

# Working paper

## COVID-19 trends in Oregon: Implications for interventions

*Results as of 4/29/2020, 4:00 pm*

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## Executive Summary

**Purpose of this report:** To estimate the number of people who are likely to have COVID-19 and need hospital services in Oregon over the next 6 weeks, assuming interventions with different levels of effectiveness are implemented.

**Methods:** This report uses available data from April 27, 2020 on confirmed positive diagnoses, number of tests completed, hospitalizations, intensive care unit (ICU) admittance, and deaths for Oregon to calibrate an agent-based COVID-19 model (Covasim), which is then used for projecting future epidemic trends.

**Key Findings:** We predict that there have been approximately 9,200 cumulative infections in Oregon, of which 2,300 had been diagnosed by April 23rd. The aggressive interventions (“Stay Home, Save Lives”) have been effective in dramatically reducing transmission rates. However, relatively small increases in transmission levels in the community could cause an increase in infections. As Oregon plans for loosening the current aggressive community mitigation strategies (“Stay Home, Save Lives”), we recommend other public health control strategies be put into place first (e.g., expanded contact tracing) and the aggressive community mitigation strategies be loosened incrementally to prevent any large increases in cases.

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## Methods

Orpheus data on COVID-19 cases were used. Orpheus is an integrated electronic disease surveillance system for public health to manage communicable disease reports ([Orpheus description](#)). The data file was obtained on April 27<sup>th</sup>, but data after April 23<sup>rd</sup> were considered incomplete because of lags in reporting.

We applied Covasim ([Covasim code](#)), an individual-based COVID-19 transmission model with parameters informed by literature (assumptions given in the Appendix). The model was calibrated by modifying the assumptions to best fit data from Orpheus on confirmed positive COVID-19 diagnoses, number of tests completed, hospitalizations (referred to as severe cases below), intensive care unit (ICU) admittance (referred to as critical cases below, and included in severe case counts), and deaths for Oregon. The model was then used for projecting future epidemic trends.

## Interventions

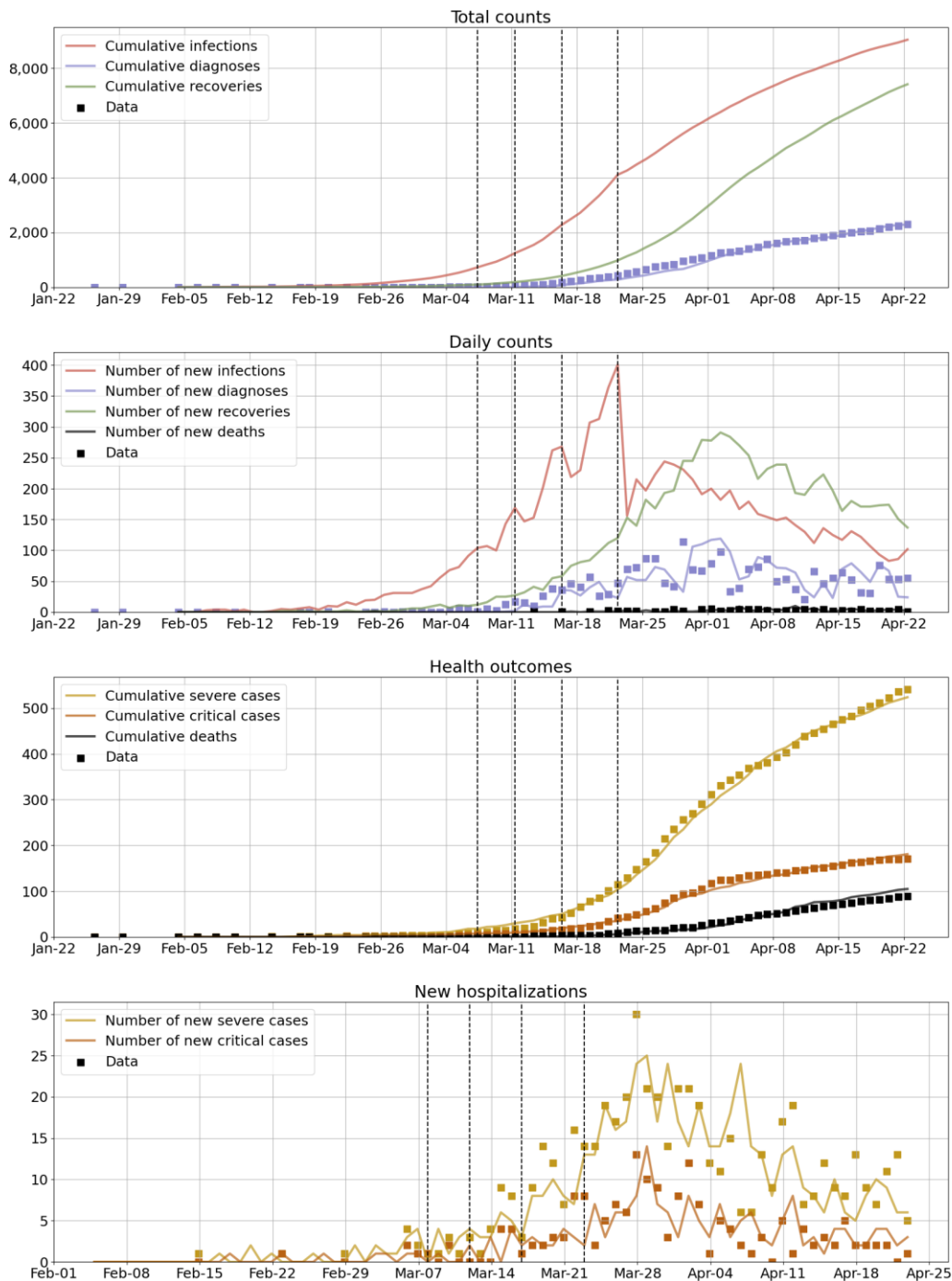
Oregon has implemented numerous measures to slow the transmission of COVID-19 over time:

- On March 12, 2020: A large number of measures were put in place, such as bans on gatherings of more than 250 people; these are detailed [here](#).
- On March 16, 2020: Schools were closed statewide, as detailed [here](#). Further measures were put in place on March 16<sup>th</sup>, including the closure of restaurants and bars and gatherings of more than 25 people, as detailed [here](#).
- On March 23, 2020: Aggressive interventions, namely the [“Stay Home, Save Lives” recommendations](#), were put in place.

## Results

From modeling results calibrated to Oregon data, we predict that there have been approximately 9,200 cumulative infections in Oregon, of which 2,300 had been diagnosed by April 23<sup>rd</sup> (Figure 1).

There is evidence that Oregon’s interventions -- combined with increased hygiene and other measures that appear to have begun earlier -- have dramatically reduced the burden of COVID-19 in Oregon (Figure 1). The data are consistent with a stepped reduction in transmission in Oregon, beginning with a 10% decrease in transmission by March 8<sup>th</sup>, through to a sustained 70% decrease in transmission after March 23<sup>rd</sup>. Indeed, while the interventions before March 23<sup>rd</sup> appeared to have slowed epidemic growth, the additional aggressive measures implemented on March 23<sup>rd</sup> (i.e., “Stay Home, Save Lives”) appear to have reversed the growth. These results are consistent with large reductions in movement as shown in Google data for Oregon ([Google mobility reports](#)).



**Figure 1:** Best-fit model calibration with Oregon case data. Dotted vertical lines correspond to estimated reductions in transmission relative to baseline, from left to right, of 10%, 20%, 30%, and 70%. The impacts of these interventions were estimated by calibrating to numbers of positive diagnoses (squares, top two plots), and to new severe cases (based on hospital admission date), new critical (intensive care unit (ICU)) cases, and deaths (bottom two plots). Note: Because of delays in reporting, data after April 23<sup>rd</sup> were considered incomplete. In addition, the estimated effect of the moderate interventions is imprecise, given it was based on only one week of data.

## Scenario projections

We modeled three scenarios from May 4<sup>th</sup> until June 4<sup>th</sup>, assuming interventions with different levels of effectiveness in reducing transmission:

1. Interventions continue that reduce transmission by 70%: We assume interventions as effective as the current aggressive interventions (“Stay Home, Save Lives”) are continued.
2. Change interventions for 60% reduction in transmission: Interventions are loosened, but still are able to reduce transmission by 60%.
3. Change interventions for 30% reduction in transmission: Interventions are loosened, but still are able to reduce transmission by 30%. This corresponds to the estimated reduction in transmission from the interventions implemented March 16<sup>th</sup> to March 22<sup>nd</sup>.

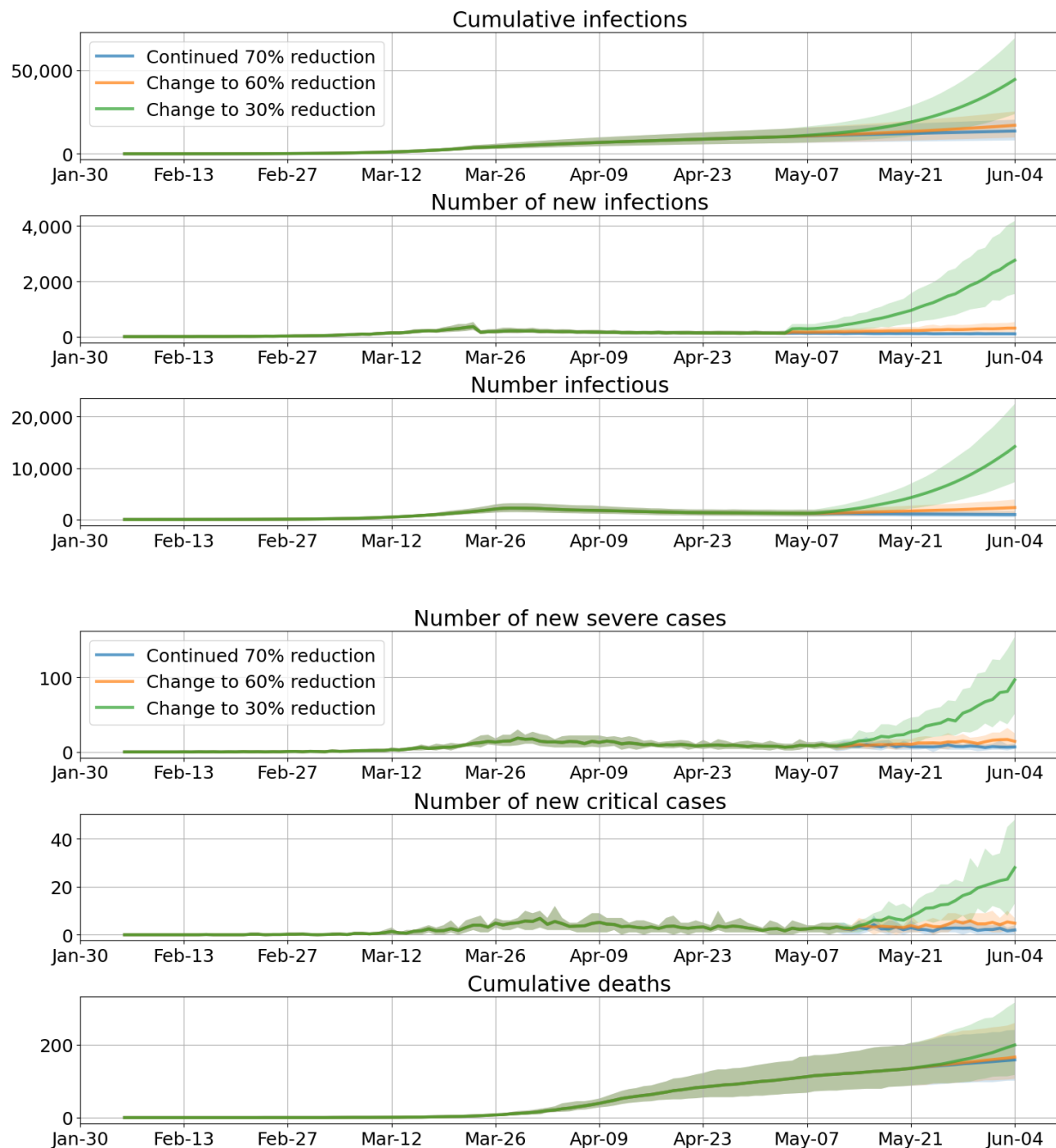
With continued aggressive interventions resulting in a 70% reduction in transmission (as with “Stay Home, Save Lives”), the number of cumulative infections is projected to slowly increase, while the number of those infectious slowly declines over the next 6 weeks (Figure 2). If Oregon were to return to interventions with a 30% reduction in transmission, the number of those infectious are projected to rise rapidly, compared to the interventions with 70% and 60% reductions in transmission. A similar pattern is seen for new hospitalizations (Figure 2).

Upon a closer look at the comparison of the interventions resulting in a 70% versus 60% reduction in transmission (Figure 3), this epidemic is clearly very sensitive to changes in policies or public adherence to community mitigation strategies. Indeed, under the scenario with interventions reducing transmission by 60%, the model projects that by June 4<sup>th</sup>: about 3,500 more cumulative infections (17,100 vs 13,600), 200 more new infections per day (300 vs 100), and 9 more new severe cases per day (16 vs 7), compared to interventions reducing transmission by 70%.<sup>1</sup>

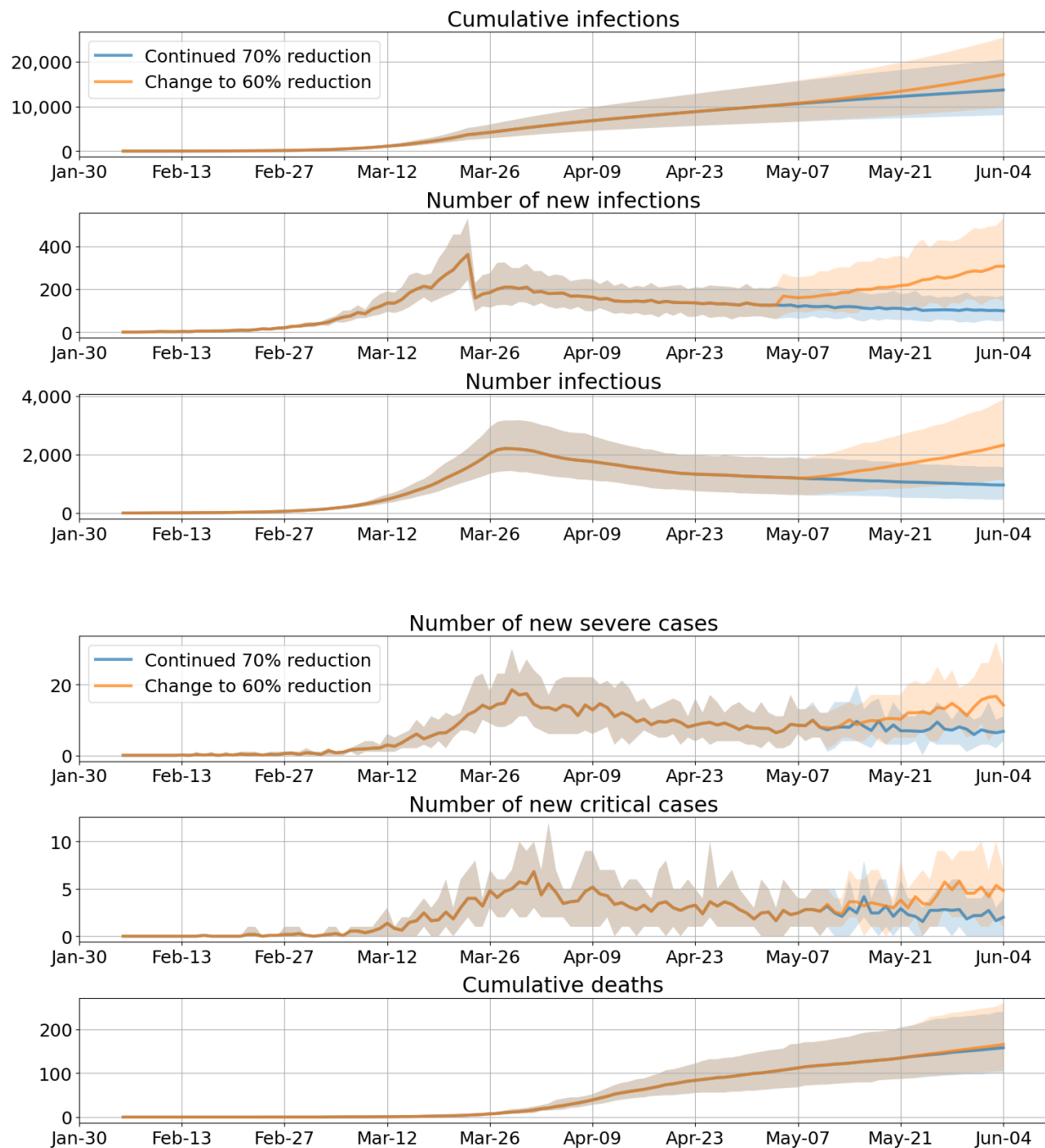
To further illustrate the sensitivity of the epidemic to such changes, we ran one more scenario, included in Appendix 3. If Oregon were to implement interventions resulted in a 50% reduction in transmission on May 4<sup>th</sup>, the cases rise quickly, resulting in about 9,400 more cumulative infections (23,000 vs. 13,600), 600 more new infections per day (700 vs 100), and 22 more severe cases per day (29 vs 7) by June 4<sup>th</sup>, compared to the 70% reduction scenario.<sup>1</sup>

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<sup>1</sup> Per-day scenario differences are based on average of last 4 days (June 1<sup>st</sup>-4<sup>th</sup>) to stabilize estimates.



**Figure 2:** Model projections for the next 6 weeks assuming that starting May 4<sup>th</sup>: 1) interventions continue that reduce transmission by 70% (blue line), 2) there is a change to interventions that reduces transmission by 60% (orange line), and 3) there is a change to interventions that reduces transmission by 30% (green line). The lighter shaded areas correspond to 80% forecast intervals ((i.e., 10<sup>th</sup> and 90<sup>th</sup> percentiles of the projection).



**Figure 3:** Model projections for the next 6 weeks, assuming that starting May 4<sup>th</sup>: 1) interventions continue that reduce transmission by 70% (blue line), and 2) there is a change to interventions that reduces transmission by 60% (orange line). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10<sup>th</sup> and 90<sup>th</sup> percentiles of the projection).

## Limitations

These projections should be considered preliminary and subject to change as more data become available, the science to inform the model assumptions expands, and modeling methods continue to be refined. There are several limitations worth mention. First, the projections included in this report are based on the best available local data and evidence as of April 27, 2020, but the local collection of epidemiology data on COVID-19 cases may lag in ways we did not account for, and data improvement efforts are ongoing. Second, the model does not assume any cases are “imported” from elsewhere over time, but such cases would cause increases in local transmission. Third, we did not try to forecast hospital burden (i.e., active hospitalized patients) in this current report, in part, because of challenges accurately modeling the flow through the hospital system (e.g., Covasim does currently not allow for critical care patients returning to acute care) to fit the data. Last, there remain significant unknowns, including the current extent of physical distancing, testing policies, and compliance with new interventions and how these vary throughout the state.

## Conclusions

We commend Oregon for introducing aggressive interventions early in the epidemic. Using Oregon data through April 27, we found that the current aggressive interventions (i.e., “Stay Home, Save Lives”) are effective in reducing the level of transmission by about 70%, with the case rates leveling off and even slowly declining. However, as we found in King County, Washington ([IDM King County Report April 24, 2020](#)) and others have found in Colorado ([Colorado Modeling Report April 2020](#)), the Oregon model simulations suggest that the future outcomes remain very sensitive to policy changes and public adherence to physical distancing guidelines. Indeed, our projections suggest that interventions with a 60% reduction in transmission would lead to a growth in cases in Oregon, with about 200 more new infections per day by June 4th, than interventions with a 70% reduction in transmission. These findings underscore the need to continue monitoring outcomes extremely carefully over time, especially in view of the difficulties in translating specific policies to percent reduction in transmission, and measuring adherence to those policies.

While “Stay Home, Save Lives” has been effective in reducing transmission, we recognize that there is an enormous economic and social cost to these aggressive community mitigation strategies, especially for low-income families, and a need for the state to start reopening. To loosen the community mitigation strategies without a large increase in infections, we emphasize the need to make these changes incrementally and to implement other interventions to keep transmission levels low. Examples of such interventions include increased testing capacity, detailed contact tracing (e.g., Kretzschmar et al, 2020), and likely the quarantining of infected individuals away from households, where significant transmission occurs. Additional vigilance to reduce the risk of reintroduction if travel restrictions were relaxed would also require substantial testing capacities. Governor Kate Brown recently announced a framework for reopening Oregon ([framework](#)), which is consistent with this type of approach. In addition, on April 27<sup>th</sup> ([OHA April 27 press release](#)), she expressed her commitment to collaborating with Nevada, Colorado, Washington, and California Governors in developing a coordinated plan for reopening as part of a Western States Pact.



To inform these reopening plans, researchers have begun forecasting cases based on different scenarios (e.g., [Colorado Modeling Report April 2020](#)), and IDM is working with Washington State to quantify trade-offs among strategies with different costs, feasibilities, and benefits ([IDM King County Report April 24, 2020](#)). We will share those results with the Western states when the analyses are completed. However, decision-making for leadership will continue to be challenged by large uncertainty due to limited and changing scientific evidence during this pandemic. In addition, even with excellent control measures, importations or other "escaped infections" will be inevitable, as the recent examples in Singapore and Taiwan have illustrated. To avoid the need to return to widespread lockdown after such an event, very good surveillance measures and high compliance with symptoms-based testing will need to be in place.

## Appendices

### Appendix 1: Detailed transmission model methods

We applied Covasim, an individual-based COVID transmission model with parameters informed by literature; the full source code is [available on GitHub](#). The model simulated a population based on American Community Survey 2018 single-year, age-specific estimates for Oregon. The simulation begins on 2020-02-05. It is not possible to calibrate the model with a single importation event near the date of the first diagnosis (2020-02-27), which is consistent with the fact that this case was community acquired, implying other infections occurred before this date. To match observed epidemic trends, five infected individuals are assumed by 2020-02-05. This indicates either multiple importation events, or a single importation occurring earlier.

Internally, COVID-19 (SARS-CoV-2) infection within each individual is represented by four stages: susceptible, exposed, infectious, recovered (SEIR). The exposed (latent) period prior to the onset of viral shedding is normally distributed with a mean of 4 days and standard deviation of 1 day; this is one day shorter than the 5-day consensus estimate of the incubation period prior to symptom onset ([MIDAS-network](#)) to acknowledge reports of pre-symptomatic shedding. The infectious period is normally distributed with mean 8 days and standard deviation 2 days, based on measured upper-respiratory viral shedding after symptom onset (Zou et al., 2020).

Viral transmission from one individual to the next proceeds on a fixed contact network with undirected edges. The degree distribution of the network is Poisson-distributed with rate parameter  $\lambda=20$ . Individual network edges are selected at random. On each day, infectious individuals expose susceptible “close contacts” (neighboring nodes in the graph) to possible infection. We began by assuming the daily probability of an infectious individual infecting each neighboring susceptible individual is binomially distributed with  $p = 0.015$ , but modified this to 0.019 to fit the pattern in the Oregon data. With an average of 20 contacts per individual per day and a mean duration of infectiousness of 8 days, this per-day probability roughly translates to  $R_0 = 3.0$ . Before being diagnosed, all infected individuals with symptoms are assumed to be equally infectious; those who remain asymptomatic are assumed to be 20% less infectious. Once a case is diagnosed, they are assumed to be in isolation, so the transmission rate is assumed to be zero.

The probability of death for each infection is approximately 0.8%, dependent on age (Ferguson et al., 2020). Time from infection to death is drawn from a normal distribution with mean of 17 days and standard deviation of 4 days.

Testing probability in the model is based on an individual’s symptoms, contact with known positives, and other factors, including a realistic delay between infection, symptom onset, and diagnosis.

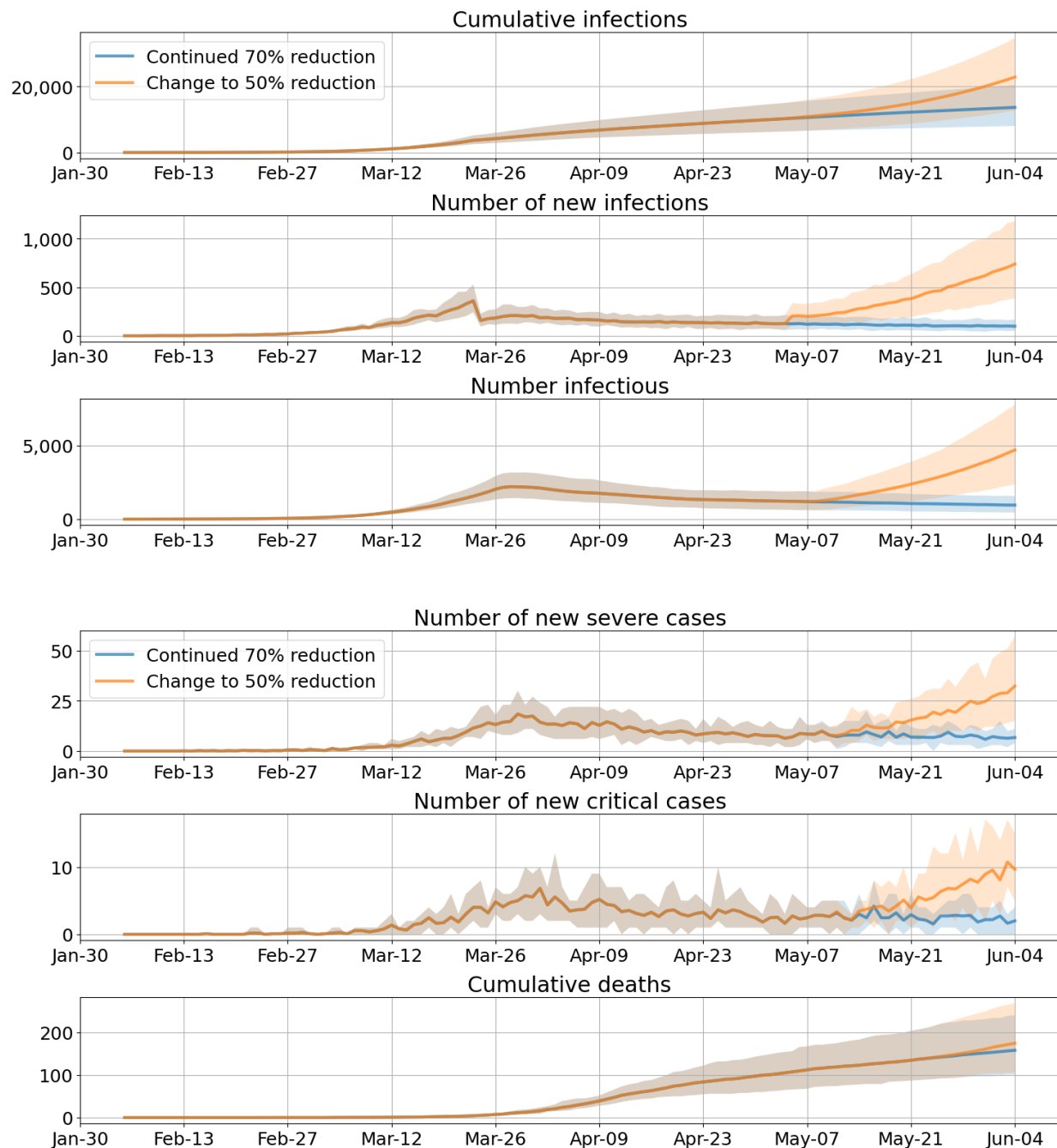
## Appendix 2: Healthcare system modeling methods

There is still a high degree of uncertainty about the healthcare needs of COVID-19 patients in the United States, since the clinical care protocols are rapidly evolving and will depend substantially on the comorbidities and level of opportunistic infections that are seen in a given patient population. With that in mind, we triangulated between several published sources in order to estimate starting parameters, and then modified those during the calibration process to best fit trends in the Orpheus data.

We extrapolated the symptomatic rate, the hospitalization rate, and the rate of ICU bed needs based on various sources. We assumed an overall symptomatic rate of 68%, similar to Ferguson et al (2020), and assumed the symptomatic rate was higher for older cases. Age-specific hospitalization rates were taken from Verity et al. (2020) and age-specific rates of ICU bed need from CDC COVID-19 Response Team (2020). Combining these sources and applying to the Oregon population, we estimate that 6.3% of all cases (symptomatic or not) require hospitalization (i.e., severe illness) and 2.0% of all cases require an ICU bed as part of an inpatient stay (i.e., critical cases). This translates to about 30% of hospitalized cases requiring an ICU bed, which is consistent with our local Hospital Capacity Web System (HOSCAP) data ([Oregon COVID-19 Daily Update](#)) and Bouadma et al. (2020).

The model is a discrete event simulation, which models each individual patient as they contract COVID-19 and subsequently seek hospital care. Patients arrive at the hospital with symptoms according to the pattern projected by the epidemiological model described above.

### Appendix 3: Projections for interventions with 70% vs. 50% reduction in transmission



**Figure 4:** Model projections for the next 6 weeks, assuming that starting May 4<sup>th</sup>: 1) interventions continue that reduce transmission by 70% (blue line), and 2) there is a change to interventions that reduces transmission by 50% (orange line). The lighter shaded areas correspond to 80% forecast intervals ((i.e., 10<sup>th</sup> and 90<sup>th</sup> percentiles of the projection).

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