IHME
Measuring what matters

Potential trajectories of COVID-19

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Ranking of COVID-19 among the leading causes of mortality this week

Global

Cause name	Weekly deaths	Ranking
Ischemic heart disease	175,727	1
Stroke	126,014	2
Chronic obstructive pulmonary disease	63,089	3
Lower respiratory infections	47,946	4
Tracheal, bronchus, and lung cancer	39,282	5
COVID-19	36,393	6
Neonatal disorders	36,201	7
Alzheimer's disease and other dementias	31,217	8
Diabetes mellitus	29,830	9
Diarrheal diseases	29,509	10

European Region

Cause name	Weekly deaths	Ranking
Ischemic heart disease	44,253	1
Stroke	22,622	2
Tracheal, bronchus, and lung cancer	8,918	3
Alzheimer's disease and other dementias	8,022	4
Chronic obstructive pulmonary disease	6,719	5
Colon and rectum cancer	5,881	6
Lower respiratory infections	5,254	7
COVID-19	4,738	8
Cirrhosis and other chronic liver diseases	4,290	9
Hypertensive heart disease	3,949	10

United States

Cause name	Weekly deaths	Ranking
Ischemic heart disease	10,724	1
COVID-19	4,551	2
Tracheal, bronchus, and lung cancer	3,965	3
Chronic obstructive pulmonary disease	3,766	4
Stroke	3,643	5
Alzheimer's disease and other dementias	2,768	6
Chronic kidney disease	2,057	7
Colon and rectum cancer	1,616	8
Lower respiratory infections	1,575	9
Diabetes mellitus	1,495	10

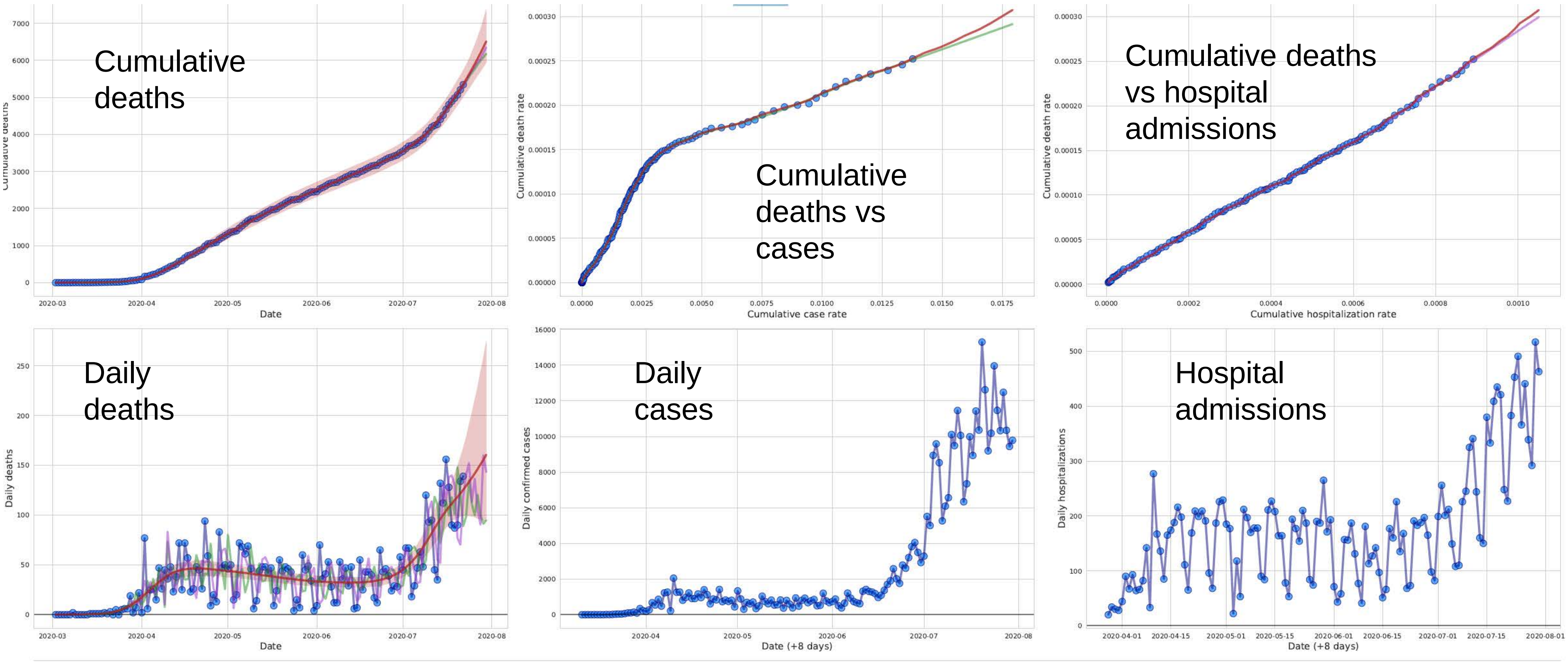
Covid model development over the past 5 months

CurveFit **Mar 26 – May 3**	**Curvefit-SEIR Hybrid** **May 4 – June 10**	**RKCS-SEIR Hybrid** **June 11-**
• Statistical, deaths-based model • Performed well initially for locations with >50 deaths • Focused on predicting initial peak of hospital resource use as a function of social distancing • Did not predict decline after the peak well	• 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 • Future transmission a function of covariates: mobility, testing, temperature, pop density • Better fit to observed declines after peak	• Analysis of cases, hospitalizations, and deaths to estimate past & next 8 days • Fit an SEIR model to these trends • Future transmission a function of covariates: mask use, cell-phone based mobility, pneumonia seasonality, testing per capita, population density, PM2.5, smoking, altitude, pneumonia death rate

Making sense using multiple indicators

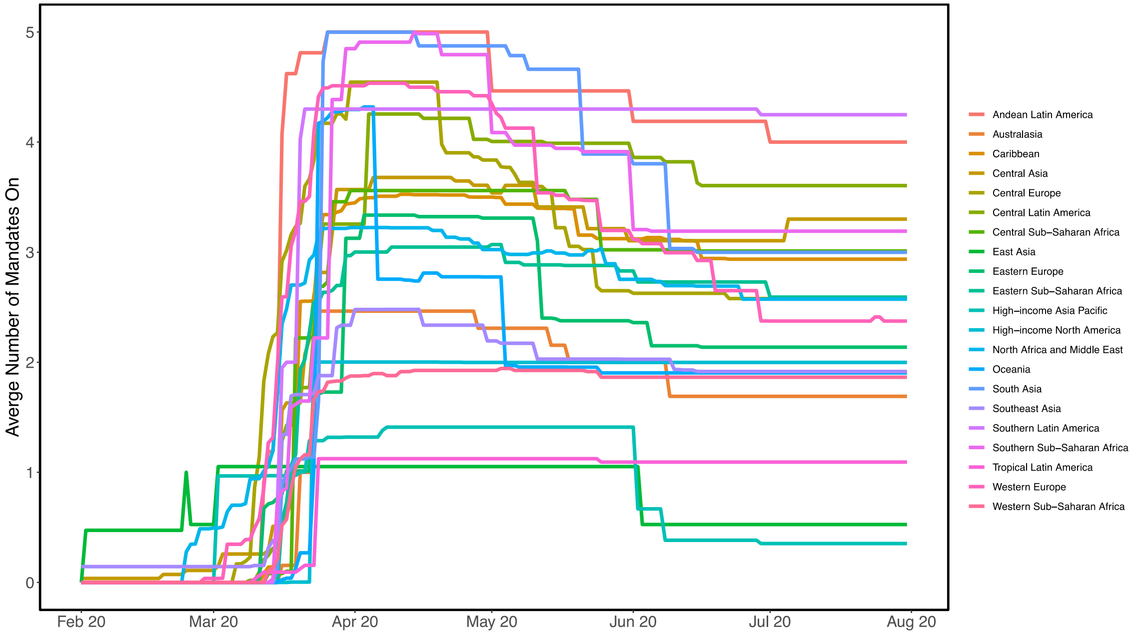
- Daily deaths – as reported by JHU, directly by governments or based on analysis of excess mortality. Least biased indicator of epidemic progression, much less sensitive to the availability of testing.
- Daily hospital admissions – available for only a smaller subset of locations, relatively insensitive to trends in testing availability.
- Daily hospital census – more widely available but sensitive to variation in clinical practice manifested through length of stay.
- Case reports – as reported by JHU or directly by governments. Level and trend very sensitive to the availability of testing.

Noisy data for all indicators and locations - Florida example

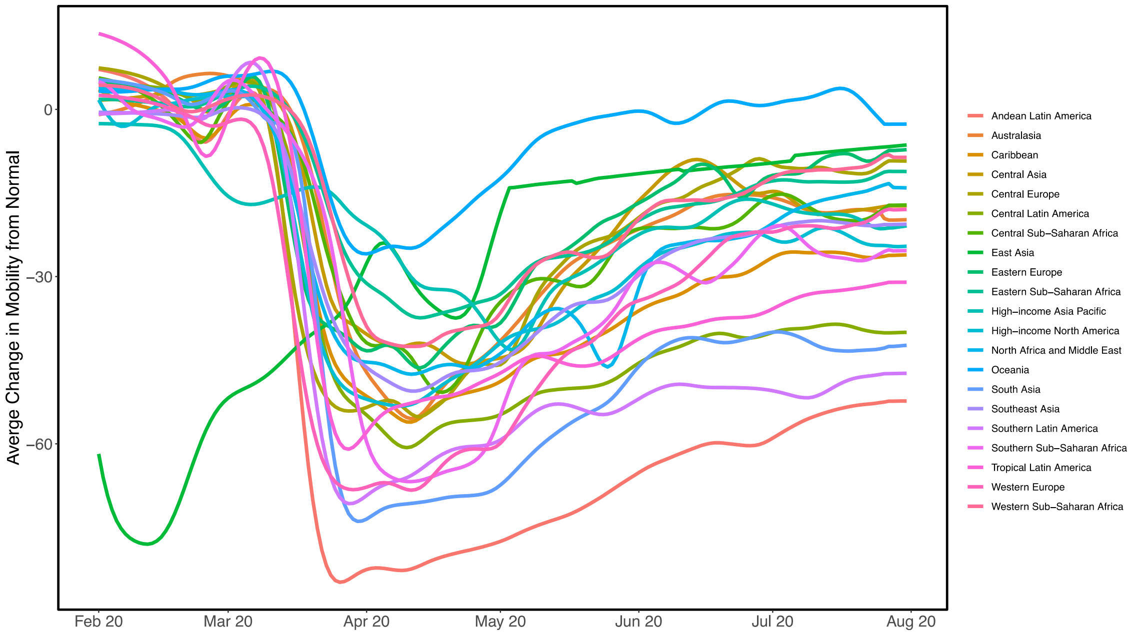


Mandates and mobility

Number of mandates

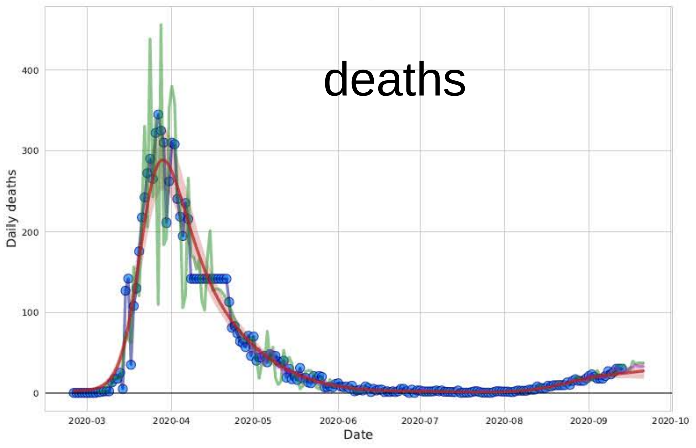


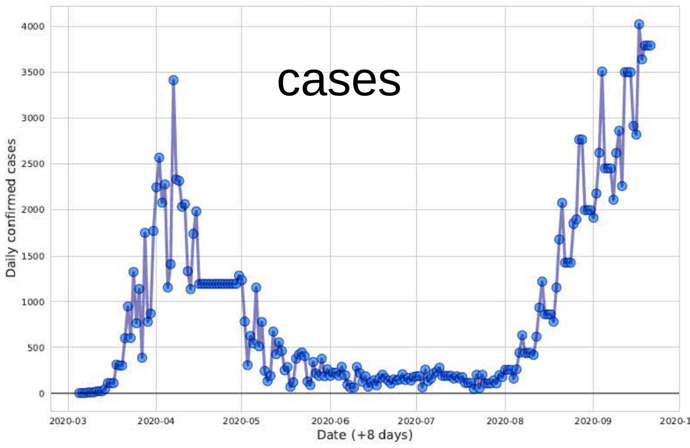
Cell-phone mobility

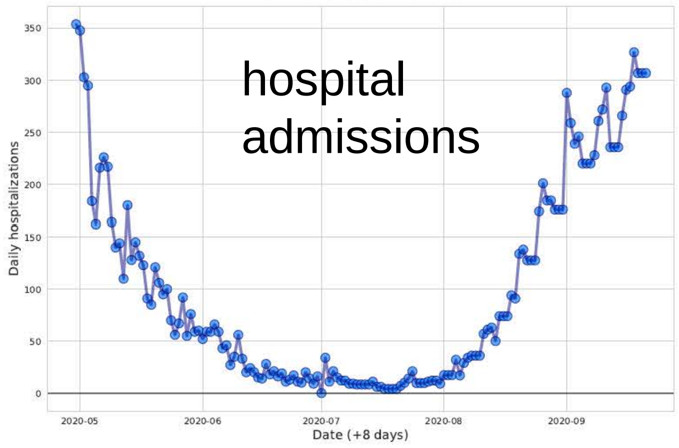


Rollercoaster: individual behavior and mandates

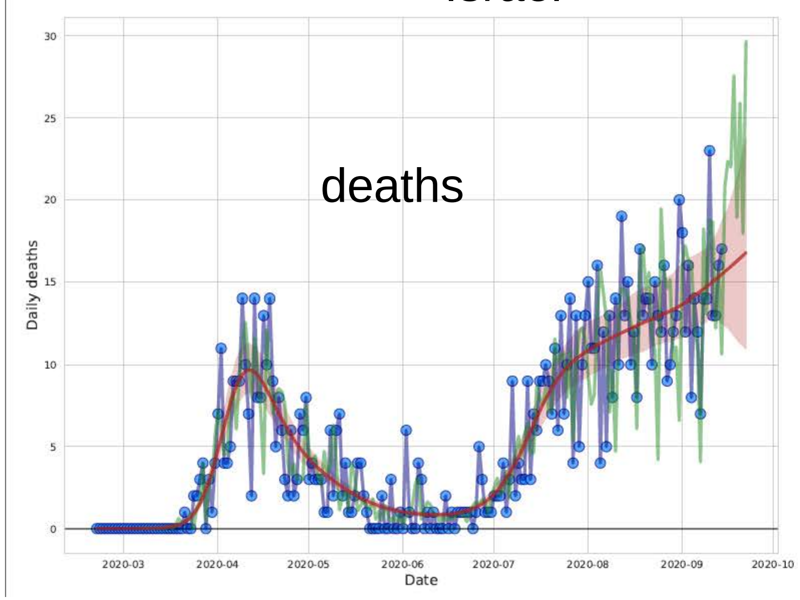
Madrid

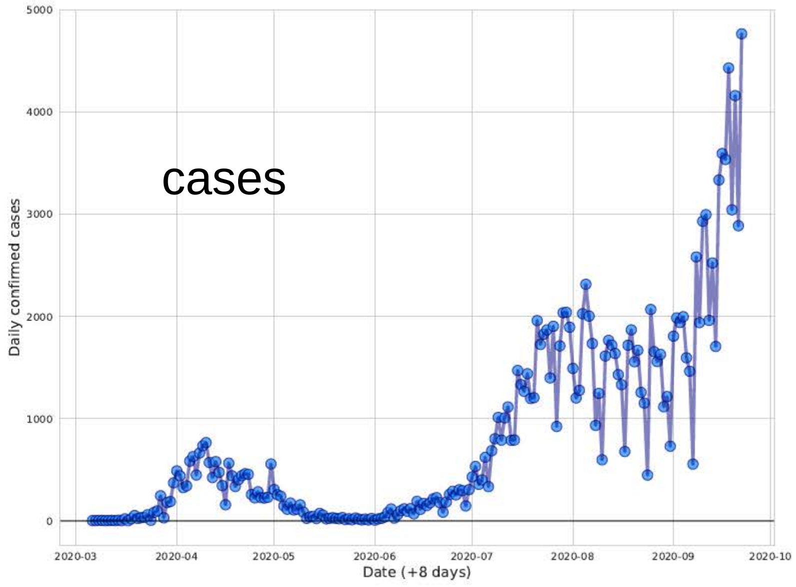




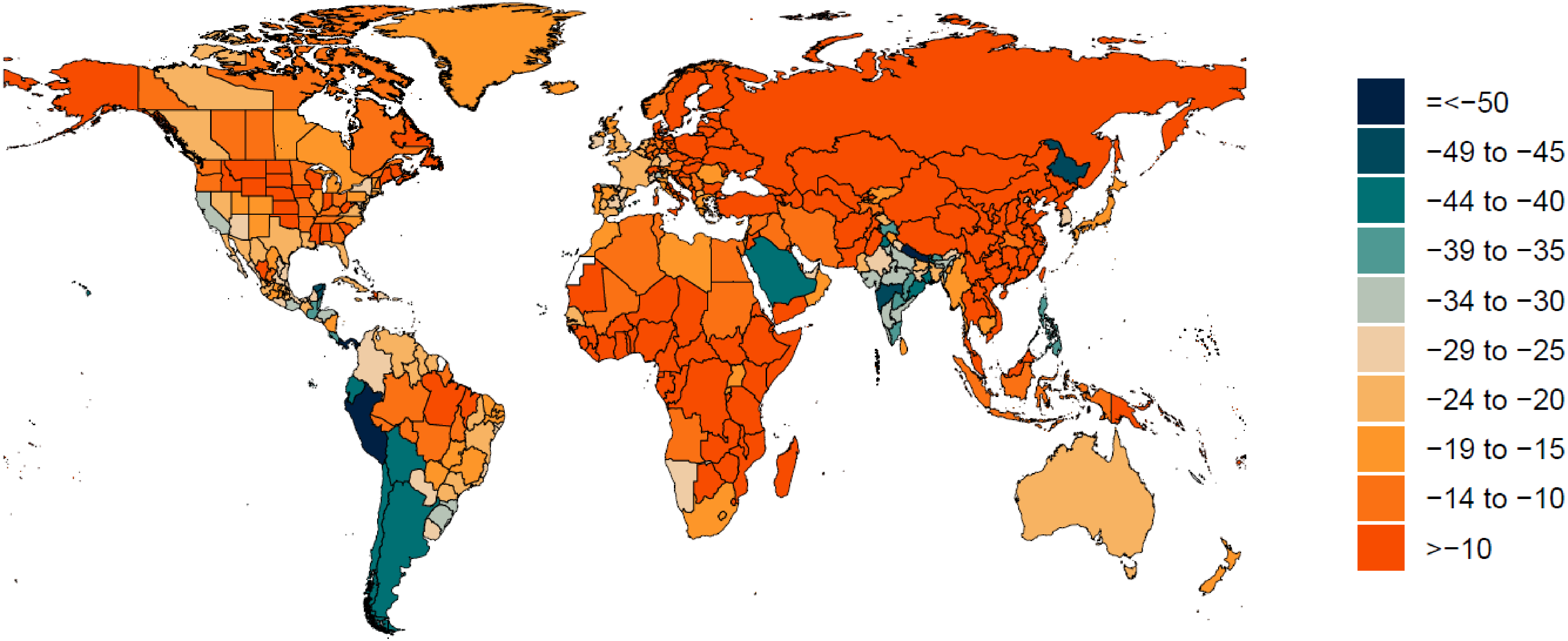


Israel





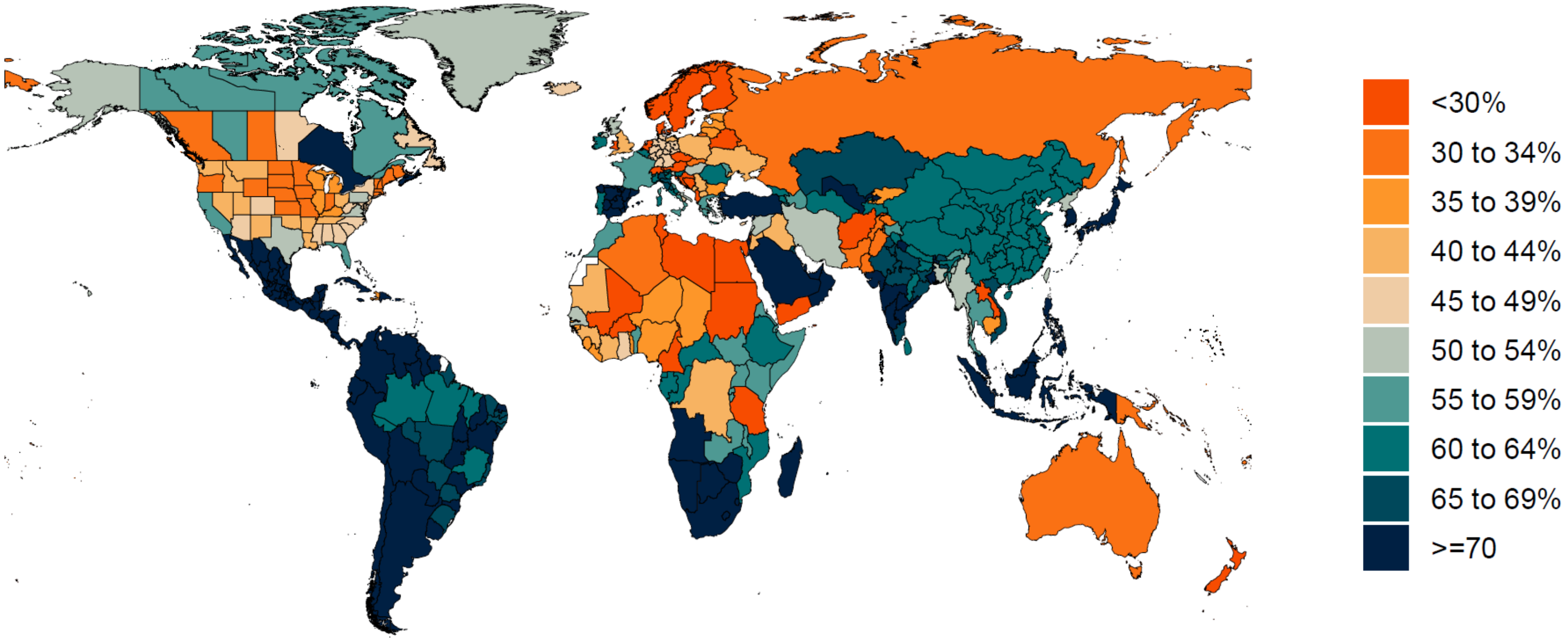
Key drivers of cases and deaths: Mobility
smartphone based measurement compared to Jan 2020 baseline (percent)



Key drivers of cases and deaths: Masks

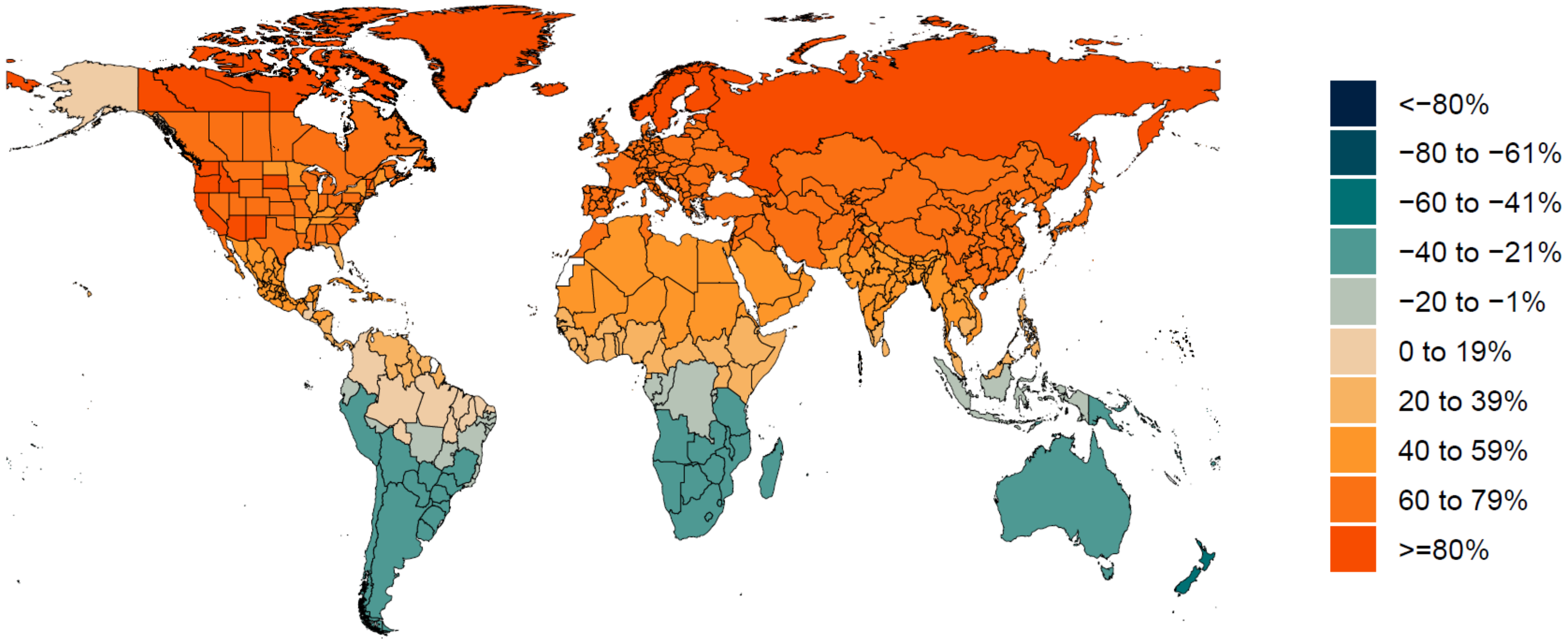
% who self-report they always wear a mask when leaving home (Sept 14, 2020)

Meta-analysis of individual studies suggests simple cloth masks worn by the general public provide a 40% risk reduction

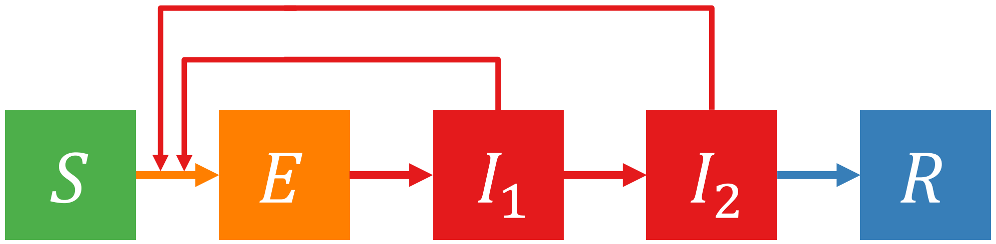


PREMISE/Facebook Global symptom survey (This research is based on survey results from University of Maryland Social Data Science Center)

COVID seasonality? Past transmission (effective R) is highly correlated with pneumonia seasonality pattern: ratio of weekly pneumonia deaths in February to early August



SEIR model fit to death data



$$\frac{dS}{dt} = -\frac{\beta(t)S\,(I_1 + I_2)^{\alpha}}{N}$$

$$\frac{dE}{dt} = \frac{\beta(t)S\,(I_1 + I_2)^{\alpha}}{N} - \sigma E$$

$$\frac{dI_1}{dt} = \sigma E - \gamma_1 I_1$$

$$\frac{dI_2}{dt} = \gamma_1 I_1 - \gamma_2 I_2$$

$$\frac{dR}{dt} = \gamma_2 I_2$$

SEIR model steps:

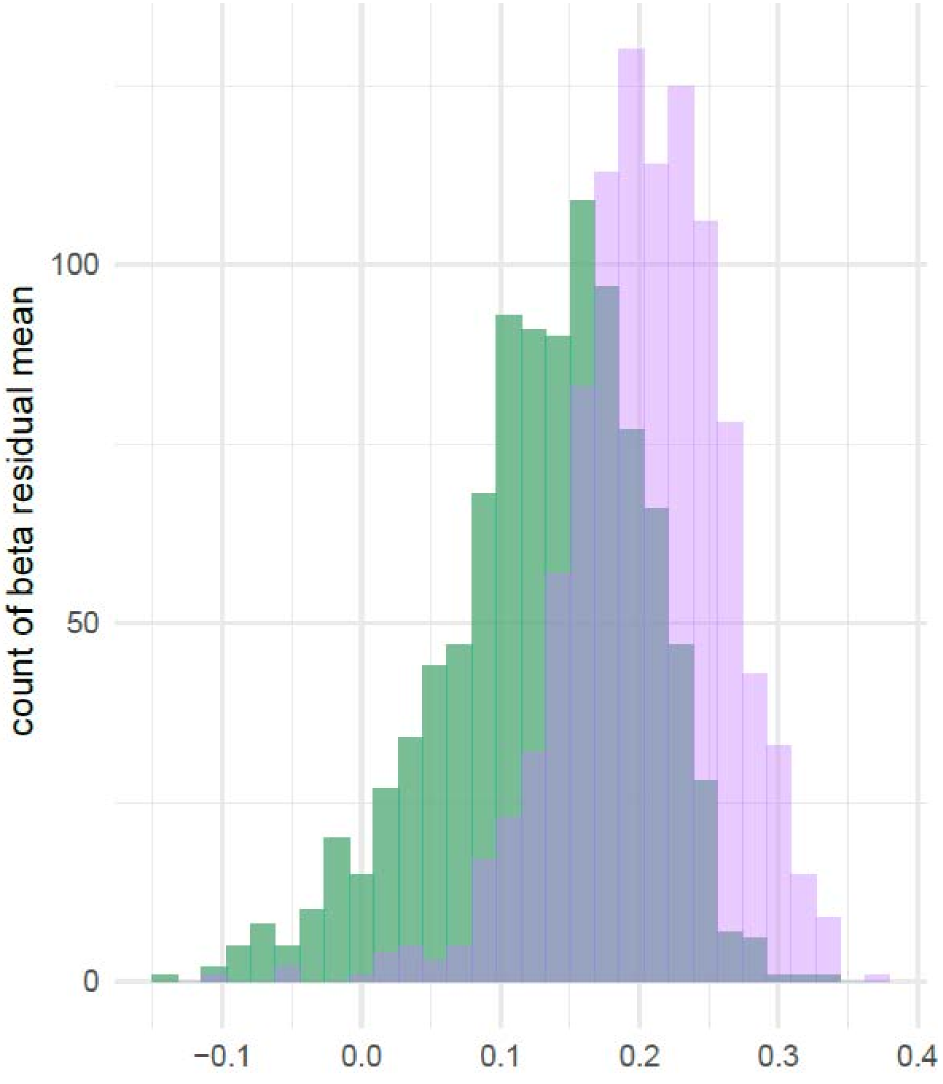
- Fit SEIR model (e.g., fit $\beta(t)$)* to past and recent death model output for all locations.
- Regress $\beta(t)$ on available covariates*
- Forecast time-varying covariates into the future
- Combine regression with forecasts to forecast $\beta(t)$*
- Run forecasted $\beta(t)$ through SEIR model to forecast infections*
- Calculate deaths from infections and IFR*

*** By draw**

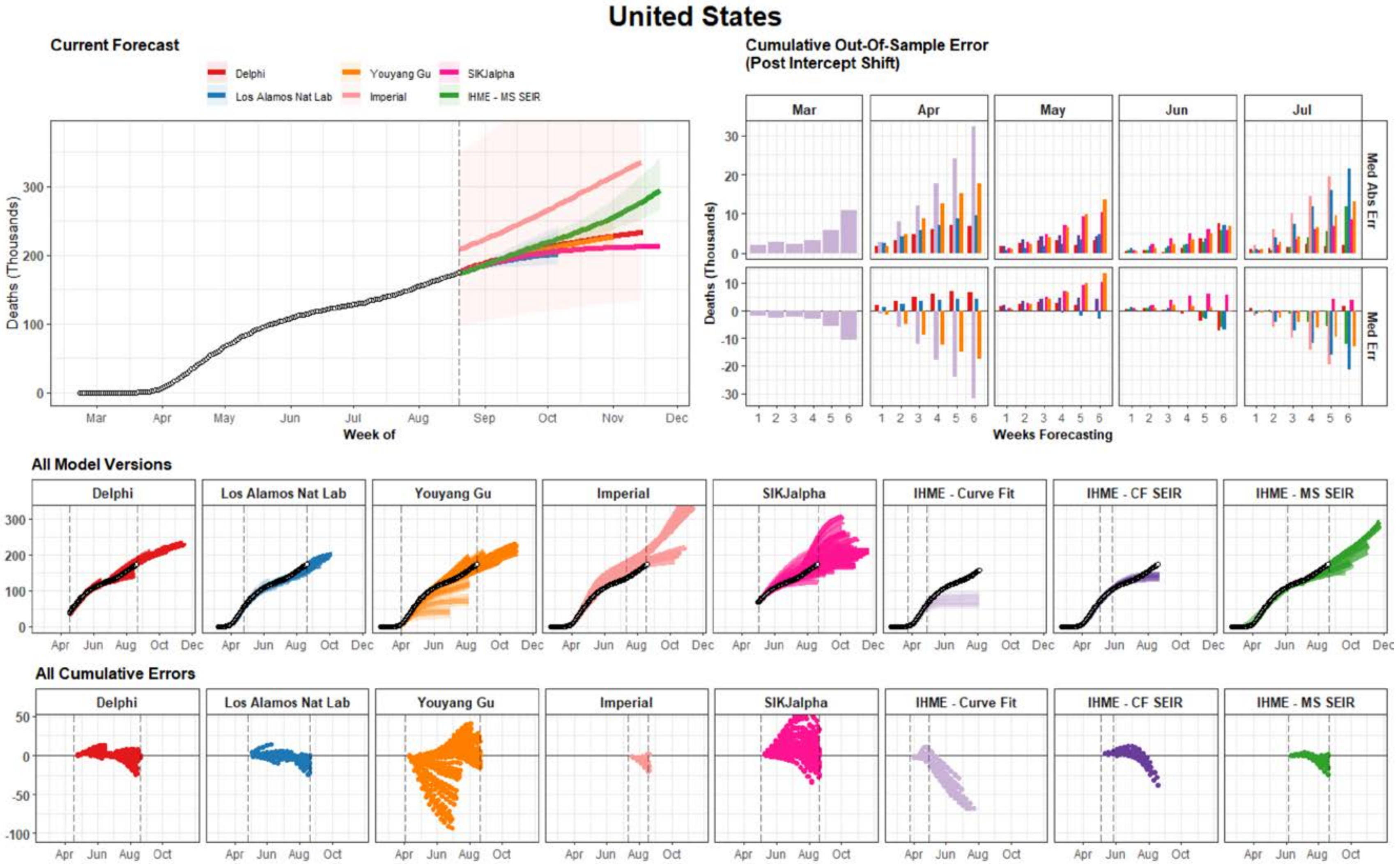
Unexplained differences in effective R

- Considerable variation in transmission that is not explained by mobility, mask use, testing, seasonality, PM2.5, population density, altitude, smoking.
- Models for each location use the residual from the regression of Ln Bjt in the forecasts.
- Residuals are averaged over the last 7-28 days based on the draw.

Florida residual across 1000 models



Should you listen to our model: Comparing publicly available models



IHME model performs best at 10 weeks

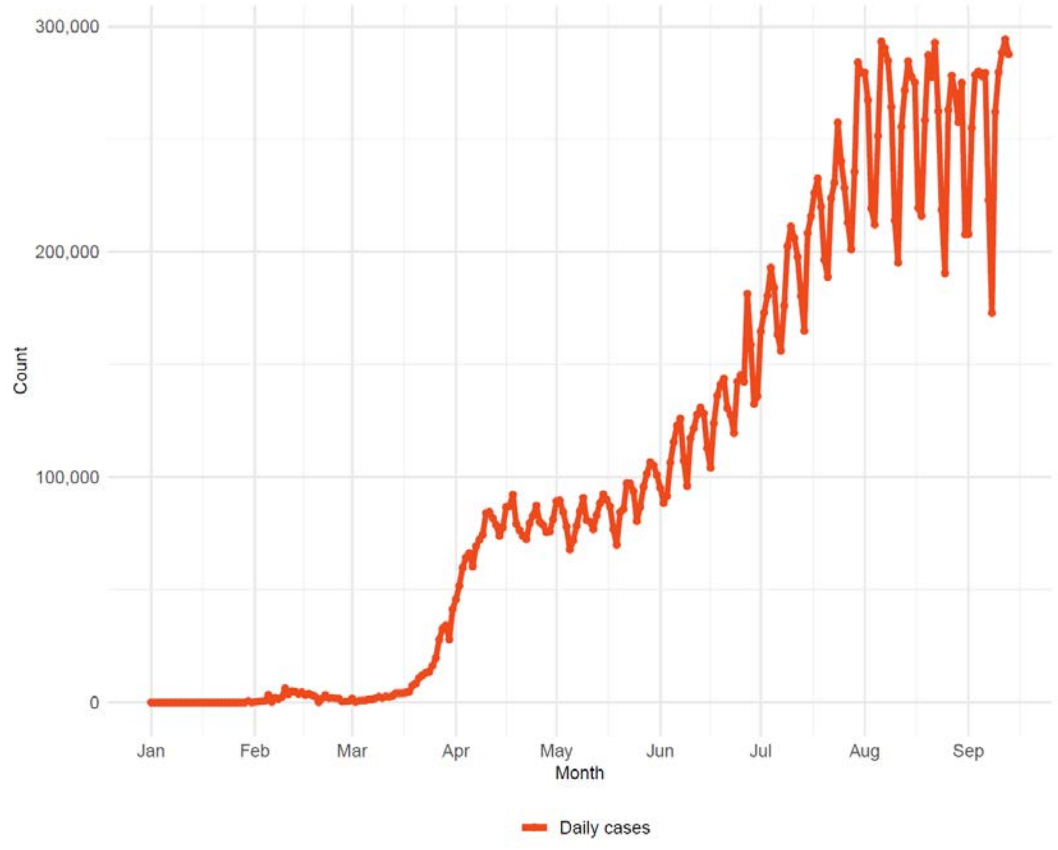
Median Absolute Percent Error – Models Released in June

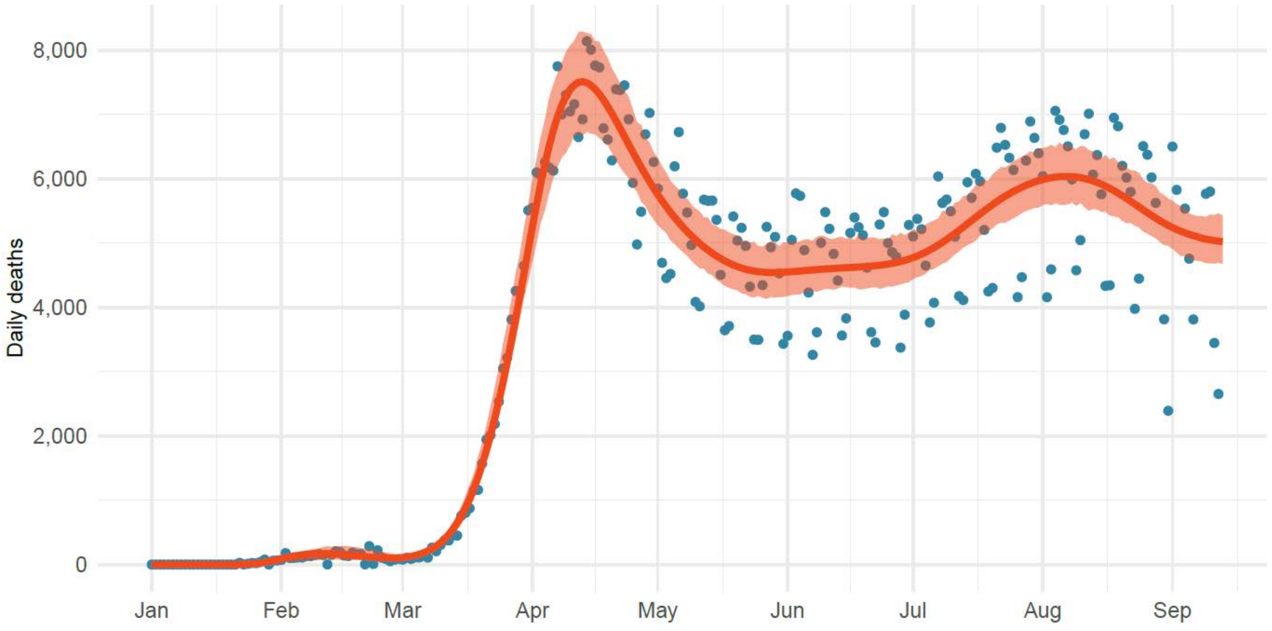
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Global

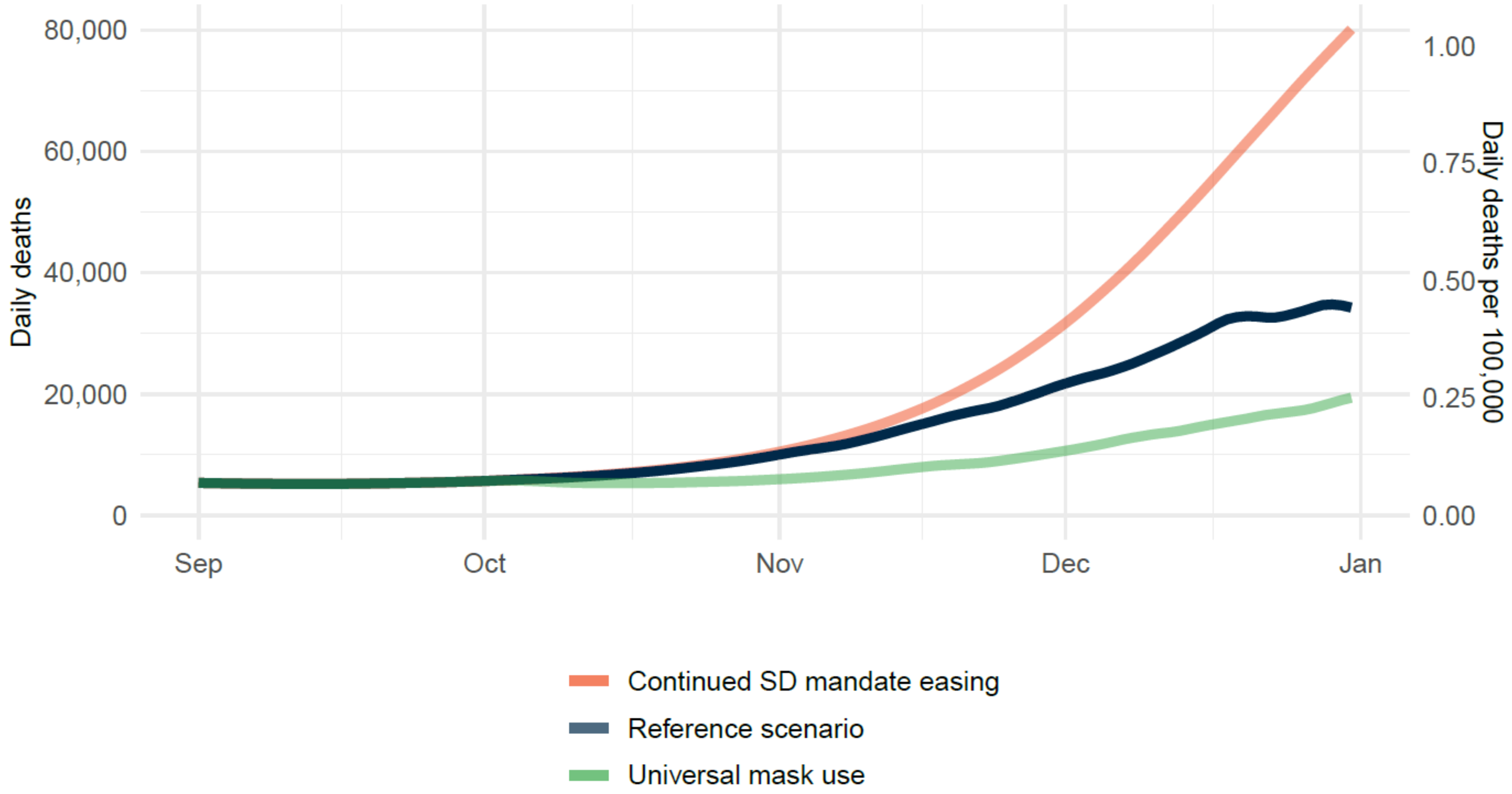
Forecasting Weeks	Delphi	LANL	YYG	Imperial	SIKJalpha	IHME−MS−SEIR	Pooled
10			22.1%	548.9%	33.1%	20.3%	32.6%
9	29.0%		18.4%	462.3%	28.5%	15.6%	28.1%
8	25.3%		14.5%	495.6%	24.6%	17.4%	24.4%
7	20.7%		11.7%	330.5%	20.2%	16.5%	20.1%
6	17.7%	12.6%	9.9%	227.4%	16.9%	13.4%	16.5%
5	14.4%	9.7%	7.7%	155.8%	13.6%	10.3%	13.2%
4	11.2%	7.5%	5.7%	101.1%	10.5%	7.9%	10.2%
3	8.6%	5.6%	4.2%	64.6%	7.3%	5.9%	7.2%
2	6.0%	3.7%	2.6%	33.7%	4.5%	3.8%	4.5%
1	3.0%	2.1%	1.1%	15.2%	2.1%	2.0%	2.2%

Global epidemic in a slight lull period: Latin America improving, Europe and India surging

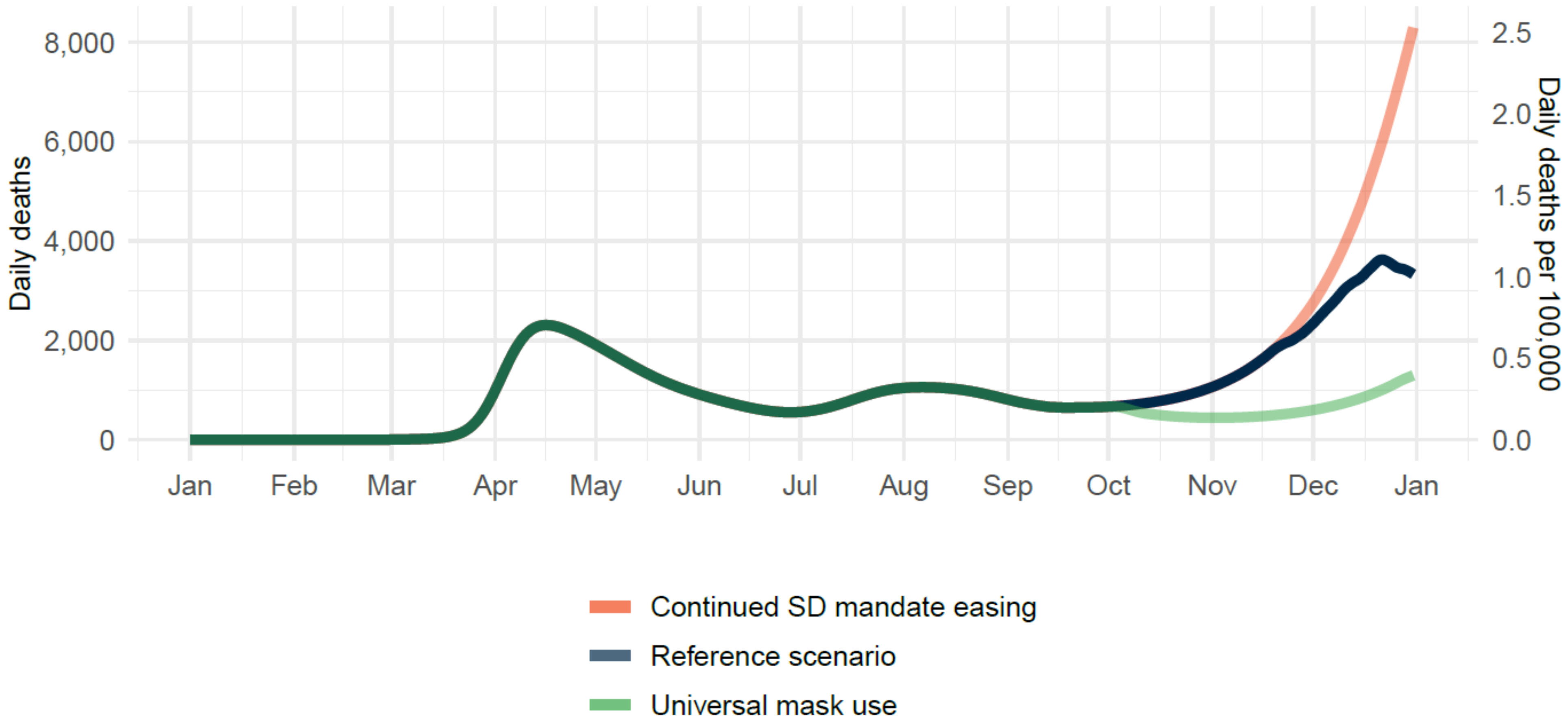




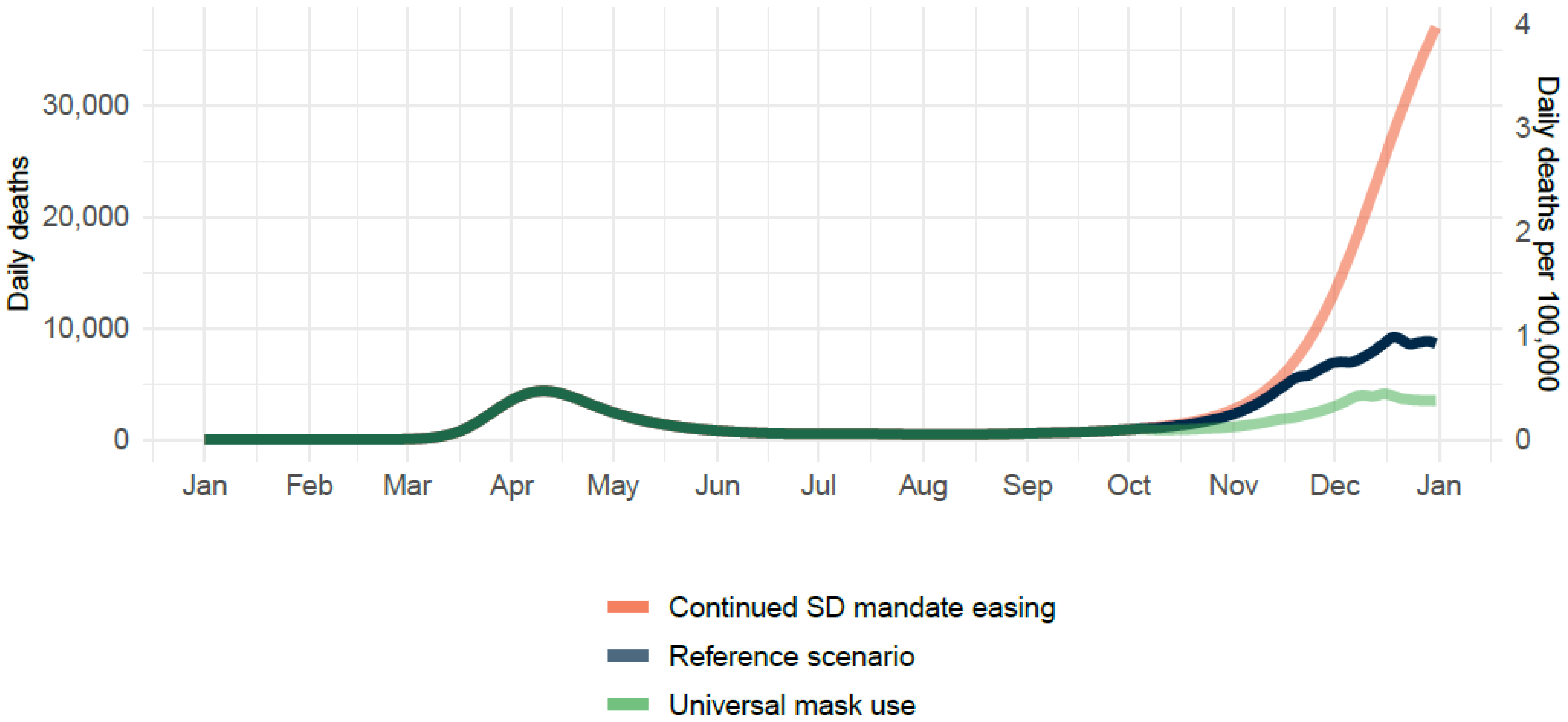
Due to mandate relaxation driven by economic considerations and Northern Hemisphere seasonality expect large winter surge: Daily Global Covid-19 deaths to Jan 1, 2021



Daily Covid-19 deaths in the US to Jan 1, 2021



Daily Covid-19 deaths in the European Region to Jan 1, 2021



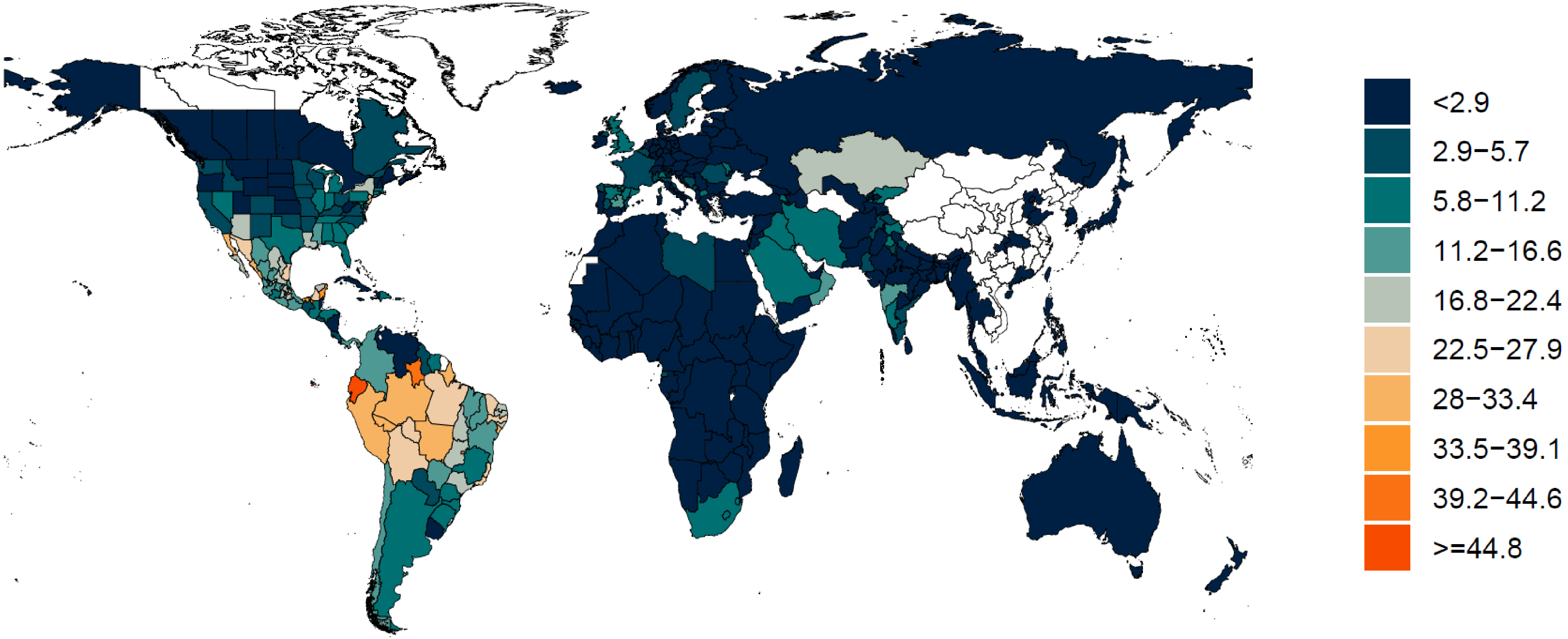
Is the infection-fatality rate improving?

- Better ventilation procedures, dexamethasone and remdesivir should have led to improved outcomes.
- In the US, the admission-fatality rate (deaths/admissions) has remained constant since April. But length of stay has increased considerably.
- The infection-fatality rate measured directly through sero-prevalence surveys is profoundly related to age but so far has not changed overtime. May just be due to sparse data to date.
- If new products entering phase 2 are successful, IFR in places with access could drop next year.

Herd immunity

- Lots of junk science circulating on herd immunity -- such as the claim that the US and Europe are at herd immunity.
- Charles de Gaulle aircraft carrier – of healthy young sailors 70% infected. So 80% in Europe and the US are not immune.
- High levels of cumulative infection already seen: New Jersey at 25%, Ecuador and Mexico City over 40%.
- Simpler explanation for the declines in Europe from the peak, namely mandates worked.

Global levels of cumulative infection September 14



When can we expect to see herd immunity?

- Simple infectious disease models would suggest 80-90%
- But the role of superspreaders, non-overlapping social networks, non-random mixing and in some regions (Southeast Asia, sub-Saharan Africa, Pakistan) background immunity could all contribute to herd immunity at much lower levels.
- Given we have observed rates up to 40% cumulative infection, lowest credible levels would be 40% but the range could be higher.

Eventual deaths (2023?) expected on the basis of the level of herd immunity and the infection-fatality rate – no vaccine or breakthrough treatment

herd Immunity	Global deaths	US deaths
40%	10,446,745	815,150
45%	11,752,588	917,044
50%	13,058,431	1,018,938
55%	14,364,274	1,120,831
60%	15,670,117	1,222,725

The Institute for Health Metrics and Evaluation (IHME) was founded in 2007 as an academic center of excellence in health measurement.

IHME's mission is to provide comprehensive data and analytics to support global efforts to improve health.

IHME Client Services is a social enterprise within UW Medicine and a partner with IHME designed to encourage use of IHME data and analytics in health care systems, business and governmental programs.

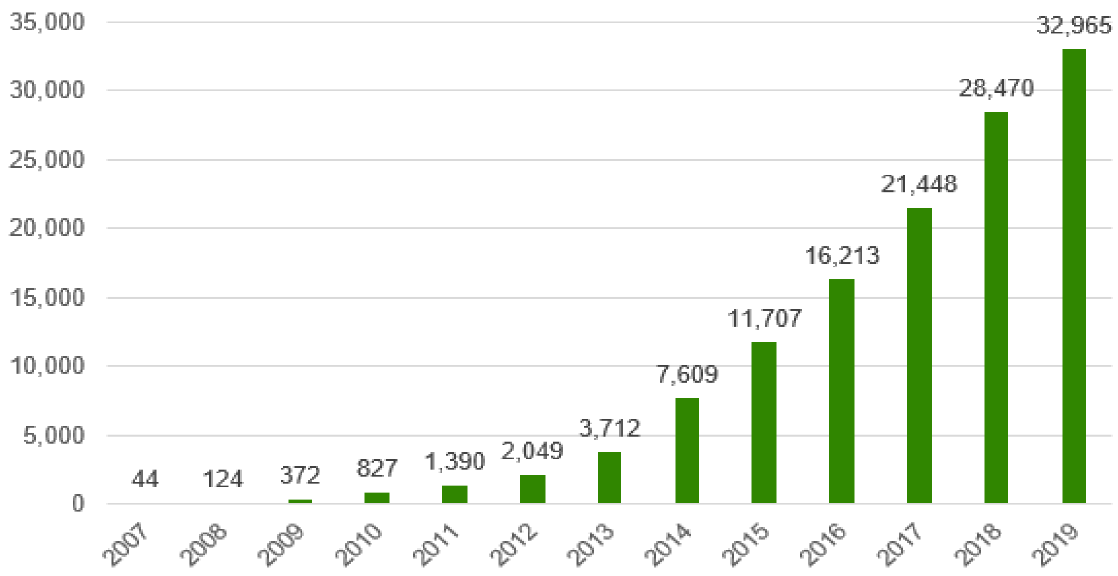
IHME is the world's largest independent health data resource with state-of-the-art search, analytic, and display tools

500+ full-time professionals in Seattle, USA, including 30 full-time faculty & 30 member scientific counsel

5,000+ international collaborators

900+ Geographical units covered, including all countries, with extensive subnational data

Count of citations to IHME research in peer-reviewed literature



IHME's research is published annually as dedicated issues of The Lancet.

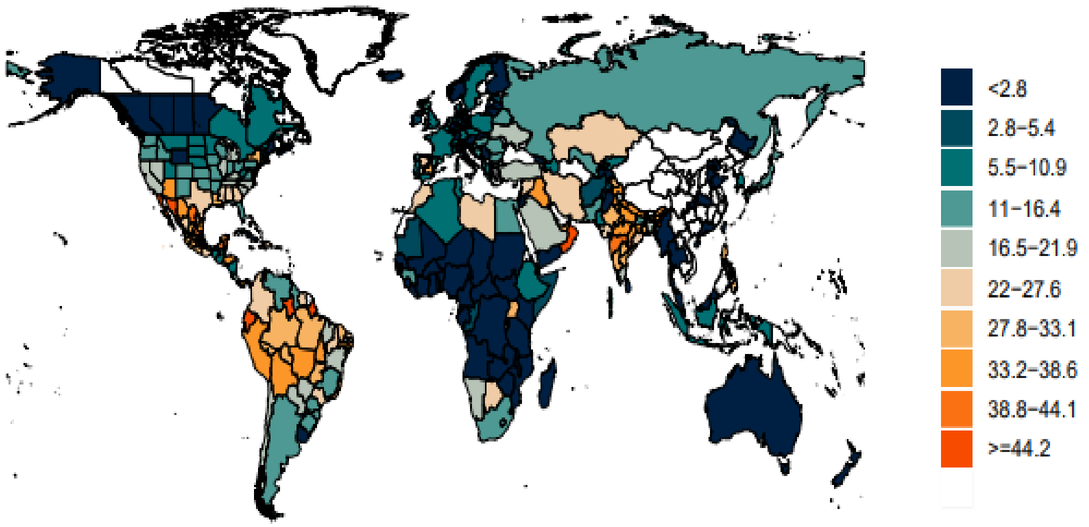
IHME has become a trusted source for COVID-19 projections.

Since the outbreak of the pandemic, IHME has been one of the leading organizations **providing data for science-based decision-making during the COVID-19 crisis**, decision-making that has led to increased public safety measures. IHME is working closely with national and state governments, international agencies, biotech firms, and the global health community, providing extensive insights into the course of the pandemic.

IHME COVID-19 Projections provide a **data-driven** model that is iteratively re-run, **incorporating new and better data as they become available** and advancing the methodology as we learn more about the virus. The model incorporates new elements as data are available to better **account for real-time changes** in the pandemic. Examples include:

- Population mobility
- % of population living in high density areas
- Effectiveness of masks
- Seasonality
- Testing per capita

Forecasted percent infected with COVID-19 on January 1, 2021



To learn more about IHME's Covid-19 analytics and services, contact:
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