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

Results as of 6/10/2020, 6pm

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, 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 are 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

Success of Oregon's interventions

- The aggressive community interventions in Oregon were effective in dramatically reducing COVID-19 transmission.

Changes after Oregon has begun to reopen

- Recent data and model calibration provide evidence that transmission has increased since reopening began on May 15th.
- It is too early to accurately estimate the effects of phased reopening on changes in COVID-19 trends. Because of this, we made three different assumptions about the recent COVID-19 trends for our projections:

  - Most optimistic assumption: We assumed a 10 percentage point increase in transmission after re-opening on May 15th. This model fit the hospitalization trend in late May well and assumed that trend would continue. It assumed the more pronounced increase in hospitalizations in the last few days of data (June 2nd-4th) was only a temporary increase.
    - Under this scenario, the number of new infections per day will remain relatively stable over the next month.

  - Less optimistic assumption: We assumed a slightly larger increase in transmission (15 percentage points) after May 15th, which fit the recent observed hospitalization and diagnoses trends better.
    - Under this scenario, the number of new infections per day will gradually increase over the next month.

  - More pessimistic assumption: We assumed a 15 percentage point increase in transmission after May 15th, as in the "less optimistic" scenario, plus an additional 10 percentage point increase in transmission after May 25th. By doing so, this model assumed that the recent increase in the number of new diagnoses is indicative of increased transmission, rather than largely due to increased testing.
    - Under this scenario, the number of new infections per day will increase more dramatically. Compared to the most optimistic scenario, this model projects about 14,000 more cumulative infections (35,400 vs. 21,400), 925 more new infections per day (1,040 vs. 115), and 17 more new severe cases per day (22 vs. 5) by July 3rd.

Conclusions

The results suggest that the epidemic has slowed in Oregon since its beginning, but that transmission appears to be increasing since reopening. In our most optimistic scenario, the effective reproduction number is estimated to be currently at about 1. The other scenarios demonstrate that even small increases in transmission levels could lead to increased cases.

PURPOSE OF THIS REPORT

To describe epidemic trends in COVID-19 since Oregon began to re-open, and project trends over the next month assuming different scenarios.

METHODS

This brief report presents analyses done using methods consistent with the previous May 29, 2020 report, with some key updates:

- Newer data from Orpheus on COVID-19 cases (Orpheus description) were used. The Orpheus data file was obtained on June 8th, but data after June 5th were considered incomplete because of lags in reporting and not used.
- Parameter assumptions were modified to vary susceptibility by age, such that the age distribution of infected individuals in the model follows that of recently diagnosed cases in Oregon.
- We included a comparison of our results to a few other published models.
- We moved the model simulation start date and number of starting infections forward (to 45 infections on February 15th) in order to reduce forecast interval uncertainty.

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 25 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, asked those cases to identify their close contacts, and then notified those contacts of their exposure (i.e., contact tracing). 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 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: Some counties began to reopen, and certain restrictions were eased statewide, such as allowing social gatherings of under 10 people and cultural/civic/faith gatherings of up to 25 people with physical distancing, as detailed here and here). Briefly:
    - On May 15th, 31 of the 36 counties in Oregon had been approved for Phase 1 of reopening.
    - By June 1st, 35 counties were approved for Phase 1 reopening. The most populous county (Multnomah) has applied for Phase 1 reopening on June 12th.

- On June 5th and 6th, 28 counties were approved for Phase 2 reopening, as well as one more on June 8th.

RESULTS

As with previous modeling reports, the results in this brief report are 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). The models simulate the spread of COVID-19 in Oregon statewide under different scenarios. They do not take into account the complex disease spread or intervention effectiveness within and between specific populations over time, such as for communities of color, workers in certain occupations, or people in congregate settings. They are using average transmission levels; hence they do not, for example, model the recent outbreaks in work settings differently than other types of transmission.

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 levels 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 changes in transmission 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 -- 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 were 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 these dramatic reductions in transmission waned somewhat after March 31st, but the number of new daily infections was still declining through mid-May.

The calibration also provides evidence that transmission has increased since reopening began on May 15th. Based on daily hospitalizations flattening out after a lengthy decline, transmission appears to have increased by at least 10 percentage points since May 15th, but it is too early to determine the full extent of these changes. Hospitalizations typically follow new infections by about 12 days. Therefore, the effects of 31 counties reopening on May 15th would be expected to start appearing after May 27th. In addition, the three most populated counties (Clackamas, Washington, Multnomah) opened later (May 23rd, June 1st, and anticipated on June 12th), so we would not expect to see most of the effect of those counties reopening on hospitalizations yet. A recent increase in diagnosed cases (June 1st-5th) suggests a potential further increase in transmission, but was due at least in-part to recent workplace outbreaks and associated testing (OHA Weekly COVID-19 Report). It is unclear if this increased level of transmission will be sustained. Given this uncertainty, we calibrated the model three different ways:

- The most optimistic calibration assumed that the hospitalization trend in late May would continue, but that the more pronounced increase in the last few days of data (June 2nd-4th) would not continue. That is, we assumed that it was a temporary increase due to random variability. This corresponds to a ten percentage point increase in transmission after May 15th (i.e., from a 70% baseline reduction baseline to a 60% reduction baseline reduction).
- A less optimistic calibration assumed a slightly larger increase in transmission (15 percentage points) after May 15th, which fit the recent observed hospitalization and diagnoses trends better.
- A more pessimistic calibration used the recent data on new diagnoses to further modify transmission estimates. Specifically, we assumed that the recent increase in new diagnoses (June 1st-5th) was indicative of increased transmission, rather than being due to more widespread testing, increased contact tracing, and/or active monitoring of close contacts of cases (OHA Weekly COVID-19 Report) [1]. Following a 15 percentage point increase in transmission after May 15th, we assumed an additional 10 percentage point increase after May 25th.

In Figure 1, we present the most optimistic calibration. Appendix 3 contains a comparison of the three calibrations.

Of note, it is too early to assess the effects of the recent marches for Black Lives Matter, which began in Oregon on May 28th and greatly expanded around May 31st.[2] The COVID-19 data used for this report includes only 5 days since May 31st.

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[1] 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 and then decreased. The recent increases appeared after that decrease.

[2] https://en.wikipedia.org/wiki/George_Floyd_protests_in_Portland,_Oregon#May_28

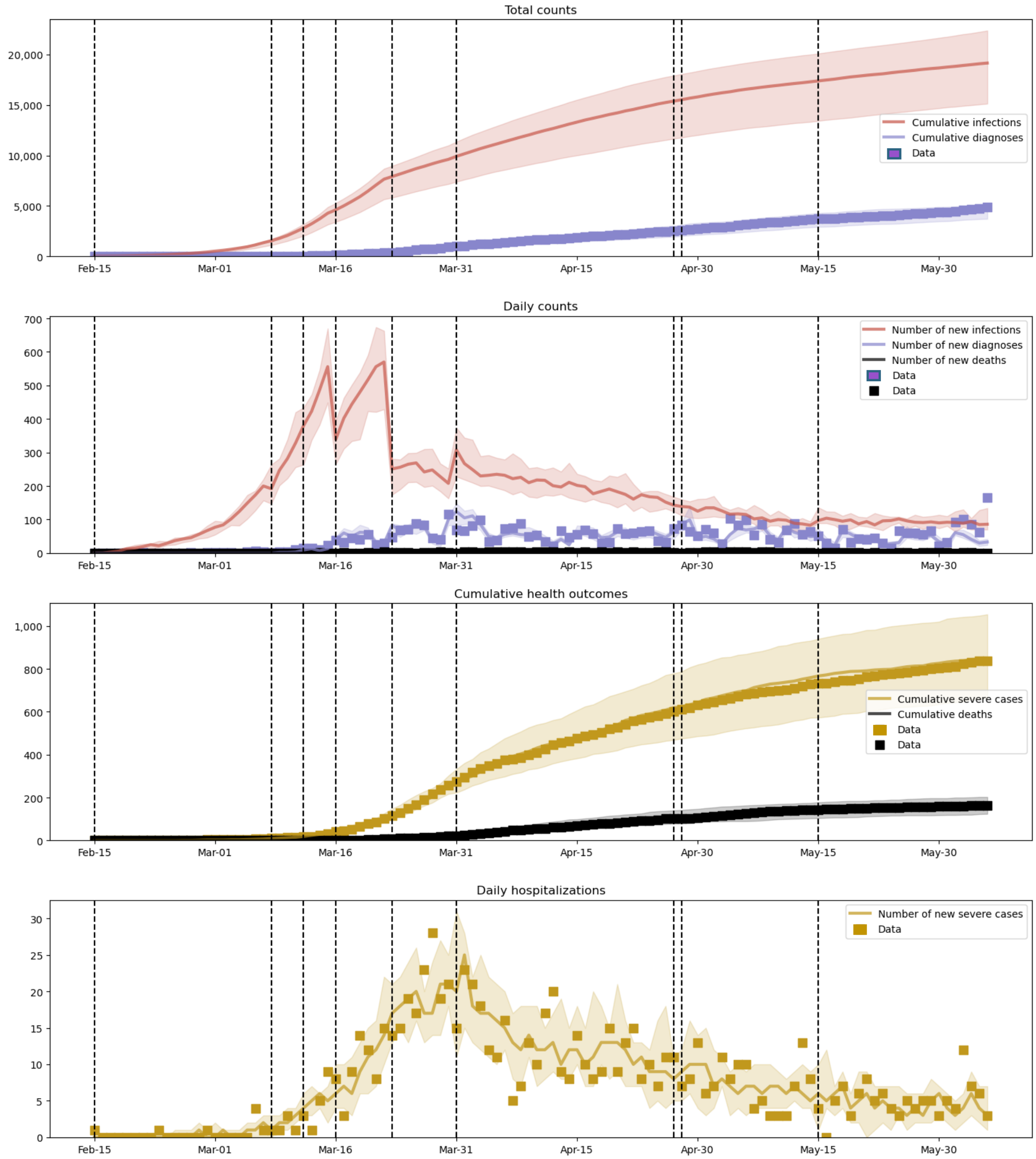

Figure 1: Model calibration with Oregon case data. Dotted single vertical lines correspond, from left to right, to simulation start date (February 15th); estimated reductions in transmission relative to baseline of 5% (March 8th), 10% (March 12th), 50% (March 16th), 80% (March 23rd), 70% (March 31st), and an early-estimate change to 60% after reopening (May 15th). The double vertical line at April 27th-28th indicates a change in the portion of tests allocated to symptomatic people. Raw data are presented as squares; estimates from the calibration are presented as lines. Note: The estimated reductions in transmission are imprecise, especially given some are based on few data points. The shaded areas represent variability among the calibration runs.

Scenario projections

We modeled three future scenarios through July 3rd based on the three different calibration assumptions described above. For all scenarios, we assumed 2,000 tests per day to conservatively[3] reflect current testing levels (OHA COVID-19 Testing). We ran the forecast model 11 times to simulate the epidemic and produce forecast intervals.

Most optimistic scenario: We assumed a 10 percentage point increase in transmission after May 15th.

- If this trend continues over the next month, the number of new infections per day is projected to remain relatively stable (Figure 2). The effective reproduction number (Re) – the expected number of secondary cases that a single case generates – is estimated to remain at about 1 (Figure 4).

Less optimistic scenario: We assumed a 15 percentage point increase in transmission after May 15th.

- If this trend continues over the next month, the number of new infections per day is projected to slowly increase (Figure 2). Specifically, the model projects about 3,600 more cumulative infections (25,000 vs. 21,400), 170 more new infections per day (270 vs. 100), and 4 more new severe cases per day (9 vs. 5) by July 3rd than the most optimistic scenario. [1] The Re is estimated to increase to about 1.2 (Figure 4).

More pessimistic scenario: We assumed a 15 percentage point increase in transmission after May 15th and an additional 10 percentage point increase in transmission after May 25th.

- If this trend continues over the next month, the number of new infections per day is projected to increase more dramatically (Figure 3).[4] Specifically, the model projects about 14,000 more cumulative infections (35,400 vs. 21,400), 900 more new infections per day (1,000 vs. 100), and 17 more new severe cases per day (22 vs. 5) by July 3rd than the most optimistic scenario. [1] The Re is estimated to increase to about 1.6 (Figure 4).

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[3] Higher total levels of testing are anticipated, but increases are partially driven by additional virus surveillance and study-related testing. Since the nature of how tests relate to diagnoses, and how diagnoses related to transmission may be different for additional, non-clinical tests, we conservatively assumed 2,000 tests / day in the model.

[4] Figure 3 projections for the "more optimistic" and "less optimistic" scenarios are identical to those in Figure 3; these scenarios were first presented separately to show differences at the smaller y-axis scale.

Summary

While these results can be used to understand the potential trends in COVID-19 under different scenarios, it is important to note that the 80% forecast intervals for these predictions are wide, reflecting their uncertainty.[5]

Nevertheless, modeling results suggest that transmission, after over a month of decline, appears to be increasing since reopening: the Re is estimated to be currently at about 1 in our most optimistic scenario. The other scenarios demonstrate that even small increases in transmission -- whether due to changes in policies, workplace practices, or public adherence to physical distancing, hygiene, and facial covering recommendations -- could lead to increased cases. Indeed, other models have suggested that physical distancing measures and/or other precautions (e.g., wearing facial masks, hand washing) will likely need to continue to some extent for COVID-19 even with extensive testing and contact tracing (e.g., Giordano et al., 2020; Kretzschmar et al., 2020; Rosenfeld et al., 2020).

Comparison with other model results

Results from the most optimistic calibration in this report are consistent[6] with the results from Imperial College London and with RT Live , which estimate the Re for Oregon is currently very close to 1. Columbia University's projections for Oregon are more similar to this report's projections for the less optimistic scenario, with increasing number of new infections.

Trends in mobility measures

For context, we examined trends in physical distancing measures based on smartphone mobility data (Appendix 4). From these data, physical distancing appears have reached a peak in the first week of April and has slowly decreased since then. That decrease has continued since re-opening began May 15th. However, these measures are based on mobility data, and do not measure personal practices related to hygiene, wearing of facial coverings, maintenance of six-foot physical distance from others outside the home, or workplace practices.

[5] "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)
[6] Imperial College, RT Live, and Columbia University reports / projections accessed 6/10/2020.

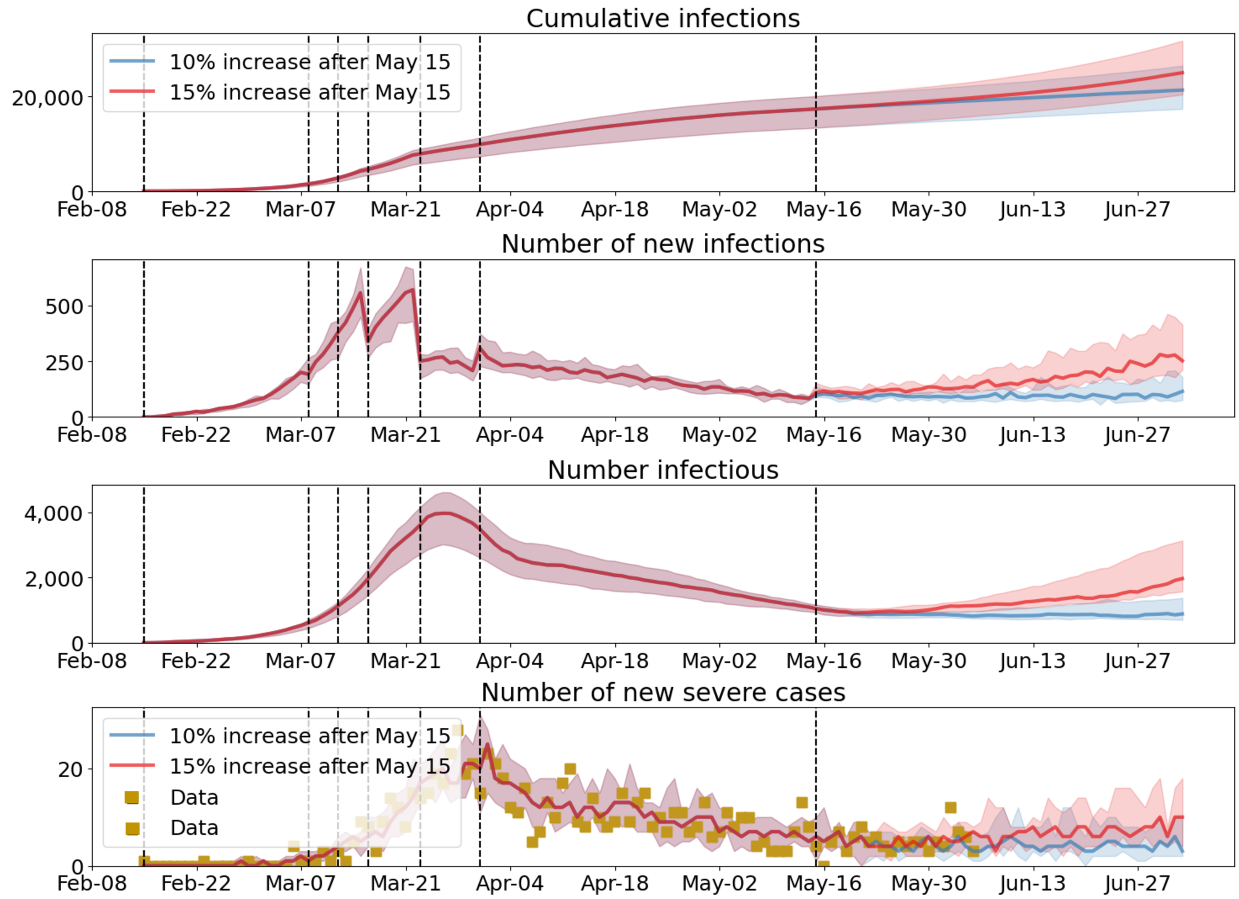


Figure 2: Model projections for the next 4 weeks, assuming that after May 15th: 1) transmission increased by 10 percentage points (blue line), and 2) transmission increased by 15 percentage points (red line). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection).

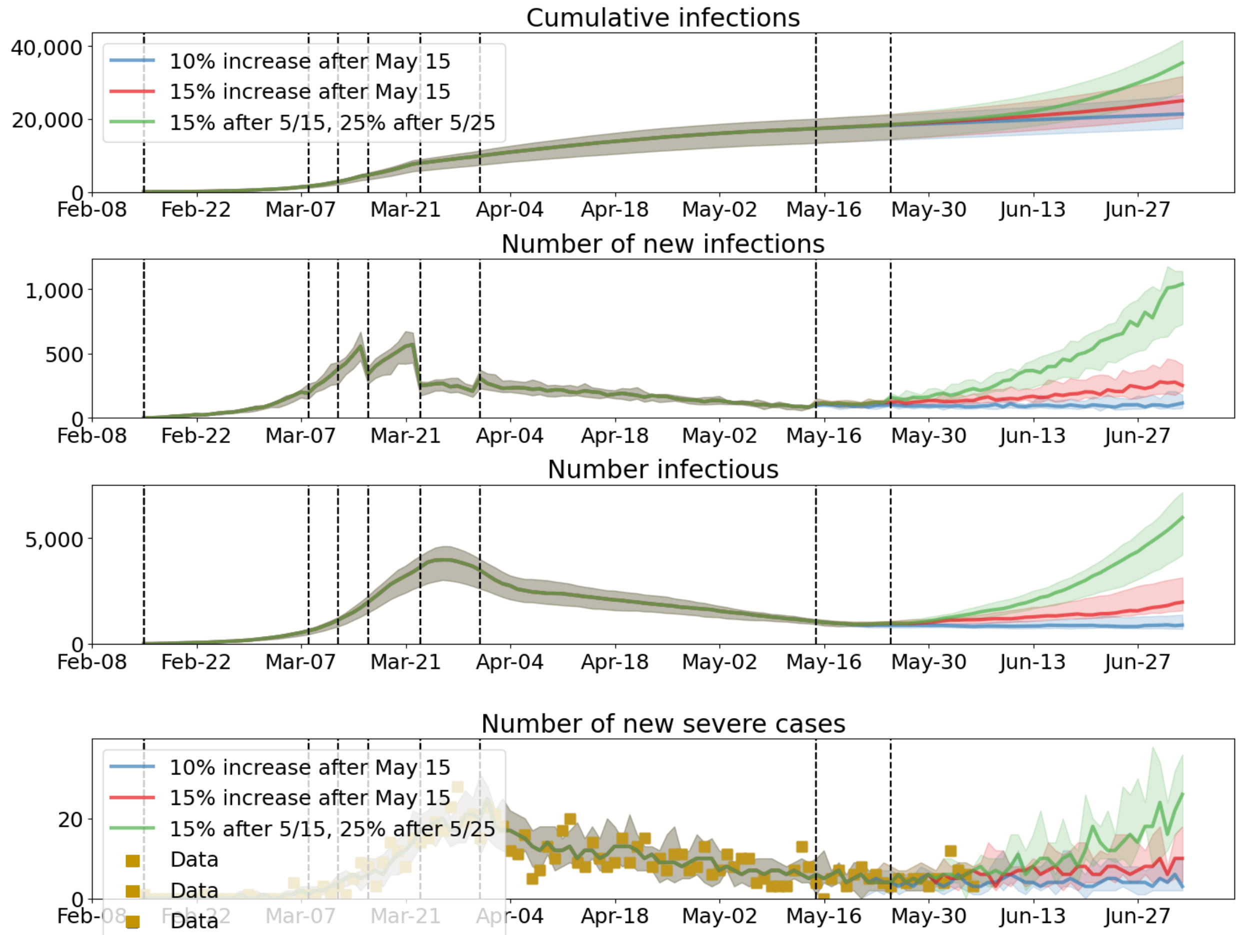


Figure 3: Model projections for the next 4 weeks, assuming that after May 15th: 1) transmission increased by 10 percentage points (blue line), 2) transmission increased by 15 percentage points (red line), and 3) transmission increased by 15 percentage points, then an additional 10 percentage points on May 25th (green line). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection).

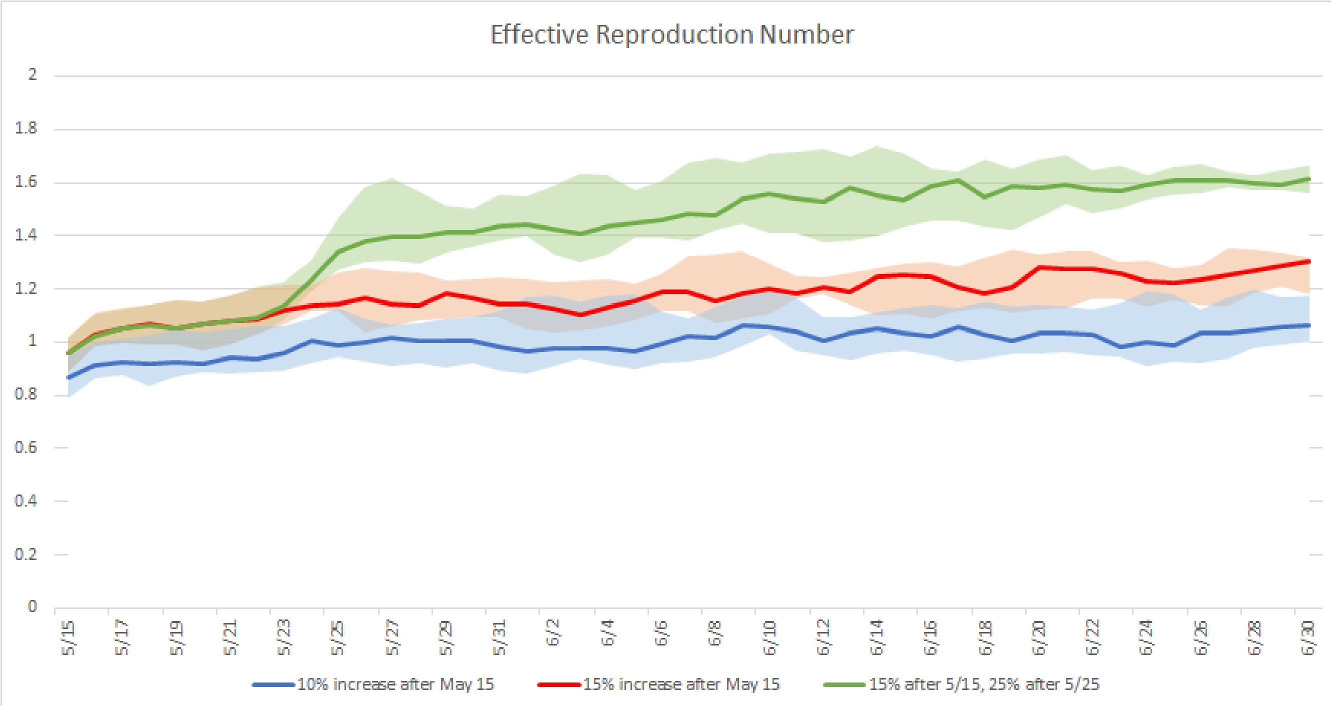


Figure 4: Projected effective reproduction number (Re) through June 30th, assuming that starting May 15th: 1) transmission increased by 10 percentage points (blue line), 2) transmission increased by 15 percentage points (red line), and 3) transmission increased by 15 percentage points, then an additional 10 percentage points on May 25th (green line). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection). Re is the expected number of secondary cases that a single case generates.

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 420,000 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).[7]
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) Parameter assumptions were modified to vary susceptibility by age, such that the age distribution of infected individuals in the model follows that of cases diagnosed between April 16th and May 15th in Oregon.
5) The relative probability of symptomatic individuals being tested was adjusted to match actual diagnoses counts given our inputted number of tests, with a change in relative odds on April 28th-onward.

To match observed epidemic trends, we started the model with 45 infected individuals on Feb. 15th, 2020; this date was moved forward and the number of infections increased from prior reports to produce narrower forecast intervals. It is not possible to calibrate the model with a single importation event near the first diagnosis (Feb. 21, 2020), which was a community acquired infection.

[7] 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 are 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 June 8th, 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.
- After the initial imported cases, the model assumes that no additional cases were imported from elsewhere over time. Any such cases would inflate local transmission levels, though any actual resulting diagnoses, hospitalizations, and deaths from imported cases are included in the data the model is calibrated to.
- 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, but Covasim does have the ability to incorporate more complex network dynamics and specific intervention effects (as described here). We will explore those and other modeling options in the future.
- The model produces diagnoses largely among the symptomatic population, whereas in actuality an increasing number of high risk but asymptomatic individuals are being diagnosed through contact tracing and testing in workplaces and congregate settings.
- 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.
- We assumed that individuals who were diagnosed subsequently reduced their transmission by 80%, but this reduction may vary as social norms change.
- Although our model was calibrated to track actual testing and diagnoses counts, it did not explicitly account for reduced transmission from individuals who are not tested but undergo quarantine due to contact tracing efforts.
- Given the fairly low number of cases in Oregon, trends in cases and their age distribution (and therefore prognosis) are sensitive to a single outbreak or super spreader event, such as the recent Pacific Seafood outbreak with over 100 cases.
- These models simulated the spread of COVID-19 in Oregon statewide under different scenarios. They did not take into account the complex disease spread or intervention effectiveness within and between specific populations over time, such as for communities of color, workers in certain occupations, or people in congregate settings.

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: Comparison of model calibrations

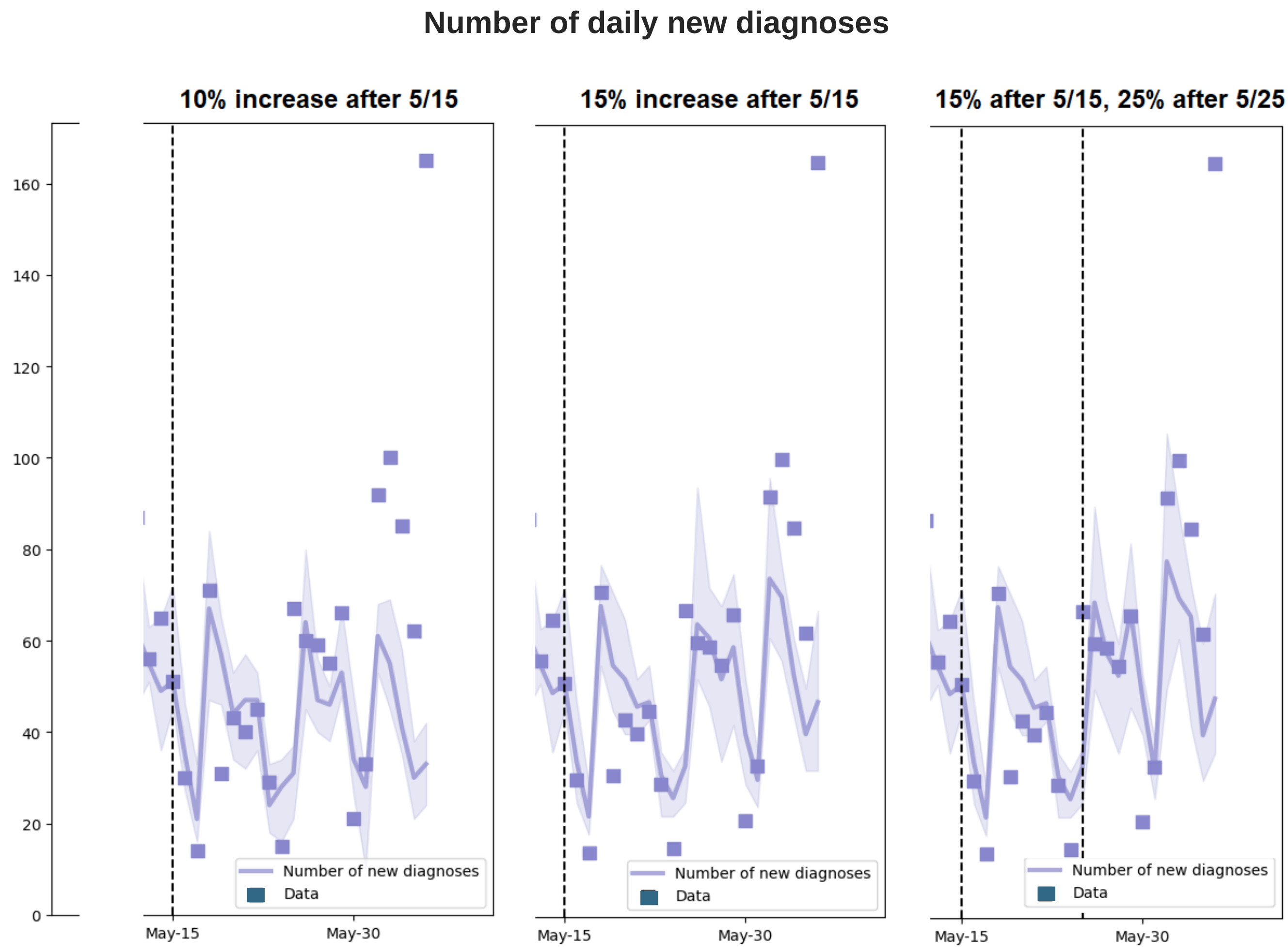


Figure A-1: Daily diagnoses by model calibration. Raw data are presented as squares; estimates from the calibration are presented as lines.

Number of daily new severe cases

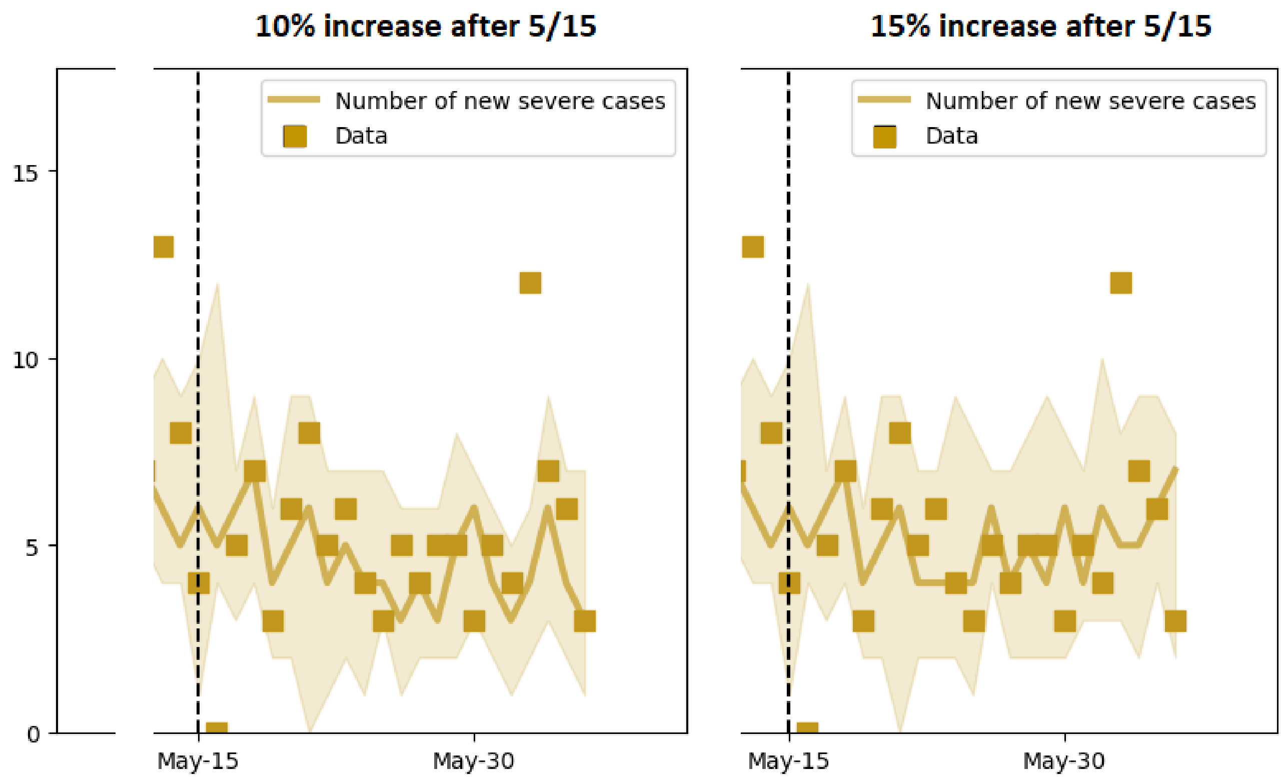


Figure A-2: Daily severe cases (hospitalizations) by model calibration. Raw data are presented as squares; estimates from the calibration are presented as lines. Note: hospitalization results for the 3rd calibration ("15% after 5/15, 25% after 5/25") are identical to that of "15% increase after 5/15" during the calibration timeline (the May 25th change would not affect hospitalizations until approximately June 6th).

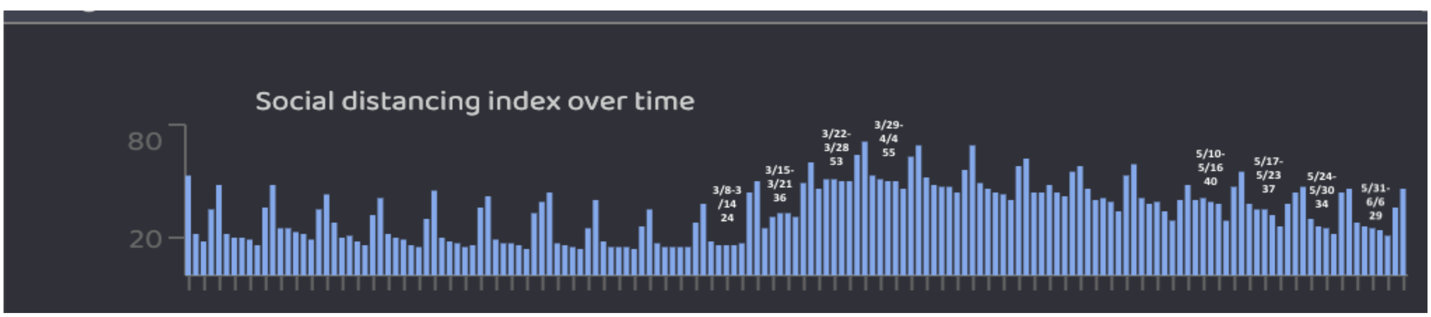
Appendix 4: Mobility Data

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 social 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.

Social distancing sharply increased in mid-March, reaching a high of 55 during the first week of April. It has slowly decreased since then. When some counties began to reopen on May 15th, the trend continued the slow decline. Specifically, the index was 40 from May 10th to May 16th, 37 from May 17th to 23rd, and 34 from May 24th to May 30th, and 29 from May 31 to June 6.

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 continues. 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.[ii]

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



[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] 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