Regional situational awareness and forecasting for COVID-19

3 May 2020

In this report we present estimates of the covid-19 epidemic at county level (fylke). We run the same SEIR model which is used for the national estimates[1]. In this regional analysis, we use hospitalisation data at hospital level, aggregated to county level, allowing us to obtain calibrated parameters specific to each county.

We assume three reproduction numbers for each county:

- R_0 active until March 14;
- R_1 active from March 15 to April 19;
- R_2 active from April 20 until today.

This results in 33 reproduction numbers. On March 12 restrictions on activities were introduced and kindergarten, schools and universities were closed. On April 20, kindergarten were re-opened and on April 27 part of primary schools reopened too. The model makes important assumptions about the mechanisms and parameters of the epidemic. See https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/ for details.

We estimate all reproduction numbers by fitting our model to the number of beds occupied in hospitals by covid-19 confirmed patients (here called hospitalisation data). Hospitalisation data are available per hospital, and we distribute them to municipalities which refer to each hospital. For the hospitals that cover municipalities in different counties, we distribute the cases according to the relative population sizes. For example, Akershus university hospital (Ahus) has patients from Oslo and from other municipalities. We distributed the patients at Ahus simply proportionally to the population of these municipalities and the proportion of the population in Oslo that refers to Ahus. For this reason, some hospitalisation data are not integer valued. We will soon be able to use the municipality of residence of hospitalised patients.

We get more reliable results for the counties which have most covid-19 hospitalisations. For some counties the hospitalisations are so few, that estimated reproduction numbers are very uncertain. Oslo and Viken have had more than 30 cases at the same time; Vestland almost 30 cases, and all other counties up to 20 cases. For these last counties confidence intervals are particularly large, and the model fit is not good.

Compared to the previously published report for Oslo[2], the present estimated basic reproductive number is lower. Viken is strongly coupled with Oslo through the mobility network, so that a higher reproductive number for Viken can give a lower reproductive number for Oslo and vice versa (as the estimated reproductive numbers are negatively correlated).

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

[2] https://www.fhi.no/contentassets/e6b5660fc35740c8bb2a32bfe0cc45d1/vedlegg/lokale-rapporter/oslo_2020.04.18-corona_report.pdf

1 Estimated reproduction numbers in all counties

Calibration of our model with the hospitalisation data of each county, leads to the following estimates:

Table 1: Estimated reproduction numbers (mean and 95% confidence intervals)

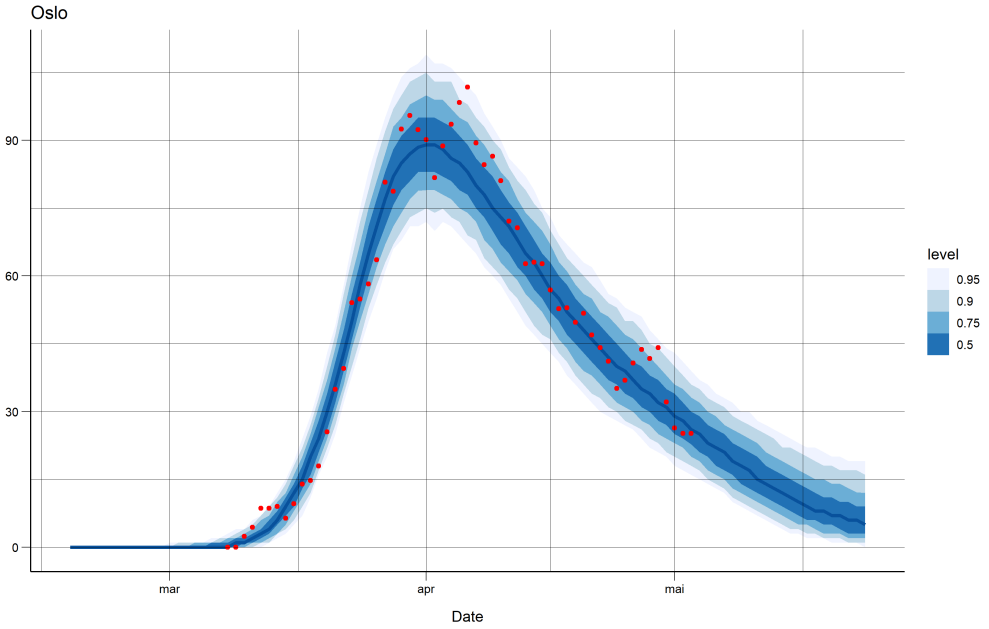
Region	R0; until 14 March	R1 from 15 March	R2 from 20 April
Agder	2.95 (2.23 3.69)	0.43 (0.14 0.80)	0.58 (0.10 1.11)
Innlandet	3.14 (2.34 3.98)	0.57 (0.24 0.93)	0.84 (0.32 1.31)
Møre og Romsdal	3.71 (2.45 4.88)	0.60 (0.24 0.96)	0.69 (0.22 1.12)
Nordland	3.43 (2.49 4.54)	0.64 (0.25 1.01)	0.73 (0.20 1.29)
Oslo	2.85 (2.24 3.51)	0.68 (0.52 0.81)	0.60 (0.14 1.07)
Rogaland	2.60 (1.88 3.38)	0.45 (0.22 0.67)	0.86 (0.32 1.38)
Troms og Finnmark	2.75 (1.74 3.77)	0.66 (0.20 1.02)	0.55 (0.09 1.10)
Trøndelag	3.39 (2.46 4.26)	0.60 (0.31 0.86)	0.78 (0.28 1.27)
Vestfold og Telemark	2.38 (1.70 3.33)	0.78 (0.46 1.02)	0.65 (0.26 1.06)
Vestland	2.89 (2.23 3.56)	0.47 (0.25 0.78)	0.72 (0.23 1.27)
Viken	3.72 (3.28 4.16)	0.50 (0.36 0.68)	0.62 (0.17 1.04)

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

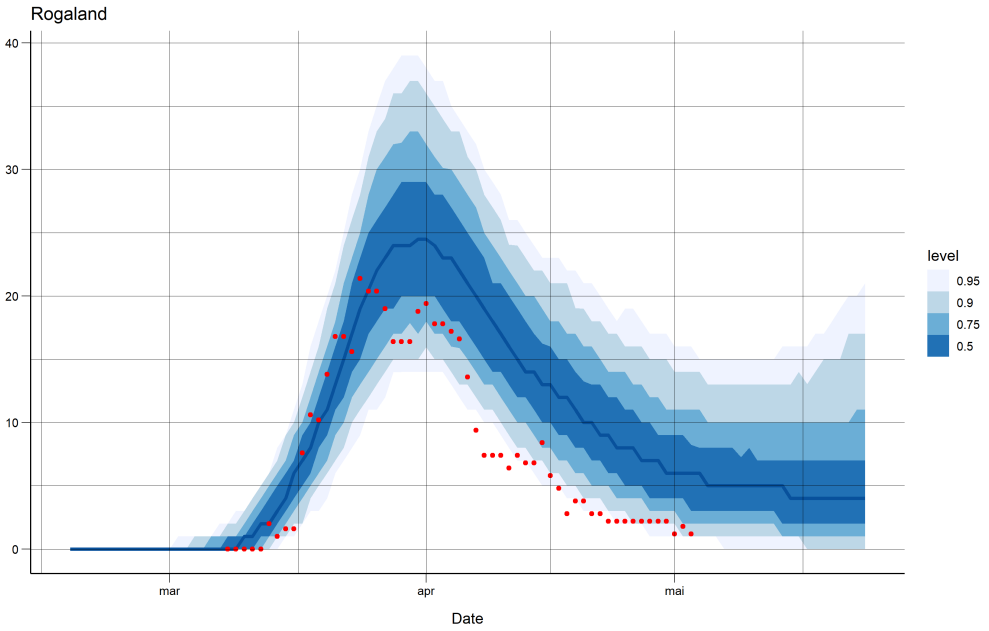
Our model estimates the number of hospitalised covid-19 patients in each county, plotted below with blue median and uncertainty bands, which are compared to the actual hospitalisation data of the county, in red. The blue bands describe the uncertainty in the calibrated parameters in addition to the stochastic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

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

Region	1 week prediction (10 May)	2 weeks prediction (17 May)	3 weeks prediction (24 May)
Agder	1 (0-7)	1 (0-7)	1 (0-6)
Innlandet	6 (0-17)	5 (0-16)	5 (0-18)
Møre og Romsdal	1 (0-5)	1 (0-5)	1 (0-5)
Nordland	1 (0-7)	1 (0-5)	1 (0-4)
Oslo	17 (5-34)	10 (2-25)	6 (0-21)
Rogaland	6 (0-17)	5 (0-17)	6 (0-22)
Troms og Finnmark	2 (0-12)	2 (0-8)	1 (0-8)
Trøndelag	2 (0-8)	2 (0-8)	1 (0-8)
Vestfold og Telemark	3 (0-10)	3 (0-9)	2 (0-9)
Vestland	8 (0-21)	5 (0-17)	4 (0-15)
Viken	12 (3-25)	10 (1-25)	9 (0-26)



True total number of hospitalisations (red) and predicted values (blue)



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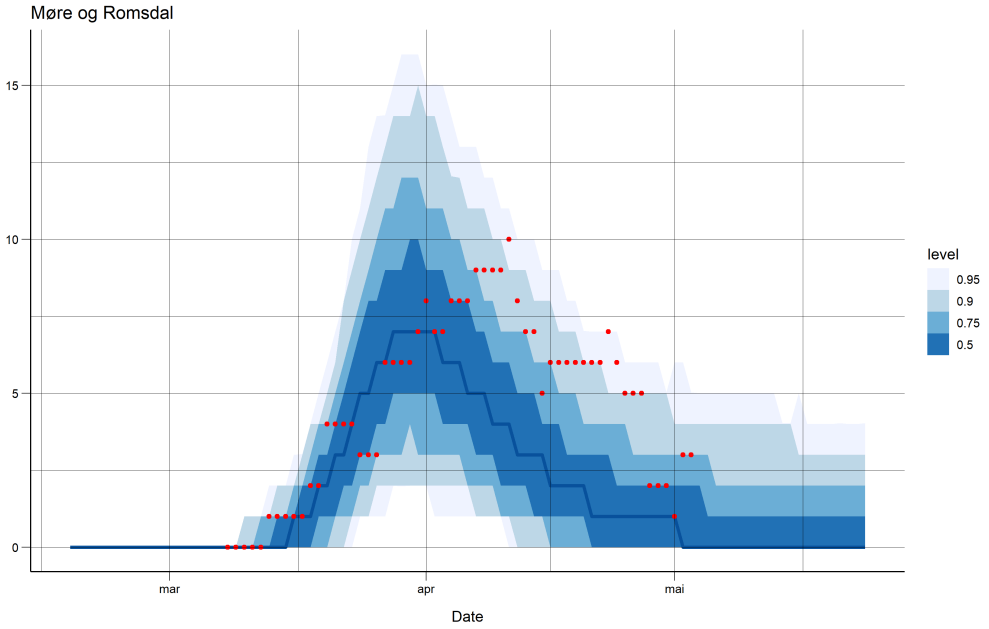

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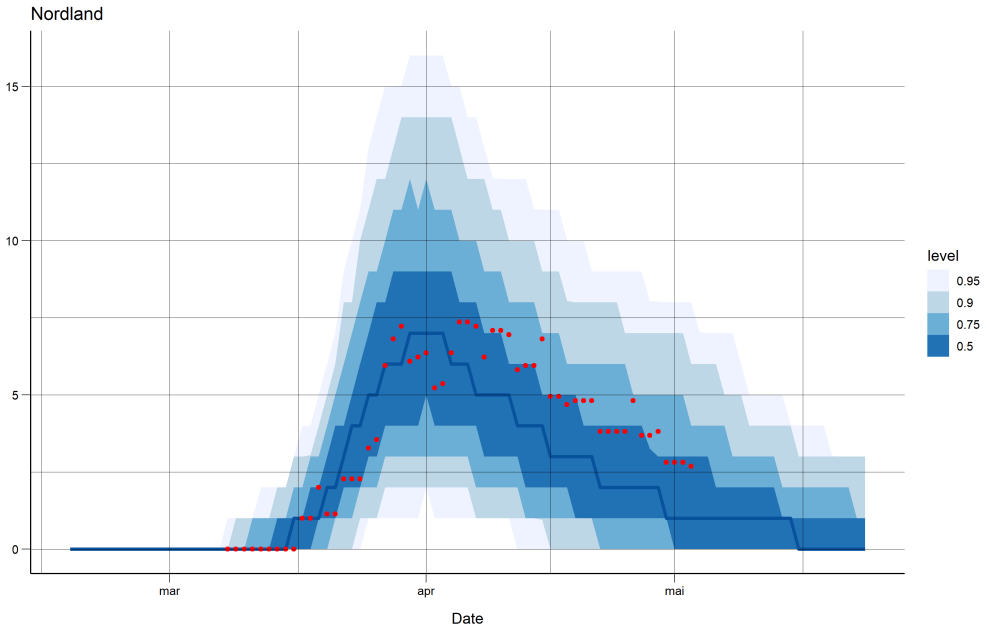
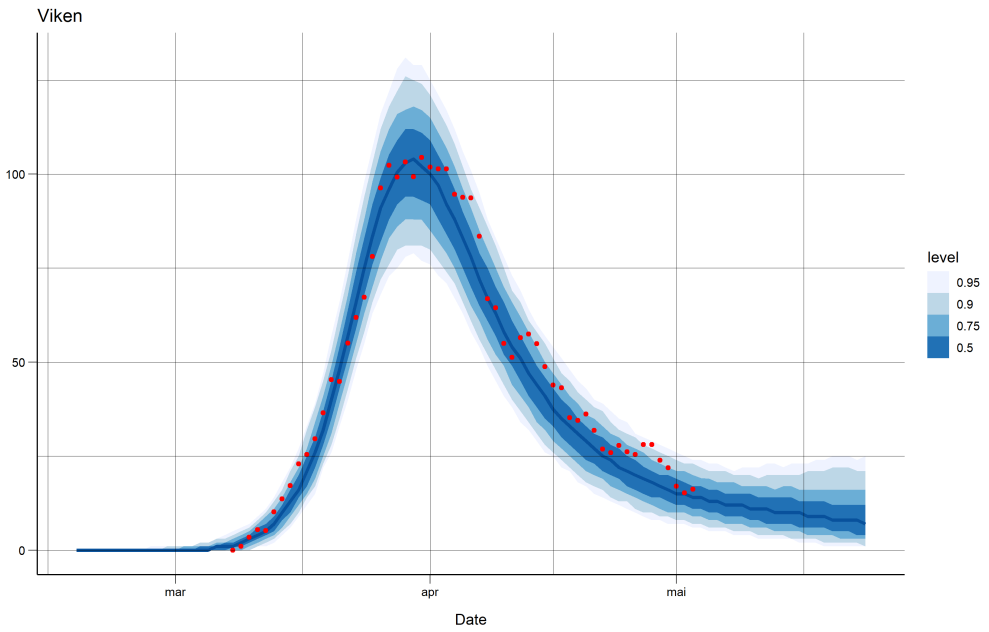
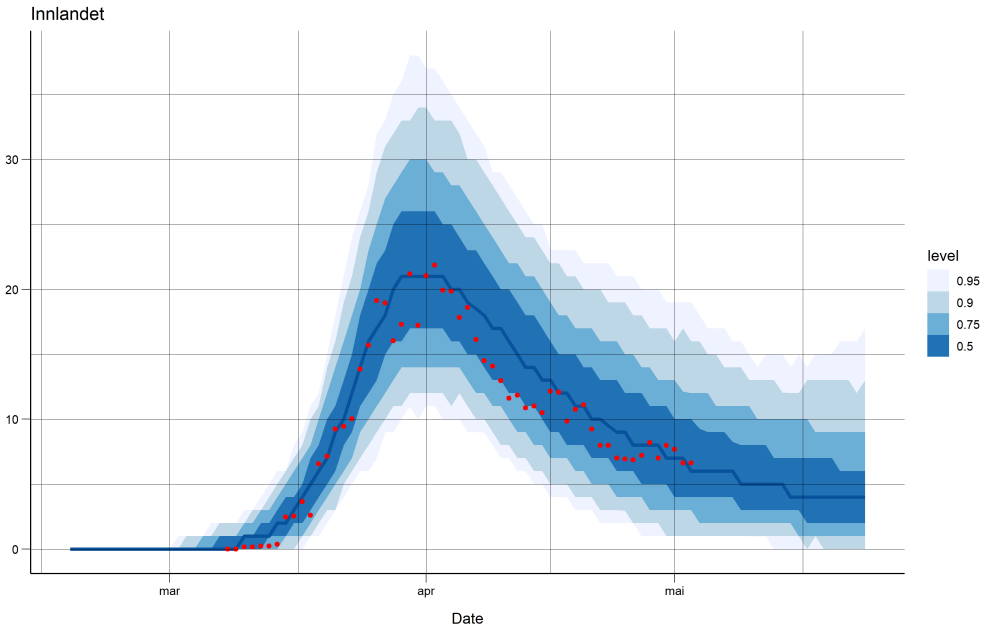


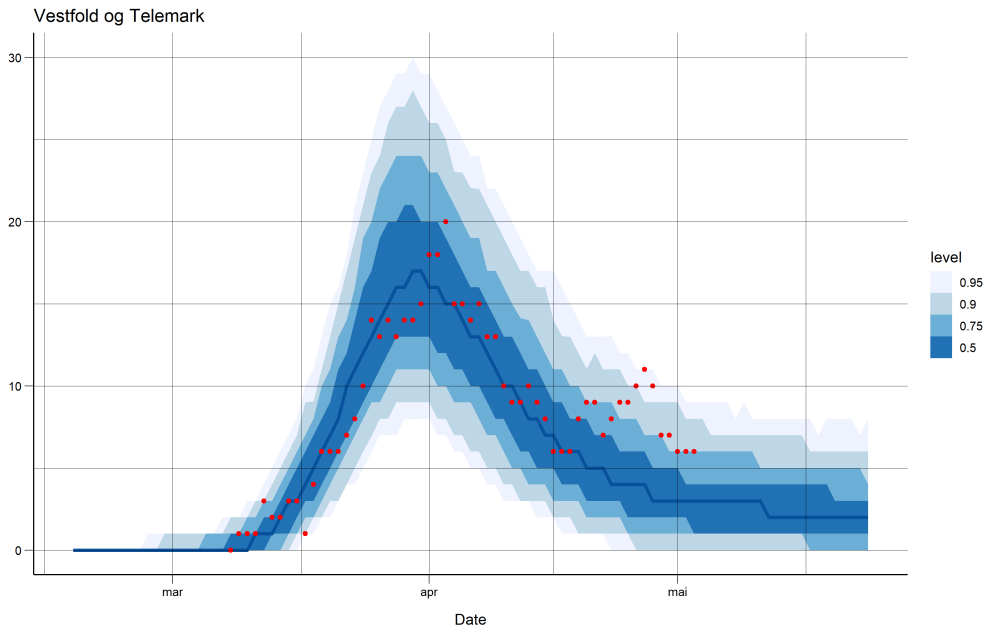
True total number of hospitalisations (red) and predicted values (blue)



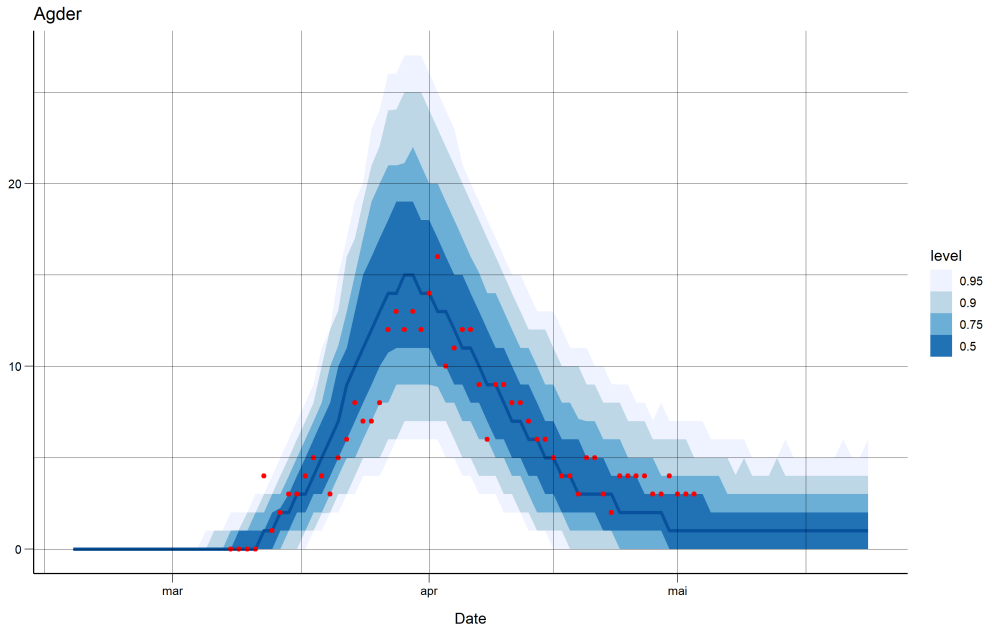
True total number of hospitalisations (red) and predicted values (blue)



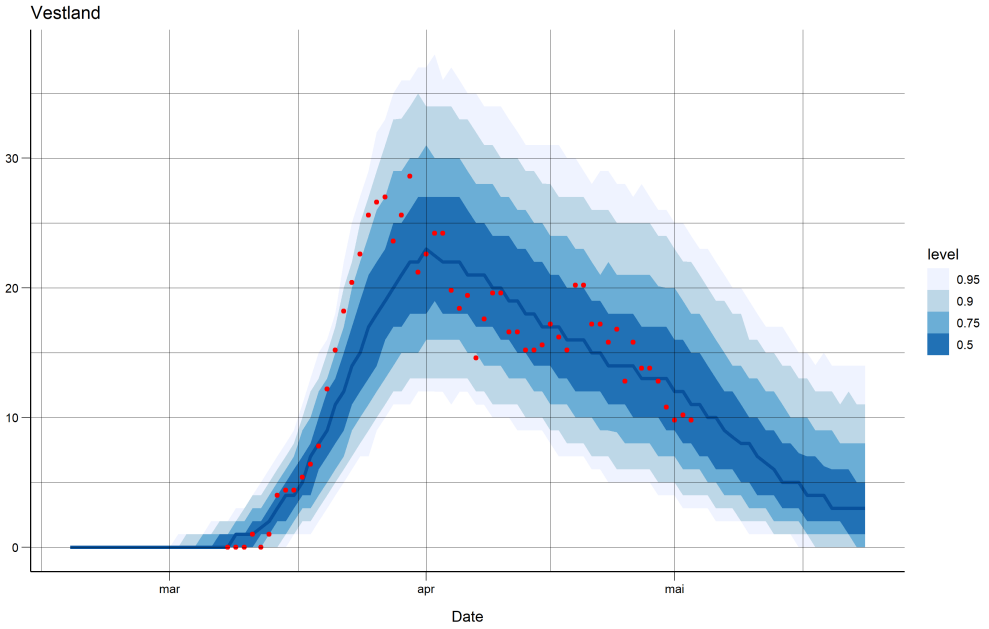
True total number of hospitalisations (red) and predicted values (blue)



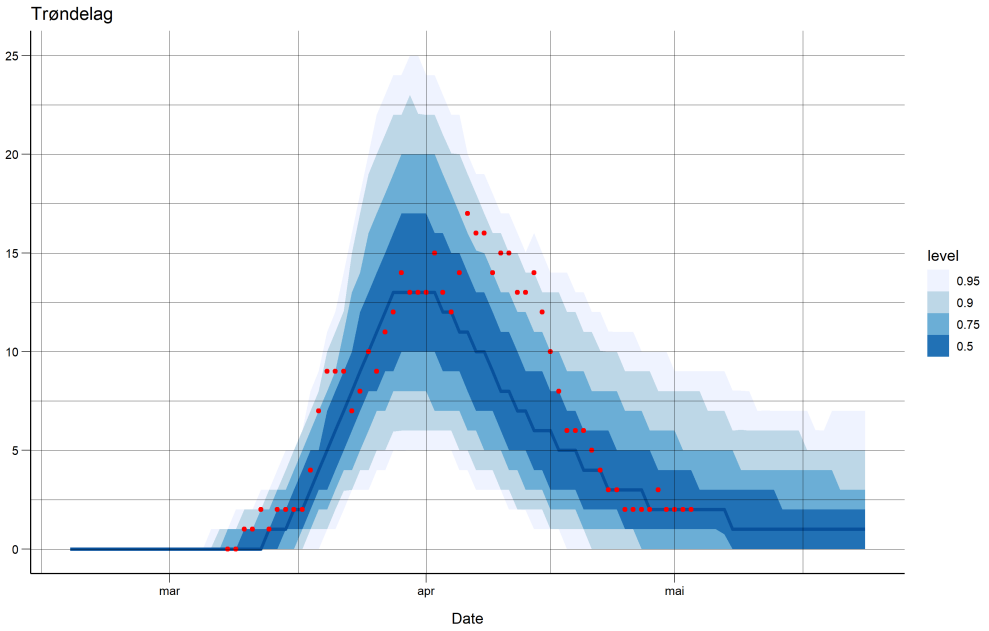
True total number of hospitalisations (red) and predicted values (blue)



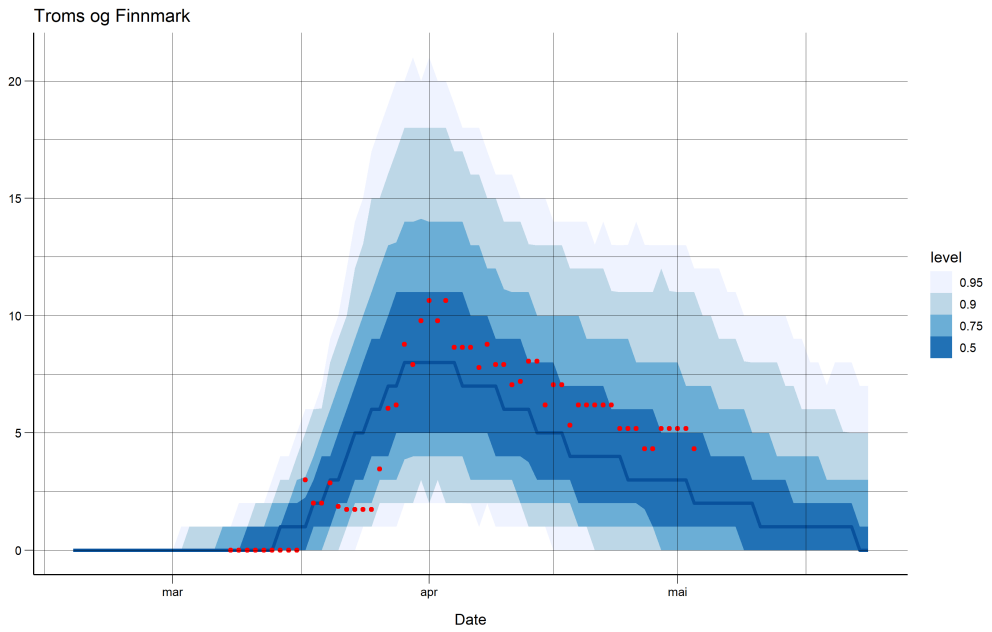
True total number of hospitalisations (red) and predicted values (blue)



True total number of hospitalisations (red) and predicted values (blue)



True total number of hospitalisations (red) and predicted values (blue)



True total number of hospitalisations (red) and predicted values (blue)

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

Table 3: Number of ICU beds occupied by Covid-19 patients.

Region	1 week prediction (10 May)	2 weeks prediction (17 May)	3 weeks prediction (24 May)
Agder	1 (0-3)	0 (0-3)	0 (0-2)
Innlandet	2 (0-7)	2 (0-6)	2 (0-6)
Møre og Romsdal	0 (0-2)	0 (0-2)	0 (0-2)
Nordland	1 (0-3)	0 (0-2)	0 (0-2)
Oslo	7 (2-13)	4 (1-10)	2 (0-7)
Rogaland	2 (0-6)	2 (0-5)	2 (0-6)
Troms og Finnmark	1 (0-5)	1 (0-3)	0 (0-3)
Trøndelag	1 (0-3)	1 (0-3)	0 (0-3)
Vestfold og Telemark	1 (0-4)	1 (0-4)	1 (0-3)
Vestland	3 (0-8)	2 (0-7)	1 (0-5)
Viken	4 (1-9)	4 (0-9)	3 (0-9)

4 Estimated number of infected individuals in each county

Table 4: 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, 10 May	Mean, 17 May	Mean, 24 May	low CI, 24 May	high CI, 24 May
Agder	36	34	34	3	139
Innlandet	122	113	107	8	458
Møre og Romsdal	22	20	19	0	100
Nordland	17	12	9	0	49
Oslo	240	179	141	11	529
Rogaland	171	181	200	6	895
Troms og Finnmark	40	32	27	0	178
Trøndelag	46	39	35	1	163
Vestfold og Telemark	62	59	58	5	222
Vestland	125	93	76	4	361
Viken	300	238	199	19	728

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.

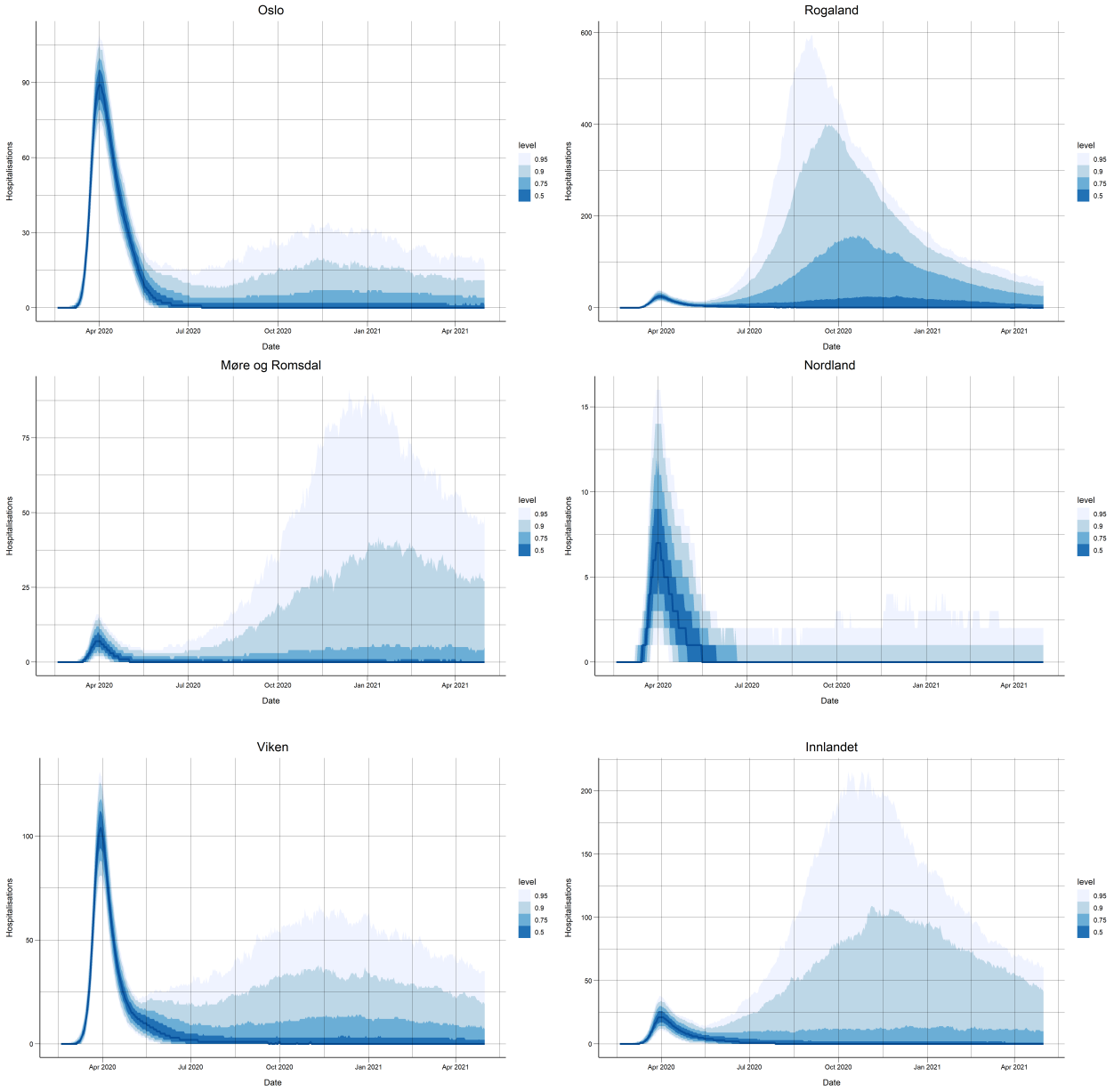
Table 5: Predicted incidence per day.

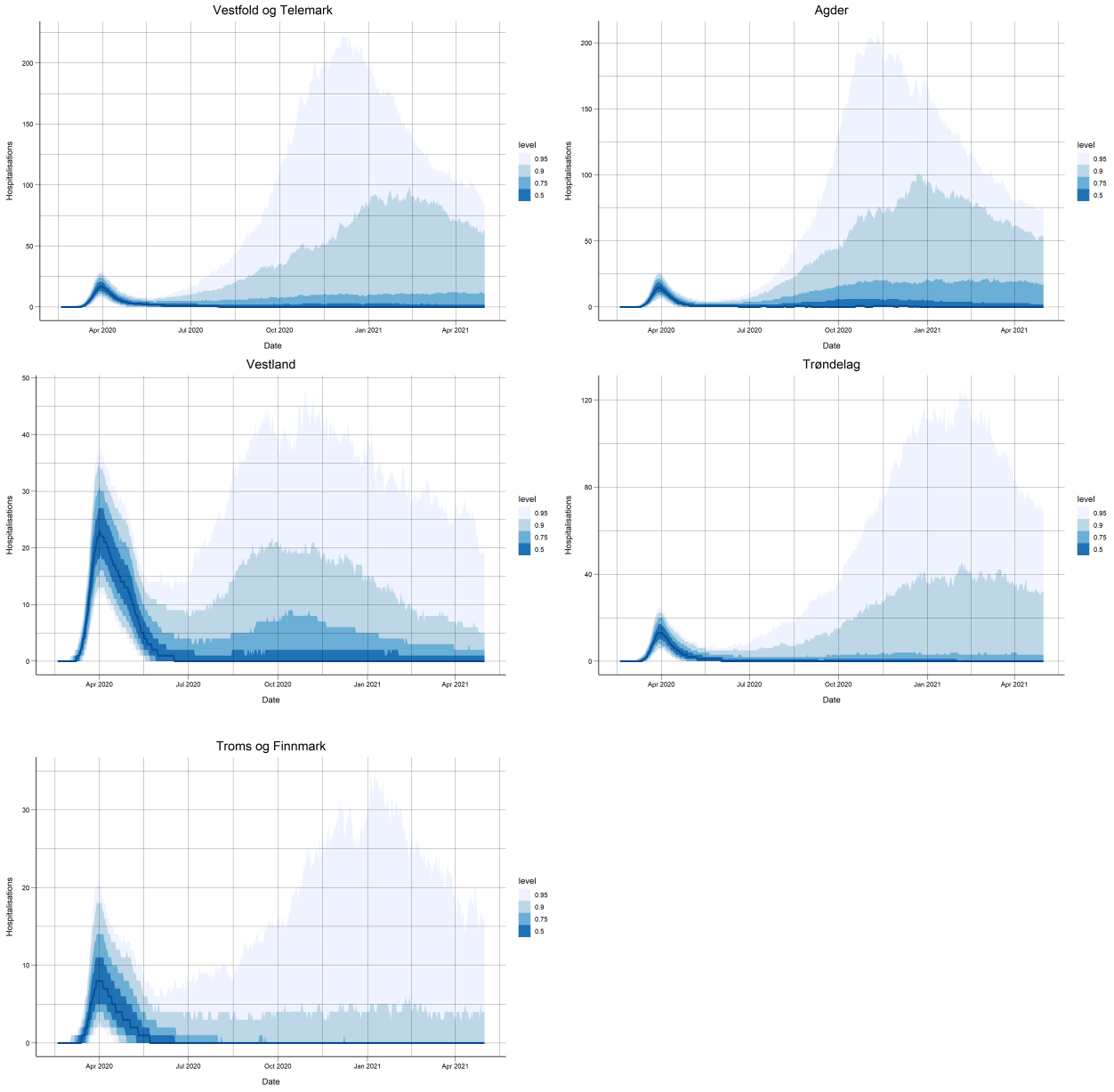
Region	1 week prediction (10 May)	2 weeks prediction (17 May)	3 weeks prediction (24 May)
Agder	6 (0-21)	6 (0-23)	6 (0-25)
Innlandet	19 (2-63)	18 (1-70)	18 (0-83)
Møre og Romsdal	3 (0-15)	3 (0-17)	3 (0-17)
Nordland	2 (0-11)	2 (0-9)	1 (0-7)
Oslo	32 (3-97)	24 (1-89)	20 (0-86)
Rogaland	28 (1-94)	30 (1-128)	34 (0-161)
Troms og Finnmark	6 (0-32)	5 (0-31)	4 (0-30)
Trøndelag	7 (0-23)	6 (0-28)	5 (0-29)
Vestfold og Telemark	10 (1-30)	9 (0-36)	10 (0-41)
Vestland	16 (1-62)	13 (0-62)	11 (0-60)
Viken	42 (6-111)	34 (3-112)	30 (1-121)

6 Long-term prediction results for each county

6.1 Hospitalisations

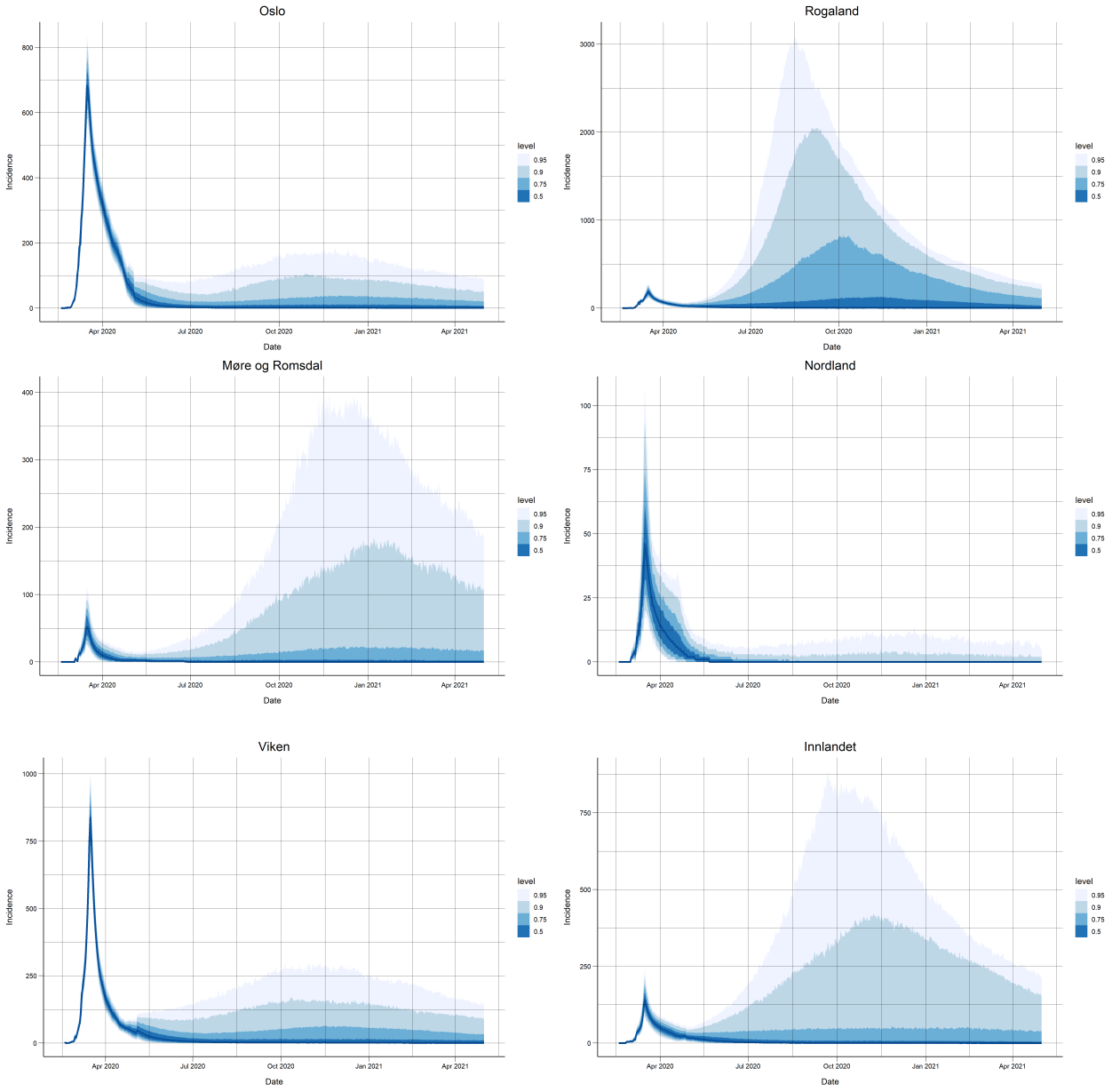
Predicted daily number of COVID-19 patients in hospital, including receiving ventilator treatment, in each county until April 2021, in addition to prevalence. It is based on 1000 runs of the future to represent the uncertainty of estimated parameters. For some counties, including Oslo, the second future peak is low compared to the other counties. This depends on the probability for the second reproductive number being above 1. Due to stochasticity, the epidemic might also die out with a reproductive number slightly above 1.

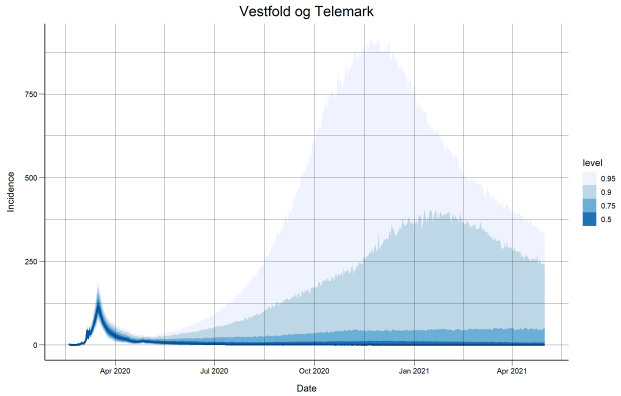


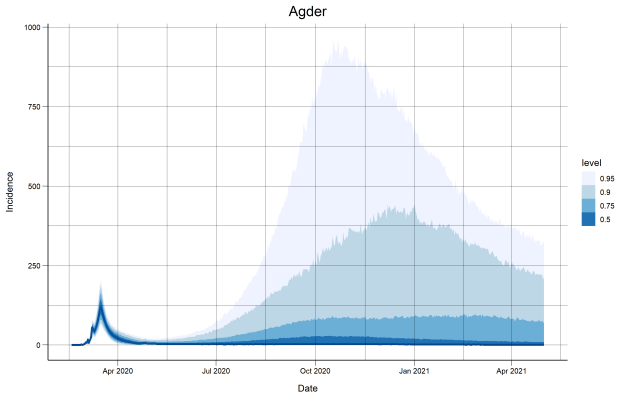

Vestfold og Telemark
Agder
Vestland
Trøndelag
Troms og Finnmark
Hospitalisations
Date
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
level
0.95
0.9
0.75
0.5

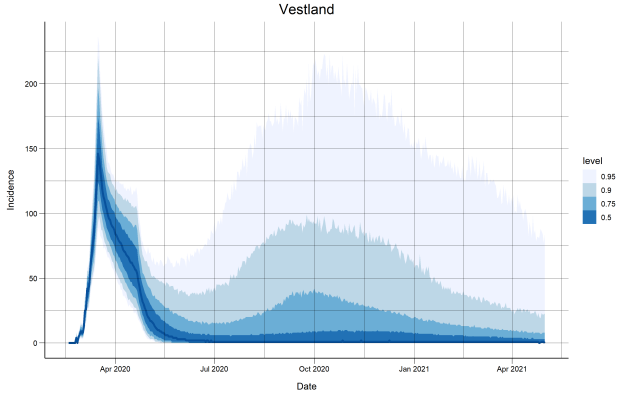
6.2 Incidence

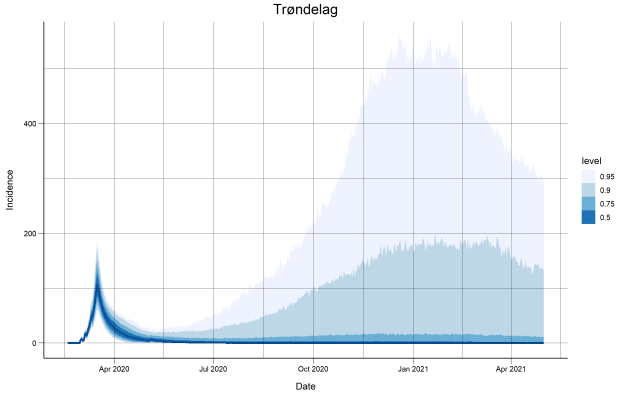
Predicted incidence (asymptomatic and symptomatic) for each county per day, with confidence intervals.

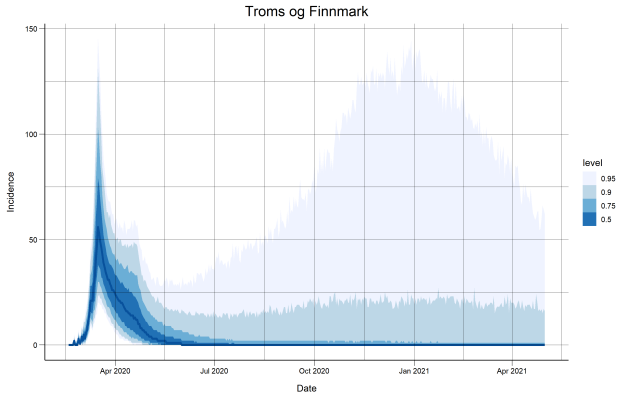



Vestfold og Telemark
Incidence
Date
level
0.95
0.9
0.75
0.5
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021


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

Methods

Details on this model and parameters used for this report can be found here https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/.
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 May 3. 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 May 3, 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. Up until the 29. April, the Telenor based mobility was used. After that, we used a regularised version of the mobility on the 29. April. In this run the amplification factors was estimated to be 2.18.

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