
Regional situational awareness and forecasting for COVID-19

8 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 estimates¹. 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, kindergartens were reopened 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, Viken and Vestland have had more cases than the other counties, for which uncertainty is particularly large and the fit to data is worse.

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

1 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 R_2 , and the estimated mean has very little meaning.

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

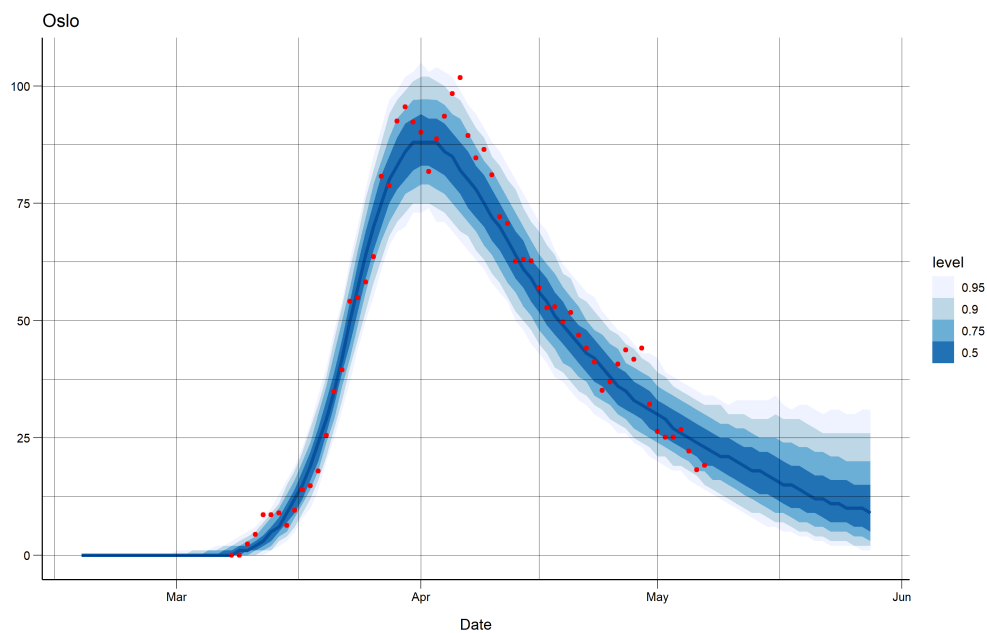
Region	R0; until 14 March	R1 from 15 March	R2 from 20 April
Agder	2.56 (1.87-3.25)	0.69 (0.46-0.90)	0.89 (0.37-1.48)
Innlandet	3.16 (2.67-3.64)	0.62 (0.41-0.80)	0.44 (0.04-0.95)
Møre og Romsdal	3.24 (2.28-4.18)	0.72 (0.33-1.08)	0.40 (0.03-0.91)
Nordland	2.55 (1.69-3.49)	0.77 (0.44-1.08)	0.65 (0.13-1.21)
Oslo	3.09 (2.63-3.59)	0.82 (0.77-0.87)	0.84 (0.41-1.30)
Rogaland	2.58 (1.97-3.22)	0.53 (0.32-0.70)	0.99 (0.41-1.58)
Troms og Finnmark	3.39 (2.82-3.96)	0.58 (0.26-0.88)	0.72 (0.21-1.30)
Trøndelag	3.17 (2.49-3.88)	0.59 (0.36-0.81)	0.61 (0.09-1.20)
Vestfold og Telemark	2.63 (2.10-3.21)	0.62 (0.43-0.79)	0.92 (0.36-1.50)
Vestland	2.72 (2.20-3.29)	0.69 (0.55-0.82)	0.84 (0.35-1.36)
Viken	3.87 (3.27-4.55)	0.49 (0.42-0.56)	0.66 (0.20-1.13)

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

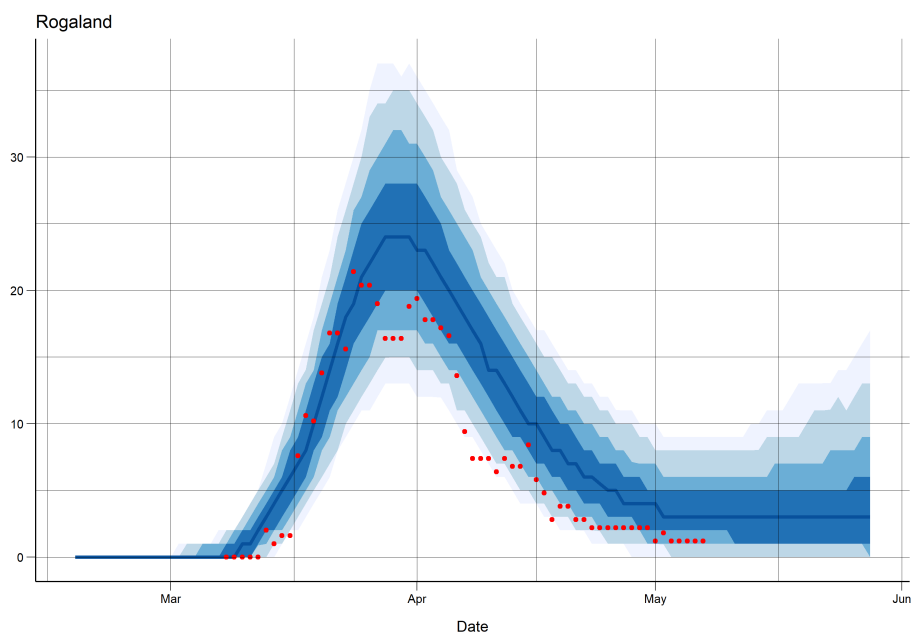
Our model estimates the number of hospitalised covid-19 patients in each county, plotted below with blue median and uncertainty bands, which are compared to the actual hospitalisation data of the county, in red. The blue bands describe the uncertainty in the calibrated parameters in addition to the stochastic 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. Notice large uncertainties in some counties in particular.

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

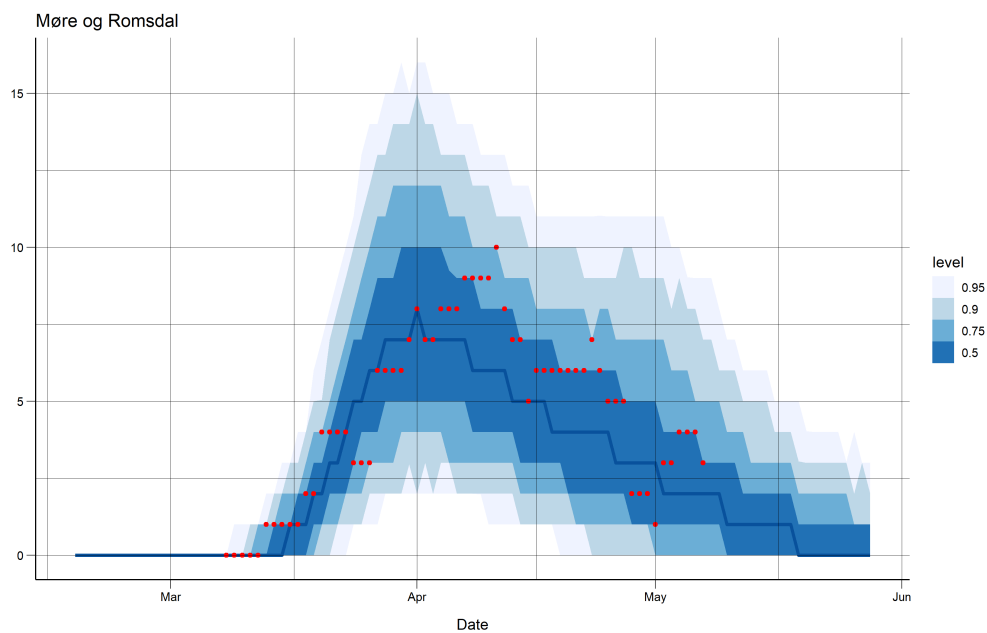
Region	1 week prediction (14 May)	2 weeks prediction (21 May)	3 weeks prediction (28 May)
Agder	4 (0-11)	4 (0-12)	4 (0-14)
Innlandet	3 (0-10)	2 (0-9)	2 (0-7)
Møre og Romsdal	1 (0-6)	1 (0-5)	1 (0-4)
Nordland	2 (0-7)	1 (0-7)	1 (0-7)
Oslo	18 (6-35)	14 (2-33)	11 (0-32)
Rogaland	3 (0-12)	4 (0-14)	4 (0-18)
Troms og Finnmark	1 (0-7)	1 (0-6)	1 (0-5)
Trøndelag	2 (0-8)	2 (0-8)	2 (0-8)
Vestfold og Telemark	6 (0-17)	6 (0-18)	6 (0-22)
Vestland	7 (0-17)	6 (0-19)	6 (0-24)
Viken	14 (3-29)	13 (2-32)	13 (1-36)



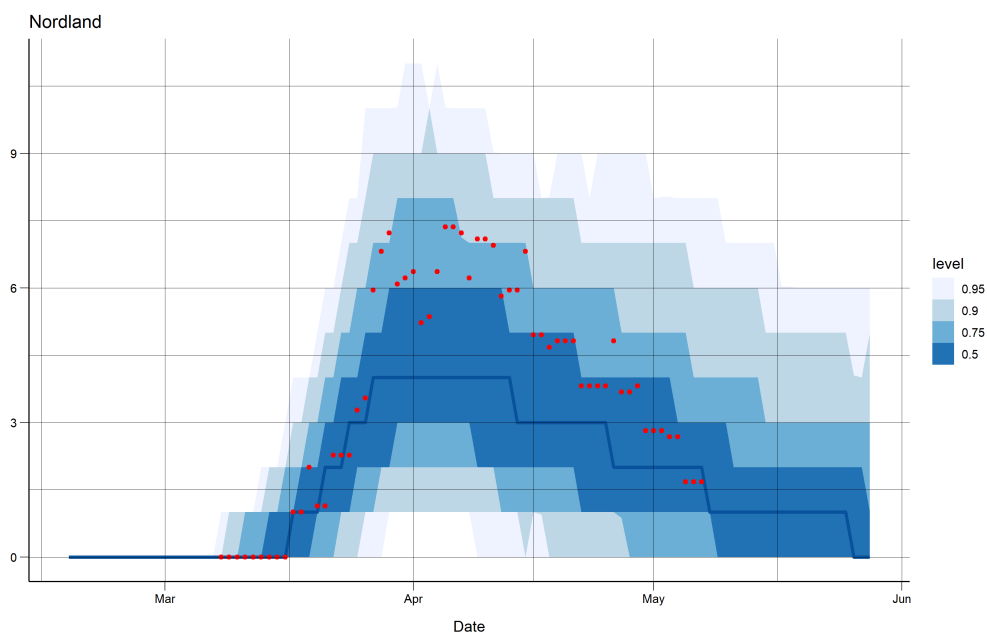
True total number of hospitalisations (red) and predicted values (blue)



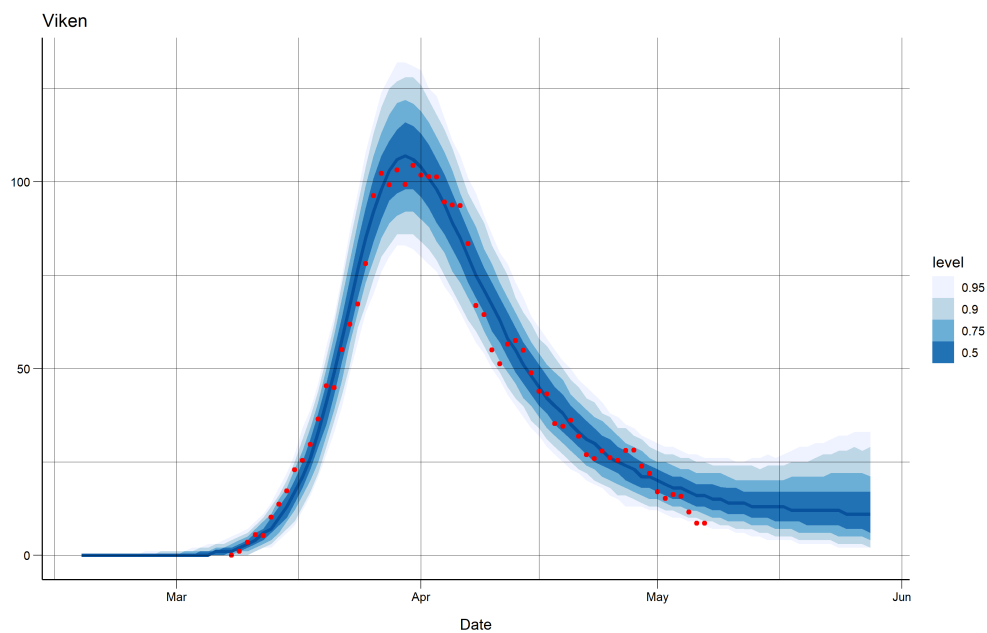
True total number of hospitalisations (red) and predicted values (blue)



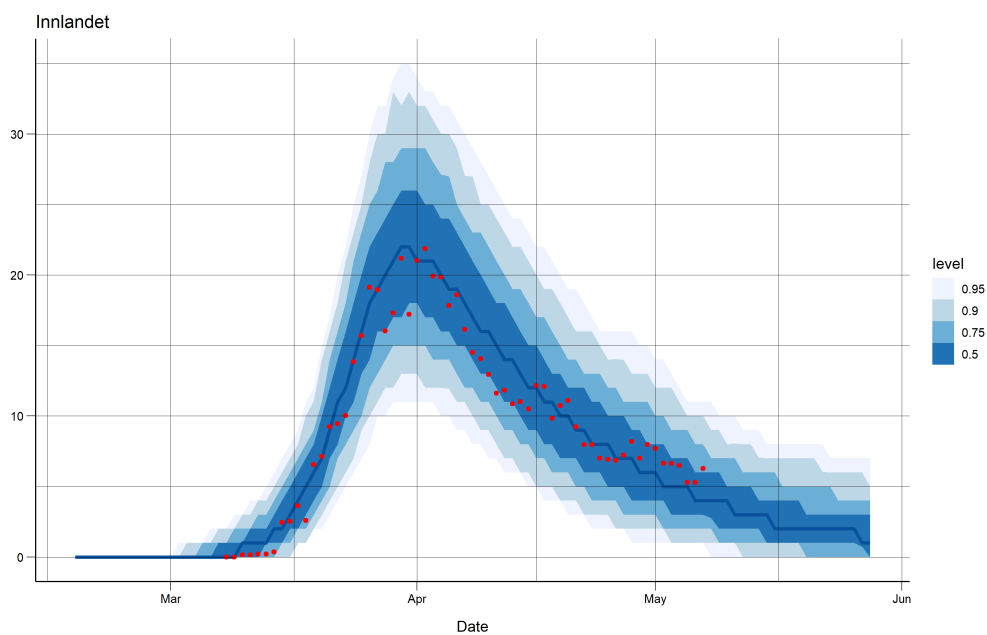
True total number of hospitalisations (red) and predicted values (blue)



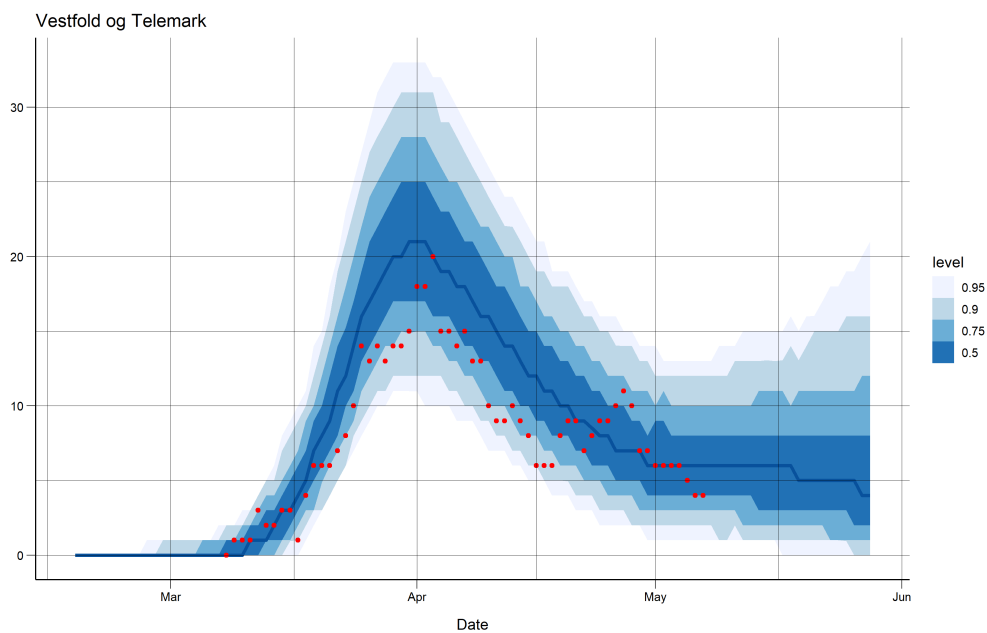
True total number of hospitalisations (red) and predicted values (blue)



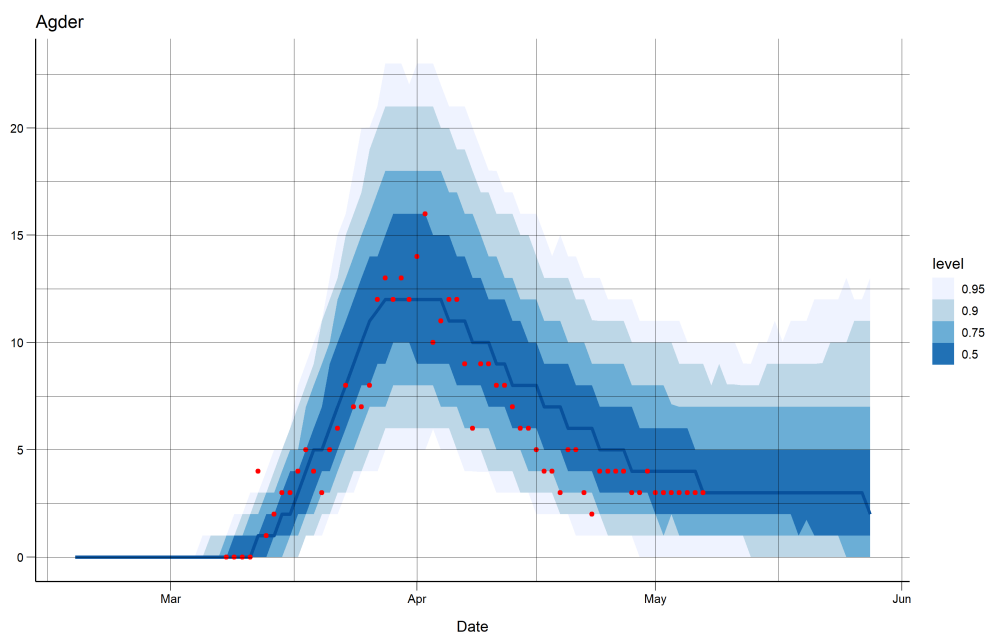
True total number of hospitalisations (red) and predicted values (blue)



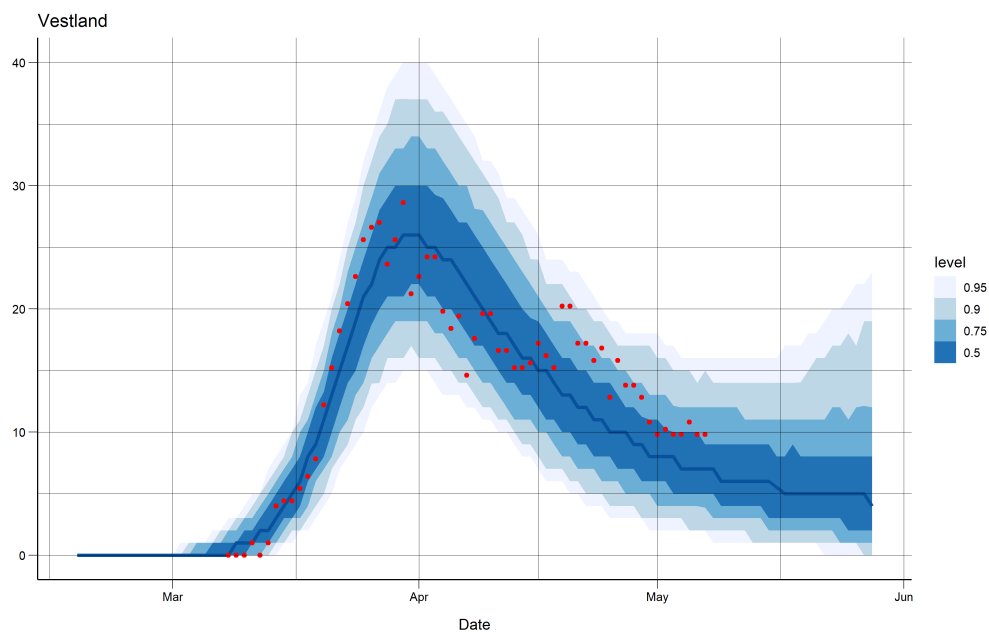
True total number of hospitalisations (red) and predicted values (blue)



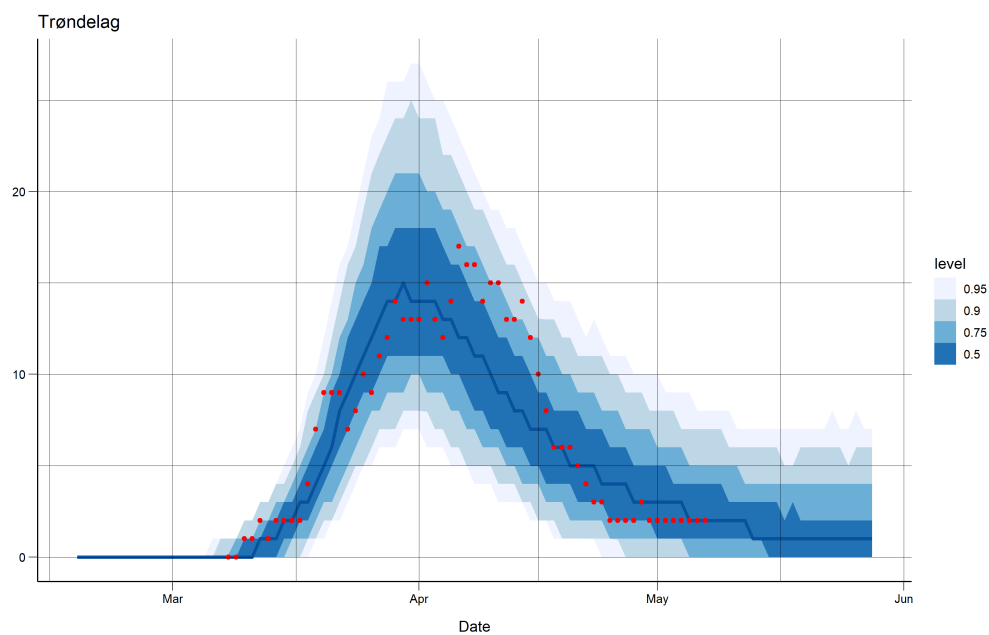
True total number of hospitalisations (red) and predicted values (blue)



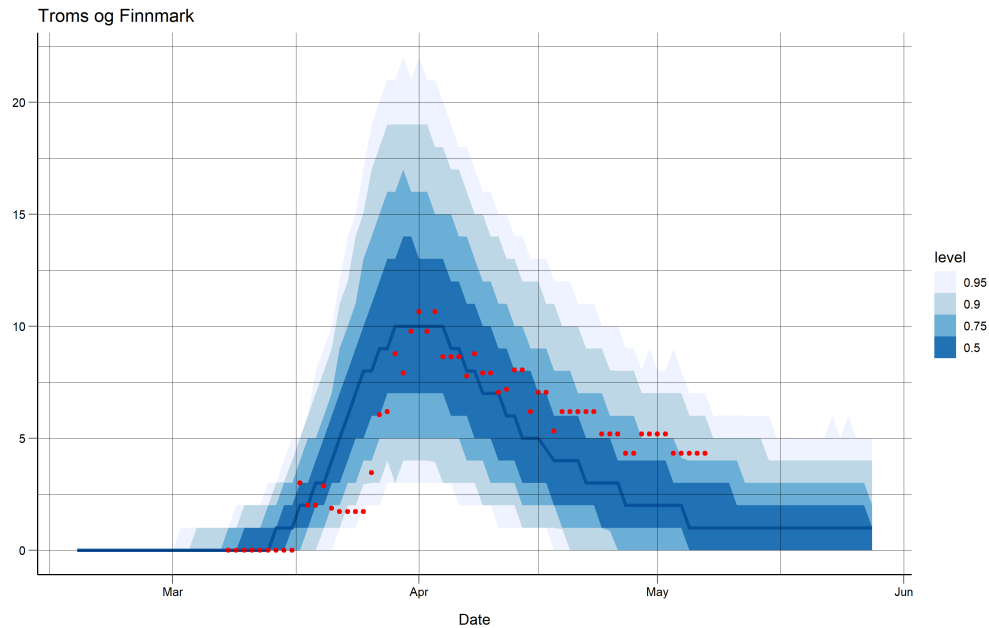
True total number of hospitalisations (red) and predicted values (blue)



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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 (14 May)	2 weeks prediction (21 May)	3 weeks prediction (28 May)
Agder	1 (0-4)	1 (0-4)	1 (0-5)
Innlandet	1 (0-4)	1 (0-4)	1 (0-3)
Møre og Romsdal	1 (0-3)	0 (0-2)	0 (0-2)
Nordland	1 (0-3)	0 (0-3)	0 (0-3)
Oslo	6 (2-12)	5 (1-11)	4 (0-10)
Rogaland	1 (0-4)	1 (0-4)	1 (0-5)
Troms og Finnmark	1 (0-3)	0 (0-2)	0 (0-2)
Trøndelag	1 (0-3)	1 (0-3)	1 (0-3)
Vestfold og Telemark	2 (0-6)	2 (0-6)	2 (0-6)
Vestland	2 (0-6)	2 (0-6)	2 (0-7)
Viken	5 (1-10)	4 (1-10)	4 (0-12)

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, 14 May	Mean, 21 May	Mean, 28 May	low CI, 28 May	high CI, 28 May
Agder	102	107	118	9	539
Innlandet	53	38	31	3	117
Møre og Romsdal	20	13	10	0	51
Nordland	31	28	27	0	132
Oslo	388	360	339	40	1284
Rogaland	126	144	173	11	885
Troms og Finnmark	33	30	29	0	147
Trøndelag	48	41	37	1	206
Vestfold og Telemark	154	166	181	10	778
Vestland	176	179	188	12	927
Viken	404	336	296	37	1036

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.

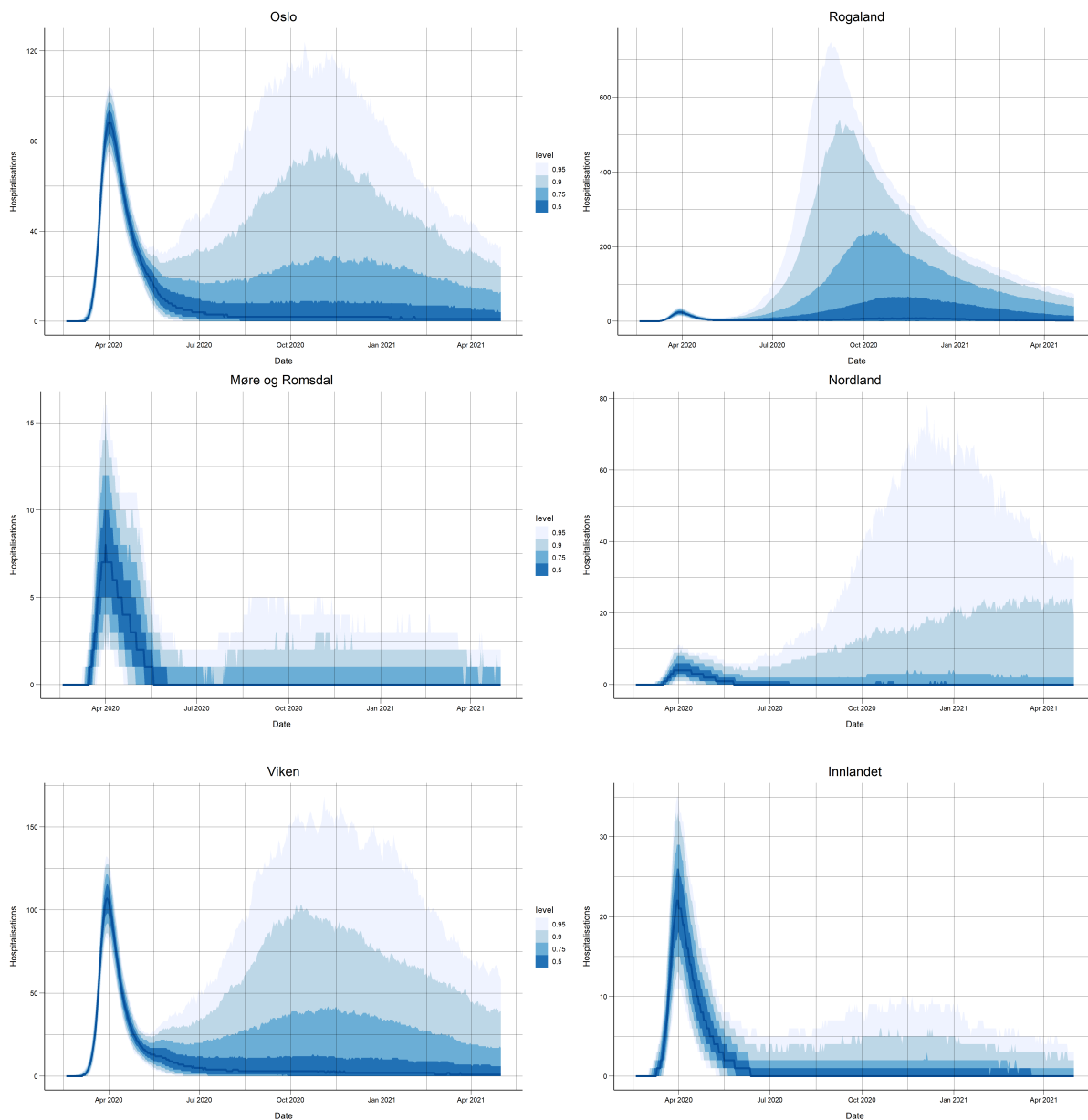
Table 5: Predicted incidence per day.

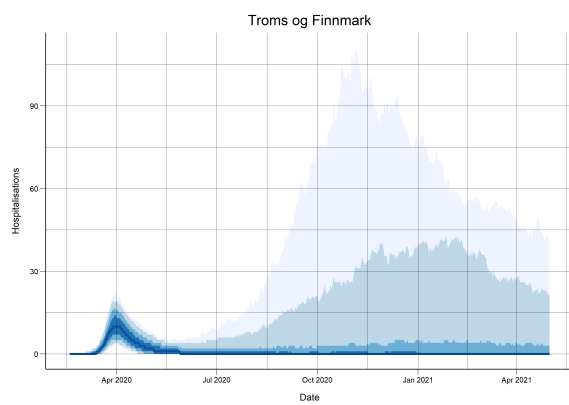
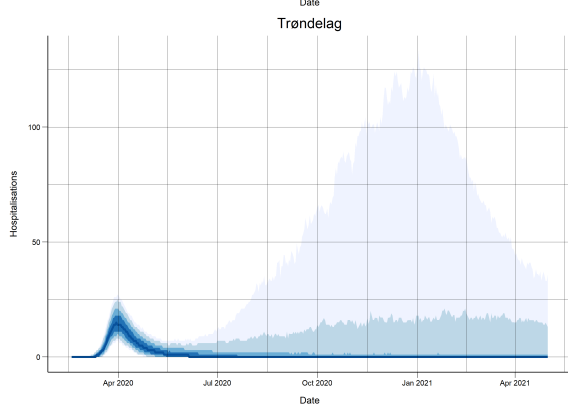
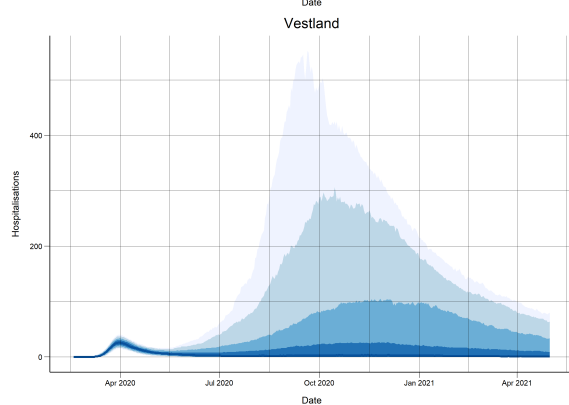
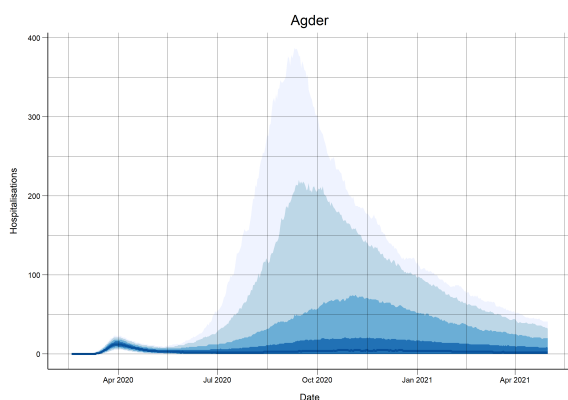
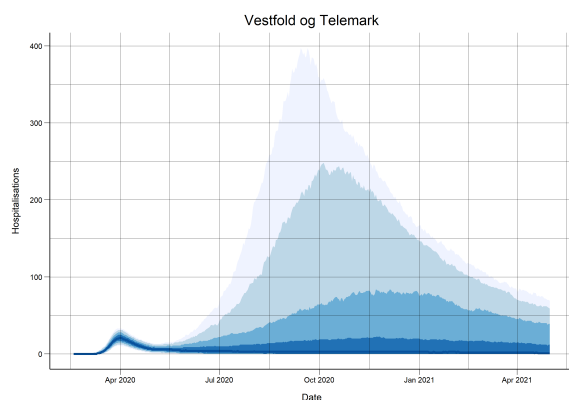
Region	1 week prediction (14 May)	2 weeks prediction (21 May)	3 weeks prediction (28 May)
Agder	16 (1-57)	18 (1-75)	20 (0-104)
Innlandet	7 (0-23)	5 (0-21)	4 (0-18)
Møre og Romsdal	2 (0-13)	2 (0-9)	1 (0-9)
Nordland	5 (0-20)	4 (0-22)	4 (0-25)
Oslo	59 (11-158)	55 (7-186)	52 (4-206)
Rogaland	22 (2-78)	25 (1-111)	30 (0-158)
Troms og Finnmark	5 (0-23)	5 (0-26)	5 (0-25)
Trøndelag	7 (0-31)	6 (0-33)	6 (0-38)
Vestfold og Telemark	26 (2-87)	29 (2-116)	31 (1-146)
Vestland	28 (3-102)	30 (1-127)	32 (1-170)
Viken	59 (12-158)	50 (6-159)	46 (4-180)

6 Long-term prediction results for each county

6.1 Hospitalisations

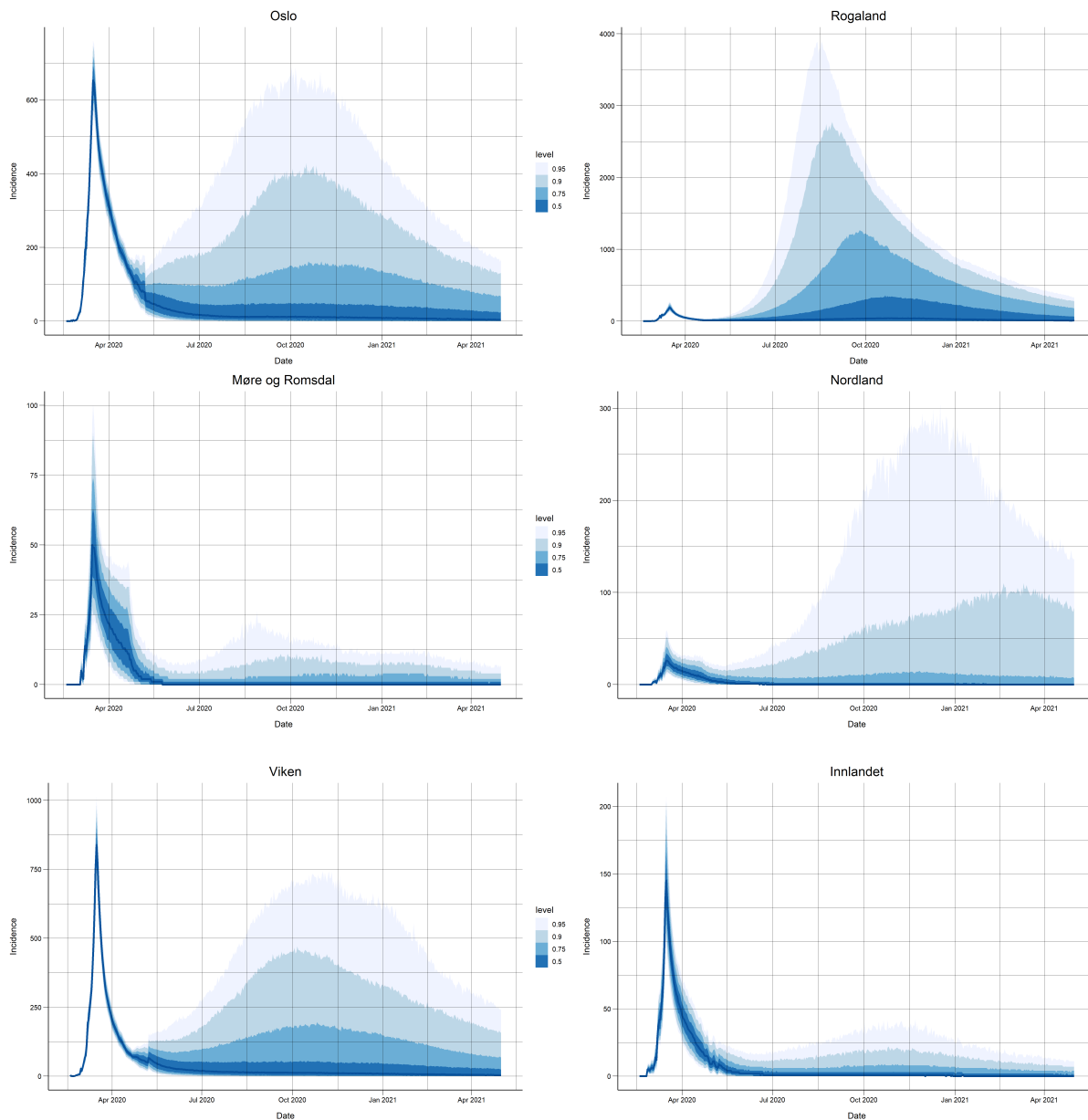
Predicted daily number of COVID-19 patients in hospital, including receiving ventilator treatment, in each county until April 2021, assuming that there are no changes with respect to today in reproduction number. It is based on 1000 runs of the future to represent the uncertainty of estimated parameters.

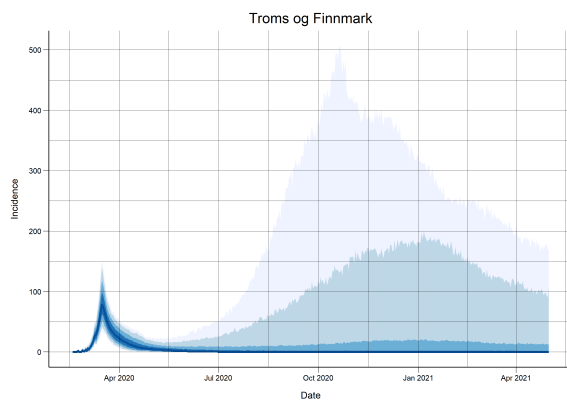
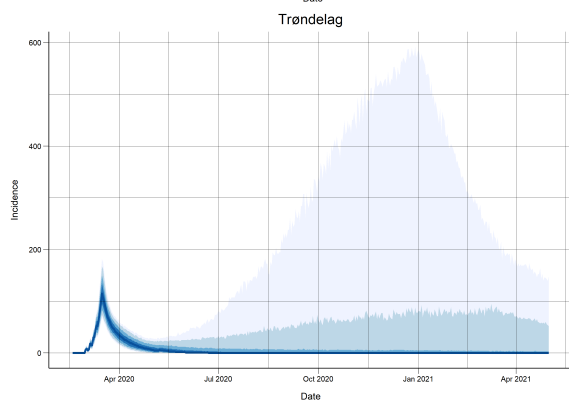
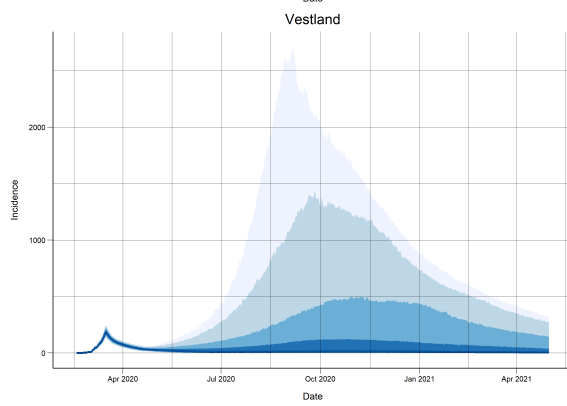
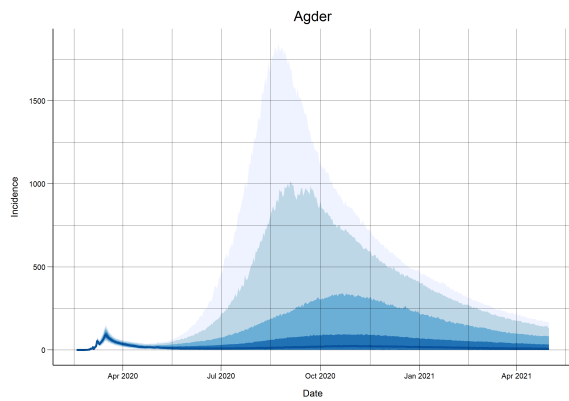
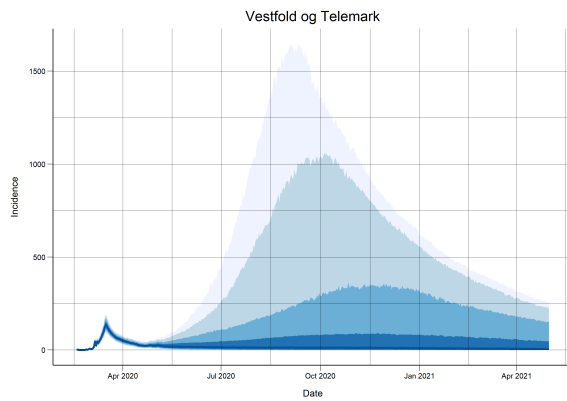




6.2 Incidence

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





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 7. 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 May 7 th, the Telenor based mobility was used. After that, we used a regularised version of the mobility matrix of May 7 th.

In this run the amplification factors was estimated to be 2.34 (1.41 3.22).

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.
- **David Swanson** - Oslo Centre for Biostatistics and Epidemiology, Oslo University Hospital.
- **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