COVID-19 Results Briefing: the United States of America

December 4, 2020

This document contains summary information on the latest projections from the IHME model on COVID-19 in the United States of America. The model was run on December 03, 2020.

Cases and deaths continue to increase steadily. Lags in reporting artificially depressed cases and deaths over the Thanksgiving holiday, and very large numbers in recent days are due to catch-up reporting. The death rate is at the critical 8 per million rate through the middle states in the US. This week our reference scenario takes into account expected scale-up of vaccination. Despite vaccination scale-up, we expect 539,000 cumulative deaths by April 1, with peak daily deaths reaching 3,000 in mid-to-late January. Vaccination is likely to speed the transition back to normal later in the year but will prevent only 9,000 deaths by April 1 in the reference scenario. A further 14,000 lives can be saved with more rapid vaccine scale-up targeting high-risk individuals. Avoiding even larger death tolls depends critically on state governors implementing packages of mandates as hospital stress becomes high. Scaling up mask use to 95% can save 66,000 lives by April 1.

Current situation

- Daily reported cases in the last week increased to 165,200 per day on average compared to 145,900 the week before (Figure 1). The increase is likely greater given substantial reporting lags over the holiday weekend.
- Daily deaths in the last week increased to 1,660 per day on average compared to 1,470 the week before (Figure 2). This makes COVID-19 the number 1 cause of death in the United States of America this week (Table 1).
- Effective R, computed using cases, hospitalizations, and deaths, is greater than 1 in 43 states (Figure 3).
- We estimated that 15% of people in the US have been infected as of November 30 (Figure 4).
- The daily death rate is greater than 4 per million in Alabama, Arkansas, Colorado, Connecticut, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, West Virginia, Wisconsin, and Wyoming (Figure 6).

Trends in drivers of transmission

- In the last week, new mandates have been imposed in North Dakota. Local mandates within states have been imposed in a number of settings (Table 2).

- Mobility last week declined slightly, to 25% lower than the pre-COVID-19 baseline (Figure 8). Mobility was near baseline (within 10%) in Alabama, Mississippi, South Dakota, and Wyoming. Mobility was lower than 30% of baseline in California, Colorado, the District of Columbia, Hawaii, Illinois, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New York, Oregon, Utah, Vermont, and Washington. No Thanksgiving bump is evident yet in the mobility data.
- As of November 30, we estimated that 71% of people always wore a mask when leaving their home (Figure 9). Mask use was lower than 50% in South Dakota and Wyoming.
- There were 400 diagnostic tests per 100,000 people on November 30 (Figure 10).
- Figure 12 shows the fraction of the population who are open to receiving the COVID-19 vaccine, according to recent survey data. Levels range from over 80% in some states to below 70%.
- Figure 13 shows the estimated scale-up of vaccine doses at the expected speed of scale-up and a hypothetical fast scale-up. The trajectory of vaccination is governed by timing of FDA approval, manufacturing capacity, delivery capacity, and willingness to accept the vaccine.

Projections

- In our **reference scenario**, which represents what we think is most likely to happen, our model projects 539,000 cumulative deaths on April 1, 2021. This represents 270,000 additional deaths from November 30 to April 1 (Figure 14). Daily deaths will peak at 3,000 in mid-January (Figure 15).
- The reference scenario assumes that 43 states will re-impose mandates by April 1, 2021.
- If **universal mask coverage (95%)** were attained in the next week, our model projects 66,000 fewer cumulative deaths compared to the reference scenario on April 1, 2021.
- Under our **mandates easing scenario**, our model projects 770,000 cumulative deaths on April 1, 2021.
- By April 1, 2021, we project that 9,000 lives will be saved by the projected vaccine rollout. If rapid rollout of vaccine is achieved, a further 11,000 lives will be saved. Rapid rollout targeting high-risk individuals only could save, compared to the reference scenario, 14,000 lives.
- Figure 17 shows the fraction of the US population that remains susceptible, taking into account both past infection and effective vaccination. By April 1 in the reference scenario, nearly 60% remain susceptible.
- Figure 21 compares our reference scenario forecasts to other publicly archived models. Our forecasts suggest a higher peak daily death toll than other models, but all models suggest continued increases except the Los Alamos National Labs model.

- 46 states will have high or extreme stress on hospital beds at some point in December through February (Figure 22). 48 states will have high or extreme stress on ICU capacity in December through February (Figure 23).

Model updates

This week's model update includes the expected impact of vaccination scale-up and alternative vaccination scenarios. To allow the transmission model to incorporate vaccinations, we added two features to the SEIIR transmission model formulation. First, because it is unclear if any potential vaccine will prevent transmission or only reduce the probability of disease, we allowed the option for some vaccinated individuals to still be infected (and become infectious to others). These individuals are tracked through their infection, and the impact of the vaccine is only calculated when estimating the probability that their infection resulted in death. As the vaccine may result in the prevention of infection, we added a second pathway where susceptible individuals may become removed from the transmission process. It is important to note that in the absence of more detailed information on pre-screening for vaccine distribution, we assume individuals who have been previously infected with COVID-19 are as likely to receive the vaccine as susceptible individuals. The modeling framework allows us to specify the number of vaccinations, their effectiveness at preventing death, and their effectiveness at preventing infections. The parameterization of these numbers is described below.

The second feature we added to the model was to split out high-risk individuals (e.g., individuals with a higher infection-fatality ratio, such as those over the age of 65 or with comorbidities) and track them explicitly through the SEIIR process with their own set of pathways. By doing this, we can easily accommodate targeted vaccination campaigns that preferentially focus early vaccine distribution on this group. There is no differential mixing or alteration of infectiousness within this group versus the rest of a location's population, but rather the creation of these new groups feeds into the calculation of future deaths by using a group-specific infection-fatality rate. This addition doubles the number of compartments in the SEIIR model as we now simultaneously track individuals who are unvaccinated, vaccinated and unprotected from disease, vaccinated and protected from disease, and vaccinated and protected from infection, in both the high-risk and low-risk groups.

This framework was used to add expected vaccination to the mandates easing scenario, reference scenario, and universal mask scenario. The pace of vaccine scale-up and how it was calculated for each country is described below. In addition, we developed a scenario where vaccine maximum capacity was doubled and the speed of vaccine scale-up was twice as fast. In addition, we developed a scenario where fast vaccine delivery was targeted exclusively to high-risk individuals. Finally, to help quantify the marginal impact of vaccination, we included an alternative no vaccine scenario that has the same assumptions as the reference scenario such as the re-imposition of mandates when the daily death rate exceeds 8 per million.

The scale-up of COVID-19 vaccine by location was estimated using data specific to each candidate vaccine on: (i) Manufacturer capacity by quarter through the end of 2021 (Linksbridge, https://pharmanews.linksbridge.com/Covid-19); (ii) Secured doses by country or purchasing group, e.g., COVAX; (iii) Current vaccine candidate development status (discovery, Phase I-III, limited use; Linksbridge); (iv) Probability of success by vaccine candidate development status (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6139376/); and (v) Self-reported rates of vaccine hesitancy from surveys conducted by Facebook (https://covidsurvey.mit.edu/). We assumed efficacy of 95% for the Pfizer/BioNTech and Moderna mRNA vaccines (https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech-conclude-phase-3-study-covid-19-vaccine; https://investors.modernatx.com/news-releases/news-release-details/moderna-announces-primary-efficacy-analysis-phase-3-cove-study); 70% for the AstraZeneca/Oxford vaccine (https://www.astrazeneca.com/media-centre/press-releases/2020/azd1222hlr.html); 90% for other mRNA vaccines; and 75% for all other vaccines (assumed). Among individuals who are effectively vaccinated, in the absence of any data from the trials on efficacy blocking transmission, we assumed 50% of them are protected from infection and the remaining 50% are protected from death due to severe disease if infected. We assumed the Pfizer/BioNTech vaccine would be available for use on December 15, 2020; the Moderna vaccine on December 22, 2020; and the AstraZeneca/Oxford vaccine on January 7, 2021. Availability dates for other vaccines were based on development status (Discovery, 12 months; Phase I, 9 months; Phase II, 6 months; and Phase III, available February 1, 2021). These data were combined to estimate the number of effective doses available by location and time.

For our reference scenario, we assumed, based on the number of annual seasonal flu vaccinations in the USA of 180 million, with most doses delivered over three months, that the maximum number of vaccines delivered per day is 3 million, and assumed a scale-up period to this maximum rate of 90 days using an exponential growth function. For the fast scale-up scenario, the maximum number of vaccines, delivery was assumed to be 6 million per day with a scale-up period of 45 days. We estimated the maximum delivery rate per day for other locations by linearly scaling the delivery rate for the United States, using the Healthcare Access and Quality (HAQ) Index (http://ghdx.healthdata.org/record/ihme-data/gbd-2016-healthcare-access-and-quality-index-1990-2016). We assumed vaccine wastage was 10% and the dropout rate between the first and second doses was 10%. Vaccine doses were distributed between the two priority populations of essential workers and adults aged 65 years and over, proportional to size. Doses were delivered to these two populations first, before doses were administered to the general adult population aged 18 to 64 years. We defined the essential worker population as the proportion of people who left their homes for work at the period of time with the lowest mobility during the pandemic, using data from surveys from Facebook.

Current situation

Figure 1. Reported daily COVID-19 cases

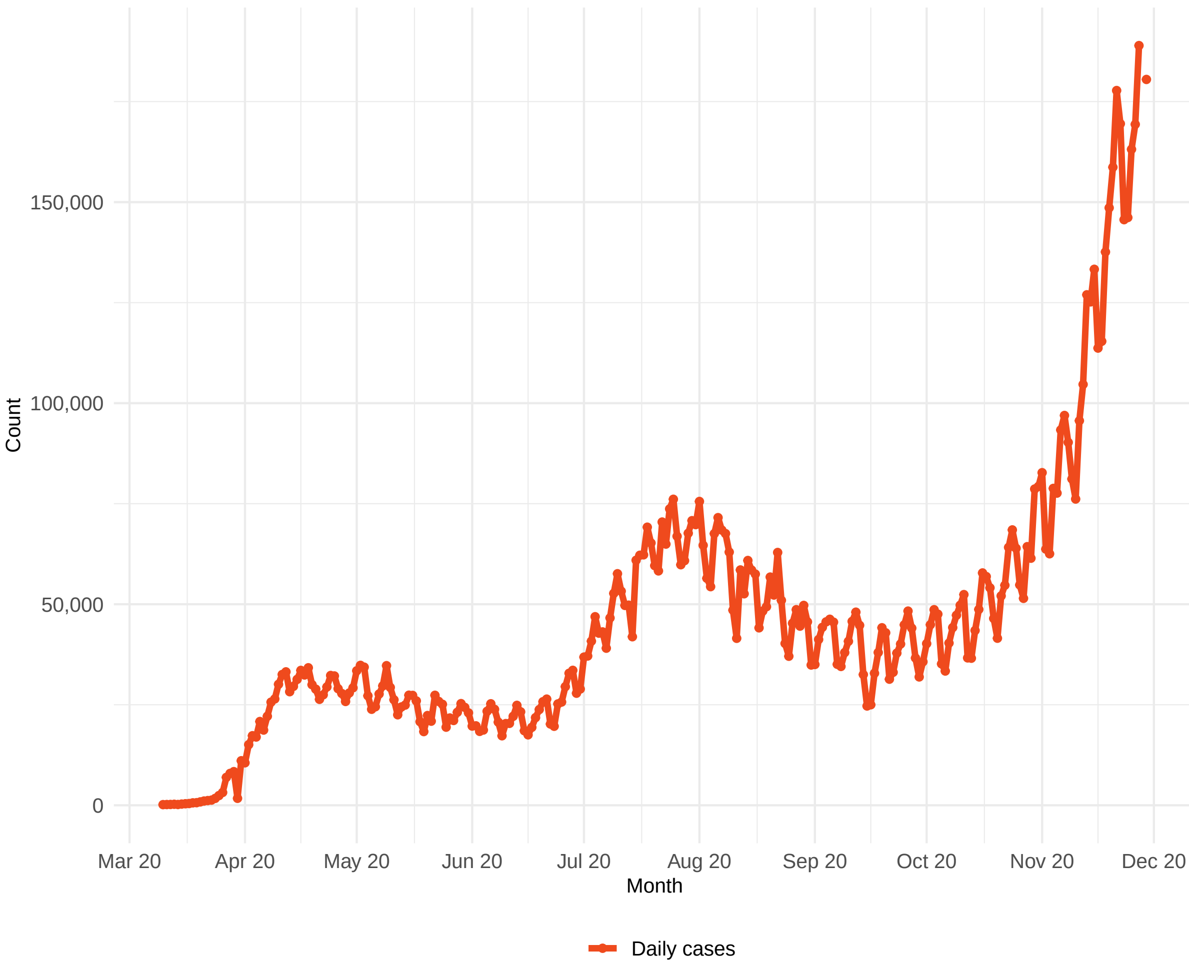


Table 1. Ranking of COVID-19 among the leading causes of mortality this week, assuming uniform deaths of non-COVID causes throughout the year

Cause name	Weekly deaths	Ranking
COVID-19	11,820	1
Ischemic heart disease	10,724	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

Figure 2a. Reported daily COVID-19 deaths

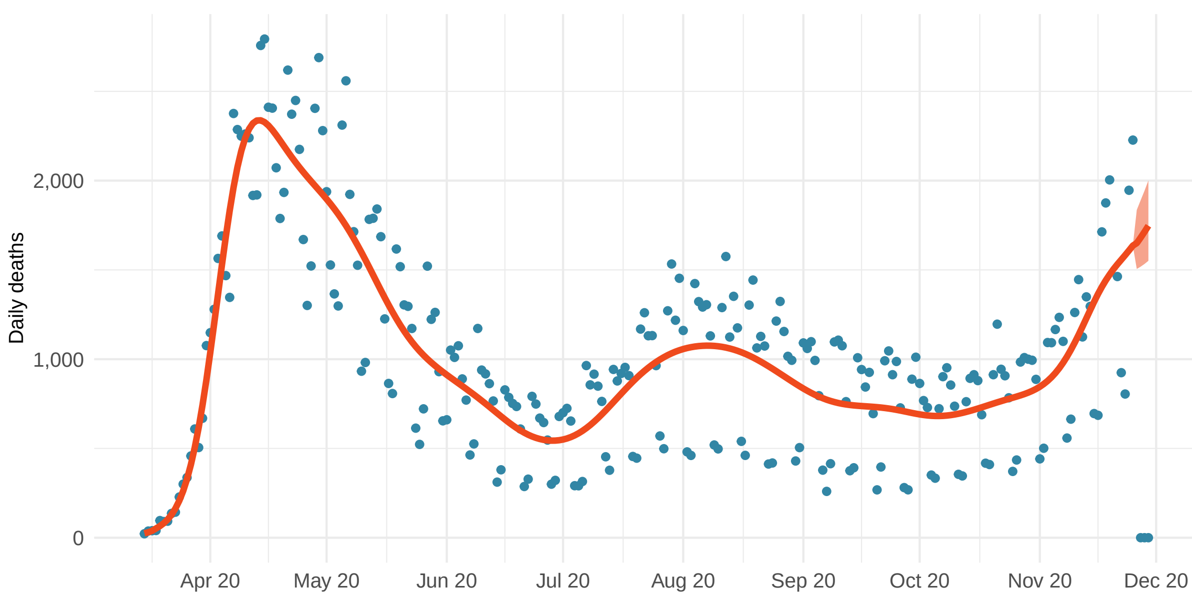


Figure 2b. Estimated cumulative deaths by age group

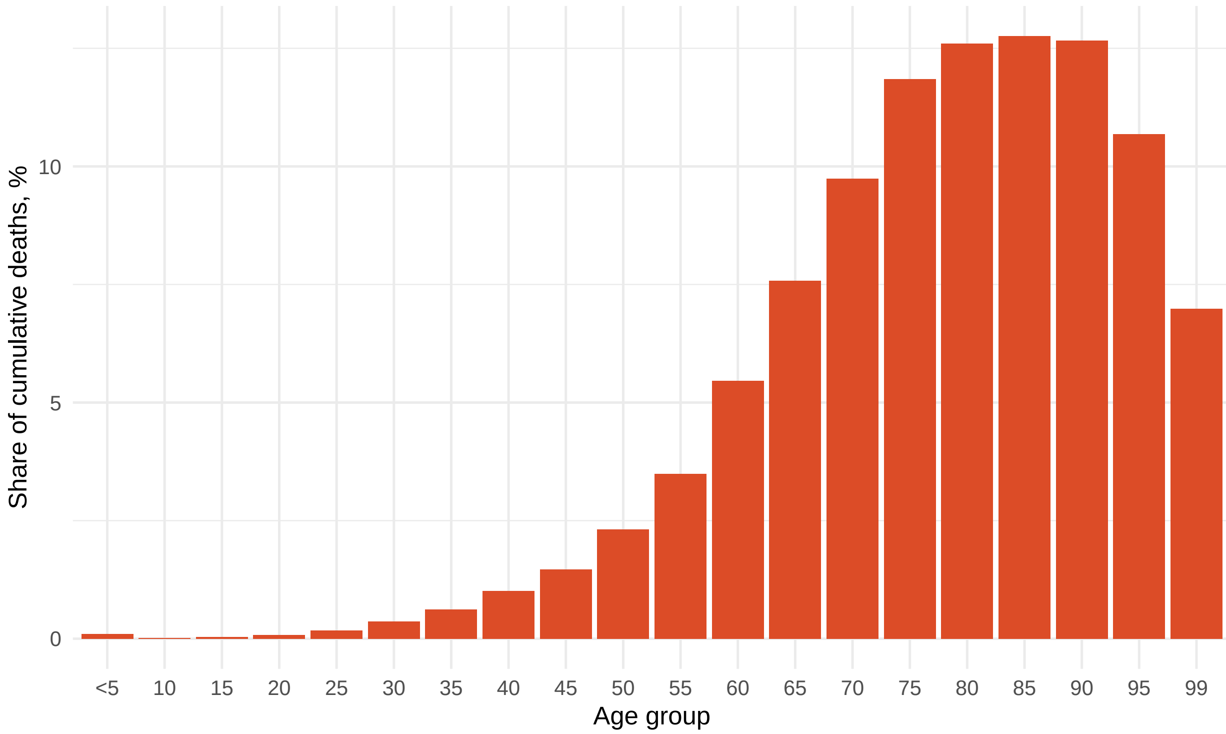


Figure 3. Mean effective R on November 19, 2020. The estimate of effective R is based on the combined analysis of deaths, case reporting, and hospitalizations where available. Current reported cases reflect infections 11-13 days prior, so estimates of effective R can only be made for the recent past. Effective R less than 1 means that transmission should decline, all other things being held the same.

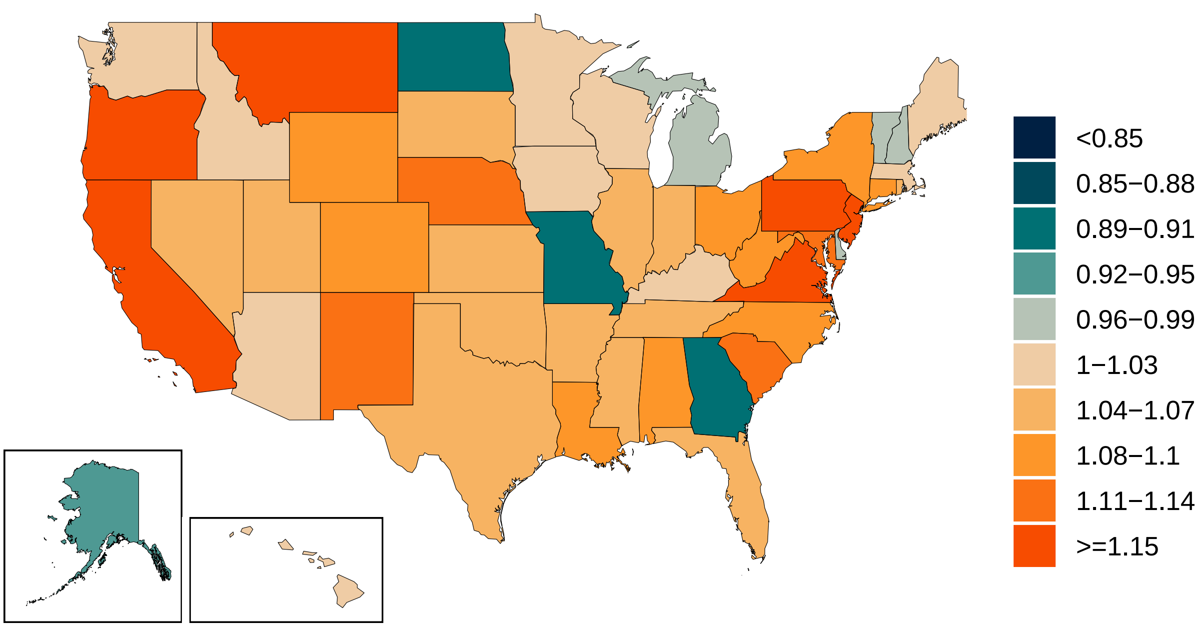


Figure 4. Estimated percent of the population infected with COVID-19 on November 30, 2020

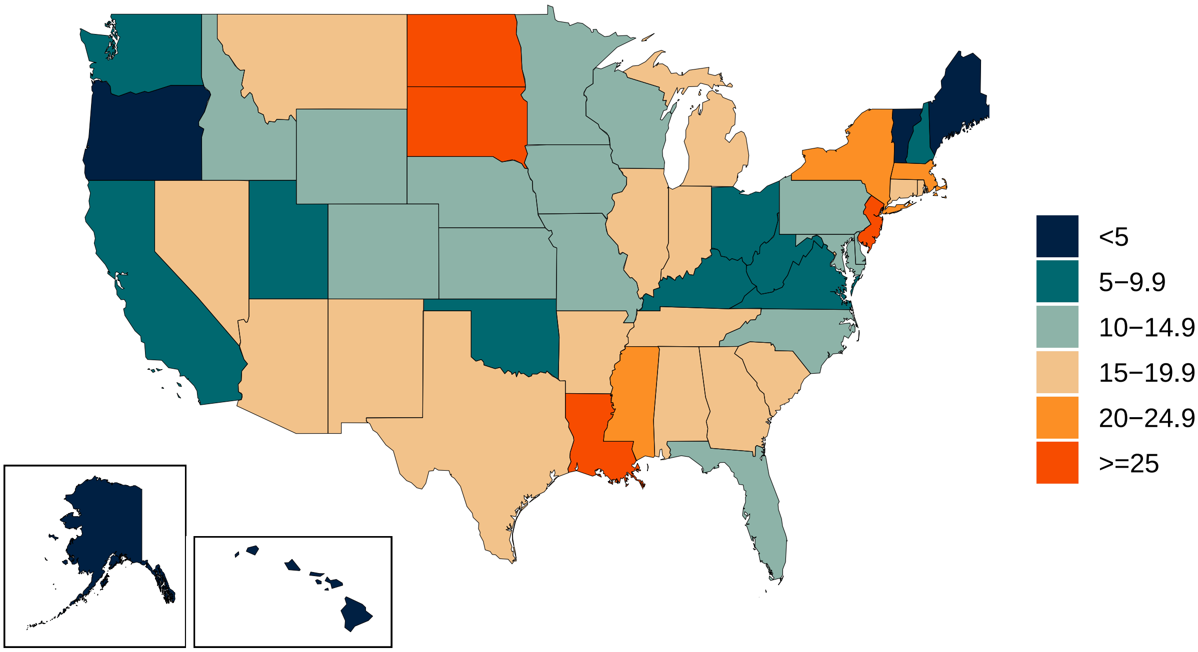


Figure 5. Percent of COVID-19 infections detected. This is estimated as the ratio of reported daily COVID-19 cases to estimated daily COVID-19 infections based on the SEIR disease transmission model.

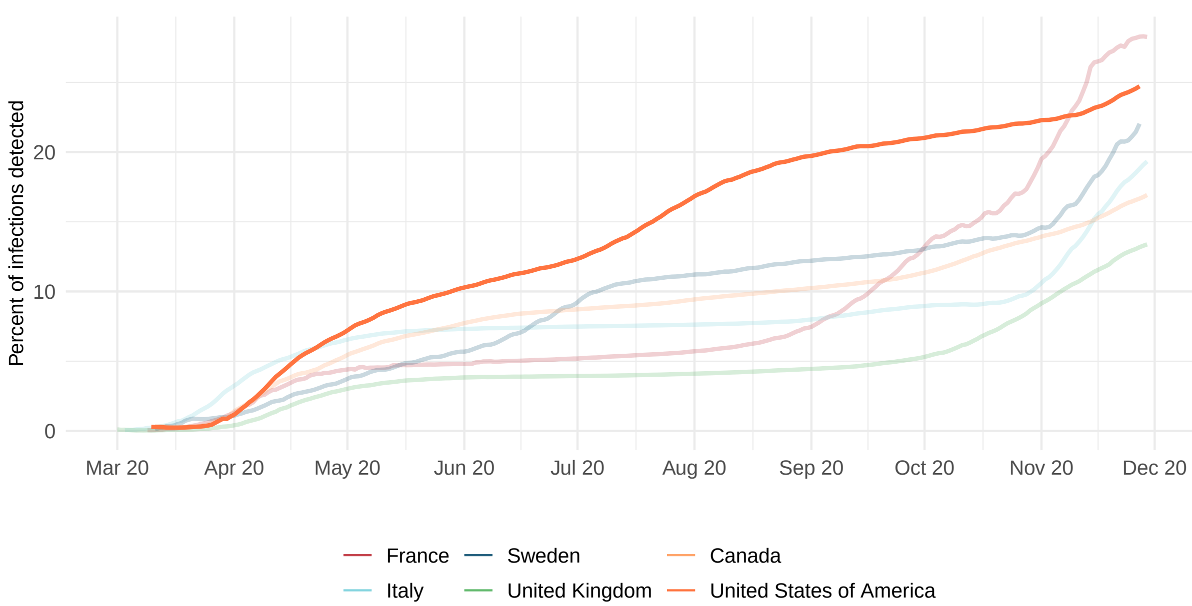
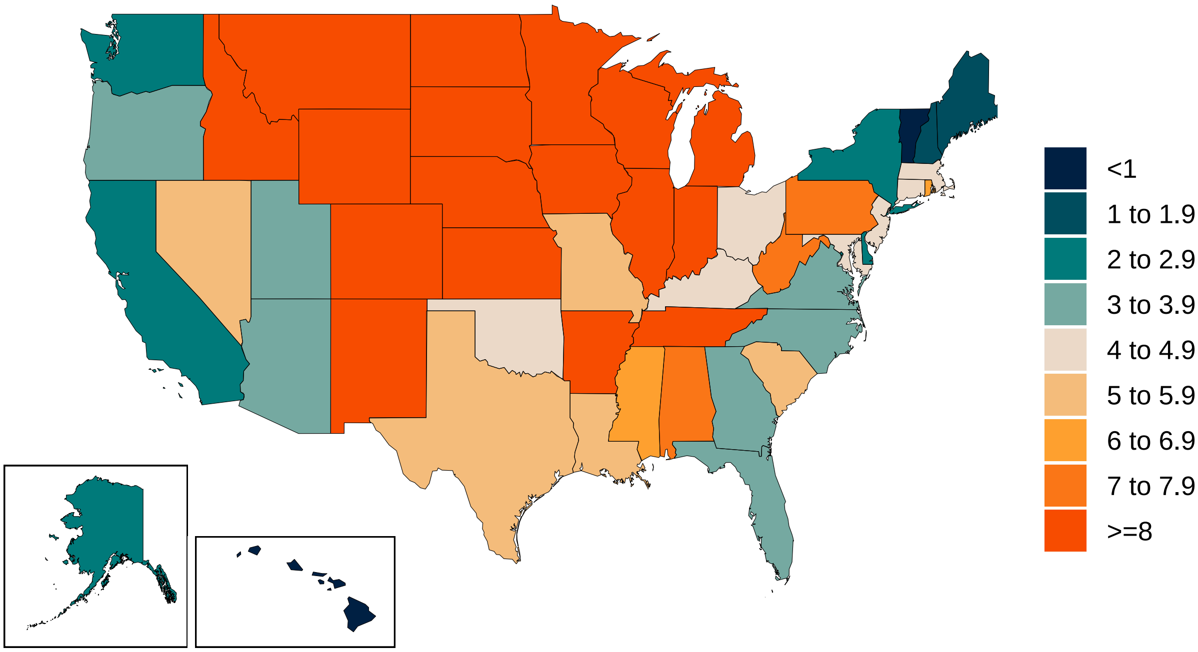


Figure 6. Daily COVID-19 death rate per 1 million on November 30, 2020



Critical drivers

Table 2. Current mandate implementation

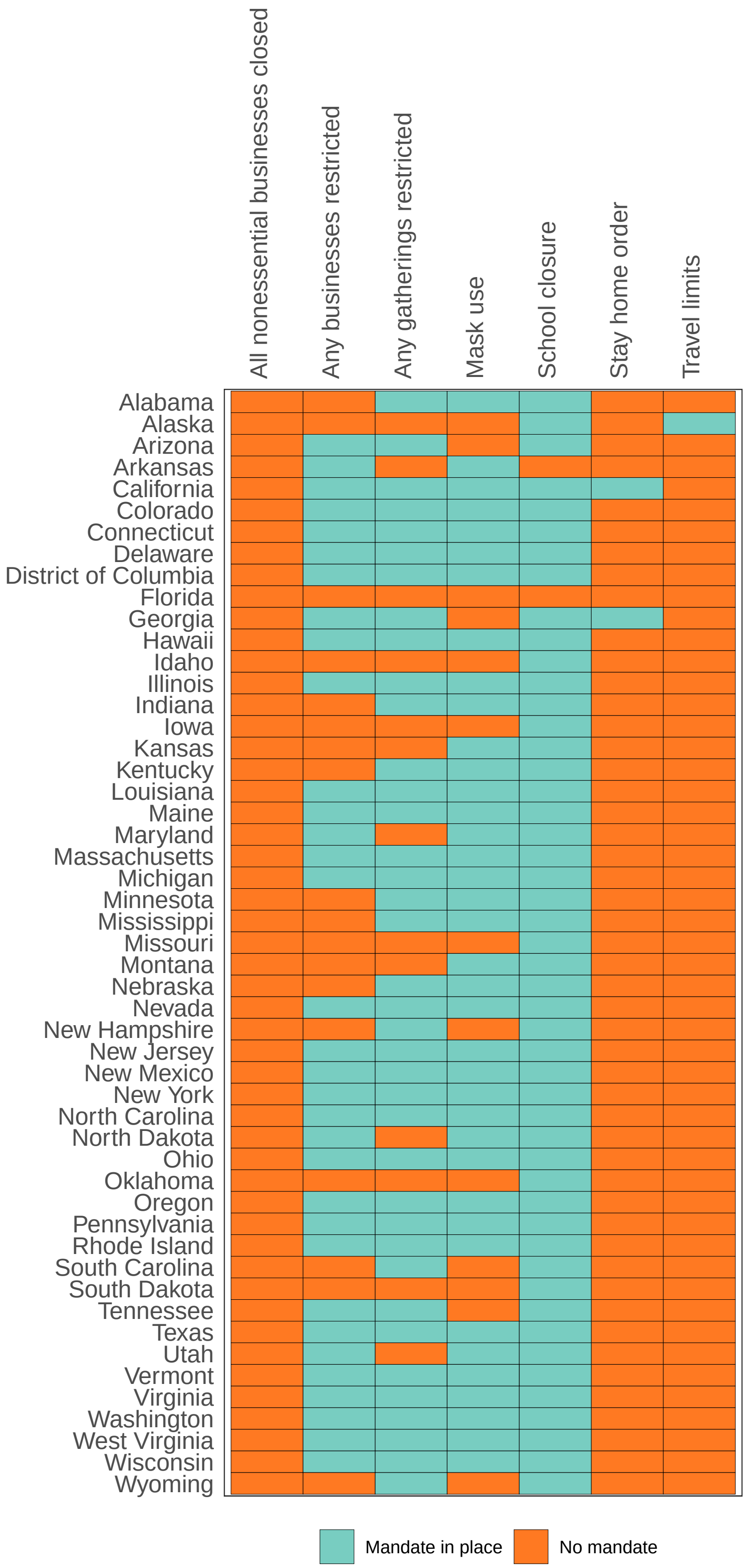


Figure 7. Total number of social distancing mandates (including mask use)

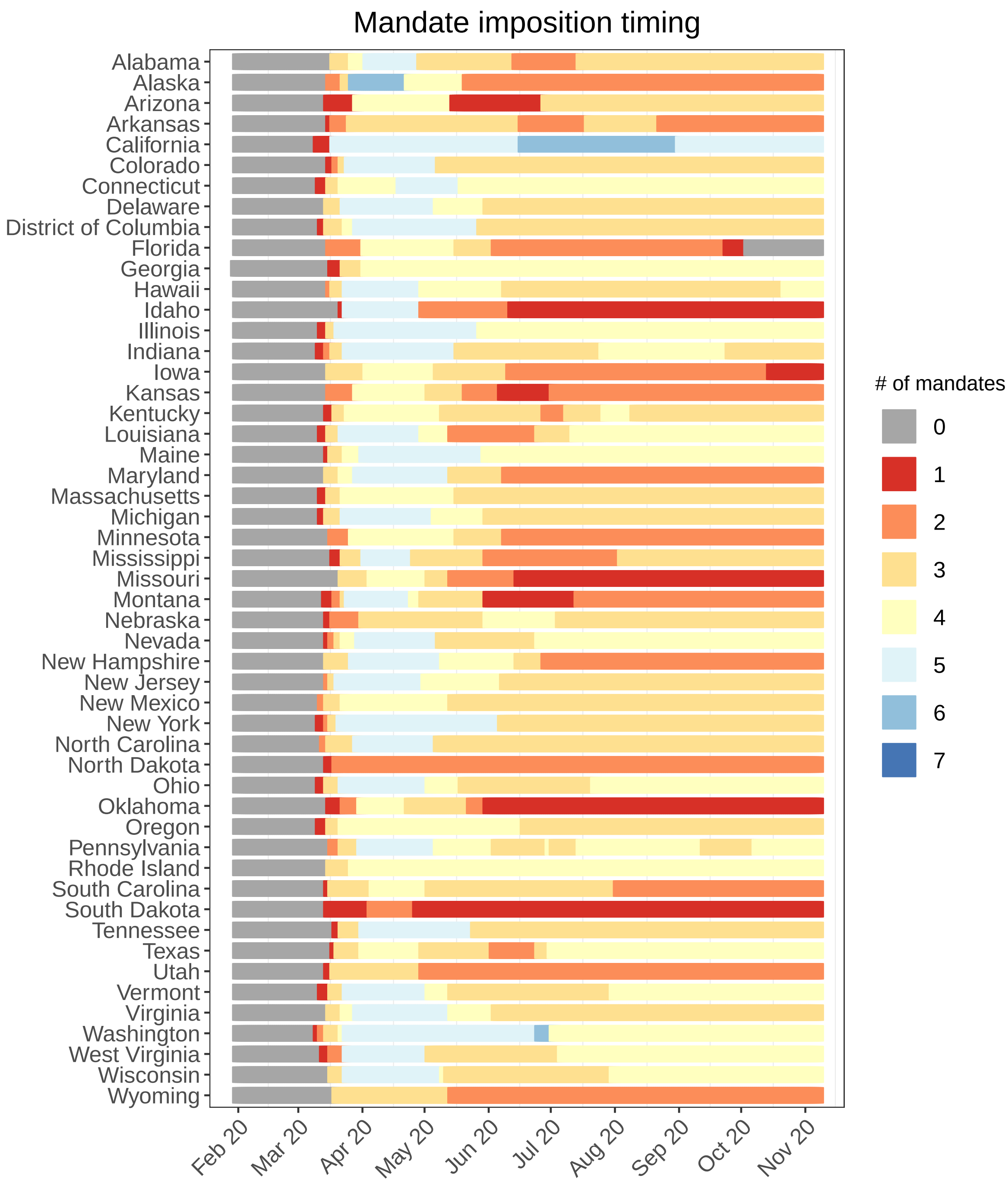


Figure 8a. Trend in mobility as measured through smartphone app use compared to January 2020 baseline

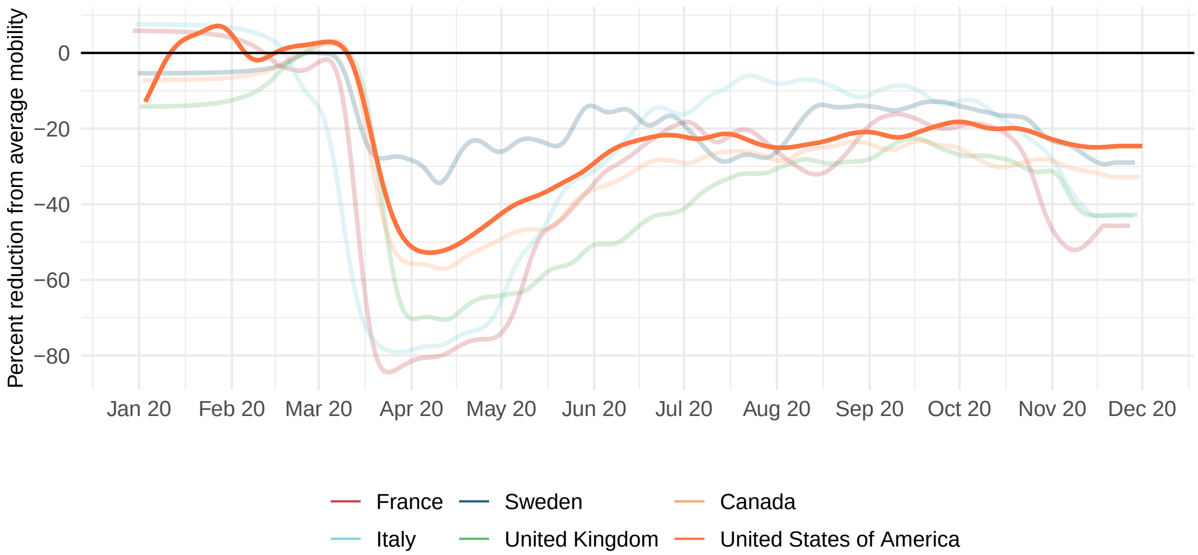


Figure 8b. Mobility level as measured through smartphone app use compared to January 2020 baseline (percent) on November 30, 2020

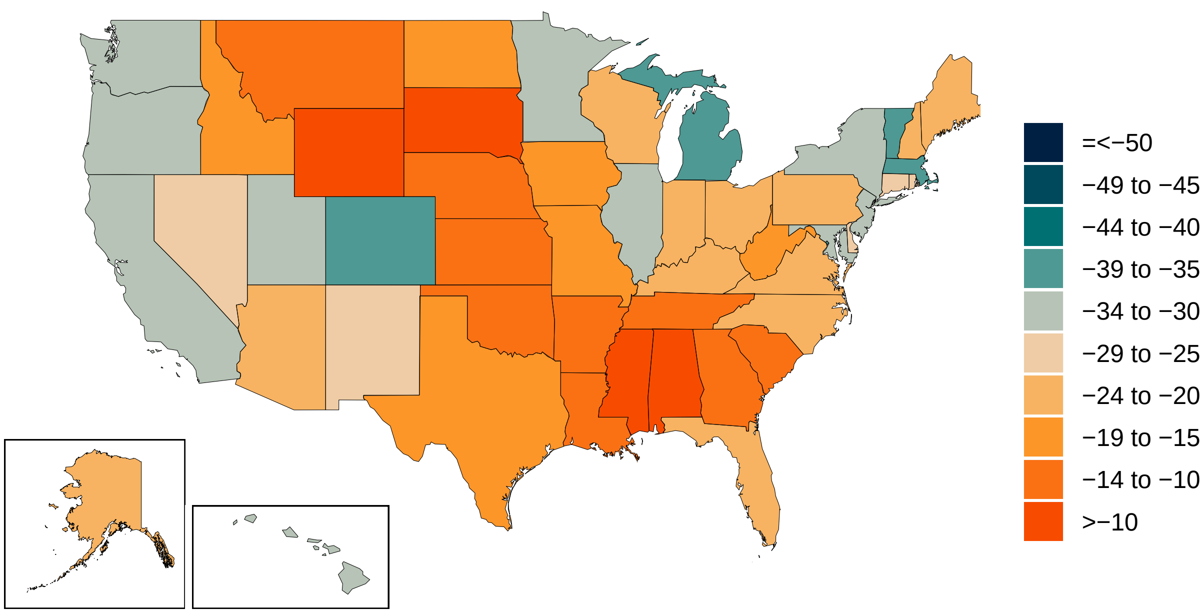


Figure 9a. Trend in the proportion of the population reporting always wearing a mask when leaving home

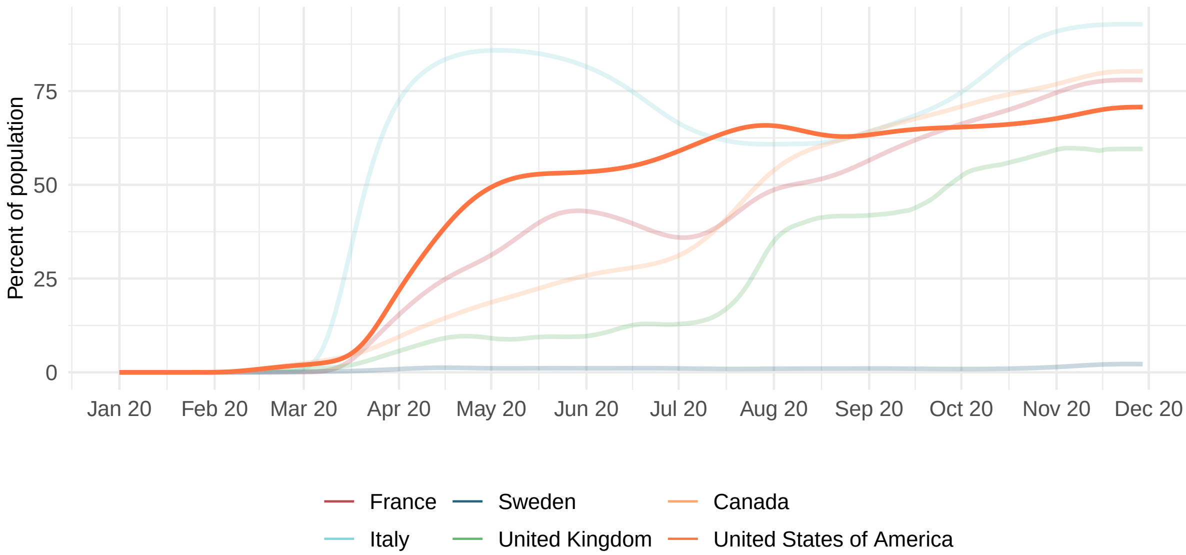


Figure 9b. Proportion of the population reporting always wearing a mask when leaving home on November 30, 2020

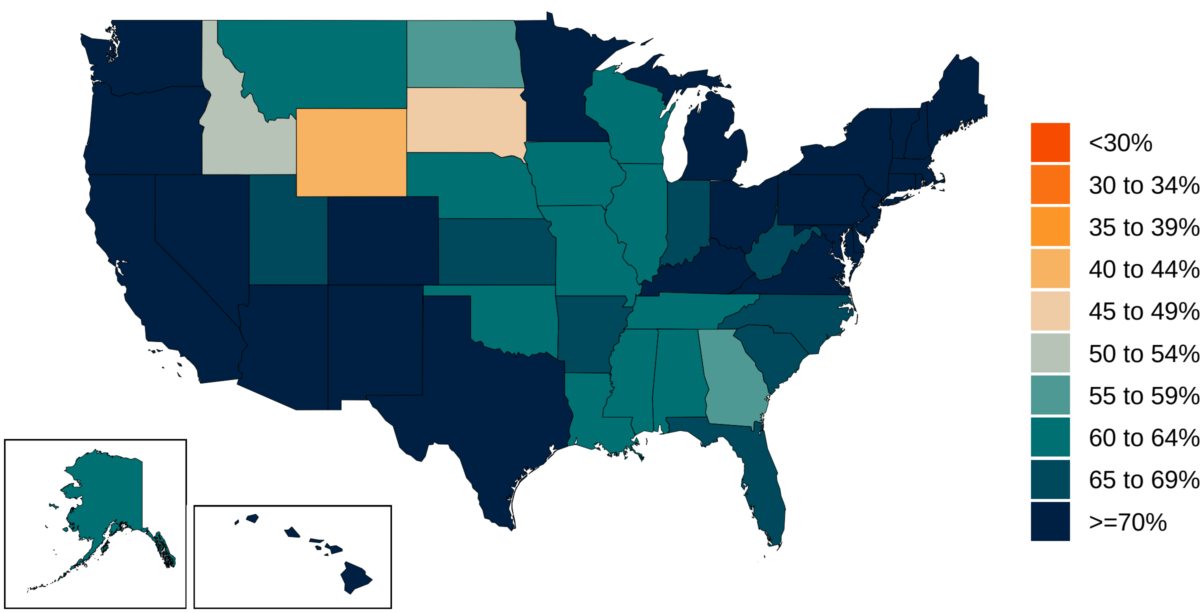


Figure 10a. Trend in COVID-19 diagnostic tests per 100,000 people

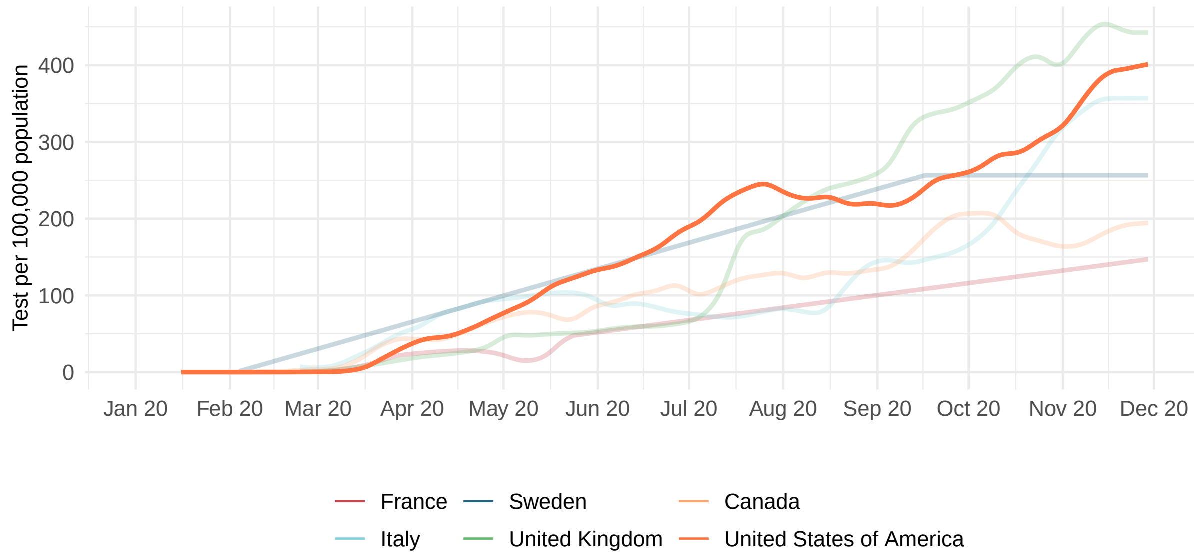


Figure 10b. COVID-19 diagnostic tests per 100,000 people on November 22, 2020

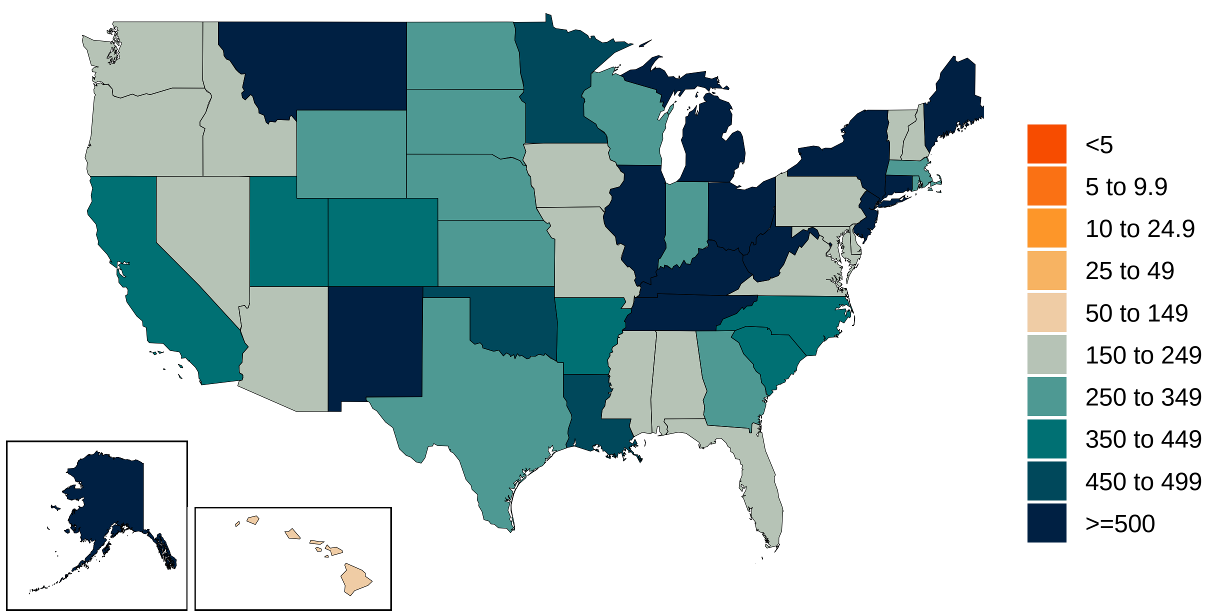


Figure 11. Increase in the risk of death due to pneumonia on February 1 2020 compared to August 1 2020

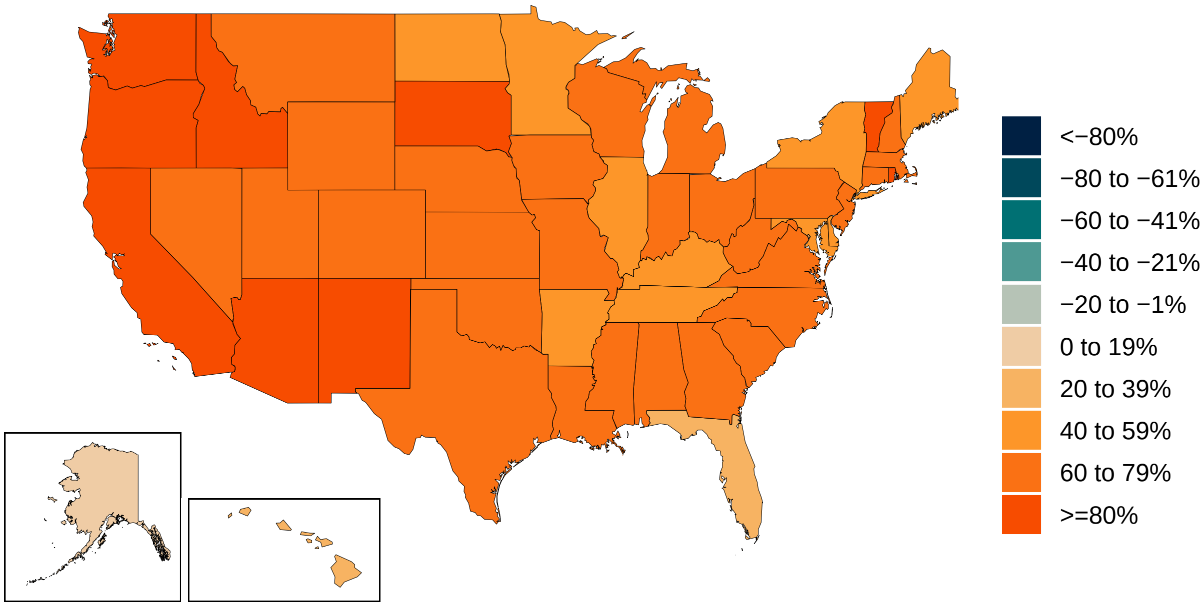


Figure 12. This figure shows the estimated proportion of the adult (18+) population that is open to receiving a COVID-19 vaccine based on Facebook survey responses

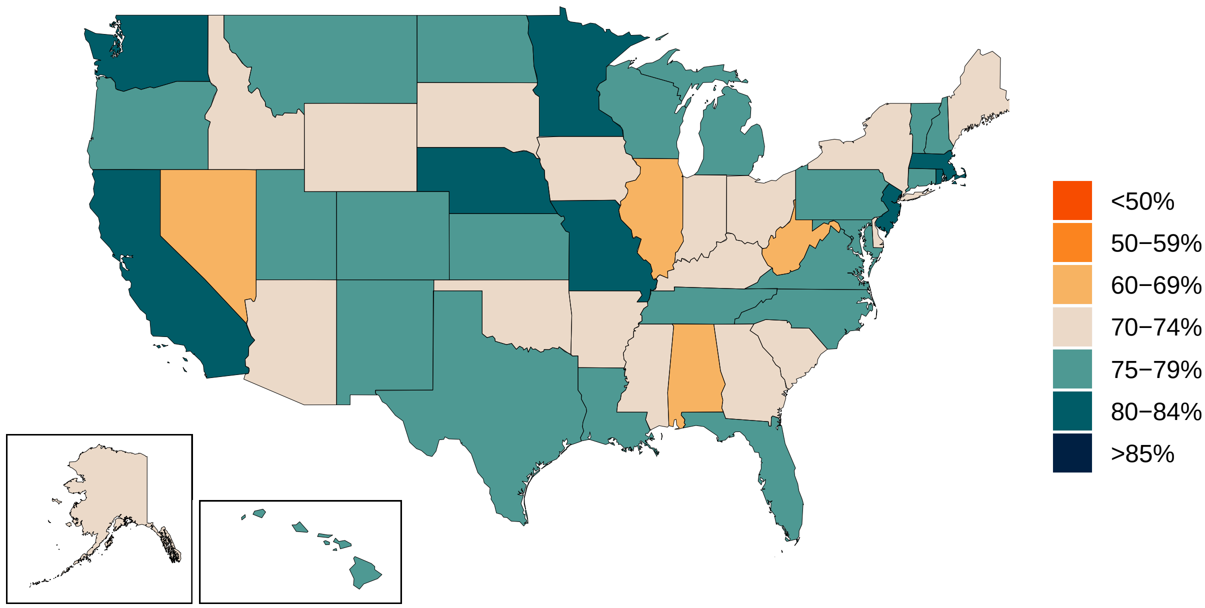
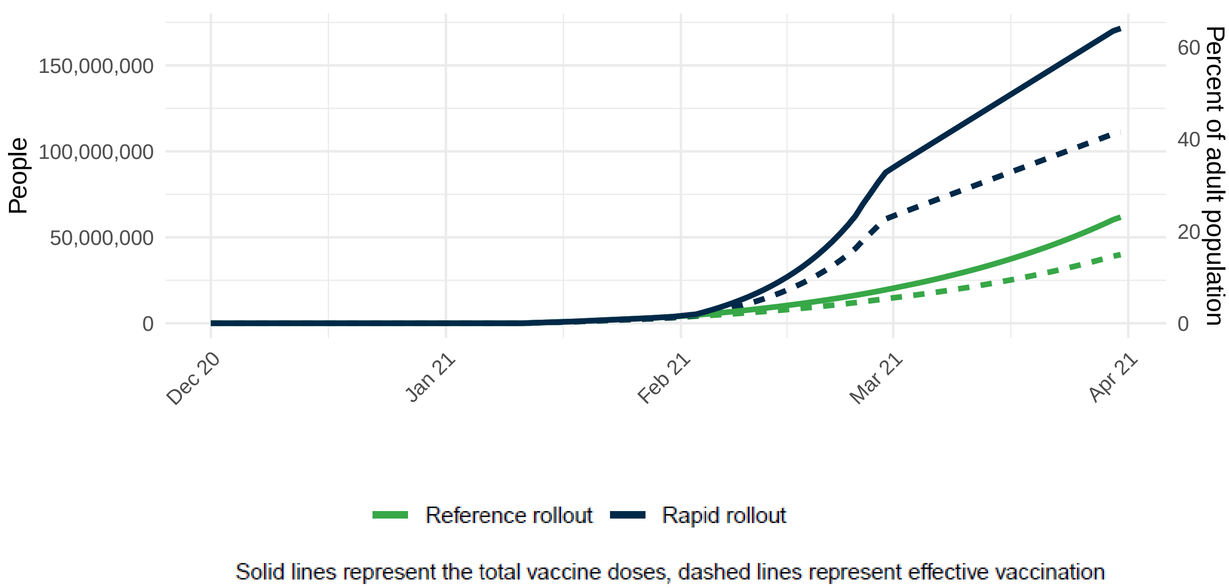


Figure 13. The number of people who receive any vaccine and those that are immune accounting for efficacy, loss to follow up for 2 dose vaccines, and a 28 day delay between first dose and immunity for 2 dose vaccines.



Projections and scenarios

We produce six scenarios when projecting COVID-19. The reference scenario is our forecast of what we think is most likely to happen. We assume that if the daily mortality rate from COVID-19 reaches 8 per million, social distancing (SD) mandates will be re-imposed. The mandate easing scenario is what would happen if governments continue to ease social distancing mandates with no re-imposition. The universal mask mandate scenario is what would happen if mask use increased immediately to 95% and social distancing mandates were re-imposed at 8 deaths per million. These three scenarios assume our reference vaccine delivery scale up where vaccine delivery will scale to full capacity over 90 days.

The rapid vaccine rollout scenario assumes that vaccine distribution will scale up to full delivery capacity in half the time as the reference delivery scenario and that the maximum doses that can be delivered per day is twice as much as the reference delivery scenario. The rapid vaccine rollout to high-risk populations scenario is the same but high-risk populations are vaccinated before essential workers or other adults. The no vaccine scenario is the same as our reference scenario but with no vaccine use.

Figure 14. Cumulative COVID-19 deaths until April 01, 2021 for six scenarios

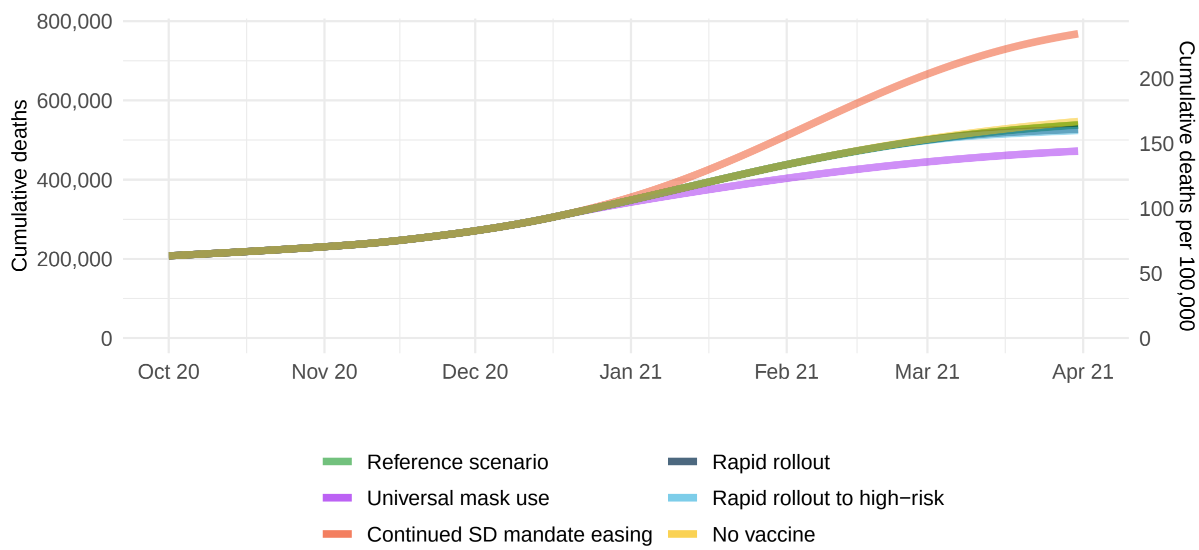


Figure 15. Daily COVID-19 deaths until April 01, 2021 for six scenarios

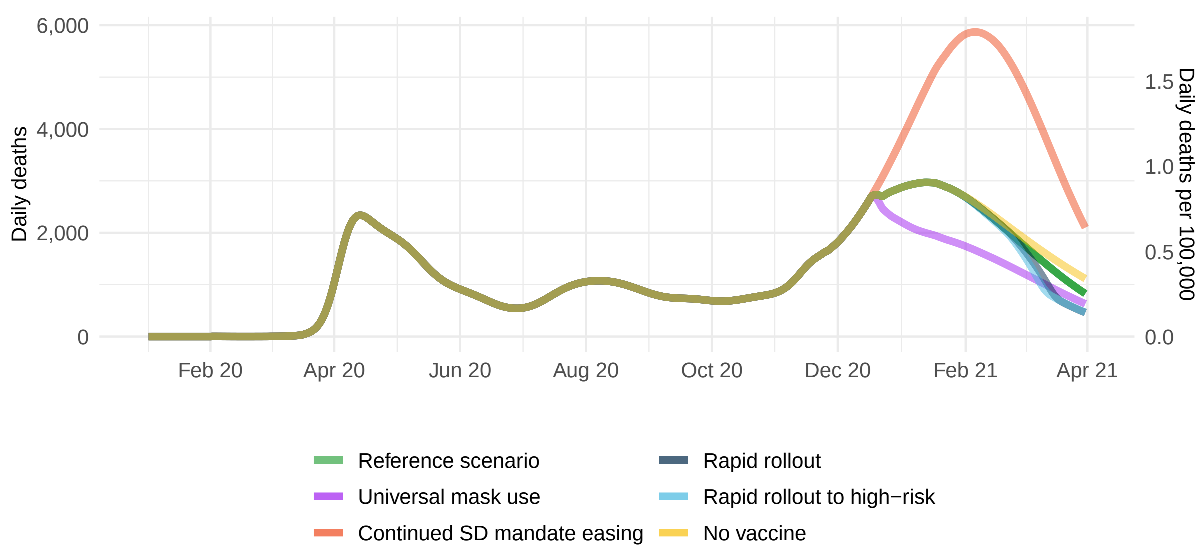


Figure 16. Daily COVID-19 infections until April 01, 2021 for six scenarios

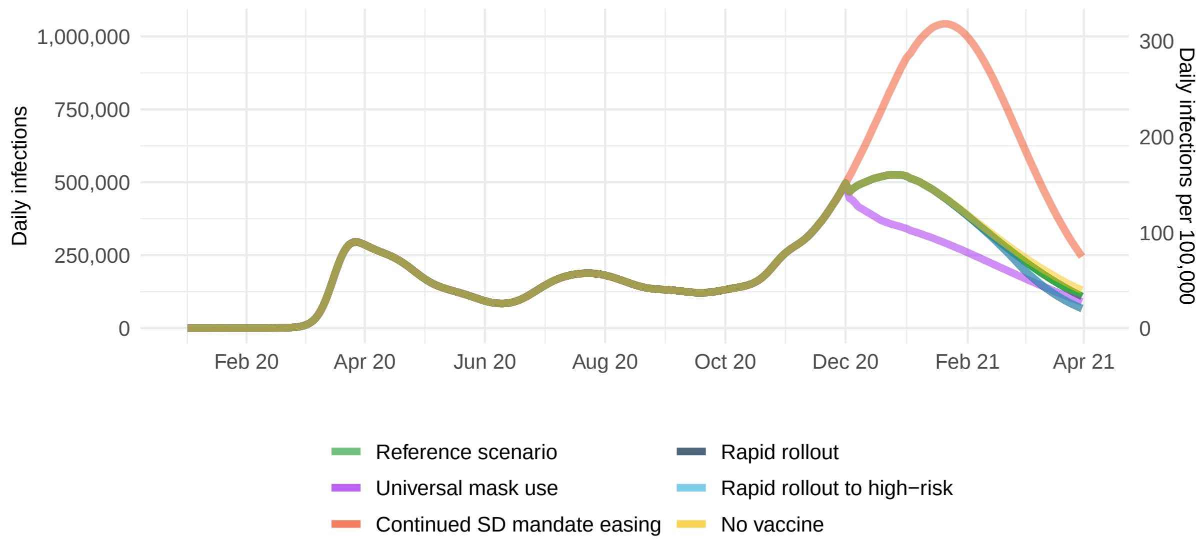


Figure 17. Susceptible population, accounting for infections and people immune through vaccination

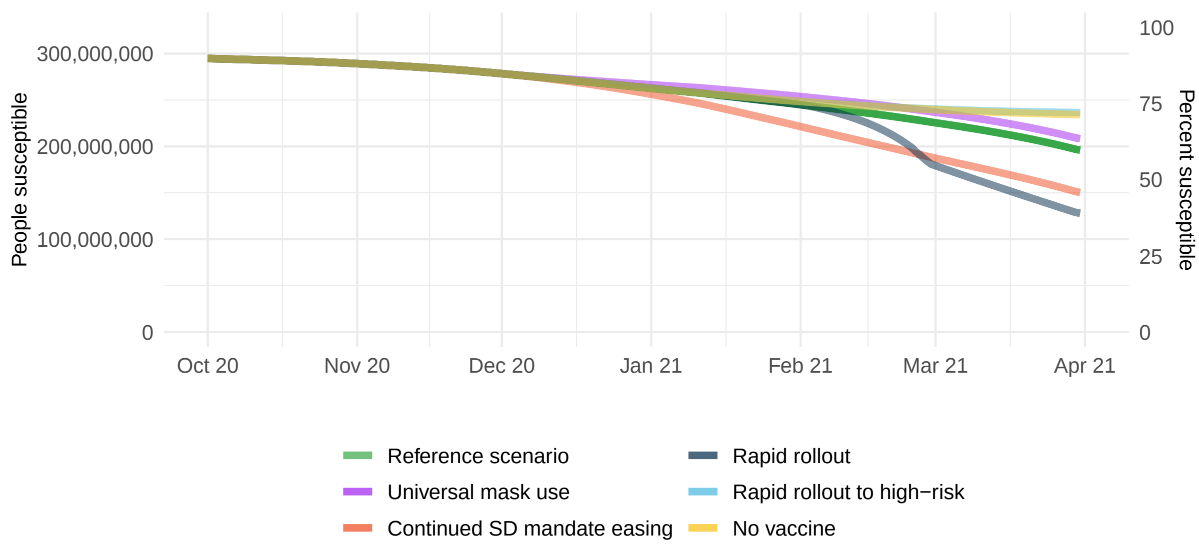


Figure 18. Month of assumed mandate re-implementation. (Month when daily death rate passes 8 per million, when reference scenario model assumes mandates will be re-imposed.)

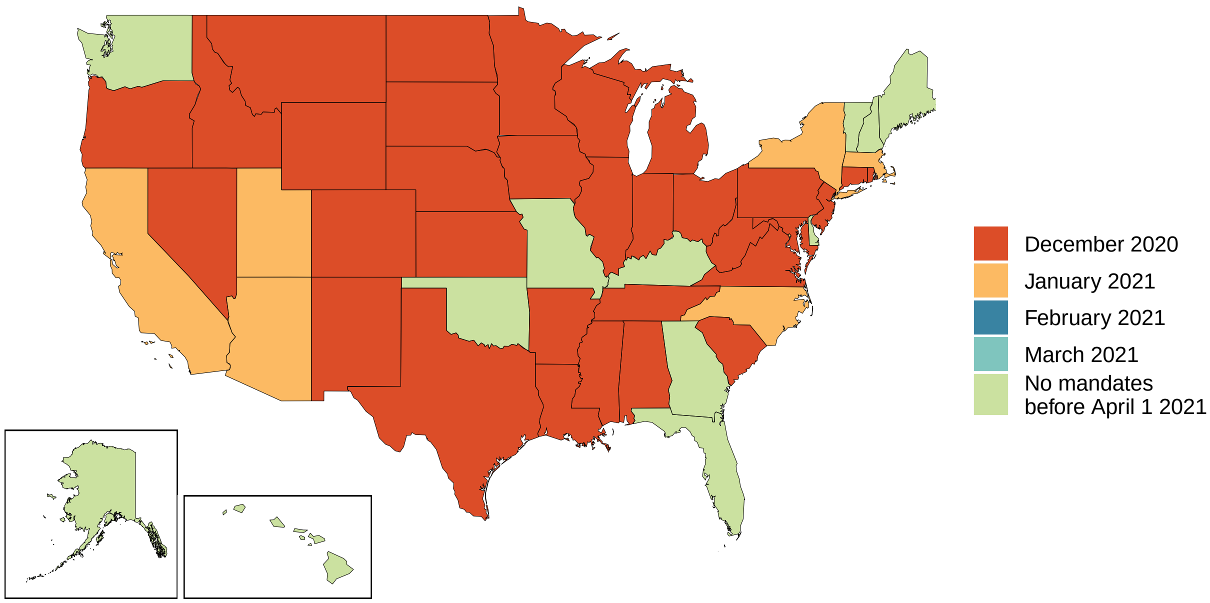


Figure 19. Forecasted percent infected with COVID-19 on April 01, 2021

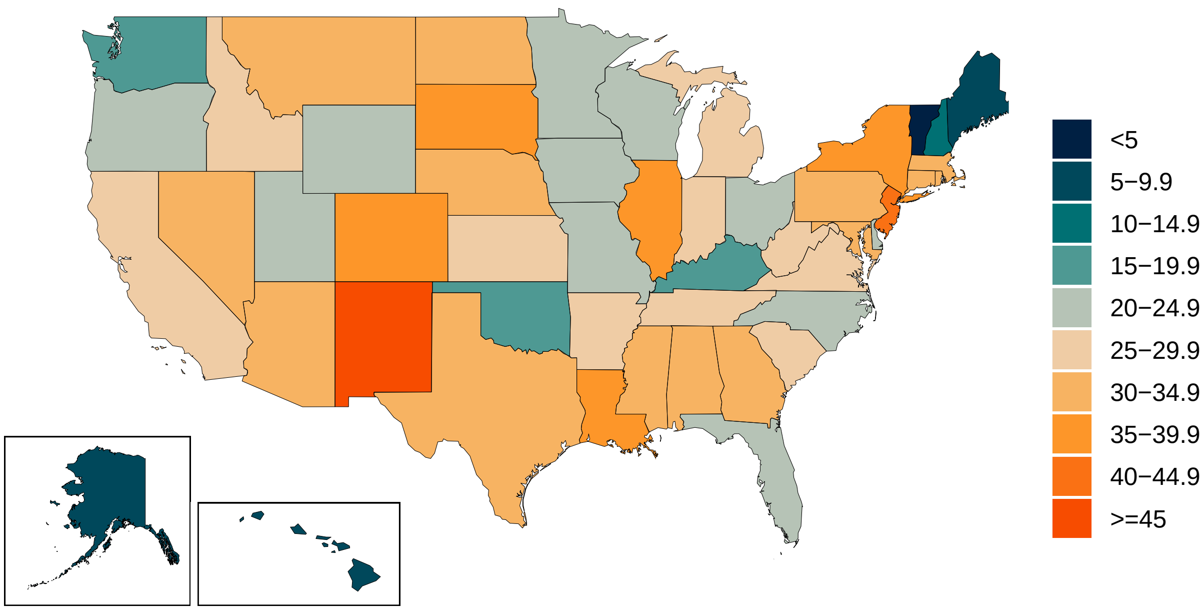


Figure 20. Daily COVID-19 deaths per million forecasted on April 01, 2021 in the reference scenario

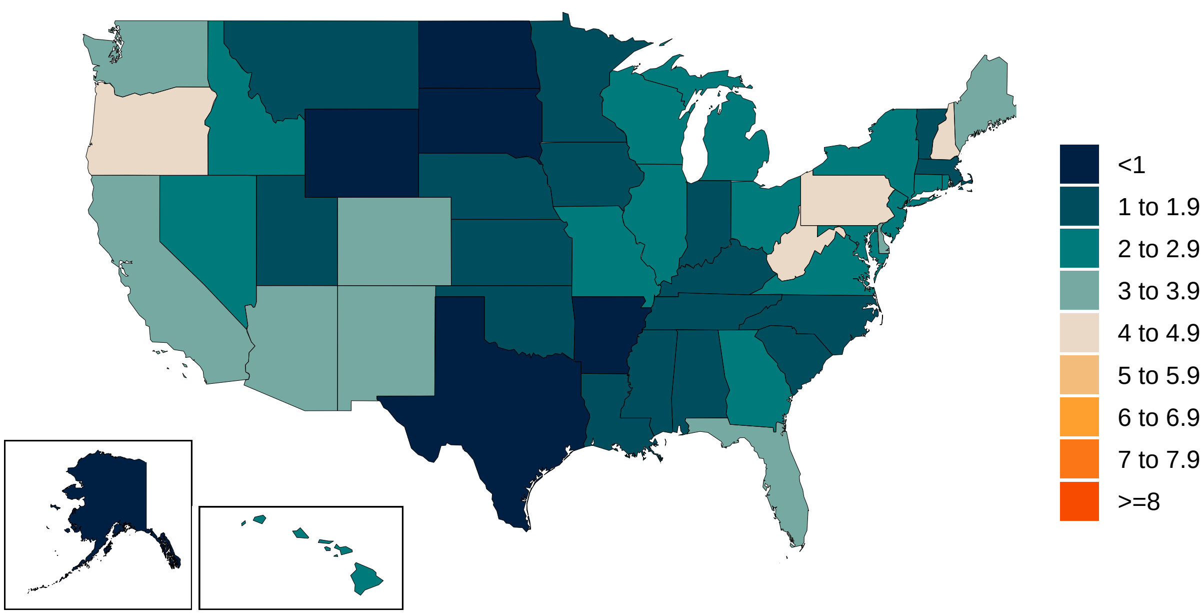


Figure 21. Comparison of reference model projections with other COVID modeling groups. For this comparison, we are including projections of daily COVID-19 deaths from other modeling groups when available: Delphi from the Massachussets Institute of Technology (Delphi; https://www.covidanalytics.io/home), Imperial College London (Imperial; https://www.covidsim.org), The Los Alamos National Laboratory (LANL; https://covid-19.bsvgateway.org/), and the SI-KJalpha model from the University of Southern California (SIKJalpha; https://github.com/scc-usc/ReCOVER-COVID-19). Daily deaths from other modeling groups are smoothed to remove inconsistencies with rounding. Regional values are aggregates from availble locations in that region.

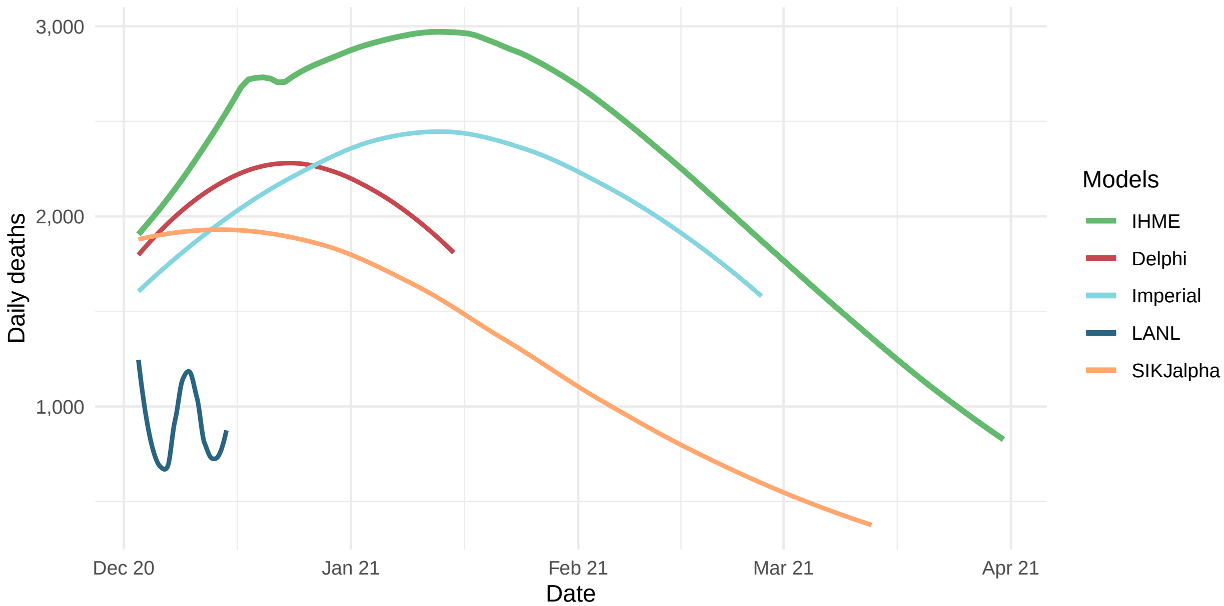


Figure 22. The estimated inpatient hospital usage is shown over time. The percent of hospital beds occupied by COVID-19 patients is color coded based on observed quantiles of the maximum proportion of beds occupied by COVID-19 patients. Less than 5% is considered *low stress*, 5-9% is considered *moderate stress*, 10-19% is considered *high stress*, and greater than 20% is considered *extreme stress*.

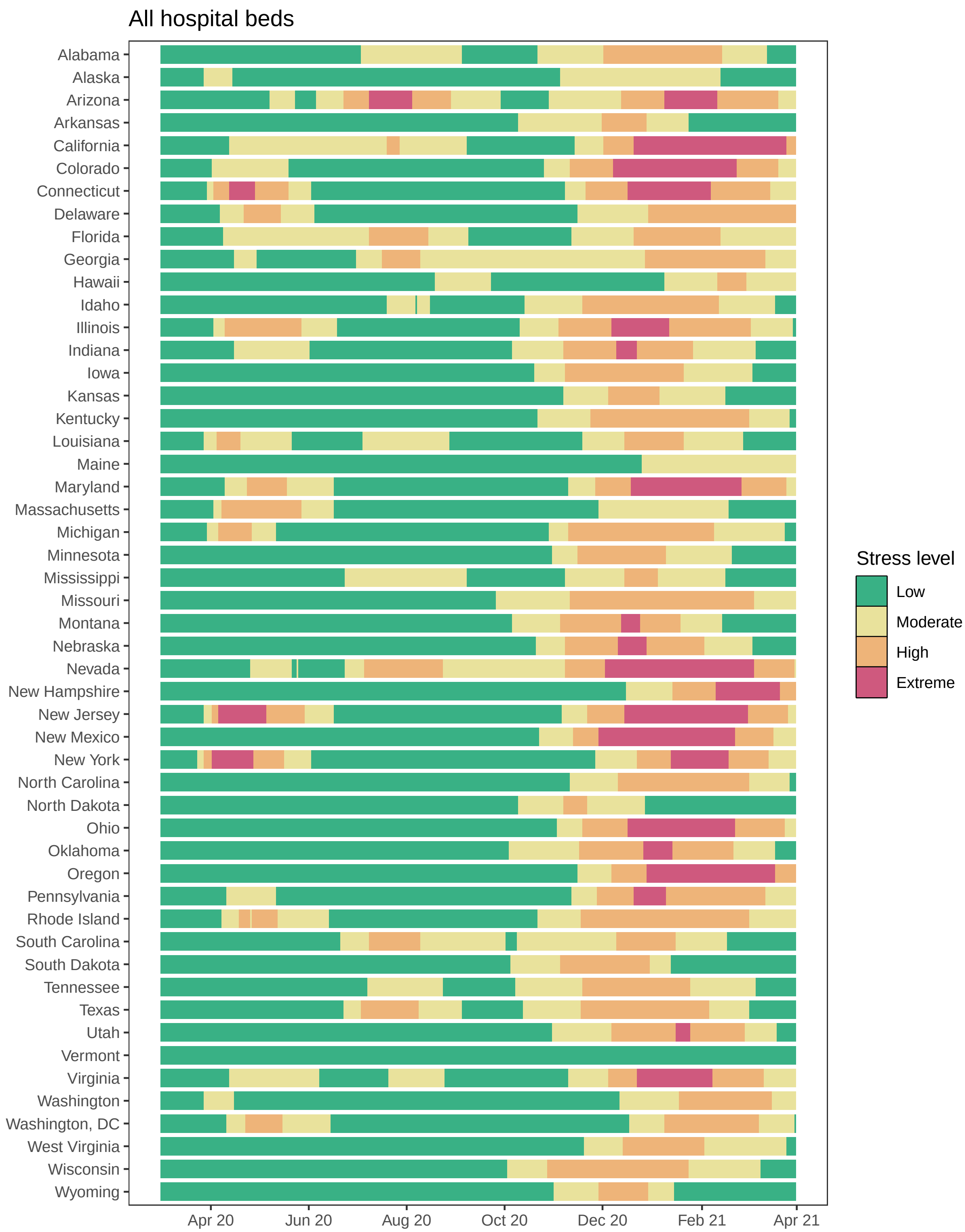


Figure 23. The estimated intensive care unit (ICU) usage is shown over time. The percent of ICU beds occupied by COVID-19 patients is color coded based on observed quantiles of the maximum proportion of ICU beds occupied by COVID-19 patients. Less than 10% is considered *low stress*, 10-29% is considered *moderate stress*, 30-59% is considered *high stress*, and greater than 60% is considered *extreme stress.*

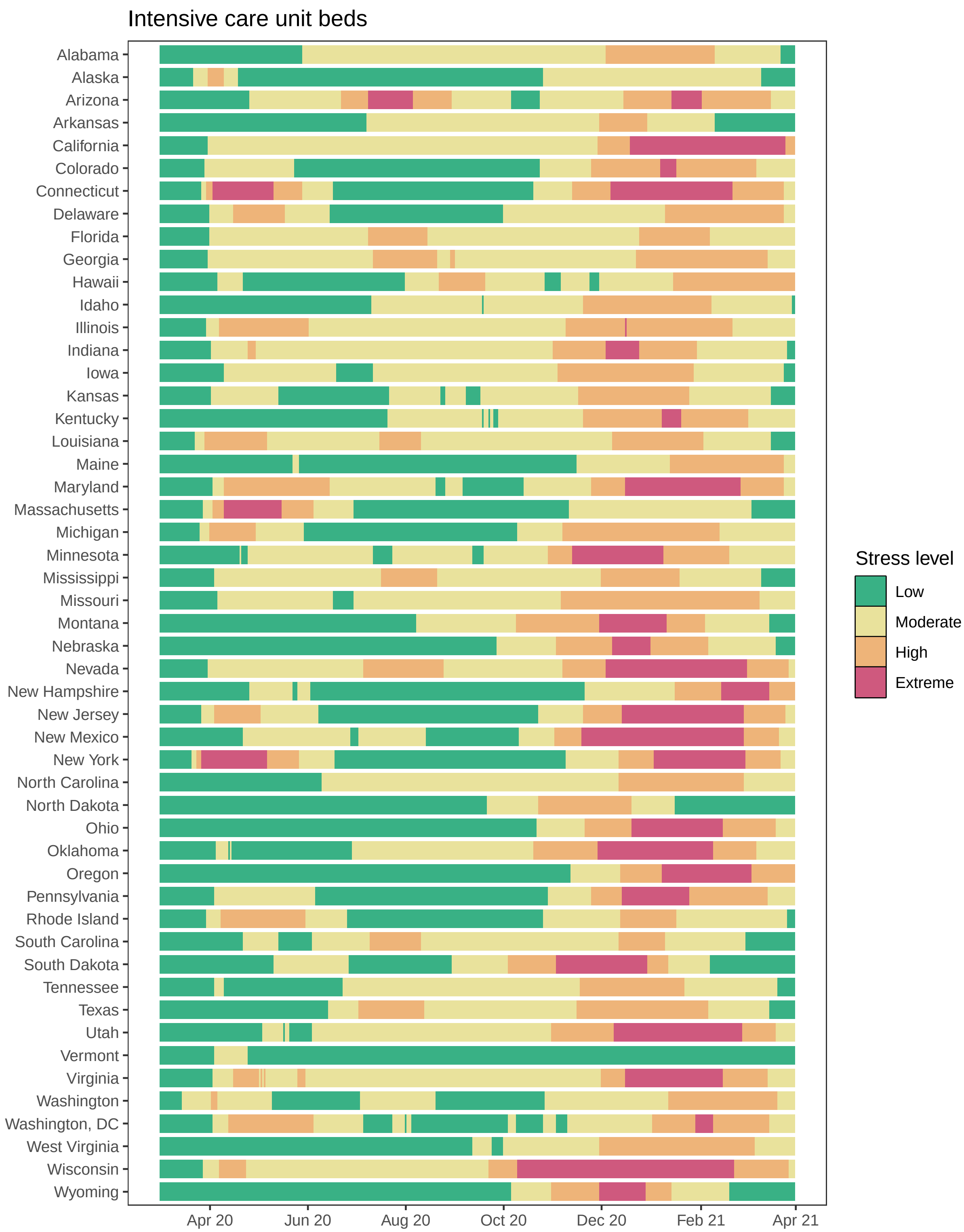


Table 3. Ranking of COVID-19 among the leading causes of mortality in the full year 2020. Deaths from COVID-19 are projections of cumulative deaths on Jan 1, 2021 from the reference scenario. Deaths from other causes are from the Global Burden of Disease study 2019 (rounded to the nearest 100).

Cause name	Annual deaths	Ranking
Ischemic heart disease	557,600	1
COVID-19	348,311	2
Tracheal, bronchus, and lung cancer	206,200	3
Chronic obstructive pulmonary disease	195,800	4
Stroke	189,500	5
Alzheimer's disease and other dementias	143,900	6
Chronic kidney disease	107,000	7
Colon and rectum cancer	84,000	8
Lower respiratory infections	81,900	9
Diabetes mellitus	77,700	10

More information

Data sources:

Mask use data sources include PREMISE; Facebook Global symptom survey (This research is based on survey results from University of Maryland Social Data Science Center) and the Facebook United States symptom survey (in collaboration with Carnegie Mellon University); Kaiser Family Foundation; YouGov COVID-19 Behaviour Tracker survey.

Vaccine hesitancy data are from the COVID-19 Beliefs, Behaviors, and Norms Study, a survey conducted on Facebook by the Massachusetts Institute of Technology (https://covidsurvey.mit.edu/).

Data on vaccine candidates, stages of development, manufacturing capacity, and pre-purchasing agreements are primarily from Linksbridge and supplemented by Duke University.

A note of thanks:

We wish to warmly acknowledge the support of these and others who have made our covid-19 estimation efforts possible.

More information:

For all COVID-19 resources at IHME, visit http://www.healthdata.org/covid.

Questions? Requests? Feedback? Please contact us at https://www.healthdata.org/covid/contact-us.