BRIEF REPORT: COVID-19 EPIDEMIC TRENDS AND PROJECTIONS IN OREGON

Results as of 5/29/2020, 12pm

ACKNOWLEDGEMENTS

This is a brief update to the Institute for Disease Modeling's (IDM's) previous reports. IDM developed the Covasim software, provided Oregon Health Authority (OHA) with programming scripts for the models, reviewed this report, and provided extensive support and technical assistance to OHA. OHA especially wishes to thank Cliff Kerr, Katherine Rosenfeld, Brittany Hagedorn, Dina Mistry, Daniel Klein, Assaf Oron, Prashanth Selvaraj, Jen Schripsema, and Roy Burstein at IDM for their support (Contact: covid@idmod.org).

RESULTS SUBJECT TO CHANGE

Please note that the data reported here are continually being updated. For daily up-to-date information visit the OHA COVID-19 web page. The results in this brief report 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. While these results can be used to understand the potential effects of different scenarios, it is important to note that the 80% forecast intervals for these predictions are wide, so point estimates should be interpreted with caution.

KEY FINDINGS

Infections to date

- These model simulations suggest that there have been approximately 20,000 cumulative infections (80% forecast interval: 14,400 – 27,300) in Oregon by May 22nd, of which about 4,000 have been diagnosed based on the local epidemiologic data. This is a higher estimate of cumulative infections than previously reported because we updated our parameter assumptions; we now conservatively assume a smaller proportion of total infections (asymptomatic and symptomatic) have been hospitalized based on recent data from the Centers for Disease Control and Prevention.

Success of Oregon's interventions

- The aggressive interventions in Oregon have been effective in dramatically reducing transmission rates.
- Hospitalization data suggest that infections have continued to decline in recent weeks, though this trend may change as Oregon counties begin phased re-opening.

Future projections

- For each of our future scenarios, we assumed that 2,000 tests would be conducted per day.
- If we were to assume interventions effective as the current interventions are continued even with reopening, the model projects the number of new infections per day would continue to decrease (from about 55 to 15), with cumulative infections growing to about 21,400 over the next 6 weeks.
- However, moderate increases in transmission levels in the community could cause a much larger increase in infections. For example, under the scenario with interventions reducing transmission by 50% (vs. 70%), the model projects about 3,000 more cumulative infections (24,400 vs. 21,400), 155 more new infections per day (170 vs. 15), and 4 more new severe cases per day (5 vs. 1) by July 3rd.

PURPOSE OF THIS REPORT

To project how interventions with different levels of effectiveness would change the trend in COVID-19 cases in Oregon.

METHODS

This brief report uses methods consistent with the previous May 13, 2020 report (May 13 Report), with some key updates:

- Newer data from Orpheus on COVID-19 cases (Orpheus description) were used. The Orpheus data file was obtained on May 26th, but data after May 22nd were considered incomplete because of lags in reporting.
- Parameter assumptions for hospitalization probability by age among infected individuals were updated to match recent recommendations from the Centers for Disease Control and Prevention (CDC).
- Methods to model Oregon's testing (OHA COVID-19 Testing) and resulting diagnoses were improved, including changing the likelihood an individual experiencing symptoms is tested over time and assuming the current expanded level of testing continues in the scenarios.

More information about the methods is in Appendix 1.

INTERVENTIONS

Oregon implemented numerous measures to slow the transmission of COVID-19, including:

- On March 8, 2020: Governor Brown declared an emergency due to the public health threat.
- On March 12, 2020: A large number of measures were put in place, such as bans on gatherings of more than 250 people, as detailed here.
- On March 16, 2020: Schools were closed statewide, as detailed here. Further measures were put in place on March 16th and 17th, including the closure of restaurants and bars and gatherings of more than 25 people, as detailed here.
- On March 19, 2020: Non-urgent health care procedures were suspended to conserve personal protective equipment and hospital beds.
- On March 23, 2020: Aggressive interventions, namely the "Stay Home, Save Lives" recommendations, were put in place.
- On April 22, 2020: Testing guidelines were revised to allow for expanded testing, including testing of people who are asymptomatic and work in care settings or are in congregate settings; they were refined on May 1, 2020 (Revised testing guidelines).

- Since the beginning of the epidemic in Oregon: Public health staff have routinely investigated diagnosed cases and then notified people whom cases identify as close contacts of their exposure. Because of limited public health resources in Oregon, public health staff had only been able to actively follow up with contacts in households and congregate settings. Contacts have been asked to voluntarily stay in quarantine for 14 days after their last known exposure. Any diagnosed cases have been asked to voluntarily stay isolated for at least 72 hours after their symptoms resolve (i.e., quarantine). Contact tracing efforts have recently started to expand, as mentioned below (see also May 12 weekly report).

REOPENING

On May 1, 2020, Oregon announced plans for phased relaxation of community mitigation strategies, with additional expansion of testing and contact tracing to keep transmission rates low (Reopening Plans May 1, 2020). Some key changes have included:

- On May 1, 2020: Certain elective and non-urgent medical procedures resumed (Medical Procedures May 1, 2020).
- On May 2, 2020: The widespread use of face coverings was encouraged (Face Coverings May 2, 2020).
- On May 5, 2020: Some parks, outdoor recreation facilities, and areas across Oregon were opened for day use (Parks May 5, 2020).
- On May 7, 2020: Governor Brown published detailed guidance on reopening. This included requirements for counties to reopen, such as having sufficient capacity for testing and contact tracing. The guidance also called for the widespread public use of face coverings, maintaining physical distance of six feet between individuals as much as possible, and following good hygiene and disinfection practices (Reopening Guidance May 7, 2020).
- On May 15, 2020: Counties began to reopen. On May 15th, 31 of the 36 counties in Oregon had been approved to move to Phase 1 of reopening; by May 26th, 34 counties were approved and one pending approval, as detailed here. In addition to the counties reopening, some restrictions were loosened statewide, such social gatherings of under 10 people and cultural/civic/faith gatherings of up to 25 people with physical distancing.

RESULTS

As with previous modeling reports, the results in this brief report 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 (see Appendix 2 for information on the limitations).

Epidemic trends to date

The model was calibrated by modifying the assumptions from the literature to best fit data from Orpheus on confirmed positive COVID-19 diagnoses, number of tests completed, hospitalizations (referred to as severe cases below), and deaths for Oregon. The dates on which model transmission rates change were selected based on key policy enactment dates, with the exception of 3/31/20 (which was based on data observation). The degree of all changes were informed by hospitalization and diagnoses data (i.e., not by the assumed effect of any policy). The model was run 11 times in calibration.

The calibration provides 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 5% decrease in transmission by March 8th up to a brief 80% decrease in transmission after March 23rd. Indeed, while the interventions before March 23rd appeared to have slowed epidemic growth, the additional aggressive measures implemented on March 23rd (i.e., "Stay Home, Save Lives") appear to have curtailed that growth. The reductions are likely due to people spending more time at home, as well as an increase in hygiene and disinfection practices, wearing of facial coverings, and physical distancing outside the home, but we do not have the data to determine the relative contribution of each change.

- The data suggest that transmission rates increased slightly after the initial aggressive-intervention (to a 70% net decrease in transmission from baseline after March 31st), but the number of recent new cases are still declining.

- We could not yet assess the potential effects of reopening on hospitalization numbers because we only analyzed data through May 22nd, one week after reopening started. Hospitalizations are assumed to typically follow new infections by about 12 days.

- For context, we examined trends in physical distancing measures based on smartphone mobility data (Appendix 4). These data suggested increases in physical distancing beginning around mid-March and peaking during the first week of April. Physical distancing appears to be slightly decreasing since mid-April. However, these measures are based on mobility data, and do not measure personal practices related to hygiene, wearing of facial coverings, and maintenance of six-foot physical distance from others outside the home.

Of note, because testing guidelines were updated April 22nd to expand testing and presumptive cases were recently added, the number of new diagnoses in early May increased temporarily (Figure 1) (see also May 12 weekly report), but then decreased.

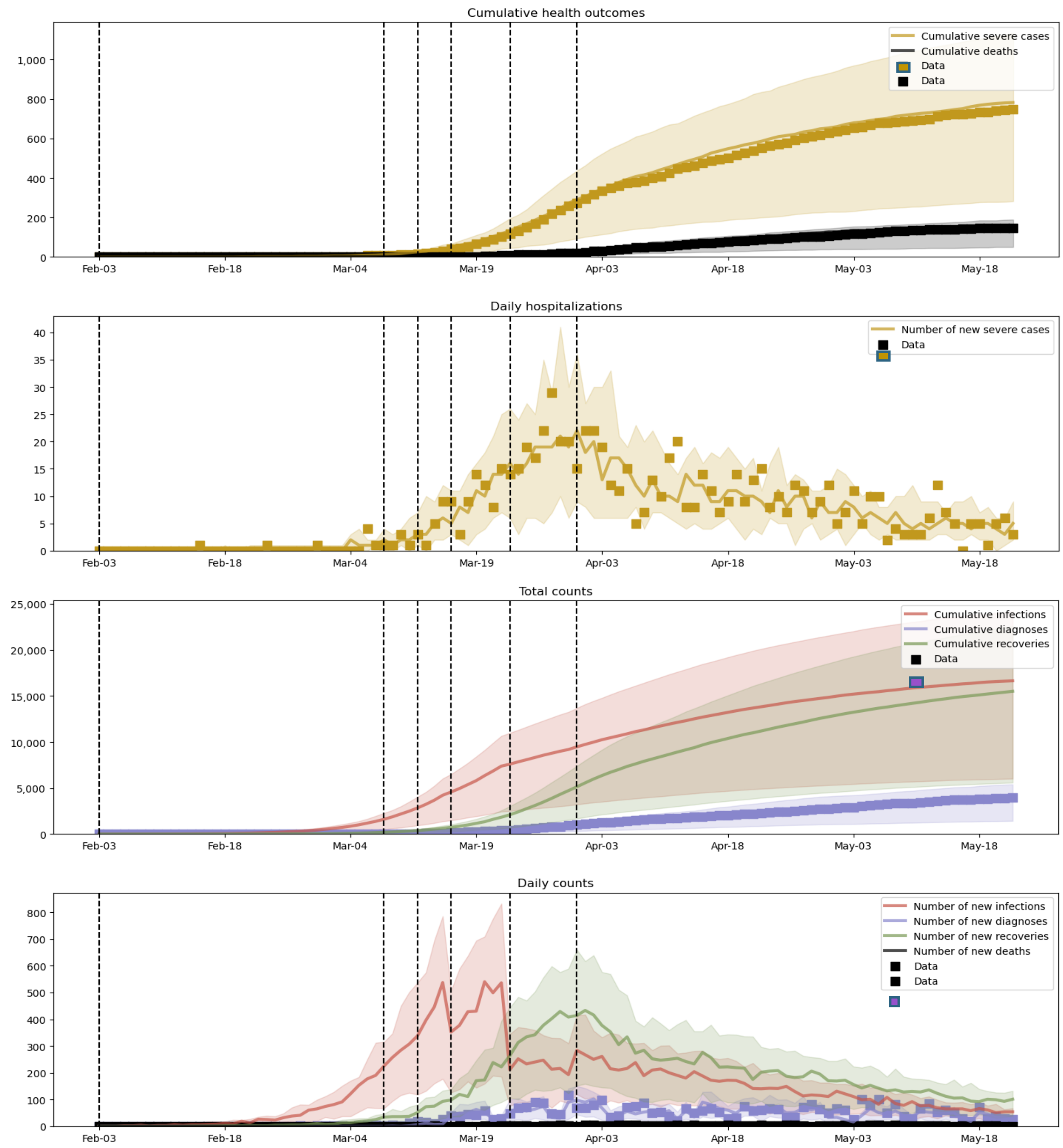


Figure 1: Best-fit model calibration with Oregon case data. Dotted vertical lines correspond to simulation start date (February 3rd) and estimated reductions in transmission relative to baseline, from left to right, of 5% (March 8th), 15% (March 12th), 50% (March 16th), 80% (March 23rd), and 70% (March 31st). Raw data are presented as squares; estimates from the calibration are presented as lines. Note: The estimated reductions in transmission are based on best fit to the data; they are imprecise, especially given some are based on few data points. The shaded areas represent variability among the calibration runs.

Scenario projections

Based on the calibrated model, we ran the forecast model 11 times to simulate the epidemic and produce forecast intervals (Figure 2). These model simulations estimate that there have been approximately 20,000 (80% forecast interval: 14,400 – 27,300) cumulative infections in Oregon by May 22nd (Figure 2). Of those, 4,000 had been diagnosed based on the local epidemiologic data. This is a higher estimate of cumulative infections than previously reported because we updated our parameter assumptions; we now conservatively assume a smaller proportion of total infections (asymptomatic and symptomatic) have been hospitalized based on recent data from the Centers for Disease Control and Prevention. Our estimate is similar to the recent estimate of cumulative infections from Imperial College London (Imperial College).[1]

We modeled three future scenarios from May 29th until July 3rd, assuming interventions with different levels of effectiveness in reducing transmission. For all scenarios, we assumed 2,000 tests per day to conservatively reflect current testing levels (OHA COVID-19 Testing).

1) We assume interventions as effective those currently in place **would reduce transmission by 70%** compared to baseline**.** This could reflect a combination of community mitigation strategies (which include personal behaviors and community actions), as well as expanded testing, contact tracing, quarantine, and isolation. Under this scenario:
   - The model projects the number of new infections per day would decrease over the subsequent weeks (from about 55 to 15), with cumulative infections growing from an estimated 20,200 to about 21,400 by July 3rd (Figure 2). New severe cases would decrease to about 1 per day.[2]

2) We assume that some relaxation of community mitigation strategies -- but continued expansion of testing, contact tracing, quarantine, and isolation -- together **would reduce transmission by 60%.** Under this scenario:
   - The model projects the number of cases to remain fairly steady, rather than decreasing. The model projects about 850 more cumulative infections (22,250 vs. 21,400), 35 more new infections per day (50 vs. 15), and 2 more new severe cases per day (3 vs. 1) by July 3rd, compared to the 70% reduction scenario (Figure 2).[1]

3) We assume that additional relaxation of community mitigation strategies -- but continued expansion of testing, contact tracing, quarantine, and isolation -- together **would reduce transmission by 50%.** Under the scenario:
   - The model projects that cases would rise, resulting in about 3,000 more cumulative infections (24,400 vs. 21,400), 155 more new infections per day (170 vs. 15), and 4

[1] Imperial College London estimated .4% (0.2% - 0.6%) of Oregon's population had been infected as of May 17th. Assuming 4.3 million people are in Oregon, this translates to about 17,200 cumulative infections (range: 8,600-25,800).

[2] Per-day scenario differences are based on average of last 4 days (June 30th- July 3rd) to stabilize estimates.

more severe cases per day (5 vs. 1) by July 3rd, compared to the 70% reduction scenario (Figure 3).[1]

The results suggest that the epidemic is slowing in Oregon, but it is very sensitive to changes in policies, practices, and public adherence to community mitigation strategies. While these results can be used to understand the potential effects of different scenarios, it is important to note that the 80% forecast intervals for these predictions are wide, reflecting their uncertainty.[3]

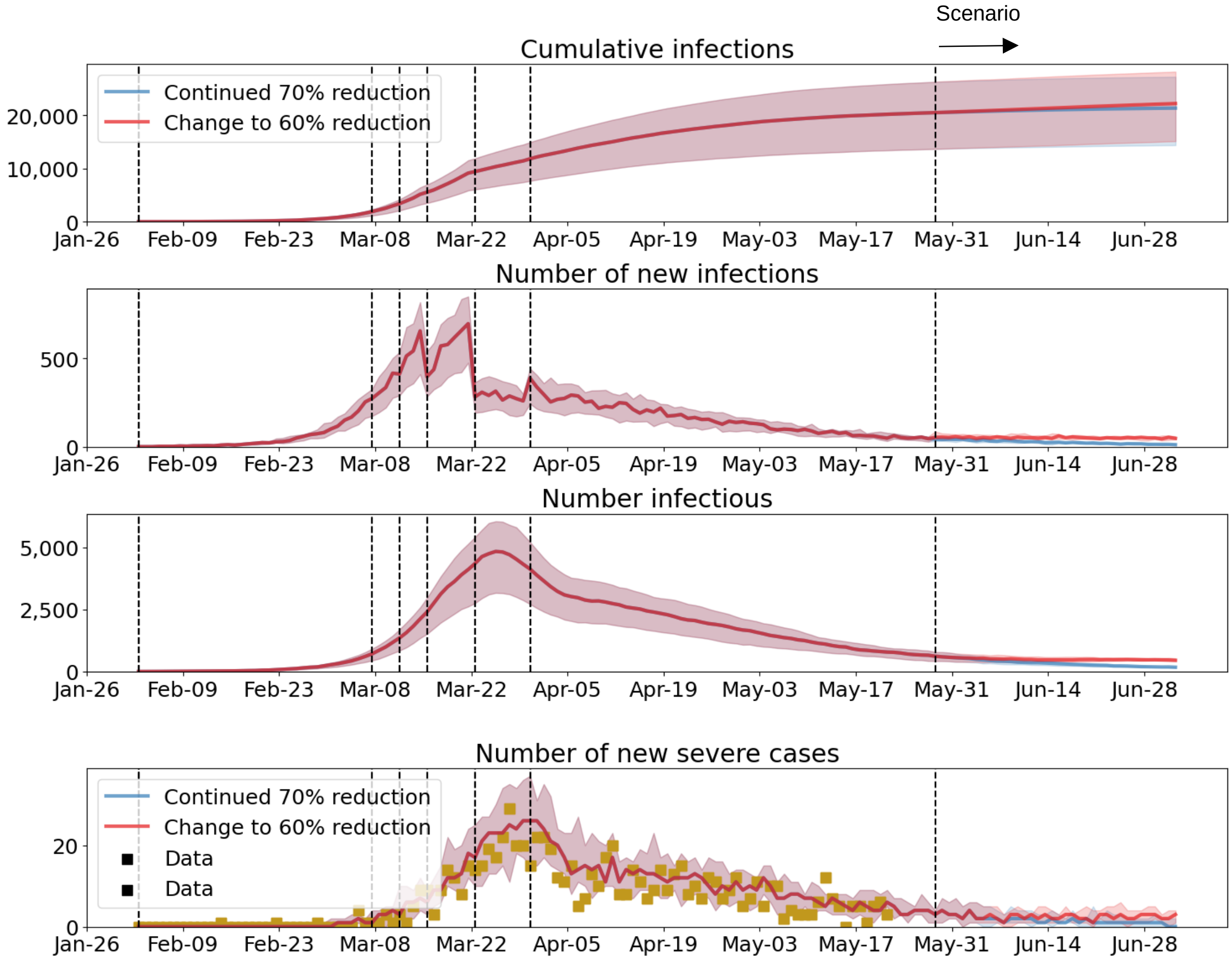


Figure 2: Model projections for the next 6 weeks, assuming that starting May 29th: 1) interventions continue that reduce transmission by 70% (blue line), and 2) there is a change to interventions that reduce transmission by 60% (red line). Raw data are presented as squares; estimates from the models are presented as lines. The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection). New severe cases are newly hospitalized cases.

[3] "the forecast intervals used correspond to the 10th and 90th percentiles of the simulated trajectories. Although these forecast intervals bear some similarities to confidence or credible intervals, since they are typically produced through a combination of stochastic variability and parameter uncertainty, they do not have a rigorous statistical interpretation." (p 18 of IDM report)

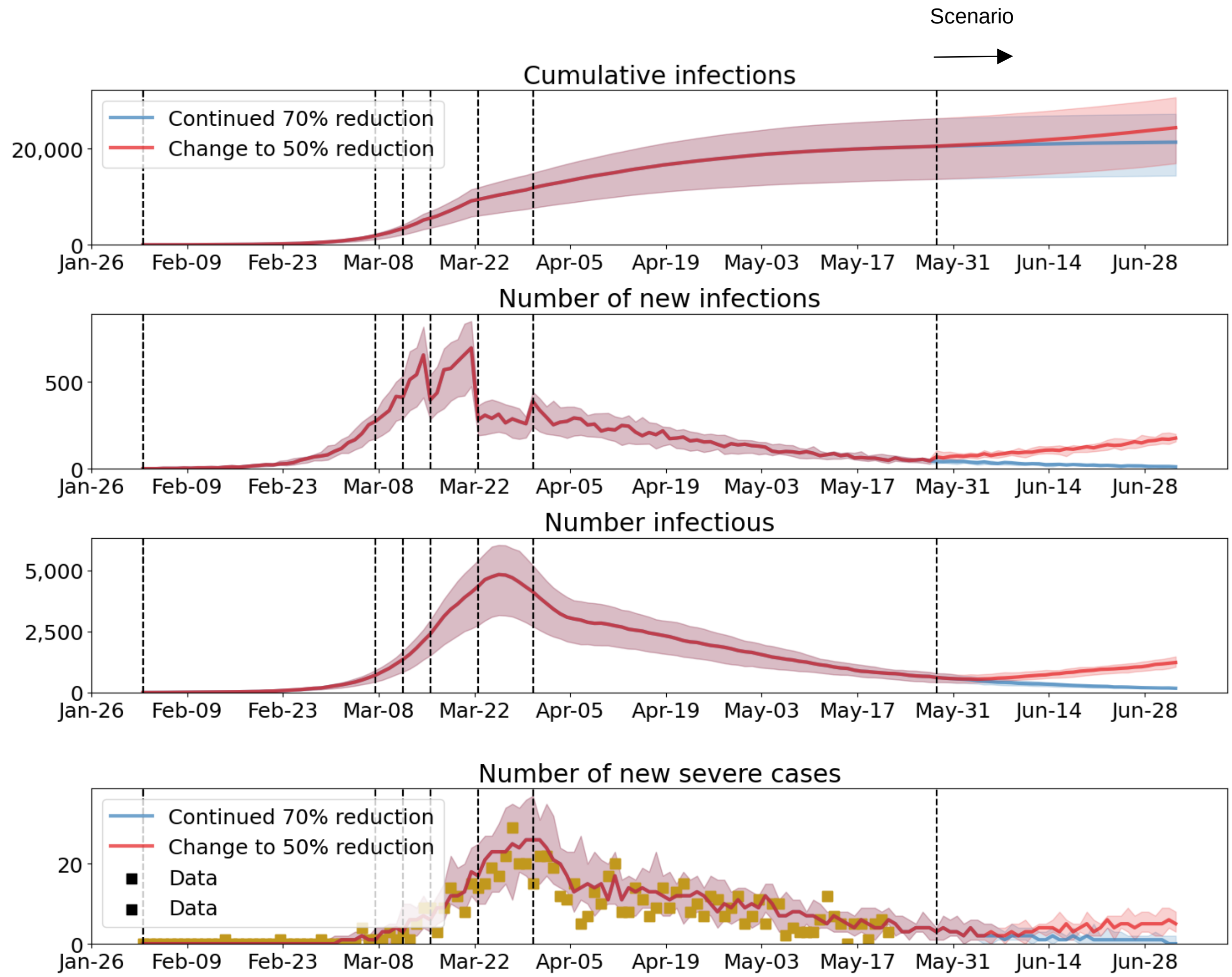


Figure 3: Model projections for the next 6 weeks, assuming that starting May 29th: 1) interventions continue that reduce transmission by 70% (blue line), and 2) there is a change to interventions that reduce transmission by 50% (red line). Raw data are presented as squares; estimates from the models are presented as lines. The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection). New severe cases are newly hospitalized cases.

The differences between these future scenarios are also illustrated by examination of the estimated effective reproduction number (Re) over time (Appendix 3). Re is the expected number of secondary cases that a single case generates. While the 60% scenario keeps the projected Re close to 1, the 50% scenario is clearly above whereas the 70% scenario is clearly below.

APPENDICES

Appendix 1: Detailed transmission model methods

We applied Covasim version 1.0.2, an individual-based (i.e., "agent-based") COVID transmission model with parameters informed by the literature; the full source code is available on GitHub. The methods and assumptions for Covasim are described in detail here.

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), and deaths for Oregon.

Our model assumed random network connections, had scenario noise set at zero, and used default parameters from Covasim version 1.0.2, except for the following changes:

1) Population age distribution was based on American Community Survey 2018 single-year estimates for Oregon. We used a simulation population size to 250,000 with Covasim's population rescaling functionality enabled.
2) The COVID-19 virus had a pre-intervention Beta value of 0.021, instead of 0.016 (based on observed hospitalizations before interventions took effect).[4]
3) Disease parameters were updated to match recent CDC best estimates for pandemic planning scenarios (CDC Planning Scenarios) for age-specific hospitalization probabilities. Specifically, we adjusted Covasim's more granular age-specific severe probabilities (given infection) such that for Oregon's population they equated to 2.6% for ages 0-49, 6.9% for ages 50-64, and 11.4% for ages 65 and older.
4) Hospitalized patients were 10% less likely to become critically ill, and critically ill patients were 10% less likely to die across age groups (to better reflect local data).
5) The probability of symptomatic individual being tested was adjusted such that the overall positive result rate from Feb 3rd – May 22nd was approximately 4% This rate decreased over time as testing became more expansive, dropping to around 2% by the end of calibration data.

The model simulation begins on Feb. 3, 2020. It is not possible to calibrate the model with a single importation event near the date of the first diagnosis (Feb. 21, 2020) because other infections occurred before this date as this case was community acquired. To match observed epidemic trends, eight infected individuals are assumed by Feb. 3, 2020. This indicates either multiple importation events, or a single importation occurring earlier.

[4] 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 an R0 of 3.

Appendix 2: Limitations

The results in this brief report 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 limitations important to note:

- The projections included in this report are based on the best available local data and evidence as of May 26th, 2020, but the local collection of epidemiologic data on COVID-19 cases may lag in ways we did not account for, and data improvement efforts are ongoing.
- Given the fairly low number of new cases in Oregon observed recently, we anticipate that trends in cases and their age distribution (and therefore prognosis) could be sensitive to a single outbreak or super spreader event.
- After the initial February 3rd importation, the model assumes that no additional cases were imported from elsewhere over time. Such cases would cause increases in local transmission, however, observed trends do not currently support an assumption of substantial subsequent importations
- For simplicity, we assumed random network connections and a combined effect of various interventions for the future scenarios (e.g., physical distancing, expanded testing and contact tracing) on overall transmission rates, but Covasim does have the ability to incorporate more complex network dynamics and specific intervention effects (as described here). We will explore those options with IDM in the future.
- Estimated reductions in transmission over time are imprecise and not necessarily due to any particular policy, especially given some are based on few data points.
- Although our model was calibrated to track actual testing and diagnoses counts (with assumed 80% reduction in transmission of diagnosed cases due to isolation or behavior changes), it did not explicitly account for reduced transmission from individuals who are not tested but undergo quarantine due to contact tracing efforts.
- We assumed that individuals who were diagnosed subsequently reduced their transmission rate by 80%, but this percentage reduction may vary as social norms change.

Last, there remain significant unknowns, including information about public compliance with recommendations (e.g., hygiene, face coverings, physical distancing) and the disease dynamics. As CDC stated (CDC Planning Scenarios) “new data on COVID-19 is available daily; information about its biological and epidemiological characteristics remain limited, and uncertainty remains around nearly all parameter values.”

Appendix 3: Projected Effective Reproductive Number

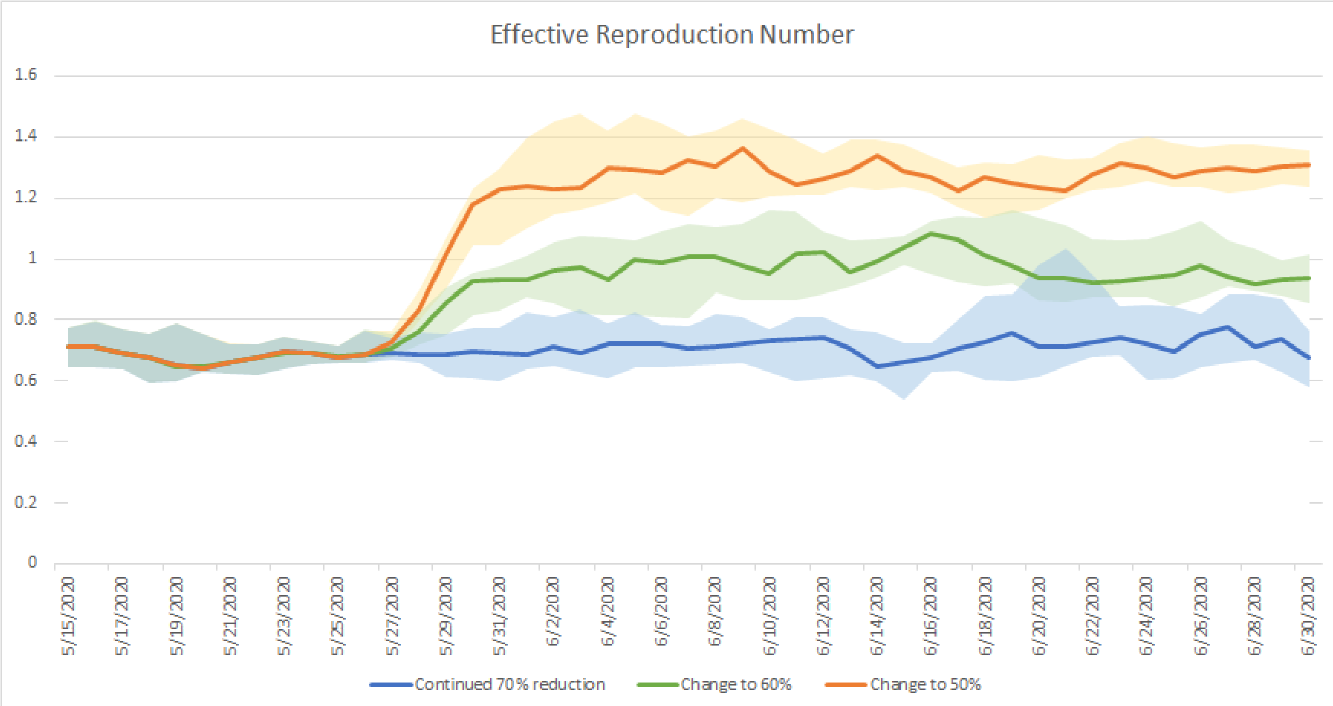


Figure 4: Projected effective reproduction number (Re) over the next 6 weeks, assuming that starting May 29th: 1) interventions continue that reduce transmission by 70%, 2) there is a change to interventions that reduce transmission by 60%, and 3) there is a change to interventions that reduce transmission by 50%. Re is the expected number of secondary cases that a single case generates.

Appendix 4: Mobility Data

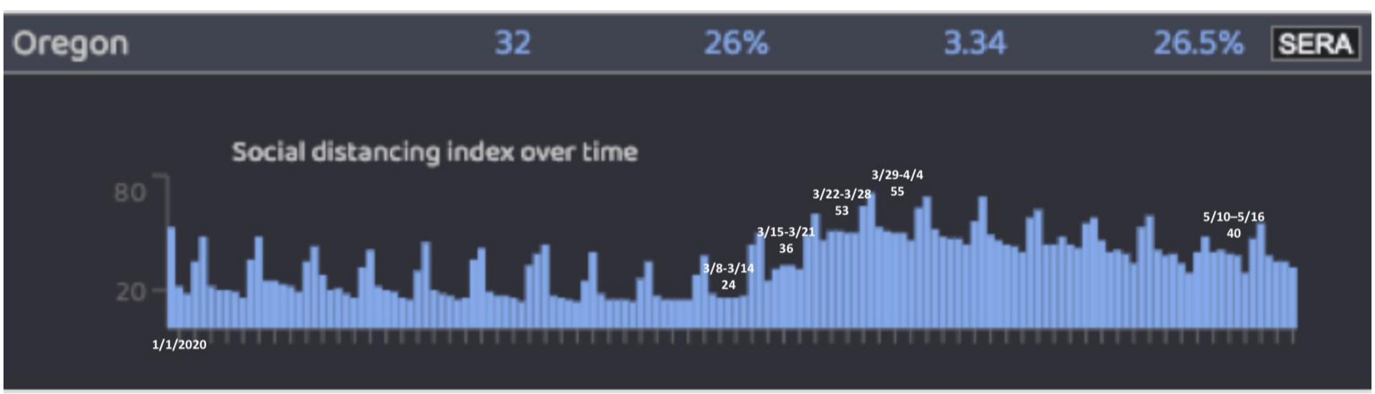
Results as of 5/26/2020, 3:00 pm

We examined data from the University of Maryland COVID-19 Impact Analysis Platform which has compiled and displayed a large number of indicators related to physical distancing. Specifically, the platform has developed a Social Distancing Index[i] that combines smartphone data for the following metrics: percent staying home, reduction in all trips, work trips, non-work trips, travel distance, and out-of-county trips. We chose this data source over previously reported data from Safegraph because of the additional metrics included.

The Social Distancing Index sharply increased in mid-March, reaching a high of 55 during the first week of April. It has slowly decreased to 40 during the week of May 10th through 16th. Percent working from home[ii] also sharply increased during March and has since declined somewhat.

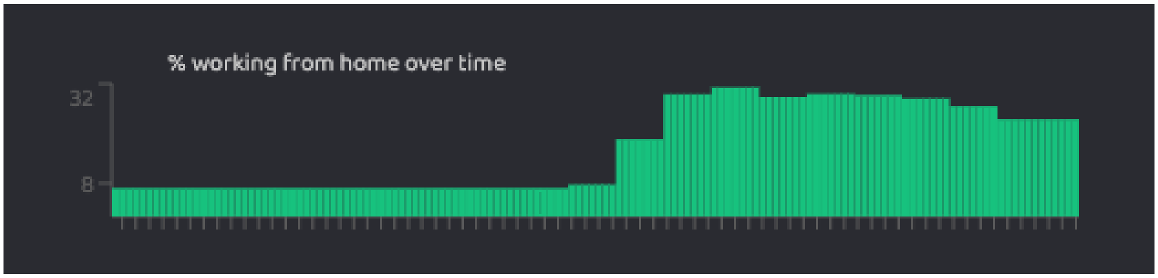
These data reflect human mobility and as such, provide helpful information on the extent of transmission opportunities. However, they are imprecise, as they do not directly represent physical proximity to potentially infected persons. Most of these metrics will also relax by necessity as the state reopens. Therefore, data on personal practices, such as maintenance of physical distance from others, wearing masks, and hand washing practices could be quite valuable as reopening proceeds. In a national survey, for example, most respondents (60%) said they are maintaining a distance of at least 6 feet from others outside their homes and half (50%) reported wearing a mask all of the time.[iii] Similar data for Oregon would be helpful as mitigation practices change.

Social Distancing Index, University of Maryland COVID-19 Impact Analysis Platform, Oregon, January – May 2020



Beginning date: Thurs. Jan. 2: 22
Mid-March: Thurs. Mar. 12: 16
Late March: Thurs. Mar. 26: 50
Most recent: Thurs. May 21: 32

Percent Working from Home, University of Maryland COVID-19 Impact Analysis Platform, Oregon, January – May 2020



Lowest value: Fri. Mar. 7: 6.8%
Most recent: Thurs. May 21: 23.4%

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[i] The social distancing index is computed from six mobility metrics by this equation: social distancing index = 0.8*[% staying home + 0.01*(100 - %staying home)*(0.1*% reduction of all trips compared to pre-COVID-19 benchmark + 0.2*% reduction of work trips + 0.4*% reduction of non-work trips + 0.3*% reduction of travel distance)] + 0.2*% reduction of out-of-county trips. The weights are chosen based on share of residents and visitor trips (e.g., about 20% of all trips are out-of-county trips, which led to the selection of a weight of 0.8 for resident trips and 0.2 for out-of-county trips); what trips are considered more essential (e.g., work trips more essential than non-work trips); and the principle that higher social distancing index scores should correspond to fewer chances for close-distance human interactions and virus transmissions.

[ii] Percentage of workforce working from home based on UMD models, calculated based on changes in work trips and unemployment claims.

[iii] Ipsos conducted this survey using the KnowledgePanel, a representative address-based panel of U.S. adults age 18 and over. Interviews were conducted in English. Sample size was 1,009 and margin of error was +/- 3.2%. Data are from May 12 survey.