

Determinants and spatio-temporal structure of wastewater SARS-CoV-2 viral load in Switzerland

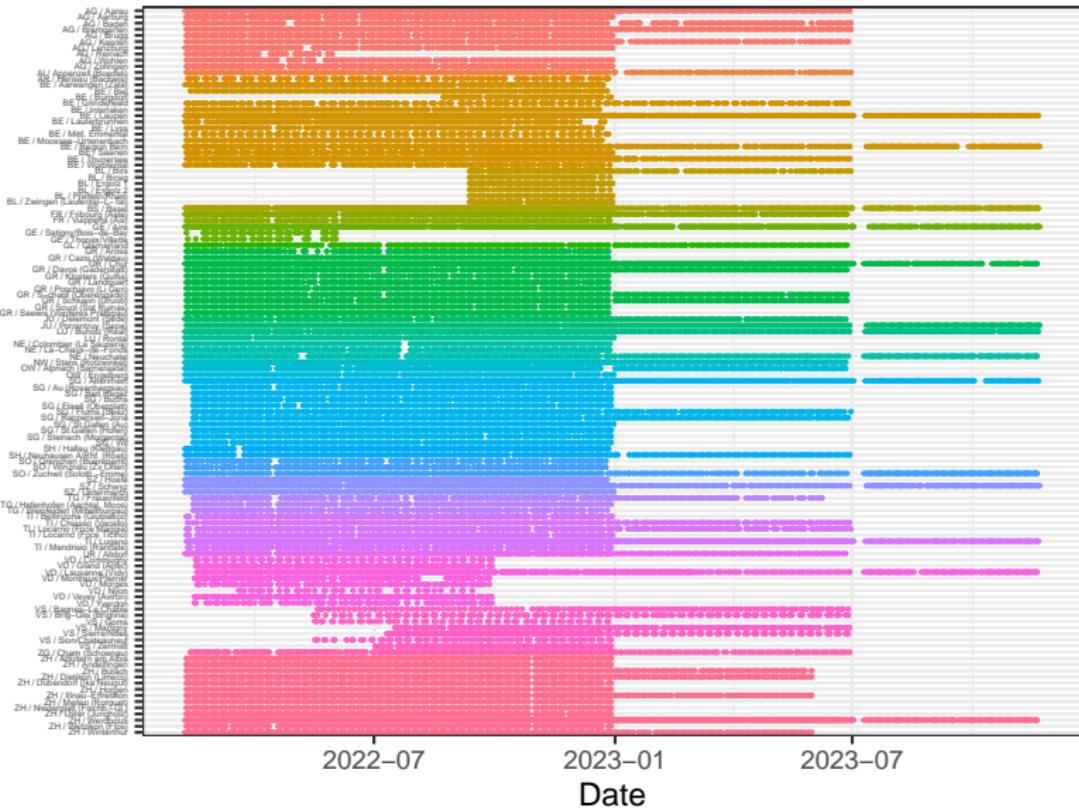
key insights for future surveillance efforts

Julien Riou

27 June 2024

Data

WWTP



Data

Large heterogeneity across time and space:

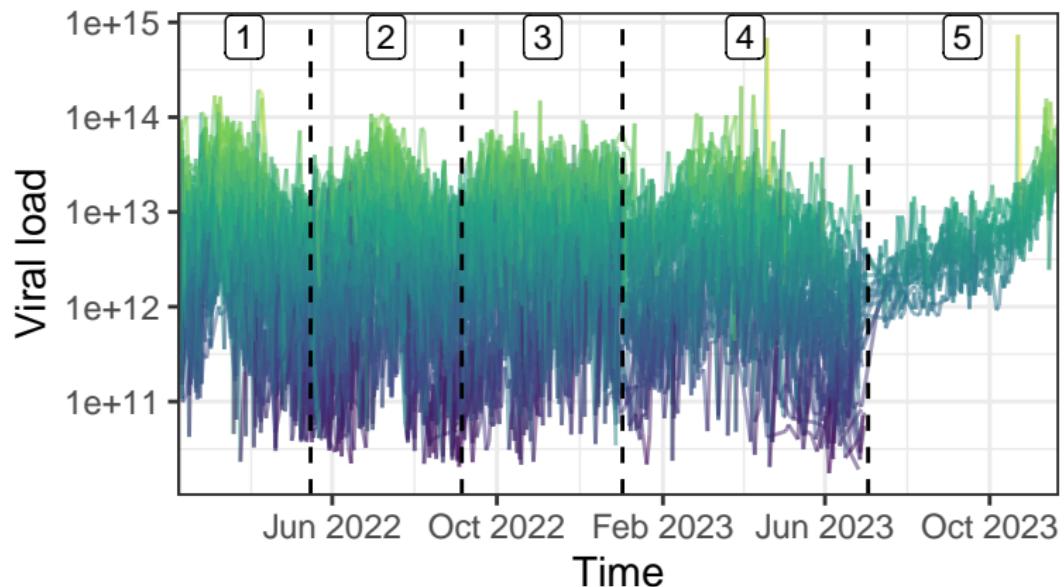
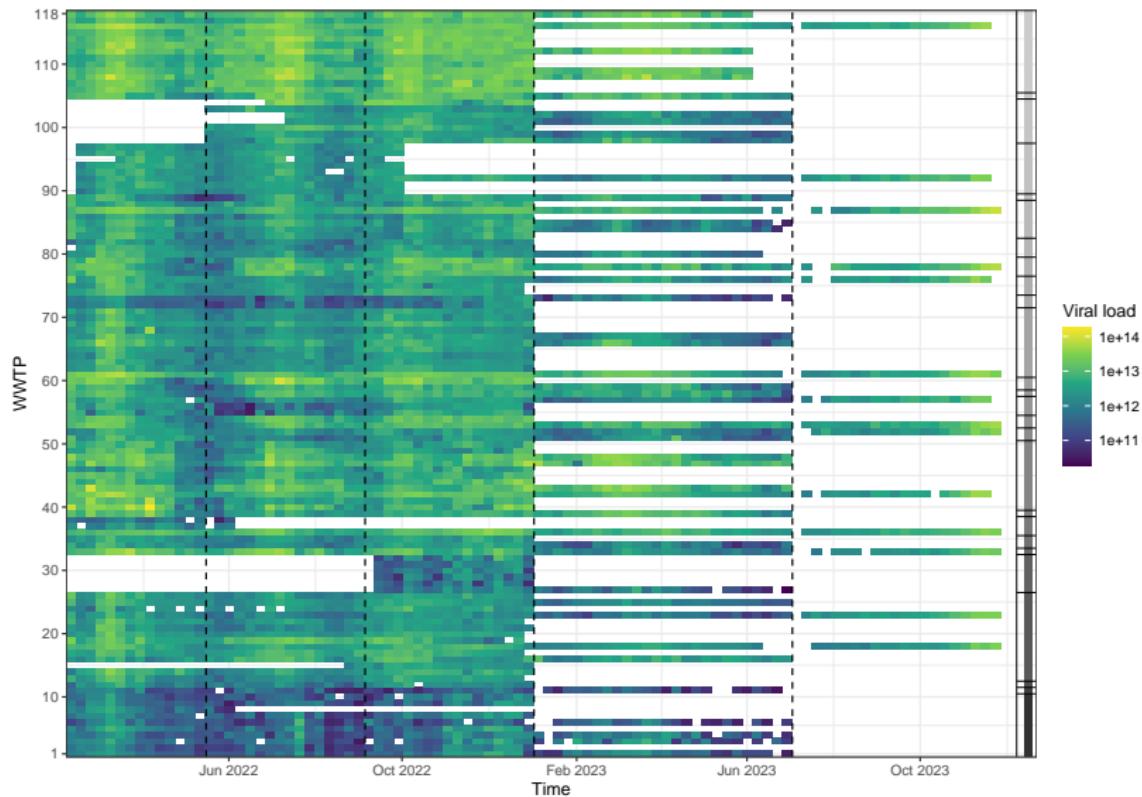


Figure 1: Daily SARS-CoV-2 viral load in wastewater by ARA (removing values below the LOD or LOQ).

Data



Data

Difficulties of interpretation:



Figure 2: Viral load in wastewater as of 31 October 2023, Lausanne VD (Vidy) (*FOPH dashboard, covid19.admin.ch*).

Objectives

1. Disentangle the various sources of heterogeneity (Julien)
 - ▶ laboratory, quantification method, systematic temporal or spatial effects, local characteristics...
2. Extract a clean, “noise-free” temporal signal (Julien)
 - ▶ at the regional level
3. Identify clusters among WWTPs (James)
 - ▶ WWTPs with similar dynamics

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Methods

Space-time model based on gamma regression, accounting for:

- ▶ limits of detection (LOD) and of quantification (LOQ)
- ▶ systematic temporal effects (public holidays, weekends)
- ▶ effect of laboratory and quantification method
- ▶ other local characteristics
- ▶ regional time trends (RW2)
- ▶ systematic shift for each ARA (IID)
- ▶ deviations from national trend for each ARA (BYM)

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Methods

Other local characteristics of WWTPs:

- ▶ proportion of population aged >65 (from STATPOP)
- ▶ proportion of population aged <20 (from STATPOP)
- ▶ median index of socio-economic position (Panczak et al. 2023)
- ▶ employment factor (full-time equivalent jobs per population from STATENT)

Methods

Besag-York-Mollié model:

- ▶ tendency for adjacent areas to share similar characteristics
- ▶ Intrinsic Conditional Auto-Regressive (ICAR) models for spatial auto-correlation between neighboring areas
- ▶ The BYM model (1991) includes both an ICAR component and an ordinary random effect (Independent and identically distributed, iid)
- ▶ Parameter ϕ measures the proportion of spatial variability that follows the neighbor structure

Methods



Results

Posterior predictive check (**model fit**) is quite good.

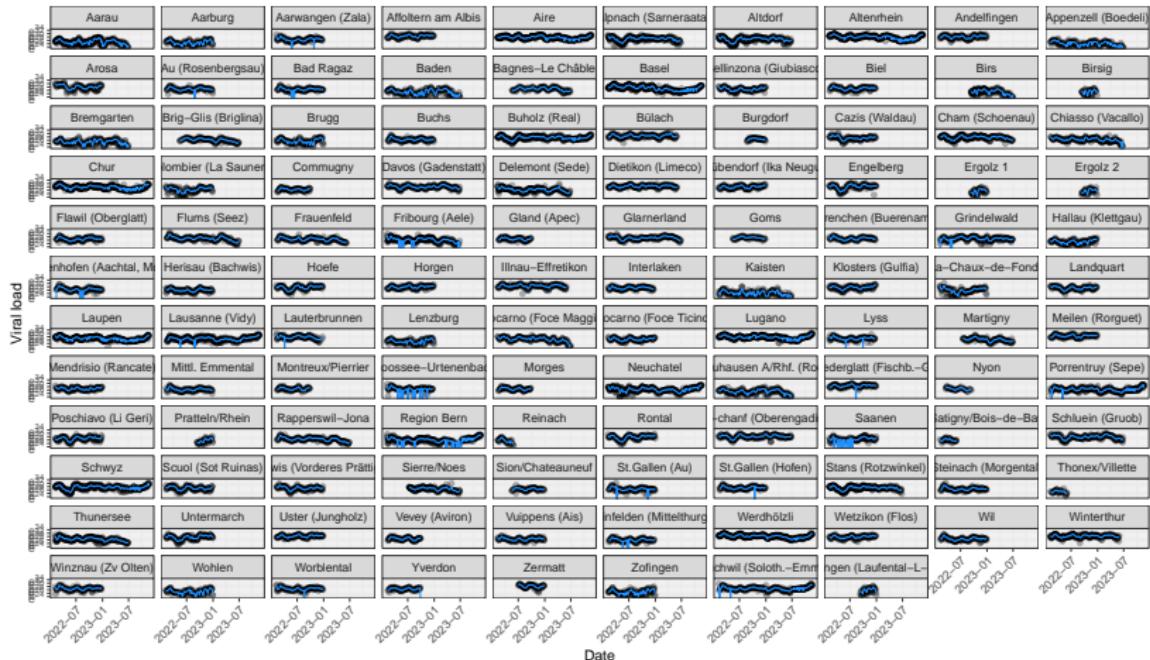


Figure 3: Model fit.

Results

Posterior predictive check ([model fit](#)) is generally quite good.

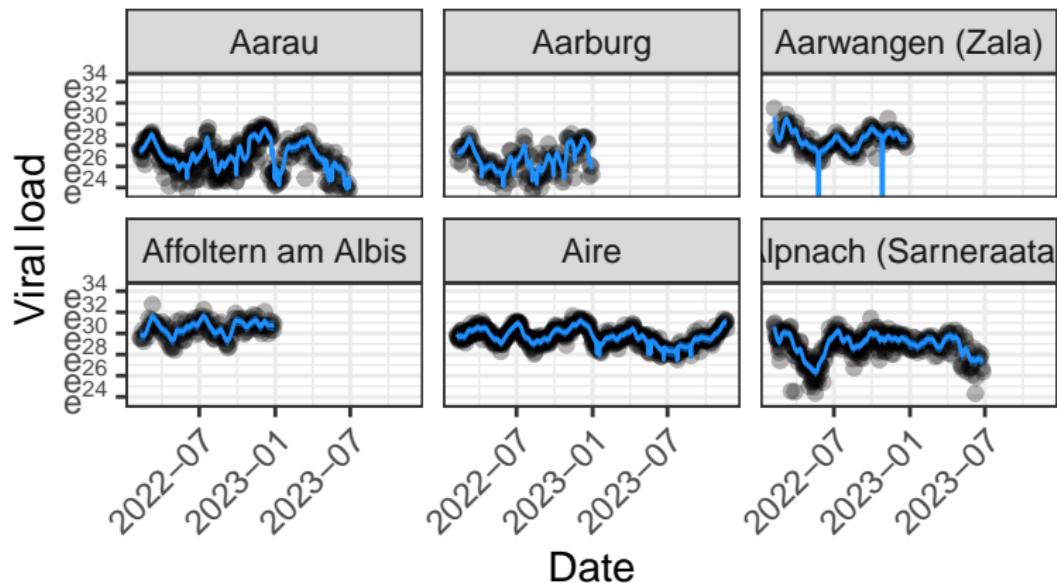


Figure 4: Model fit.

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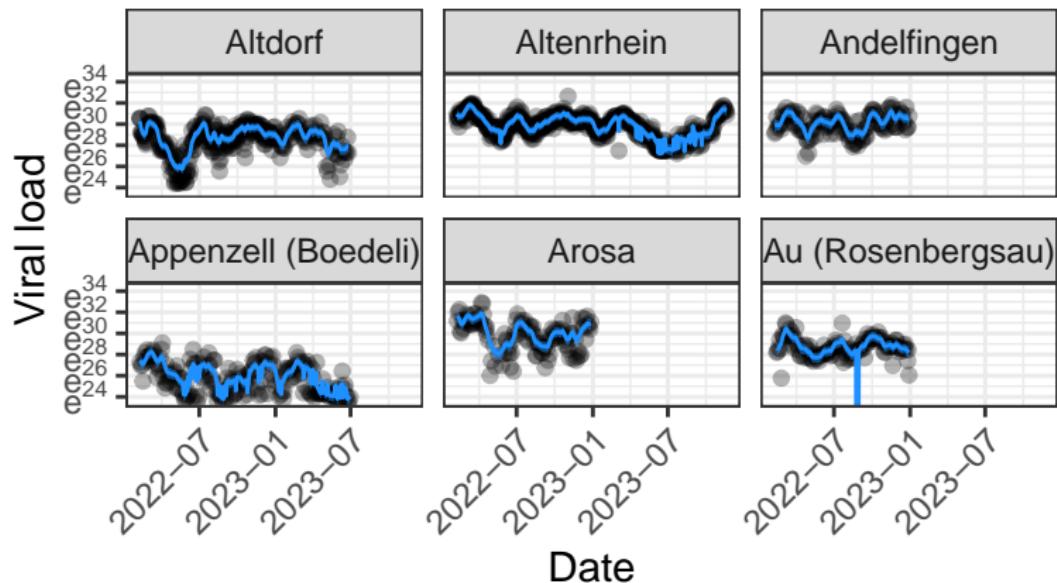


Figure 5: Model fit.

Results

Effect of laboratory and method (reference is EAWAG_0):

- ▶ $\exp(\beta)$ can be interpreted as a relative viral load, e.g., the viral load is *on average* 33 times lower in lab C1 than lab A

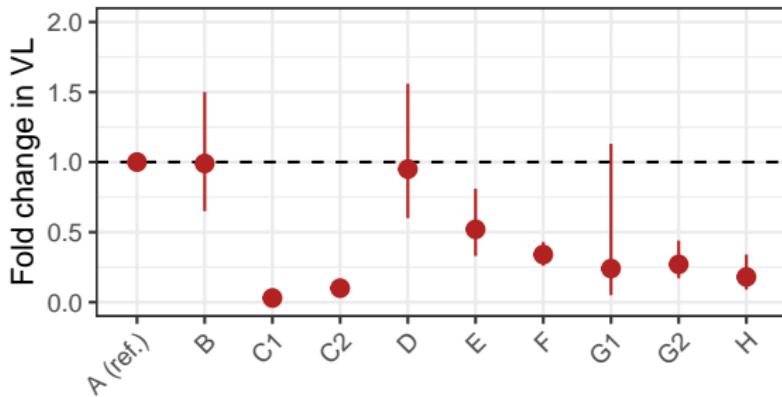


Figure 6: Estimated effect of laboratory (laboratory name) and method change (marked by 0 and 1).

Results

Effect of public holidays and weekends:

- ▶ no clear influence

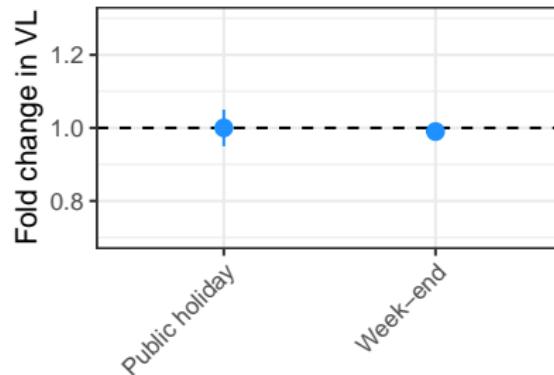


Figure 7: Estimated effect of holidays and weekends.

Results

Effect of local characteristics:

- ▶ association with population age structure

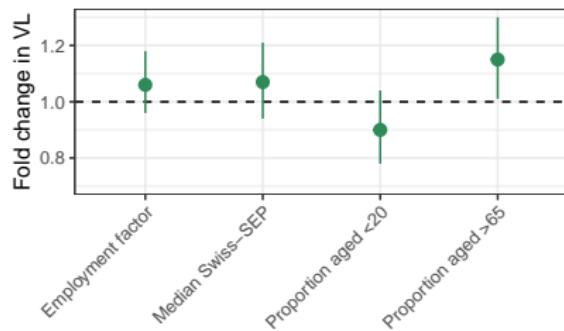
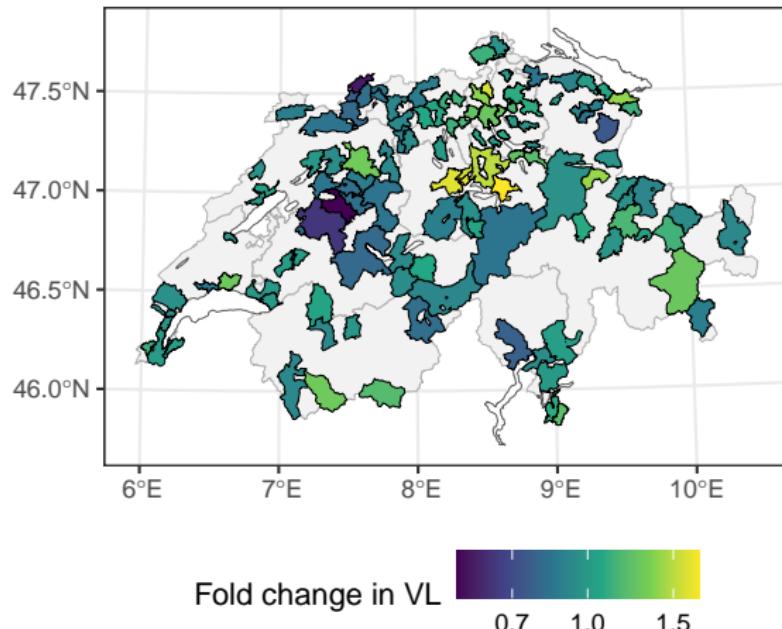


Figure 8: Estimated effect of holidays and weekends.

Results

Specificities of specific WWTPs:

- ▶ some WWTPs have consistently higher or lower viral loads
- ▶ structured geographically ($\phi=0.46$)



Results

Average temporal trend at the regional level:

- ▶ accounts for all aspects described before

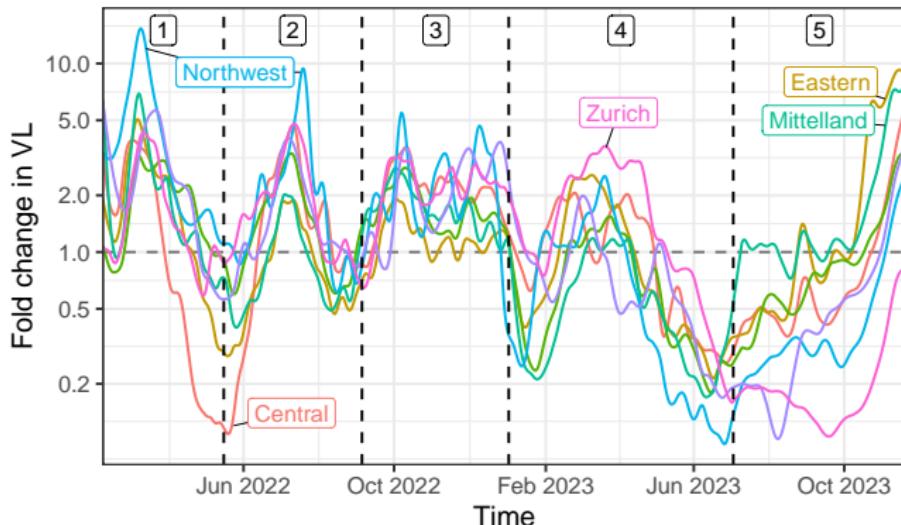


Figure 10: Estimated average temporal trend at the national level.

Results

Correlation with hospitalizations:

- ▶ come on top of all aspects described before

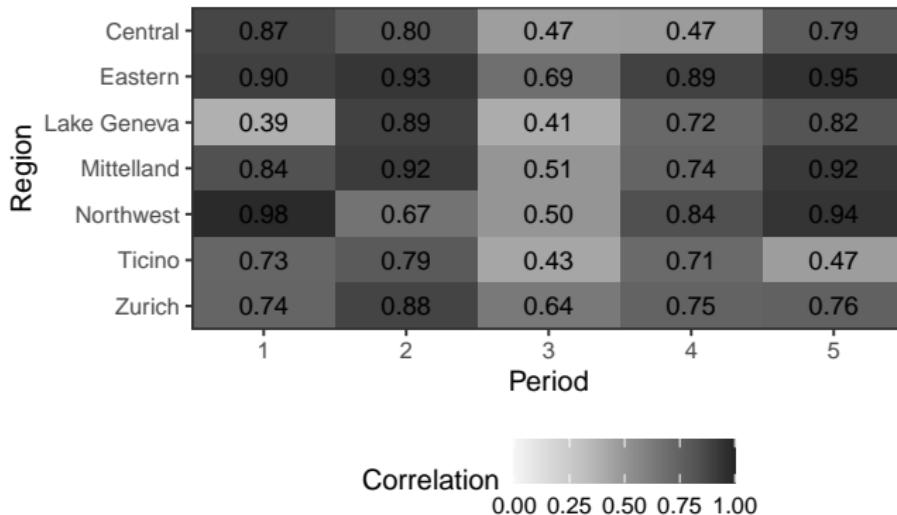


Figure 11: Correlation between regional trends and hospitalizations.

Results

Correlation with hospitalizations:

- ▶ higher than with raw viral load

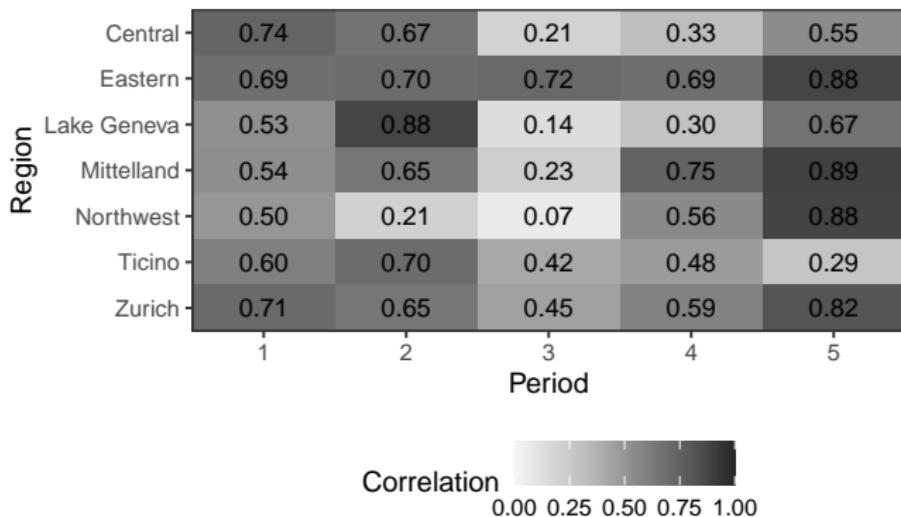


Figure 12: Correlation between regional trends and hospitalizations.

Discussion

1. Disentangle the various sources of heterogeneity
 - ▶ important variations across laboratories
 - ▶ association with population age structure
 - ▶ small remaining spatial variability (commuting, tourism...)

2. Extract a clean, “noise-free” temporal signal
 - ▶ regional time trends
 - ▶ high correlation with COVID-19 hospitalizations

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Paper

- ▶ First draft circulated to James
- ▶ Journal?
- ▶ Co-authors? (EAWAG, FOPH, ETHZ...)