OSLO: situational awareness and forecasting for COVID-19

18 April 2020

In this report we present estimates of the covid-19 epidemic for Oslo (fylke). We run two models:

(A) 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 Oslo and Norway excluding Oslo, allowing us to obtain calibrated parameters specific to Oslo.

(B) The so-called EpiEstim model, as in Thompson et al. (2019). This model uses number of lab-confirmed cases as data.

Results based on number of lab-confirmed cases need to be interpreted cautiously since changes in testing strategy influence the estimates without reflecting changing rates of infection. Hospitalisation data are less volatile, but capture changes in infection rates with a delay of roughly two weeks. The results from EpiEstim model (B) allow us to capture more immediately changes in infection rates, while results from the SEIR model (A) are more reliable. The SEIR model has currently only two reproduction numbers, with a changepoint on March 15. The EpiEstim model has a daily reproduction number.
Both models make important assumptions about the mechanisms and parameters of the epidemic. See https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/ for details on the SEIR model (A). Regarding (B), one has to take into account the delay from infection to onset of illness and to day of testing. We try to correct for under-reporting of lab-positive cases during the last days, but all our estimates from the last few days are more uncertain.

NB: 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 is covered by Ahus.

# 1 (A) SEIR based results, Oslo only

1.1 Estimated reproduction numbers in Oslo

Calibration of our model with Oslo's hospitalisation data leads to the following estimates for Oslo:

- R_0 (until 15 March) : median is 3.47, inter-quartile range is (3.25 - 3.65)

- R_{eff} (from 16 March) : median is 0.88, inter-quartile range is (0.82 - 0.96)

- amplification factor F (seeding): median is 2.26, inter-quartile range is (2.05 - 2.54).

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[1]see our daily report at: https://www.fhi.no/sv/smittsomme-sykdommer/corona/koronavirus-modellering/

Estimated densities of the three calibrated parameters are plotted below:
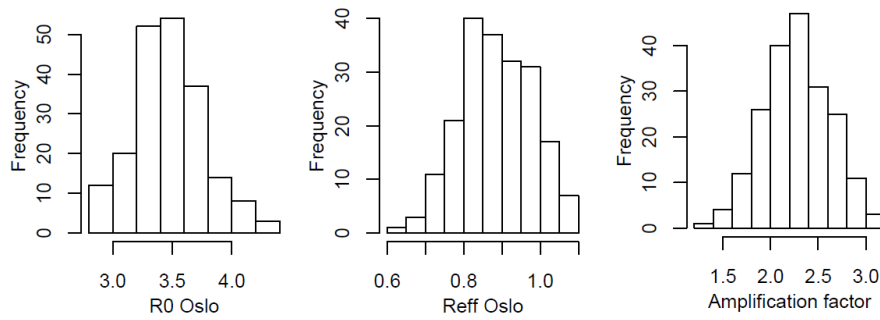
Our model estimates the number of hospitalised Covid-19 patients in Oslo, plotted below with blue median and inter-quartile bands, which are compared with the actual Oslo hospitalisation data, in red. The uncertainty captures the uncertainty in the calibrated parameters in addition to the stochastic elements of our model.
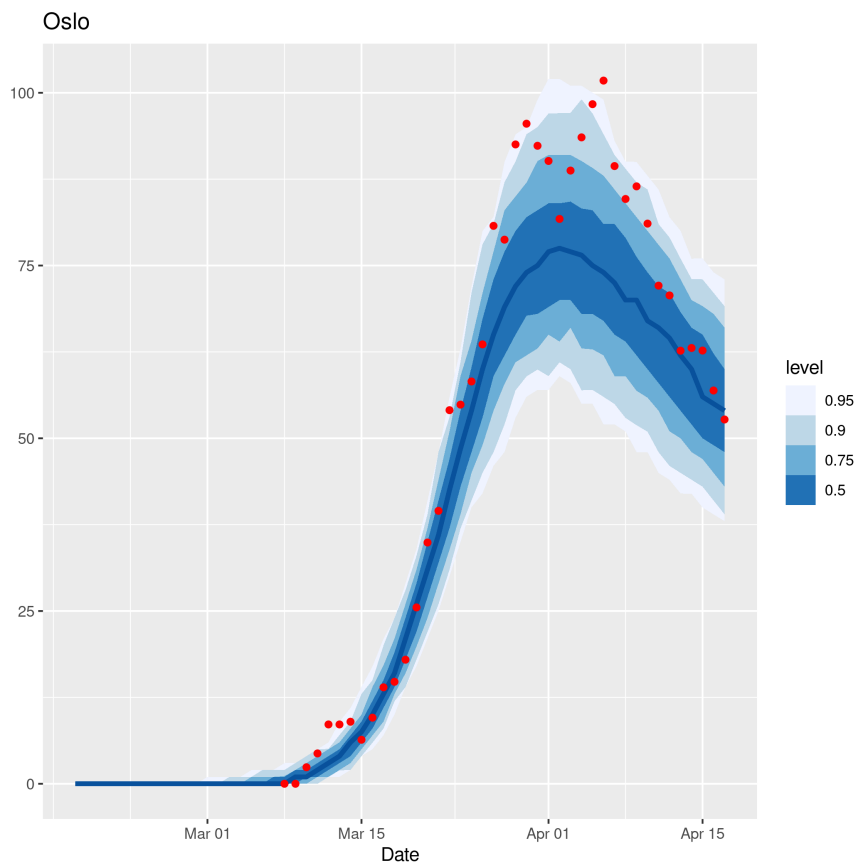
True total number of hospitalisations (red) and predicted values (blue)

1.2 Estimated cumulative number of infected individuals in Oslo

Table 1: Estimated cumulative number of infections, 2020-04-18

Region	Total	Symptomatic
Oslo	14194 (10980; 17925)	8541 (6584; 10722)

1.3 Predicted incidence of infected individuals, next three weeks in Oslo

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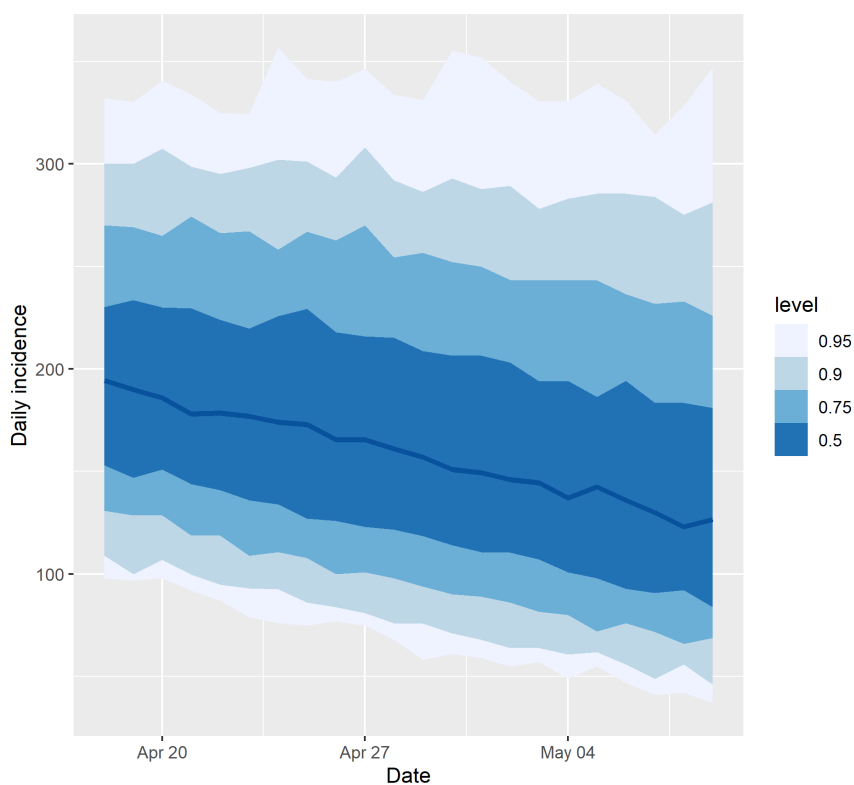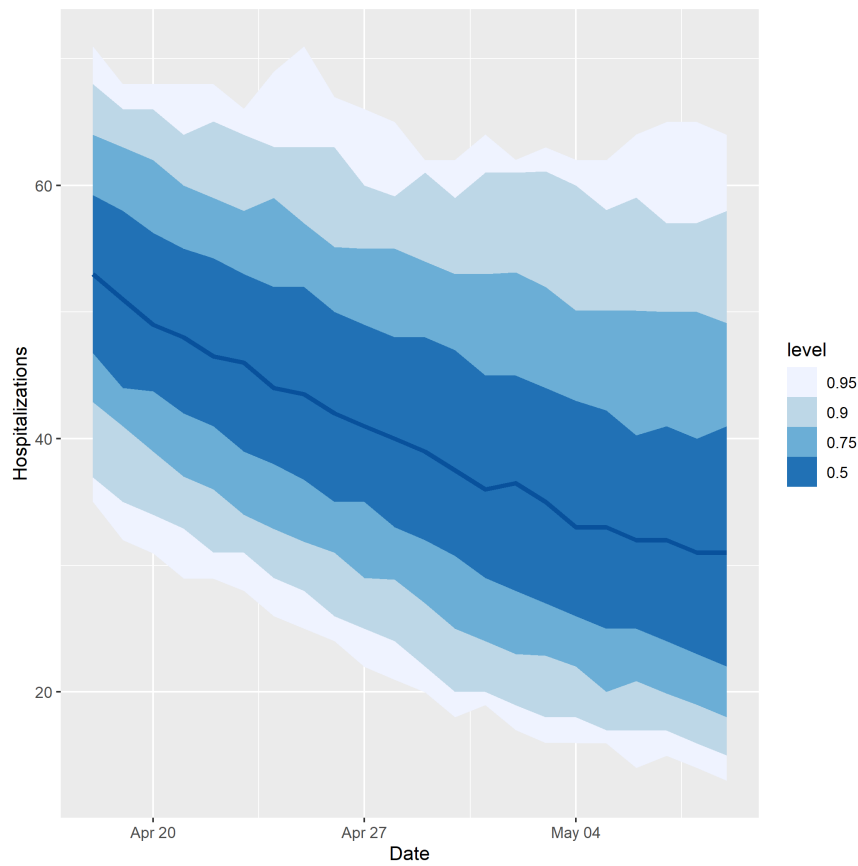

Table 2: Predicted incidence per day.

Region	1 week prediction (25 April)	2 weeks prediction (02 May)	3 weeks prediction (09 May)
Oslo	180 (74-341)	160 (55-340)	141 (37-347)

1.4 Predicted hospitalisation, next three weeks, including patients in ventilator treatment in Oslo

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

Region	1 week prediction (25 April)	2 weeks prediction (02 May)	3 weeks prediction (09 May)
Oslo	44 (21-72)	37 (15-65)	33 (11-64)

Predicted daily number of COVID-19 patients in hospital in Oslo (95% confidence intervals and inter-quartile range), next three weeks, including patients in ventilator treatment.
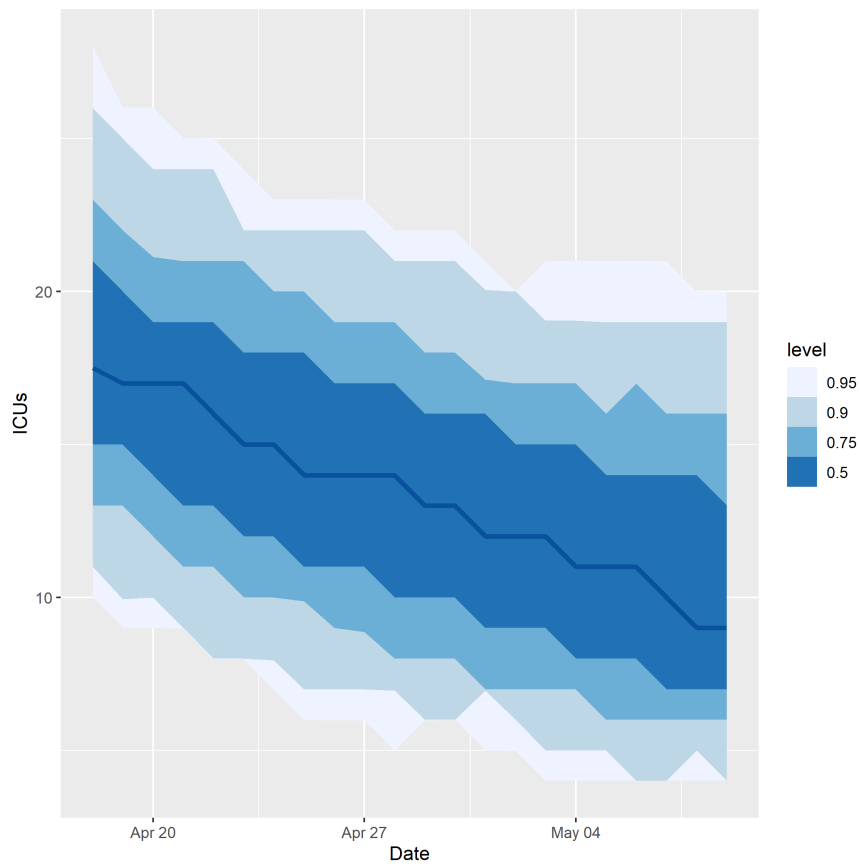
1.5 Predicted number of patients in ventilator treatment: next three weeks in Oslo

Table 4: Number of ICU beds occupied by Covid-19 patients.

| Region	1 week prediction (25 April)	2 weeks prediction (02 May)	3 weeks prediction (09 May)
Oslo	15 (6-23)	12 (5-20)	10 (4-20)

Predicted daily number of COVID-19 patients in ventilator treatment in Oslo (95% confidence intervals and interquartile range), next three weeks.

1.6   Long-term prediction results: Oslo

Predicted daily number of COVID-19 patients in hospital and receiving ventilator treatment in Oslo until April 2021, in addition to prevalence. We use the most recent estimate of the reproductive rate, unchanged in all the future.
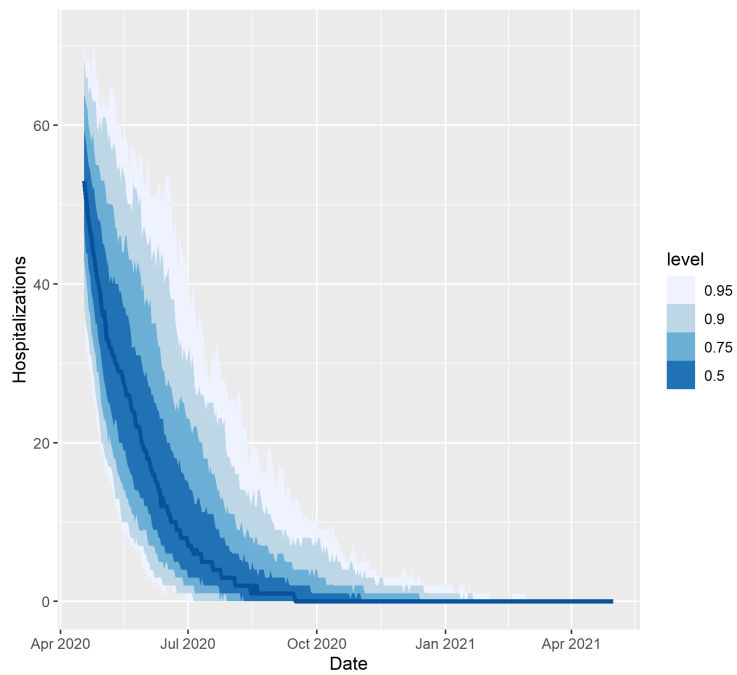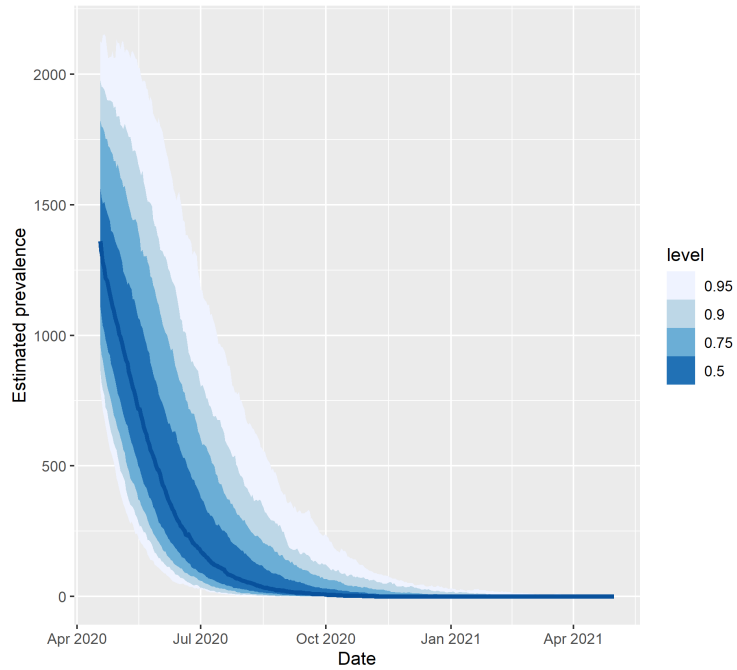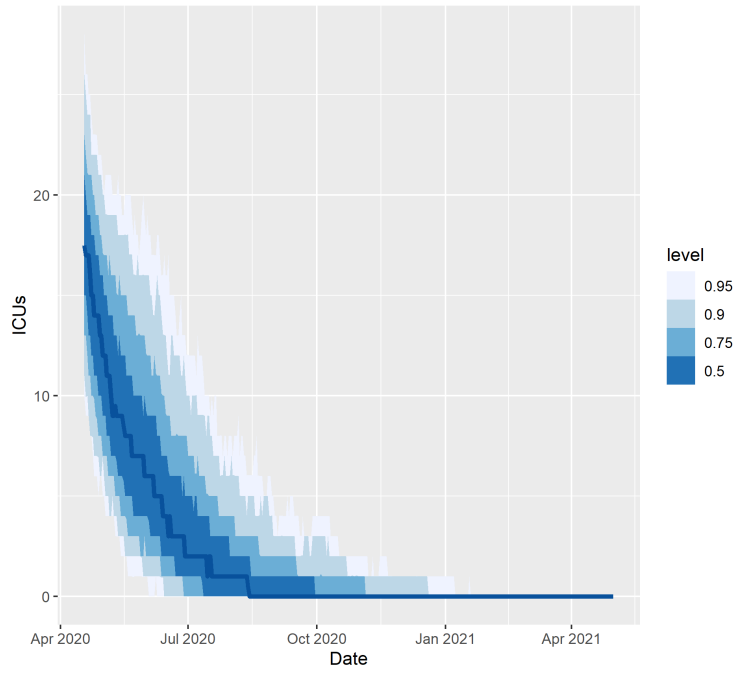
2 (B) OSLO: EpiEstim based results

Estimated Reproduction Number for infections for Oslo on 2020-04-08:

- R_t (on 8 April) : mean is 0.82, and 95% confidence interval is (0.59 - 1.12).

In the figure below: right panel contains the estimated daily reproduction number with the 95% confidence interval. The left panel has in black the histogram of the daily lab-confirmed cases and in blue the corresponding estimated date of infection of the same cases.

Figure 1: Epi Curve and Reproduction number for Oslo
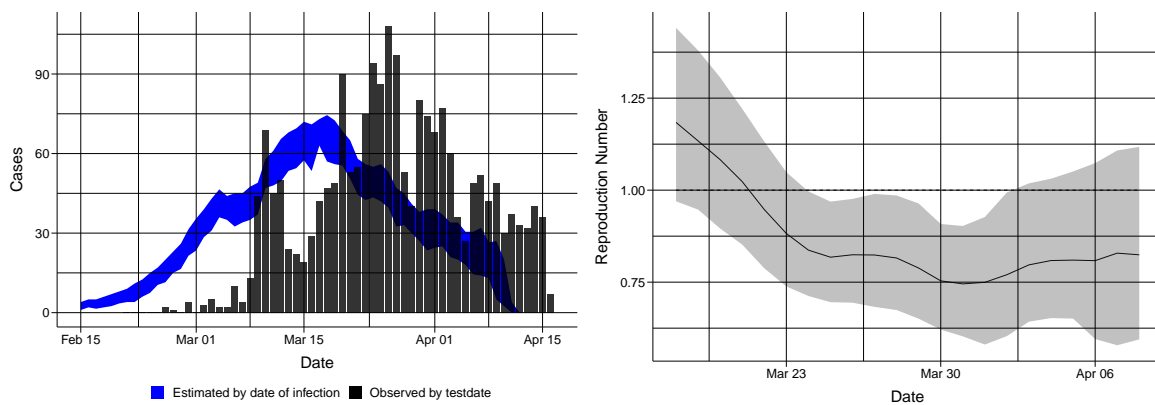
3 Methods

(A) SEIR model

Details on this model and parameters used for the run 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 200 parameter sets (F, R_0, R_{eff}) for Oslo and for the aggregated rest of Norway, which fit best the Oslo hospitalization data up to 17th of April, and the rest-of-Norway hospitalisation data, respectively. Next we run our SEIR model with these 200 parameter sets again, from the beginning until today plus three weeks in the future (or a full year in the future), to get 200 trajectories of the future. We use these trajectories to make future predictions.

(B) EpiEstim model

To estimate the reproduction number, we first need to estimate the date of infection for each lab-confirmed case. We use data from MSIS where we get date of testing. Based on the initial cases we fitted a negative binomial distribution with mean 6 and size 1.5. We also use a 5 day incubation period from date of infection to date of onset. Using the same delay distribution we also correct for under-reporting. We then use the R package EpiEstim to estimate the reproduction number with a serial interval with mean 5 days and standard deviation 2. In EpiEstim we use a smoothing window of 3 days.

So in practice we first estimate 100 epi-curves for the date of infection. For each case we draw a date of onset from a negative binomial distribution and calculate the date of infection as 5 days earlier. We then aggregate by date of infection and for the cases that were tested in the last 2 weeks, we estimate the number of cases that were infected on the same day, but have not been tested yet due to the delay by drawing these extra cases from a negative binomial with a probability given by the cumulative distribution of the delays. For each of the 100 epi-curves we use EpiEstim to estimate a posterior gamma distribution for the reproduction number and we then draw samples from each of these 100 posterior distributions to estimate the total uncertainty in the reproduction number.