Estimating Local Protective Behavior in Denmark with dynamic MRP

HOPE Project

2020-11-30

The goal of this brief report is to introduce the HOPE project's efforts in estimating COVID-19 protective behavior at local levels in Denmark.

The Data

We are relying on a survey collected by Gallup since May 13, 2020 with a new wave of 500 respondents on each day. Gallup recruits participants through stratified random sampling based on a database of CPR numbers (Danish social security numbers).

As of 2020-11-30 our sample sizes are:

- Gallup N = 131,774

Variables from the survey:

- **ContactFamily1m**: Share of people with one or more (>=1) physical contacts with non co-residing family members.[1]
- **ContactFriends1m**: Share of people with one or more (>=1) physical contacts with friends.
- **ContactColleagues1m**: Share of people with one or more (>=1) physical contacts with colleagues.
- **ContactStrangers1m**: Share of people with one or more (>=1) physical contacts with stranger.
- **SumContact1m**: Total *number* of non-home contacts. Note that while dichotomize the specific contact variables (family, friends, colleagues, strangers), here we sum up the number of contacts.
- **Contact_attention**: An index on compliance with 5 protective behaviors: avoiding physical contact, distancing from elderly and sick, keeping 1-2m distance from others in general, avoiding crowds
- **Hygiene_attention**: An index on compliance with 3 protective behaviors: handwashing, sneezing and coughing in sleeve, ensuring frequent cleaning.

The Method: MRP – Multilevel Regression with Post-stratification.

MRP has been developed as a technique to estimate attitudes on subnational level relying on data from national public opinion surveys. In recent years, it has been validated as a tool for generating reliable and valid subnational estimates of public opinion, which is superior to most naive alternatives (e.g. slicing up data). In a nutshell. MRP relies on both demographic and geographic variables in the modeling process and employs partial pooling (to the extent warranted by the data) in order to improve estimates for smaller units. There many excellent (https://en.wikipedia.org

/wiki/Multilevel_regression_with_poststratification) and intuitive (https://scholar.princeton.edu/sites/default/files/jkastellec/files/mrp_primer.pdf) introductions about MRP online, so we refrain from a general introduction here. Instead, we give a brief summary of the analytical steps we took. We implemented MRP relying on the *rstanarm* R library in a fully Bayesian framework.

Stage 1 - Estimating individual level protective behavior with multilevel models

First, we seek to build a model of individual level protective behavior. Our independent variables are the following:

- age_cat: 5year age categories from 20-24 … to 70+. (11 levels)
- female: participant sex. (2 levels)
- edu_clean: Participant's highest level of education (7 levels)
- region: Participant's region of residence (5 levels).
- kommune: Participant's municipality of residence (98 levels, we drop Christiansø from all analyses).
- week: Week of interview.
- kommune-week: we include the interaction between all weeks and municipalities.

The R code for the full multilevel model is displayed below. Note that we model age conditional on gender.

Moreover, note that the type of regression varies with the DV. For count variables (total contacts and handwashing) we run negative binomial regressions, for binary variables (avoid crowds of 10+, nonzero contact variables) we run logistic regressions and for the continuous variables (level of behavior change, distancing attention, hygiene attention) we run simple linear regression.

```
model <-  stan_glmer(DV ~ 1 + (1 | age_cat:female) +
                               (1 | edu_clean) +
                               (1 | region) +
                               (1 | kommune) +
                               (1 | kommune:week) +
                               (1 | week),
                     family = neg_binomial_2,
                     data = data,
                     seed = 3012, iter=2000,
                     control = list(adapt_delta = 0.99))
```

We evaluate the performance of the models with leave-one-out (LOO) cross-validation.

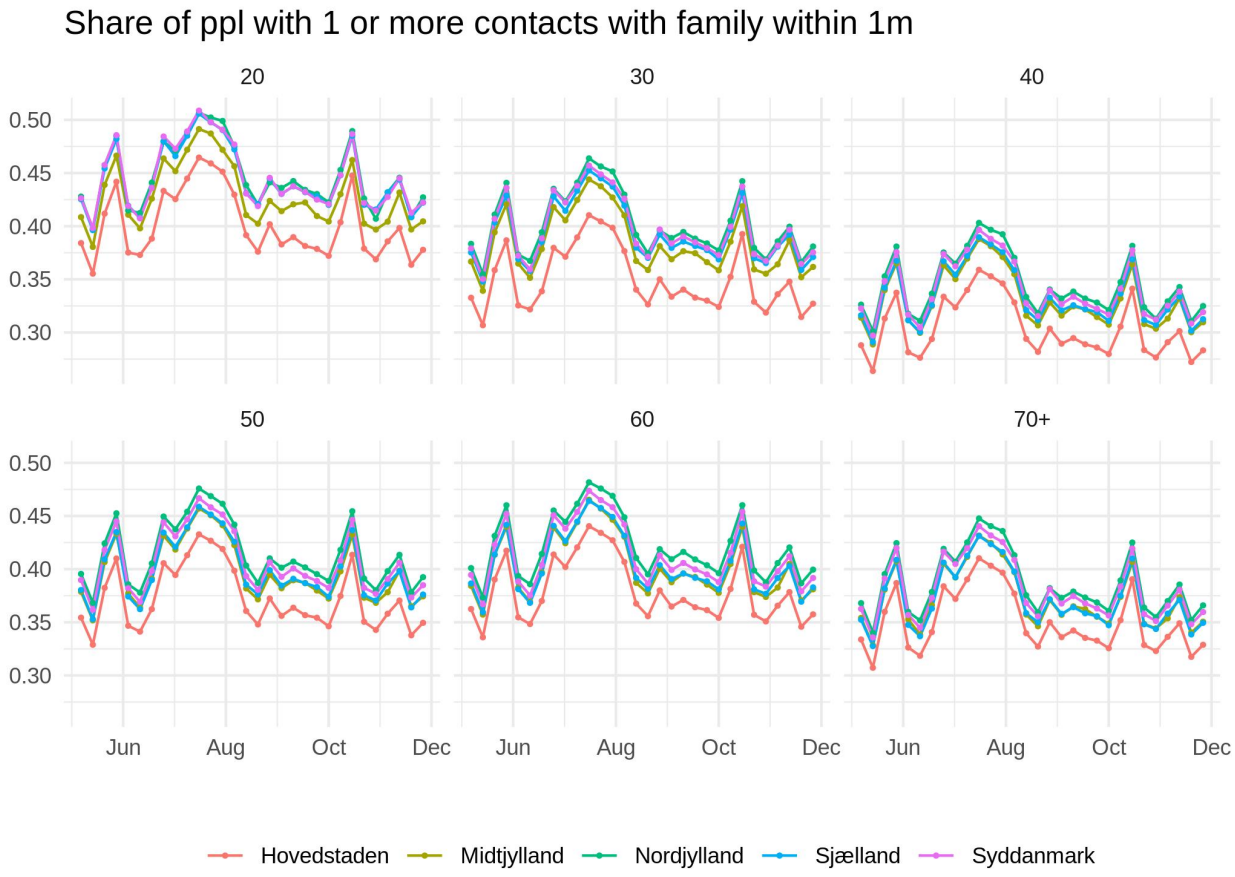
Stage 2 - Simulation and Post-stratification

As the multilevel model informs us about the 'effects' of various demographic factors, we can next simulate the outcome for every type of person in our model. In other words, we predict the expected outcome for every possible combination of age, sex, education, and municipality ($11 * 2 * 7 * 98 = 15,092$). Next, we rely on census data from the Statistics Denmark (https://www.statistikbanken.dk/statbank5a/default.asp?w=1440) to weigh the frequency of each type of respondent in each municipality[2] We repeat this procedure for every week in our data. (We assume population distribution does not change between our dates.) We then aggregate these for region × 10 year age groups and estimate 50% and 90% credible intervals based on the posterior

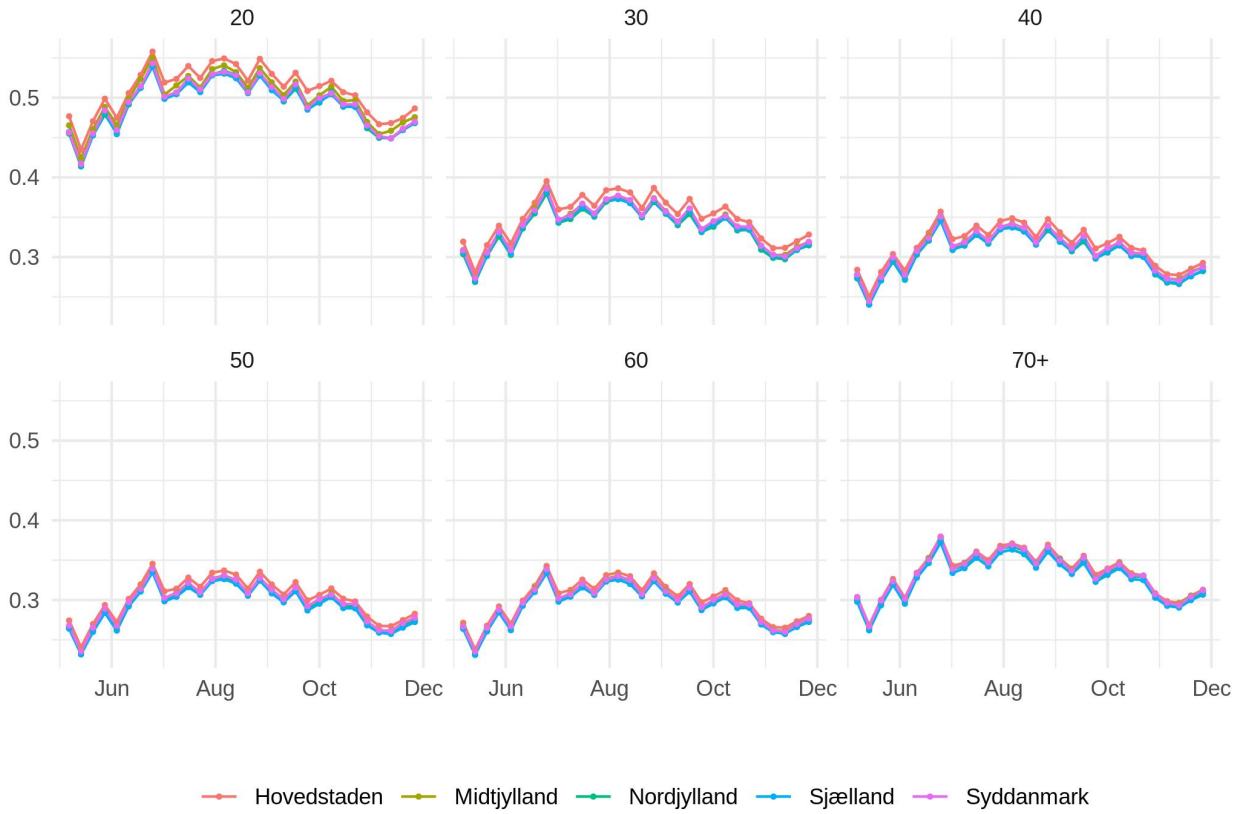
distributions.

Results

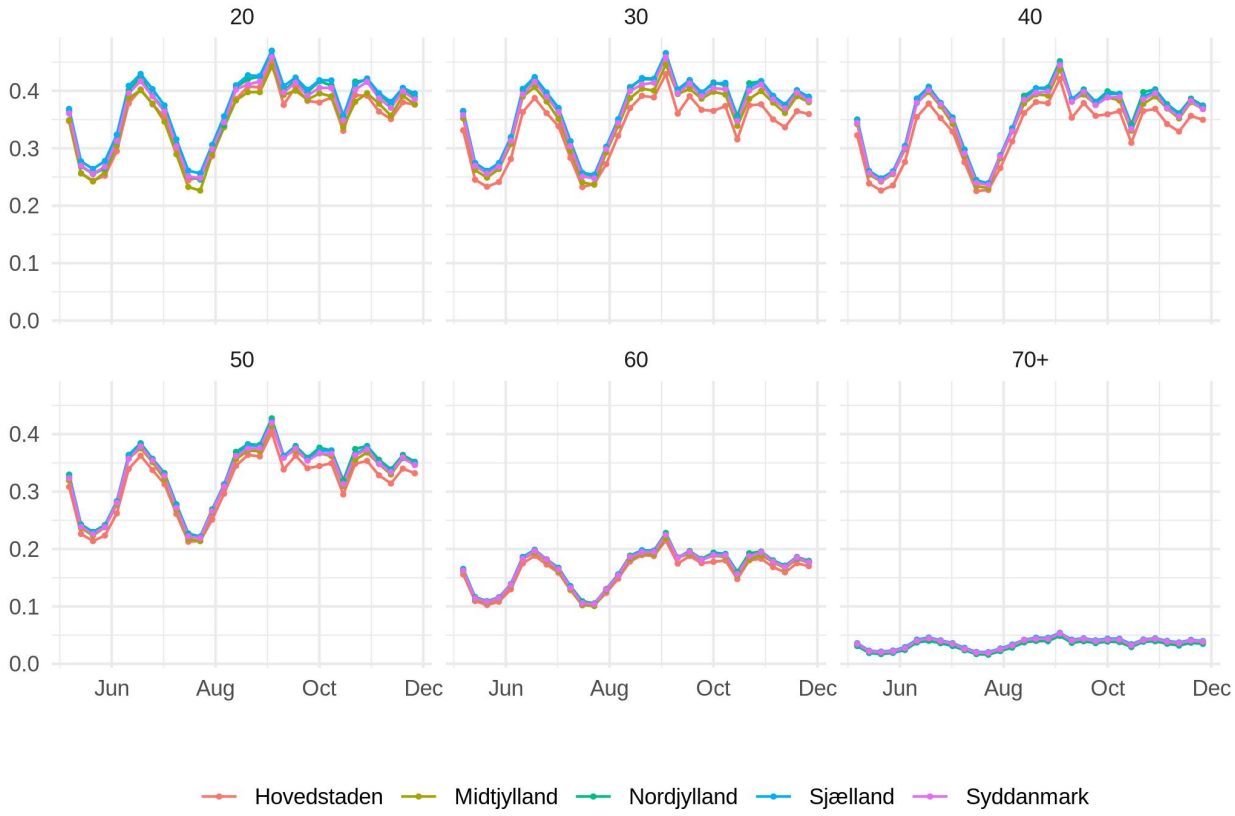
The plots below show our main results: the level of protective behavior for every age group in every region for every date in our data. We omitted credible intervals, which would be highly overlapping given the limited variation by region.



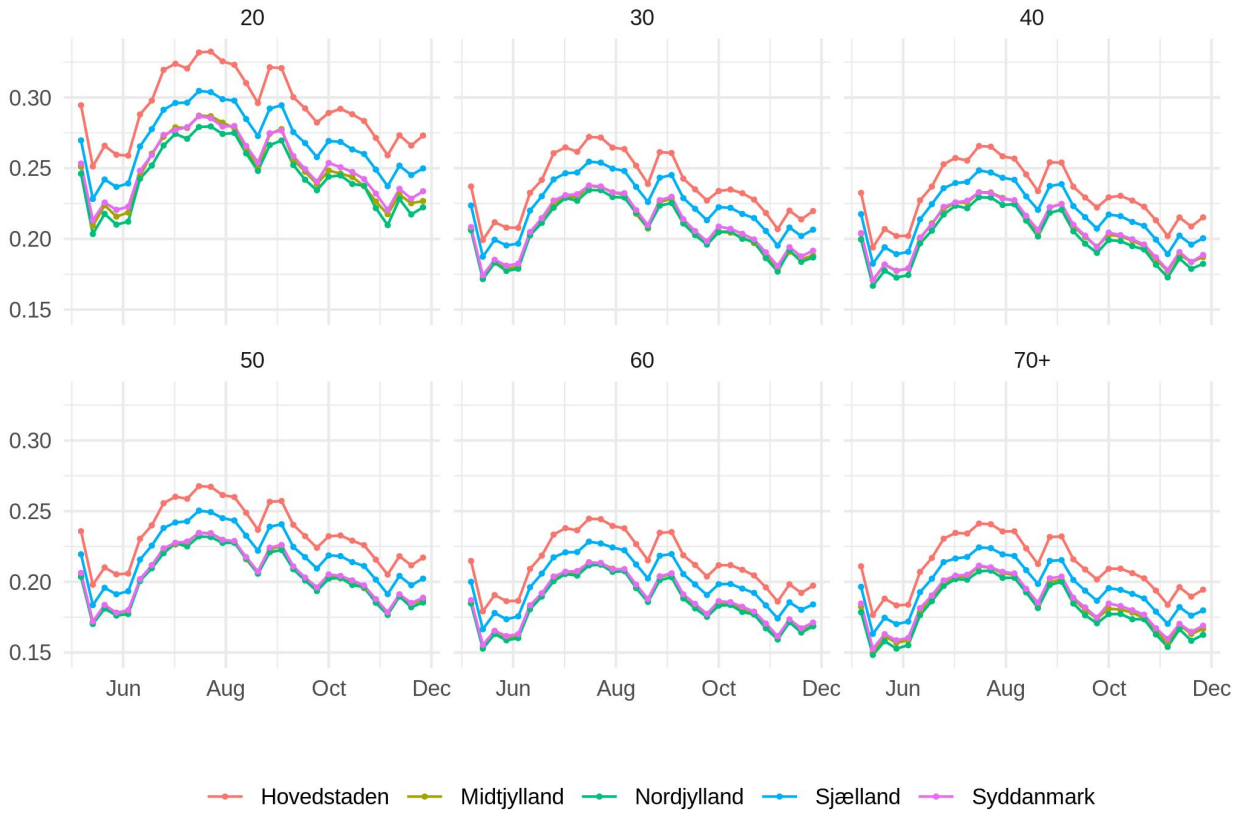
Share of ppl with 1 or more contacts with friends within 1m



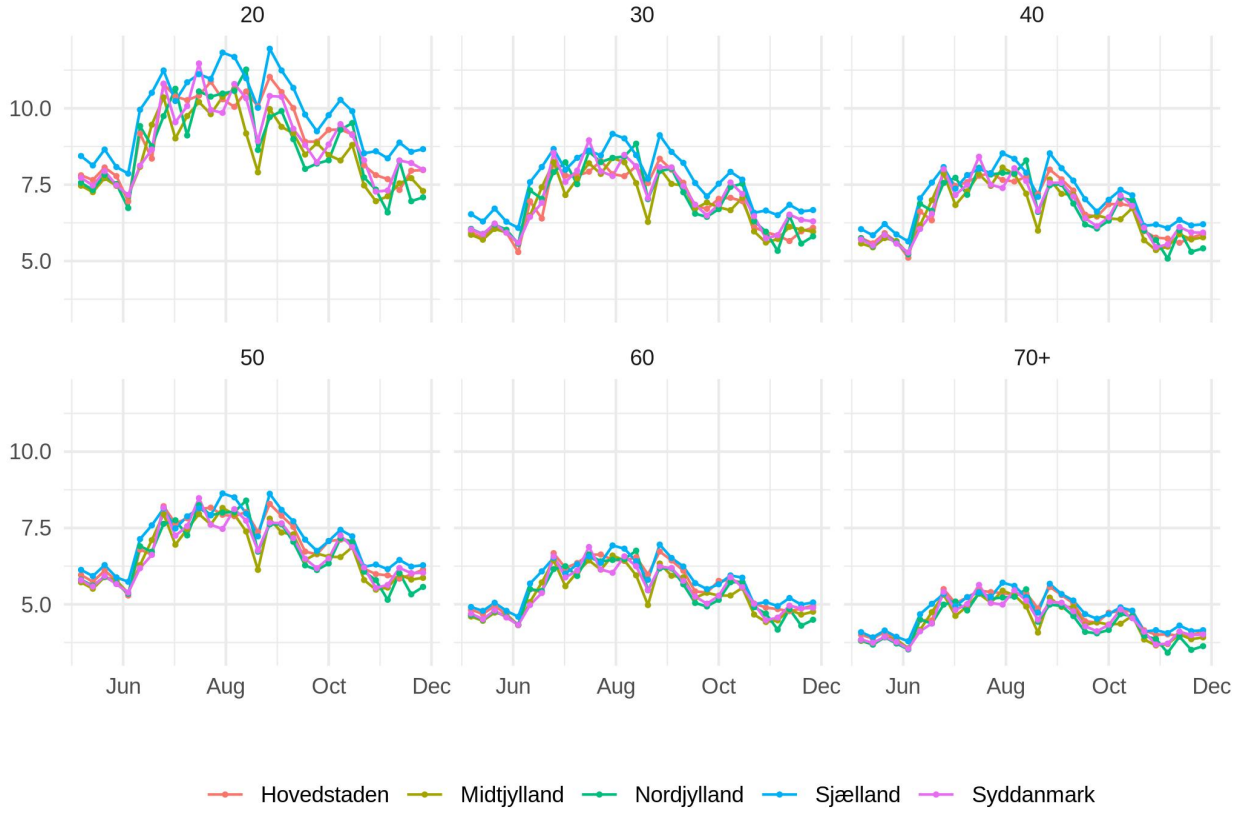
Share of ppl with 1 or more contacts with colleagues within 1m



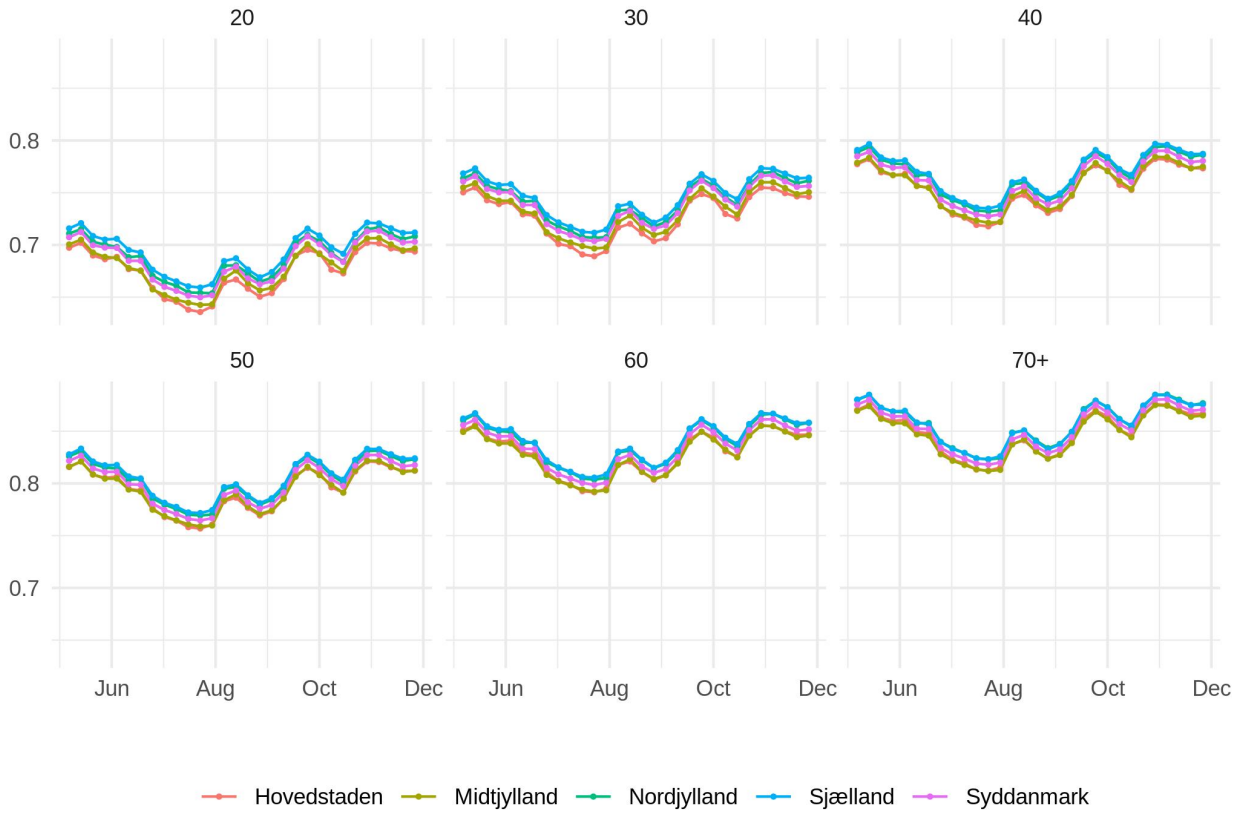
Share of ppl with 1 or more contacts with strangers within 1m



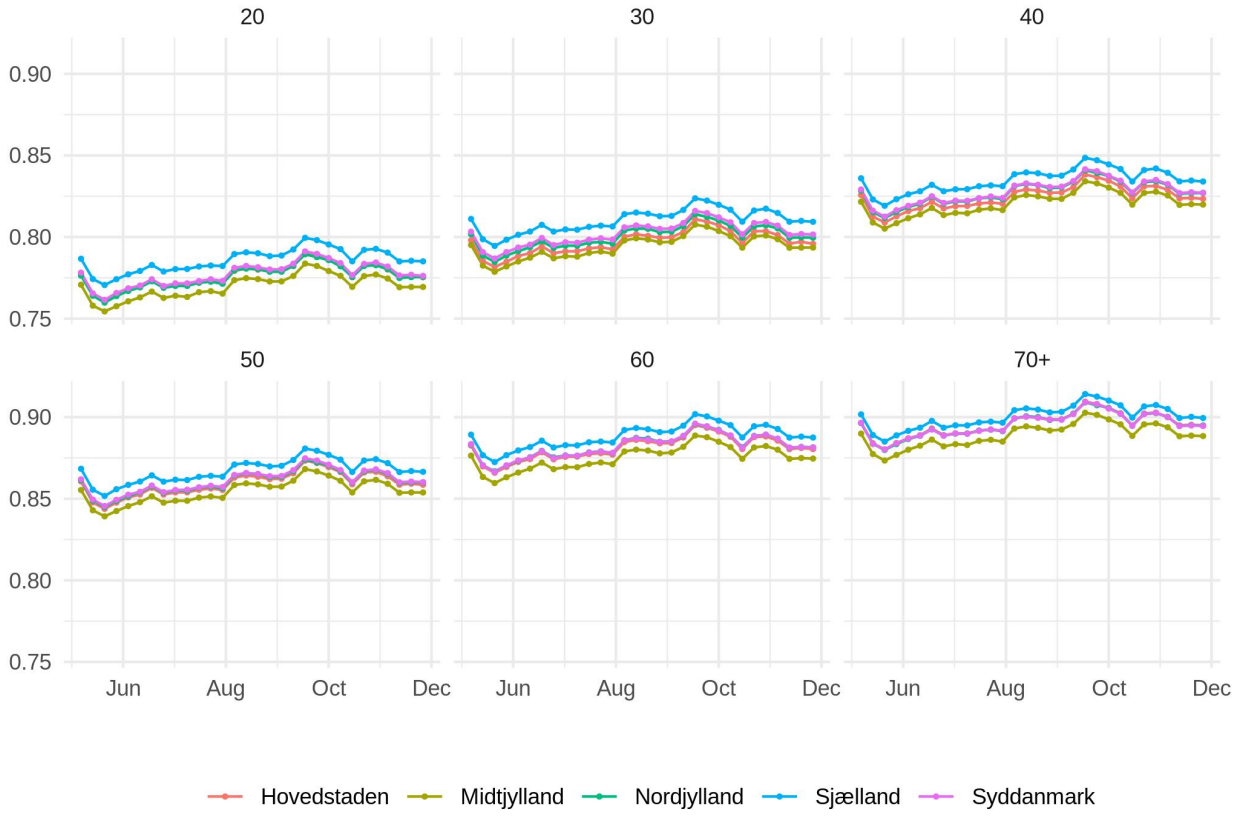
Sum of 1m contacts outside of household



Attention to social distancing



Attention to hygiene measures



Contact

If you have any comments about these models, please contact Alexander Bor

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Acknowledgements

We are grateful for help by Magnus Storm Rasmussen, Mathias Tromborg, and Gabor Simonovits.

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1. Specifically, respondents are asked to remember “how many people they have been physically close to in the past 24 hours. Physically close is understood here as closer than 1 meters for at least 15 minutes.”↩
2. The publicly available census info is limited to 5 year age categories between 15 and 69, we purchased the Census data for the elderly (70+).↩