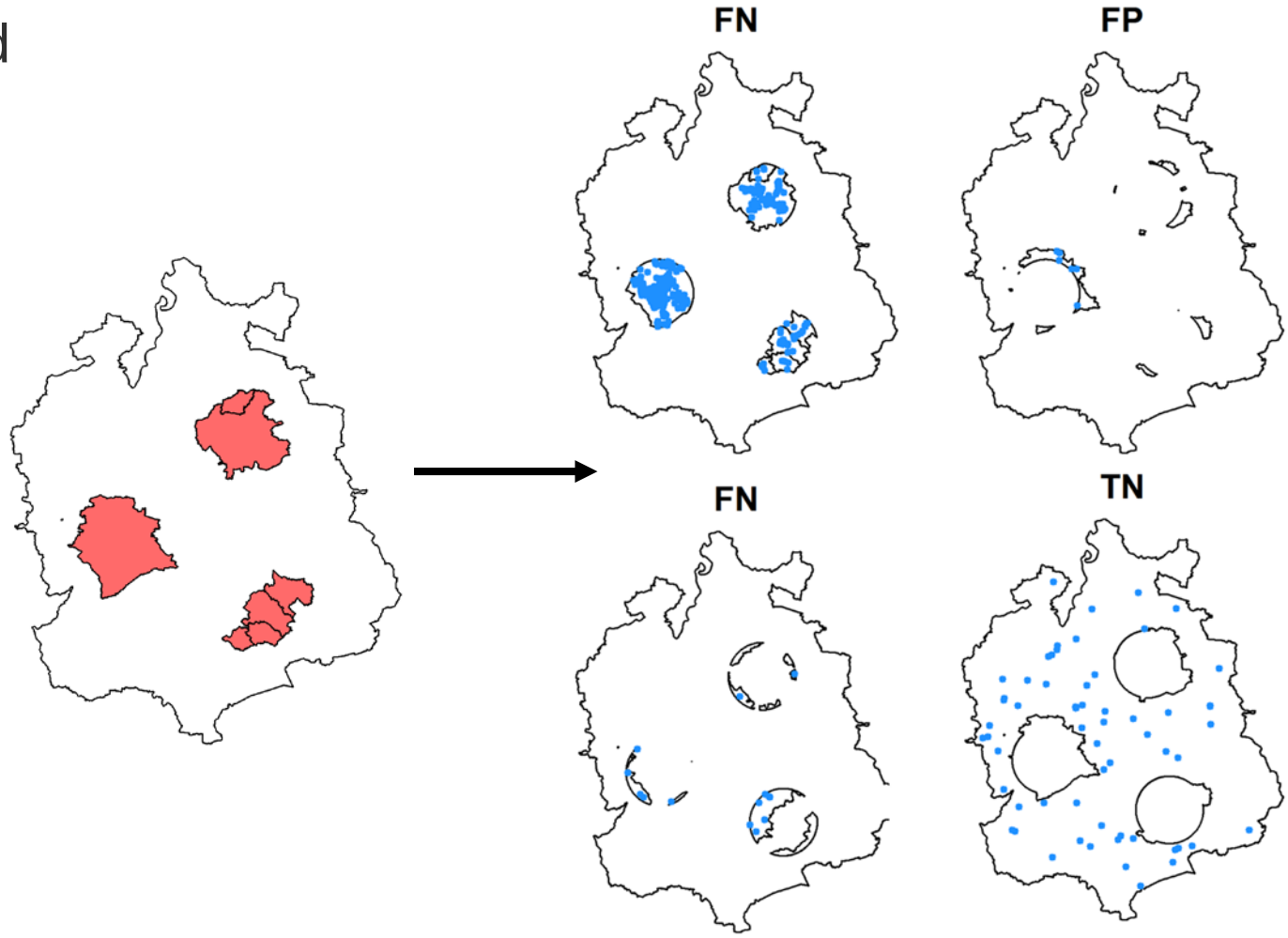
- Case based



Results

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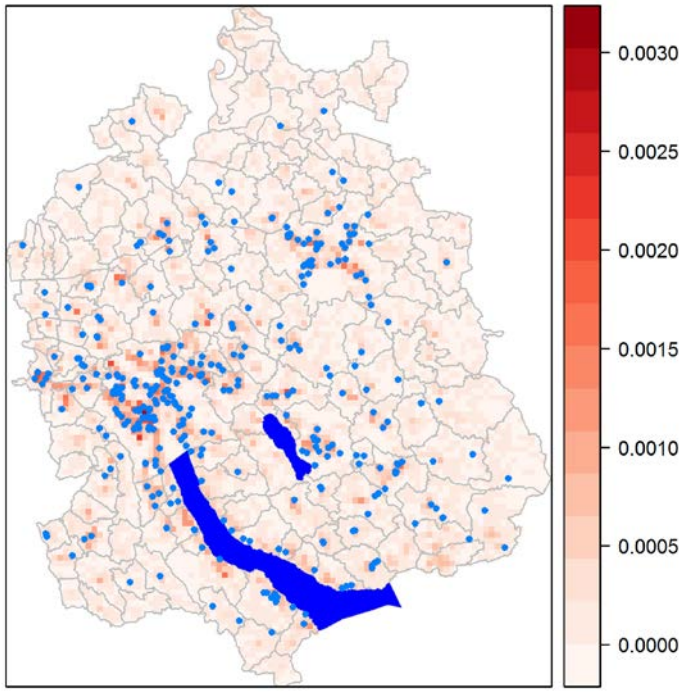
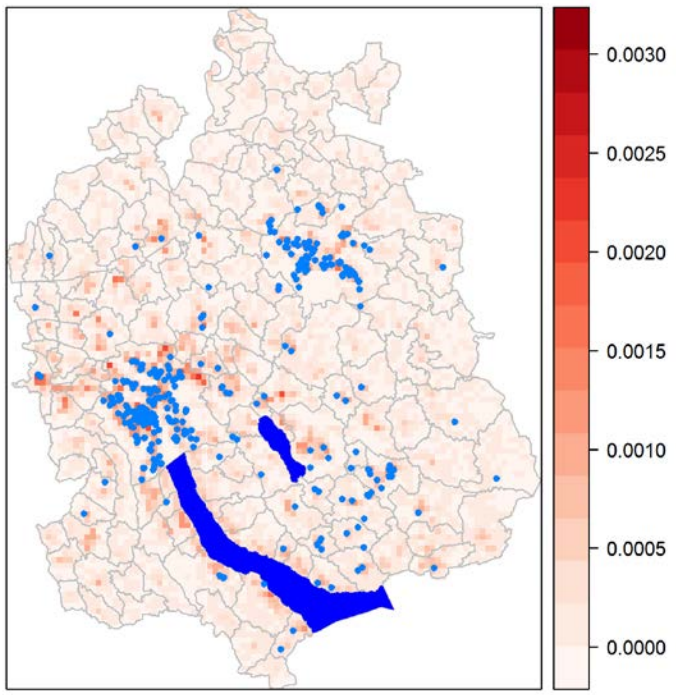
> Results will focus of 5km radius and 2-fold (left plot) or 10-fold (right plot) increase within the high risk area



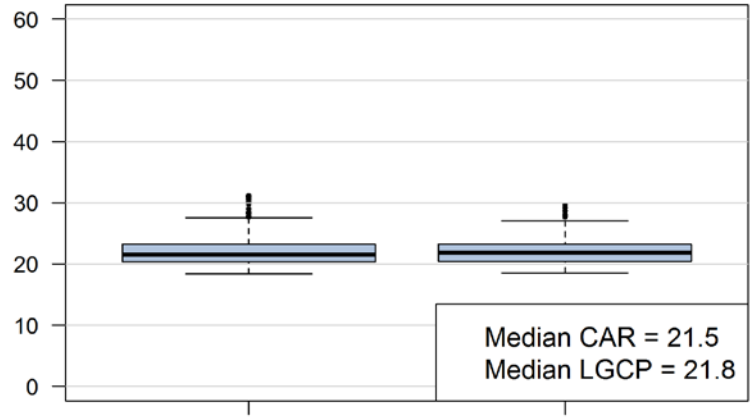


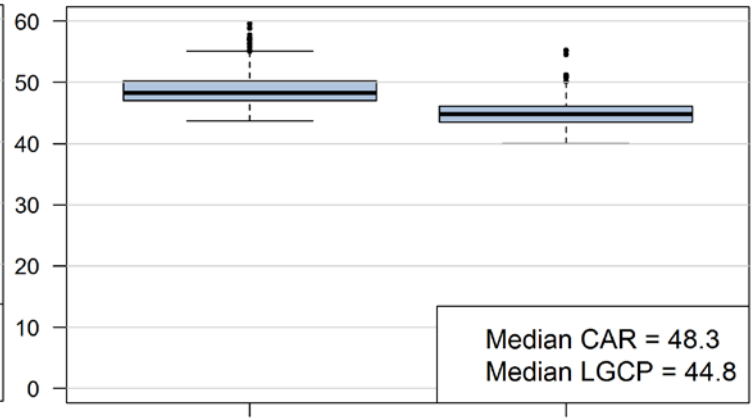
Results: RMISE

2-fold increase 5km radius

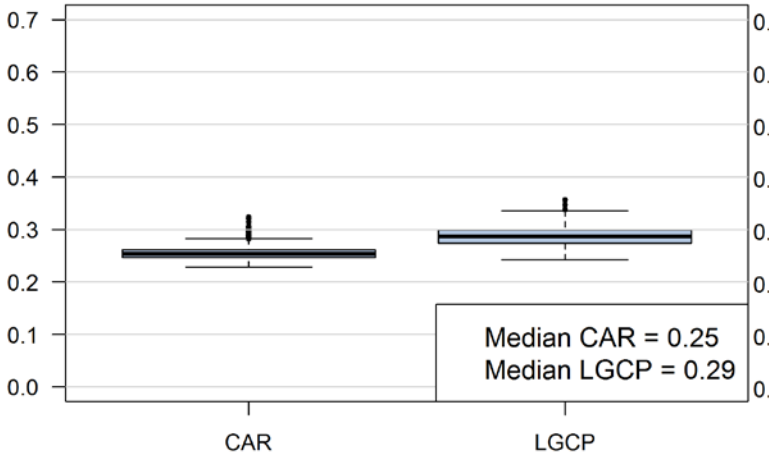
10-fold increase 5km radius

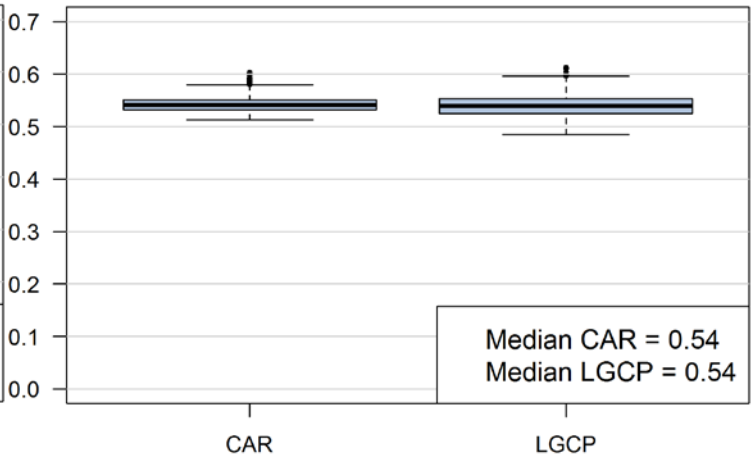
$RMISE_1$





$RMISE_2$





Results: Sensitivity/Specificity (Areas)

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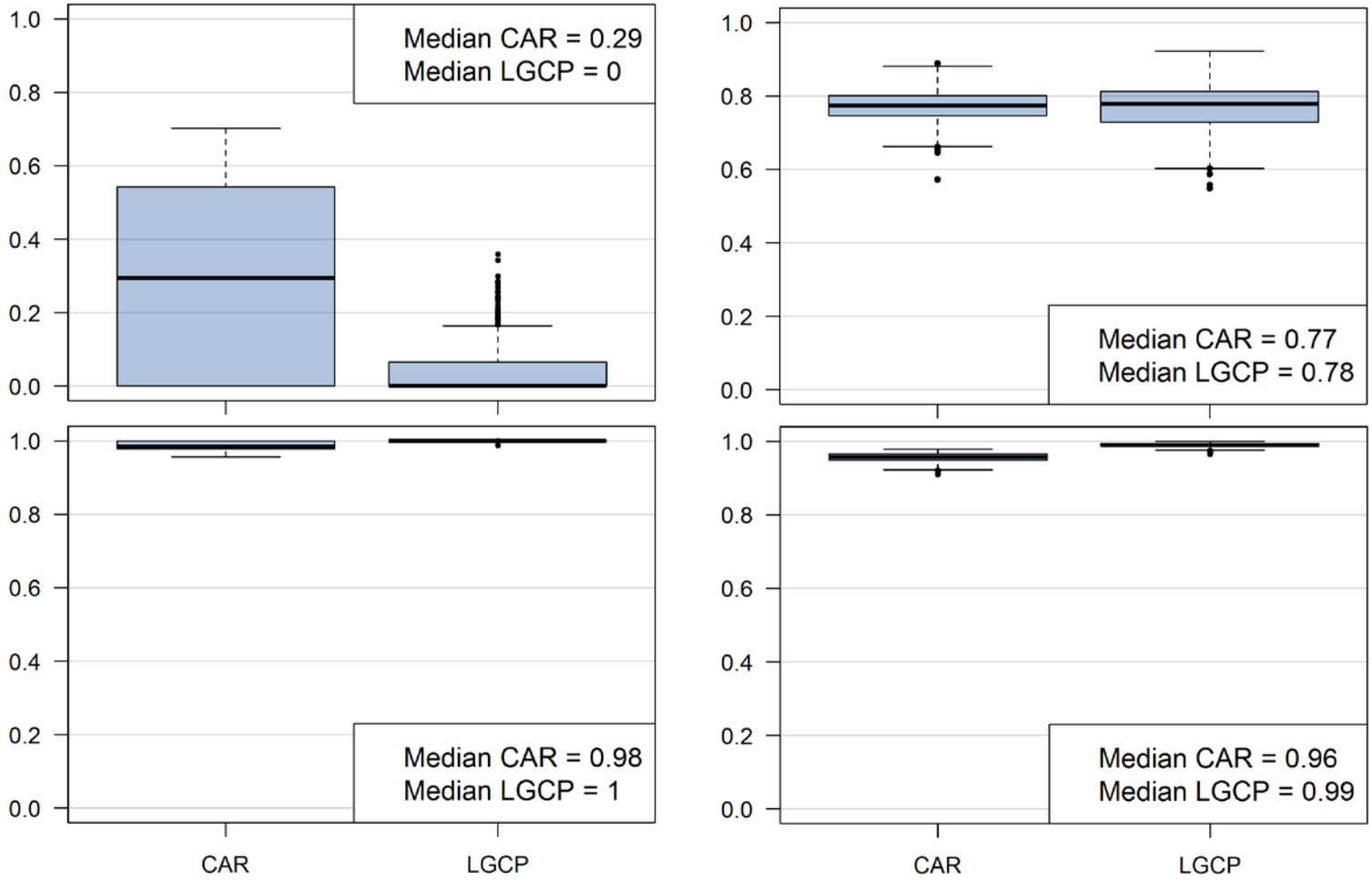
2-fold increase 5km radius

10-fold increase 5km radius

Sensitivity

Specificity



Results: Specificity/Specificity (individuals)

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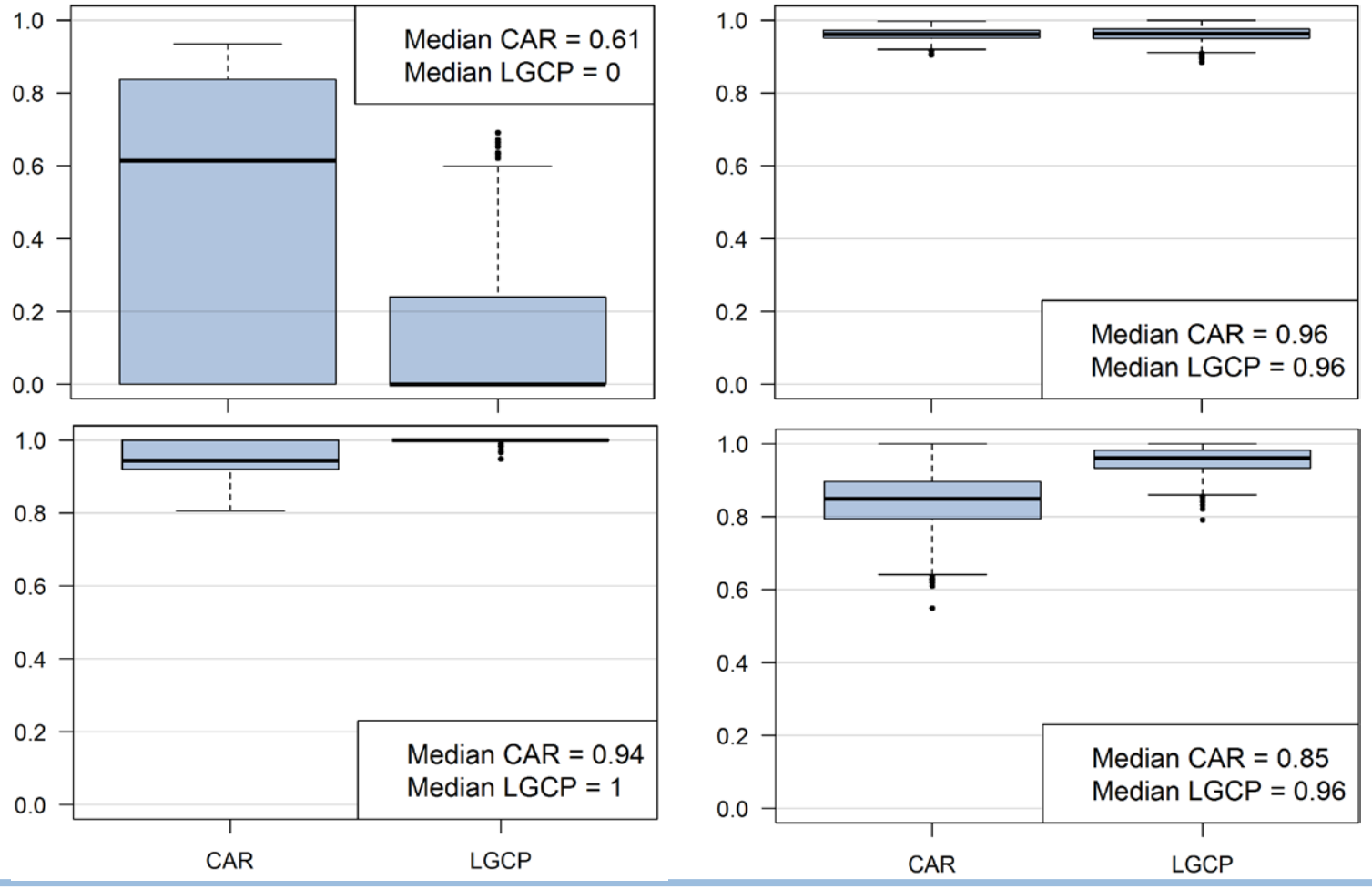
2-fold increase 5km radius

10-fold increase 5km radius

Sensitivity

Specificity



Summary of the results

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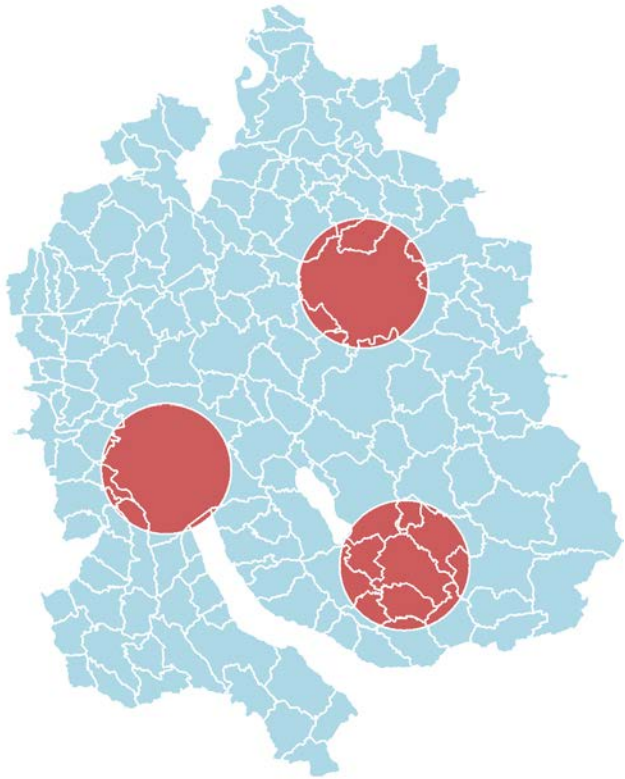
- RMISE:
  - Similar performance on low risk increase
  - LGCP better on higher risk increase
- Sensitivity/Specificity
  - CAR higher sensitivity in lower risk increase
  - LGCP very high specificity in both scenarios

Discussion

- Stable risk might
- ZH and WH had similar size as the municipalities of ZH and WH
- Threshold on the exceedance questionable
- On going project, more scenarios



Take home message

- The evidence so far suggests that for exploratory purposes, if the aetiology of the disease in unknown, results from both methods will be beneficial.

Thank you for your attention!

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