IHME
Measuring what matters

The IHME COVID-19 Model

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UNIVERSITY of WASHINGTON
Institute for Health Metrics and Evaluation

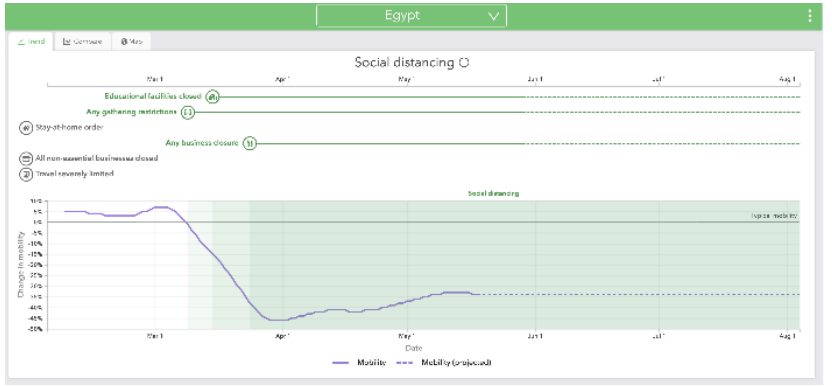
Origin of the model

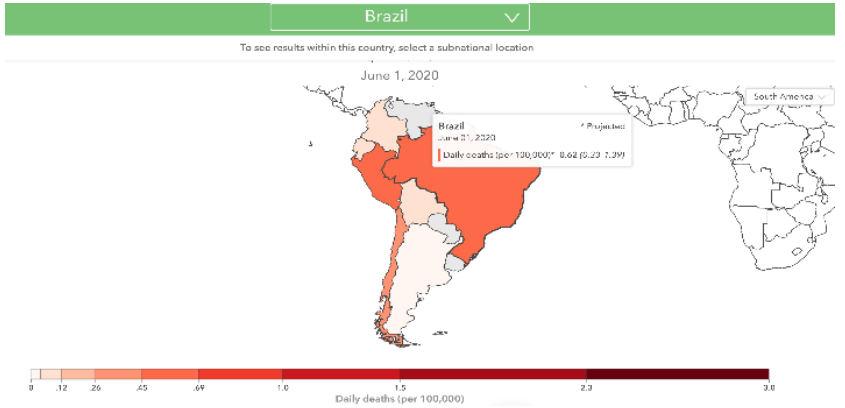
- Primary goal to provide estimates of COVID-19 patient hospital utilization to help hospital systems plan for the upcoming surge
  - Initially a response to a request from UW Medicine but demand prompted expansion to all US States and countries

- Key features
  - Projections for next 3 months
  - Regular updates
  - Started modeling deaths & resource use
  - Expanded to infections and testing

Model forecasts and scenarios

- Epidemiological outputs: infections, deaths, antibody prevalence
- Health system outputs: hospitalizations, ICU admissions, and ventilator need
- As part of the modeling process, produce forecasts of testing per capita, mobility per capita, social distancing mandates, mask use and seasonality
- We produce a reference forecast, what we think is most likely to happen but the model allows exploration of many scenarios





Covid Model Development over the past 2 months

CurveFit Mar 26 – May 3	Curvefit-SEIR Hybrid May 4 – present	RCKS-SEIR Hybrid
• Statistical, deaths-based model • Performed well for locations with >50 deaths • Focused on predicting initial peak of hospital resource use as a function of social distancing • Limited in application to countries with >50 deaths	• Mixture of CurveFit and SEIR • Fitted a statistical model to the past and next 8 days; and an SEIR model to predict after 8 days • Better fit to observed declines after peak • Still some limitations around variable input data and small epidemics • Additional covariates: mobility, testing, temperature, pop density	• No more CurveFit • Analysis of cases corrected for testing trends, hospitalizations, and deaths to estimate past & next 8 days • Fit an SEIR model to these trends • Additional covariates: mask use, human contact rates, pneumonia seasonality

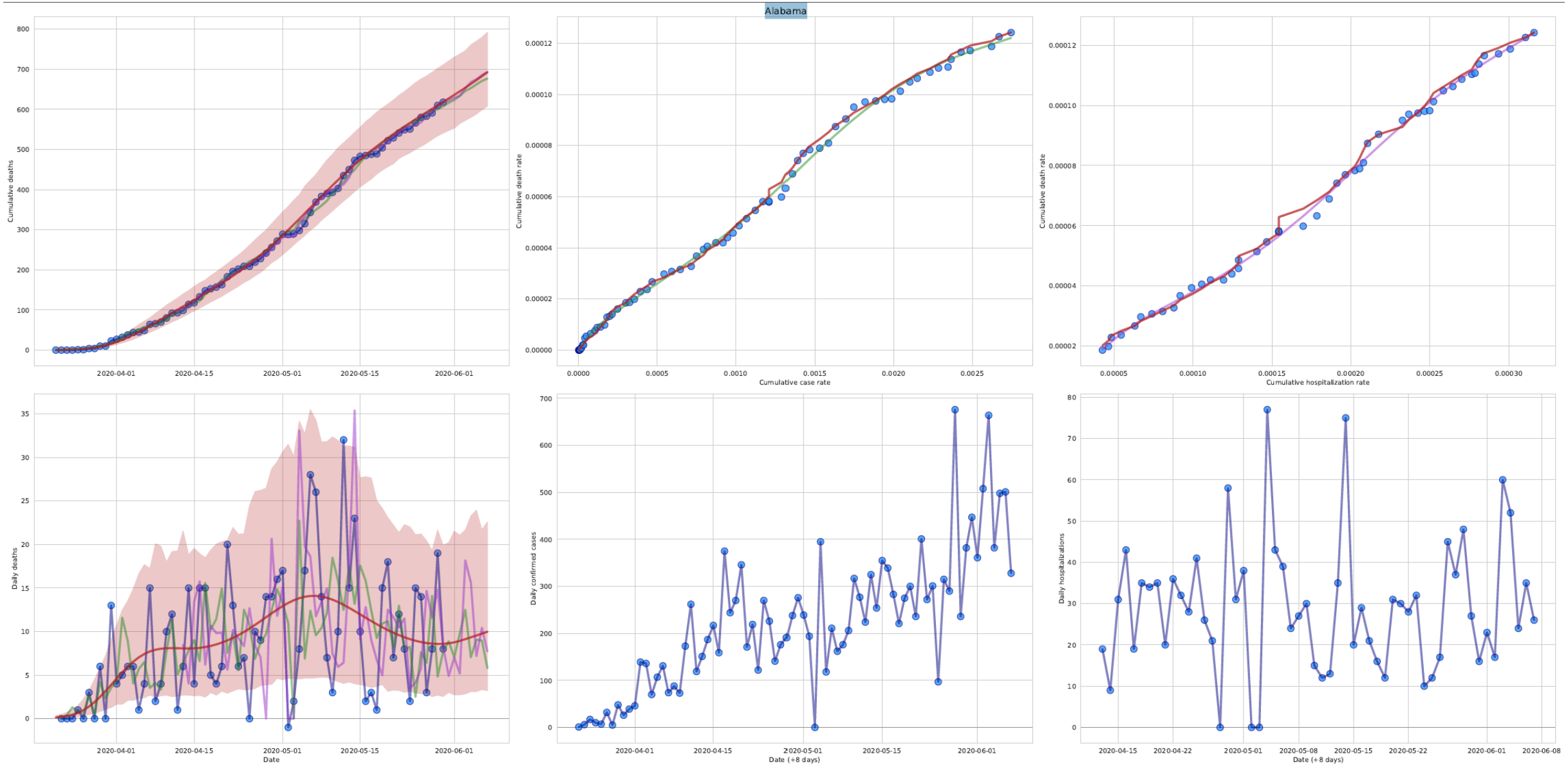
Key steps in the RKCS-SEIR model

1) Combine data on cases correcting for trends in testing, hospitalizations, and deaths into a coherent trend in daily deaths with uncertainty.
2) Resample 1000 draws of daily deaths from this trend for each location
3) Using estimated infection fatality rate by age and the distribution of time from infection to death, use daily deaths to generate 1000 distributions of estimated infections by day in the past.
4) Fit SEIR model with beta varying over time to the trend in estimated infections 1000 times to generate 1000 SEIR models. Other SEIR parameters like gamma, sigma, alpha sampled over defined ranges.
5) Estimate the statistical relationship between beta(t) and covariates

Key steps in the RKCS-SEIR model

6) Forecast covariates
7) Predict beta(t) as a function of forecasted covariates
8) Use predicted beta(t) to estimate infections, deaths in the future
9) Take predicted infections and deaths and a hospital use microsimulation to estimate hospital resource need.

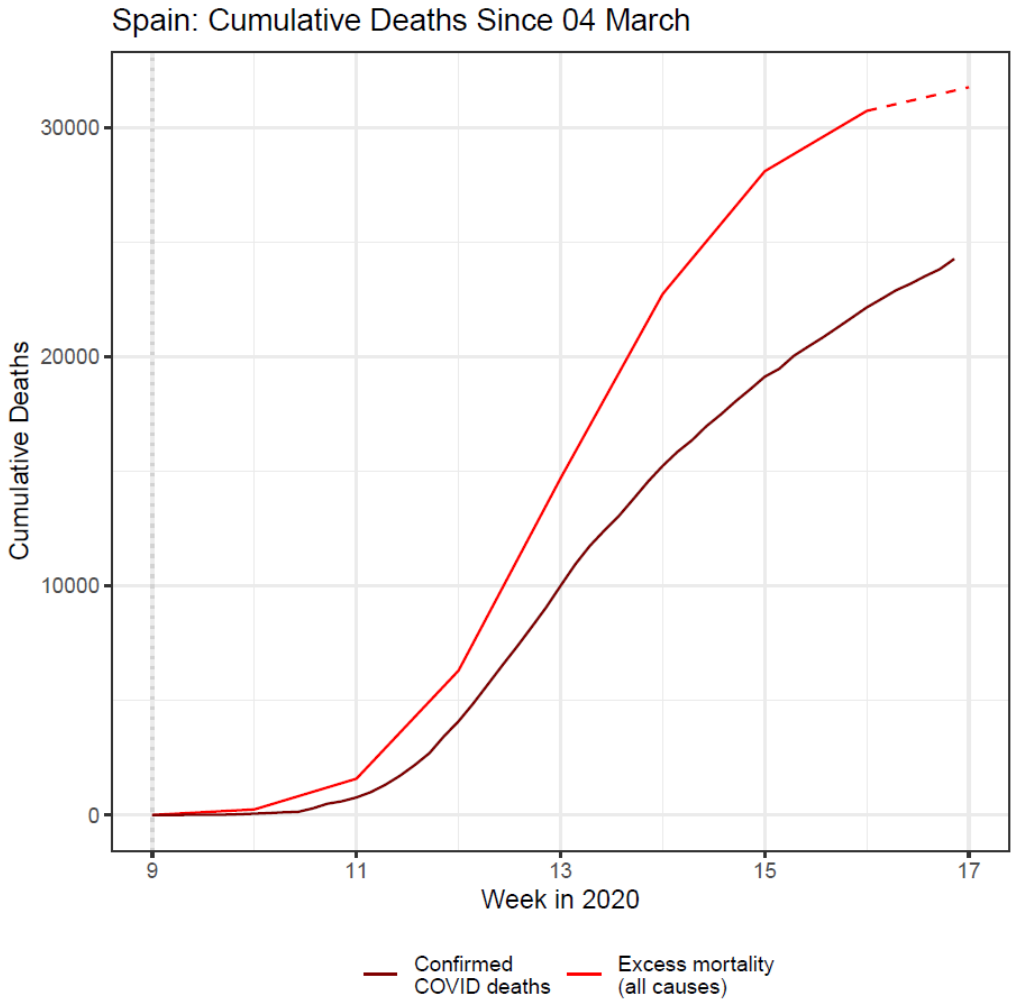
Random knot combination spline

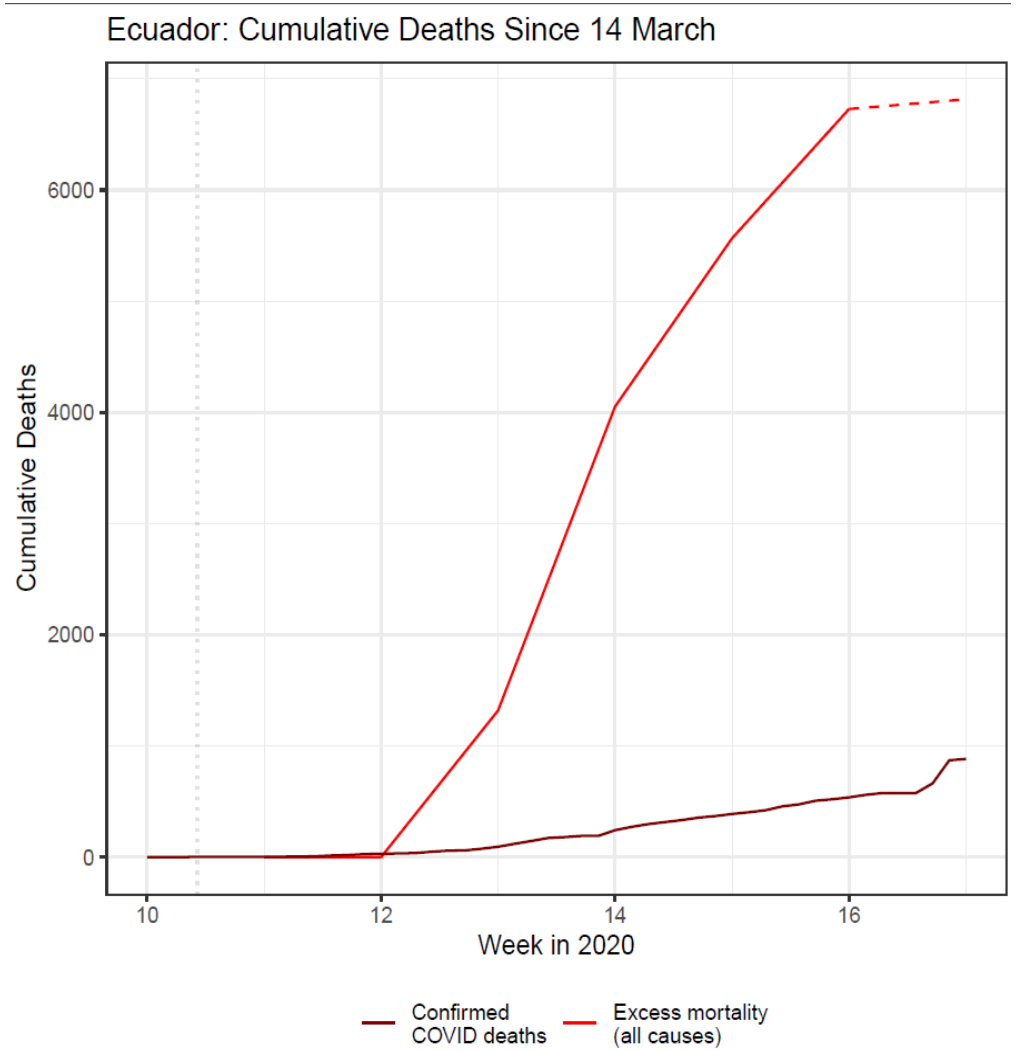


Current Deaths due to Covid-19 as of June 3, 2020

Super Region	Total deaths
Global	**345,998 (343827, 349916)**
Southeast Asia, East Asia, and Oceania	2900 (2842, 2974)
Central Europe, Eastern Europe, and Central Asia	11221 (11058, 11410)
High-income	245010 (244590, 245373)
Latin America and Caribbean	59742 (57628, 63651)
North Africa and Middle East	16590 (16490, 16856)
South Asia	8201 (8006, 8486)
Sub-Saharan Africa	2332 (2213, 2600)

Excess Mortality (all causes) vs COVID confirmed deaths





Ultra-fast computational solution for SEIR models

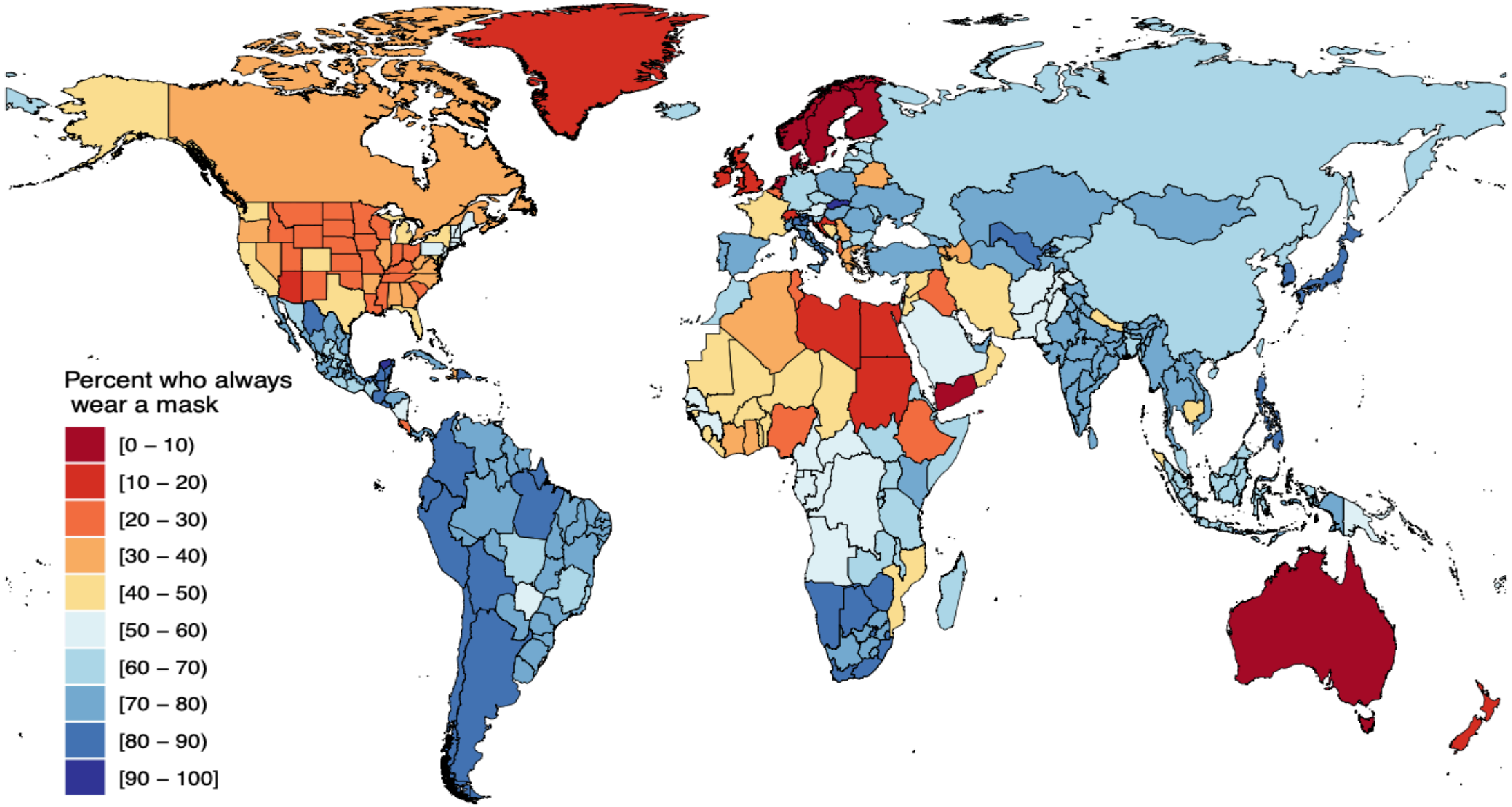
- Our Mathematical Sciences and Computational Algorithms group developed a way to fit 250,000 SEIR models in less than an hour allowing us to estimate 1000 SEIR models for each location reflecting uncertainty in cases, hospitalizations and deaths.

- Allows IHME model to incorporate a wide range of sources of uncertainty into the creation of the model pool.

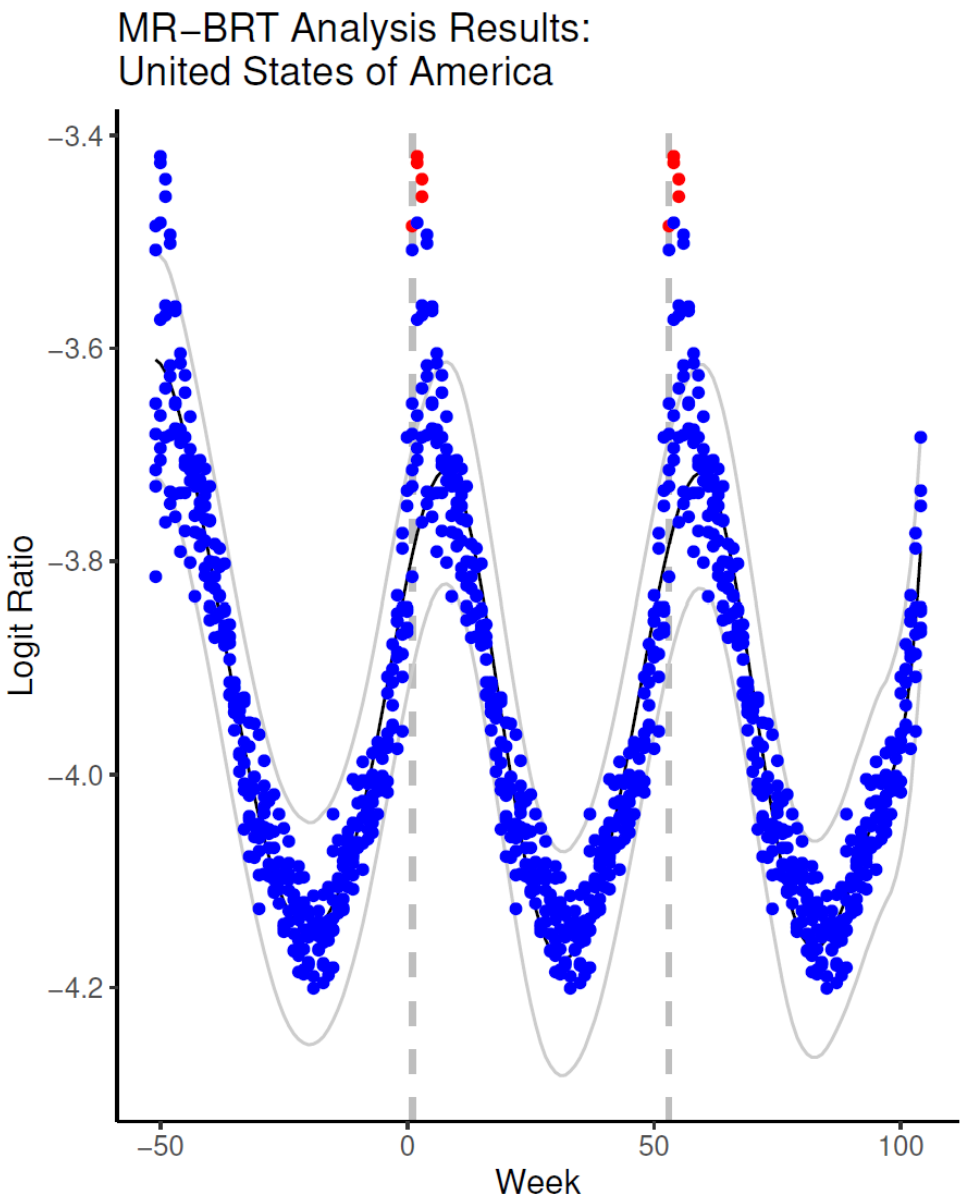
Predicting beta(t)

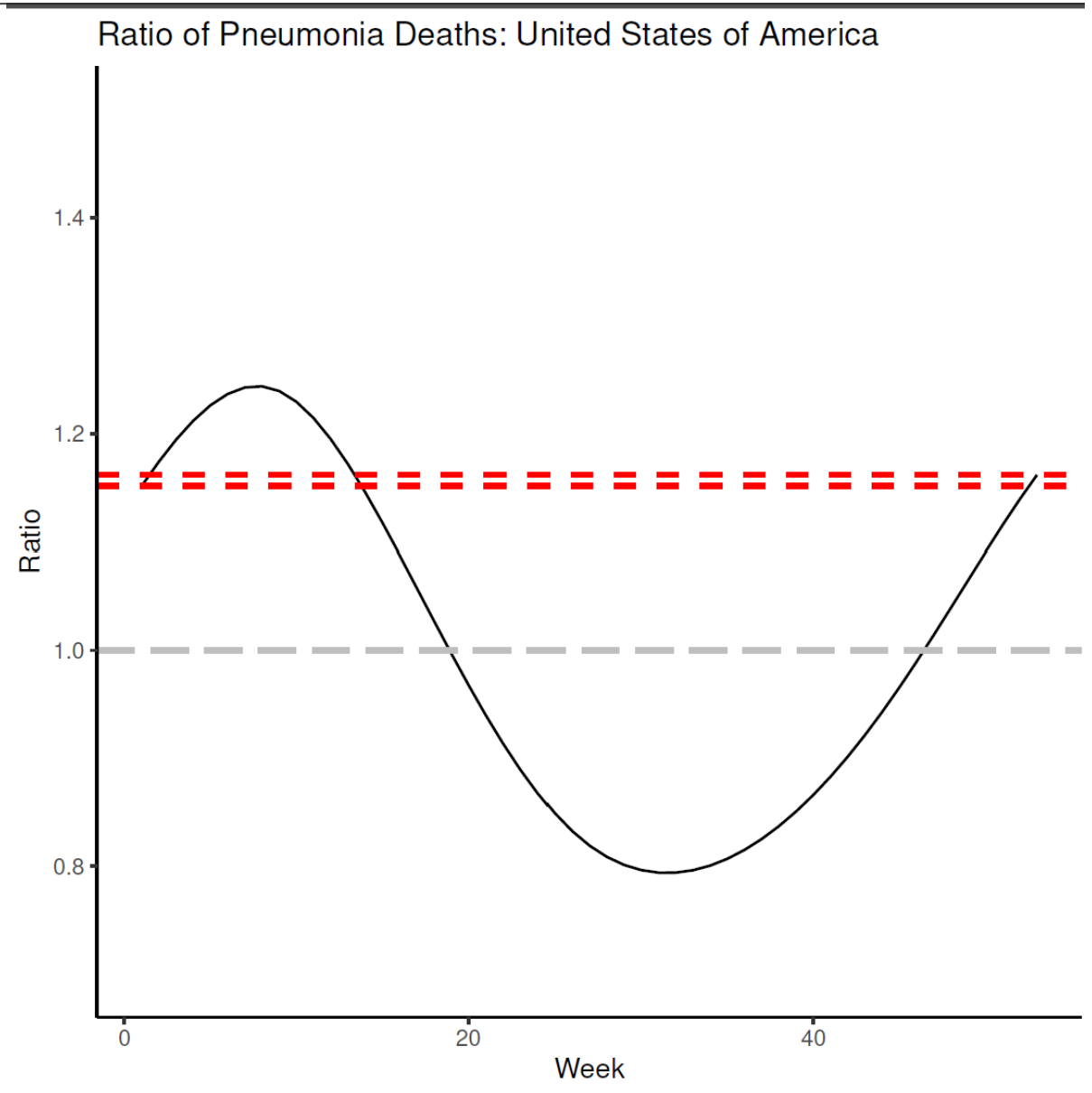
- Wide range of covariates tested or being tested: population density, household size, public transport, urban slums, flu seasonality, pneumonia seasonality, mobility, mask use, self-reported number of contacts, testing per capita, mandates, sum of mandates
- To date, regression analysis shows strong relationships for pneumonia seasonality, mobility, mask use, testing per capita, population density.
- These variables used in current iteration of model.

Mask Use: Facebook survey

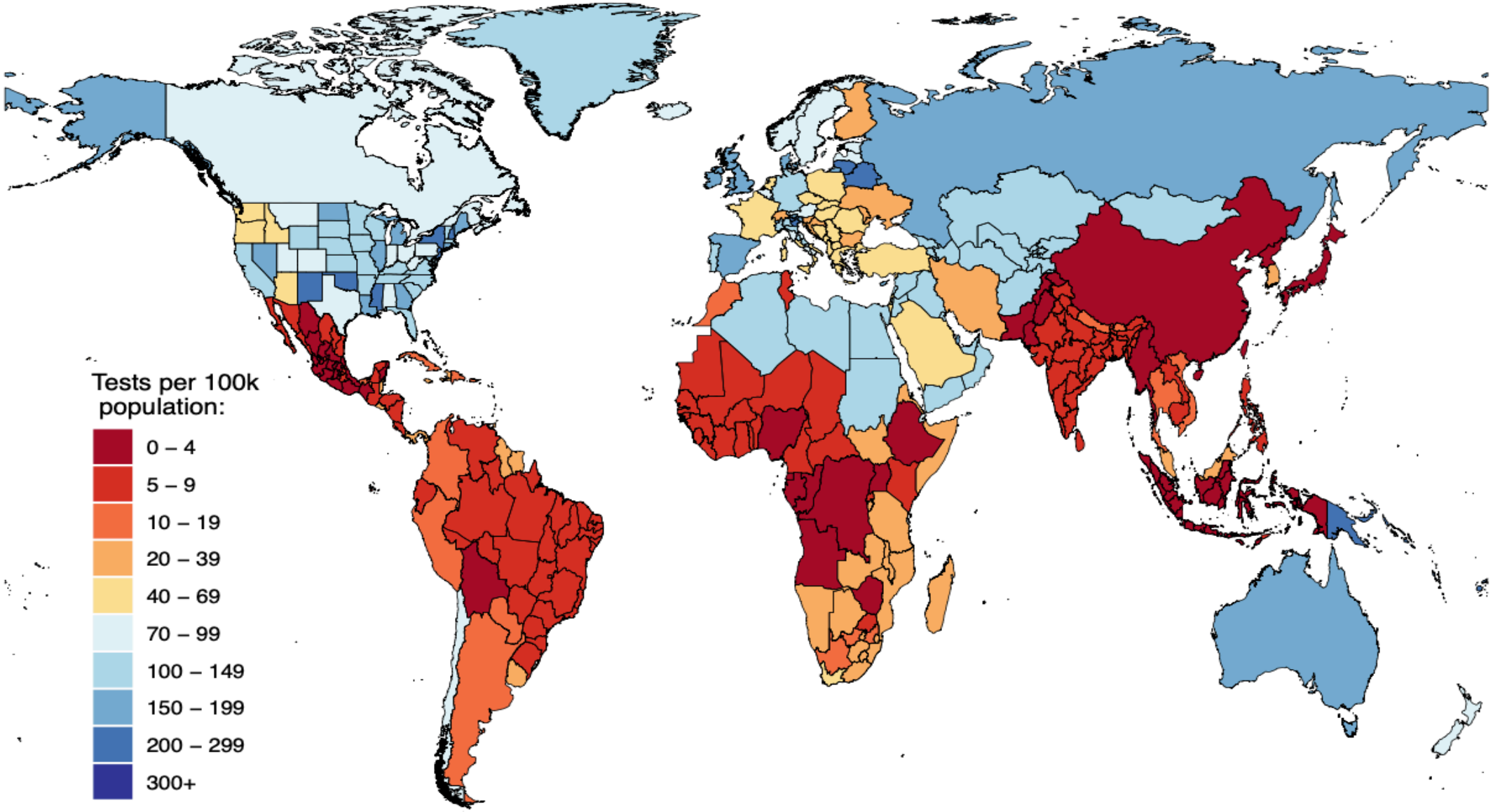


Pneumonia deaths by week



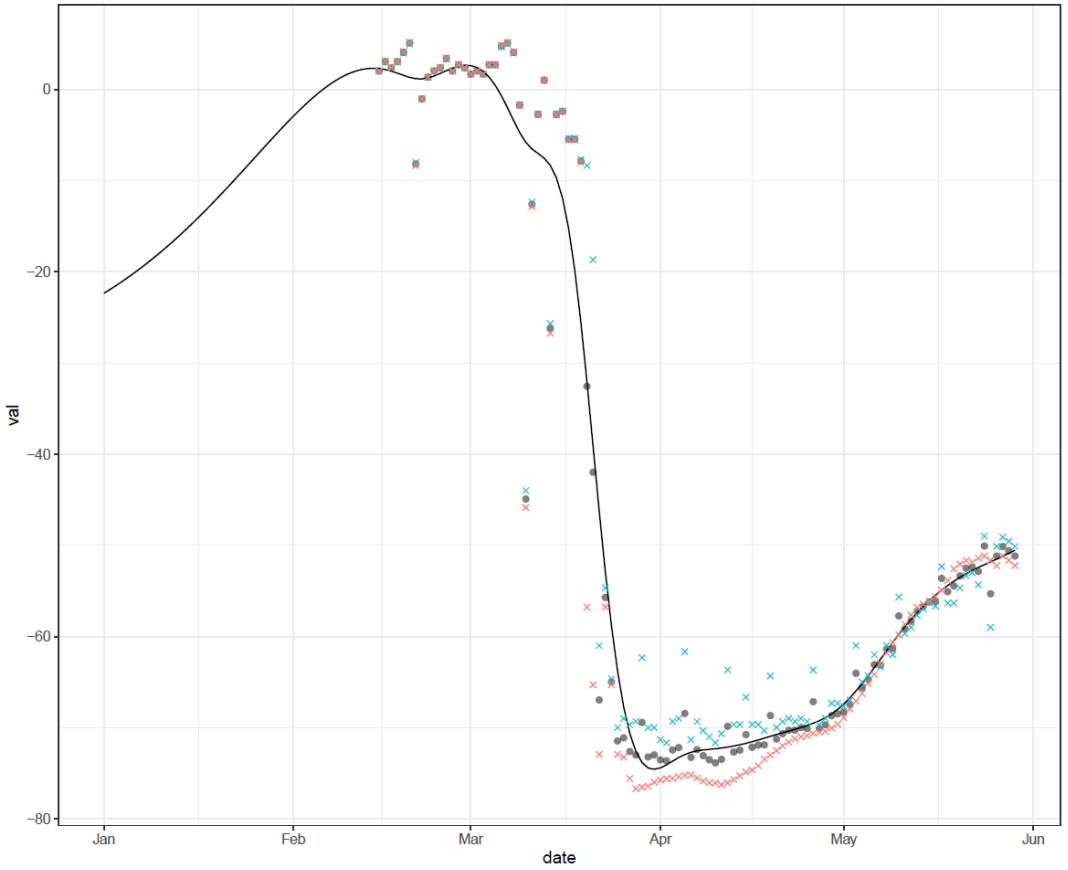


Covid daily testing per 100,000

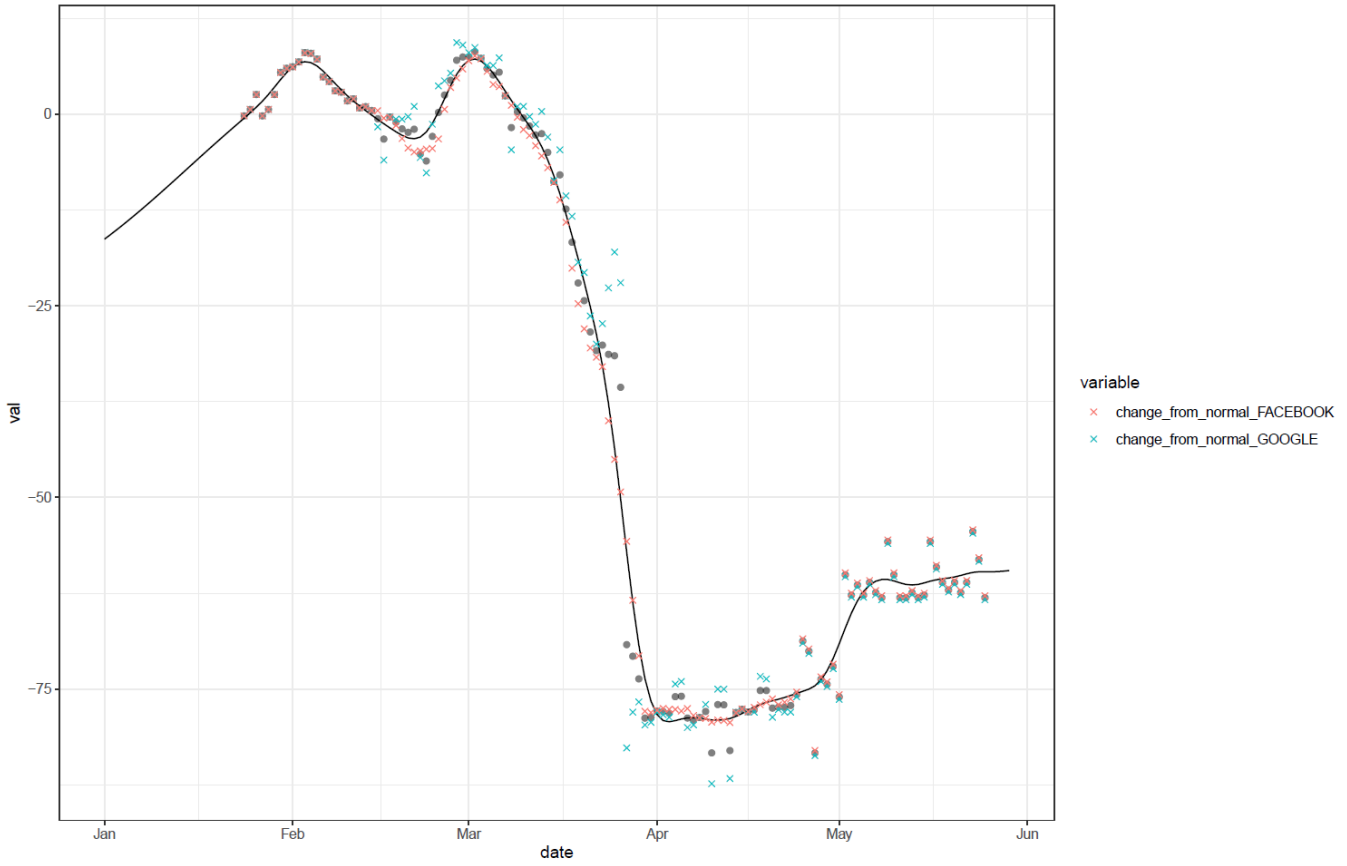


Cellphone app Mobility Data in Madhya Pradesh, India and Western Cape, South Africa

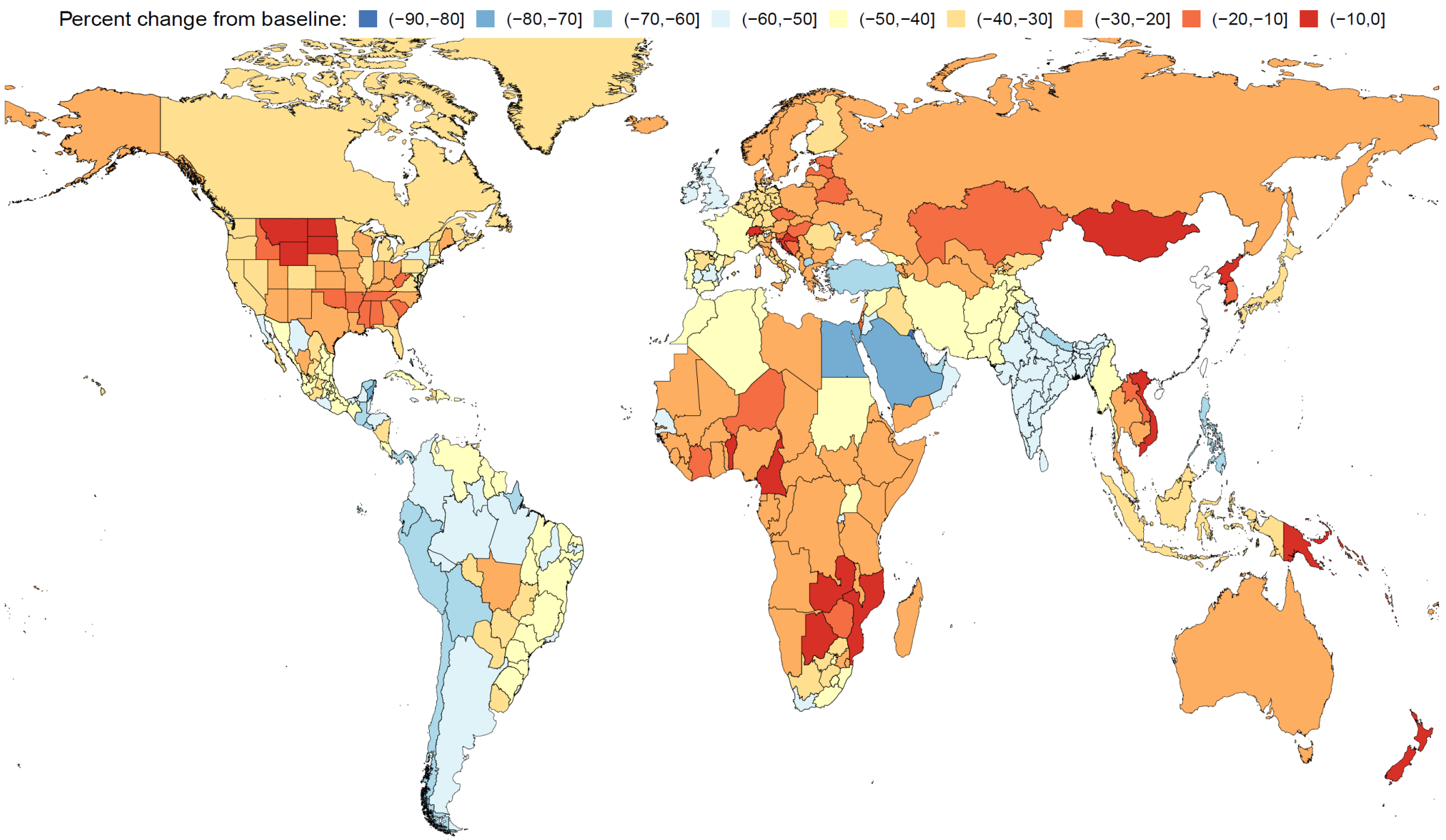
Madhya Pradesh



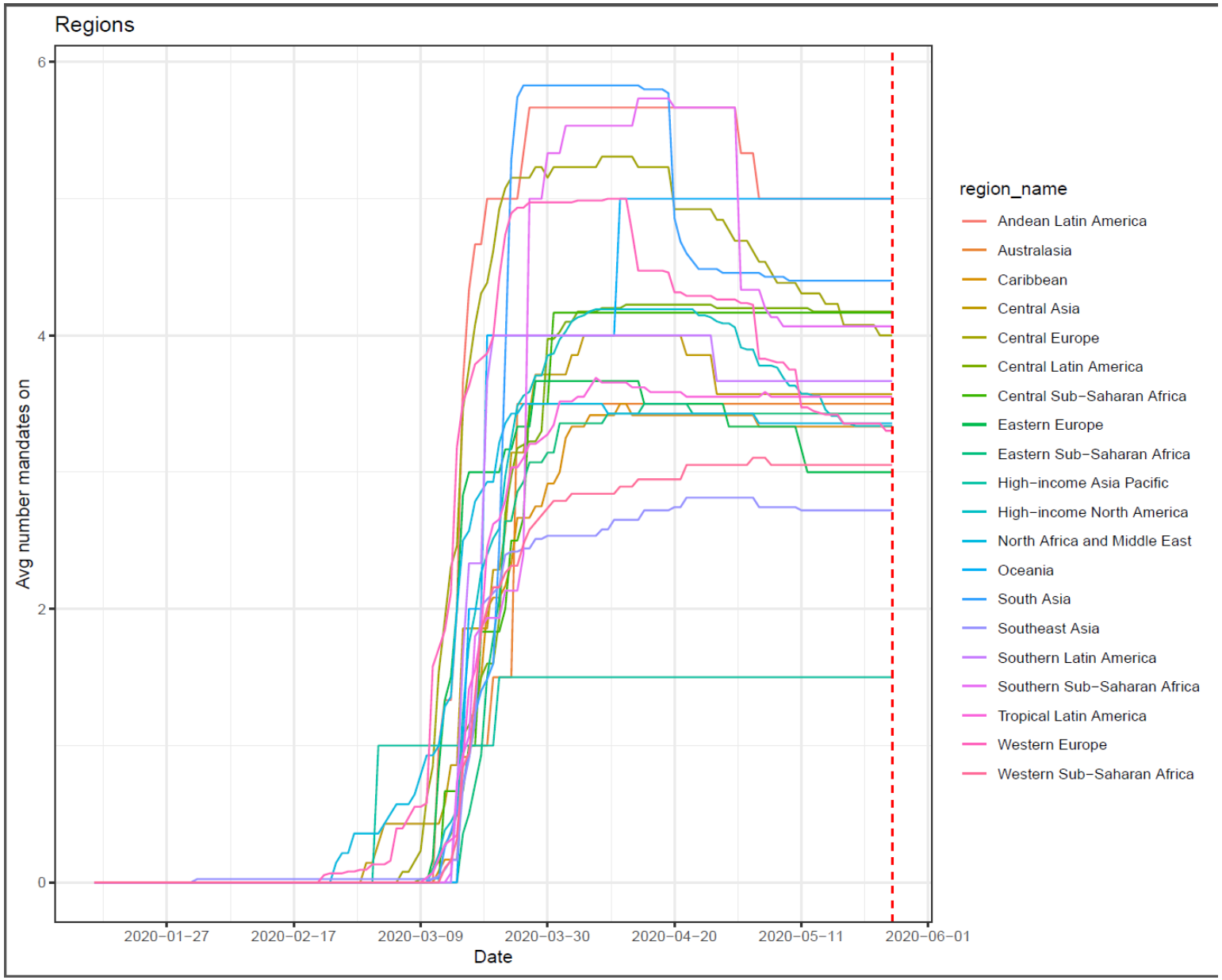
Western Cape



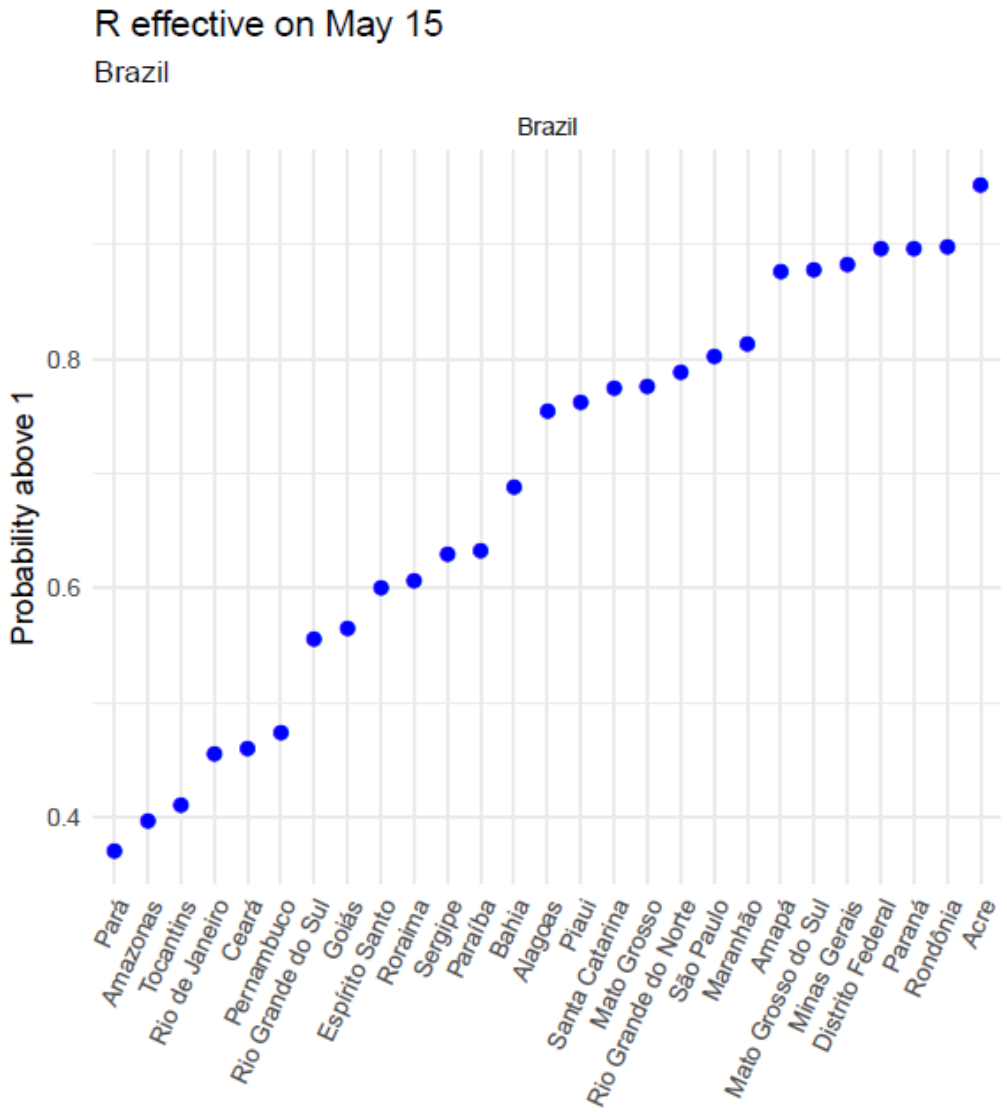
Mobility forecasted on June 1

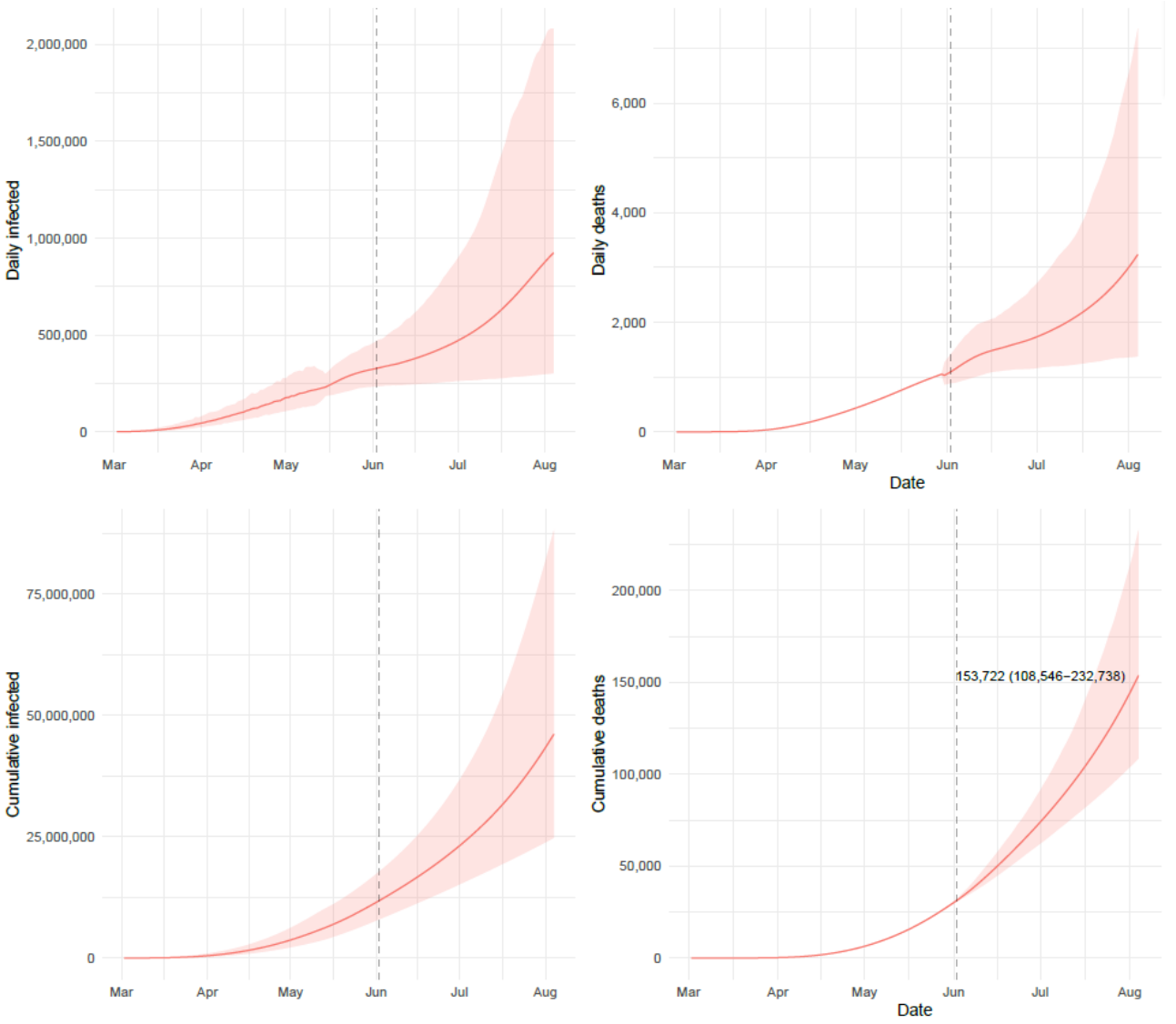


Mandates by region and time



Brazil





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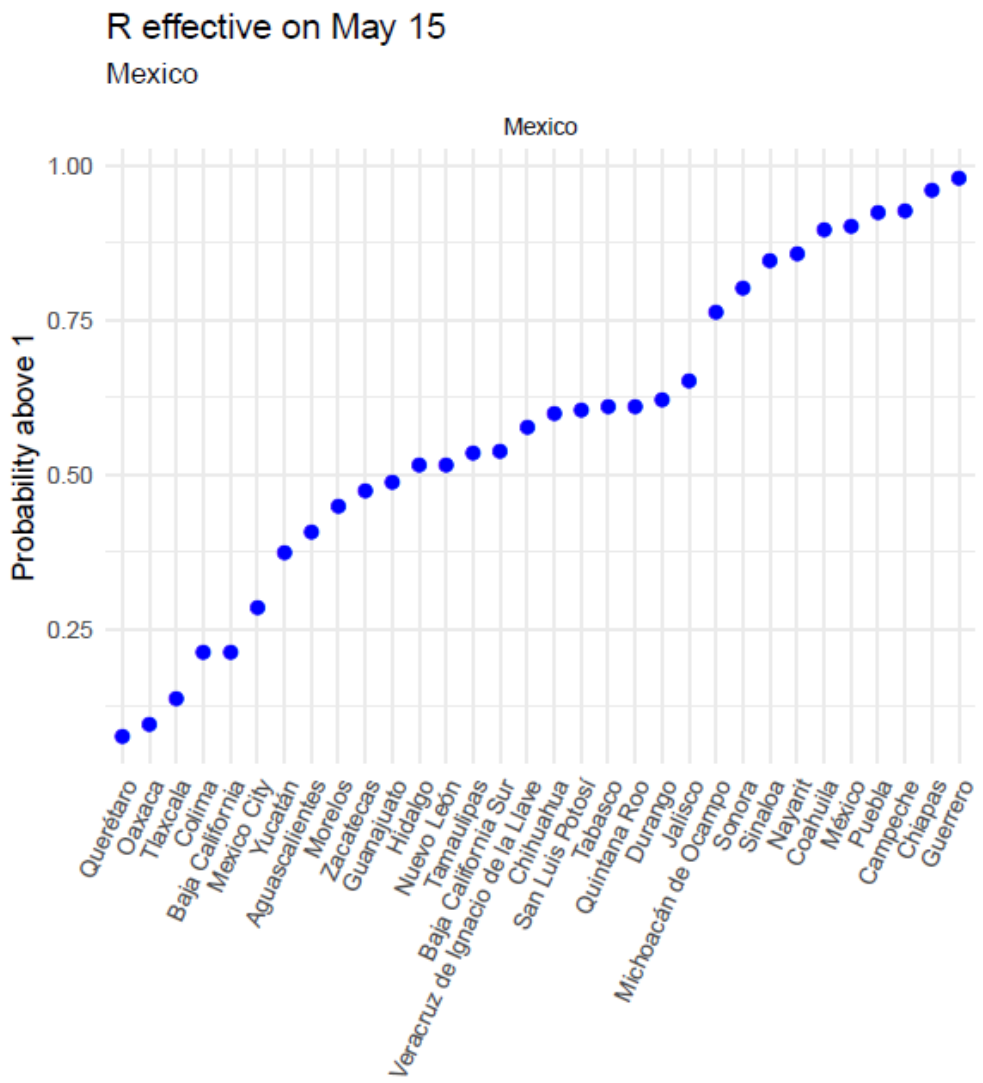
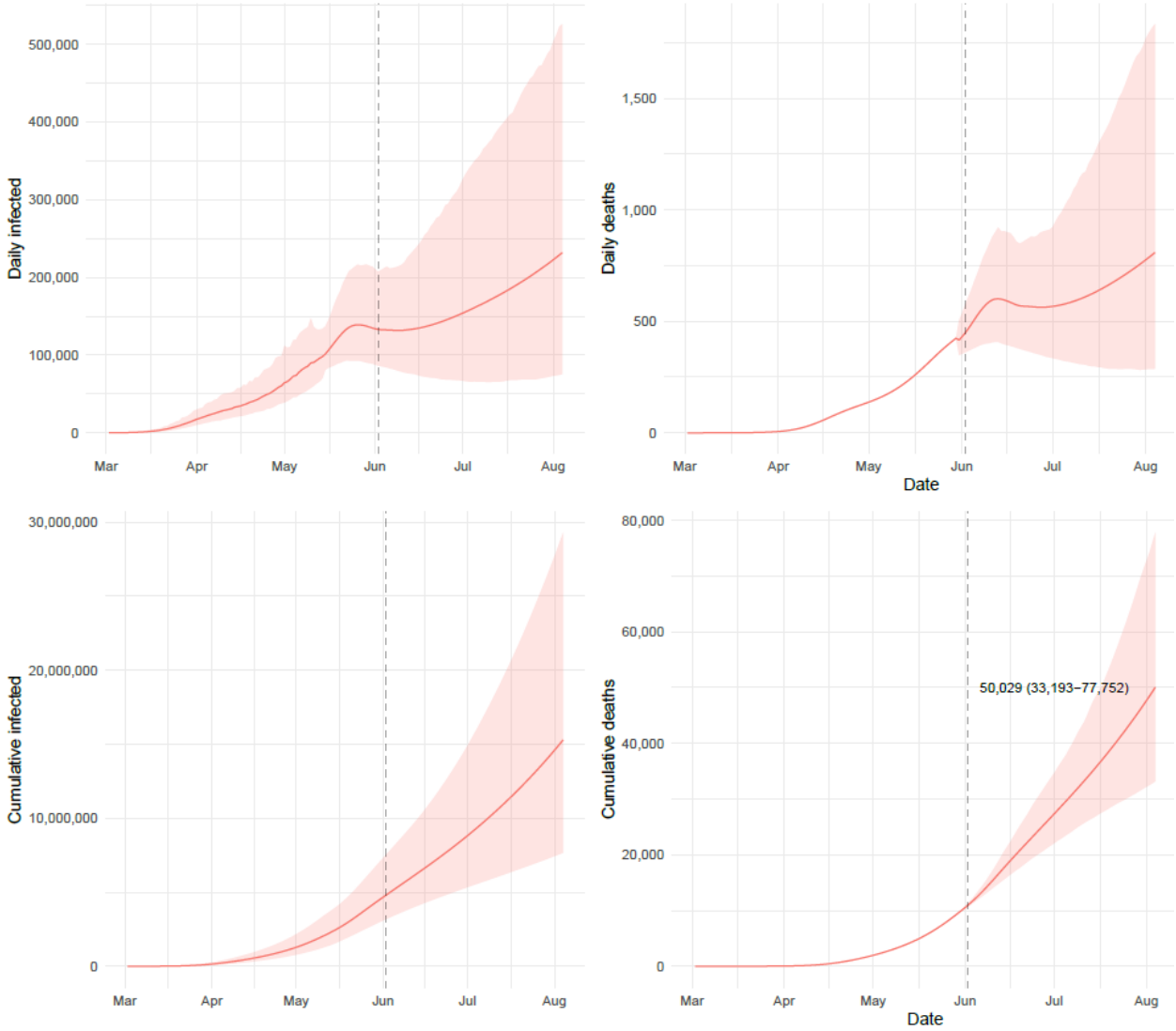
Mexico





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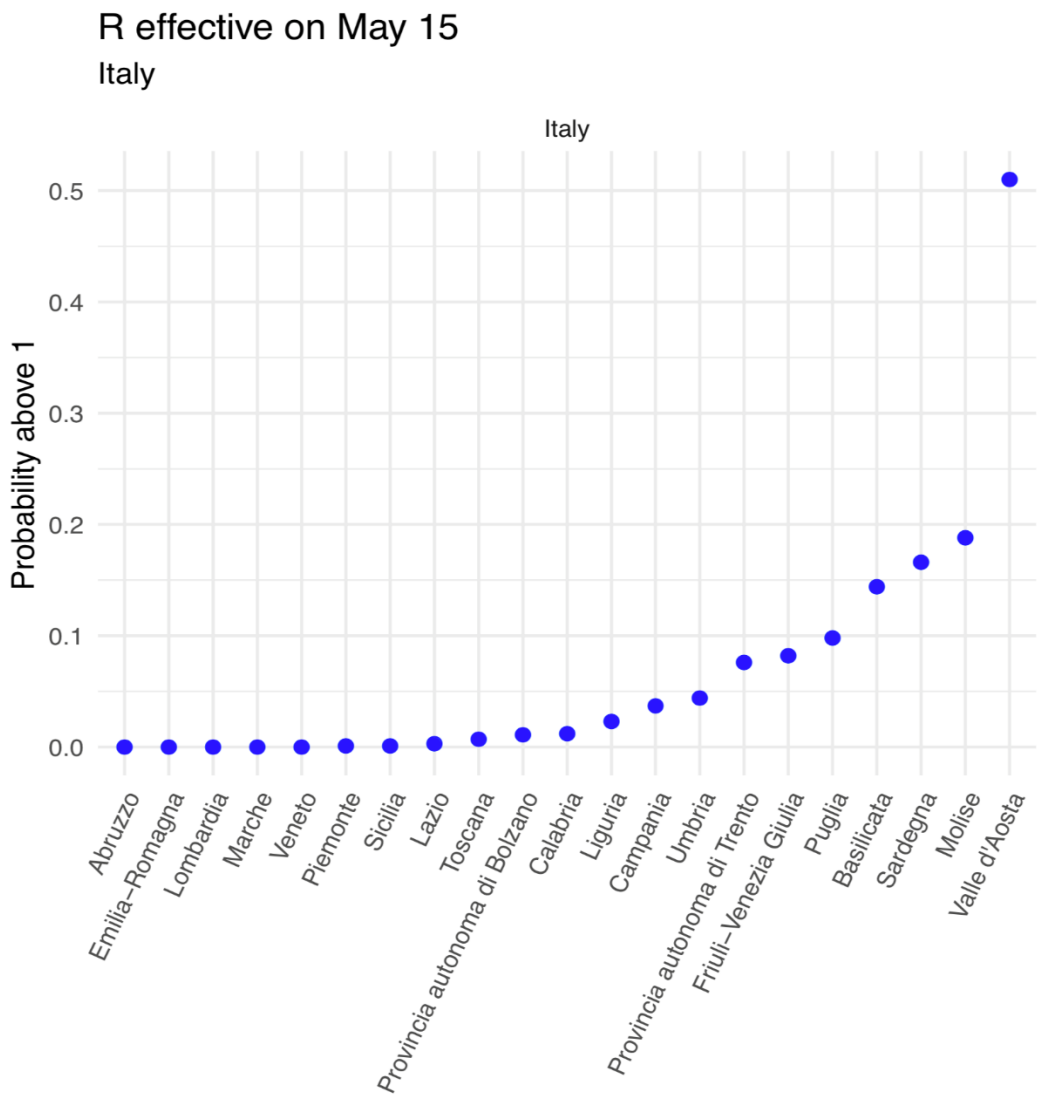
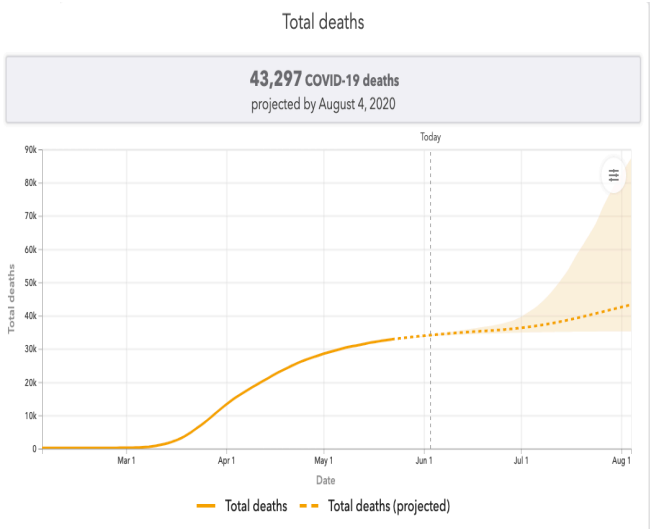
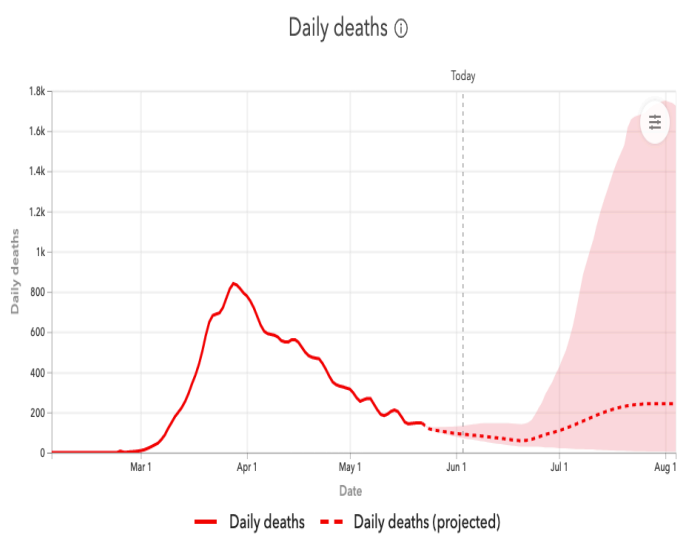
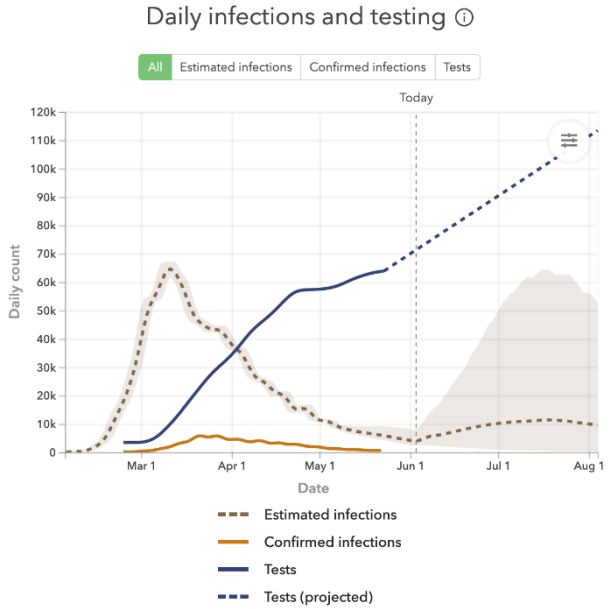
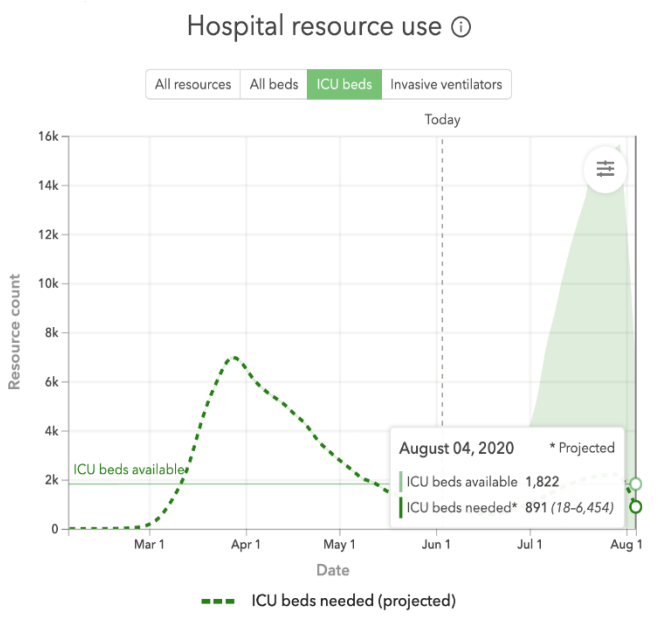
Italy


R effective on May 15
Italy
Italy
Probability above 1
0.5
0.4
0.3
0.2
0.1
0.0
Abruzzo
Emilia–Romagna
Lombardia
Marche
Veneto
Piemonte
Sicilia
Lazio
Toscana
Provincia autonoma di Bolzano
Calabria
Liguria
Campania
Umbria
Provincia autonoma di Trento
Friuli–Venezia Giulia
Puglia
Basilicata
Sardegna
Molise
Valle d'Aosta

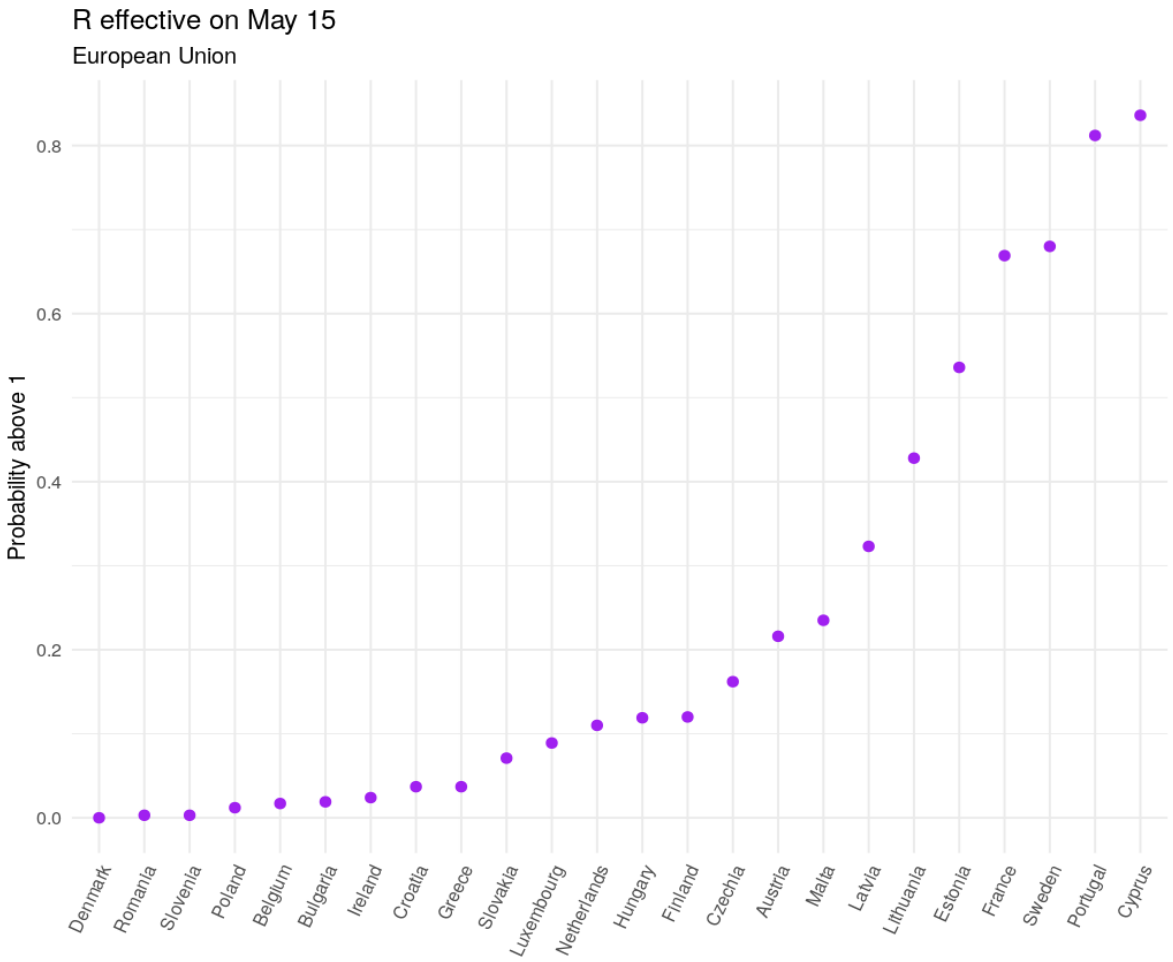

Total deaths
43,297 COVID-19 deaths
projected by August 4, 2020
Today
Total deaths
Date
Total deaths
Total deaths (projected)


Daily deaths
Today
Daily deaths
Date
Daily deaths
Daily deaths (projected)

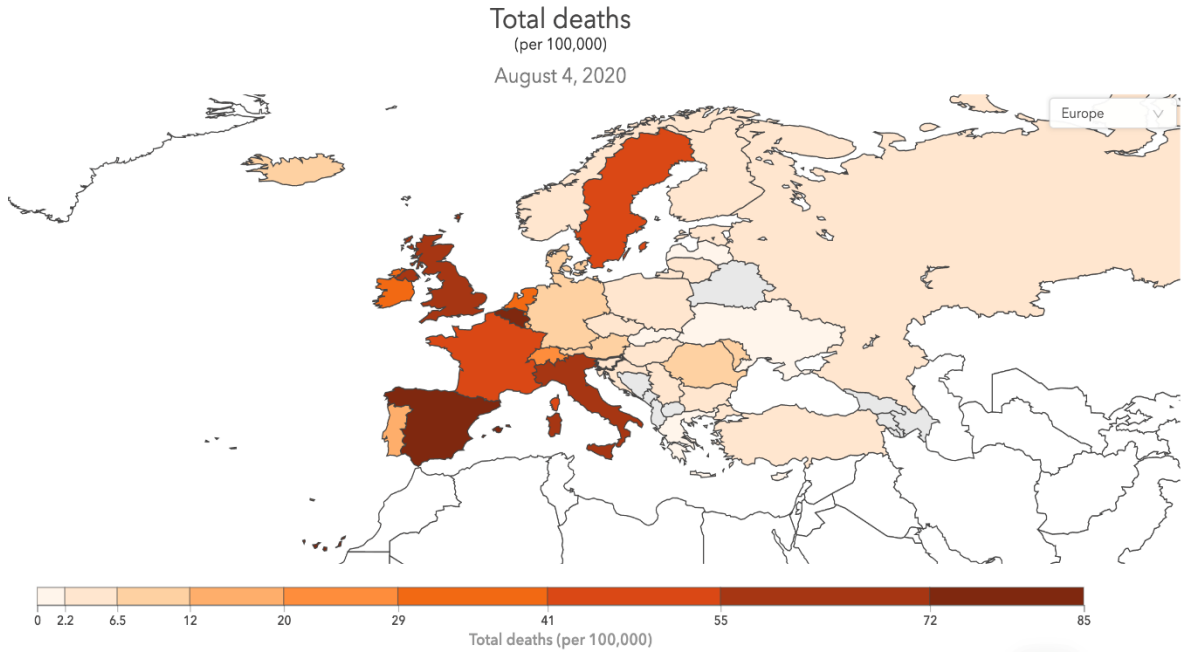

Daily infections and testing
All
Estimated infections
Confirmed infections
Tests
Today
Daily count
Date
Estimated infections
Confirmed infections
Tests
Tests (projected)


Hospital resource use
All resources
All beds
ICU beds
Invasive ventilators
Today
Resource count
ICU beds available
August 04, 2020
* Projected
ICU beds available 1,822
ICU beds needed* 891 (18–6,454)
Date
ICU beds needed (projected)

Europe



Plot for the EU countries, excluding countries with subnational projections: Italy, Spain, Germany



Highest numbers of cumulative COVID-19 deaths projected in:

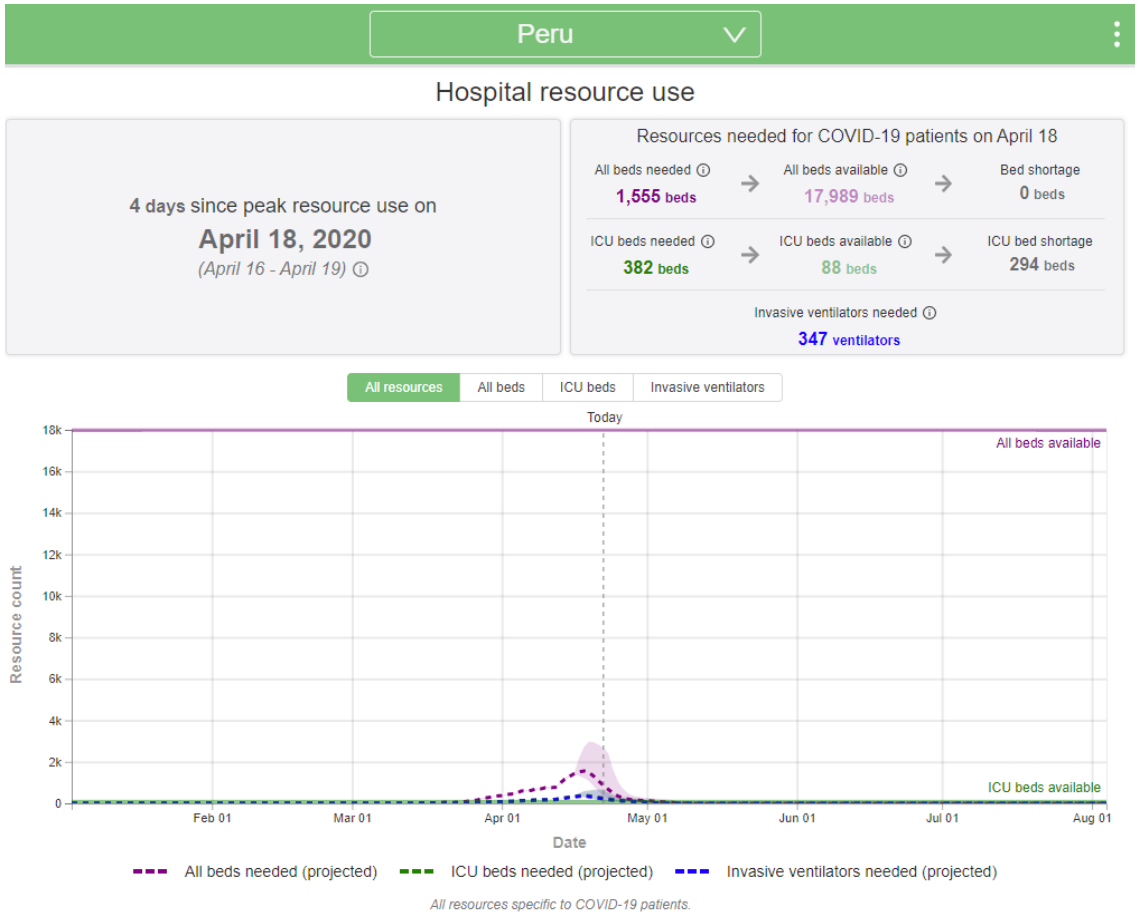
- UK
- Italy
- Spain
- France
- Belgium
- Sweden

Projected total Covid-19 infections and deaths by August 4, 2020

Region	Estimated Infections (lower, upper)	Deaths (lower, upper)
Global	**307,472,896 (147942289, 646396051)**	**733,875 (588021, 969483)**
Southeast Asia, East Asia, and Oceania	9718136 (3017274, 37562436)	7813 (5534, 12554)
Central Europe, Eastern Europe, and Central Asia	4000801 (2659770, 7352651)	24391 (19114, 34338)
High-income	46496903 (34633480, 69935667)	321032 (295840, 365580)
Latin America and Caribbean	132796828 (72436584, 224483983)	279295 (196309, 412448)
North Africa and Middle East	15545922 (6202599, 34608869)	31788 (20647, 72123)
South Asia	50404703 (12816648, 162194657)	46416 (26255, 80996)
Sub-Saharan Africa	48509598 (6539539, 189972973)	23137 (8249, 60836)

How our model can be used for planning

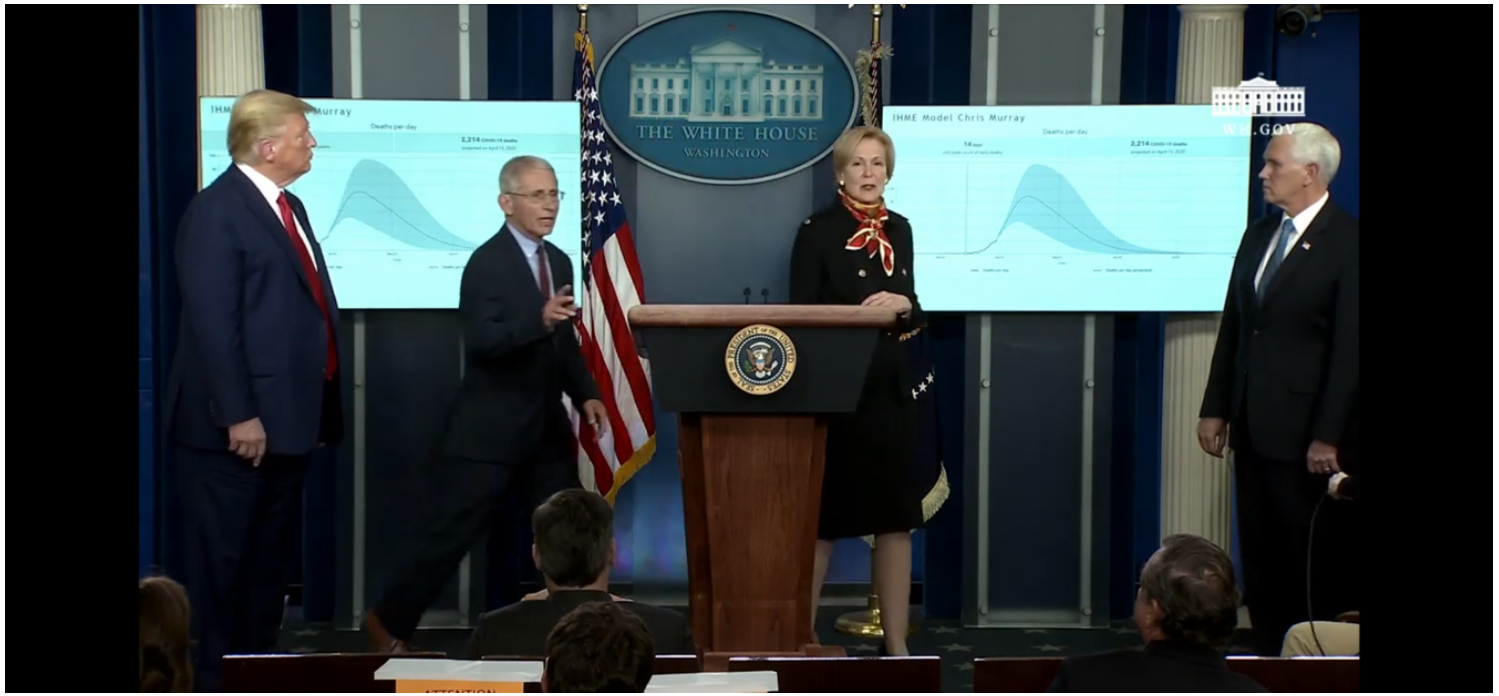
- Planning:
  - Plan what hospital resources are likely needed for the weeks and months ahead
  - Important to plan for upper range of estimates
- Tool getting better all the time:
  - New data
  - Improved models
  - Constantly refining with feedback



https://covid19.healthdata.org/projections

IHME COVID-19 Model: U.S. National Policy Impact

- White House used the model to inform the nationwide mandates on social distancing, and has since engaged with IHME daily on the projections.



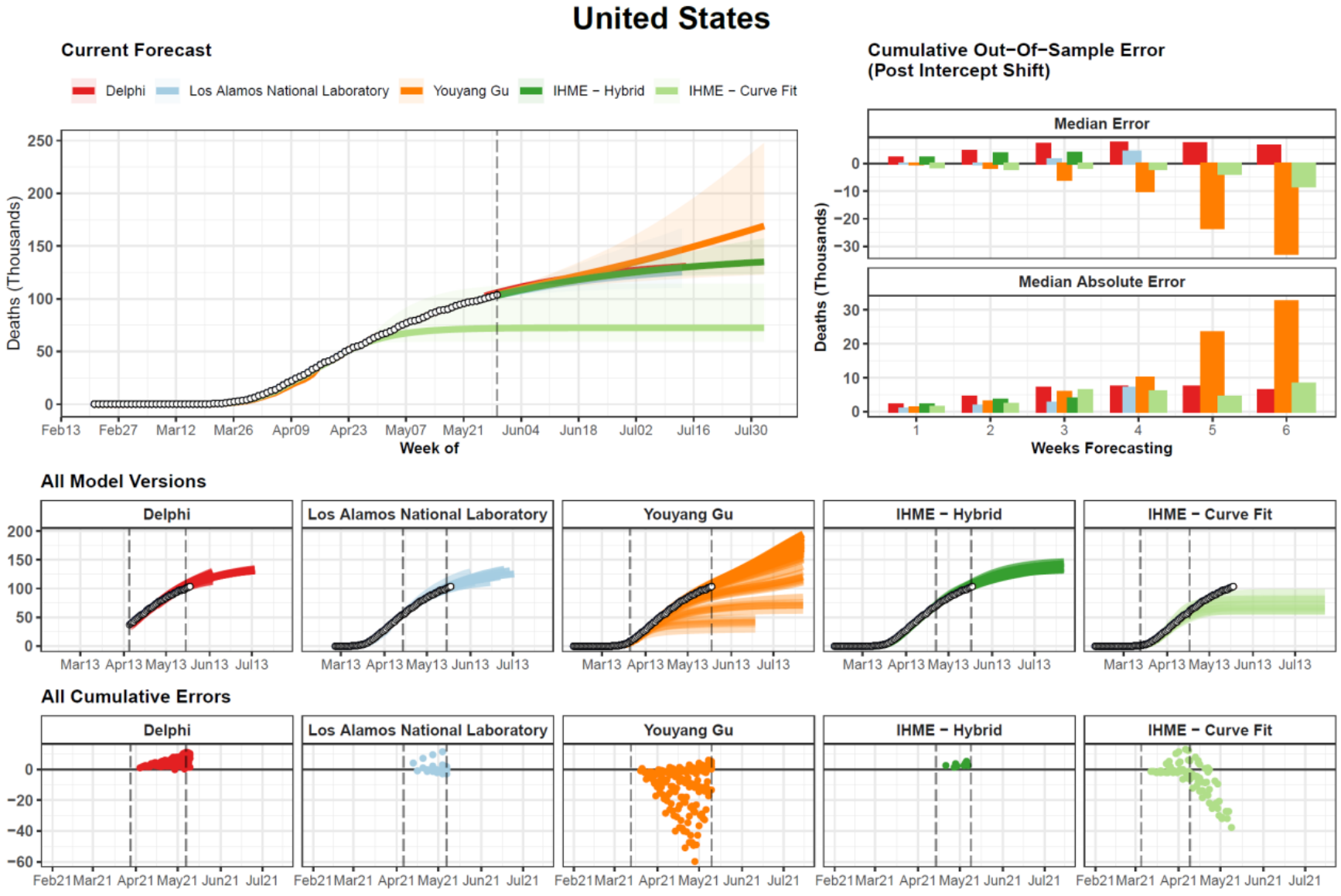
IHME COVID-19 Model: Policy Impact in the EU

- IHME's Model used to allocate PPE and medical equipment resources, such as ventilators and testing kits, via its **'Clearing house for medical equipment'** – in order to match demand by the Member States.

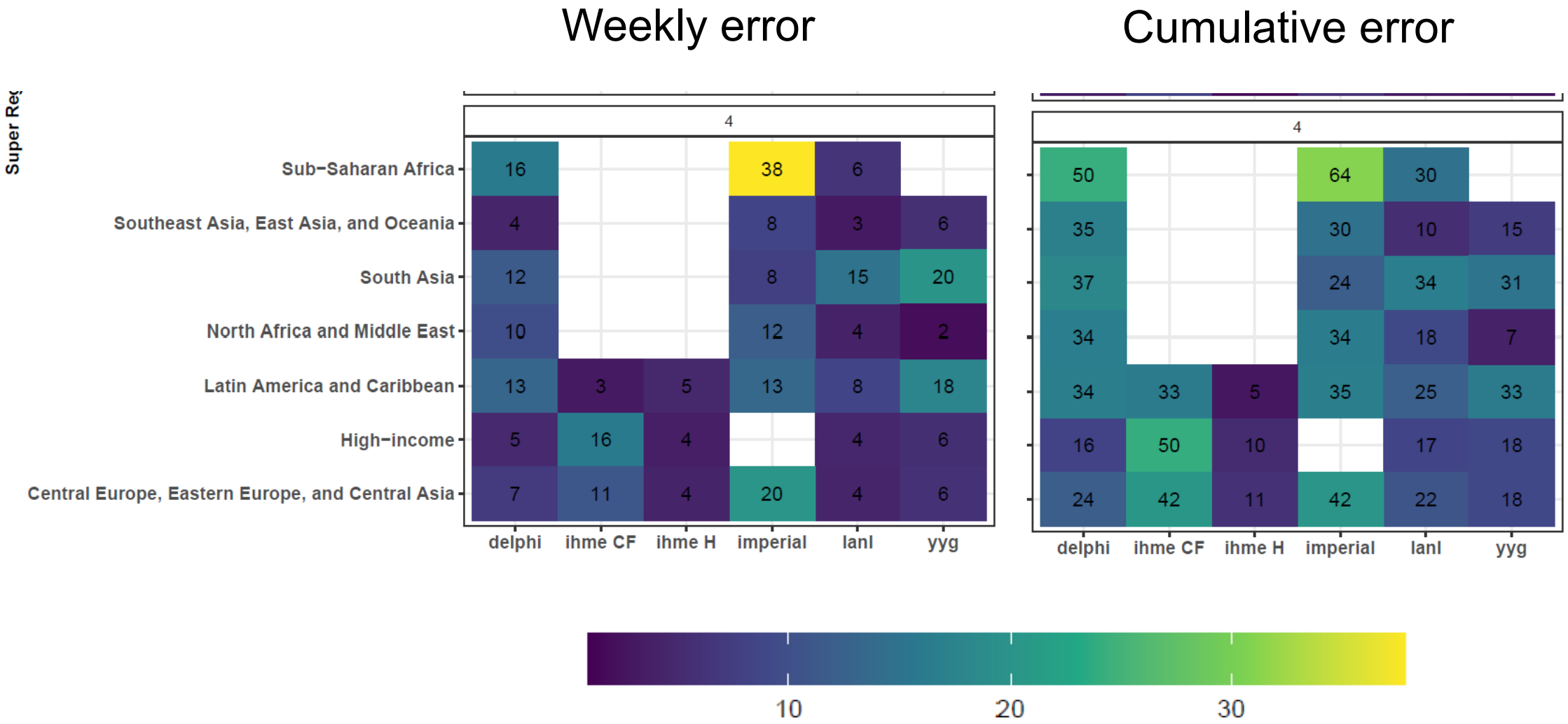
Forthcoming

- New RKCS-SEIR model to be released this week for some locations
- Estimates now produced for all countries – will release estimates once we have had some discussion with local collaborators for face validity checks.
- In some countries, continue to have concerns that low testing rates and low case and death counts may be masking true extend of the epidemic.
- Time window will be extended through October 1 by mid-June; then possibly through December 31, 2020.
- Formal evaluation of forecast accuracy of IHME three generations of models and other models that produce publicly available estimates for multiple countries.

Comparing COVID-19 model performance



Median absolute percent error at 4 weeks



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Thank You

https://www.healthdata.org

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