NIPH
Norwegian Institute of Public Health

Regional situational awareness and forecasting for COVID-19

6 October 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. New in this report is that we introduce a changepoint on August 17 for all counties. We have also reduced the number of changepoints for all counties, to improve the parameter estimation.

We assume four changepoints for Oslo and Viken, and three changepoints for the remaining counties. All counties have a changepoint on March 15, April 20 and August 17 when the schools reopened after summer. In addition, Oslo and Viken have a changepoint on June 20 when the schools closed for summer.

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 some counties, the uncertainties in the reproduction numbers are very large. This problem is related to the very low level of hospitalisation.

When confidence intervals are large, 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 reproductive numbers and of the national reproductive numbers, as reported in our national report. The confidence intervals have however large overlaps, and these differences are not significant.

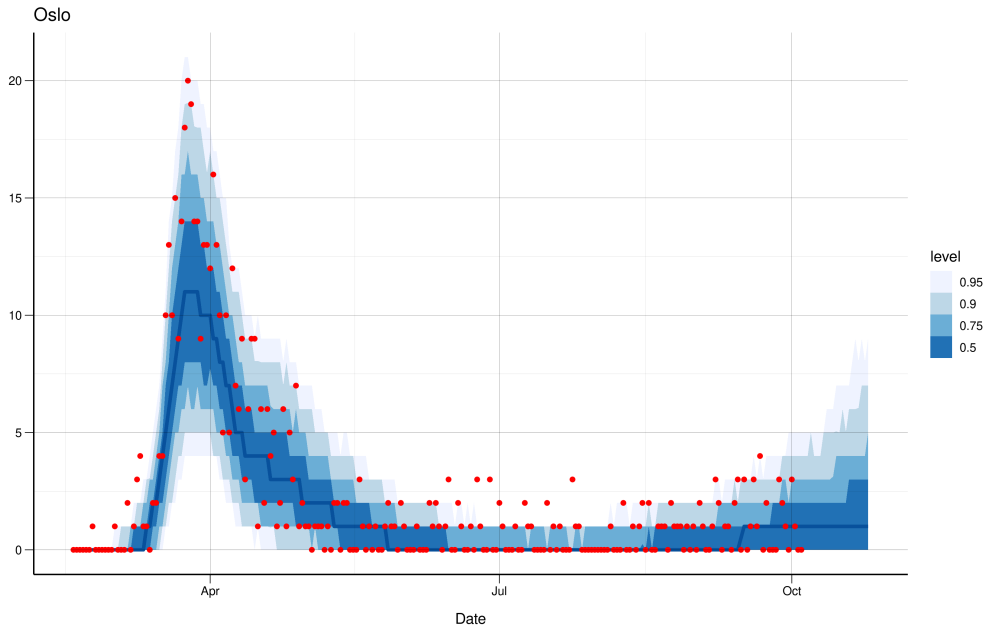
[1] https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/

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

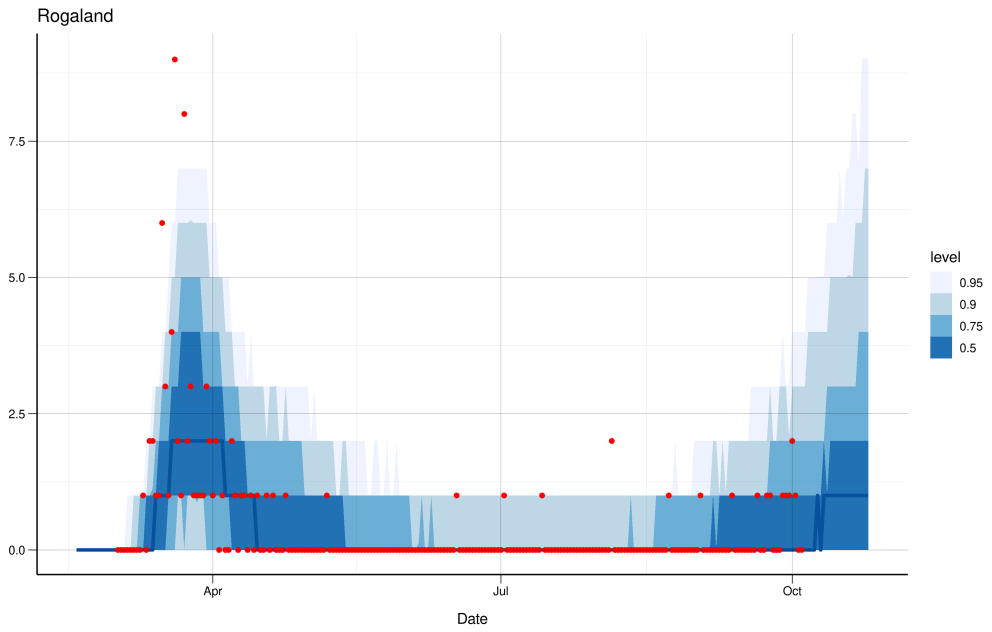
Our model estimates the hospital incidence of COVID-19 patients in each county, plotted below with blue median and uncertainty bands, which are compared to the actual hospitalisation incidence of the county, in red. The blue bands describe the uncertainty in the calibrated parameters, in addition to 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. As noted above, for some counties, in particular the last reproduction number is very uncertain. This results in uncertain predictions for some counties, even when we have reduced the number of changepoints.

Table 1: Number of hospitalisation beds occupied by Covid-19 patients: Median/Mean (95 perc CI)

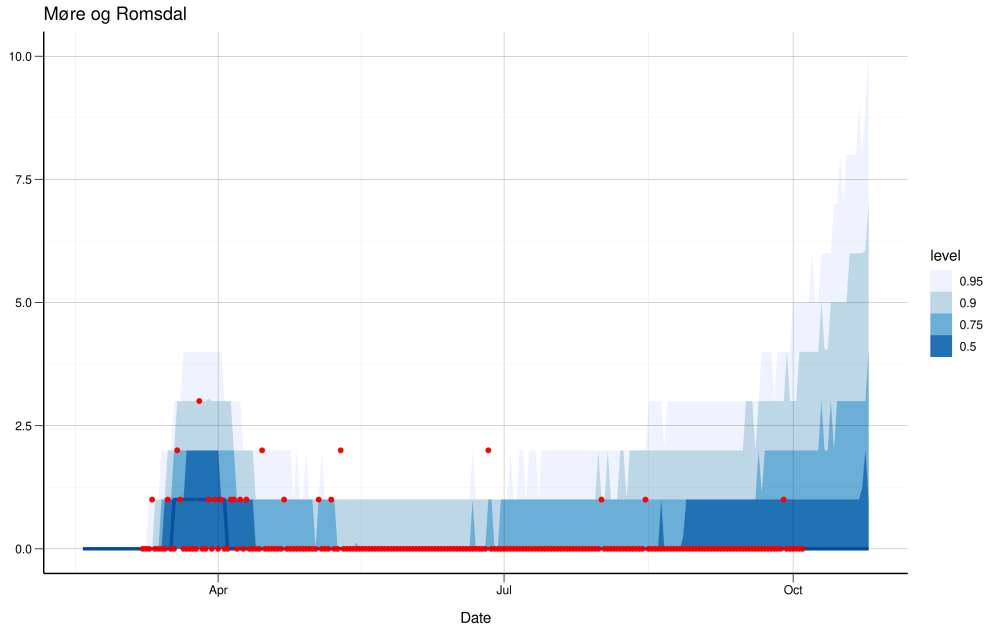
Region	1 week prediction (11 Oct)	2 weeks prediction (18 Oct)	3 weeks prediction (25 Oct)
Agder	1/2 (0-9)	2/3 (0-12)	2/4 (0-15)
Innlandet	3/5 (0-21)	5/6 (0-23)	5/7 (0-29)
Møre og Romsdal	2/7 (0-42)	3/9 (0-52)	3/11 (0-68)
Nordland	0/2 (0-13)	0/2 (0-14)	0/2 (0-16)
Oslo	8/12 (1-38)	11/14 (1-46)	12/17 (1-60)
Rogaland	5/8 (0-33)	6/10 (0-43)	7/13 (0-58)
Troms og Finnmark	0/1 (0-6)	0/1 (0-9)	0/1 (0-10)
Trøndelag	1/3 (0-15)	2/4 (0-20)	2/5 (0-25)
Vestfold og Telemark	8/13 (0-46)	11/17 (0-67)	14/23 (1-96)
Vestland	10/16 (0-63)	14/23 (0-101)	19/34 (1-160)
Viken	15/19 (2-56)	20/24 (3-76)	24/32 (3-108)



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



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



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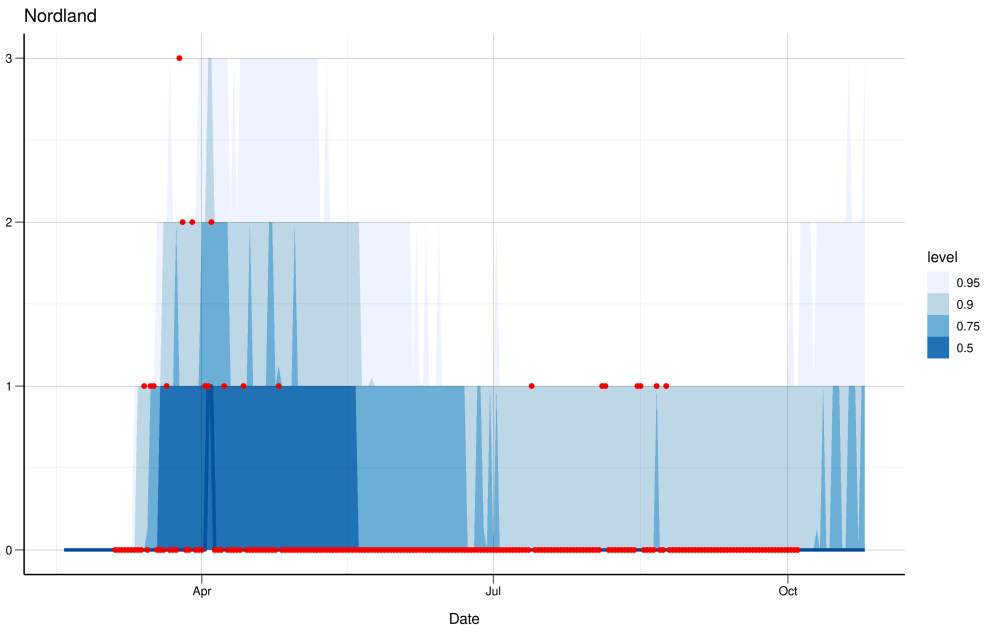
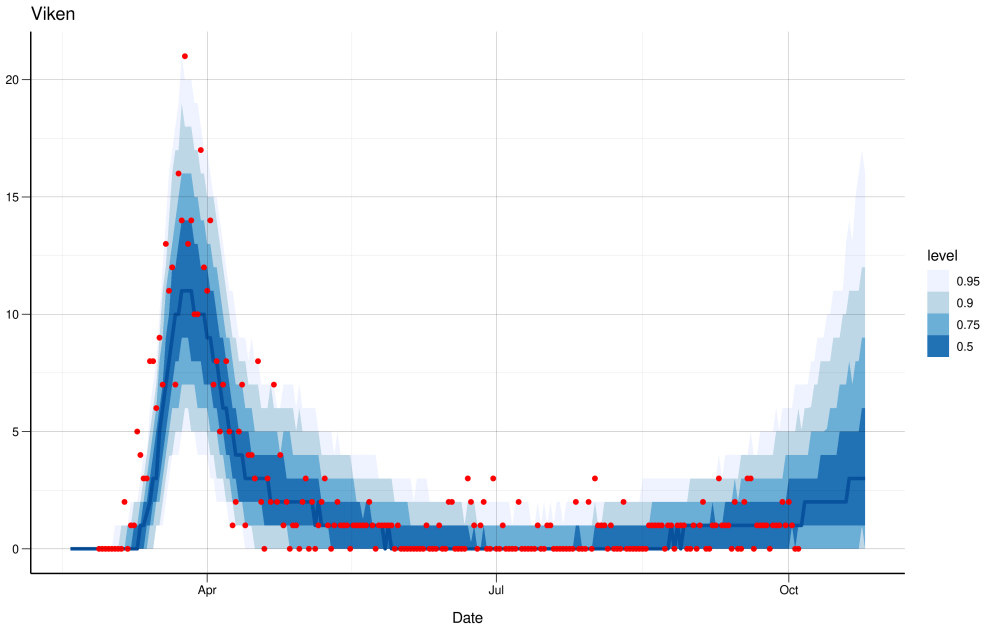
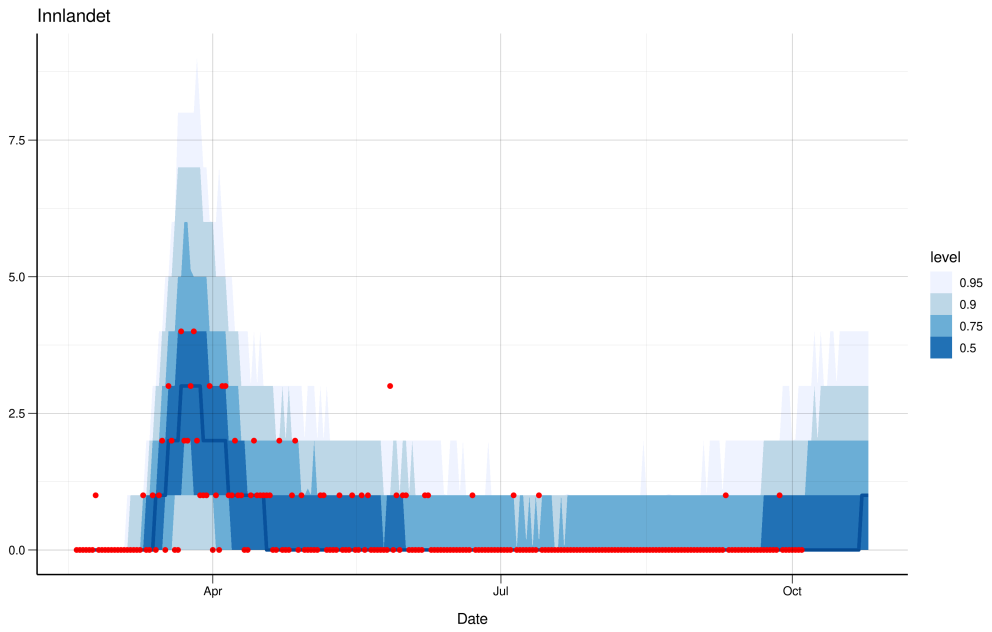


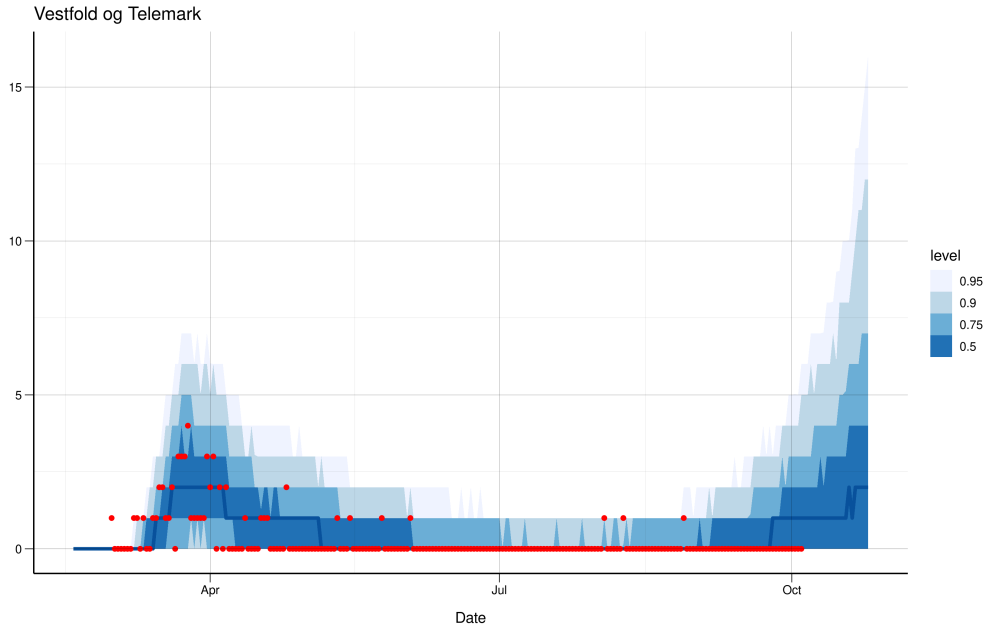
True hospitalisation incidence (red) and predicted values (blue)



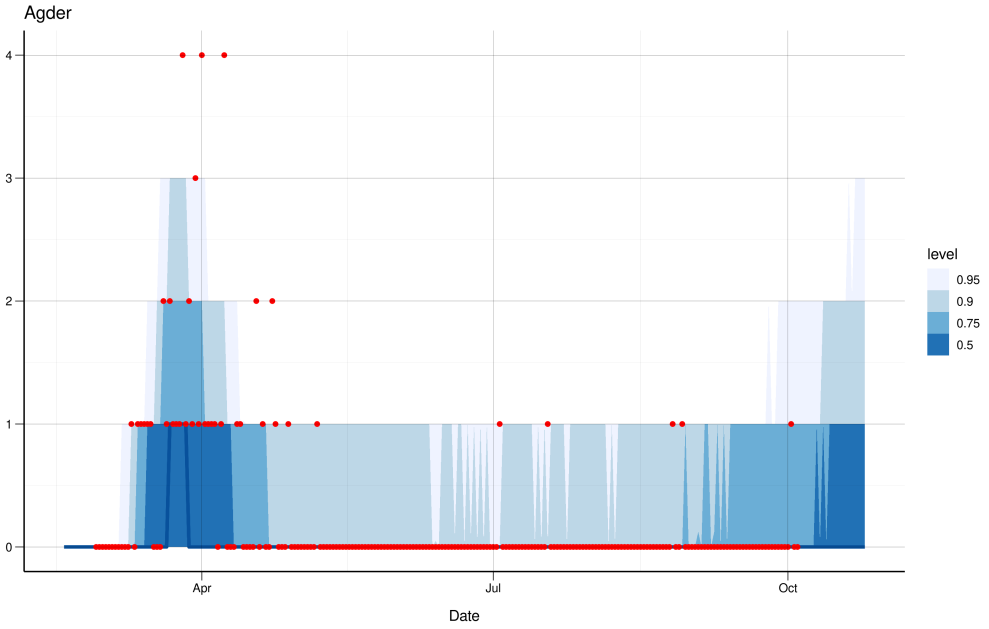
True hospitalisation incidence (red) and predicted values (blue)



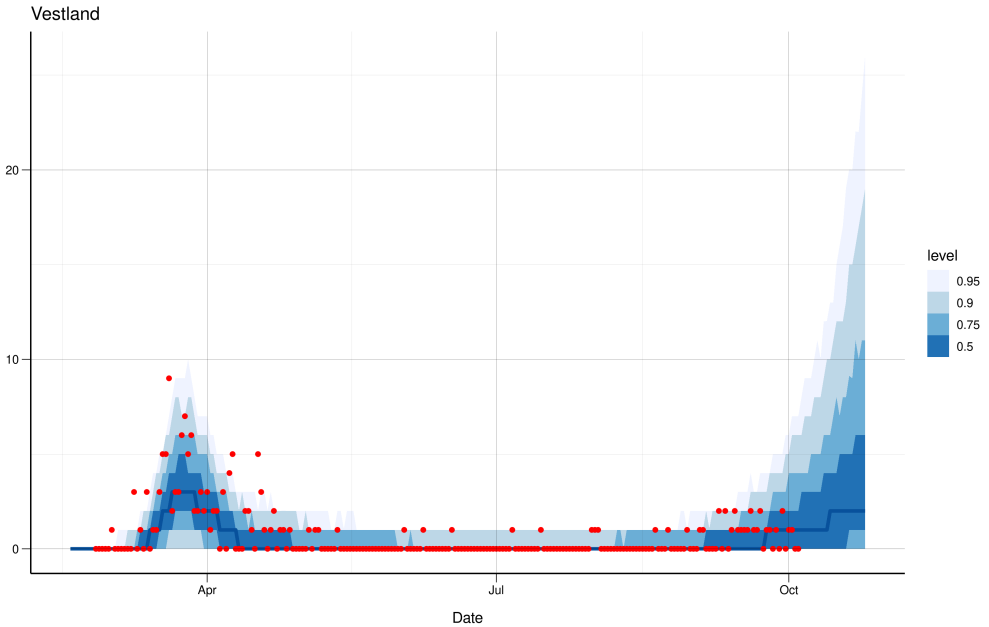
True hospitalisation incidence (red) and predicted values (blue)



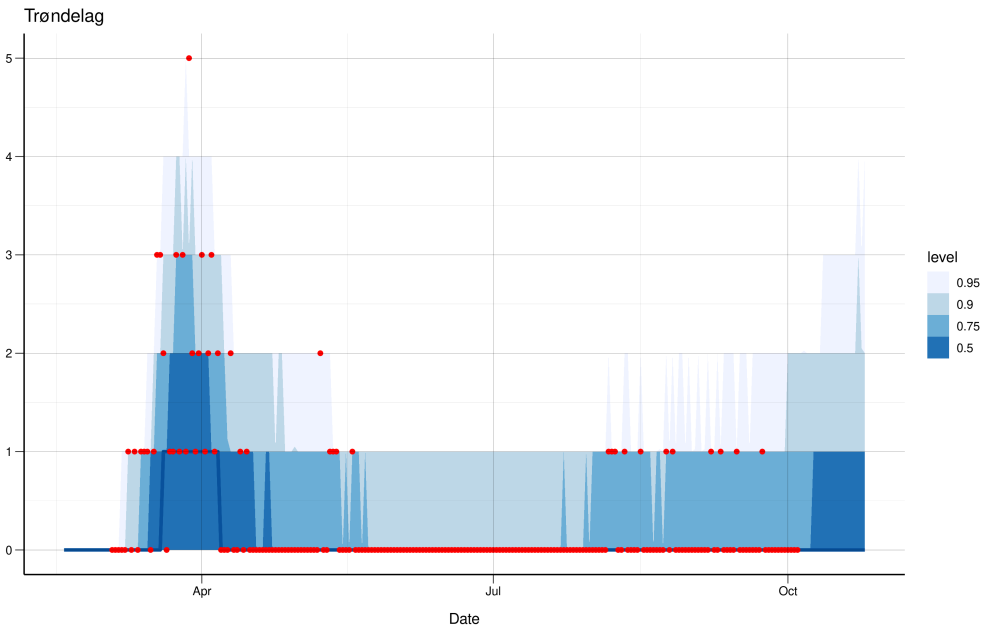
True hospitalisation incidence (red) and predicted values (blue)



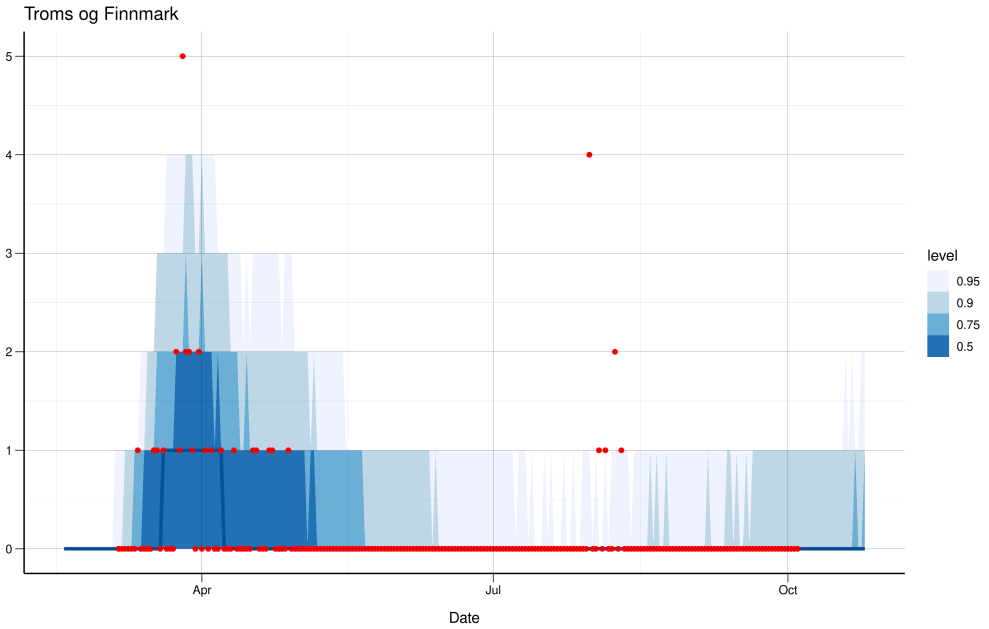
True hospitalisation incidence (red) and predicted values (blue)



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



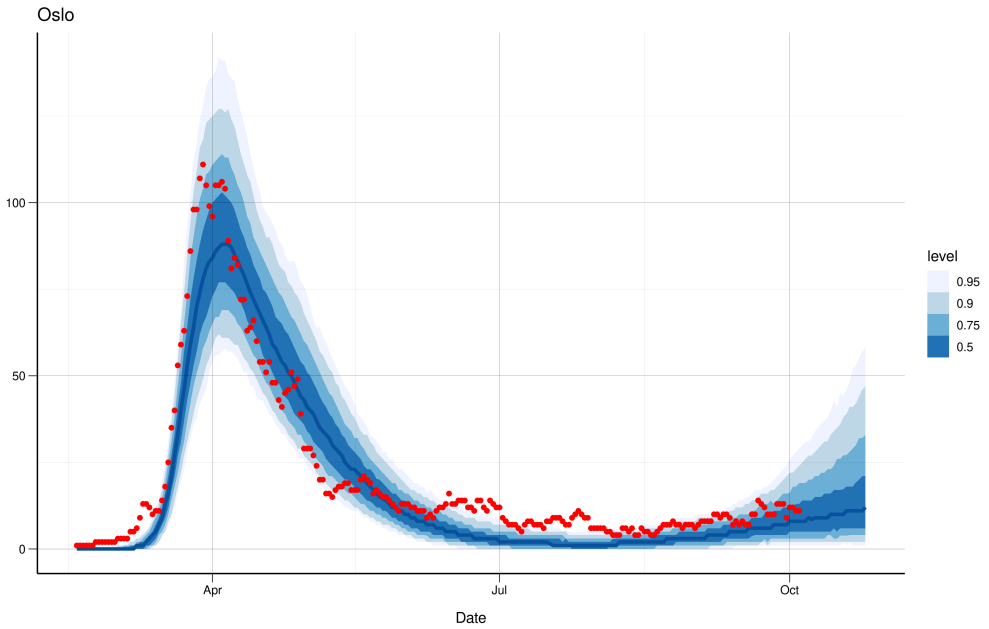
True hospitalisation incidence (red) and predicted values (blue)



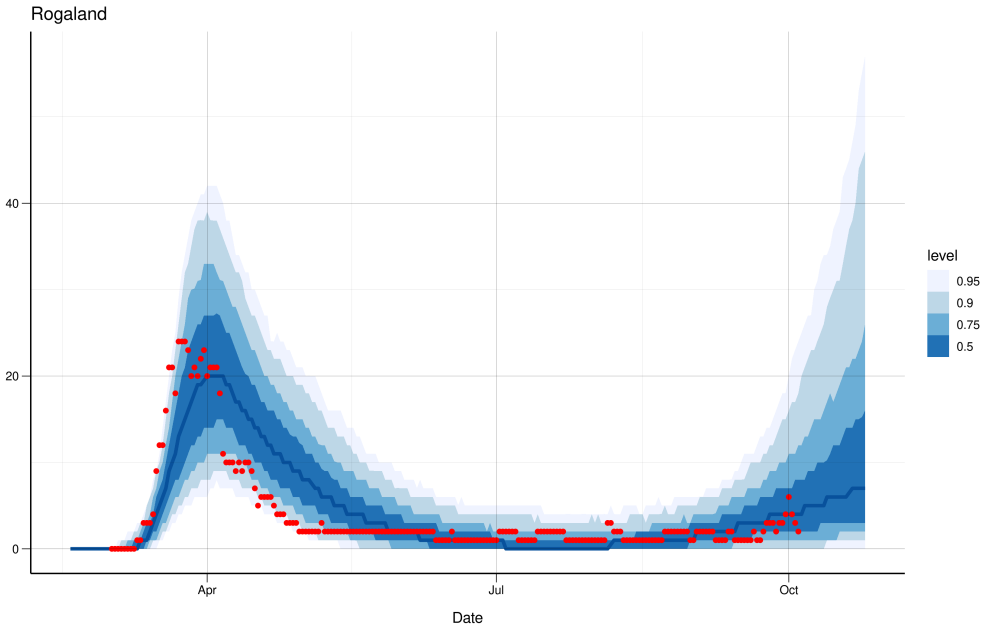
True hospitalisation incidence (red) and predicted values (blue)

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)



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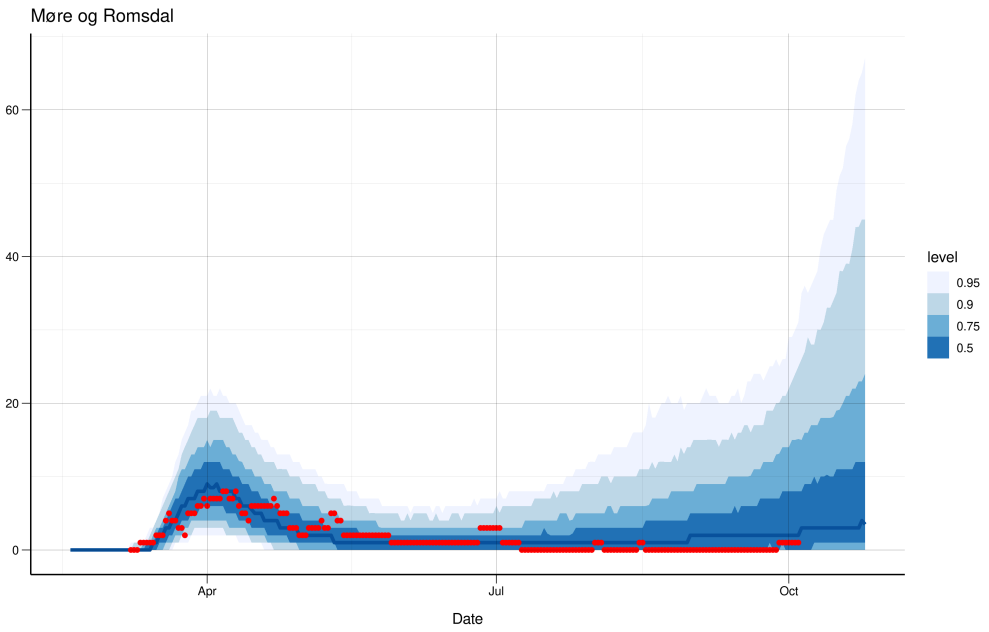
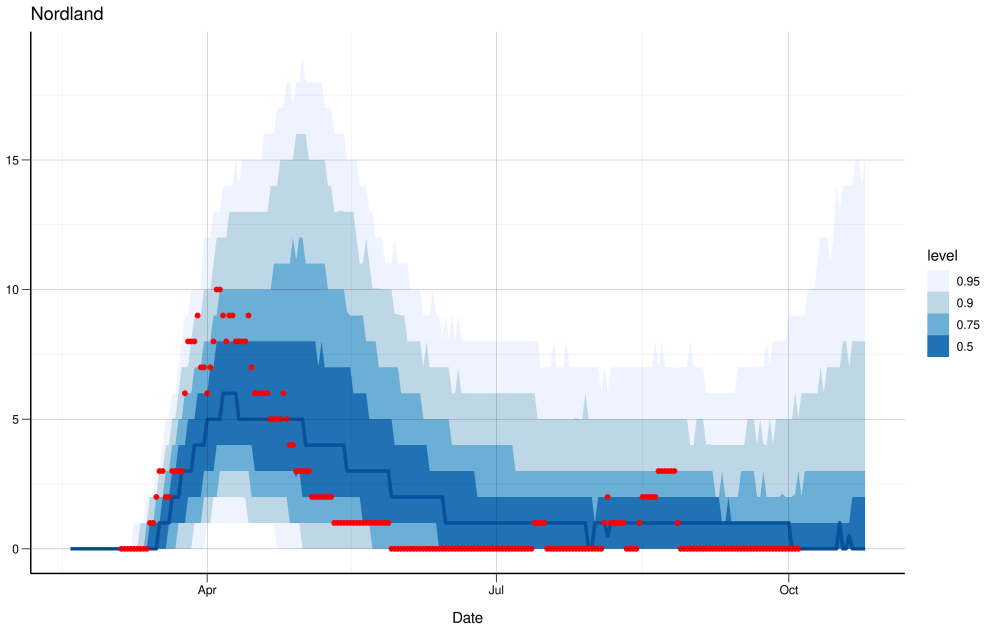
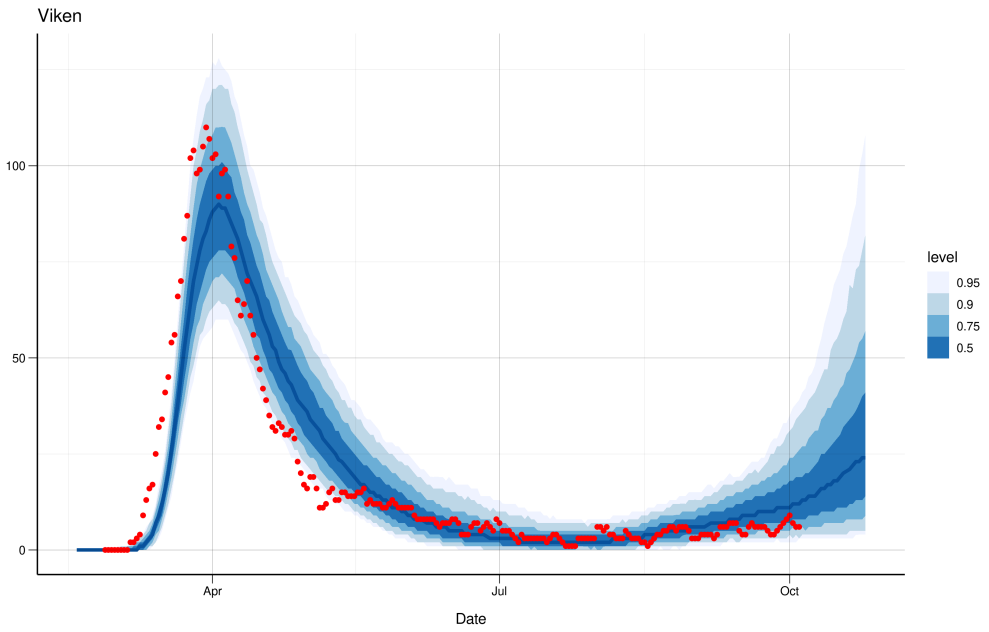


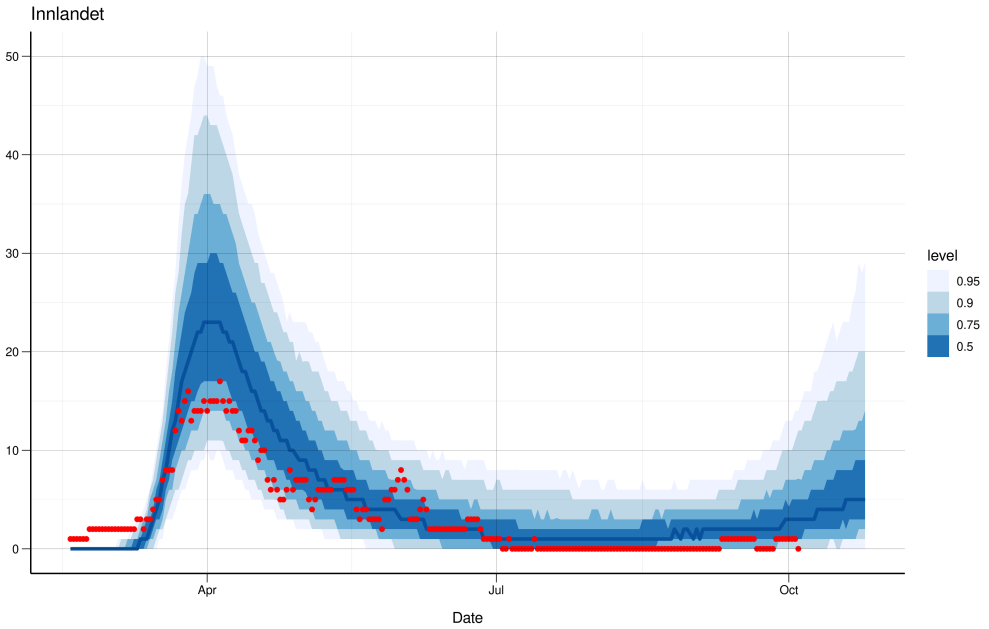
True hospitalisation prevalence (red) and predicted values (blue)



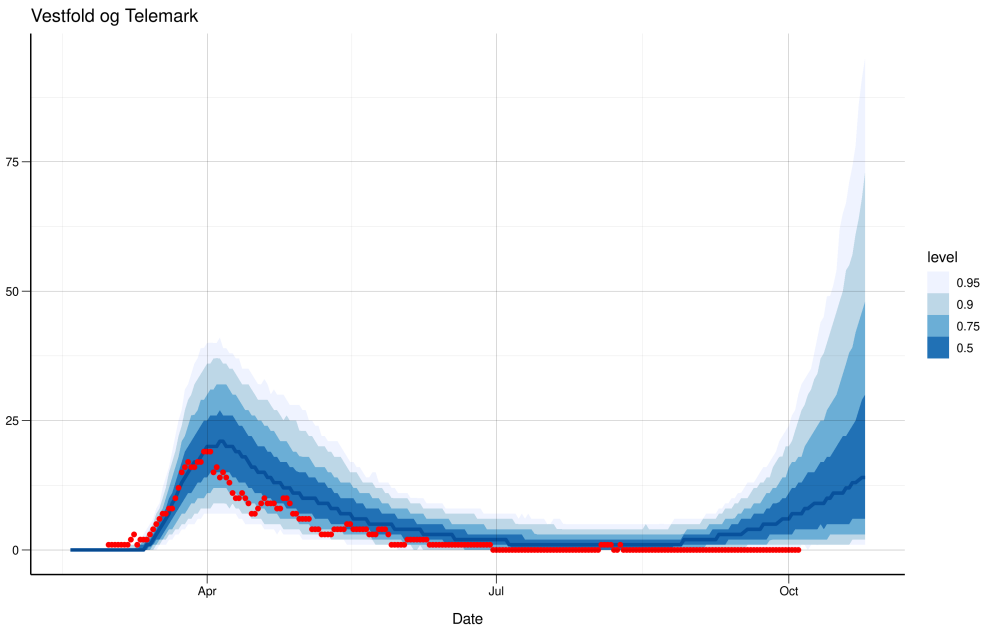
True hospitalisation prevalence (red) and predicted values (blue)



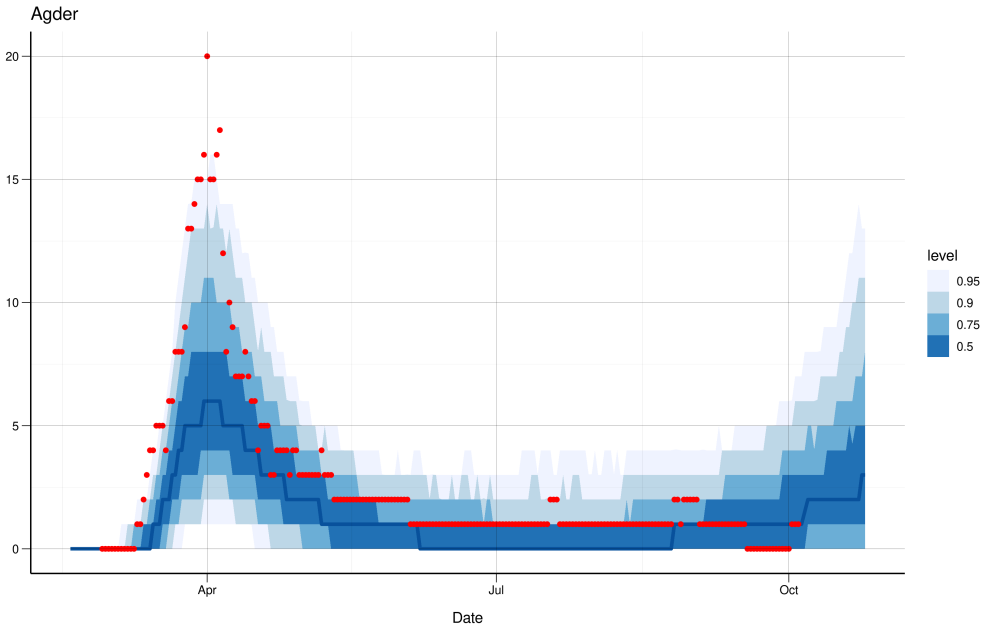
True hospitalisation prevalence (red) and predicted values (blue)



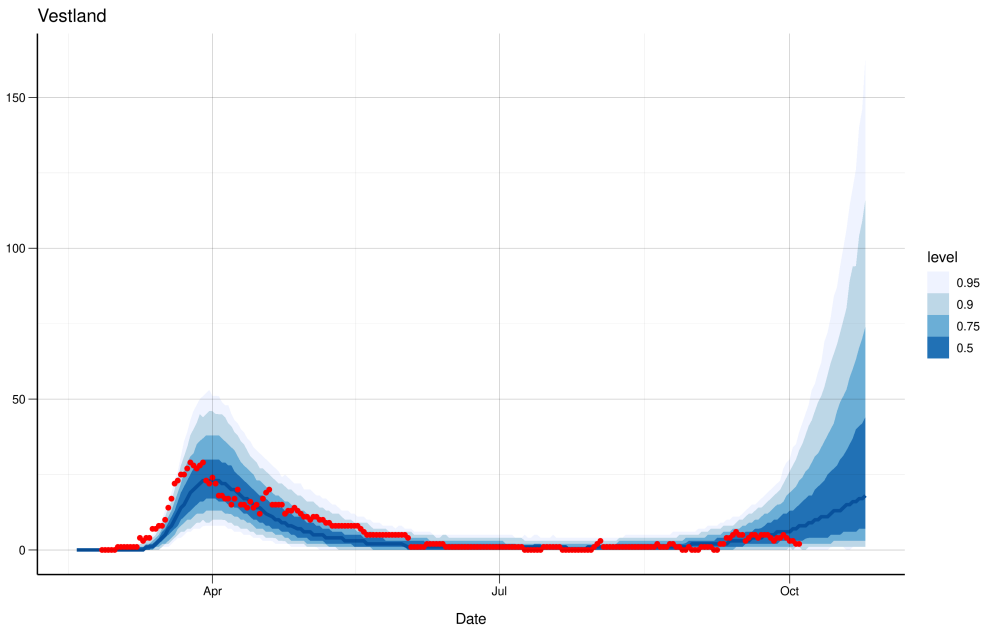
True hospitalisation prevalence (red) and predicted values (blue)



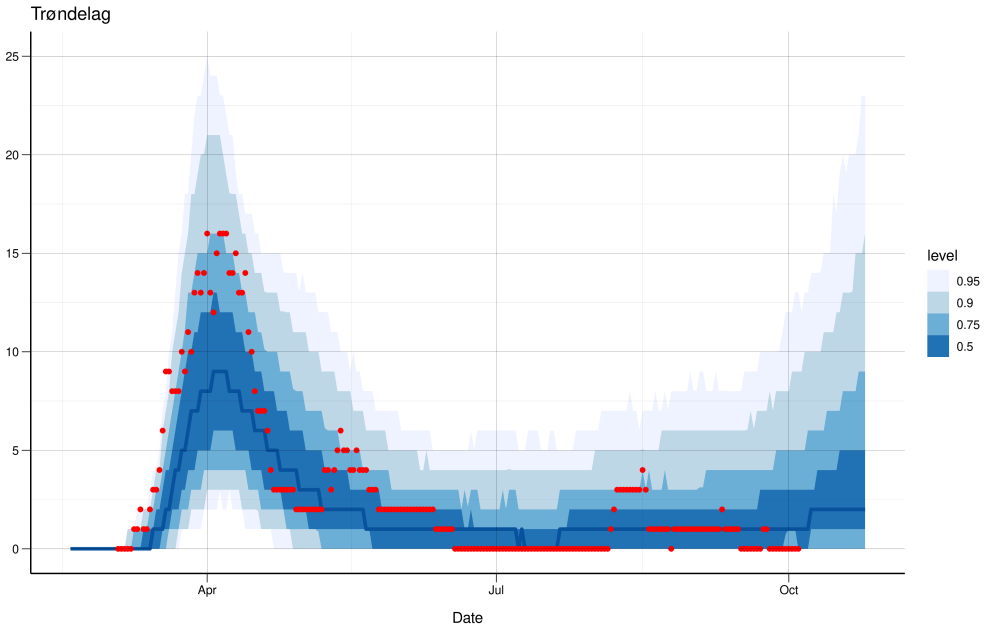
True hospitalisation prevalence (red) and predicted values (blue)



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



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



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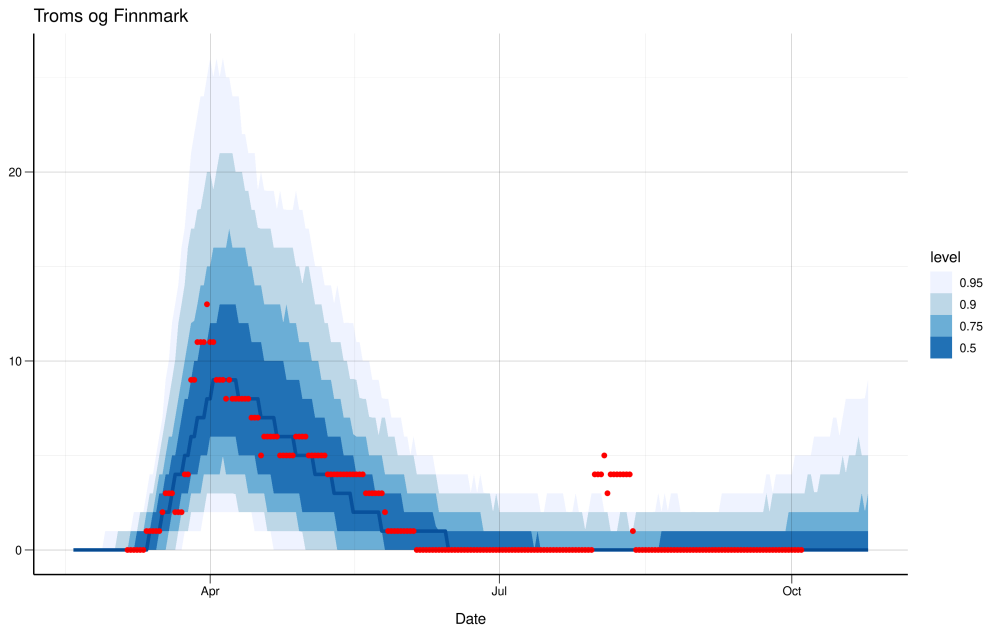


True hospitalisation prevalence (red) and predicted values (blue)

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 perc CI)

Region	1 week prediction (11 Oct)	2 weeks prediction (18 Oct)	3 weeks prediction (25 Oct)
Agder	0/0 (0-2)	0/0 (0-3)	0/1 (0-3)
Innlandet	0/1 (0-4)	1/1 (0-4)	1/1 (0-5)
Møre og Romsdal	0/1 (0-8)	0/1 (0-9)	0/2 (0-11)
Nordland	0/0 (0-2)	0/0 (0-3)	0/0 (0-3)
Oslo	1/2 (0-7)	2/2 (0-9)	2/3 (0-10)
Rogaland	1/1 (0-6)	1/2 (0-7)	1/2 (0-9)
Troms og Finnmark	0/0 (0-1)	0/0 (0-2)	0/0 (0-2)
Trøndelag	0/0 (0-3)	0/1 (0-4)	0/1 (0-4)
Vestfold og Telemark	1/2 (0-7)	2/2 (0-10)	2/3 (0-14)
Vestland	1/2 (0-9)	2/3 (0-13)	3/5 (0-20)
Viken	2/3 (0-9)	3/4 (0-12)	4/5 (0-16)

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	11 Oct	18 Oct	25 Oct	low CI, 25 Oct	high CI, 25 Oct
Agder	104/134	125/169	182/244	26	821
Innlandet	189/242	218/294	286/388	56	1428
Møre og Romsdal	128/348	152/435	202/559	11	3549
Nordland	26/73	30/92	43/123	7	725
Oslo	448/600	513/752	608/966	76	3822
Rogaland	285/469	344/615	452/827	35	4102
Troms og Finnmark	26/49	36/66	55/98	11	497
Trøndelag	111/181	125/222	165/293	24	1275
Vestfold og Telemark	449/686	579/962	738/1305	58	6457
Vestland	642/1126	833/1617	1066/2269	72	11912
Viken	927/1167	1066/1423	1293/1816	217	6381

4 Estimated cumulative number of infected individuals

The changepoint model estimates both the total number of infections and the symptomatic cases that have occurred both nationally and in each county. This result together with number of true confirmed cases can be found in table 4.

Table 4: Estimated cumulative number of infections, 2020-10-04

Region	Total	Symptomatic
Agder	2025 (1131; 4009)	1355 (795; 2517)
Innlandet	6215 (3506; 10903)	3930 (2272; 6662)
Møre og Romsdal	4250 (1059; 14221)	2707 (782; 8519)
Nordland	2901 (1115; 7022)	1832 (747; 4298)
Oslo	24043 (16960; 34426)	14501 (10325; 20588)
Rogaland	6744 (3145; 11815)	4310 (2118; 7270)
Troms og Finnmark	2682 (997; 5734)	1728 (682; 3557)
Trøndelag	3284 (1343; 7247)	2153 (978; 4511)
Vestfold og Telemark	7565 (3897; 13046)	4715 (2493; 7803)
Vestland	7532 (3146; 14431)	4733 (2146; 8856)
Viken	23627 (17839; 31378)	15019 (11555; 19627)

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

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

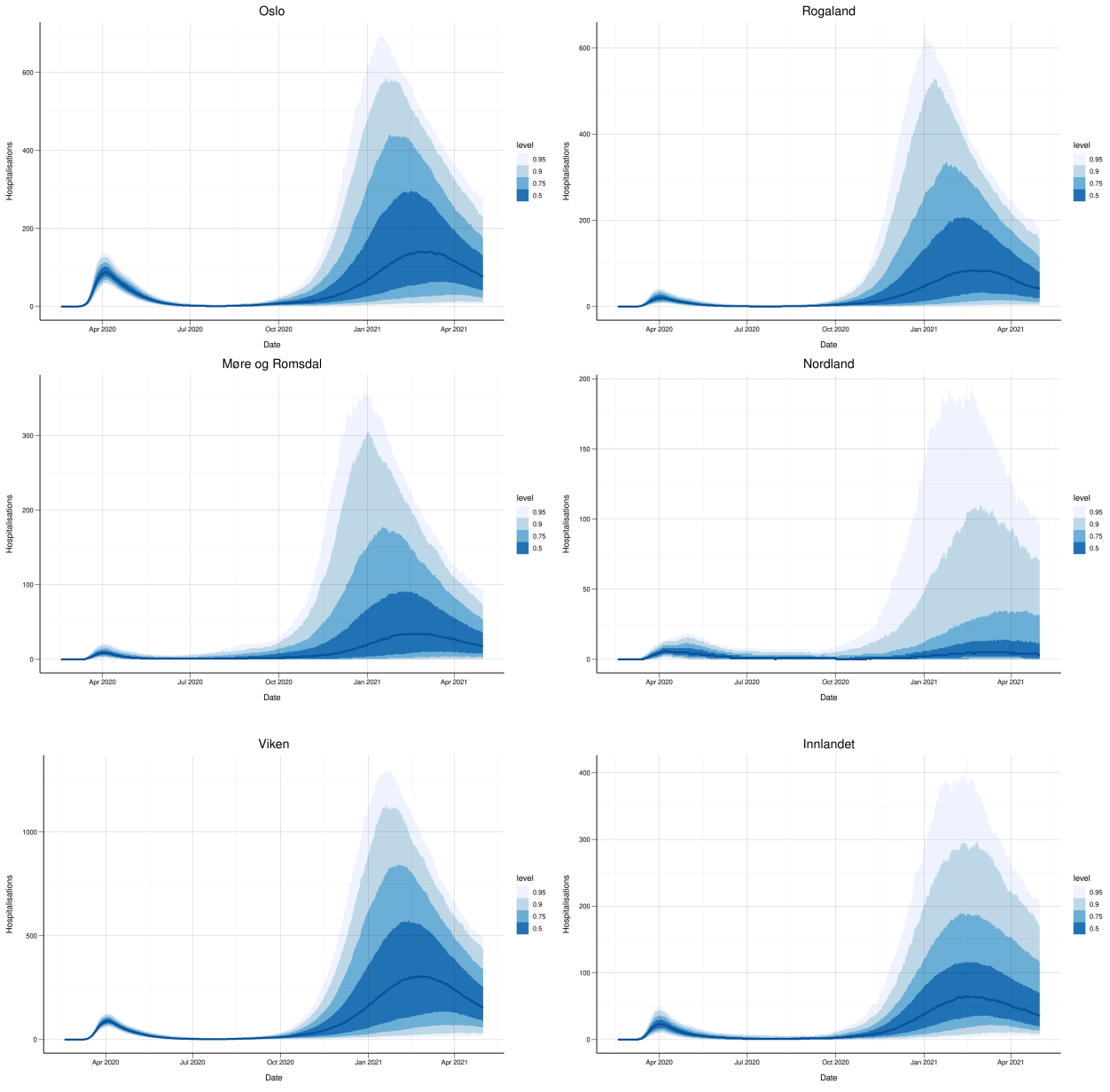
Table 5: Predicted incidence per day: Median/Mean (95 perc CI)

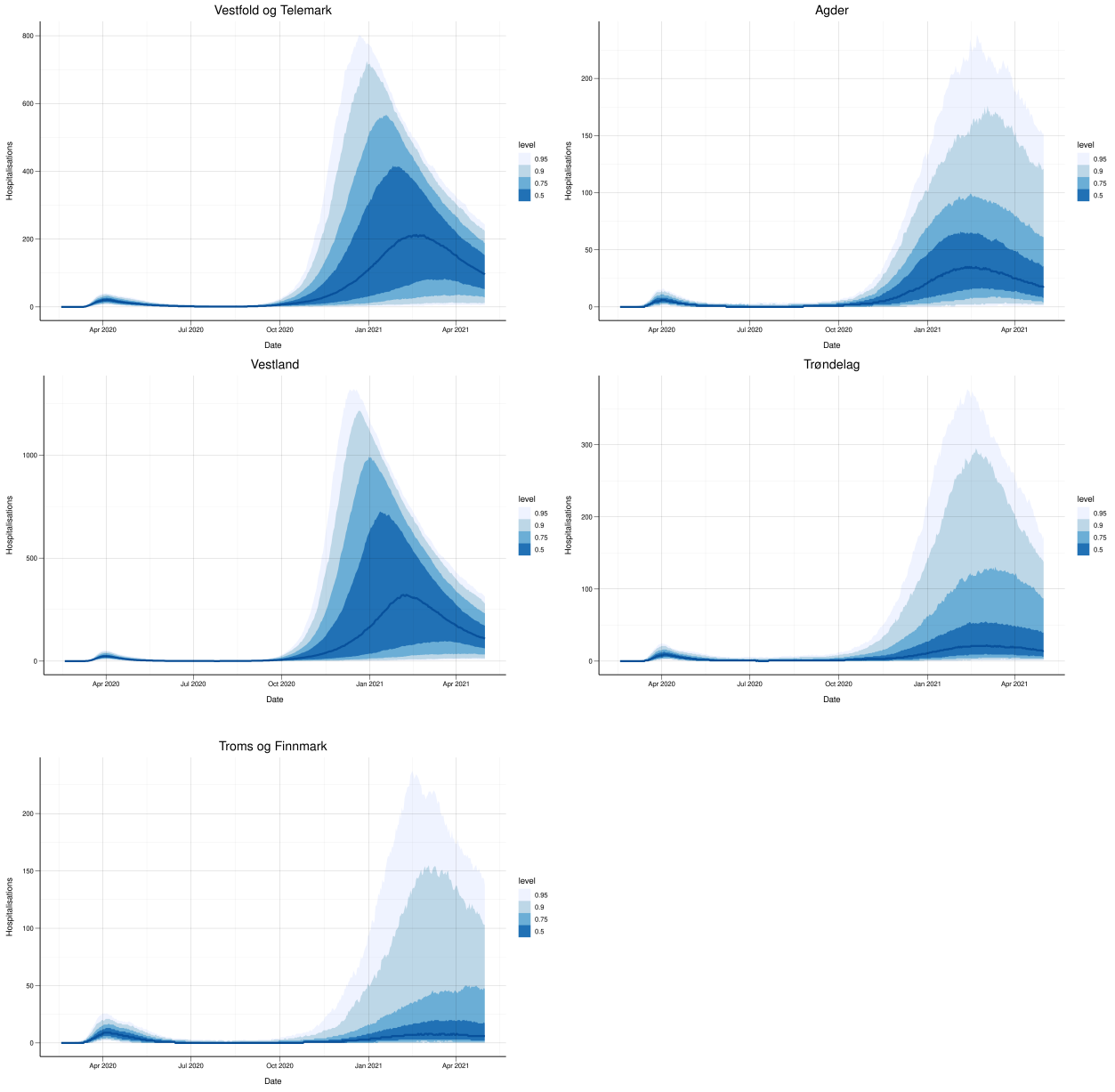
Region	1 week prediction (11 Oct)	2 weeks prediction (18 Oct)	3 weeks prediction (25 Oct)
Agder	17/24 (2-85)	20/29 (2-109)	25/38 (2-150)
Innlandet	31/42 (7-159)	34/51 (6-207)	43/65 (7-278)
Møre og Romsdal	21/62 (0-384)	24/79 (0-510)	26/101 (0-723)
Nordland	4/13 (0-76)	4/16 (0-104)	3/20 (0-155)
Oslo	76/107 (13-370)	87/135 (12-518)	103/174 (12-719)
Rogaland	51/86 (4-378)	61/113 (4-561)	74/151 (4-817)
Troms og Finnmark	4/9 (0-45)	4/10 (0-66)	5/13 (0-86)
Trøndelag	17/30 (2-142)	17/35 (1-174)	16/41 (1-227)
Vestfold og Telemark	81/129 (9-538)	103/185 (8-879)	134/258 (7-1383)
Vestland	118/215 (8-969)	148/313 (8-1570)	195/456 (8-2592)
Viken	157/206 (29-678)	181/252 (26-914)	218/321 (25-1201)

6 Scenarios assuming constant reproduction number

6.1 Hospitalisations

Estimated 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 Agder and Vestfold og Telemark are so uncertain, that long term predictions are essentially meaningless.




Vestfold og Telemark
Agder
Vestland
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Troms og Finnmark
Hospitalisations
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level
0.95
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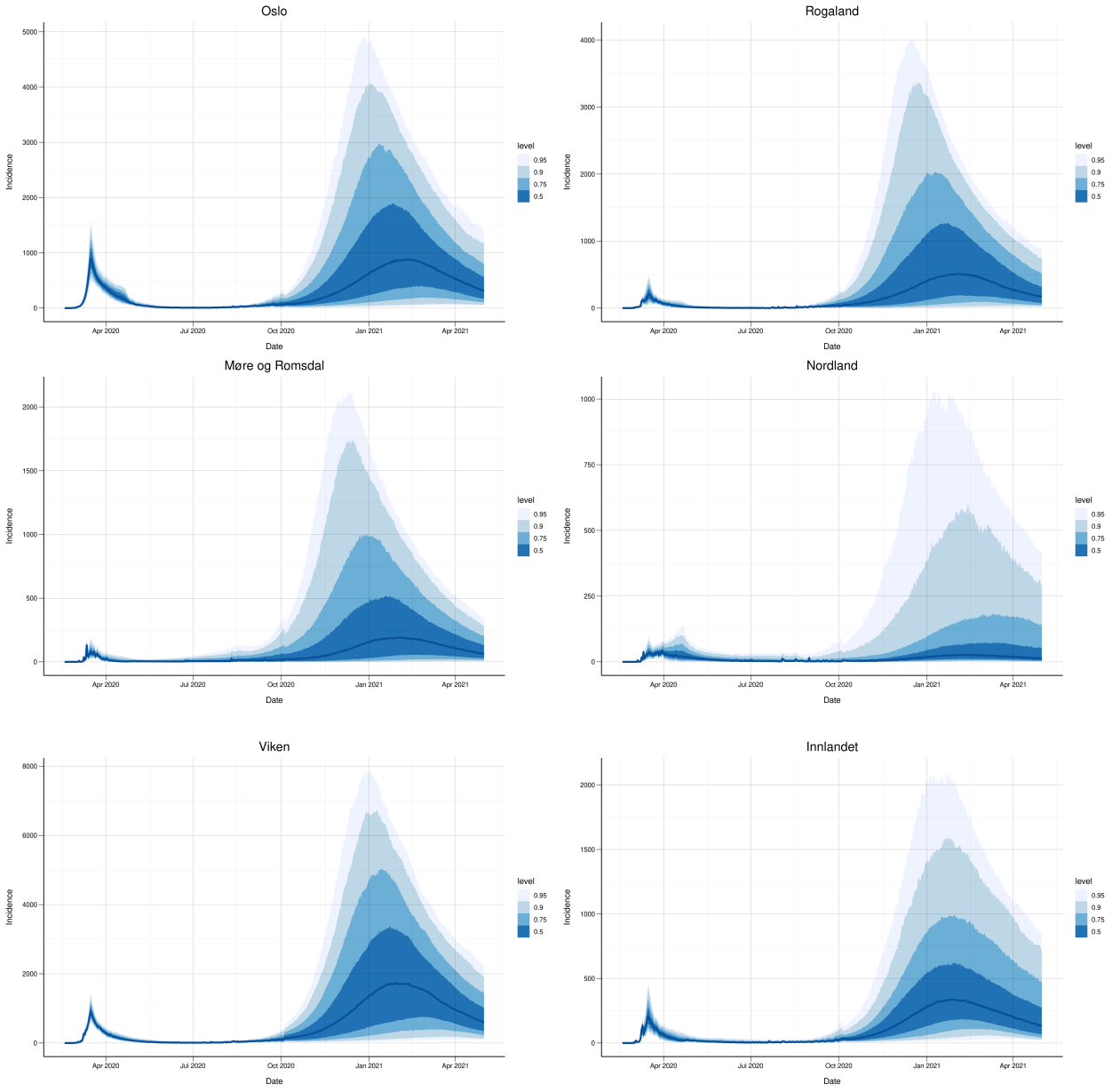
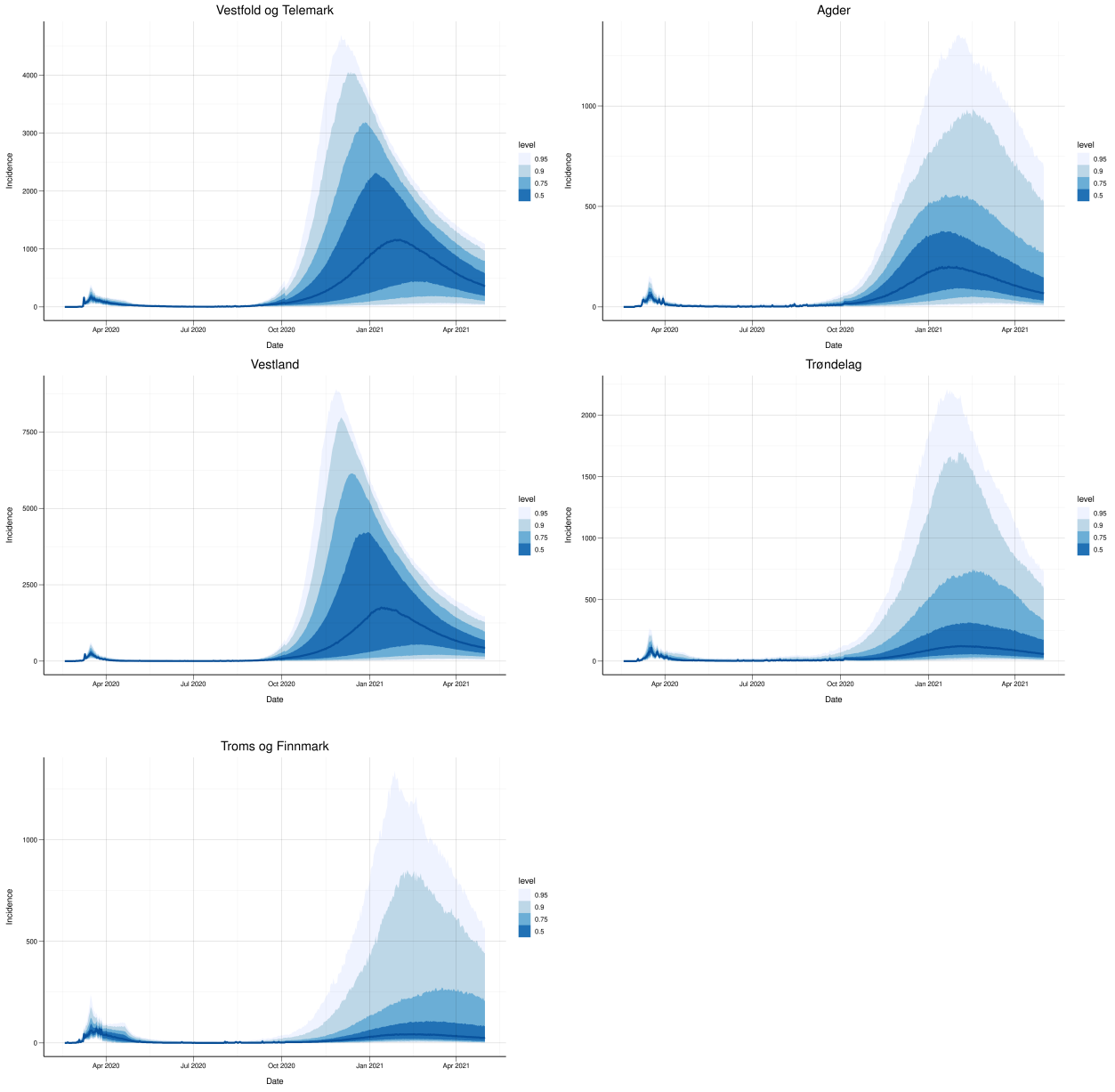
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021

6.2 Incidence

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




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

7 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 6: Estimated reproduction numbers (mean and 95 confidence intervals)

	R0; until 14 March	R1; from 15 March	R2; from 20 April	R3; from 20 June	R4; from 17 August
Oslo	4.92 (3.55-6.1)	0.77 (0.53-1.07)	0.6 (0.17-0.98)	0.83 (0.18-1.53)	1.09 (0.36-1.73)
Viken	4.13 (2.5-5.88)	0.54 (0.32-0.76)	0.6 (0.19-0.99)	0.87 (0.21-1.41)	1.11 (0.53-1.58)

Table 7: Estimated reproduction numbers (mean and 95 confidence intervals)

	R0; until 14 March	R1; from 15 March	R2; from 20 April	R3; from 17 August
Agder	2.34 (0.66-3.96)	0.39 (0.1-0.66)	0.61 (0.21-1.06)	0.8 (0.17-1.44)
Innlandet	3.03 (1.43-4.7)	0.52 (0.14-0.9)	0.78 (0.42-1.13)	0.94 (0.2-1.71)
Møre og Romsdal	2.46 (0.78-4.29)	0.39 (0.03-0.9)	0.95 (0.4-1.37)	0.95 (0.19-1.66)
Nordland	2.34 (0.42-4.41)	0.81 (0.19-1.38)	0.81 (0.47-1.14)	0.64 (0.05-1.49)
Rogaland	2.68 (0.96-4.16)	0.61 (0.2-1.06)	0.67 (0.14-1.09)	1.08 (0.45-1.63)
Troms og Finnmark	2.47 (1.04-3.78)	0.66 (0.09-1.14)	0.55 (0.11-1.04)	0.76 (0.11-1.48)
Trøndelag	3.13 (0.95-5.31)	0.47 (0.05-1.01)	0.76 (0.25-1.16)	0.78 (0.12-1.45)
Vestfold og Telemark	2.63 (0.81-4.58)	0.63 (0.15-0.99)	0.75 (0.47-1.06)	1.38 (0.67-1.97)
Vestland	3.21 (1.44-5)	0.37 (0.04-0.77)	0.75 (0.38-1.06)	1.33 (0.54-1.91)

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 of the different reproduction number for each county, which best fit the hospitalisation data of each county up to October 4th. 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 today, 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 October 3^{rd}. 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 2.93 (1.88-3.88).

New in this report is the use of different number of reproduction numbers in each of the counties (5 in Oslo and Viken, and 4 in the rest). For some of the counties, it is difficult to estimate regionally varying parameters when the hospital incidence data is so low.

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- **Anja Bråten Kristoffersen** - Department of Method Development and Analytics. Norwegian Institute of Public Health.
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