NIPH
Norwegian Institute of Public Health

Regional situational awareness and forecasting for COVID-19

26 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 predictions[1]. 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 assume six reproduction numbers:

- R_0 active until March 14;
- R_1 active from March 15 to April 19;
- R_2 active from April 20 until May 10.
- R_3 active from May 11 until June 30.
- R_4 active from July 1 until July 31.
- R_5 active from August 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, is not adequate. This problem is related to the very low level of hospitalisation.

When confidence intervals are large, as they are in this report for the R_5'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_5's and of the national R_5, as reported in our daily national report. The confidence intervals have however large overlaps, and these difference are not significant.

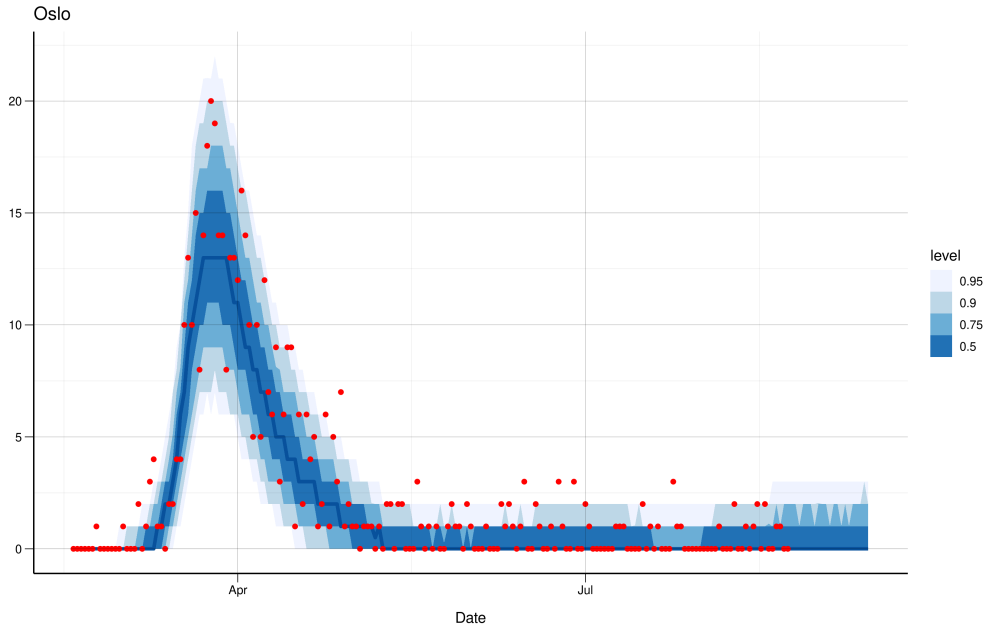
[1] https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/

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

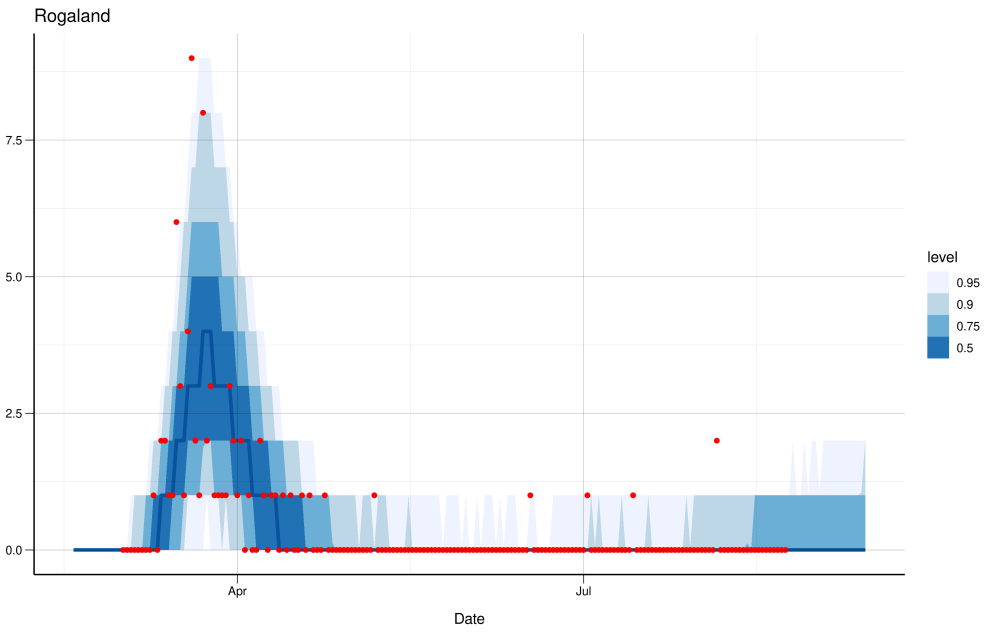
Our model estimates the hospital incidence of COVID-19 patients in each county, plotted below with blue median and uncertainty bands, which are compared to the actual hospitalisation incidence of the county, in red. The blue bands describe the uncertainty in the calibrated parameters, in addition to 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: Median/Mean(95%CI)

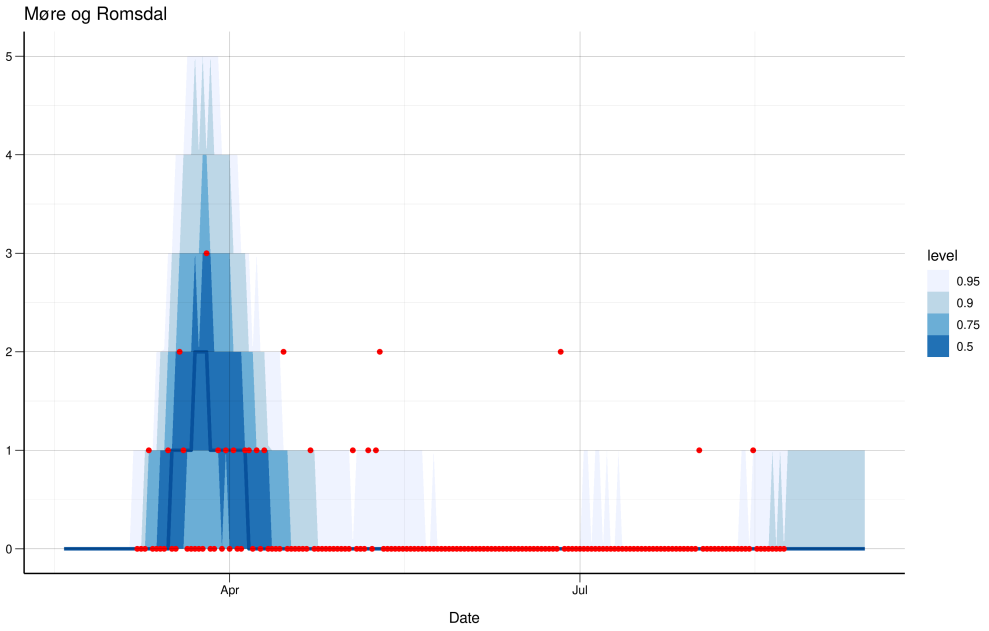
Region	1 week prediction (30 Aug)	2 weeks prediction (06 Sep)	3 weeks prediction (13 Sep)
Agder	1/2 (0-7)	1/2 (0-7)	1/2 (0-7)
Innlandet	3/4 (0-11)	4/4 (0-14)	4/5 (0-16)
Møre og Romsdal	0/0 (0-3)	0/1 (0-3)	0/1 (0-4)
Nordland	1/2 (0-10)	1/2 (0-12)	1/3 (0-15)
Oslo	5/6 (0-14)	5/6 (0-17)	4/6 (0-19)
Rogaland	1/2 (0-7)	1/2 (0-8)	1/2 (0-10)
Troms og Finnmark	0/1 (0-8)	0/1 (0-6)	0/1 (0-6)
Trøndelag	3/4 (0-17)	4/5 (0-23)	4/7 (0-35)
Vestfold og Telemark	4/4 (0-13)	4/5 (0-18)	4/6 (0-25)
Vestland	1/2 (0-7)	1/2 (0-8)	1/2 (0-10)
Viken	6/7 (1-17)	5/6 (0-17)	4/6 (0-18)



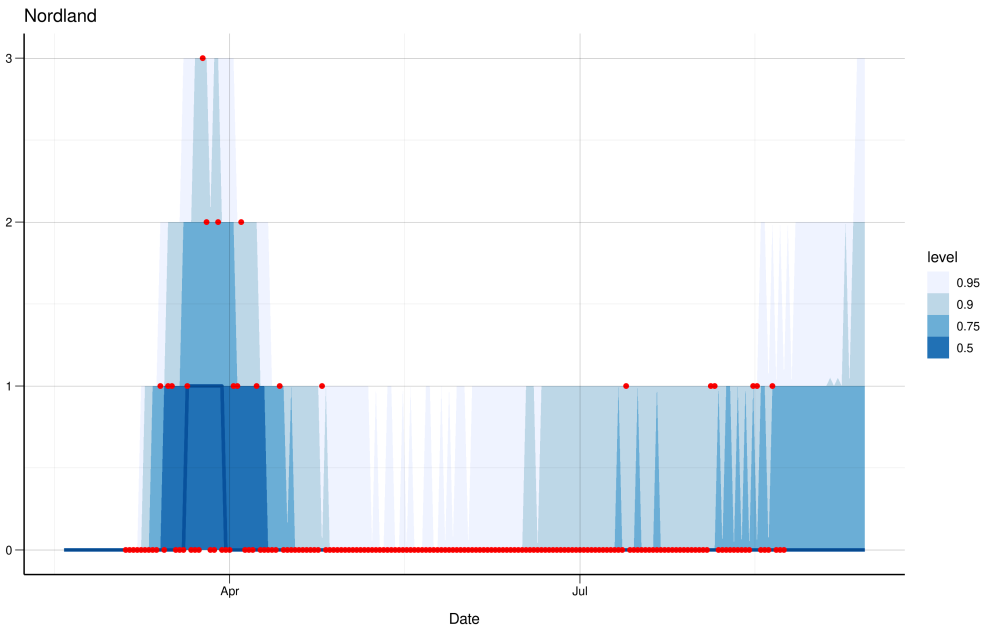
True hospitalisation incidence (red) and predicted values (blue)



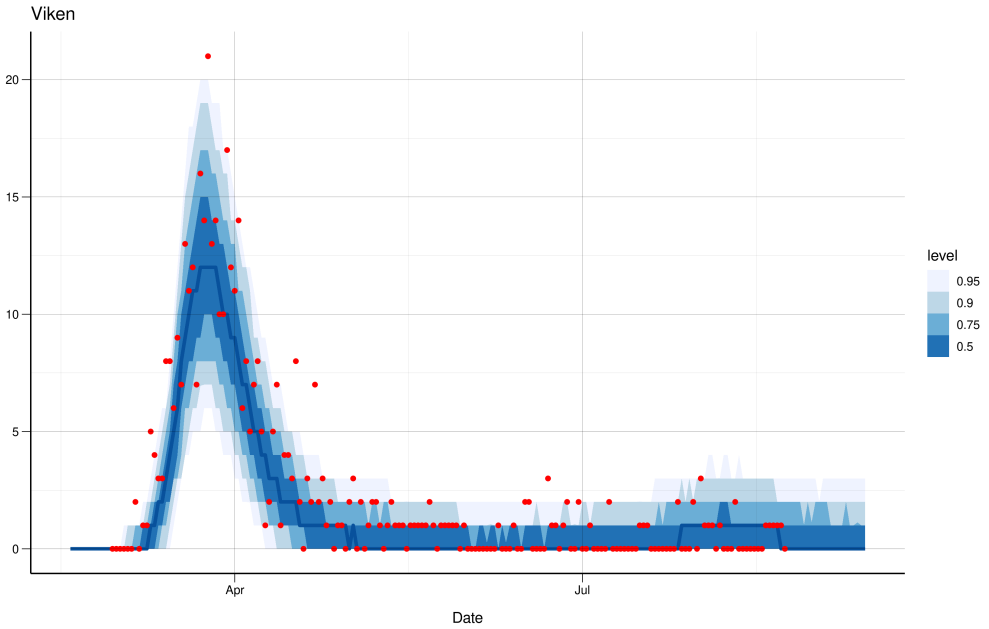
True hospitalisation incidence (red) and predicted values (blue)



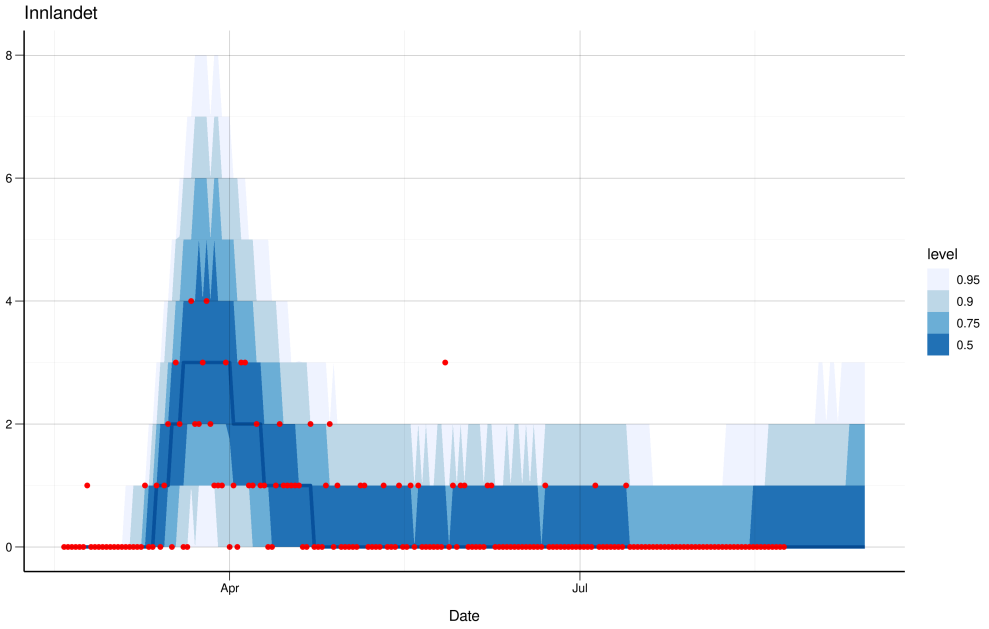
True hospitalisation incidence (red) and predicted values (blue)



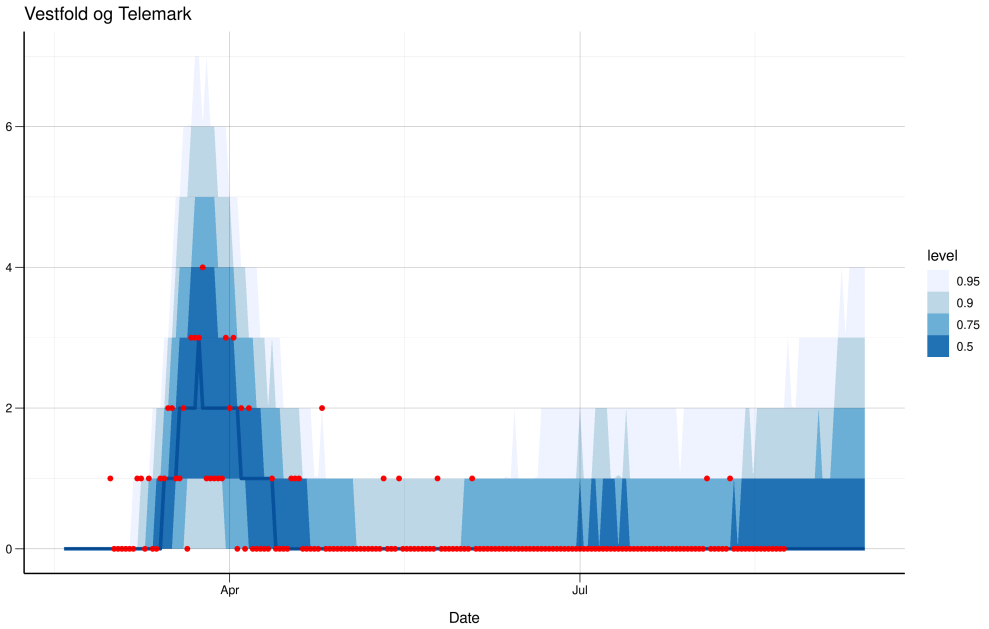
True hospitalisation incidence (red) and predicted values (blue)



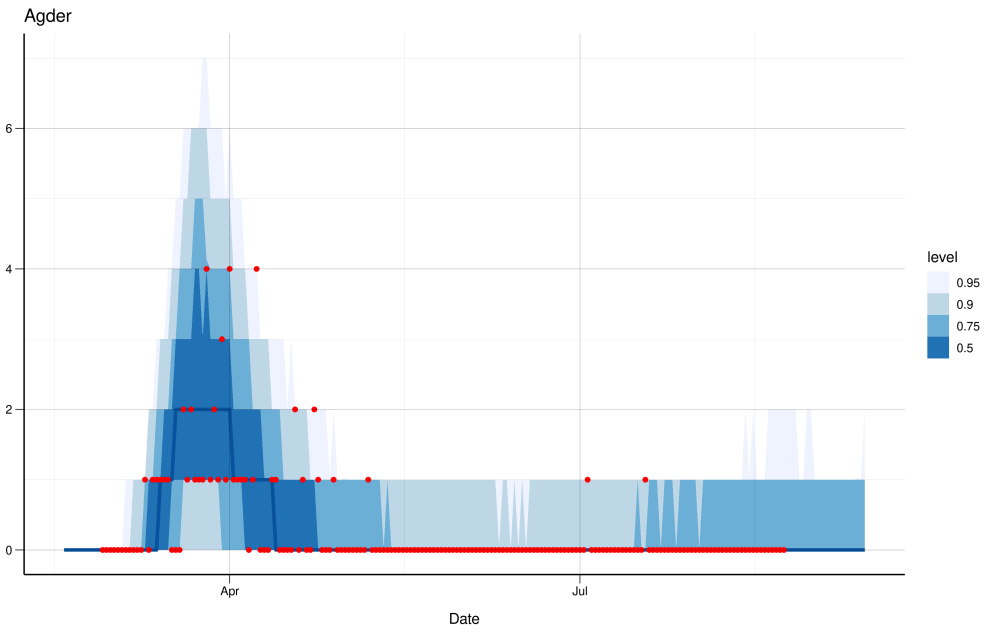
True hospitalisation incidence (red) and predicted values (blue)



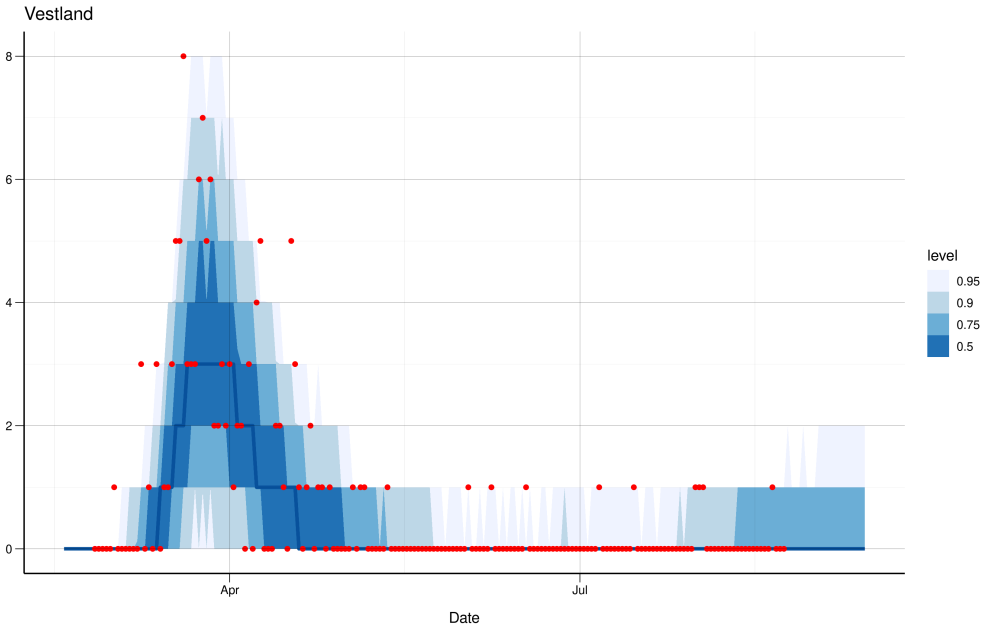
True hospitalisation incidence (red) and predicted values (blue)



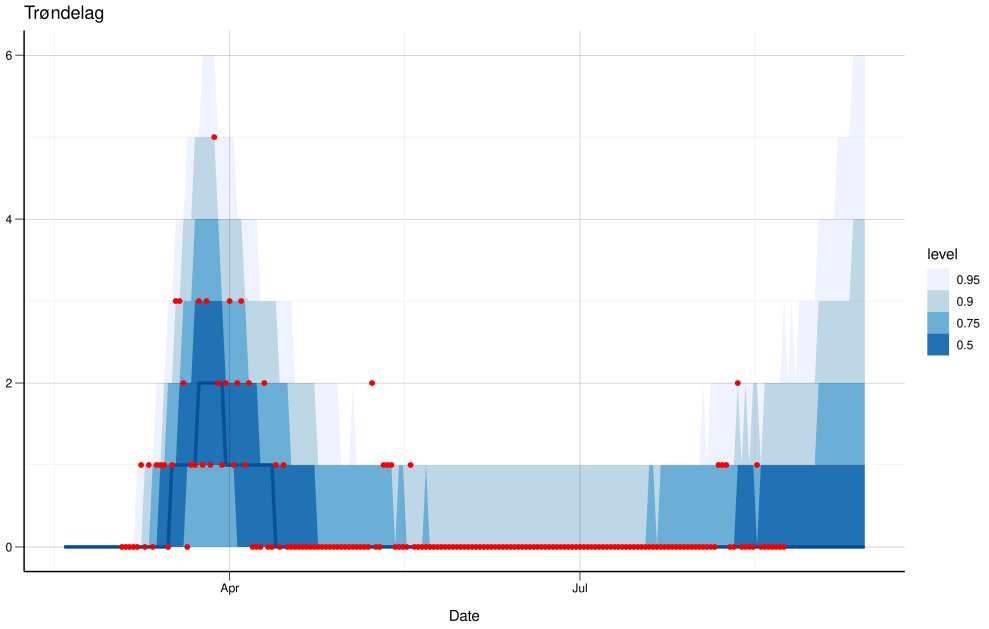
True hospitalisation incidence (red) and predicted values (blue)



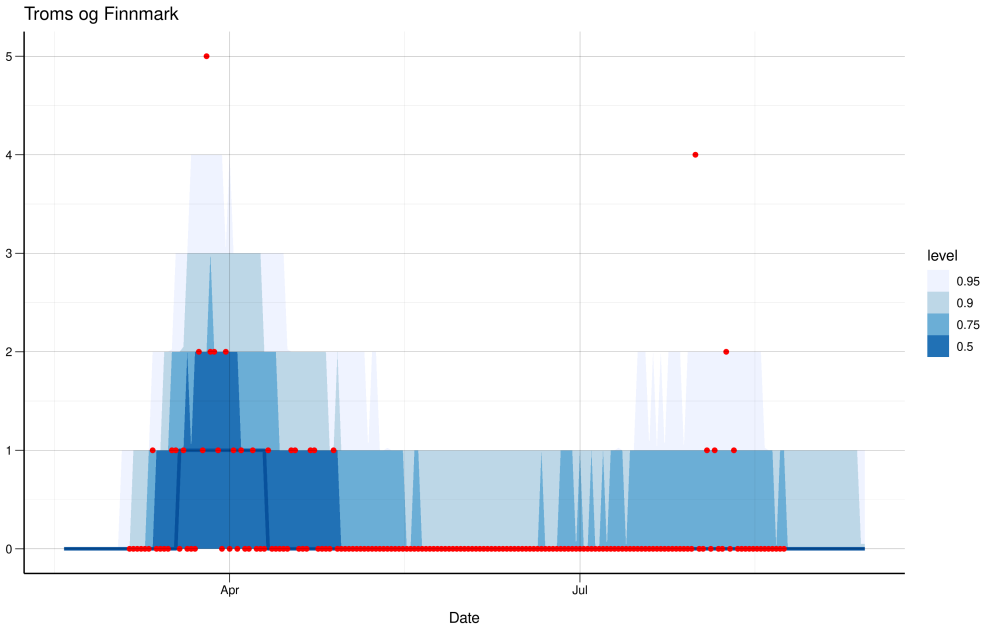
True hospitalisation incidence (red) and predicted values (blue)



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



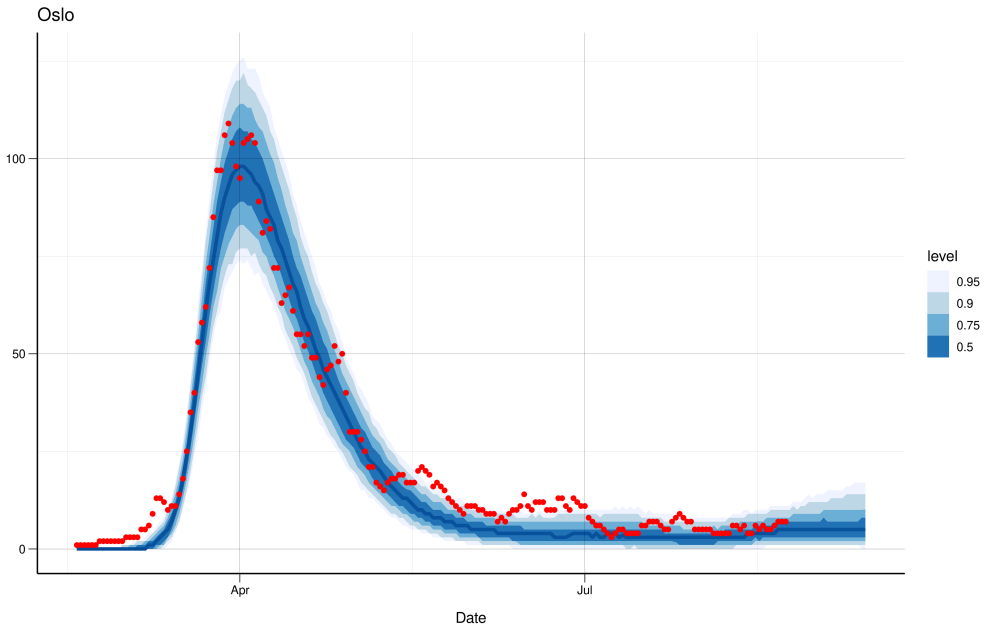
True hospitalisation incidence (red) and predicted values (blue)



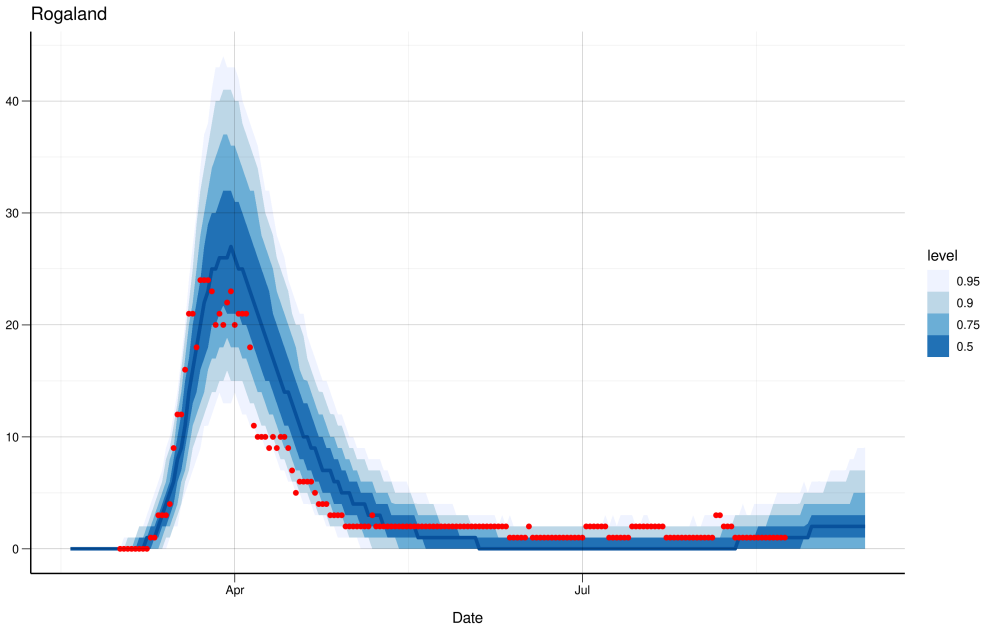
True hospitalisation incidence (red) and predicted values (blue)

1.1 Hospital prevalence

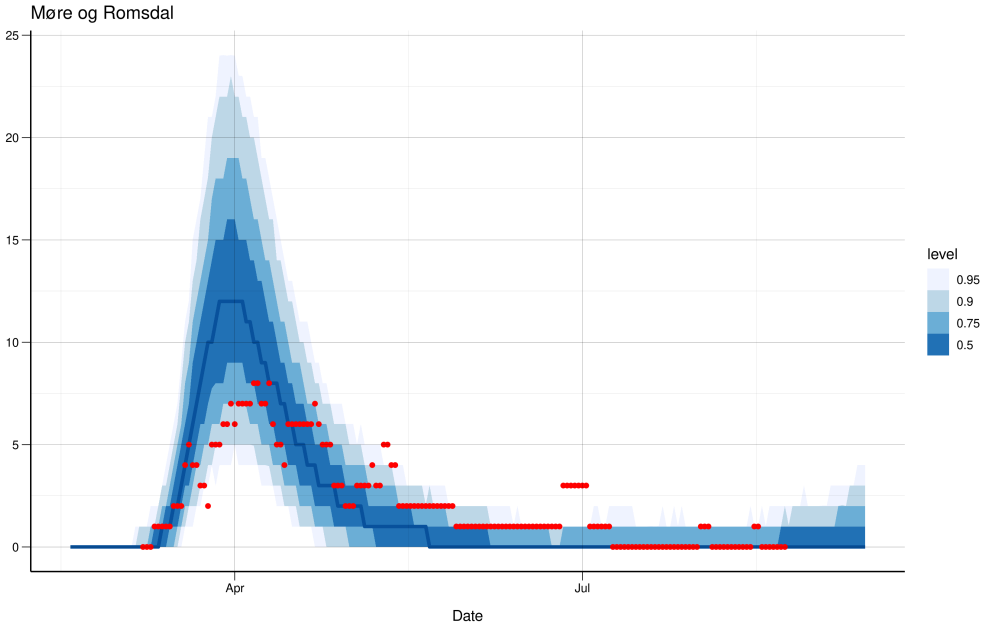
Though we do not calibrate to the hospital prevalence data, we show our simulations along with the prevalence data, as a test of our model performance. The model simulations fit the prevalence data well, but for some counties there are larger discrepancies. This indicates that there could be regional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



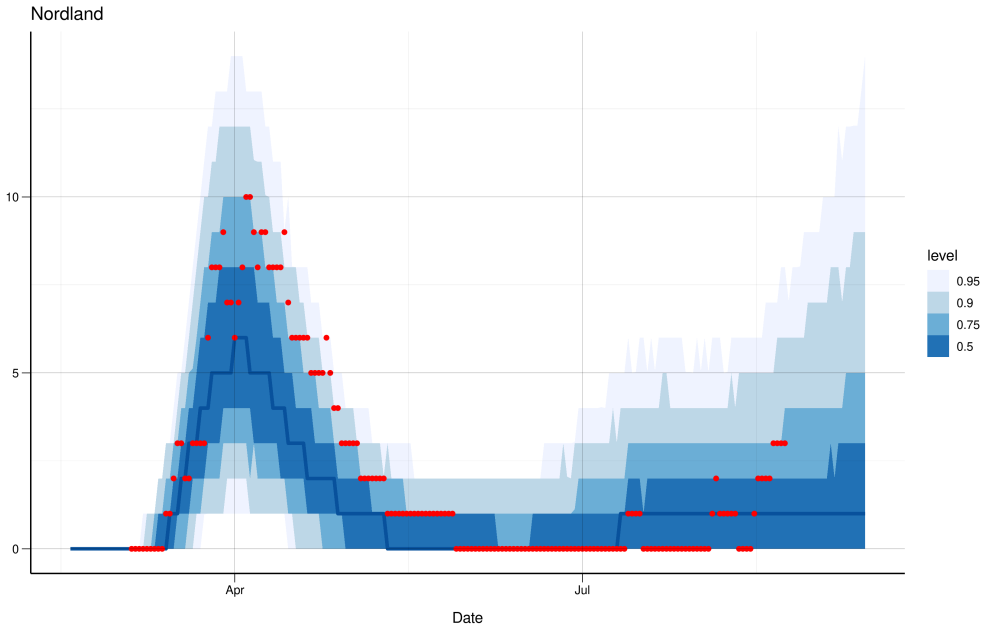
True hospitalisation prevalence (red) and predicted values (blue)



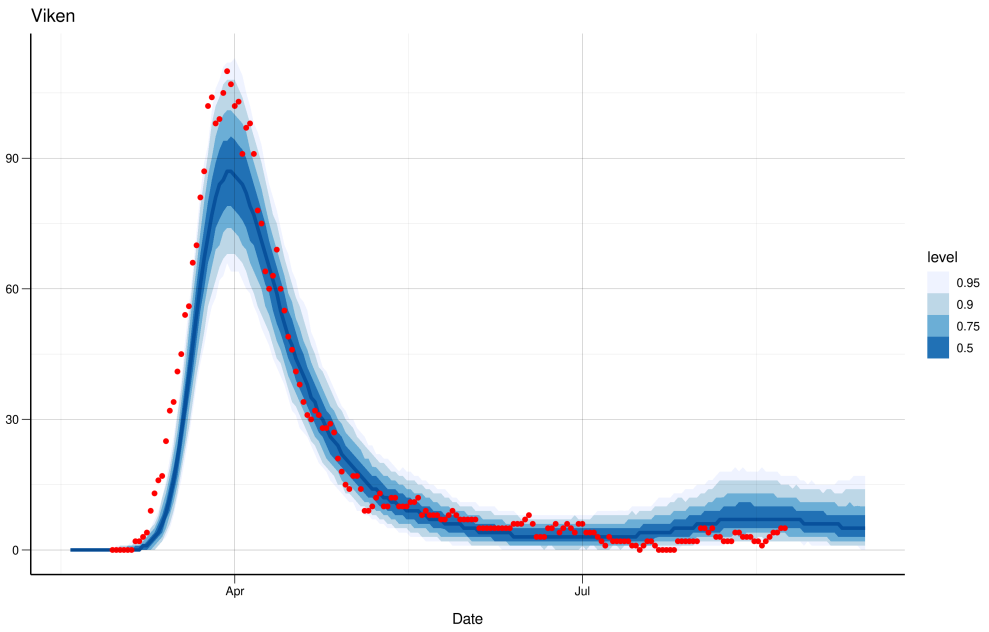
True hospitalisation prevalence (red) and predicted values (blue)



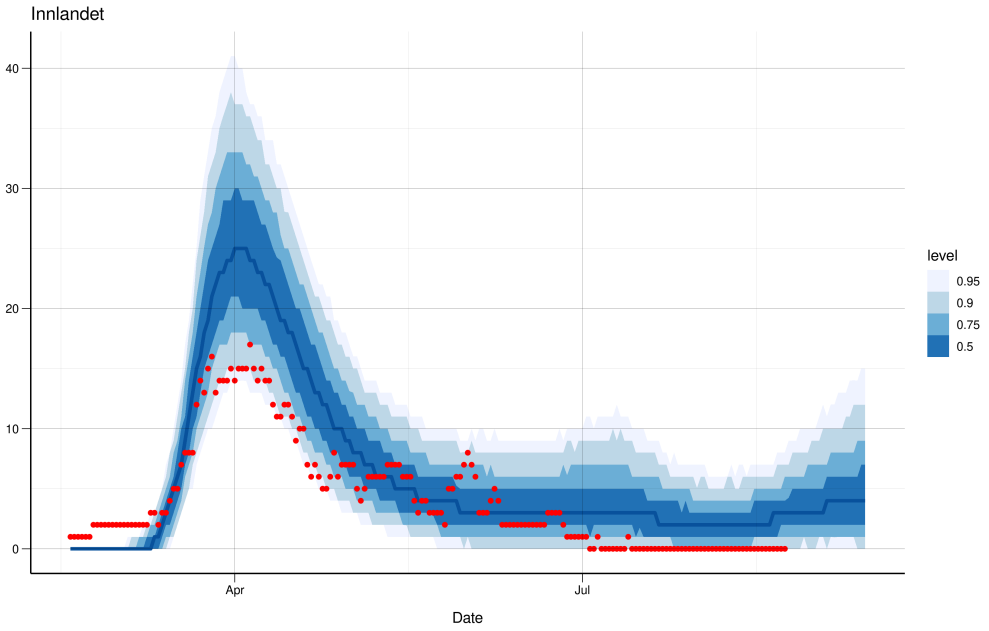
True hospitalisation prevalence (red) and predicted values (blue)



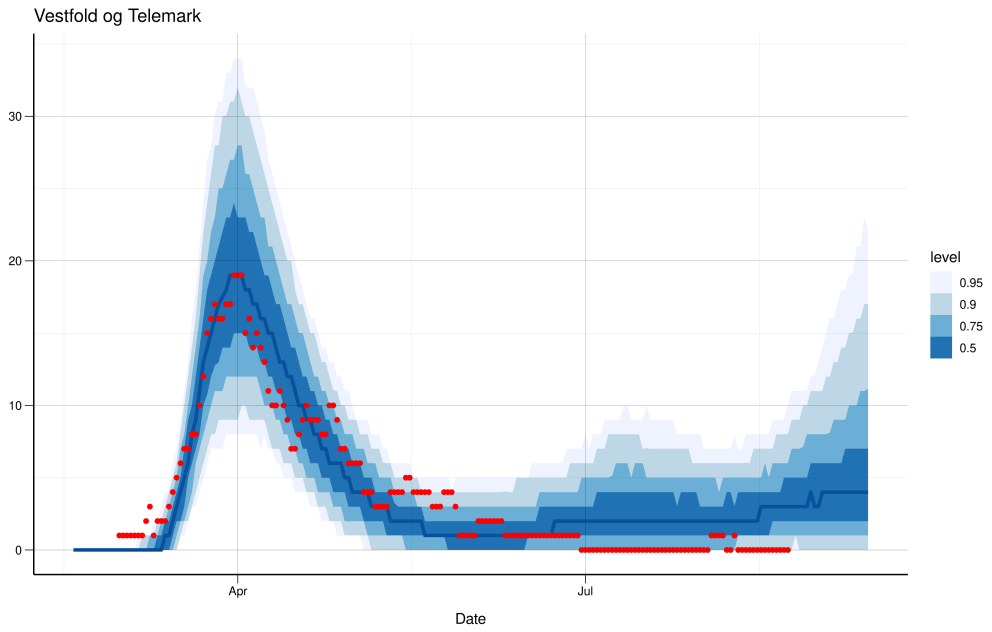
True hospitalisation prevalence (red) and predicted values (blue)



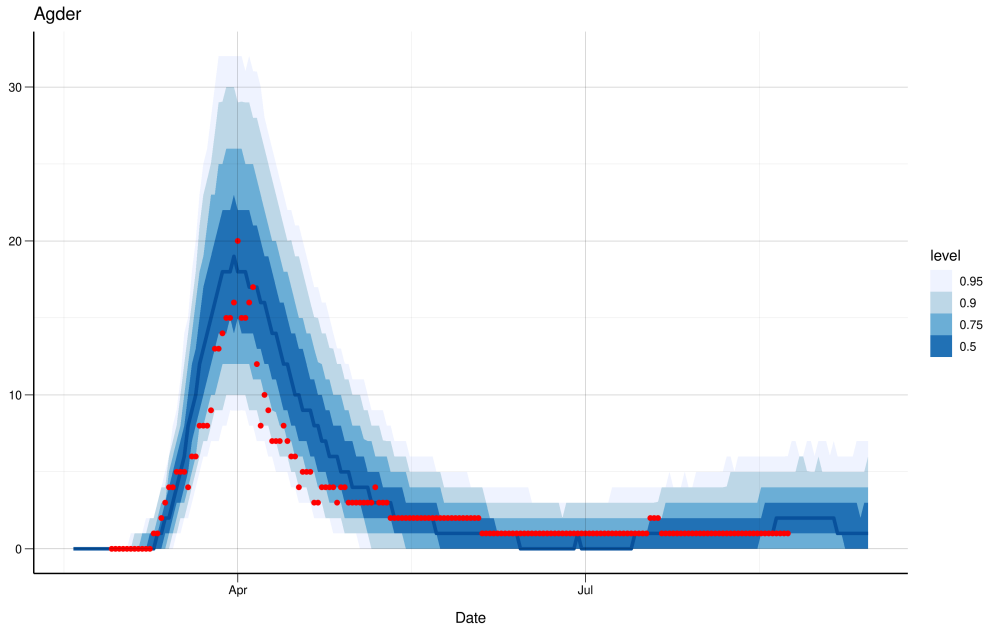
True hospitalisation prevalence (red) and predicted values (blue)



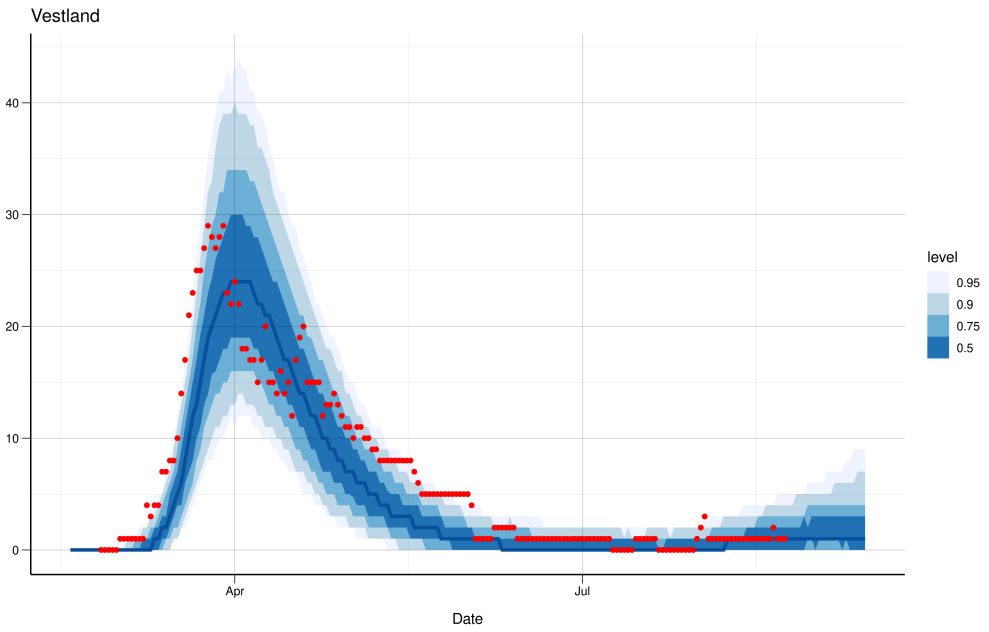
True hospitalisation prevalence (red) and predicted values (blue)



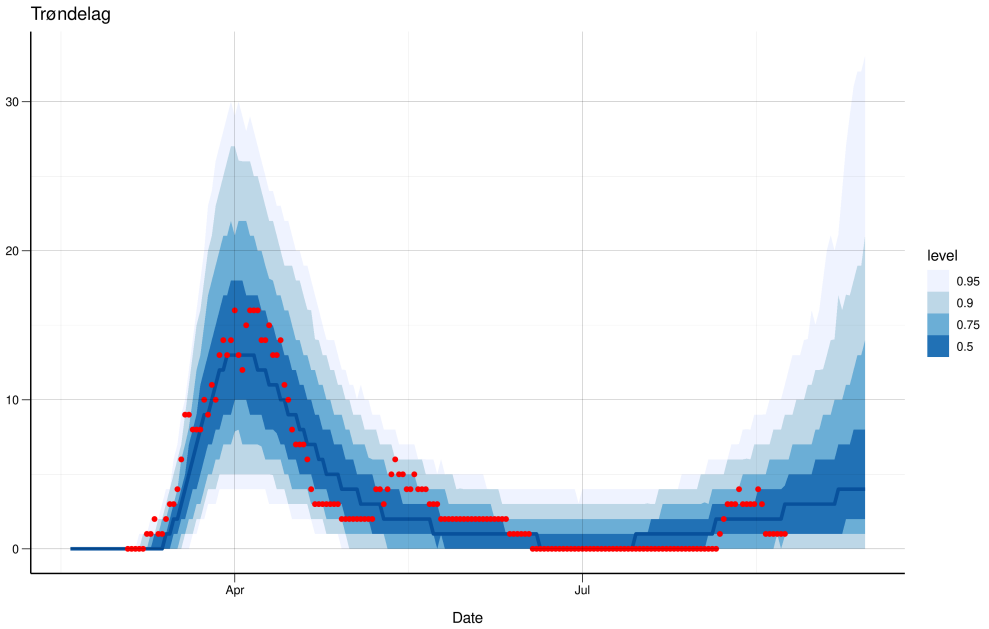
True hospitalisation prevalence (red) and predicted values (blue)



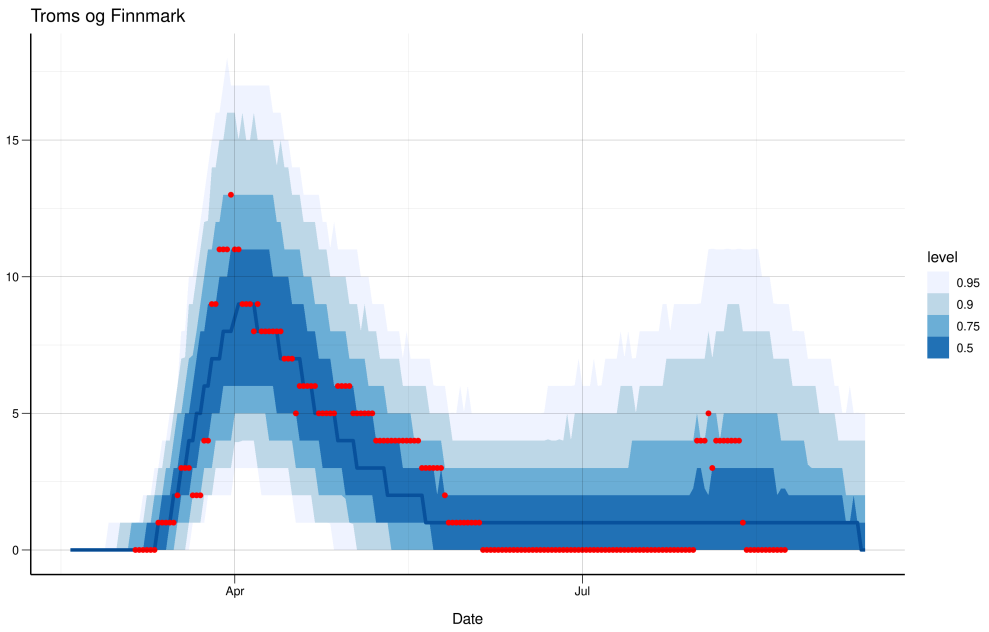
True hospitalisation prevalence (red) and predicted values (blue)



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: Median/Mean(95%CI)

Region	1 week prediction (30 Aug)	2 weeks prediction (06 Sep)	3 weeks prediction (13 Sep)
Agder	0/1 (0-2)	0/1 (0-2)	0/1 (0-2)
Innlandet	1/1 (0-3)	1/1 (0-4)	1/1 (0-4)
Møre og Romsdal	0/0 (0-1)	0/0 (0-1)	0/0 (0-1)
Nordland	0/0 (0-3)	0/0 (0-3)	0/1 (0-4)
Oslo	1/1 (0-4)	1/1 (0-5)	1/1 (0-5)
Rogaland	0/0 (0-2)	0/1 (0-2)	0/1 (0-3)
Troms og Finnmark	0/0 (0-3)	0/0 (0-2)	0/0 (0-2)
Trøndelag	1/1 (0-4)	1/1 (0-5)	1/2 (0-7)
Vestfold og Telemark	1/1 (0-3)	1/1 (0-4)	1/1 (0-6)
Vestland	0/0 (0-2)	0/0 (0-2)	0/0 (0-3)
Viken	2/2 (0-6)	1/2 (0-5)	1/2 (0-5)

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. Median/Mean and 95 perc. CI for three weeks prediction.

Region	30 Aug	06 Sep	13 Sep	low CI, 13 Sep	high CI, 13 Sep
Agder	20/27	19/29	24/36	5	150
Innlandet	53/67	63/82	71/100	13	357
Møre og Romsdal	10/13	12/17	15/26	2	125
Nordland	19/35	20/47	25/66	1	391
Oslo	97/117	98/126	89/131	11	509
Rogaland	40/48	41/55	42/64	6	245
Troms og Finnmark	9/15	8/13	8/13	0	59
Trøndelag	62/109	70/154	81/226	7	1370
Vestfold og Telemark	55/82	59/98	59/111	6	550
Vestland	27/38	26/43	30/53	5	241
Viken	82/97	66/86	78/109	16	428

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.

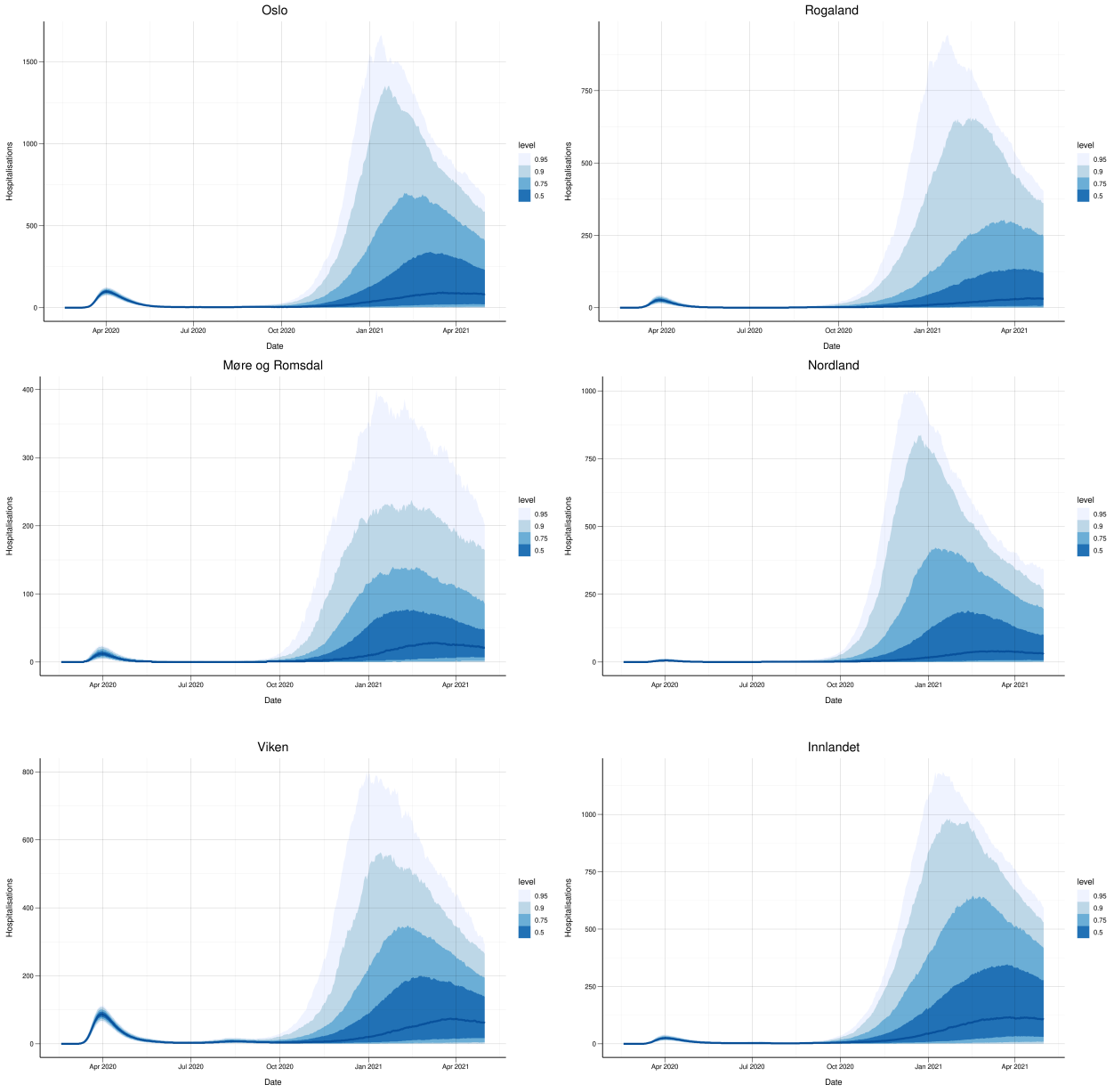
Table 4: Predicted incidence per day: Median/Mean(95%CI)

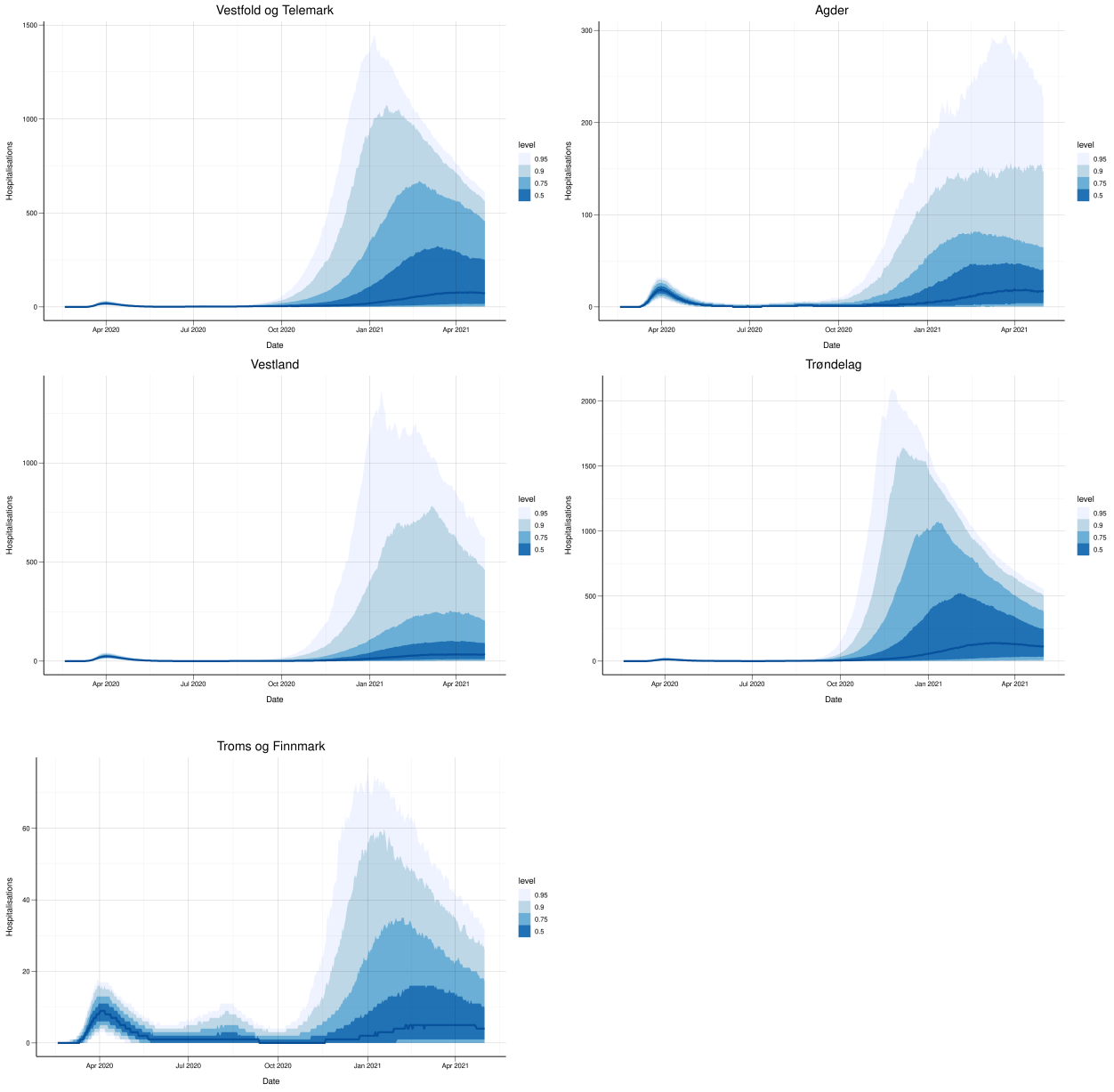
Region	1 week prediction (30 Aug)	2 weeks prediction (06 Sep)	3 weeks prediction (13 Sep)
Agder	3/4 (0-18)	3/5 (0-22)	3/6 (0-28)
Innlandet	9/12 (1-37)	10/14 (1-52)	11/18 (1-72)
Møre og Romsdal	1/2 (0-10)	1/3 (0-15)	2/4 (0-24)
Nordland	3/6 (0-33)	3/9 (0-51)	4/12 (0-78)
Oslo	15/19 (3-60)	15/21 (1-75)	14/22 (1-90)
Rogaland	6/8 (0-26)	7/9 (0-35)	6/11 (0-48)
Troms og Finnmark	1/2 (0-10)	1/2 (0-8)	1/2 (0-9)
Trøndelag	11/21 (0-108)	12/30 (0-188)	14/47 (1-331)
Vestfold og Telemark	9/15 (0-62)	10/19 (1-88)	11/23 (0-127)
Vestland	4/6 (0-26)	4/7 (0-36)	4/9 (0-50)
Viken	11/14 (2-47)	10/14 (1-57)	10/16 (1-71)

5 Long-term prediction results for each county

5.1 Hospitalisations

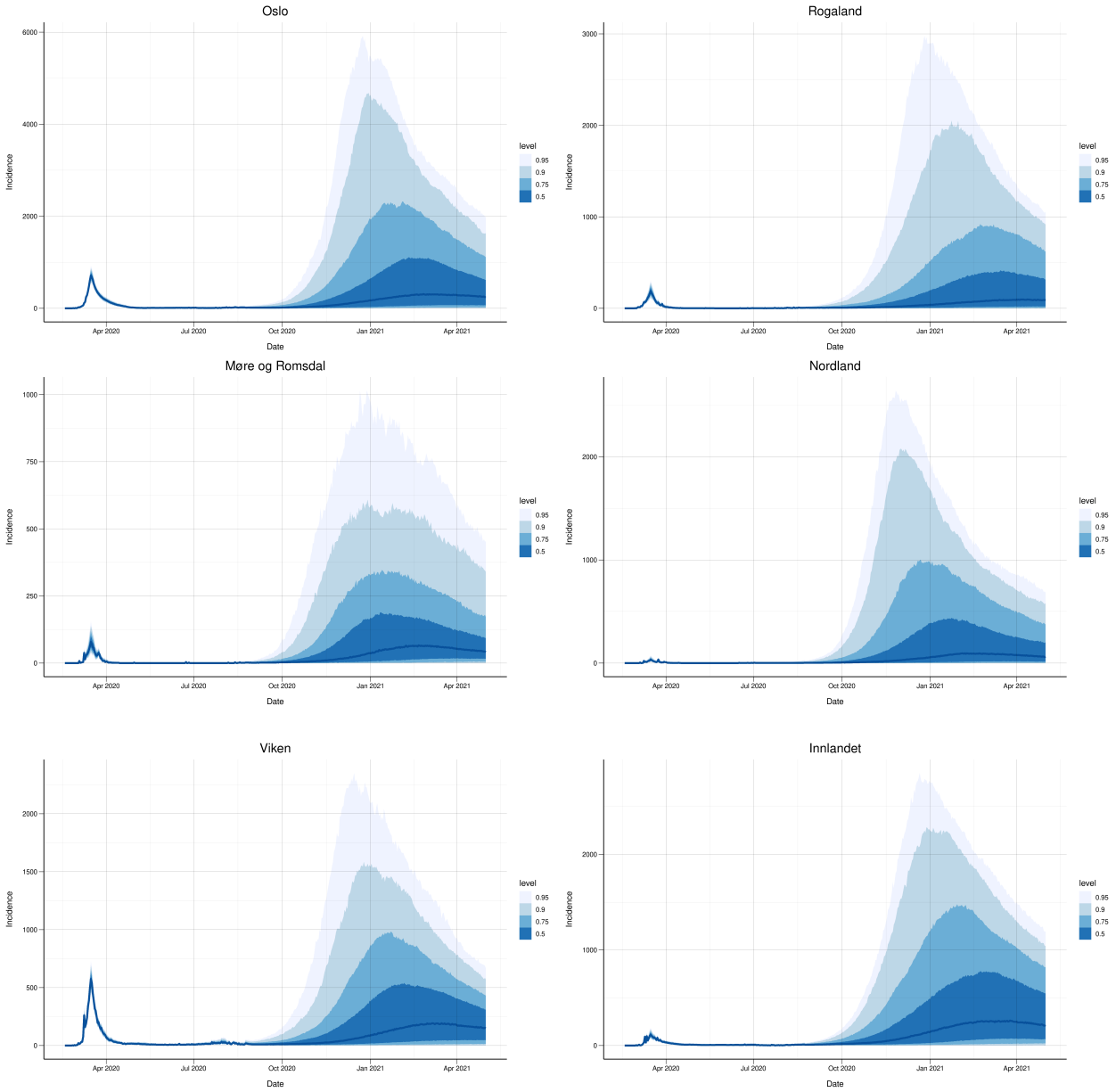
Predicted daily number of COVID-19 patients in hospital, including receiving ventilator treatment, in each county until April 2021, assuming that there are no changes with respect to today in the reproduction number. It is based on 1000 runs of the future to represent the uncertainty. Many counties,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

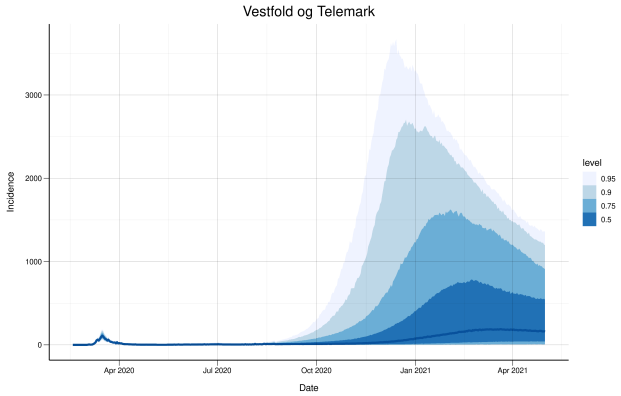


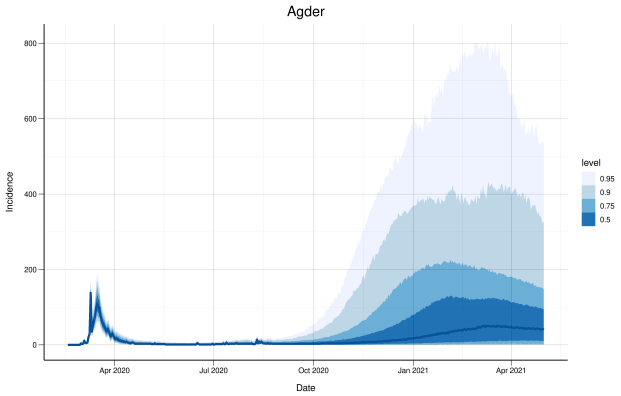

Vestfold og Telemark
Agder
Vestland
Trøndelag
Troms og Finnmark
Hospitalisations
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021

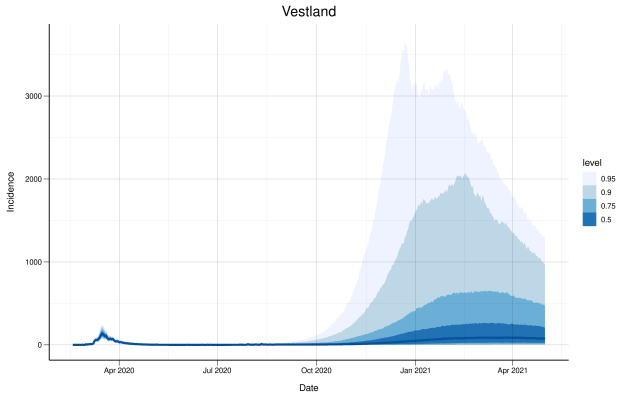
5.2 Incidence

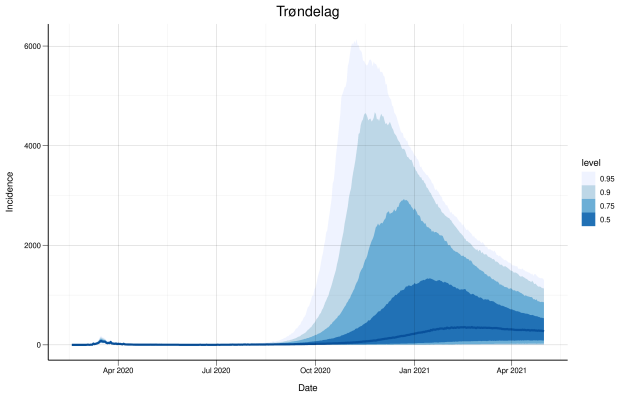
Predicted incidence (asymptomatic and symptomatic) for each county per day, with confidence intervals. Rogaland, Nordland, Troms og Finnmark and Vestland are so uncertain, that long term predictions are not useful.

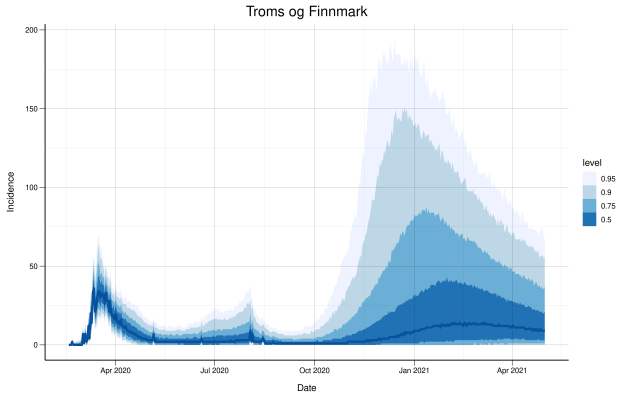



Vestfold og Telemark
Incidence
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021


Agder
Incidence
Date
level
0.95
0.9
0.75
0.5
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 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
Agder	2.806 (1.77-3.69)	0.372 (0.135-0.619)	0.746 (0.312-1.171)
Innlandet	2.682 (1.66-3.67)	0.525 (0.329-0.723)	0.836 (0.468-1.201)
Møre og Romsdal	3.961 (2.52-5.33)	0.121 (0.007-0.338)	0.83 (0.32-1.272)
Nordland	2.889 (1.41-4.41)	0.184 (0.044-0.327)	0.684 (0.156-1.278)
Oslo	4.965 (4.35-5.54)	0.6 (0.453-0.748)	0.386 (0.108-0.666)
Rogaland	3.392 (2.6-4.13)	0.211 (0.033-0.437)	0.594 (0.327-0.852)
Troms og Finnmark	1.946 (1.24-2.69)	0.606 (0.32-0.903)	0.642 (0.344-0.935)
Trøndelag	4.018 (2.29-5.67)	0.39 (0.109-0.694)	0.814 (0.353-1.263)
Vestfold og Telemark	3.308 (1.95-4.61)	0.248 (0.103-0.4)	0.44 (0.035-0.928)
Vestland	3.355 (2.37-4.34)	0.448 (0.281-0.612)	0.4 (0.122-0.711)
Viken	3.945 (3.23-4.64)	0.177 (0.038-0.321)	0.866 (0.377-1.345)

Table 6: Estimated reproduction numbers (mean and 95 confidence intervals)

Region	R3 from 11 May	R4 from 1 July	R5 from 1 August
Agder	0.73 (0.335-1.136)	0.967 (0.346-1.527)	0.643 (0.071-1.386)
Innlandet	1.112 (0.746-1.477)	0.432 (0.031-0.942)	1.277 (0.694-1.81)
Møre og Romsdal	0.337 (0.036-0.783)	0.431 (0.05-0.955)	0.765 (0.146-1.449)
Nordland	1.108 (0.464-1.75)	0.858 (0.306-1.44)	1.086 (0.303-1.827)
Oslo	1.21 (0.901-1.503)	0.718 (0.145-1.306)	1.156 (0.489-1.882)
Rogaland	0.789 (0.279-1.341)	0.757 (0.24-1.278)	1.004 (0.422-1.587)
Troms og Finnmark	1.004 (0.51-1.513)	1.098 (0.517-1.712)	0.526 (0.127-0.9)
Trøndelag	0.786 (0.403-1.179)	1.147 (0.583-1.687)	1.179 (0.445-1.935)
Vestfold og Telemark	1.181 (0.734-1.63)	0.702 (0.277-1.146)	1.215 (0.381-1.997)
Vestland	0.407 (0.031-0.942)	0.788 (0.454-1.128)	0.769 (0.107-1.552)
Viken	0.639 (0.273-0.986)	1.316 (0.778-1.828)	0.292 (0.017-0.805)

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 $\{R_0, R_1, R_2, R_3, R_4, R_5\}$ for each county, which best fit the hospitalisation data of each county up to August 23. 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 23, 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 22^{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 1.76 (1.06-3.35).

New in this report is an additional changepoint, on August 1. It is difficult to estimate regionally varying parameters, when the hospital incidence data per county are so low.

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