Regional situational awareness and forecasting for COVID-19

28 July 2020

In this report we present predictions of the covid-19 epidemic at county level (fylke). We run the same SEIR model which is used for the national predictions[1]. What is new in this regional analysis, is that we use individual-level hospital incidence data to calibrate our model, to provide regional predictions. These regional predictions are preferable to the ones presented in the national report, as there we do not use regional hospitalisation data, only the national total.

We estimate all reproduction numbers by fitting our model to the hospital incidence of covid-19 confirmed patients.

We get more reliable results for the counties which have most covid-19 hospitalisations, including Oslo, Viken and Vestlandet. For some counties the hospitalisations are few. In these cases, predictions for the next three weeks are reliable, but the estimated reproduction numbers are very uncertain. Because of the very low incidence of cases in Nordland and Troms og Finmark, we cannot make any reliable inference for these counties.

When confidence intervals are large, as they are in this report for the R_2's, the estimated mean or median do not synthesise well the results. Means and medians should not be reported without the corresponding confidence intervals. There are differences between the confidence intervals of the regional R_2's and of the national R_2, as reported in our daily national report. The confidence intervals have however large overlaps, and these difference are not significant.

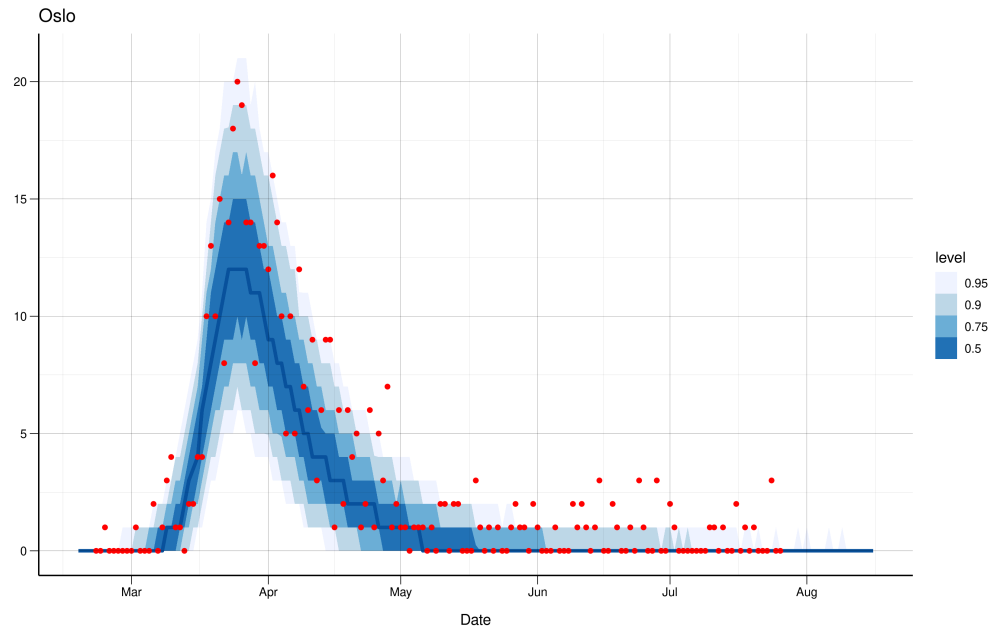
[1] https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/

1 Predicted hospitalisation, including patients in ventilator treatment: next three weeks in each county

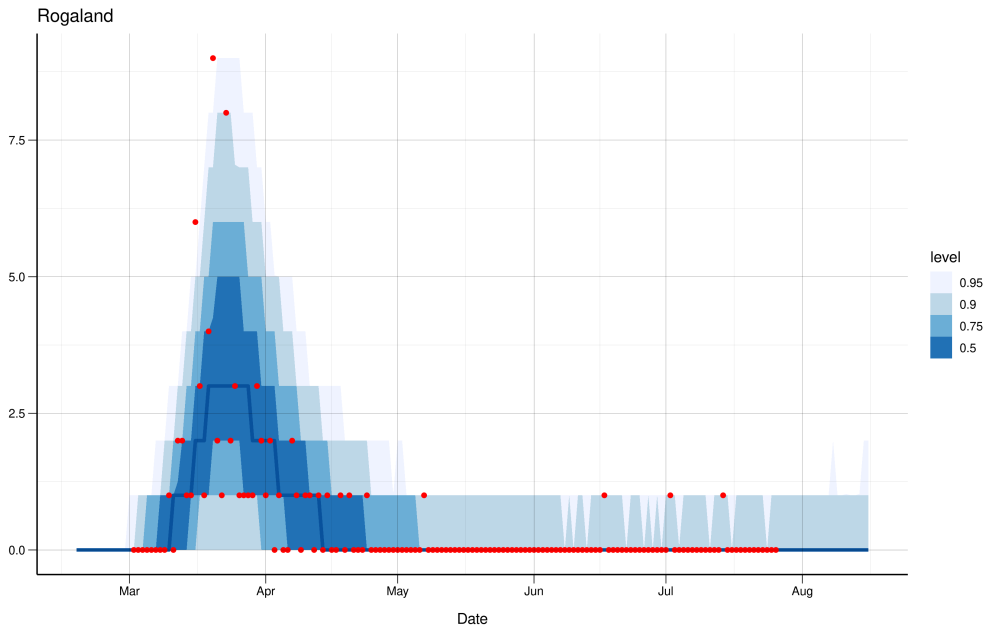
Our model estimates the number hospital incidence of covid-19 patients in each county, plotted below with blue median and uncertainty bands, which are compared to the actual hospitalisation incidence of the county, in red. The blue bands describe the uncertainty in the calibrated parameters in addition to the stochastic elements of our model. Each plot shows the predicted daily hospital incidence of covid-19 patients in each county (95% confidence intervals and interquartile range), for the next three weeks, including patients in ventilator treatment. Notice large uncertainties in some counties in particular.

Table 1: Number of hospitalisation beds occupied by Covid-19 patients.

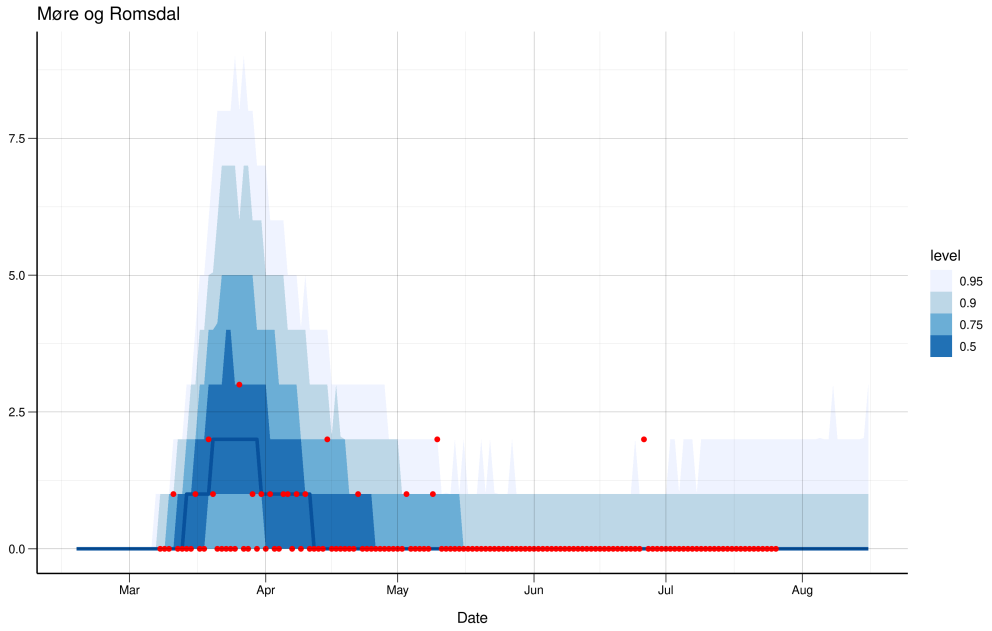
Region	1 week prediction (02 August)	2 weeks prediction (09 August)	3 weeks prediction (16 August)
Agder	1 (0-8)	1 (0-8)	1 (0-9)
Innlandet	1 (0-6)	1 (0-5)	1 (0-5)
Møre og Romsdal	2 (0-15)	2 (0-19)	3 (0-18)
Nordland	1 (0-14)	1 (0-14)	1 (0-12)
Oslo	0 (0-3)	0 (0-3)	0 (0-3)
Rogaland	1 (0-8)	1 (0-8)	1 (0-10)
Troms og Finnmark	2 (0-17)	3 (0-17)	3 (0-16)
Trøndelag	1 (0-8)	1 (0-7)	1 (0-8)
Vestfold og Telemark	0 (0-3)	0 (0-3)	0 (0-3)
Vestland	0 (0-4)	1 (0-5)	1 (0-5)
Viken	1 (0-6)	1 (0-6)	1 (0-5)



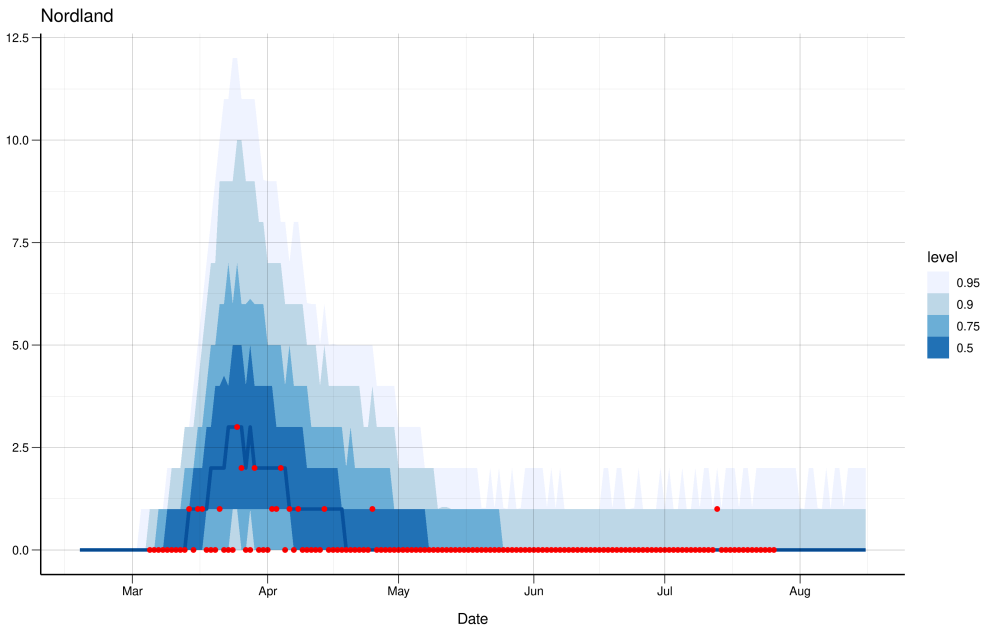
True hospitalisation incidence (red) and predicted values (blue)



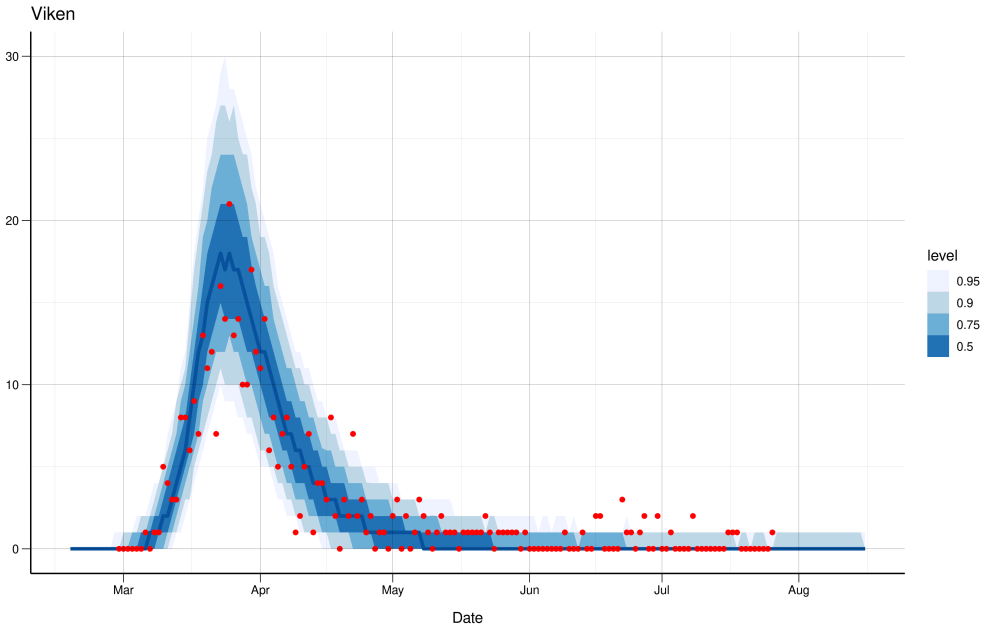
True hospitalisation incidence (red) and predicted values (blue)



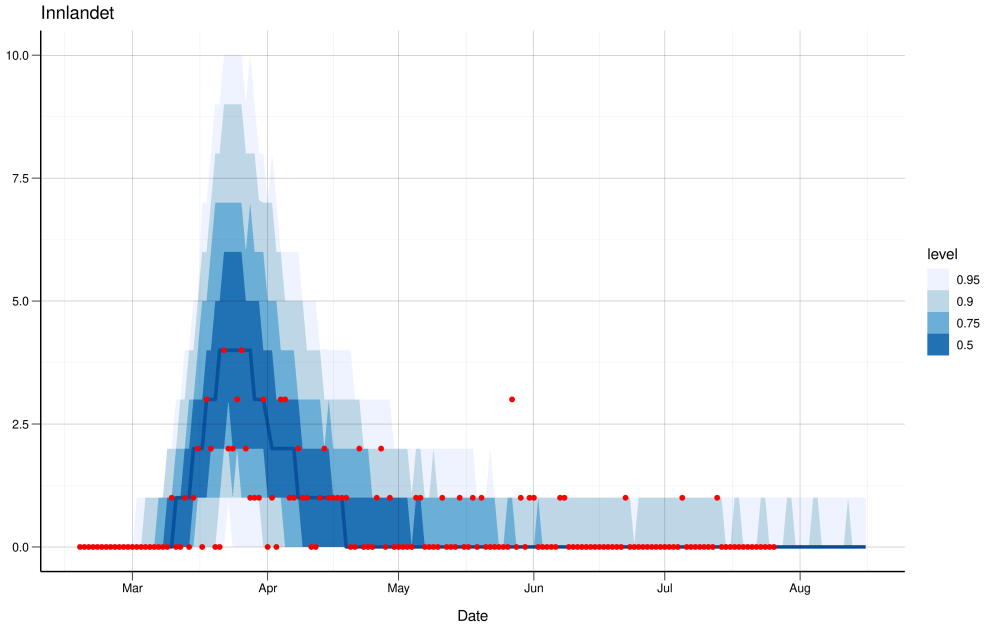
True hospitalisation incidence (red) and predicted values (blue)



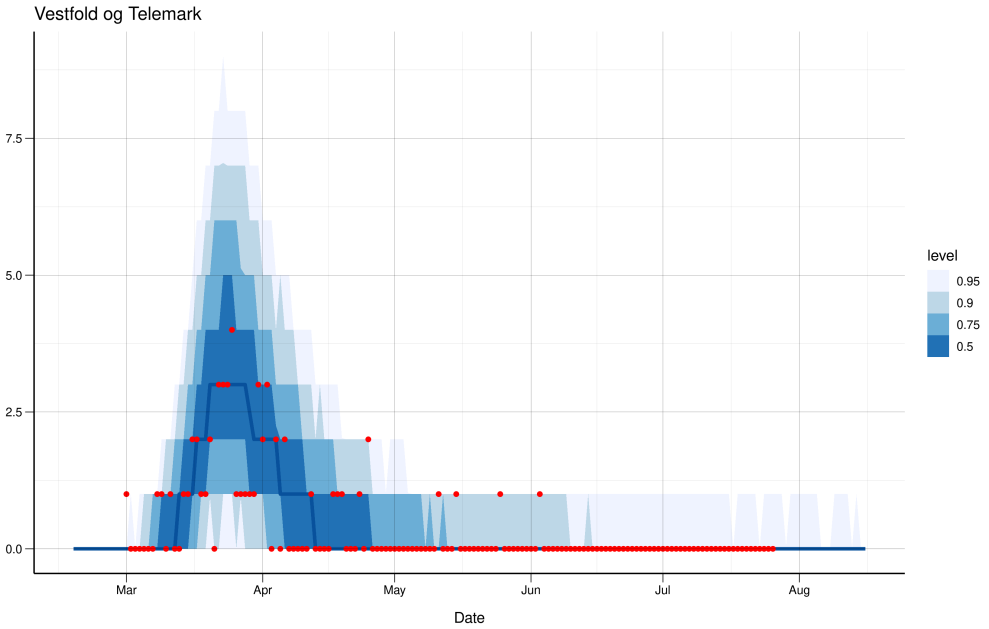
True hospitalisation incidence (red) and predicted values (blue)



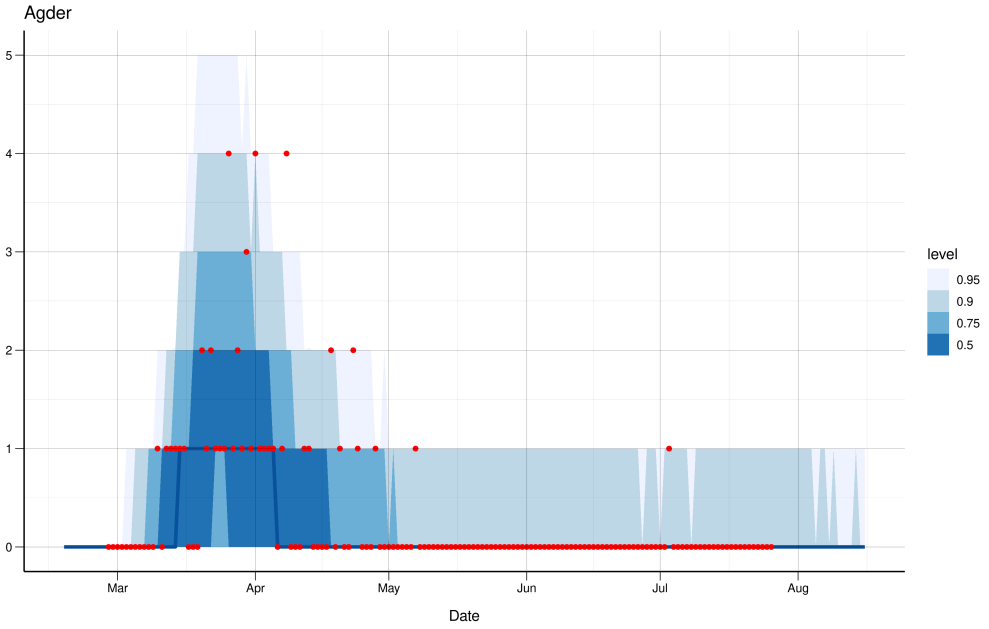
True hospitalisation incidence (red) and predicted values (blue)



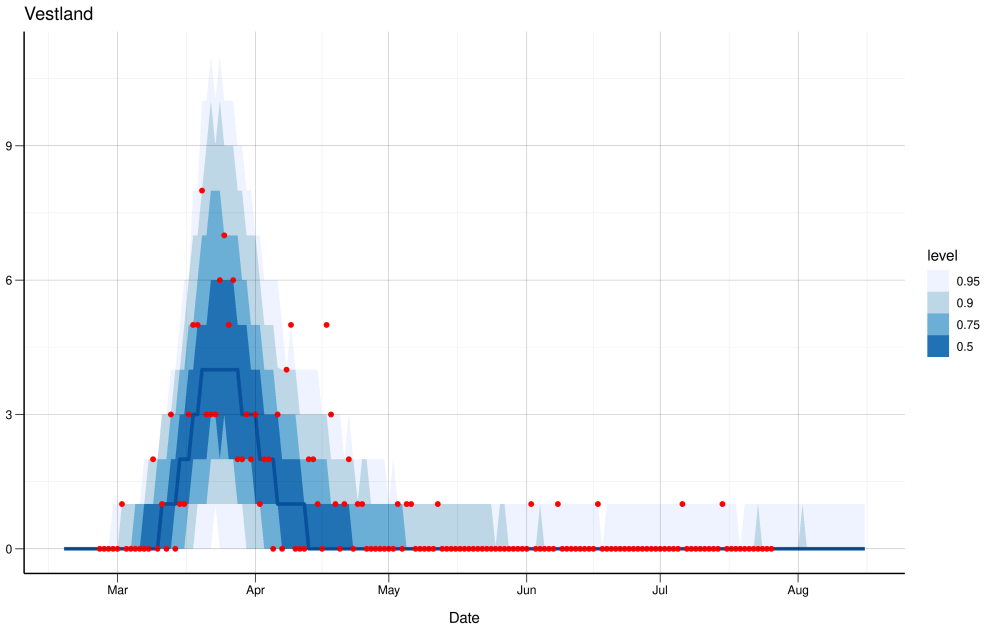
True hospitalisation incidence (red) and predicted values (blue)



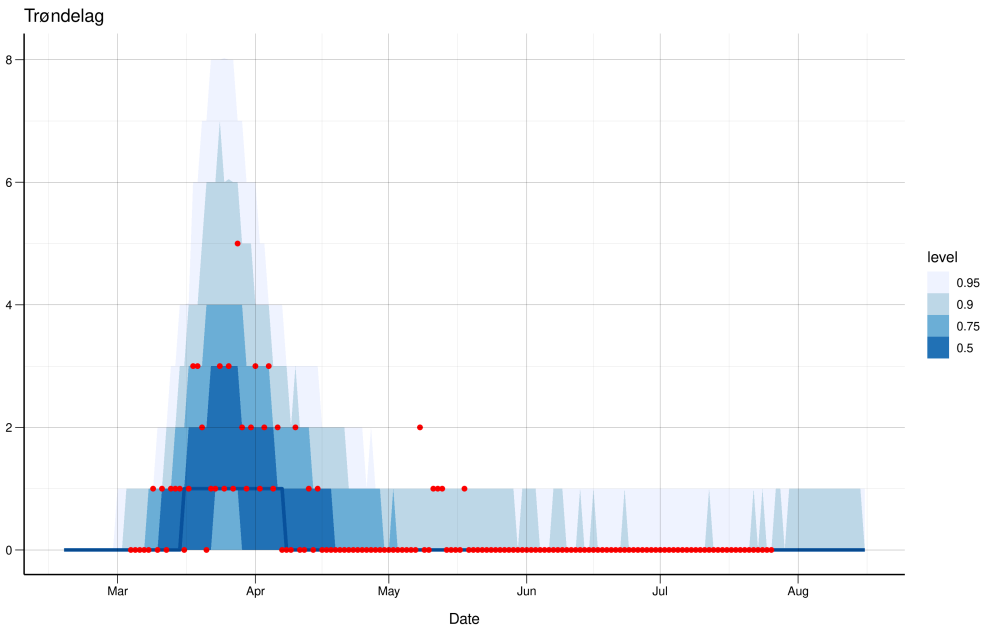
True hospitalisation incidence (red) and predicted values (blue)



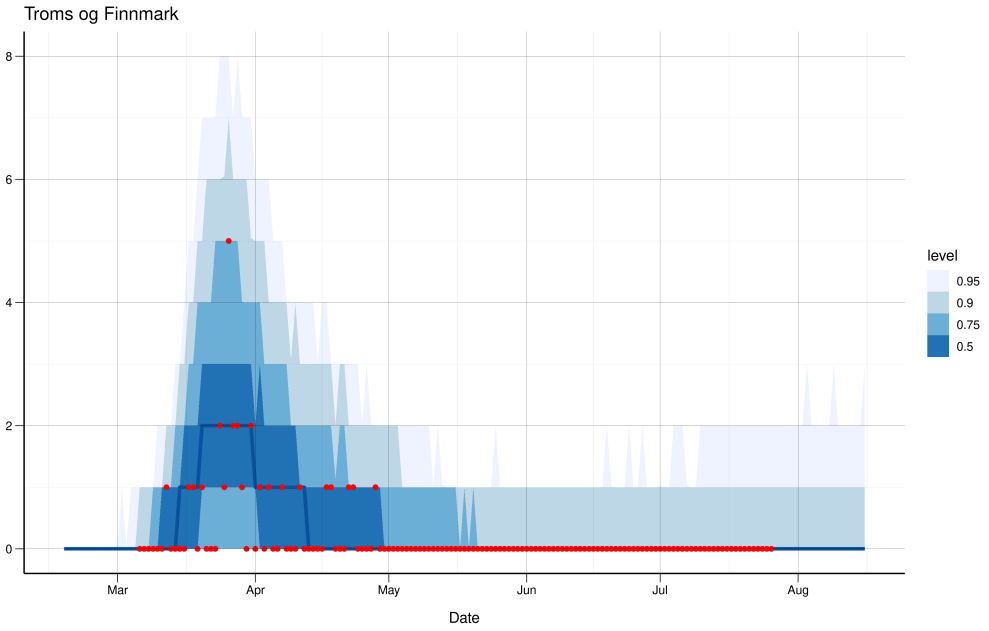
True hospitalisation incidence (red) and predicted values (blue)



True hospitalisation incidence (red) and predicted values (blue)



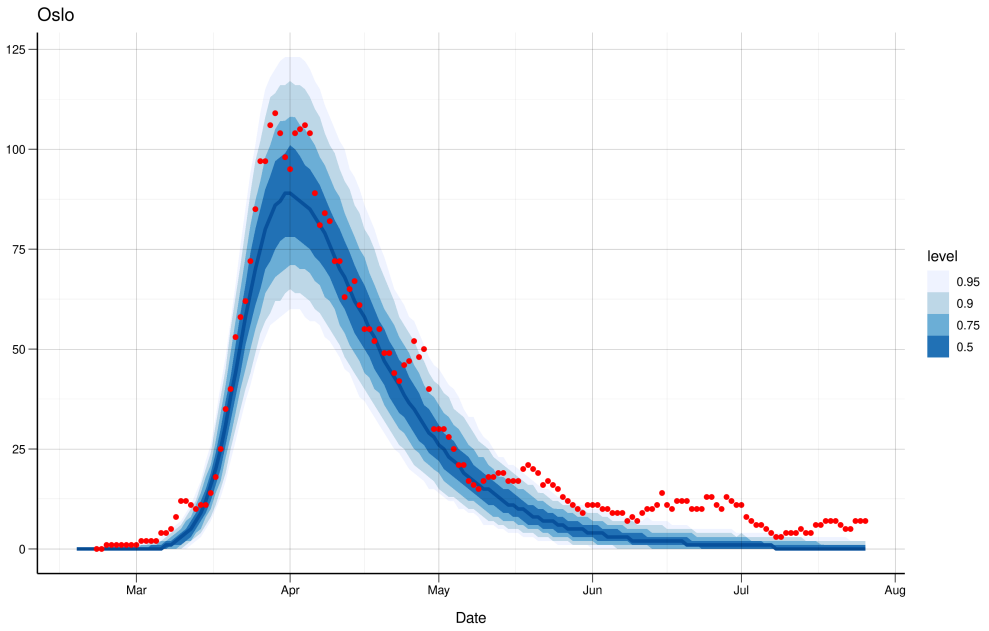
True hospitalisation incidence (red) and predicted values (blue)



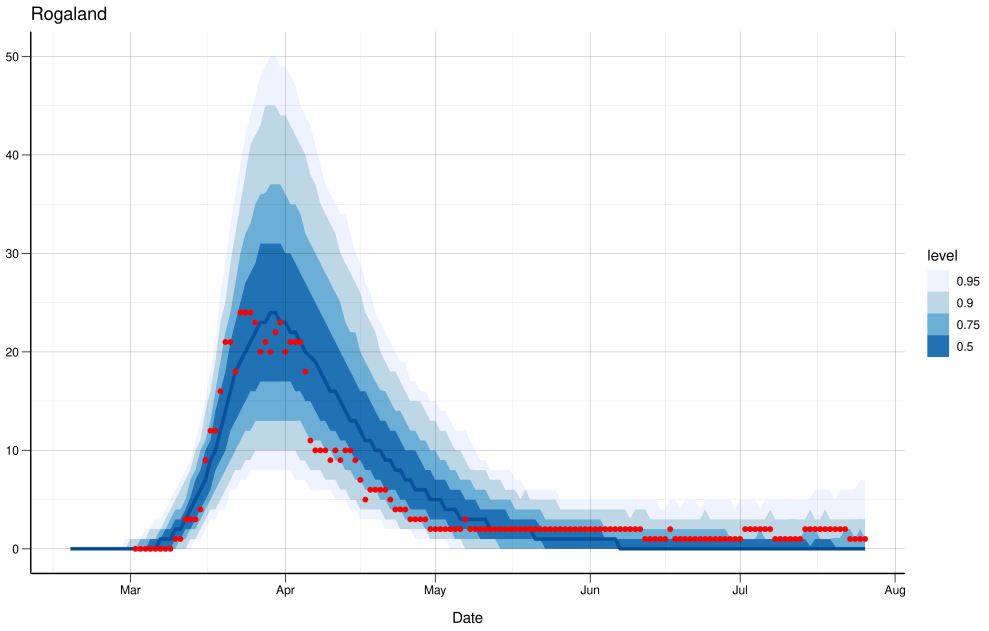
True hospitalisation incidence (red) and predicted values (blue)

1.1 Hospital prevalence

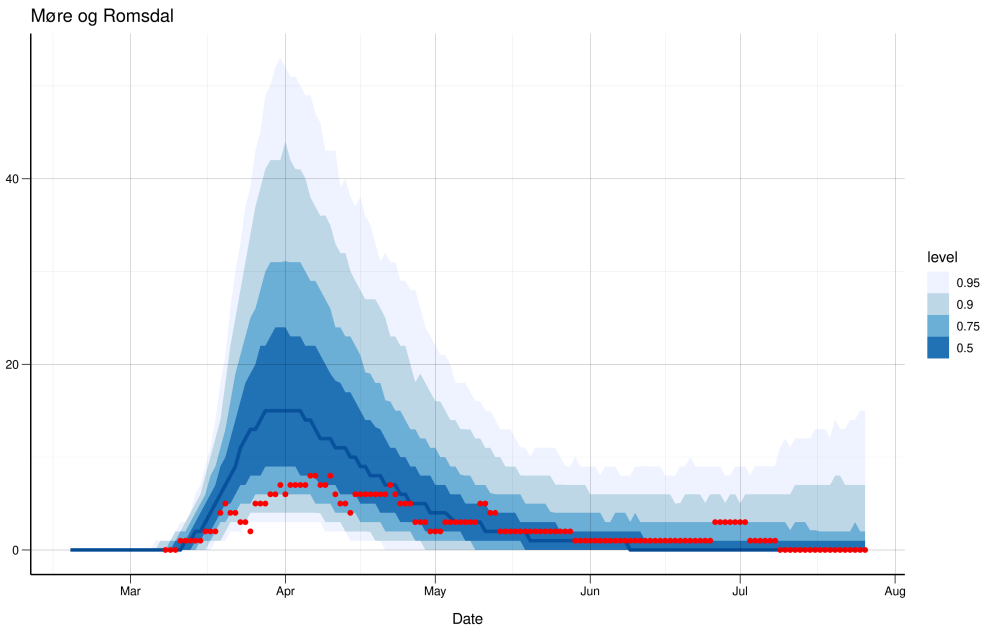
Though we do not calibrate to the hospital prevalence data, we show our simulations along with the prevalence data, as a test of our model performance. The model simulations fit the prevalence data well, but for some counties there are larger discrepancies. This indicates that there could be regional differences in the length of stay in hospital.



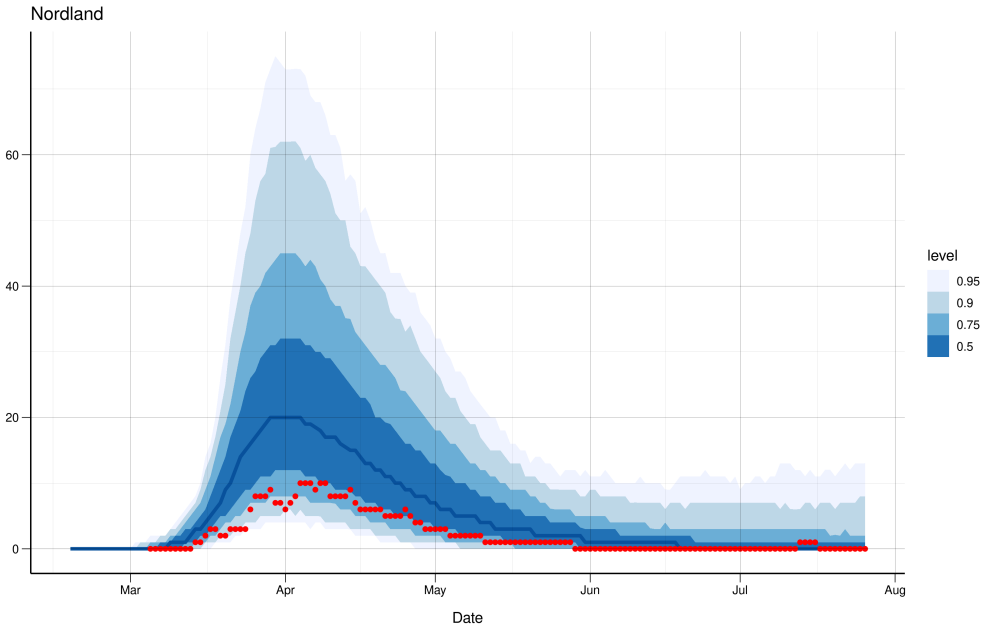
True hospitalisation prevalence (red) and predicted values (blue)



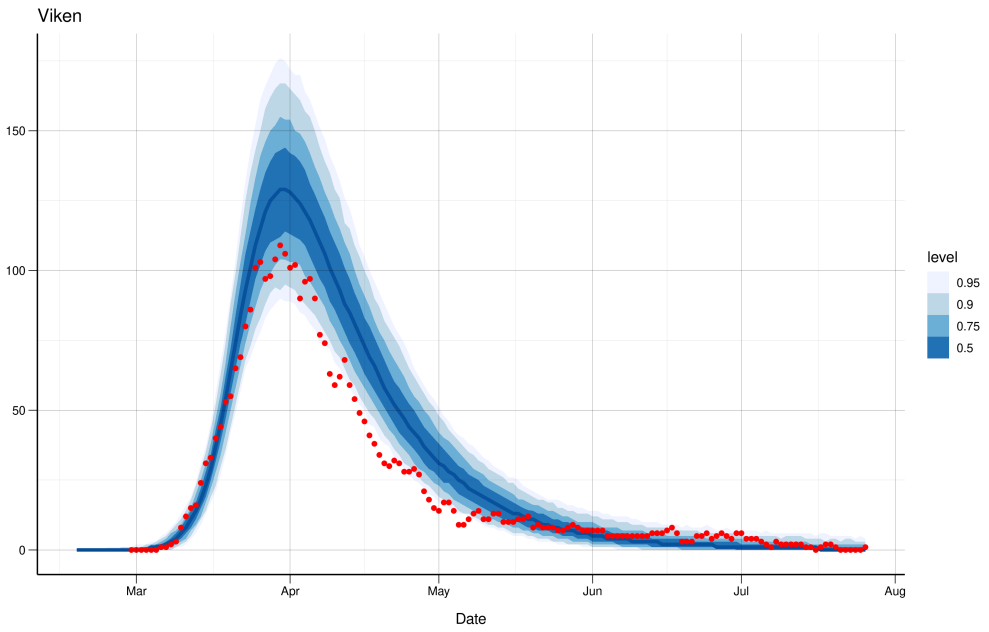
True hospitalisation prevalence (red) and predicted values (blue)



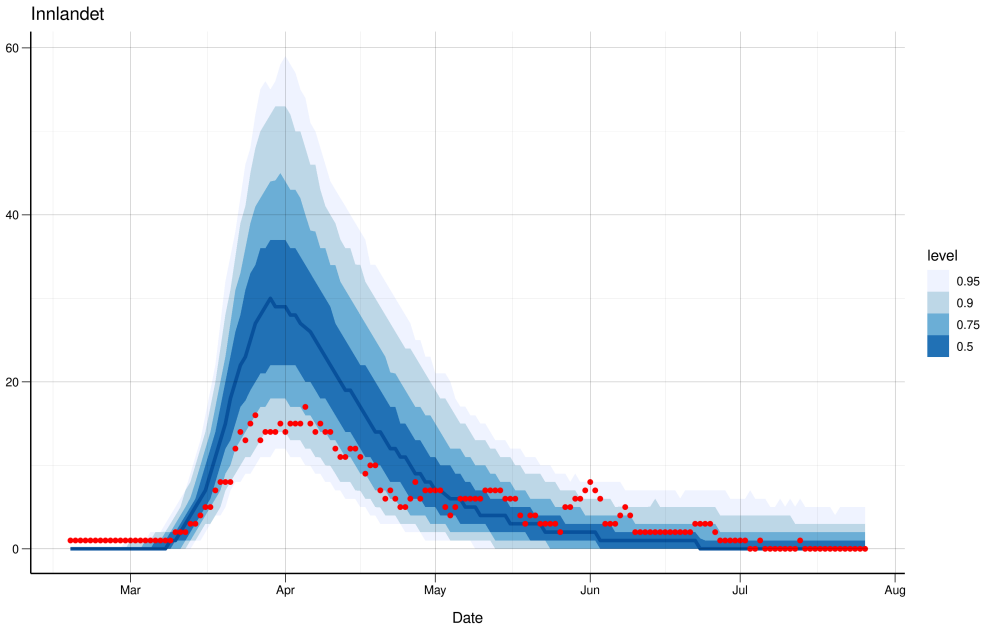
True hospitalisation prevalence (red) and predicted values (blue)



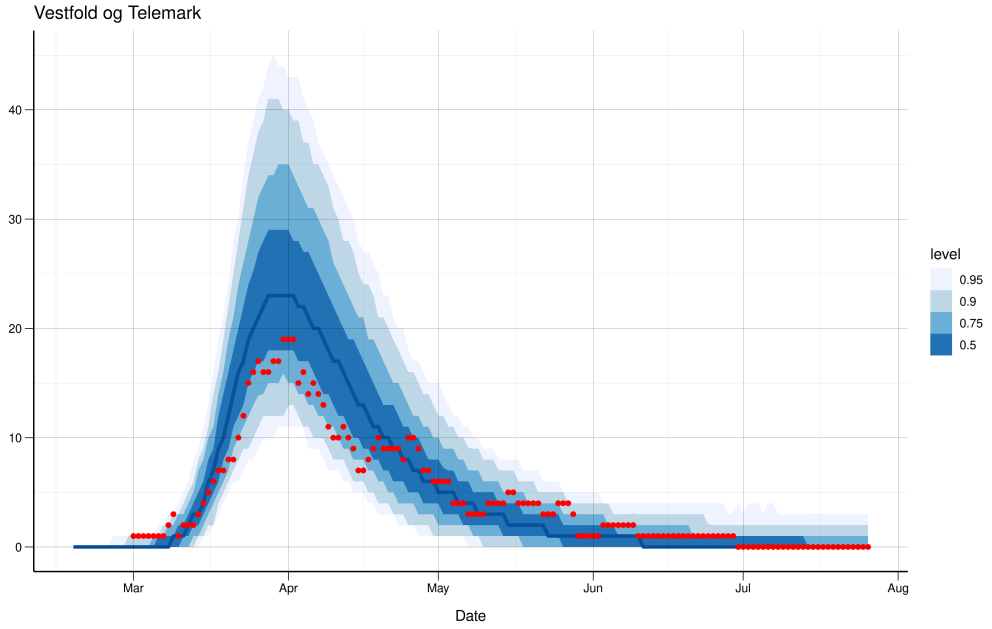
True hospitalisation prevalence (red) and predicted values (blue)



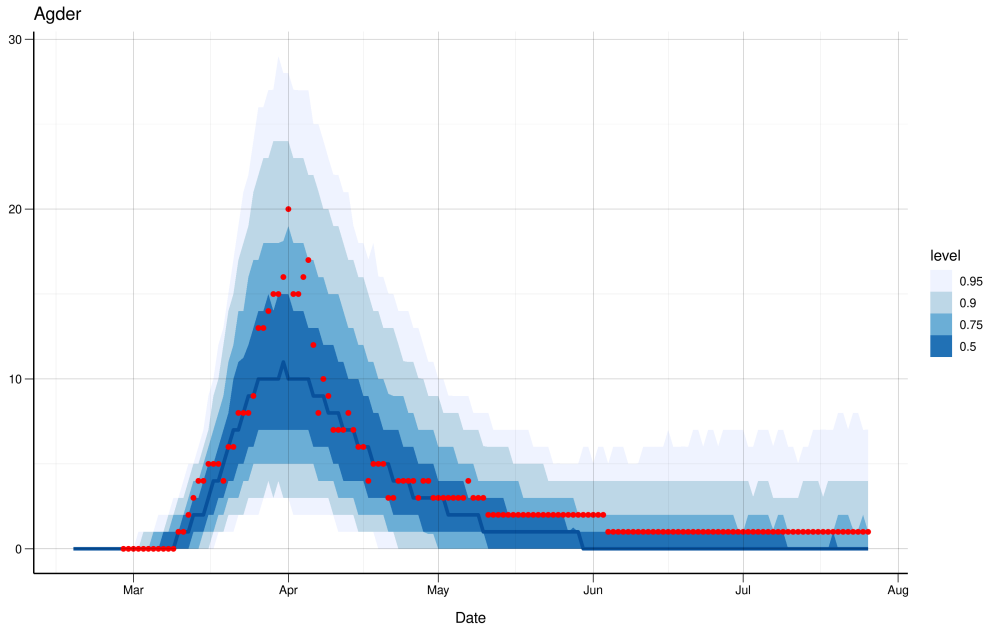
True hospitalisation prevalence (red) and predicted values (blue)



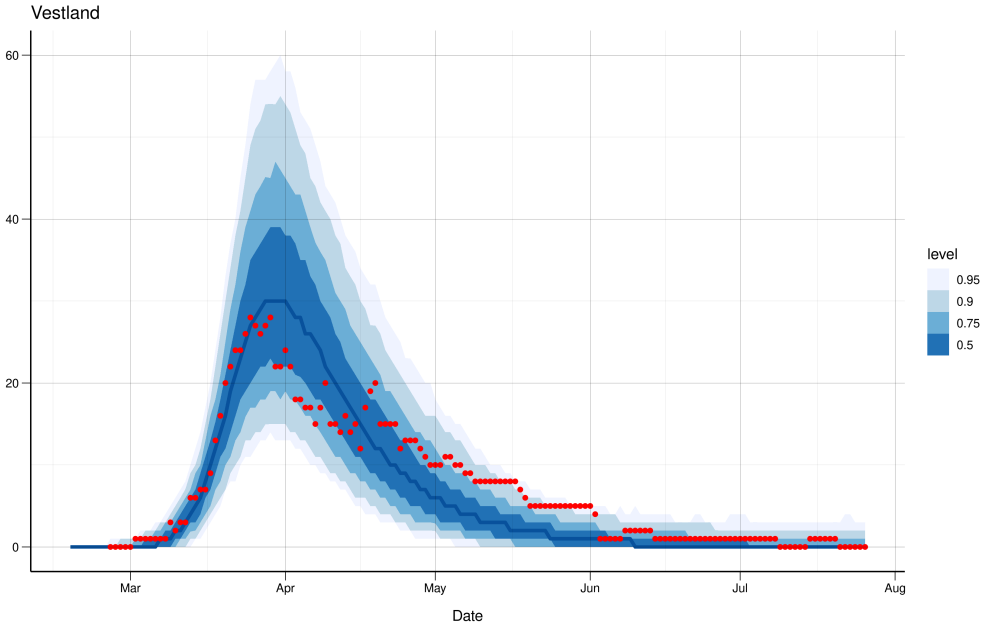
True hospitalisation prevalence (red) and predicted values (blue)



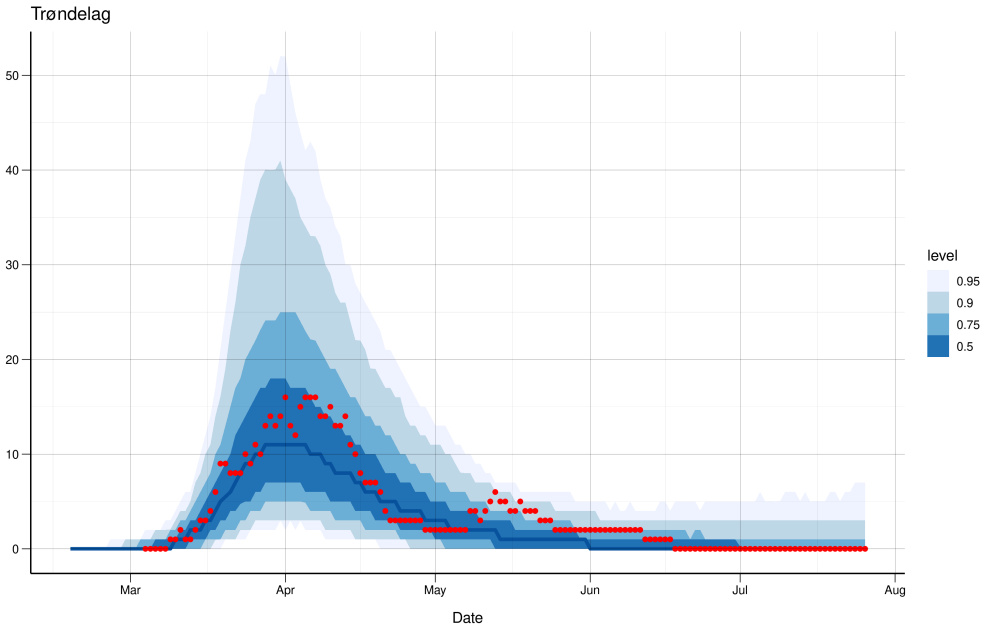
True hospitalisation prevalence (red) and predicted values (blue)



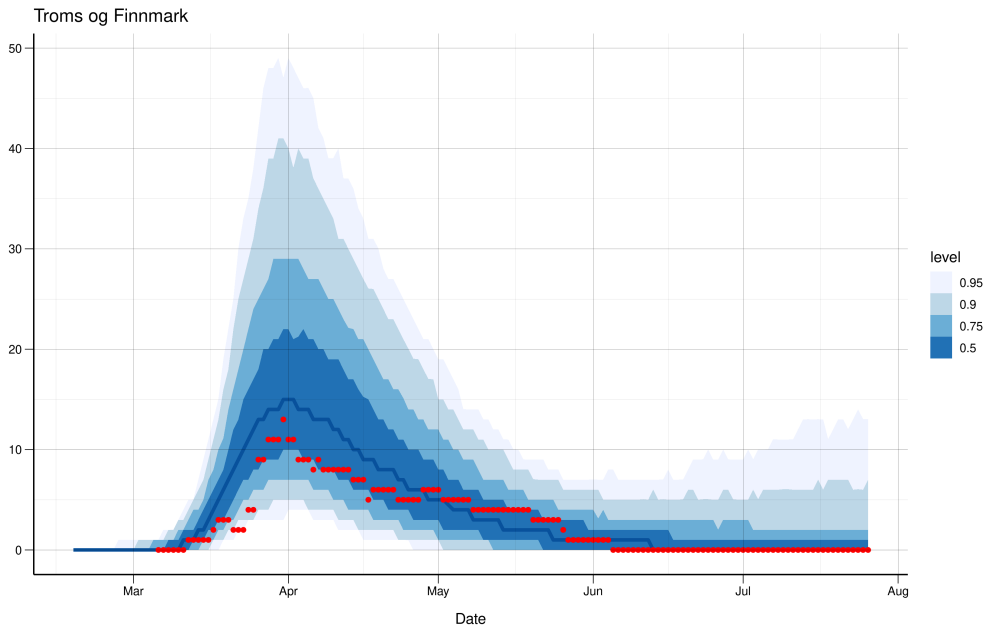
True hospitalisation prevalence (red) and predicted values (blue)



True hospitalisation prevalence (red) and predicted values (blue)



True hospitalisation prevalence (red) and predicted values (blue)



True hospitalisation prevalence (red) and predicted values (blue)

2 Predicted number of patients in ventilator treatment: next three weeks in each county

Table 2: Number of ICU beds occupied by Covid-19 patients.

Region	1 week prediction (02 August)	2 weeks prediction (09 August)	3 weeks prediction (16 August)
Agder	0 (0-2)	0 (0-3)	0 (0-3)
Innlandet	0 (0-2)	0 (0-2)	0 (0-2)
Møre og Romsdal	1 (0-3)	1 (0-4)	1 (0-4)
Nordland	0 (0-4)	0 (0-4)	0 (0-4)
Oslo	0 (0-1)	0 (0-1)	0 (0-1)
Rogaland	0 (0-2)	0 (0-2)	0 (0-3)
Troms og Finnmark	1 (0-5)	1 (0-5)	1 (0-4)
Trøndelag	0 (0-2)	0 (0-2)	0 (0-2)
Vestfold og Telemark	0 (0-1)	0 (0-1)	0 (0-1)
Vestland	0 (0-1)	0 (0-1)	0 (0-1)
Viken	0 (0-2)	0 (0-2)	0 (0-2)

3 Estimated number of infected individuals in each county

Table 3: Predicted prevalence. Number of infectious individuals (asymptomatic plus pre-symptomatic plus symptomatic) per day. Means and 95 perc. CI for three weeks prediction.

Region	Mean, 02 August	Mean, 09 August	Mean, 16 August	low CI, 16 August	high CI, 16 August
Agder	13	15	16	0	135
Innlandet	8	8	8	0	59
Møre og Romsdal	40	48	55	0	291
Nordland	20	21	23	0	188
Oslo	6	4	4	0	25
Rogaland	22	26	31	0	215
Troms og Finnmark	46	54	61	0	256
Trøndelag	16	16	19	0	180
Vestfold og Telemark	5	5	5	0	32
Vestland	10	11	14	0	133
Viken	15	13	14	0	92

4 Predicted incidence of infected individuals, next three weeks in each county

Predicted incidence (asymptomatic and symptomatic) for each county per day, with confidence intervals.

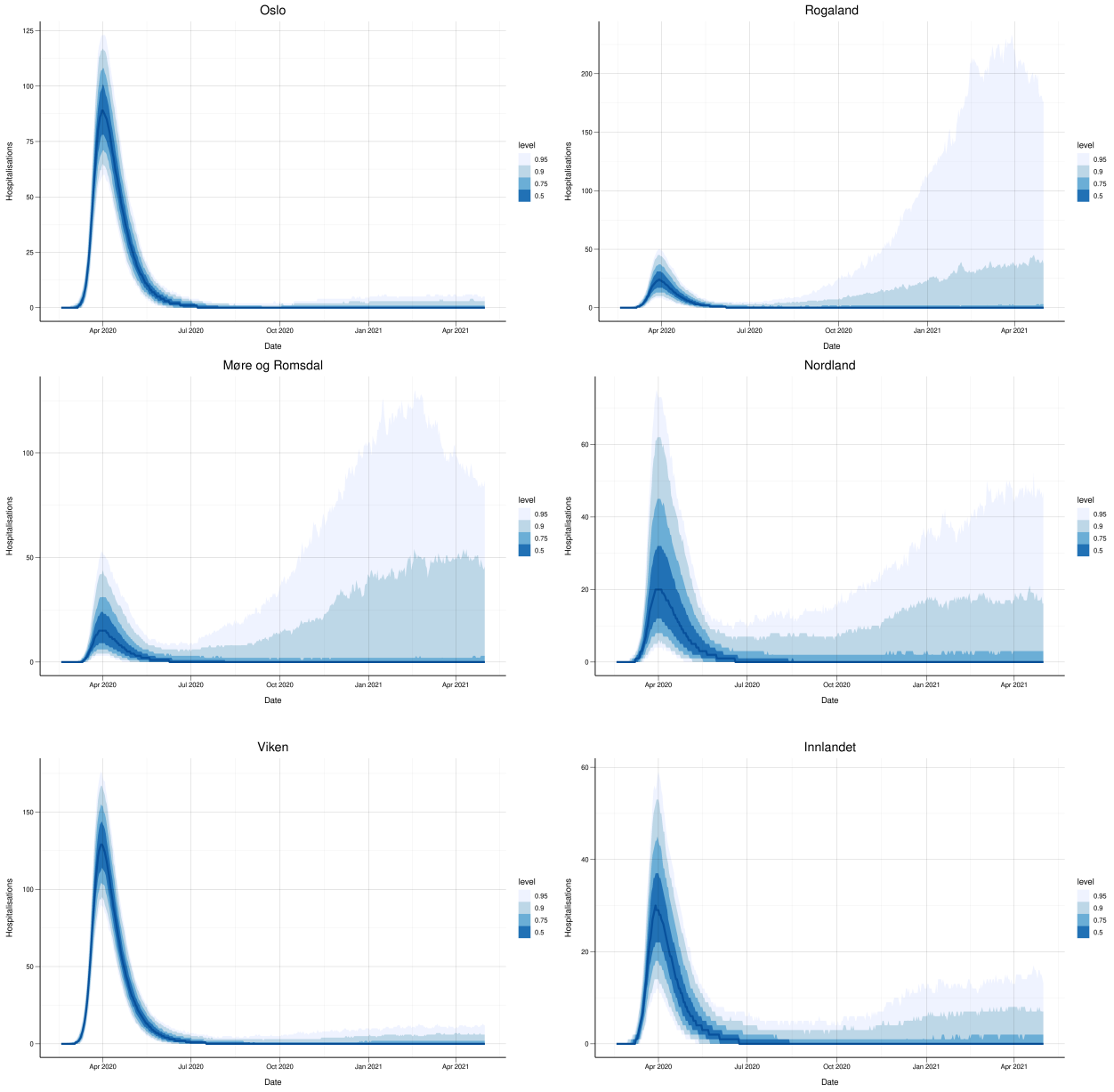
Table 4: Predicted incidence per day.

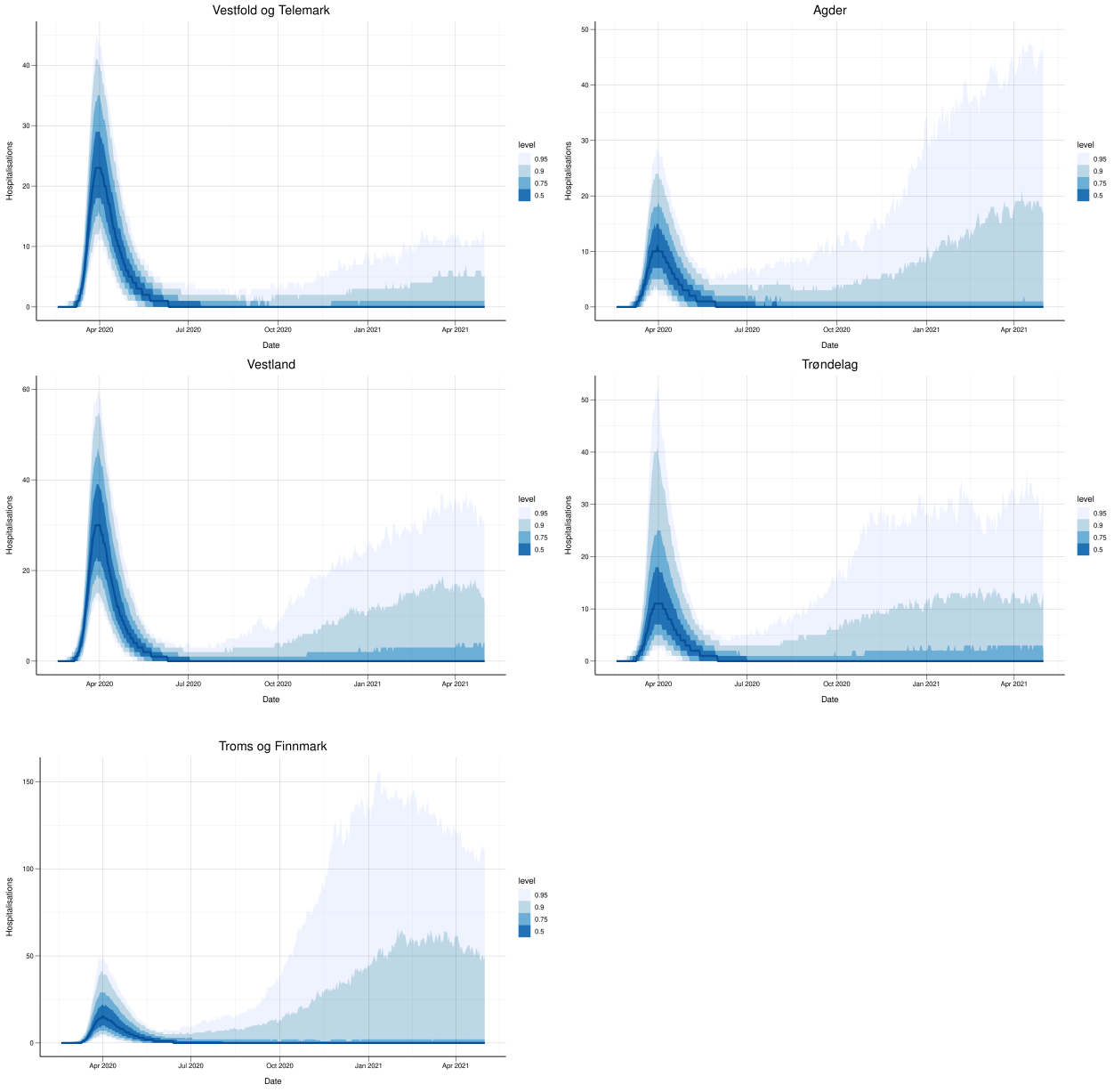
Region	1 week prediction (02 August)	2 weeks prediction (09 August)	3 weeks prediction (16 August)
Agder	2 (0-18)	3 (0-21)	3 (0-23)
Innlandet	1 (0-9)	1 (0-10)	1 (0-9)
Møre og Romsdal	7 (0-50)	9 (0-48)	11 (0-54)
Nordland	3 (0-30)	4 (0-31)	4 (0-33)
Oslo	1 (0-6)	1 (0-5)	1 (0-6)
Rogaland	4 (0-36)	5 (0-38)	6 (0-41)
Troms og Finnmark	8 (0-43)	10 (0-58)	11 (0-59)
Trøndelag	3 (0-29)	3 (0-24)	3 (0-30)
Vestfold og Telemark	1 (0-4)	1 (0-5)	1 (0-5)
Vestland	2 (0-12)	2 (0-19)	2 (0-22)
Viken	2 (0-14)	2 (0-12)	2 (0-11)

5 Long-term prediction results for each county

5.1 Hospitalisations

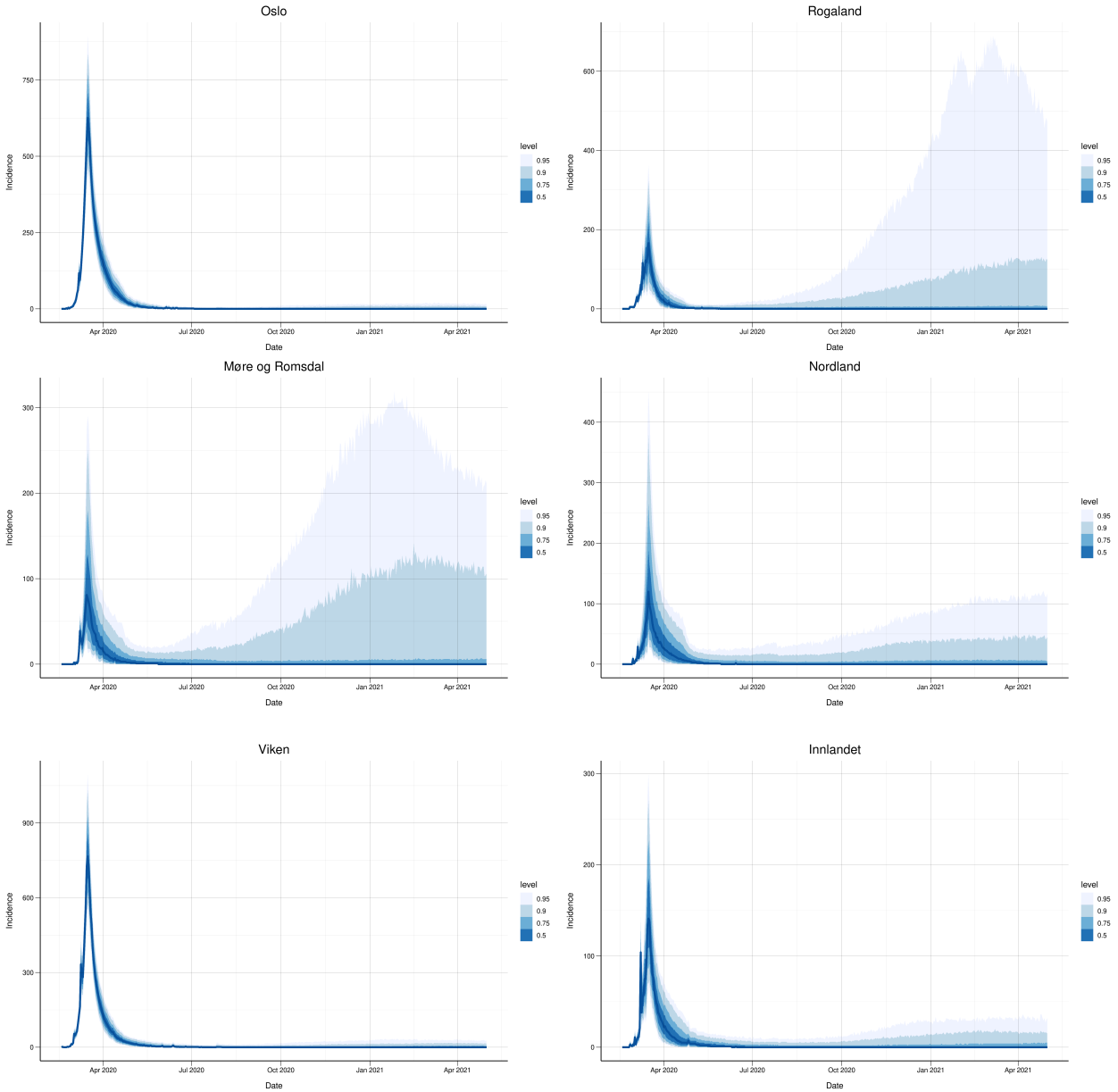
Predicted daily number of COVID-19 patients in hospital, including receiving ventilator treatment, in each county until April 2021, assuming that there are no changes with respect to today in reproduction number uncertainty. It is based on 1000 runs of the future to represent the uncertainty. Many counties, like for example Innlandet, Rogaland, Agder and Vestland are so uncertain, that long term predictions are essentially meaningless.

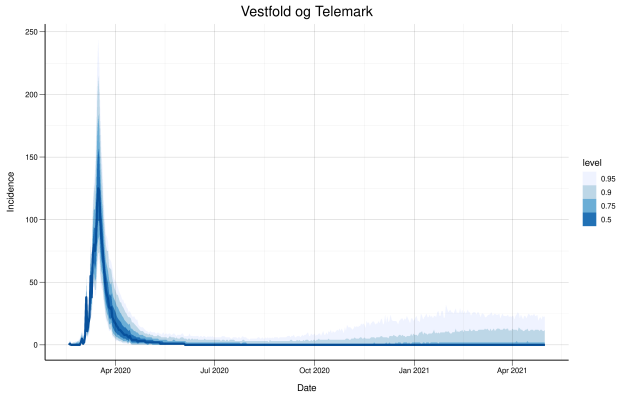


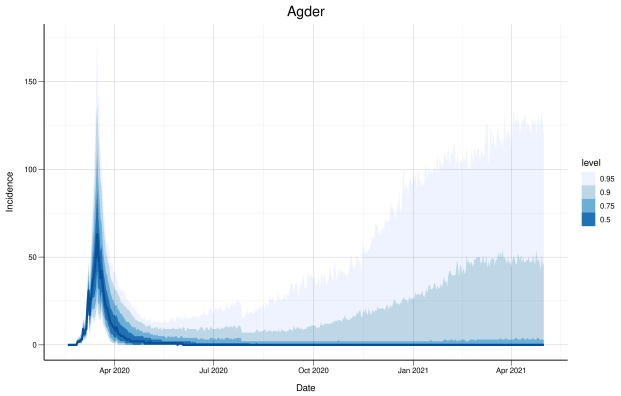

Vestfold og Telemark
Agder
Vestland
Trøndelag
Troms og Finnmark
Hospitalisations
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021

5.2 Incidence

Predicted incidence (asymptomatic and symptomatic) for each county per day, with confidence intervals. Rogaland, Nordland, Troms og Finnmark and Vestland are so uncertain, that long term predictions are not useful.




Vestfold og Telemark
Incidence
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021


Agder
Incidence
Date
level
0.95
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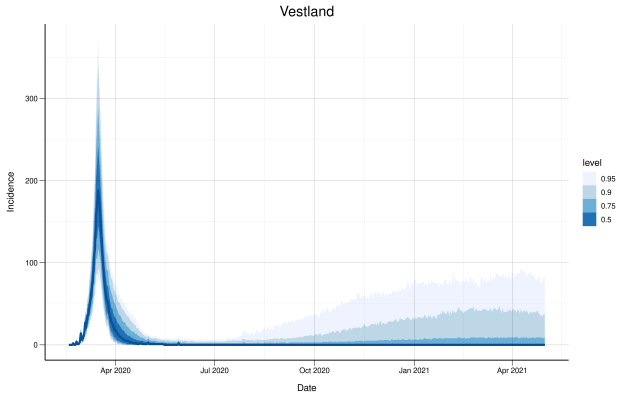
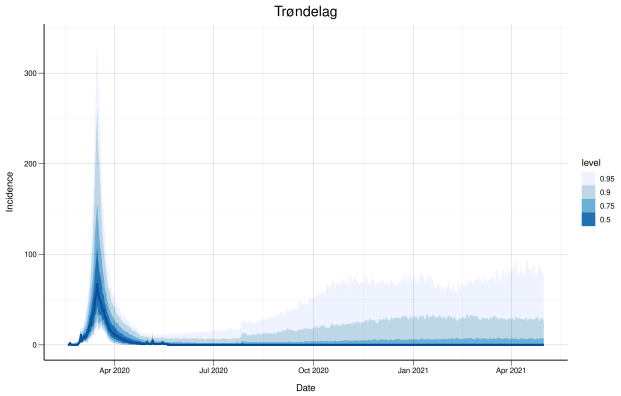
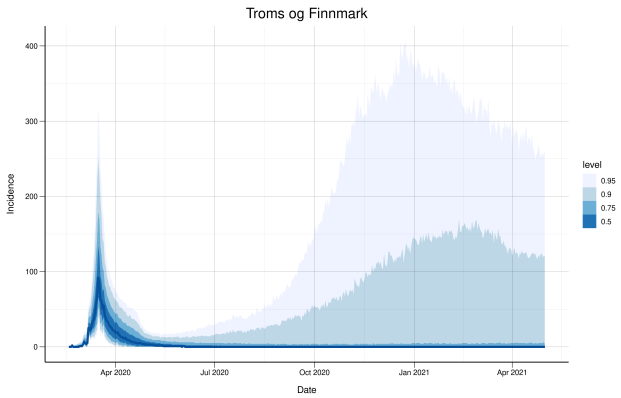
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021


Vestland
Incidence
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021


Trøndelag
Incidence
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021


Troms og Finnmark
Incidence
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021

6 Estimated reproduction numbers in all counties

Calibration of our model with the hospitalisation data of each county, leads to the estimates below. Notice that uncertainty is very large for $R2$, and the estimated mean has very little meaning.

Table 5: Estimated reproduction numbers (mean and 95 confidence intervals)

Region	R0; until 14 March	R1 from 15 March	R2 from 20 April
Agder	2.253 (0.8-3.64)	0.378 (0.032-0.815)	0.686 (0.096-1.224)
Innlandet	2.453 (1.07-3.72)	0.404 (0.055-0.852)	0.608 (0.097-1.165)
Møre og Romsdal	2.81 (0.47-5.37)	0.436 (0.06-0.864)	0.71 (0.073-1.339)
Nordland	3.071 (1.15-4.9)	0.526 (0.102-0.954)	0.557 (0.039-1.207)
Oslo	3.954 (3.21-4.65)	0.536 (0.352-0.751)	0.48 (0.073-0.917)
Rogaland	2.327 (1.03-3.53)	0.343 (0.04-0.766)	0.686 (0.057-1.318)
Troms og Finnmark	2.819 (1.21-4.25)	0.494 (0.053-0.94)	0.663 (0.083-1.3)
Trøndelag	2.379 (0.59-4)	0.396 (0.052-0.773)	0.517 (0.038-1.138)
Vestfold og Telemark	2.163 (1.08-3.24)	0.286 (0.026-0.631)	0.519 (0.049-1.126)
Vestland	2.931 (2.04-3.76)	0.272 (0.013-0.68)	0.502 (0.053-1.088)
Viken	3.495 (2.84-4.16)	0.394 (0.201-0.598)	0.535 (0.039-1.033)

Methods

Details on this model found here https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/.
We use assumptions related to hospitalisation based on Norwegian data, NPR data linked with MSIS data.
The parameters are specified in the report 2020.05.19 Corona report.pdf.
Estimation of the reproduction numbers (and of the amplification factor in seeding of the epidemic at the start) is done using Approximate Bayesian Computation (ABC), as described in Engebretsen et al. (2020): https://www.medrxiv.org/content/10.1101/2020.03.11.20033555v1.
Briefly: We run a sequential ABC in order to obtain 1000 parameter sets $\{R_0, R1, R2\}$ for each county, which fit best the hospitalisation data of each county up to July 26th. We also obtain the best estimate for the amplification factor F used to seed the epidemics. Next we run the model with these 1000 parameter sets again, from the beginning until July 26th, plus three weeks in the future (or a full year in the future). Using these 1000 trajectories of the future, we make future predictions and confidence intervals. The mobility data are updated until July 26^{th}. They account for the changes in the movement patterns between municipalities that have occurred since the start of the epidemic.

In this run the amplification factor was estimated to be 1.8 (1.13 2.55).

The national model has a third changepoint on May 11, while the present regional model does not yet. It is difficult to estimate regionally varying parameters, when the hospital incidence data per county are so low. We will introduce the additional changepoint after the summer.

FHI COVID-19 modelling team:

- **Birgitte Freiesleben de Blasio** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
- **Francesco Di Ruscio** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
- **Gunnar Øyvind Isaksson Rø** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
- **Solveig Engebretsen** - Norsk Regnesentral.
- **Arnoldo Frigessi** - Oslo Centre for Biostatistics and Epidemiology, University of Oslo and Oslo University Hospital.
- **Alfonso Diz-Lois Palomares** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
- **Magnus Nygård Osnes** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
- **Anja Bråten Kristoffersen** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
- **Kenth Engø-Monsen** - Telenor Research
- **Richard White** - Department of Method Development and Analytics. Norwegian Institute of Public Health
- **Gry Marysol Grøneng** - Department of Method Development and Analytics. Norwegian Institute of Public Health
- **Ingrid Engebretsen** - Department of Economics. University of Oslo