NIPH
Norwegian Institute of Public Health

Situational awareness and forecasting for Norway

FHI COVID-19 modelling team

Week 15, 13 April 2023

Main results:

We report the estimated national reproduction number from our changepoint model this week. The model estimates an average effective reproduction number of 1.25 since Feb 21st, which matches the recent increase in the number of new hospitalisations. The regional SMC model, which estimates daily reproduction numbers, indicate that a flat or even decreasing trend is more likely in most counties in the last couple of weeks.

Due to a lack of reliable test data, we only base our estimates on hospitalisation data, which has a longer delay. We also refer to trend analysis results Figure 12 based on various data sources.

- **National epidemiological situation:**

  The most recent reproduction numbers:

Model	Median	2.5%	97.5%	Prob>1	period/day	More info
Changepoint	1.25	1.1	138	100%	from Feb 21	Section 1

- **National forecasting:**

  One-week-ahead national forecasts from changepoint model:

Indicator	Median/Mean 95% PI	day	Info 2-3 weeks forecasts
Hospital beds	201/197 (82-348)	Apr 18	Table 2
Ventilator beds	6/5 (1-12)	Apr 18	Table 2

  Three-weeks-ahead national forecasts can be found in Tables 2. Age-specific hospital prevalence predictions are provided in Figures 4 and 5.

- **Regional epidemiological situation:**

  The newest regional effective reproduction number for Oslo:

Model	Median	2.5%	97.5%	Prob>1	day	Info other counties
SMC	0.95	0.59	1.51	0.42	25 Mar - 28 Mar	Table 3

- **Telenor mobility data and the number of foreign visitors:**

  Since 1 July 2022 we no longer receive real-time mobility data from Telenor.

1 Estimated national reproduction numbers

Table 1 shows the estimated reproductive number of our national changepoint model. Figure 1 shows the estimated daily number of COVID-19 patients admitted to hospital, with blue medians and interquantile bands, which are compared to the actual true data, provided in red. The uncertainty captures the uncertainty in the calibrated parameters in addition to the stochastic elements of our model and the variability of other model parameters.

Table 1: Calibration results

Reff	Period
2.68/2.69(2.33-3.08)	From Feb 17 to Mar 14
0.65/0.65(0.55-0.77)	From Mar 15 to Apr 19
0.27/0.3(0.02-0.73)	From Apr 20 to May 10
0.5/0.53(0.07-1.14)	From May 11 to Jun 30
0.49/0.51(0.07-1.11)	From Jul 01 to Jul 31
1.22/1.19(0.59-1.59)	From Aug 01 to Aug 31
0.97/0.98(0.81-1.18)	From Sep 01 to Oct 25
1.17/1.18(0.77-1.67)	From Oct 26 to Nov 04
0.99/1(0.87-1.15)	From Nov 05 to Nov 30
0.8/0.8(0.7-0.91)	From Dec 01 to Jan 03
0.88/0.86(0.53-1.07)	From Jan 04 to Jan 21
0.6/0.64(0.38-1.07)	From Jan 22 to Feb 07
1.47/1.46(1.26-1.63)	From Feb 08 to Mar 01
0.89/0.9(0.8-1.04)	From Mar 02 to Mar 24
0.85/0.85(0.78-0.91)	From Mar 25 to May 05
0.85/0.85(0.61-1.1)	From May 06 to May 26
0.79/0.78(0.55-0.99)	From May 27 to Jun 20
0.79/0.79(0.54-1.02)	From Jun 21 to Aug 04
1.1/1.1(0.96-1.29)	From Aug 05 to Aug 31
0.7/0.71(0.58-0.88)	From Sep 01 to Sep 24
1.01/1.01(0.96-1.06)	From Sep 25 to Dec 14
0.89/0.88(0.78-0.99)	From Dec 15 to Jan 13
1.14/1.14(1.1-1.17)	From Jan 14 to Feb 25
0.82/0.82(0.8-0.84)	From Feb 26 to May 14
1.21/1.21(1.15-1.26)	From May 15 to Jun 30
0.91/0.9(0.84-0.95)	From Jul 01 to Aug 14
0.9/0.9(0.85-0.96)	From Aug 15 to Sep 27
1.1/1.1(1.04-1.15)	From Sep 28 to Dec 18
0.84/0.84(0.78-0.9)	From Dec 19 to Feb 20
1.25/1.24(1.1-1.38)	From Feb 21

Median/Mean (95% credible intervals)

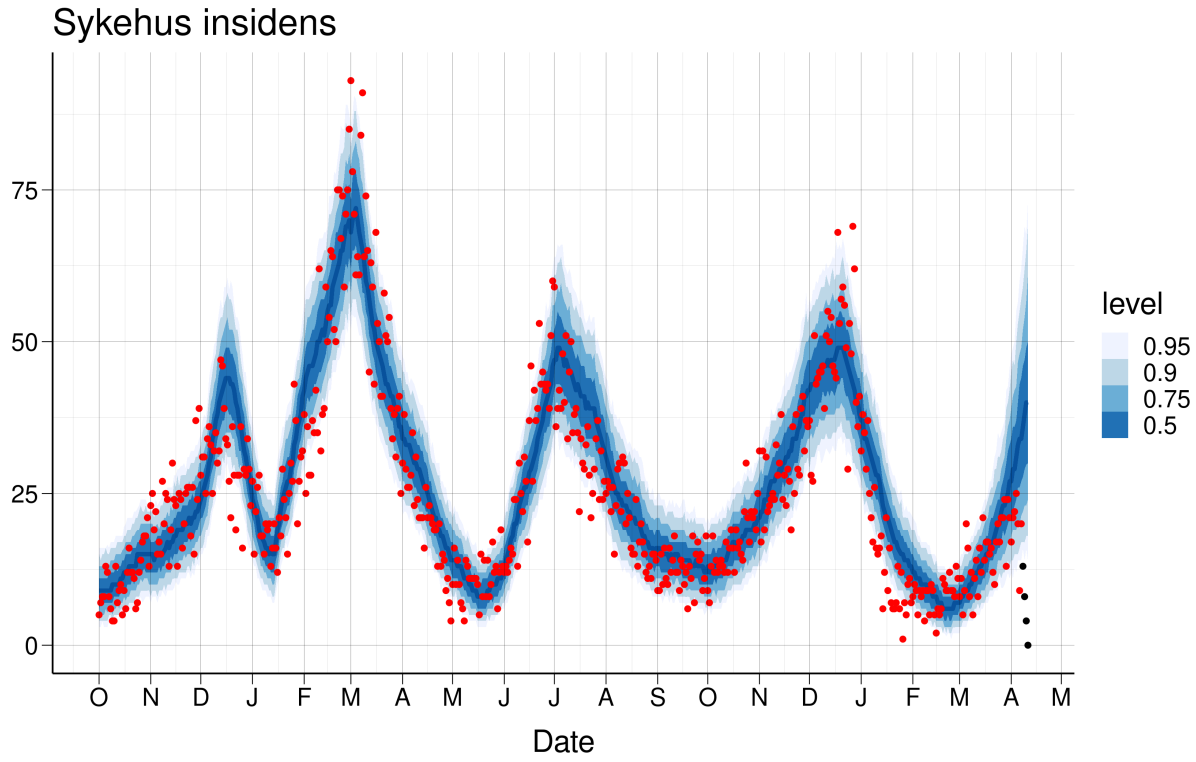
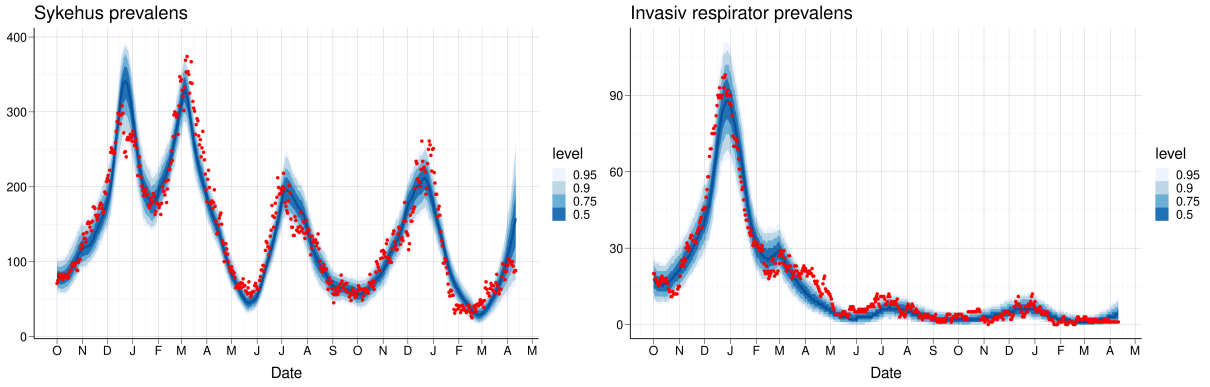


Figure 1: A comparison of true data (red) and predicted values (blue) for hospital admissions . The last four data points (black) are assumed to be affected by reporting delay. The uncertainty captures the uncertainty in the calibrated parameters, in addition to the stochastic elements of our model and the variability of other model parameters.

In figure 2, we show how our national model fits the national hospital prevalence data (2a) and the daily number of patients receiving ventilator treatment (2b). Those data sources are not used to estimate the parameters, and can therefore be seen as a validation of the model assumptions.



(a) Hospital prevalence

(b) Ventilator prevalence

Figure 2: A comparison of true data (red) and predicted values (blue) for hospital and respirator prevalence. Prevalence data is based on NIPaR and may be different to the data from Helsedirektoratet.

2 National 3-week predictions: Hospital beds and Ventilator bed

In this section we show the projected national prevalence of hospitalised patients (hospital beds) and prevalence of patients receiving ventilator treatment (ventilator beds). The projected epidemic and healthcare burden are illustrated in table 2.

Age-specific hospital prevalence predictions are provided in Figures 4 and 5.

Table 2: Estimated national hospital beds and ventilator beds. Median/Mean (CI)

	1 week prediction (Apr 18)	2 week prediction (Apr 25)	3 week prediction (May 02)
Hospital beds	201/197 (82-348)	252/248 (95-446)	304/302 (107-551)
Ventilator beds	6/5 (1-12)	7/7 (1-15)	9/8 (2-19)

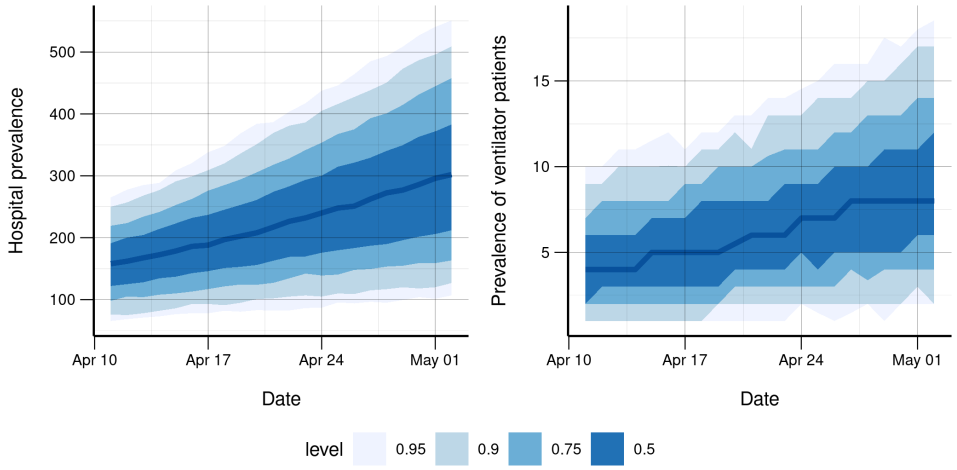


Figure 3: National 3 week predictions for hospital beds (left) and ventilator beds (right)

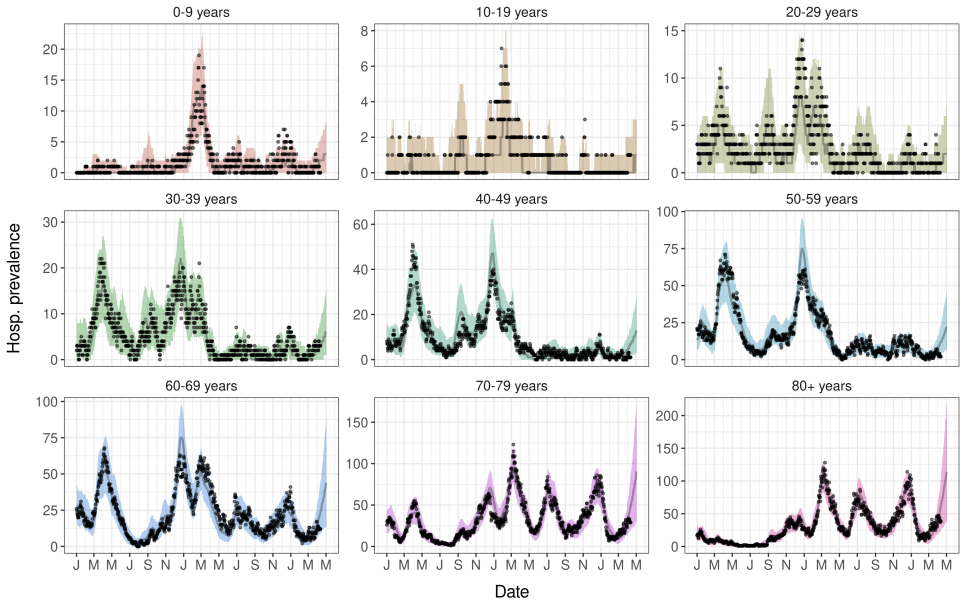


Figure 4: Simulated hospital prevalence by age group taking into account the omicron takeover. Real data is shown as black dots.

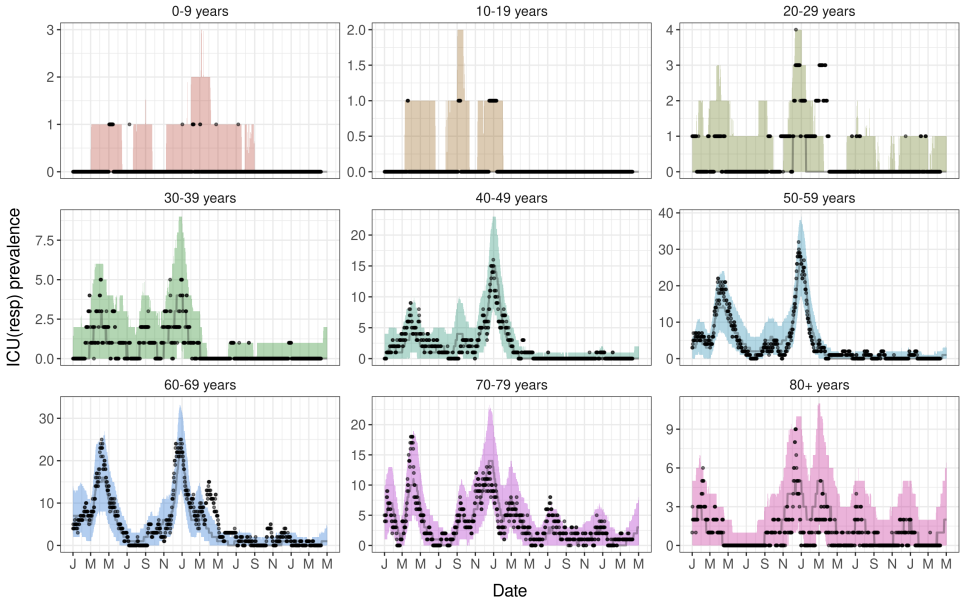


Figure 5: Simulated respirator prevalence by age group taking into account the omicron takeover. Real data is shown as black dots.

3 Estimated regional reproduction numbers

Calibration of our regional SMC model to hospitalisation incidence data leads to the following estimates for current regional effective reproduction numbers by county (Table 3).
Below we show the estimated daily number of COVID-19 patients admitted to hospital in each county. Model estimates are shown with blue medians and interquantile bands, which are compared to the actual true data, provided in red. The blue bands describe the uncertainty in the calibrated parameters, in addition to the stochastic elements of our model. Last four data points are shown in black as they may be affected by reporting delay.

Table 3: Regional estimates, 25 Mar-28 Mar

County	Median	95CI	Prob>1
Oslo	0.95	0.59-1.51	0.42
Rogaland	0.90	0.54-1.53	0.34
Møre og Romsdal	0.53	0.22-0.91	0.01
Nordland	0.93	0.58-1.5	0.38
Viken	0.72	0.54-1.03	0.03
Innlandet	0.48	0.26-0.83	0
Vestfold og Telemark	0.73	0.45-1.15	0.09
Agder	0.71	0.36-1.23	0.11
Vestland	0.95	0.6-1.45	0.39
Trøndelag	0.81	0.53-1.23	0.16
Troms og Finnmark	0.83	0.46-1.35	0.22

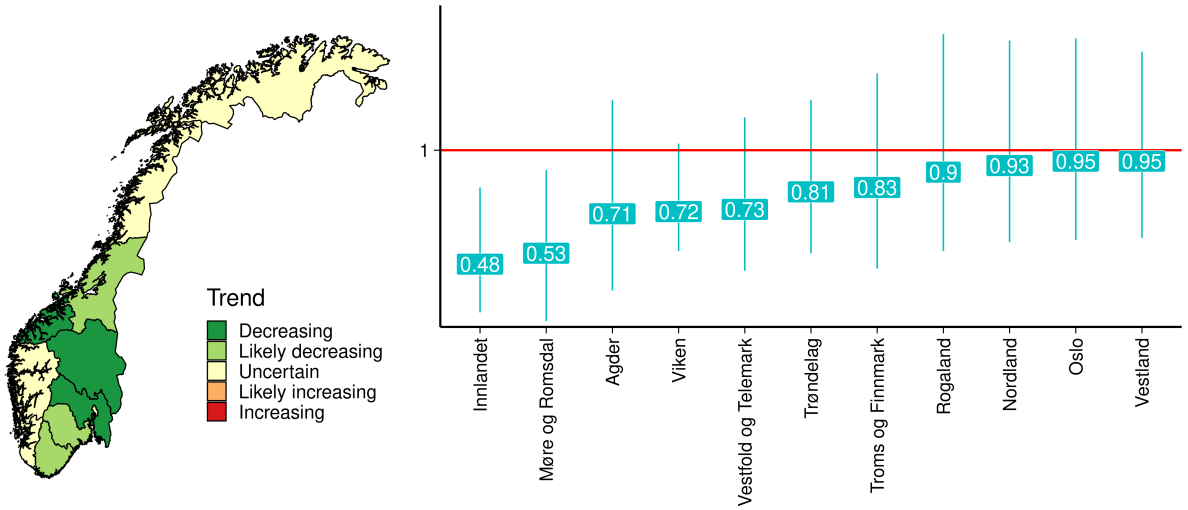
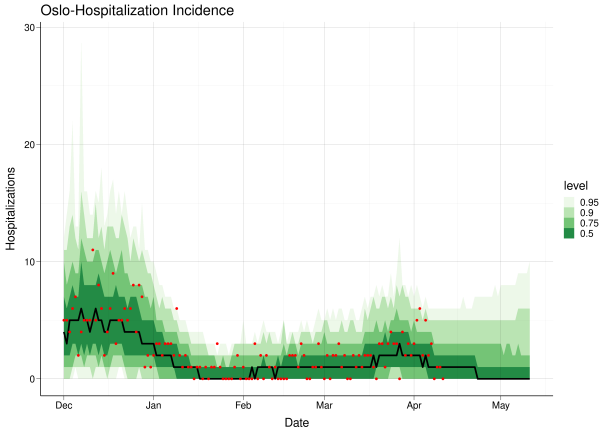
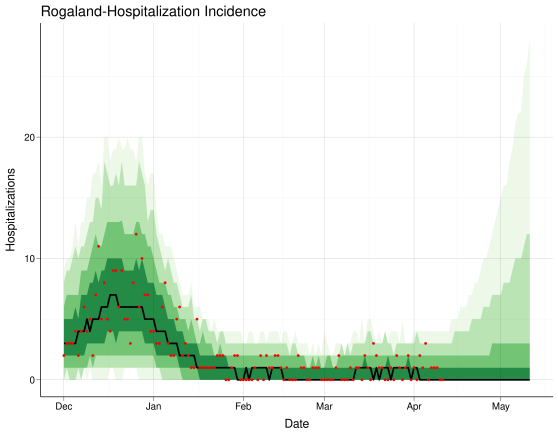


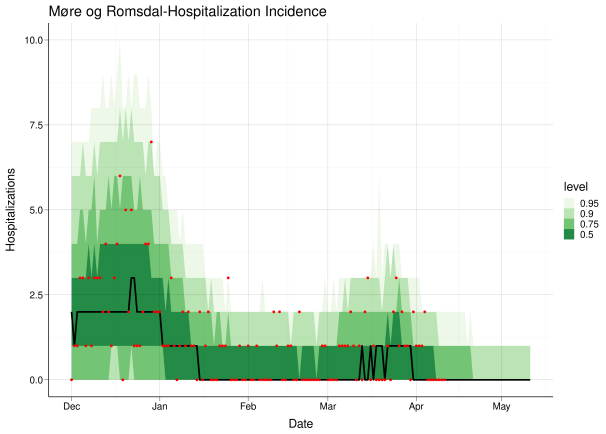
Figure 6: The map shows the direction of the trend in incidence in the counties based on the latest effective reproduction numbers shown in the other chart. The trend is increasing if the probability that the latest reproduction number is above one is above 95%, the trend is likely increasing if this probability is between 80% and 95%, the trend is uncertain if the probability is between 20% and 80%, the trend is likely decreasing if the probability is between 5% and 20% and is decreasing if the probability that the latest R is above one is less than 5%.

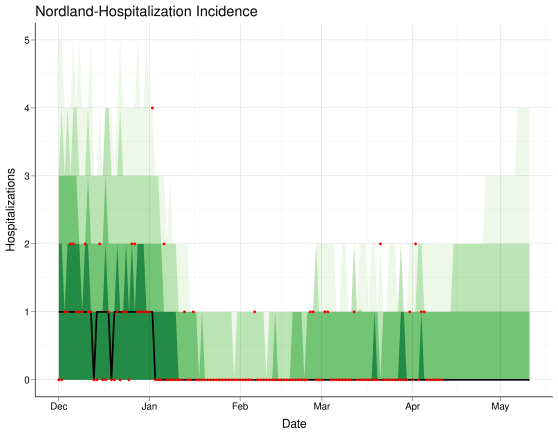
Estimated vs observed hospital incidence and 3 weeks forecast by county:

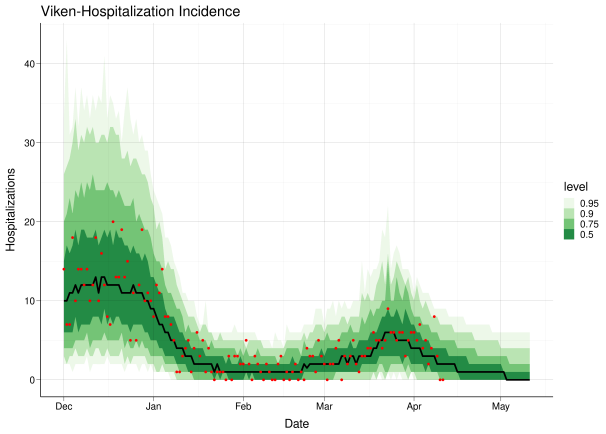
Forecasts are now based on the estimated reproduction numbers obtained by our regional SMC model, for each county. In the forecasted period of three weeks, we use the reproductive numbers showed on Table 3.

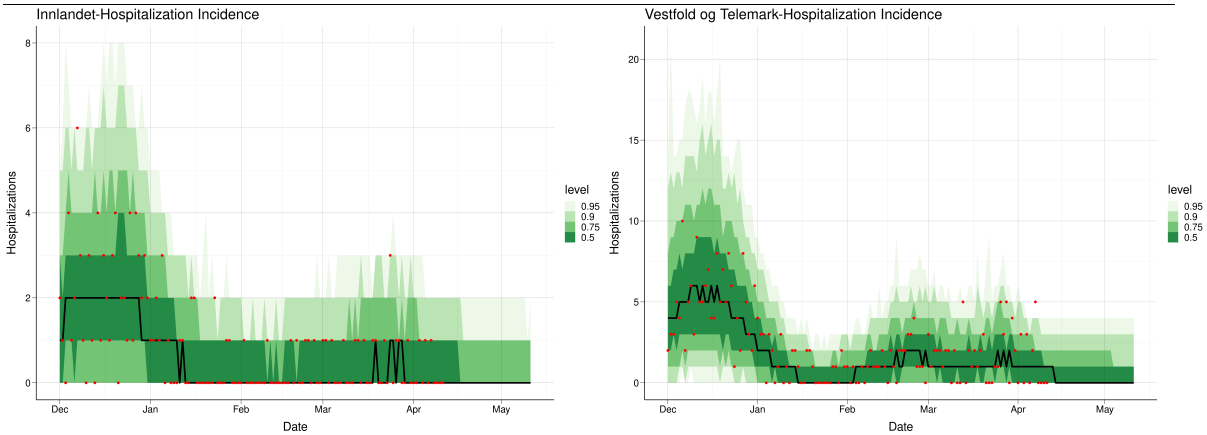











Innlandet-Hospitalization Incidence
Hospitalizations
Date
Dec
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May
level
0.95
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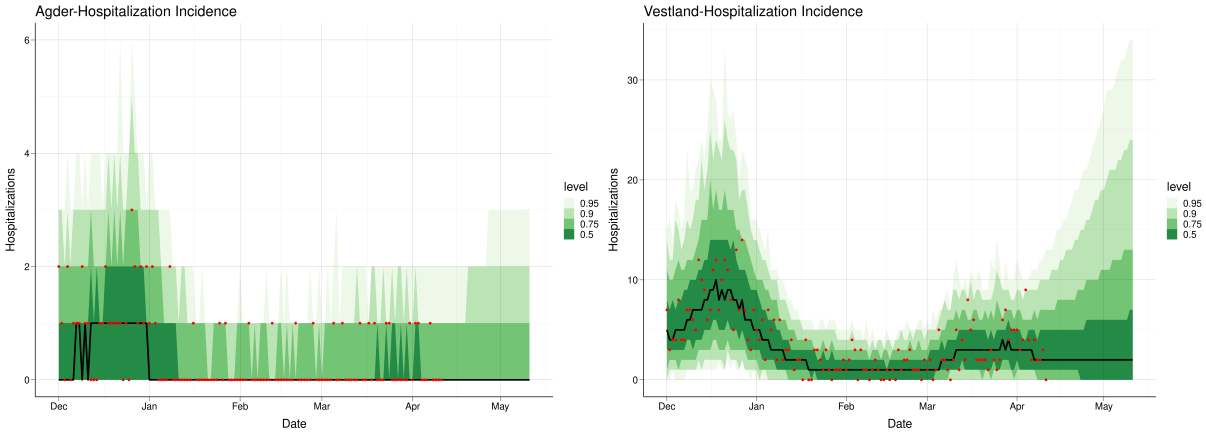
Agder-Hospitalization Incidence
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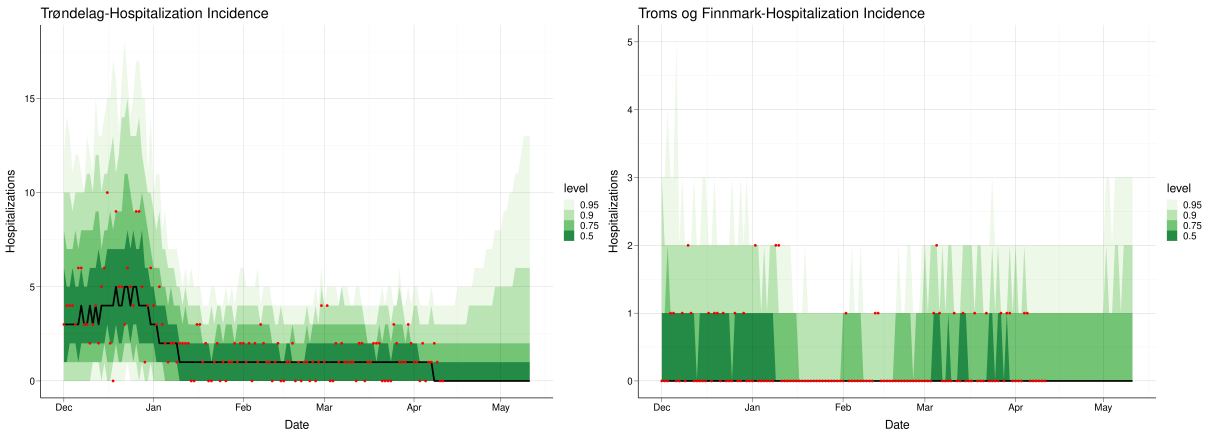
Trøndelag-Hospitalization Incidence
Hospitalizations
Date
Dec
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Vestfold og Telemark-Hospitalization Incidence
Hospitalizations
Date
Dec
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level
0.95
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Vestland-Hospitalization Incidence
Hospitalizations
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Troms og Finnmark-Hospitalization Incidence
Hospitalizations
Date
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0.95
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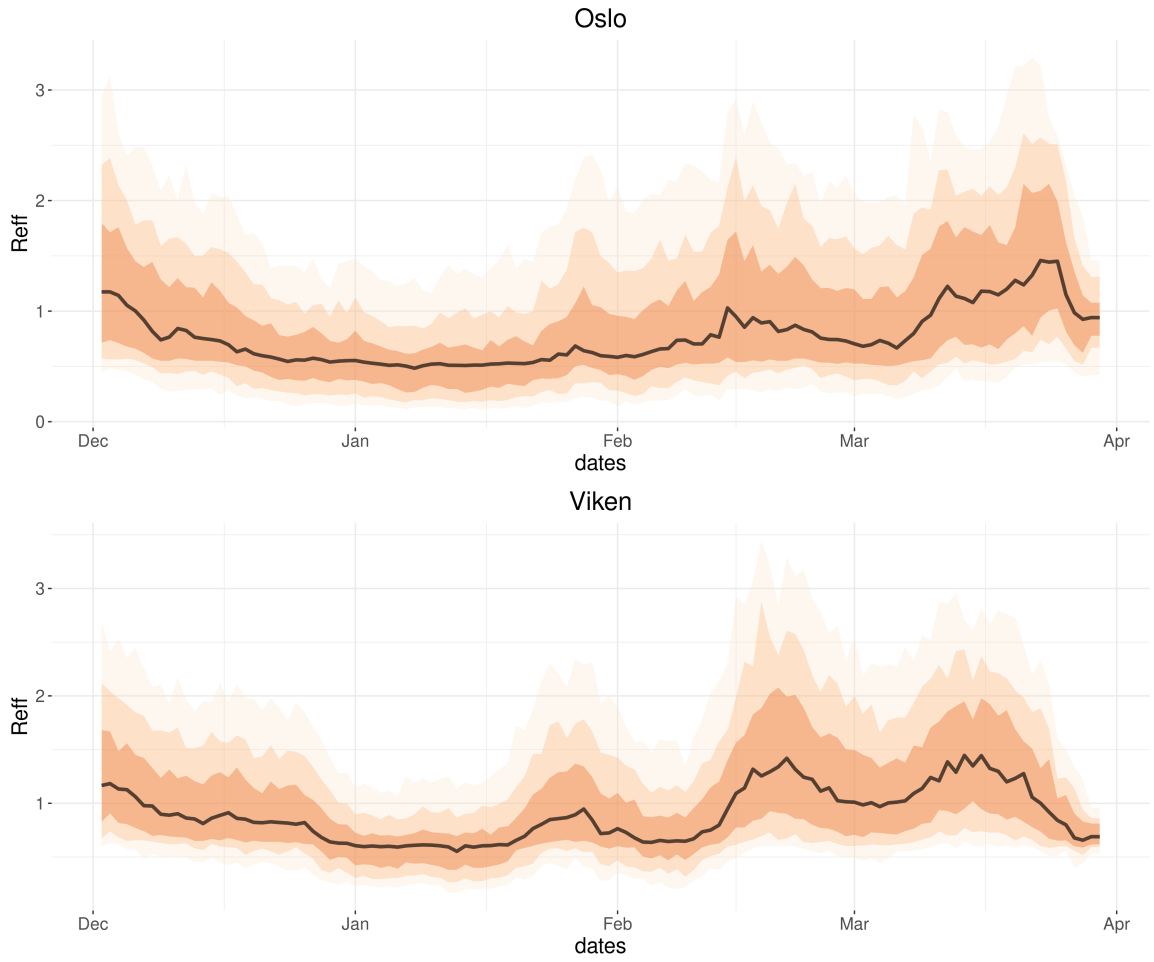
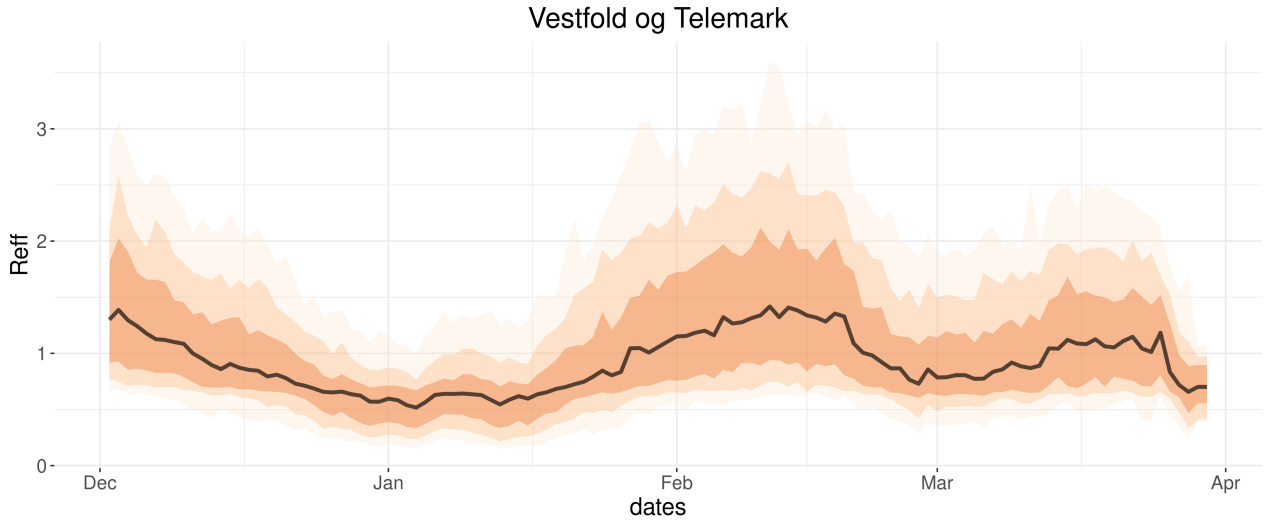
4 Regional SMC-model: Estimated daily reproduction numbers

In the figures below we plot the 95% credibility interval and quantiles of the estimated posterior distribution of the regional, daily reproduction numbers. For some counties, uncertainty is large towards the most recent time, because there are very few data and possibly reporting delays which are different in each county.




Vestfold og Telemark
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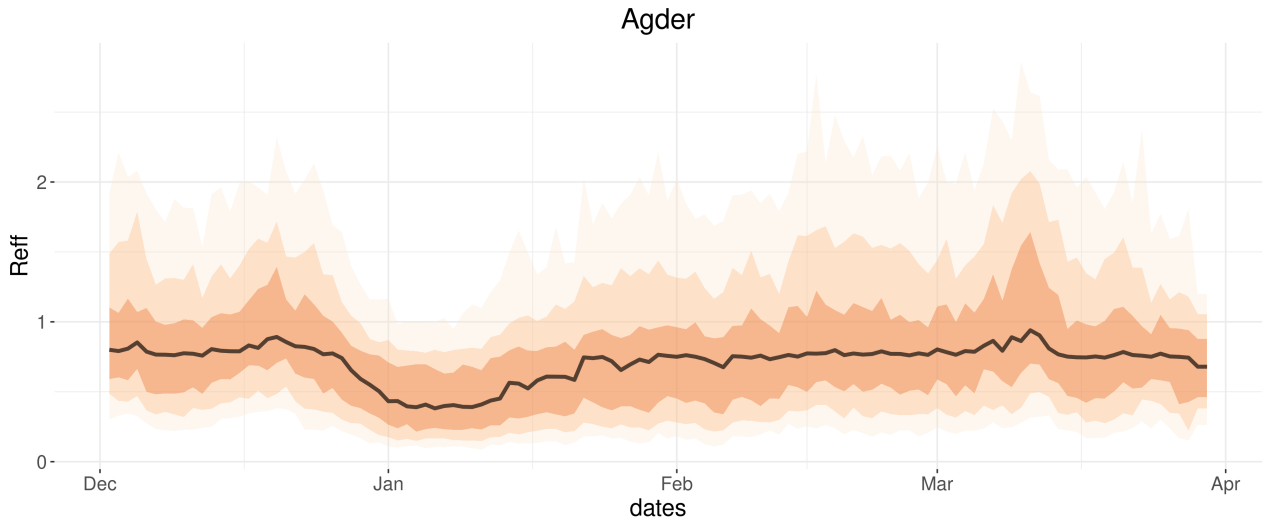
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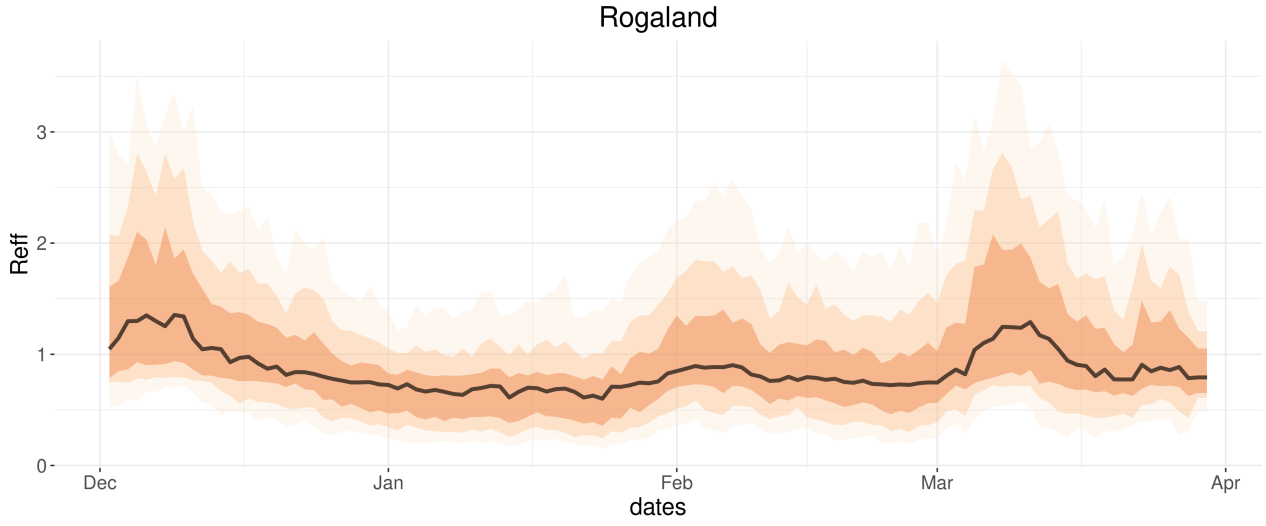
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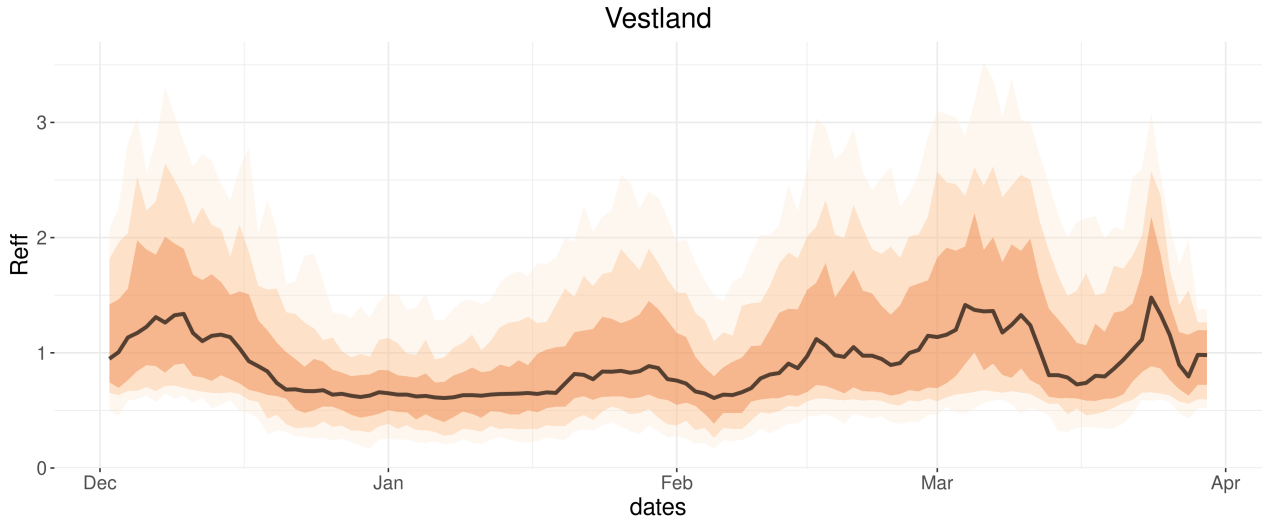
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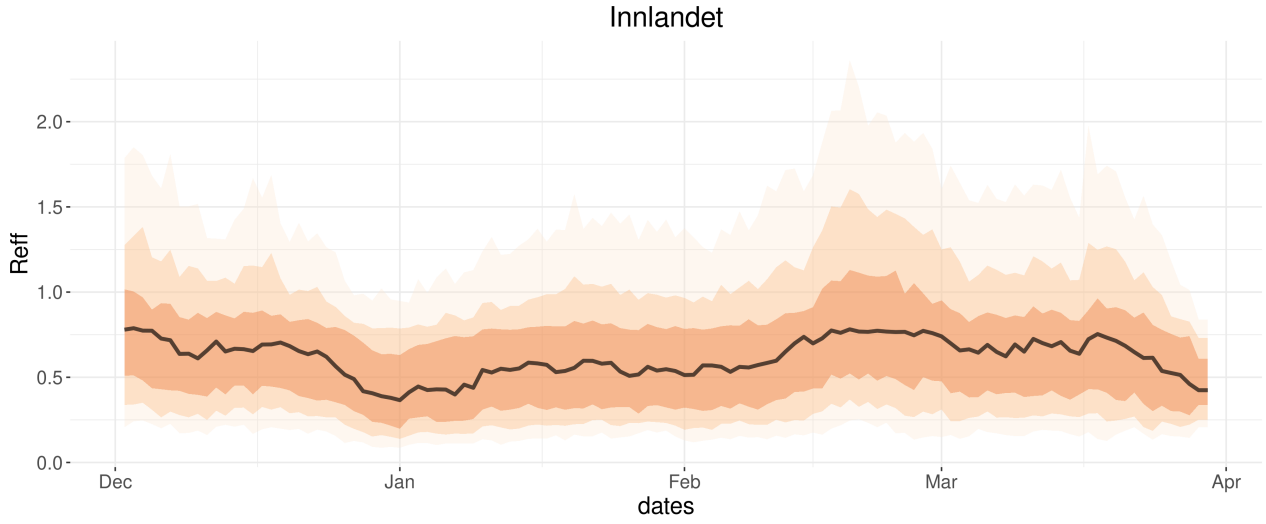
Innlandet
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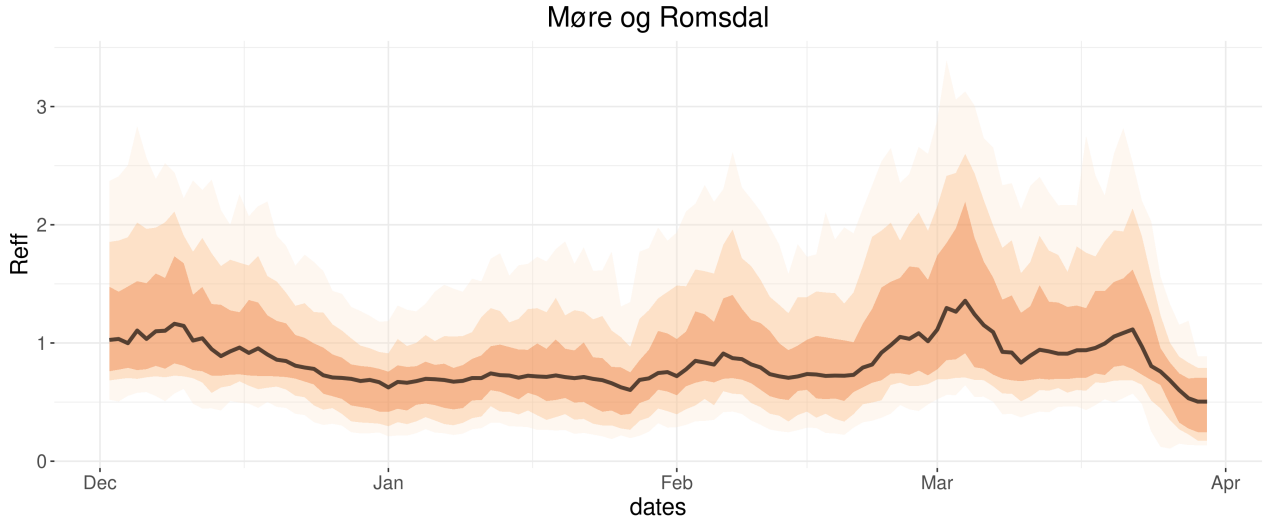
Møre og Romsdal
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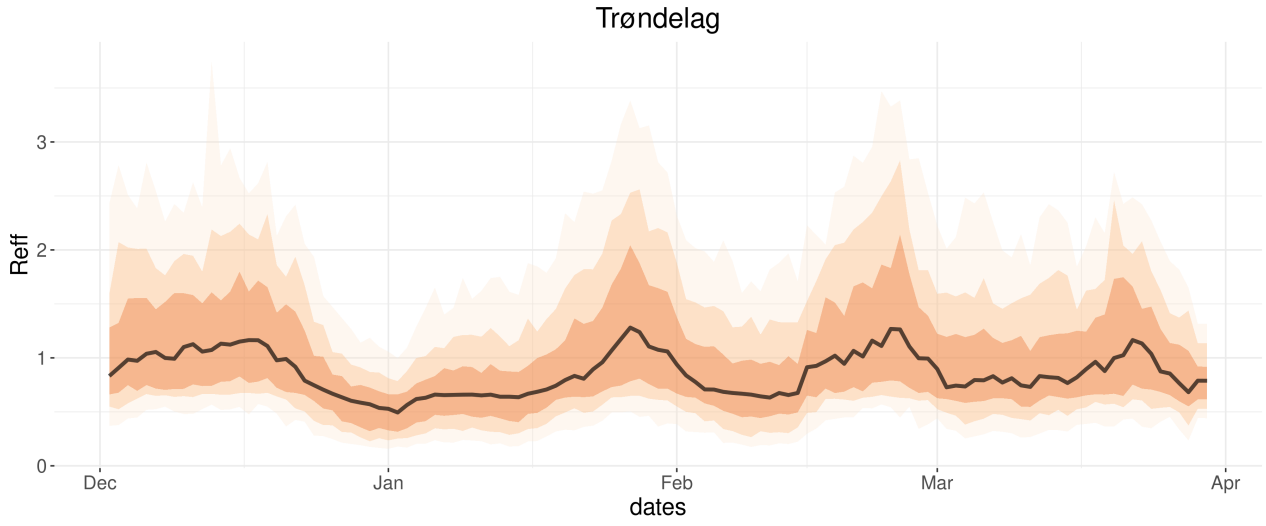
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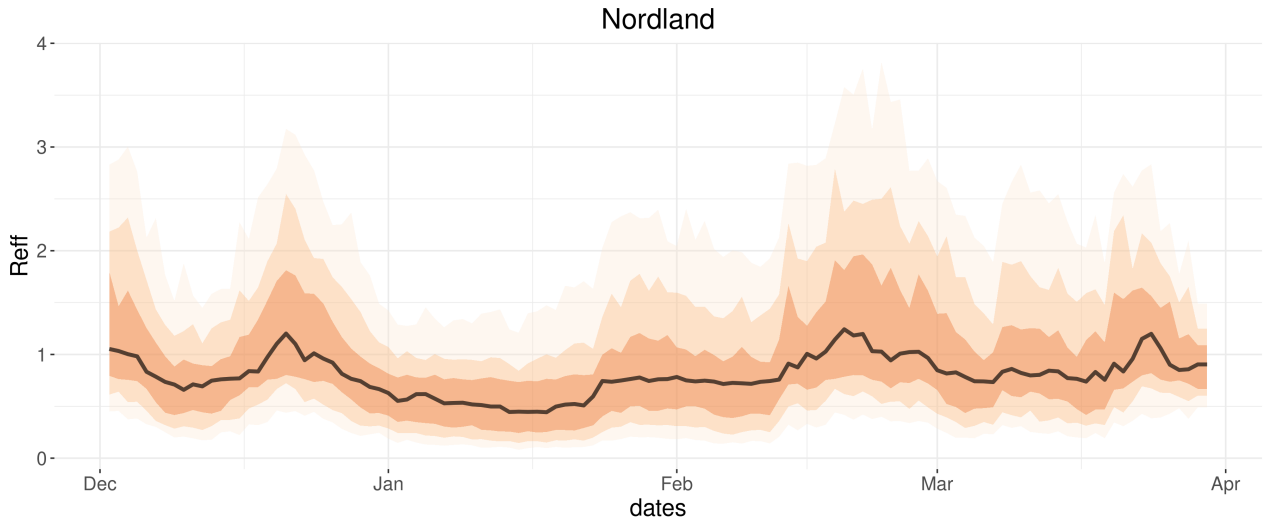
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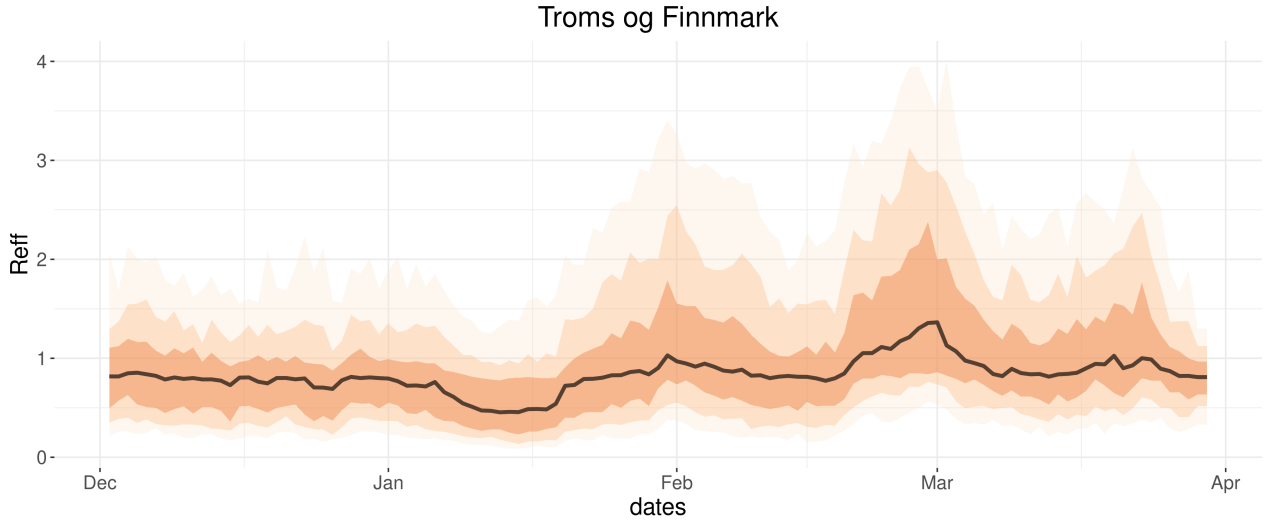
Troms og Finnmark
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Table 4: Assumptions

Assumptions	Mean	Distribution	Reference
Mobile Mobility Data			
Telenor coverage	48%		https://ekomstatistikken.nkom.no/
Data updated	Jun 5		
Data used in the predictions	Jun 3 rd	Fixed	Corrected to preserve population
Model parameters			
Exposed period ($1/\lambda_1$)	2 days	Exponential	changed from Feretti et al 2020
Pre-symptomatic period ($1/\lambda_2$)	2 days	Exponential	Feretti et al 2020
Symptomatic infectious period ($1/\gamma$)	3 days	Exponential	changed from Feretti et al 2020
Asymptomatic, infectious period ($1/\gamma$)	3 days	Exponential	changed from Feretti et al 2020
Infectiousness asympt. (r_{I_a})	0.1	Fixed	Feretti et al 2020
Infectiousness presymp (r_{E_2})	1.3	Fixed	guided by Feretti et al 2020
Prob. asymptomatic infection (p_a)	0.4		Feretti et al 2020
Healthcare			
Fraction asymptomatic infections	40%	Fixed	Mizumoto et al 2020 20% for the old population, Diamond Princess
% symptomatic and asymptomatic infections requiring hospitalization: 0-9 years 10 - 19 years 20 - 29 years 30 - 39 years 40 - 49 years 50 - 59 years 60 - 69 years 70 - 79 years 80+ years	 0.1% 0.1% 0.5% 1.1% 1.4% 2.9% 5.8% 9.3% 22.3%	Fixed	Saljie et al 2020 corrected for: % of elderly living in elderly homes in Norway (last two age groups) and corrected for presence among positive tested since May 1.
Probability that an admission has been reported on Monday From Sunday From Saturday From Friday From Thursday	 32% 49% 68% 86%	Fixed	Estimated from "Beredskapsregistret BeredtC19"
Probability that an admission has been reported From one day before From two days before From three days before From four days before	 53% 77% 82% 91%	Fixed	Estimated from "Beredskapsregistret BeredtC19"
Probability that a positive laboratory test has been reported From one day before From two days before From three days before From four days before	 6.7% 59% 90% 97%	Fixed	Estimated from MSIS
Probability that a negative laboratory test has been reported From one day before From two days before From three days before From four days before	 16% 74% 92% 98%	Fixed	Estimated from MSIS

Supplementary analysis: Trend analysis using various data sources

Due to significant changes in test recommendations, we present trend calculations from several monitoring data sources. Seen together, they can give insights on the trend of new infections. The data sources include:

- MSIS - A trend calculated from the number of confirmed positive cases. Changes in test criteria in recent weeks will likely lead to underestimating the trend of new infections.
- NOPaR: Admissions with covid-19 as the main reason, the trend is calculated from daily numbers admissions with covid-19 as the main cause. It usually takes longer from infection to hospitalization than for testing'; therefore, this indicator lacks behind the trend of transmission at around 1-2 weeks. The major difference in severity between Delta and Omicron also makes this indicator more challenging to interpret in the transition phase between the two variants.
- Symptometer - From the Symptometer survey, we calculate the proportion of respondents who self-report symptoms and a positive test for covid-19. This indicator provides a measure of the prevalence of infection in society, but after conversion, it can also provide an estimate of a trend for new infections.
- MoBa - The participants in MoBa are sent a mobile questionnaire form every other week, including questions about who has been "sick with respiratory symptoms/fever the last 14 days" and how many days ago the symptoms started. We calculate an approximate 14-day incidence of symptom onset from this indicator, which is used to estimate a trend in infection. The number of respondents is about 60-75,000 in each round.
- NPR and NoPaR: Proportion of all acute admissions with covid-19, including entries with other main causes than covid-19. This indicator measures the prevalence of infection in society and is then converted into incidence of infection.

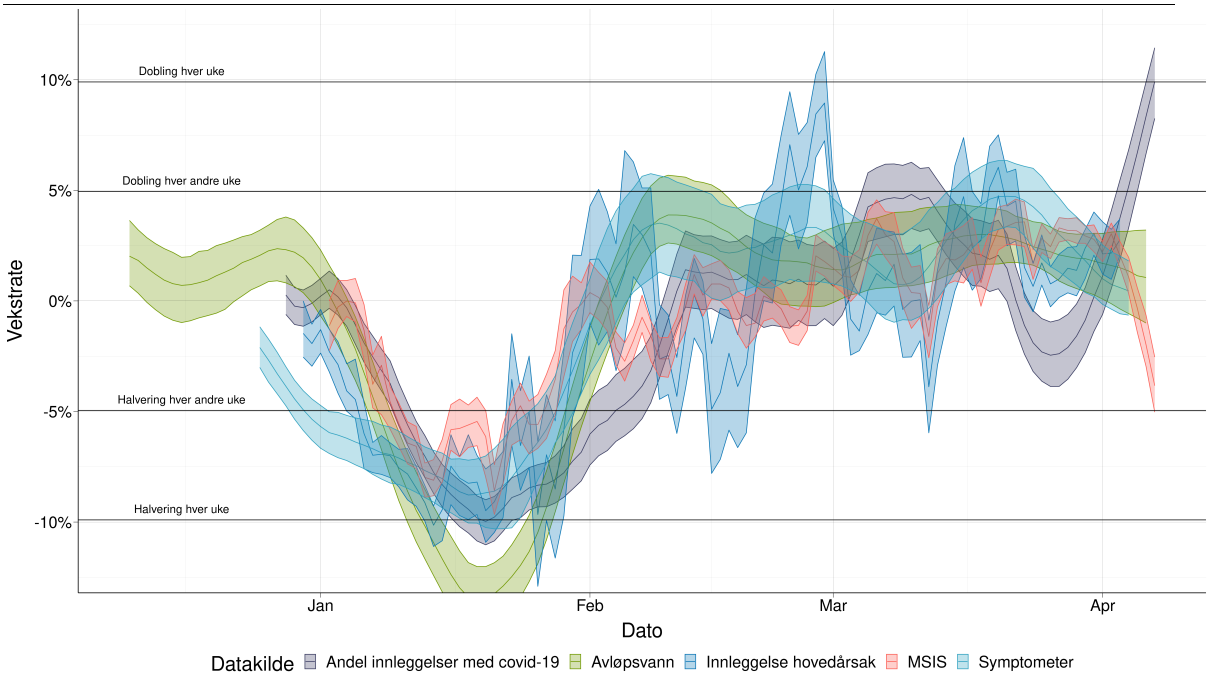

Figure 12: Trend analysis using various data sources

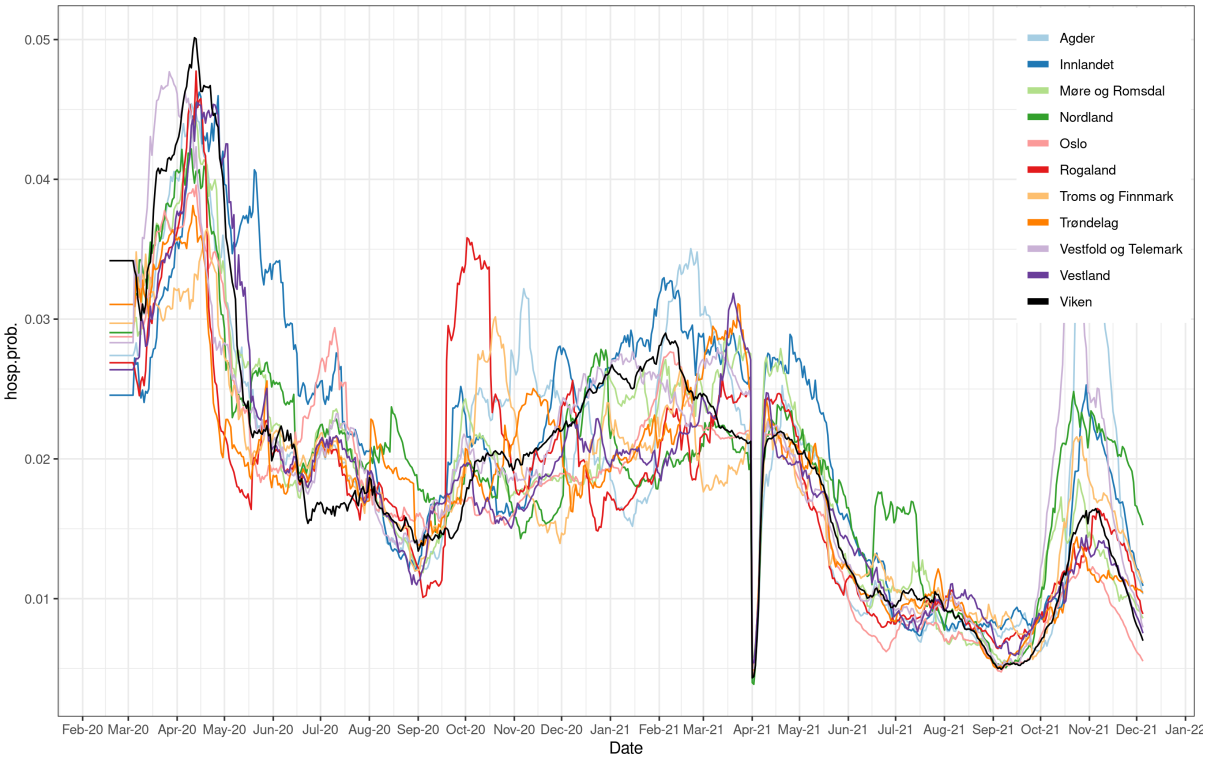

Figure 13: Regional hospitalisation probabilities per infection. The estimates are based on Salje et al., and regional data on the age distribution in the test data and the empirical case-hospitalisation rates.

Models and materials:

This report presents results based on a mathematical infectious disease model describing the geographical spread of COVID-19 in Norway. We use a metapopulation model for situational awareness and short-term forecasting and an individual-based model for long-term predictions. This report does not contain the long-term prediction results. Reproduction numbers of the metapopulation model are estimated in two ways: SMC-ABC is used to estimate a step-function in the transmissibility through prespecified changepoints, and SMC is used to estimate a daily varying reproduction number. We also provide estimates based on EpiEstim and a simple trend analysis. The models are described in previous reports and will not be explained here.
The metapopulation model takes daily varying Telenor mobility data as input. We also provide plots of the recent mobility for situational awareness.

How you should interpret the results: 3-week-ahead predictions and long-term scenarios
We provide both 3-week-ahead predictions and long-term scenarios. These are simulations of the disease spread into the future, under specific assumptions.
In the 3-week-ahead predictions, we assume that all parameters are as today, and simulate disease spread 3-weeks-ahead in time. Hence, these predictions are conditional on the current situation, and specifically on the most recently estimated reproduction number. The 3-week-ahead predictions thus do not take into account changes in transmissibility that are not yet captured by the available data, for example due to the delay between transmission and hospitalisation. Hence one of the conditions for the predictions to be valid is that the intervention policies do not change significantly in the next weeks. Hence, it does not make sense to evaluate or use the predictions if there are big changes in factors like

- new interventions
- relaxation of interventions
- a combination of new interventions and relaxations
- a significant change in vaccination coverage
- new variants with new properties
- a significant change in the contact behaviour of individuals.

As these factors are not likely to stay constant in the long-term future, we do not produce predictions for longer than three weeks ahead in time. Hence, our 3-week-ahead predictions are predictions of what may happen in the future, if there were no significant changes in the assumptions.
In this report, the term patient in ventilator treatment includes only those patients that require either invasive mechanical ventilation or ECMO (Extracorporeal membrane oxygenation).

FHI COVID-19 modelling team:

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