

Regional situational awareness and forecasting for COVID-19

17 August 2020

In this report we present predictions of the COVID-19 epidemic at county level (fylke). We run the same SEIR model as the one used for the national predictions¹. 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. As for the national model, we have now introduced two additional change points, on May 11 and July 1.

We estimate all reproduction numbers by fitting our model to the hospital incidence of COVID-19 confirmed patients at the county level.

The model indicates heterogeneity in the transmissibility between counties. For a few counties, Innlandet and Møre og Romsdal, the model does not fit well the data, and the recent reproduction number, including the uncertainty, are not adequate. This problem is related to the very low level of hospitalization.

When confidence intervals are large, as they are in this report for the R_4 's, the estimated mean or median does 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_4 's and of the national R_4 , as reported in our daily national report. The confidence intervals have however large overlaps, and these difference are not significant.

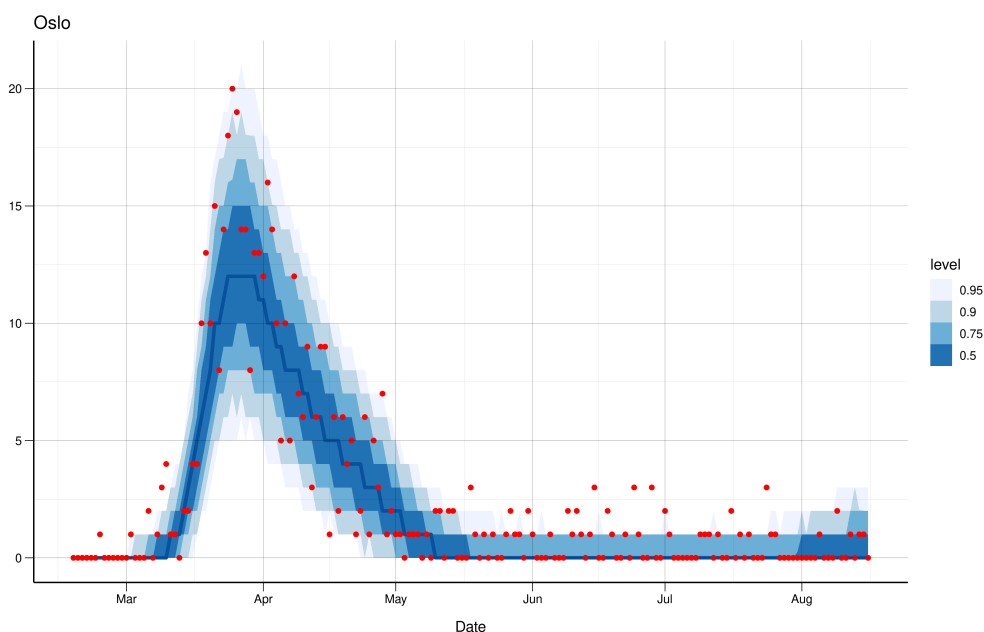
¹<https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/>

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

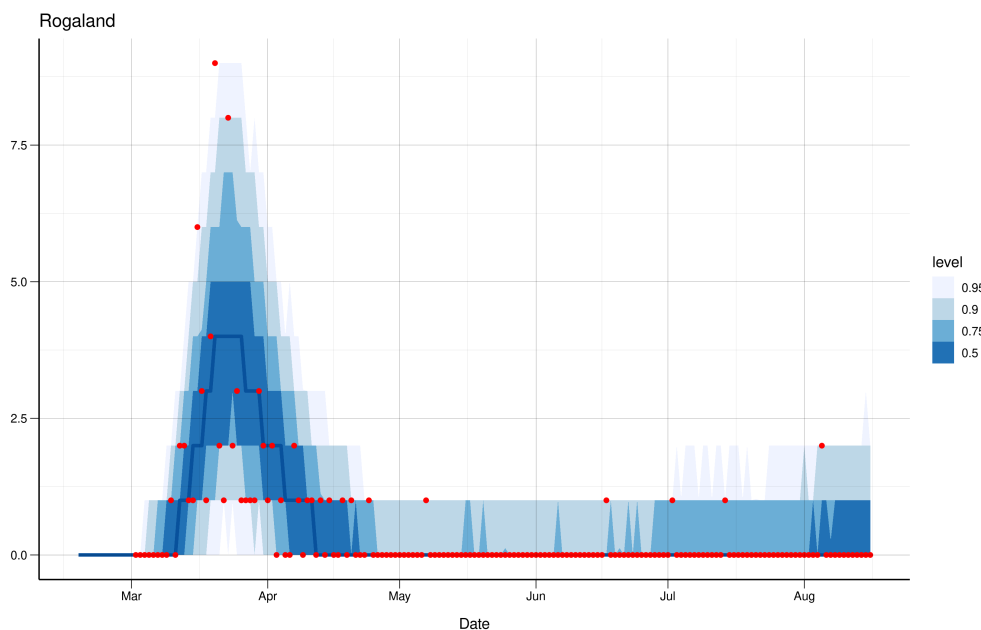
Our model estimates the hospital incidence of COVID-19 patients in each county, plotted below with blue median and uncertainty bands, which are compared to the actual hospitalisation incidence of the county, in red. The blue bands describe the uncertainty in the calibrated parameters, in addition to 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.

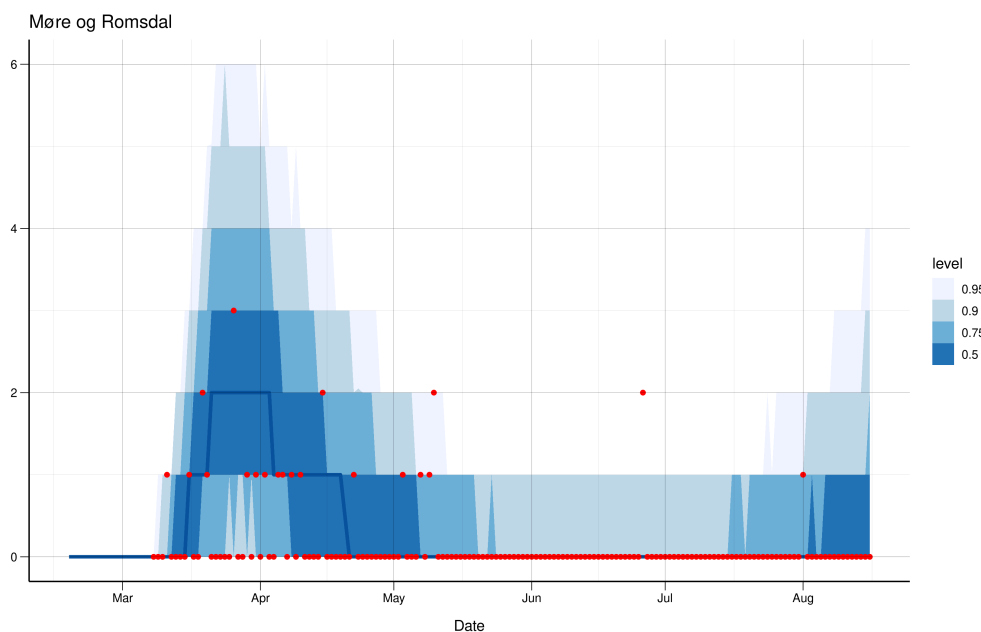
Region	1 week prediction (23 August)	2 weeks prediction (30 August)	3 weeks prediction (06 September)
Agder	1 (0-5)	1 (0-4)	1 (0-5)
Innlandet	7 (1-20)	10 (1-28)	13 (1-42)
Møre og Romsdal	6 (0-28)	8 (0-43)	13 (0-75)
Nordland	1 (0-6)	1 (0-7)	1 (0-8)
Oslo	6 (0-25)	8 (0-35)	11 (0-56)
Rogaland	4 (0-16)	4 (0-20)	5 (0-24)
Troms og Finnmark	2 (0-15)	3 (0-28)	5 (0-43)
Trøndelag	1 (0-6)	1 (0-7)	2 (0-7)
Vestfold og Telemark	2 (0-7)	2 (0-8)	3 (0-11)
Vestland	5 (0-21)	6 (0-35)	9 (0-53)
Viken	16 (3-39)	23 (4-60)	32 (5-94)



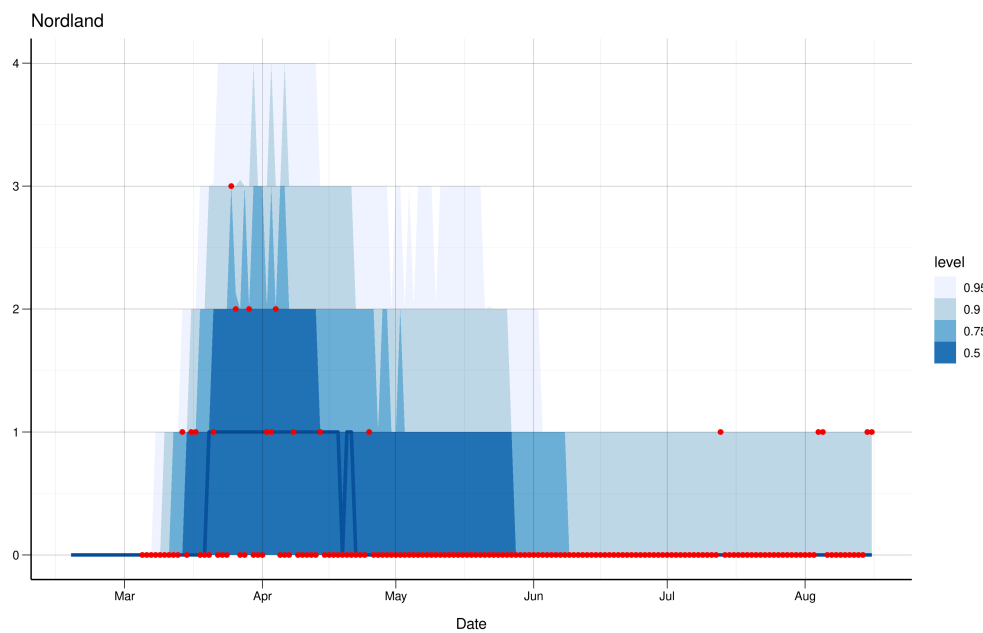
True hospitalisation incidence (red) and predicted values (blue)



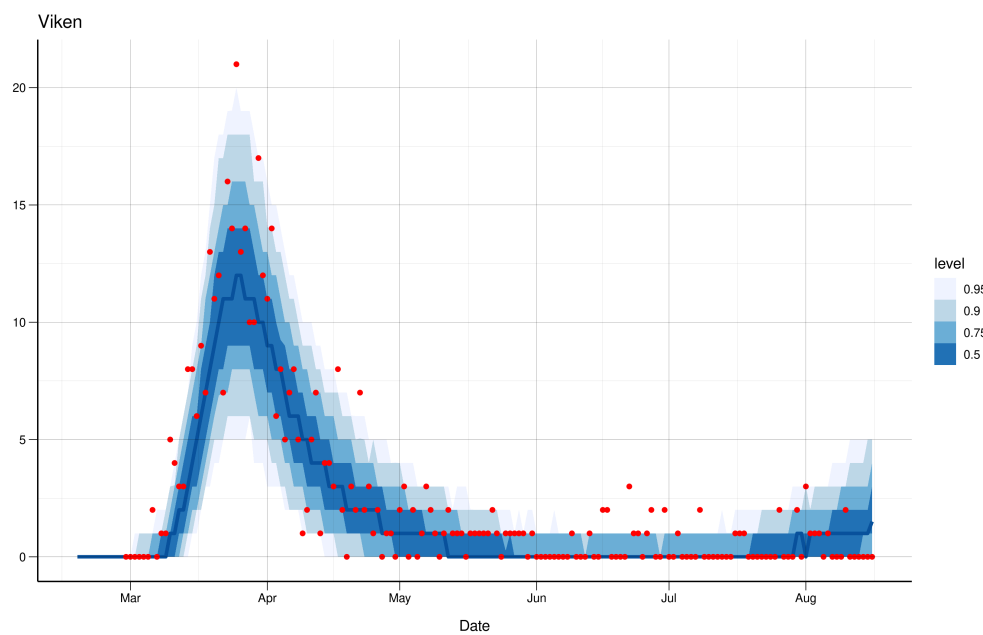
True hospitalisation incidence (red) and predicted values (blue)



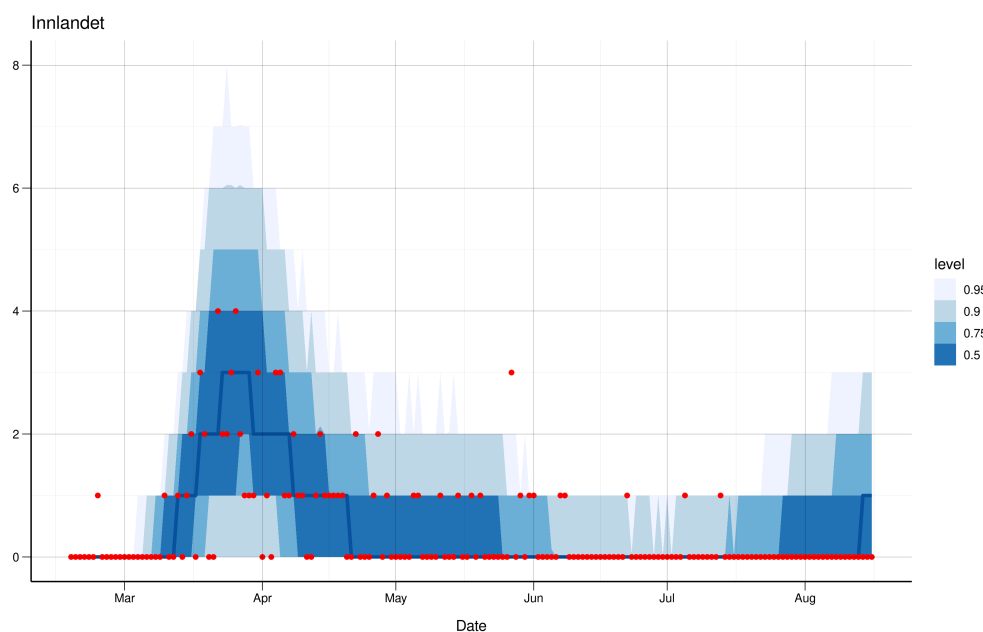
True hospitalisation incidence (red) and predicted values (blue)



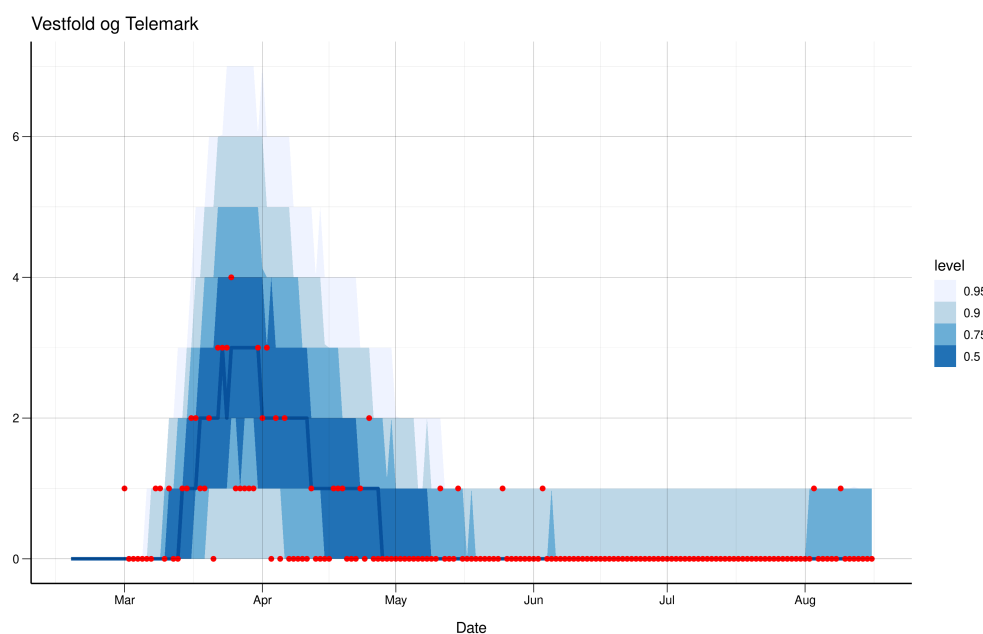
True hospitalisation incidence (red) and predicted values (blue)



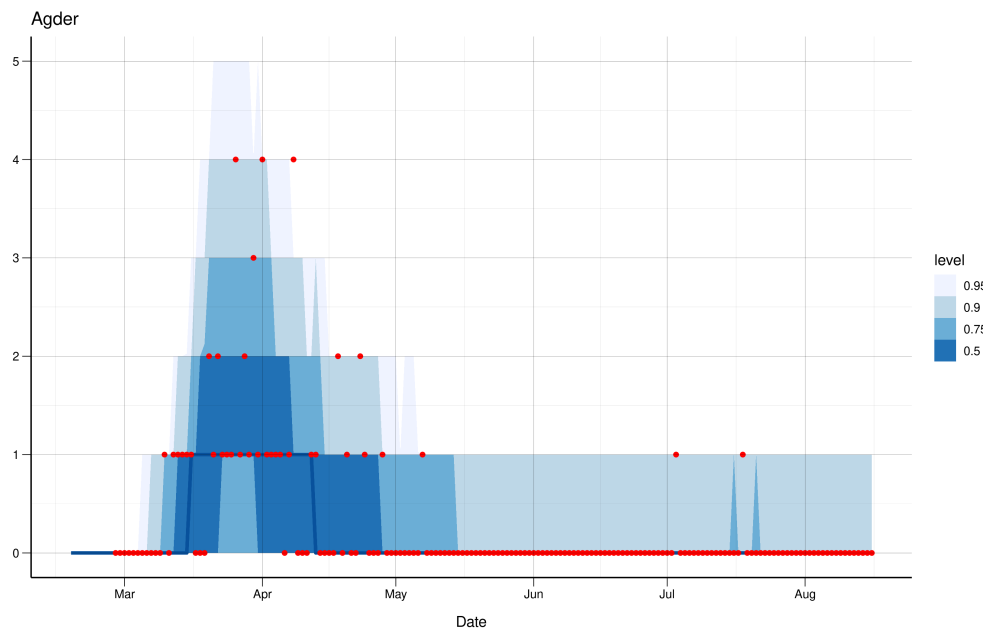
True hospitalisation incidence (red) and predicted values (blue)



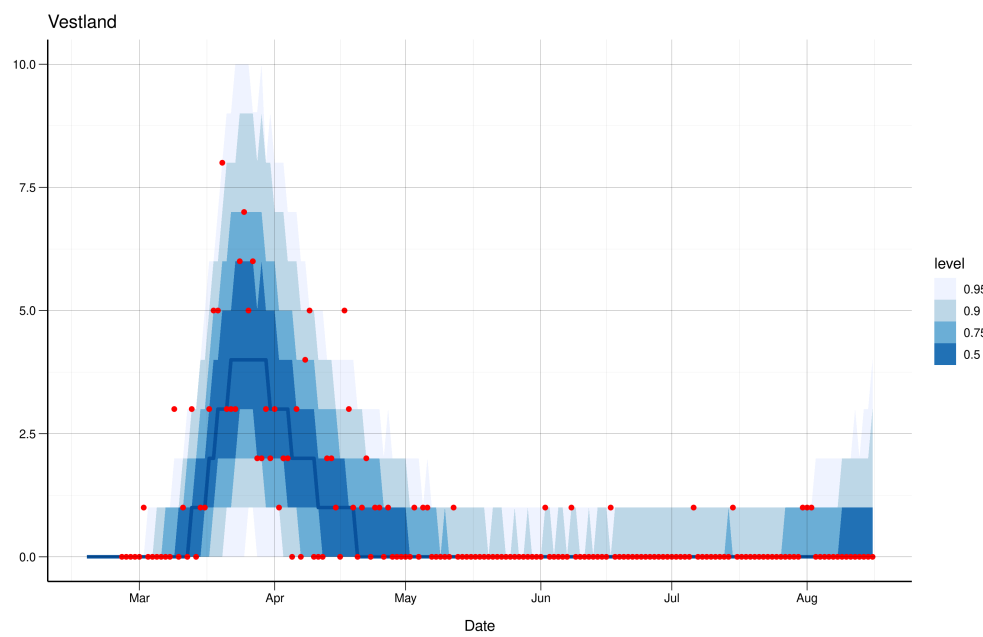
True hospitalisation incidence (red) and predicted values (blue)



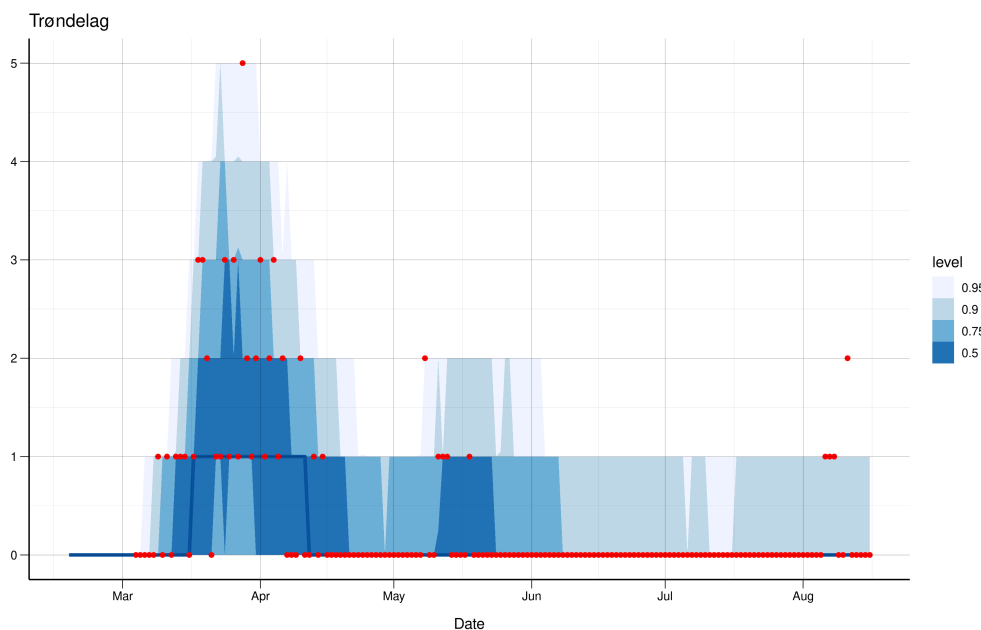
True hospitalisation incidence (red) and predicted values (blue)



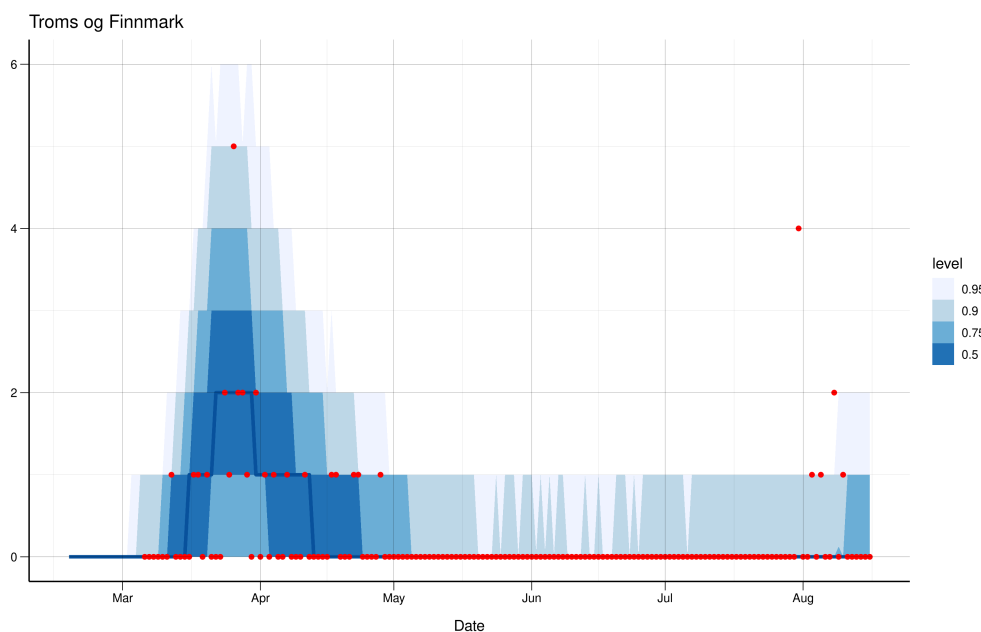
True hospitalisation incidence (red) and predicted values (blue)



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



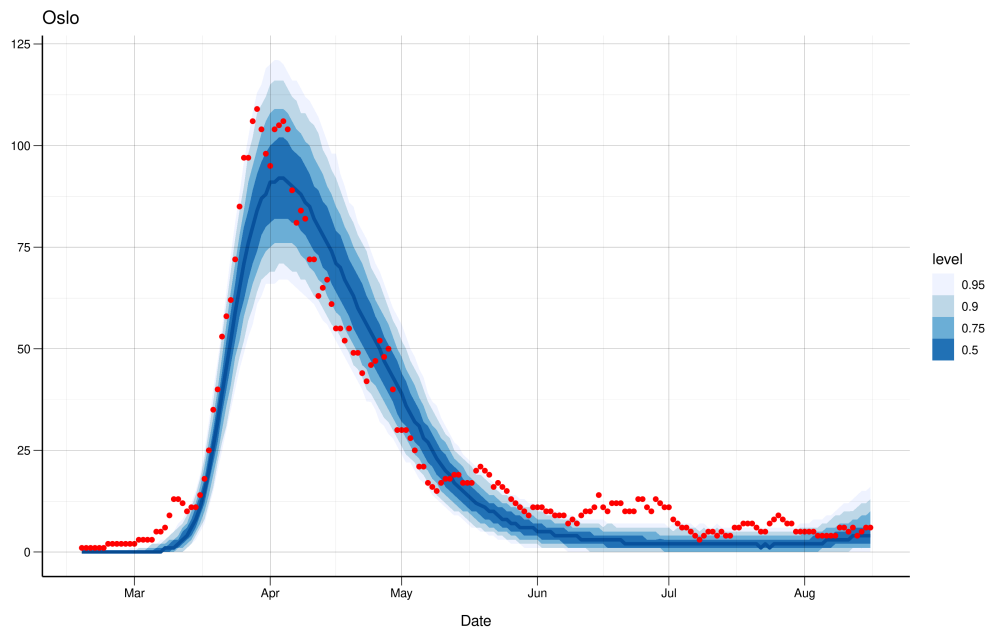
True hospitalisation incidence (red) and predicted values (blue)



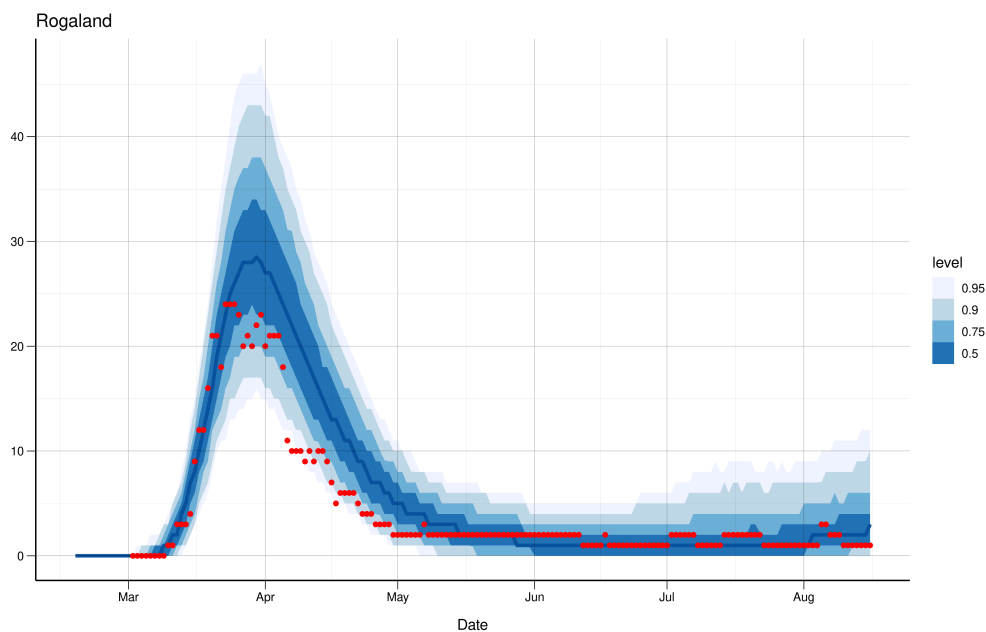
True hospitalisation incidence (red) and predicted values (blue)

1.1 Hospital prevalence

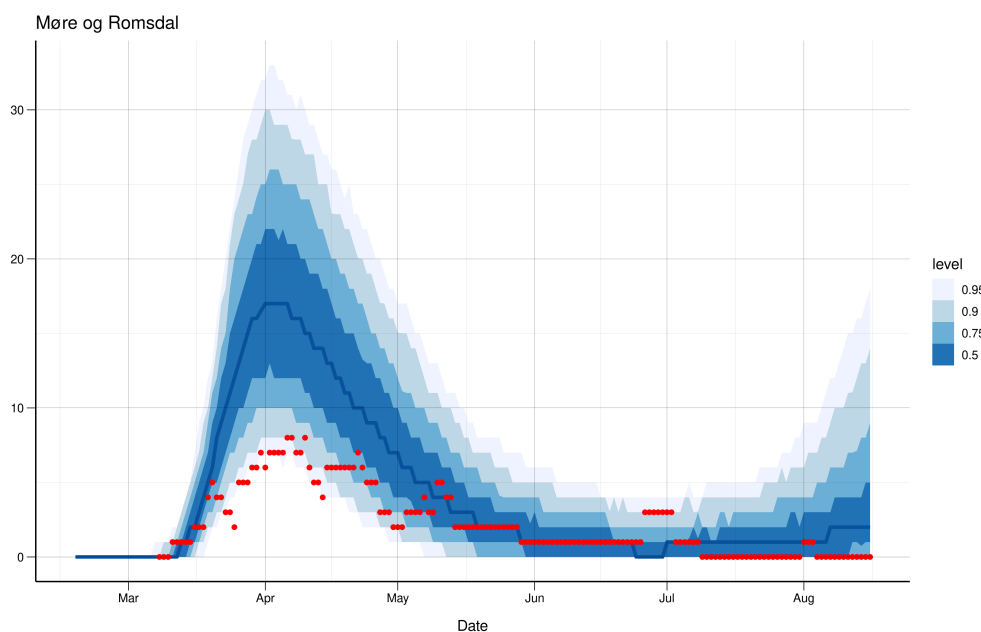
Though we do not calibrate to the hospital prevalence data, we show our simulations along with the prevalence data, as a test of our model performance. The model simulations fit the prevalence data well, but for some counties there are larger discrepancies. This indicates that there could be regional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



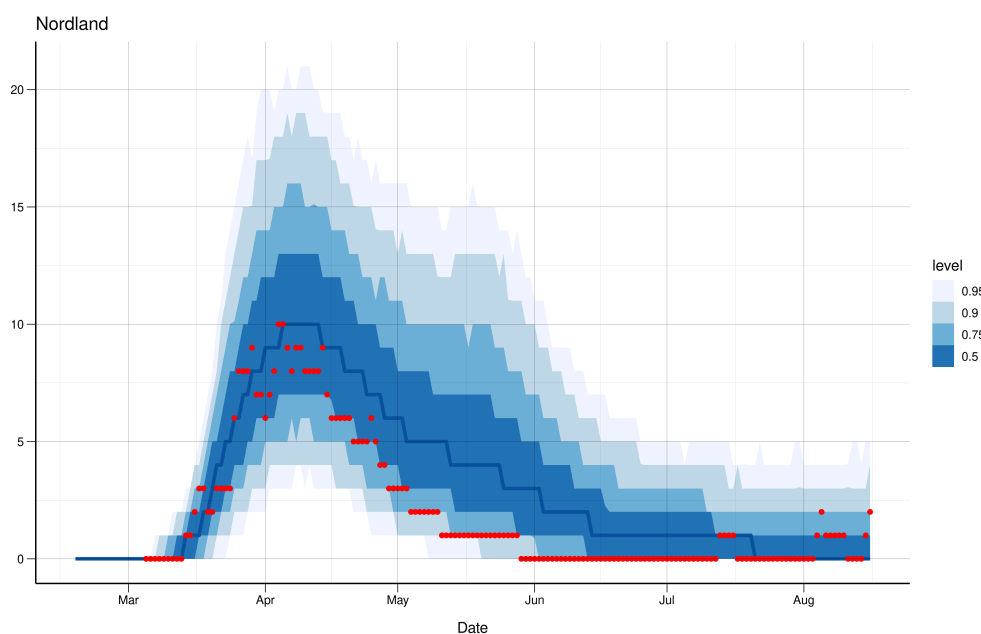
True hospitalisation prevalence (red) and predicted values (blue)



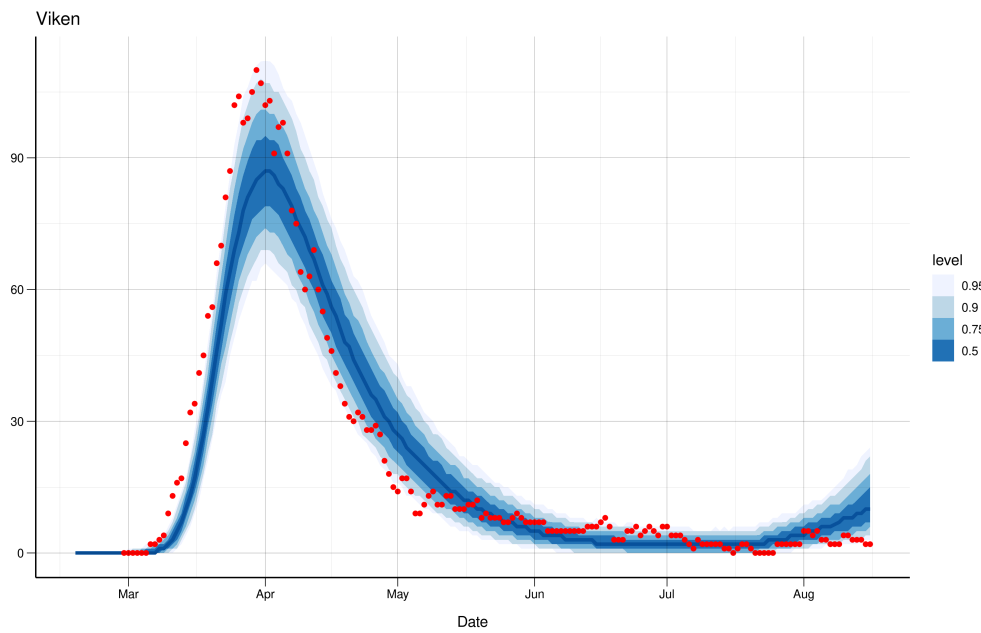
True hospitalisation prevalence (red) and predicted values (blue)



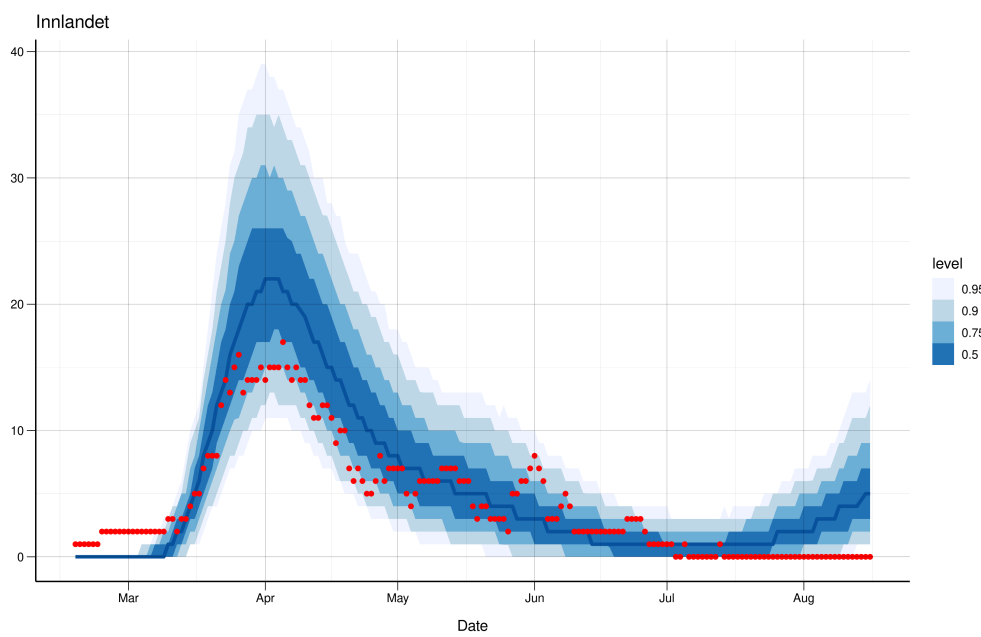
True hospitalisation prevalence (red) and predicted values (blue)



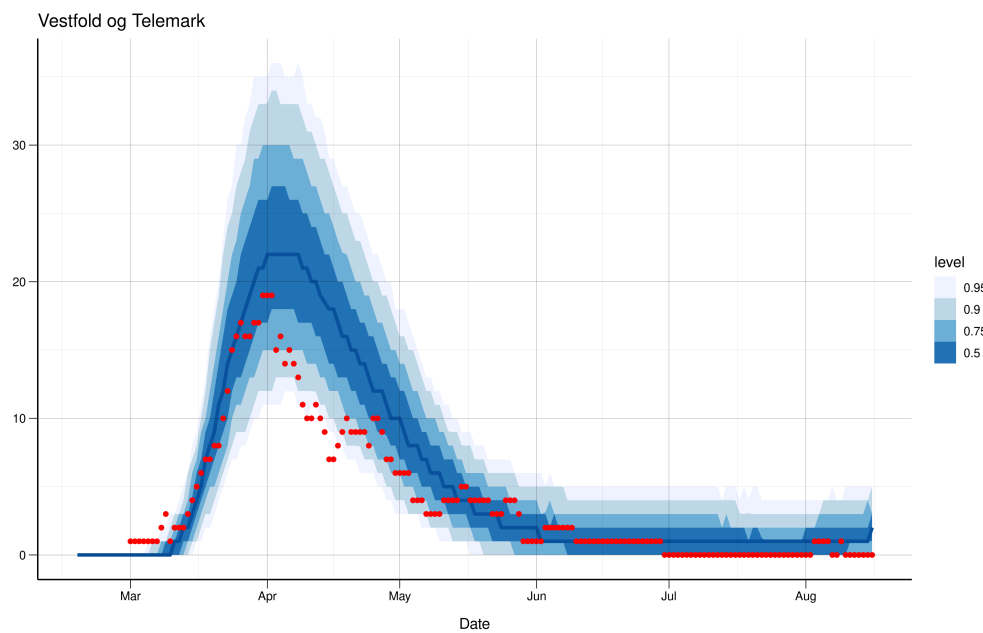
True hospitalisation prevalence (red) and predicted values (blue)



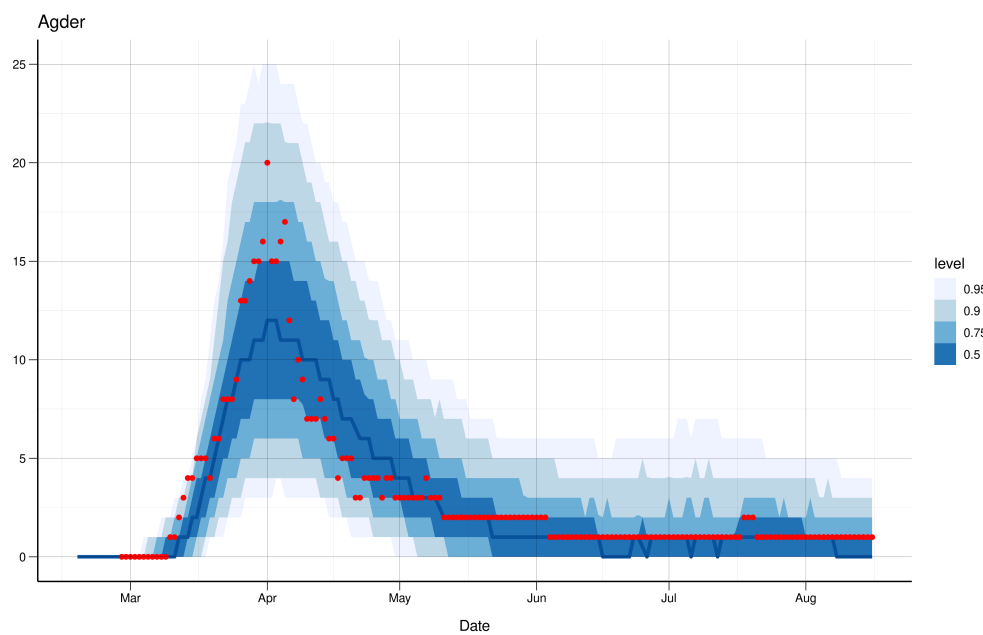
True hospitalisation prevalence (red) and predicted values (blue)



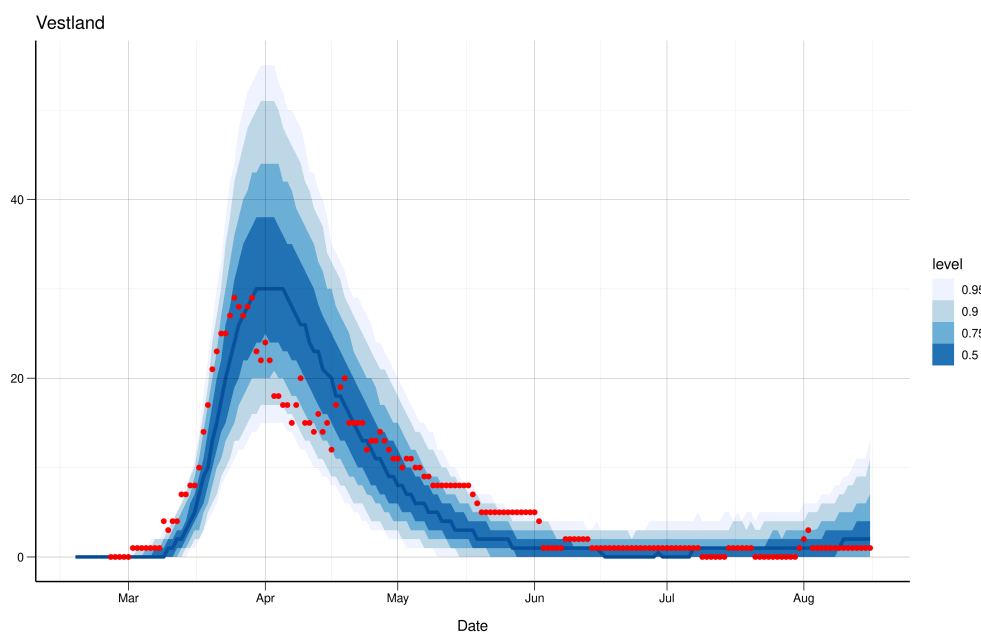
True hospitalisation prevalence (red) and predicted values (blue)



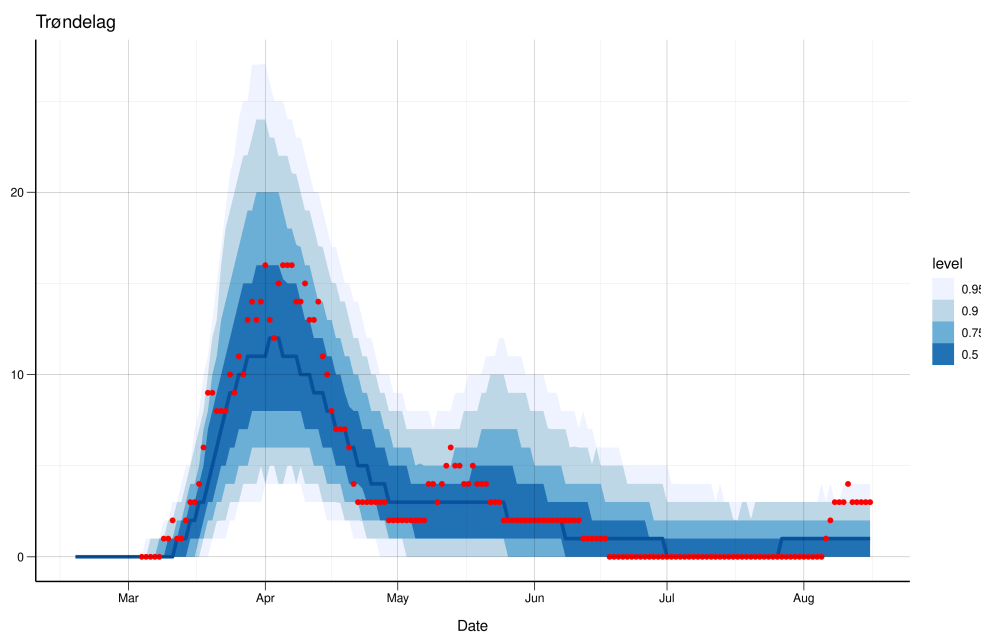
True hospitalisation prevalence (red) and predicted values (blue)



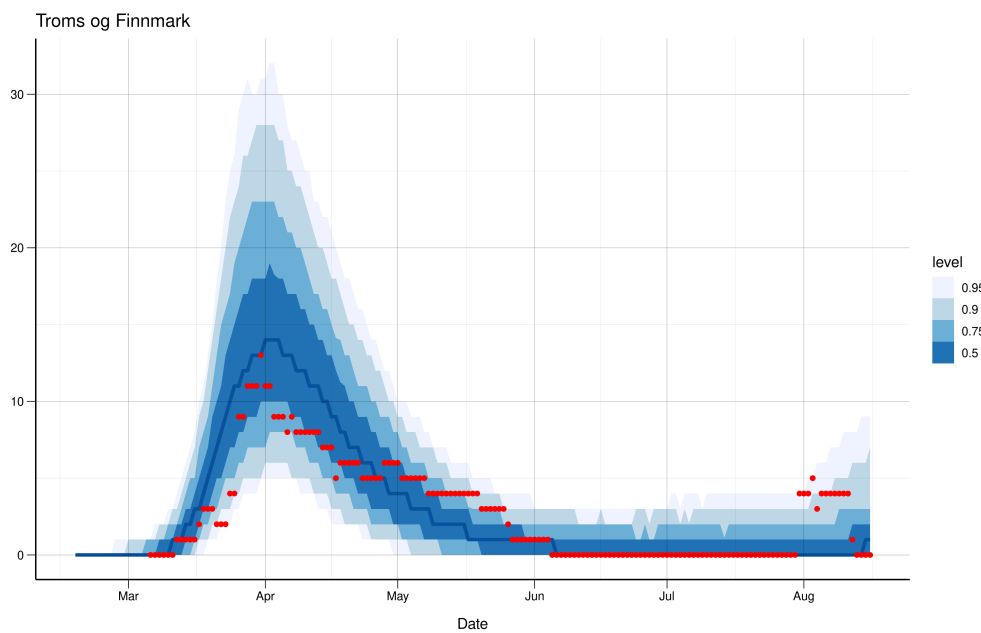
True hospitalisation prevalence (red) and predicted values (blue)



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 (23 August)	2 weeks prediction (30 August)	3 weeks prediction (06 September)
Agder	0 (0-2)	0 (0-1)	0 (0-2)
Innlandet	2 (0-5)	2 (0-7)	3 (0-9)
Møre og Romsdal	1 (0-6)	2 (0-9)	2 (0-14)
Nordland	0 (0-2)	0 (0-2)	0 (0-2)
Oslo	1 (0-6)	2 (0-7)	2 (0-11)
Rogaland	1 (0-4)	1 (0-5)	1 (0-7)
Troms og Finnmark	0 (0-3)	1 (0-5)	1 (0-8)
Trøndelag	0 (0-2)	0 (0-2)	0 (0-2)
Vestfold og Telemark	0 (0-2)	0 (0-2)	1 (0-3)
Vestland	1 (0-4)	1 (0-7)	2 (0-11)
Viken	3 (0-9)	5 (0-13)	7 (1-19)

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, 23 Aug.	Mean, 30 Aug.	Mean, 06 Sept.	low CI, 06 Sept.	high CI, 06 Sept.
Agder	17	26	43	6	155
Innlandet	174	234	322	54	1046
Møre og Romsdal	171	265	418	10	2723
Nordland	16	23	37	1	243
Oslo	208	294	420	48	2284
Rogaland	95	114	144	7	769
Troms og Finnmark	67	105	168	1	1689
Trøndelag	31	50	87	9	379
Vestfold og Telemark	37	67	117	22	365
Vestland	141	213	333	19	2095
Viken	519	688	926	156	3015

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.

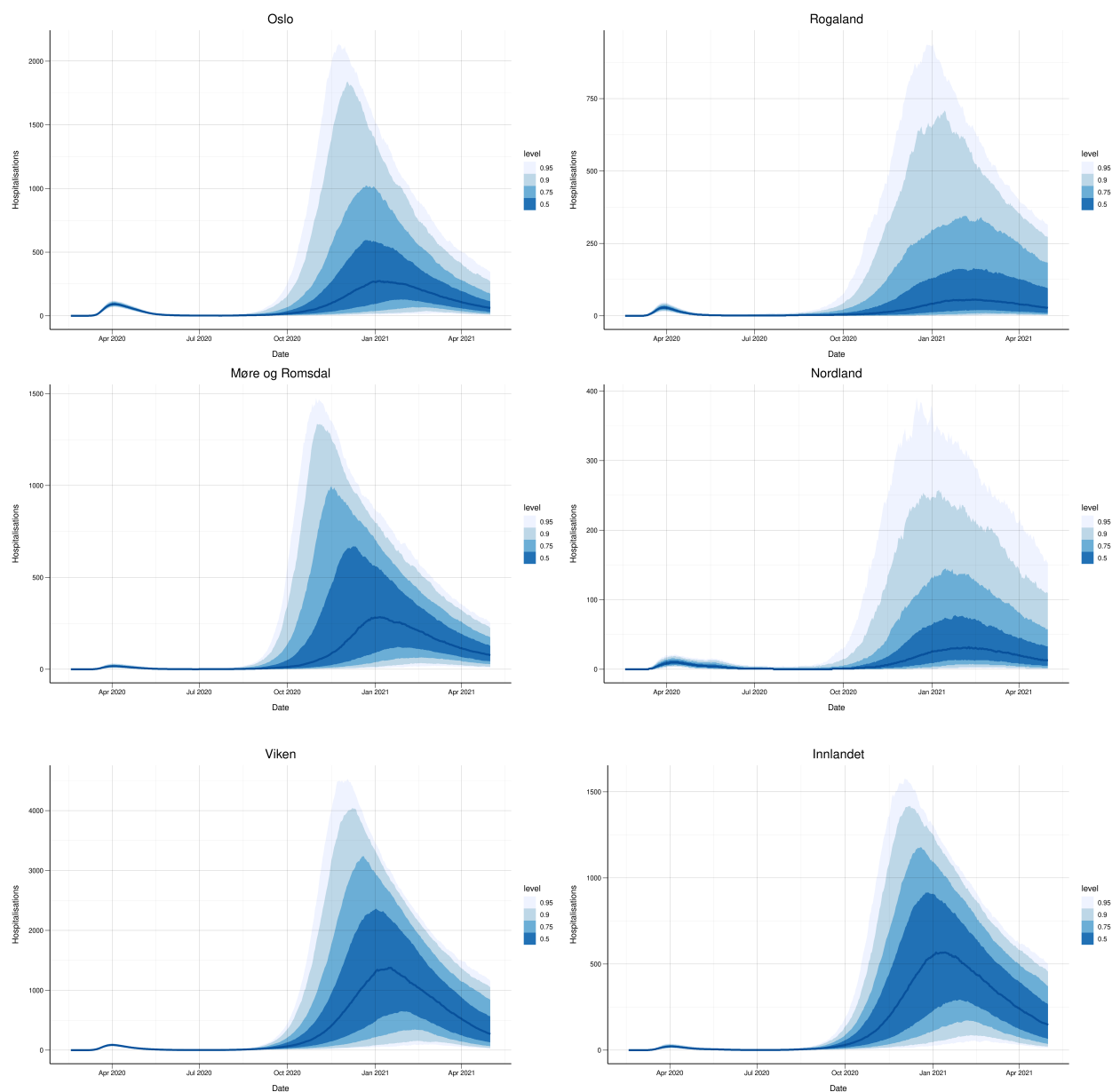
Table 4: Predicted incidence per day.

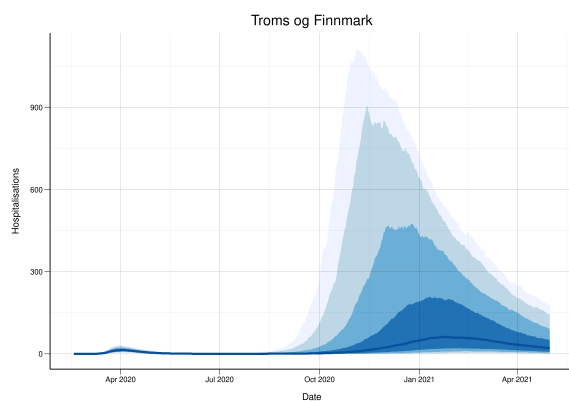
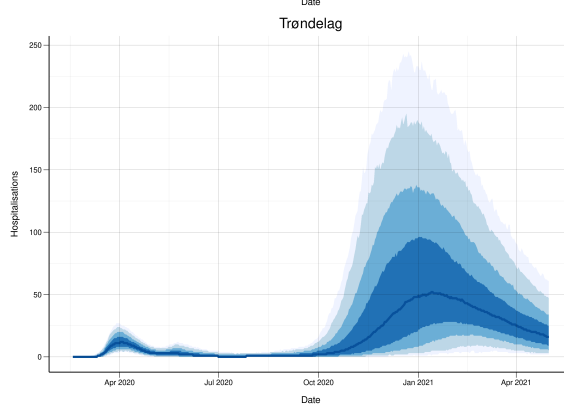
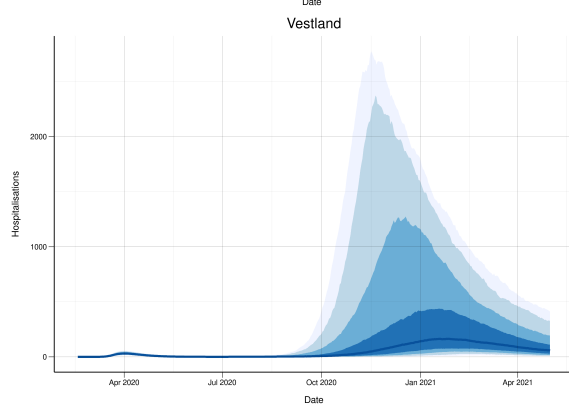
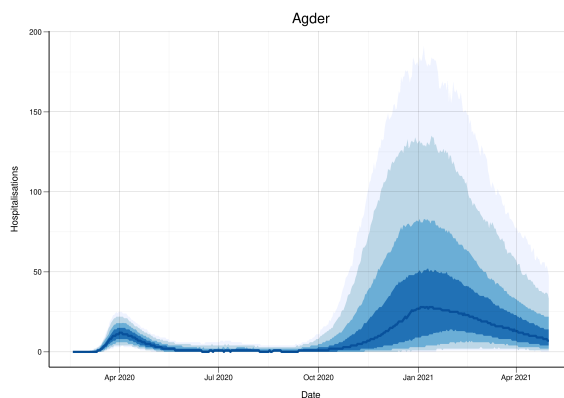
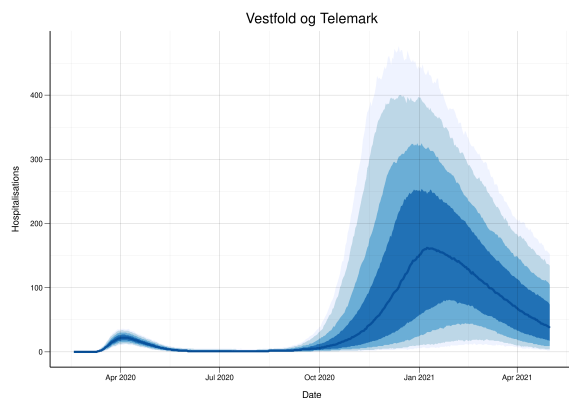
Region	1 week prediction (23 August)	2 weeks prediction (30 August)	3 weeks prediction (06 September)
Agder	2 (0-10)	3 (0-12)	4 (0-17)
Innlandet	33 (7-100)	45 (7-155)	65 (8-228)
Møre og Romsdal	34 (0-201)	54 (0-364)	89 (1-611)
Nordland	3 (0-19)	4 (0-28)	5 (0-37)
Oslo	40 (5-199)	58 (6-323)	83 (6-485)
Rogaland	17 (1-78)	20 (0-106)	26 (0-148)
Troms og Finnmark	14 (0-126)	22 (0-198)	36 (0-365)
Trøndelag	4 (0-16)	5 (0-20)	6 (0-25)
Vestfold og Telemark	8 (1-21)	11 (1-34)	16 (2-55)
Vestland	27 (1-158)	41 (1-269)	65 (1-469)
Viken	95 (20-269)	131 (23-419)	182 (23-667)

5 Long-term prediction results for each county

5.1 Hospitalisations

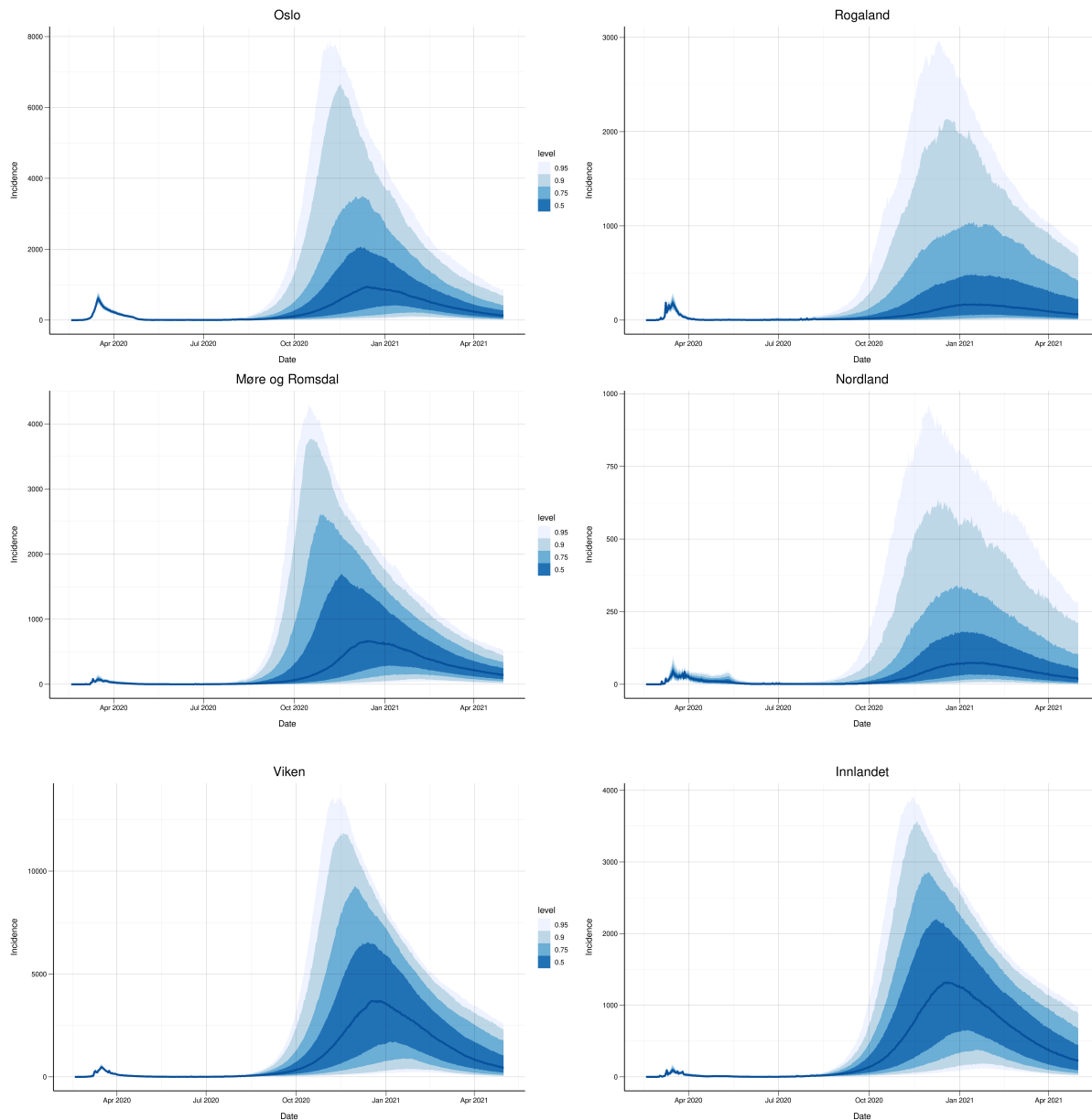
Predicted daily number of COVID-19 patients in hospital, including receiving ventilator treatment, in each county until April 2021, assuming that there are no changes with respect to today in the reproduction number. It is based on 1000 runs of the future to represent the uncertainty. Many counties,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

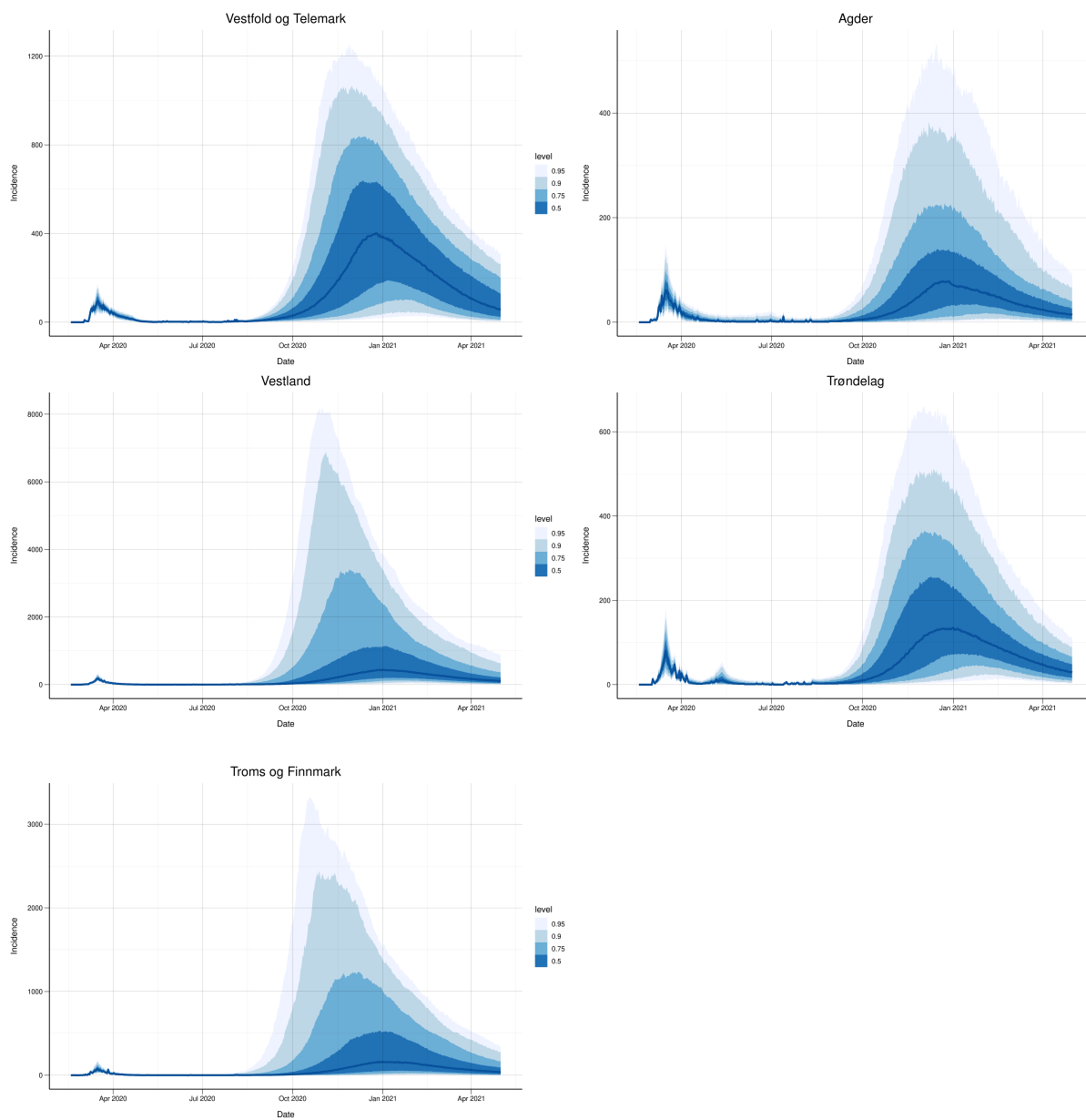




5.2 Incidence

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.





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 many of the reproduction numbers, and the estimated mean might then have 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	R3 from 11 May	R4 from 1 July
Agder	2.6 (0.94-4.21)	0.476 (0.091-0.793)	0.596 (0.169-1.128)	0.788 (0.287-1.319)	0.416 (0.01-1.161)
Innlandet	2.258 (1.05-3.49)	0.442 (0.066-0.77)	1.021 (0.422-1.612)	0.527 (0.086-0.893)	1.42 (0.885-1.903)
Møre og Romsdal	2.752 (1.07-4.49)	0.582 (0.256-0.892)	0.456 (0.046-0.978)	0.922 (0.468-1.434)	1.463 (0.888-2.103)
Nordland	3.256 (1.53-4.89)	0.686 (0.342-1.042)	0.981 (0.28-1.644)	0.611 (0.102-1.268)	0.773 (0.211-1.362)
Oslo	4.712 (3.74-5.51)	0.748 (0.632-0.872)	0.167 (0.012-0.445)	1.027 (0.611-1.364)	0.982 (0.153-2.125)
Rogaland	2.395 (1.64-3.28)	0.221 (0.045-0.428)	1.085 (0.492-1.88)	1.025 (0.343-1.639)	1.014 (0.441-1.57)
Troms og Finnmark	2.884 (1.53-4.11)	0.38 (0.095-0.648)	0.361 (0.021-0.868)	0.927 (0.537-1.318)	1.089 (0.298-2.009)
Trøndelag	3.181 (1.25-4.59)	0.267 (0.053-0.534)	1.522 (0.373-2.394)	0.527 (0.105-1.056)	0.363 (0.018-0.922)
Vestfold og Telemark	2.257 (0.89-3.45)	0.563 (0.302-0.798)	0.306 (0.018-0.909)	0.83 (0.407-1.267)	0.471 (0.094-0.885)
Vestland	3.495 (2.44-4.52)	0.412 (0.091-0.685)	0.277 (0.015-0.596)	0.784 (0.249-1.378)	0.975 (0.281-1.938)
Viken	3.259 (2.4-4.22)	0.341 (0.138-0.541)	0.572 (0.167-1.036)	0.431 (0.078-0.797)	1.429 (0.836-1.948)

Methods

Details on this model can be found here <https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/>. We use assumptions related to hospitalisation stay 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://royalsocietypublishing.org/doi/10.1098/rsif.2019.0809>.

Briefly: We run a sequential Monte Carlo ABC in order to obtain 1000 parameter sets $\{R_0, R_1, R_2, R_3, R_4\}$ for each county, which best fit the hospitalisation data of each county up to August 10th. We also obtain the best estimate for the amplification factor F used to seed the epidemic. Next we run the model with these 1000 parameter sets again, from the beginning until August 16th, plus three weeks into the future (or until April 2021). Using these 1000 trajectories of the future, we make future predictions and confidence intervals. The mobility data are updated until August 7th. 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 2.52 (1.83-3.20).

New in this report are two additional changepoints, on May 11 and July 1. It is difficult to estimate regionally varying parameters, when the hospital incidence data per county are so low.

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