IHME
Measuring what matters

COVID-19 Projections

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History of the Model

- Original model developed to provide estimates of COVID-19 patient hospital utilization and help hospital systems plan for the upcoming surge
  - Initially in response to a request from UW Medicine, but demand prompted expansion to all US States and additional countries
- Second generation model developed to better fit the observed declines, as many locations began to see longer, flatter peaks & slower declines
- Third generation model now released: Random knot combination spline (RKCS)-SEIR Model

Model introduction

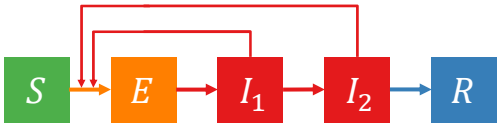
The IHME modeling process forecasts the following through Dec 1, 2020:

- Daily deaths
- Total deaths
- Hospital resource use for COVID-19 patients (beds, ICU bed, ventilators)
- Mobility
- Testing
- Confirmed and estimated infections

Covid Model Development over the past 3 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, mobility, pneumonia seasonality, testing per capita, population density, PM2.5, smoking, altitude, pneumonia death rate

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**

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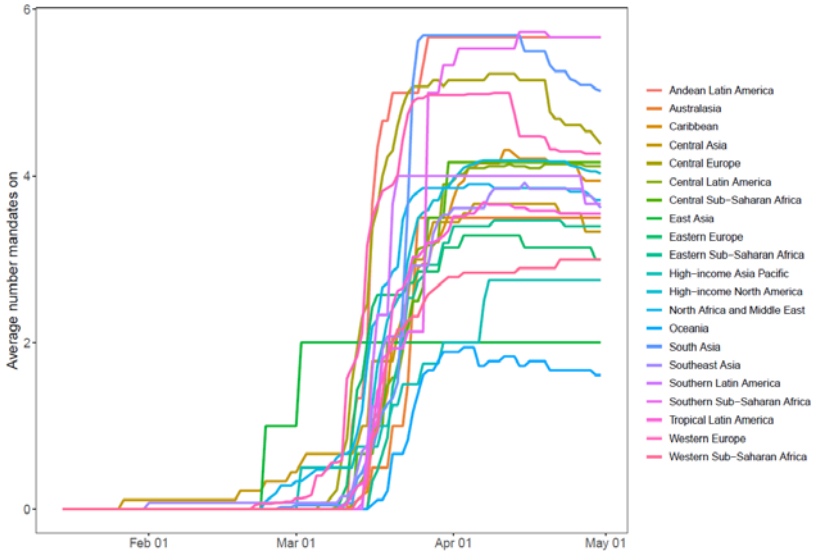
Key drivers of cases and deaths: mandates



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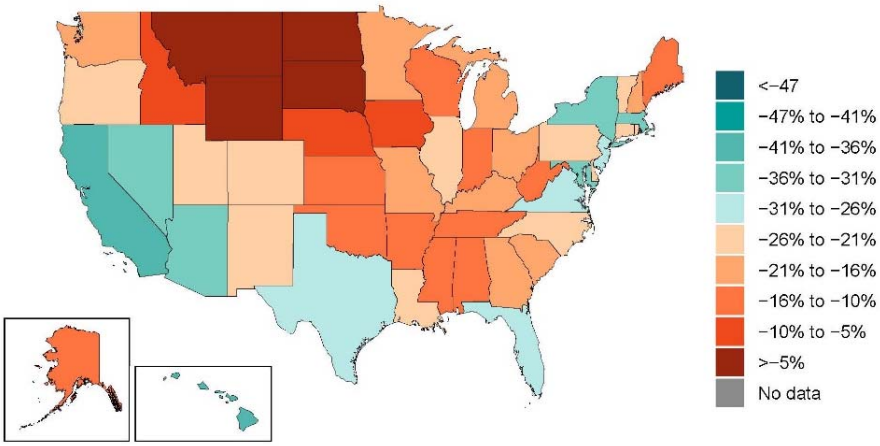
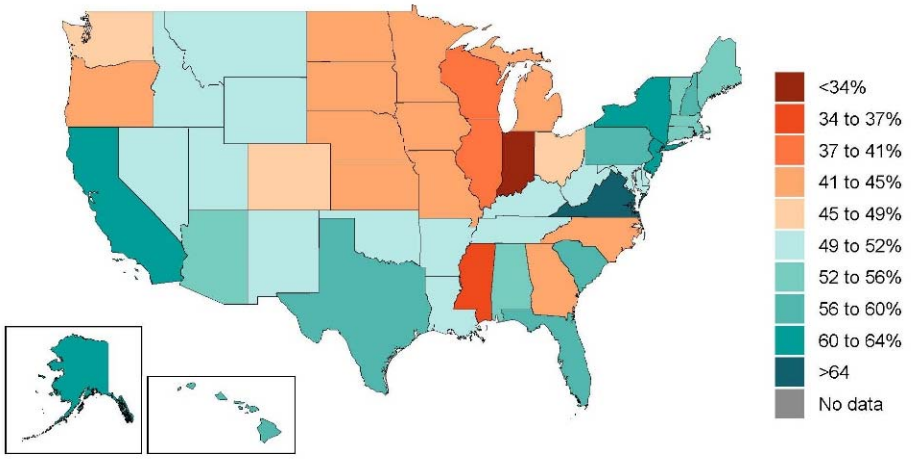
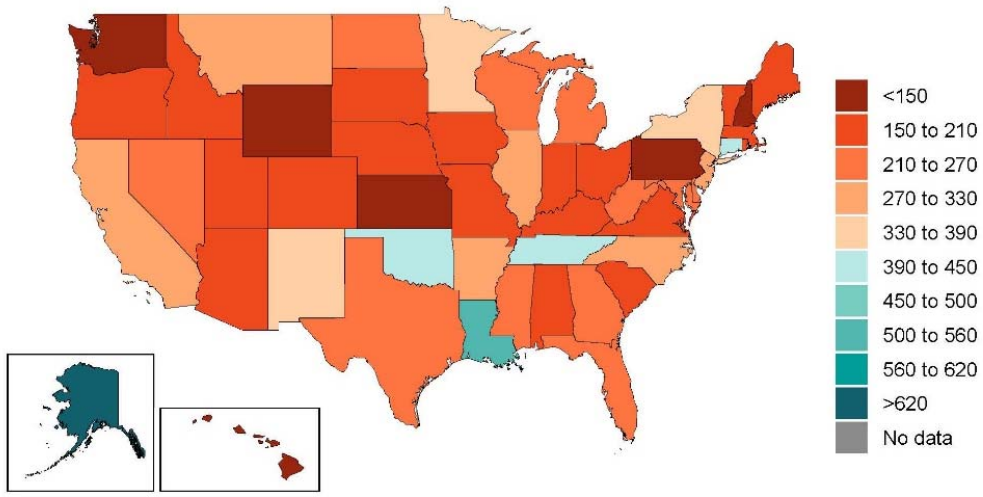
Mobility: Change from normal on Aug 03, 2020



Masks: % who self-report they always wear a mask when going out (Aug 03)



Testing: COVID-19 daily testing per 100,000 (Aug 03)



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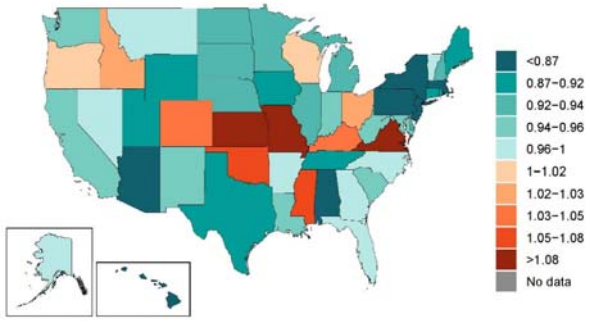
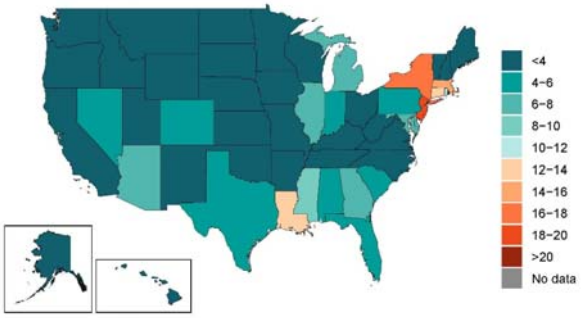


Mean R_e on (July 23)



Percent infected (August 03)

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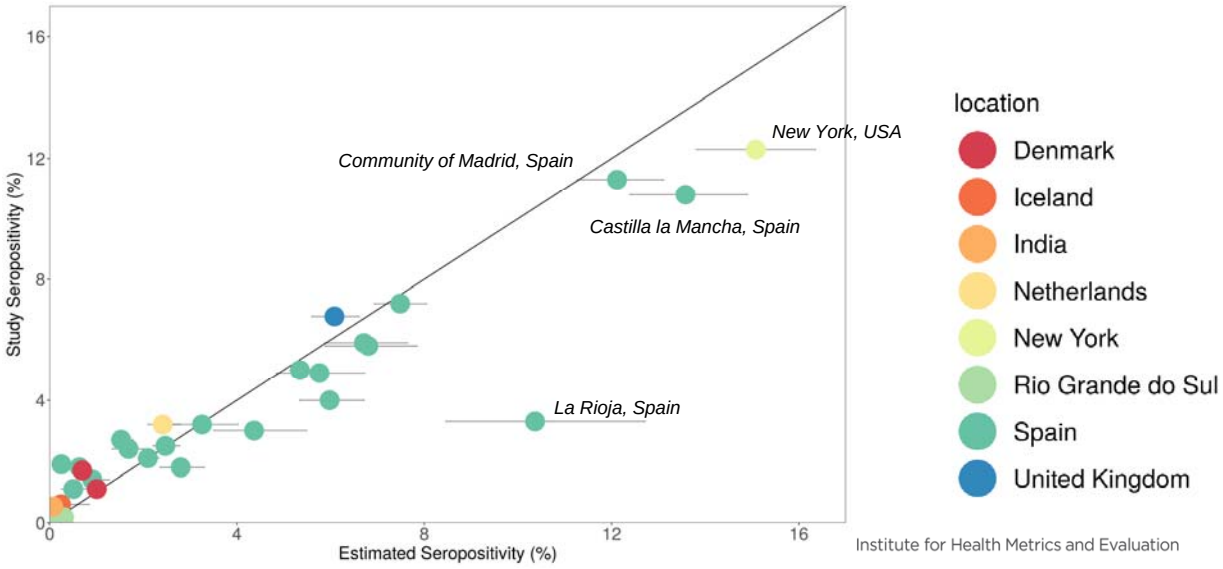
Measured antibody sero-prevalence vs model predictions



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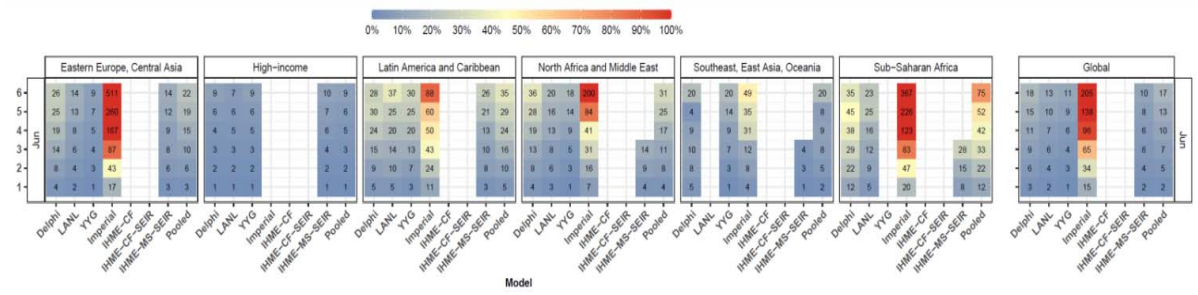
Median absolute percent error by week for 6 publicly released models



IHME hybrid SEIR model has lowest MAPE of 13% at 6 weeks

Current & Future Areas of Work

- **Current:**
  - **Easing mandates** – progressive relaxation of mandates
  - **Current prediction** – what we think is most likely to occur, including re-imposition of mandates when reaching a daily death rate of 8 per million
  - **Universal mask use** – scale up to mask use levels seen in highest country with re-imposition of mandates at a daily death rate of 8 per million
- **Future**:
  - US by Race/Ethnicity
  - US by county
  - Revised age pattern of mortality
  - Evaluate alternate shutdown scenarios

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Excess mortality and antibody testing

- In many countries and to a lesser extend in the US, evaluation of daily all-cause mortality suggests profound under-registration of deaths and cases.
- Random sample survey of antibody prevalence using a high specificity assay can also be used to evaluate completeness of death and case detection.
- Relationship between deaths and infections, the infection-fatality rate by age, has so far been very stable. Higher than expected antibody prevalence would provide an indication of under-registration.
- Individuals respond to the epidemic by modifying their behavior avoiding contact, wearing a mask, decreasing travel, increased personal hygiene.
- Governments respond by imposing mandates

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Current recommendations

- Include daily Covid-19 hospitalizations in the analysis. Trend in hospitalizations is a leading indicator that is not as sensitive to the expansion of testing as daily cases.
- Evaluate excess mortality in DHSSs in an ongoing basis
- Undertake an antibody survey every month
- Early phases of the epidemic – transmission may take off but a clear trend has not emerged. Model forecasts should be revised weekly to reflect the state of transmission and models should be developed by province.
- Implement a universal mask mandate – can reduce transmission by one third which can at the population level have a huge effect on the course of the epidemic.

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IHME predictions and scenarios

- Balancing economic activity with public health goals in some countries leading to the idea of planned intermittent mandates.
- In hotspots, consider Planned Intermittent Mandates – 2 or 3 weeks of strict social distancing mandates followed by 4-6 weeks of no mandates on a regular schedule may be useful if the epidemic enters a wide spread phase.
- Model certain businesses closure and impact on pandemic
- Model phased vaccination approach and impact on pandemic (certain groups first, etc…)

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Thank you!

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