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

Results as of 6/25/2020 – 2pm

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 webpage. 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

- Based on data through June 18th, the models suggest that transmission has increased since reopening began on May 15th. Our ability to accurately estimate how much transmission has changed recently is hindered by the limitations of data for both hospitalizations and diagnosed cases, as well as changes in testing practices.
- Hospitalization data was consistent with a 15 percentage point increase in transmission after May 15th, and an additional 10 percentage point increase in transmission after May 22nd (the Friday before Memorial Day). Hospitalizations did not appear to increase further through June 18th, suggesting that transmission did not increase again between May 23rd and June 6th, but these data would not yet reflect any potential change in transmission occurring after June 6th.
- We examined diagnosis data to understand possible changes in transmission after June 6th. The average number of daily diagnosed cases increased around June 11th (from 110 to 185), but it is too early to discern to what extent this increase may be due to more successfully detecting (testing) infections versus increased transmission.
- Because of the data limitations for hospitalizations and diagnosed cases, we made three different assumptions about the recent COVID-19 trends for our projections, as detailed below. We also assumed testing rates would continue at the recent level of 4,000 tests per day.

  - <u>Optimistic scenario</u>: We assumed that the hospitalizations trend from mid-June would continue, and that the June 11th increase in new diagnosed cases was due entirely to changes in testing practices, not to increased viral transmission.
    - Under this scenario, the number of new infections would remain relatively stable (around 180 per day) over the next month and the effective reproduction number (Re) was estimated to be about 1. Given that recently reported diagnoses have been averaging around 180 per day, however, this optimistic scenario essentially assumes that nearly all new infections are being diagnosed. This is likely implausible,[1] given about 1/3 of newly diagnosed cases do not have a known source.[2]

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[1] The "optimistic" model is unable to sustain a higher level of new infections at this transmission level; this implies either that transmission has increased since June 6th, or that the hospitalization rate among infections is lower than our assumption (implying more current infections). We will continue observing the trends in diagnoses and hospitalizations, and assess if we need to make future modifications to our model assumptions.
[2] https://public.tableau.com/profile/oregon.health.authority.covid.19#!/vizhome/OregonCOVID-19PublicHealthIndicators/COVID-19Burden

- Moderate scenario: We assumed a 10 percentage point increase in transmission after June 6th, which meant we assumed that the June 11th increase in diagnoses was due partly to increased transmission and partly to changes in testing practices.
  - Under this scenario, the estimated current number of new infections per day would be higher (310) than the optimistic scenario and would triple over the next month (reaching 910 per day). Compared to the optimistic scenario, this model projected about 10,800 more cumulative infections (38,300 vs. 27,500), 730 more new infections per day (910 vs. 180), and 19 more new hospitalizations per day (27 vs. 8) by July 16th. The Re was estimated to be about 1.4.

- Pessimistic scenario: We assumed a 20 percentage point increase in transmission after June 6th, which meant that we assumed the June 11th increase in diagnoses was entirely due to increased transmission, rather than changes in testing practices.
  - Under this scenario, the estimated current number of new infections per day would be even higher (560) and would increase dramatically over the subsequent month. Compared to the optimistic scenario, this model projects about 50,600 more cumulative infections (78,100 vs. 27,500), 4,850 more new infections per day (5,030 vs. 180), and 74 more new hospitalizations per day (82 vs. 8) by July 16th. The Re was estimated to increase to about 2.

Conclusions

The results suggest that transmission has increased since reopening. The Re stayed at one only in our optimistic scenario, in which increases in recent diagnoses were assumed to be entirely due to more effective testing practices, rather than to any increase in transmission. This assumption seems unlikely given that the positive test rate increased even as testing expanded. The other scenarios demonstrate that increases in transmission, if maintained, would lead to exponential growth in new infections.

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. This reports complements the extensive epidemiology data (e.g., demographic trends in cases, testing patterns) available at the OHA COVID-19 webpage.

METHODS

This brief report presents analyses done using methods consistent with the previous June 12, 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 22nd, but data after June 18th were considered incomplete because of lags in reporting and were not used.
- The model now assumes 4,000 tests per day in scenario projections. Testing has recently increased to approximately 4,000 per day (June 19th Testing Summary) and is assumed to maintain at least that level going forward .
- We ran models using an updated release of Covasim, version 1.4.7.

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 live in congregate settings; they were refined on May 1, 2020 and again on June 2, 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 isolate for at least 72 hours after symptoms resolve (i.e., quarantine). Contact tracing efforts started to expand with reopening plans, as mentioned below.

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) had not yet reopened.
    - On June 5th and 6th, 28 counties were approved for Phase 2 reopening, as well as one more on June 8th.
    - On June 11th, due to a rise in COVID-19 cases, the Governor temporarily halted approvals for additional phased reopening.
    - On June 17th, the Governor approved Multnomah County's plan for Phase 1 reopening, starting on Friday, June 19.

- On June 23, 2020: An update on the expansion of contact tracing efforts was issued here, reporting about 600 county and state contact tracers.
- On June 24, 2020: Implementation will begin of a new plan for testing at long-term care facilities, as described here.
- On June 24th, the Governor is requiring Oregonians in the seven most populous counties to wear a face covering when in indoor public spaces, with some exceptions (e.g., young children, people with disabilities, while eating) described here.

OTHER EVENTS

- On May 25, 2020: George Floyd was killed in Minneapolis, Minnesota. His death sparked demonstrations around the U.S. Oregon's first related demonstration was held in Portland on May 28th, and demonstration greatly expanded around May 31st.[3] Demonstrations have continued, many of which have included thousands of individuals, in cities and towns throughout Oregon.

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 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 following exceptions: 3/29/2020 (based on data observation), 5/22/2020 (based on data observation and corresponding to the start of Memorial Day weekend), and 6/6/2020 (based on data observation and corresponding to Phase 2 reopening in some counties). The degree of changes in transmission were informed by hospitalization and diagnoses data, not by the assumed effect of any policy. The model was run 11 times in calibration.

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

As in previous modeling reports, the calibration provides evidence that Oregon's aggressive 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.[4] 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") appeared 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 face 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. Our ability to accurately estimate how much transmission has changed recently is hindered by the limitations of data for both hospitalizations and diagnosed cases, as well as recent changes in testing practices.

- As seen in Figure 1, hospitalizations increased in early June. Given the approximate two-week delay between infection and hospitalization, this early June increase is reflective of earlier transmission: it is consistent with a 15 percentage point increase in transmission after May 15th and an additional 10 percentage point increase in transmission after May 22nd (the Friday before Memorial Day). Hospitalizations did not appear to increase further through June 18th, suggesting that transmission did not increase again between May 23rd and June 6th.
- We were not able to use the current hospitalization data to determine if there might be changes in transmission after June 6th because of the delay between infection and hospitalization. Therefore, we examined the number of daily diagnosed cases to understand possible changes in transmission after the first week in June; but being cognizant that increases in diagnosed cases might be due to more successfully detecting (testing) infections versus due to increases in transmission.
    - The number of daily diagnosed cases increased in early June (to an average of 110). This increase so far has not translated to an increase in hospitalizations (expected about one week after diagnosis), suggesting that this increase in diagnosed cases could be due to changes in testing practices and/or changing demographics of who is getting infected (e.g., more infections among younger, healthier people).

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[4] After the most recent Covasim software update, model calibration fit better without any further change in transmission on March 12th as included in previous modeling reports.

- The number of daily diagnosed cases increased further around June 11th (to an average of 185). Any related increase in hospitalizations cannot yet be determined, since it would be expected after our last data point (June 18th).

The importance of looking at the most recent data on diagnosed cases to supplement hospitalization data was confirmed by our last modeling report. The trends in hospitalizations over the past two weeks match most closely with the last report's projections from the pessimistic scenario, which used recent increases in diagnoses to estimate trends in transmission. As we did for our last report, we calibrated the current model three ways by making different assumptions about the recent observed trends:

- An optimistic calibration assumed that the hospitalization trend in mid-June would continue, but that the recent increase in diagnoses (June 11th-18th) was due to changes in testing or diagnosing practices rather than any increase in transmission. We thus assumed no additional post-May 22nd increase in transmission, although this is unlikely given that the positive test rate increased even as the number of tests increased. This calibration implies that new daily infections are comparable to recently reported diagnosis counts (both around 180 per day), which is likely implausible.
- A moderate calibration assumed a 10 percentage point increase in transmission after June 6th, such that the June 11th increase in diagnoses was due to both increased transmission and changes in testing practices.
- A pessimistic calibration assumed a 20 percentage point increase in transmission after June 6th. This assumes that the June 11th increase in diagnoses was fully driven by increased transmission, rather than being due to more widespread testing, increased contact tracing and testing of asymptomatic cases, and/or active monitoring of close contacts of cases (OHA Weekly COVID-19 Report).

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

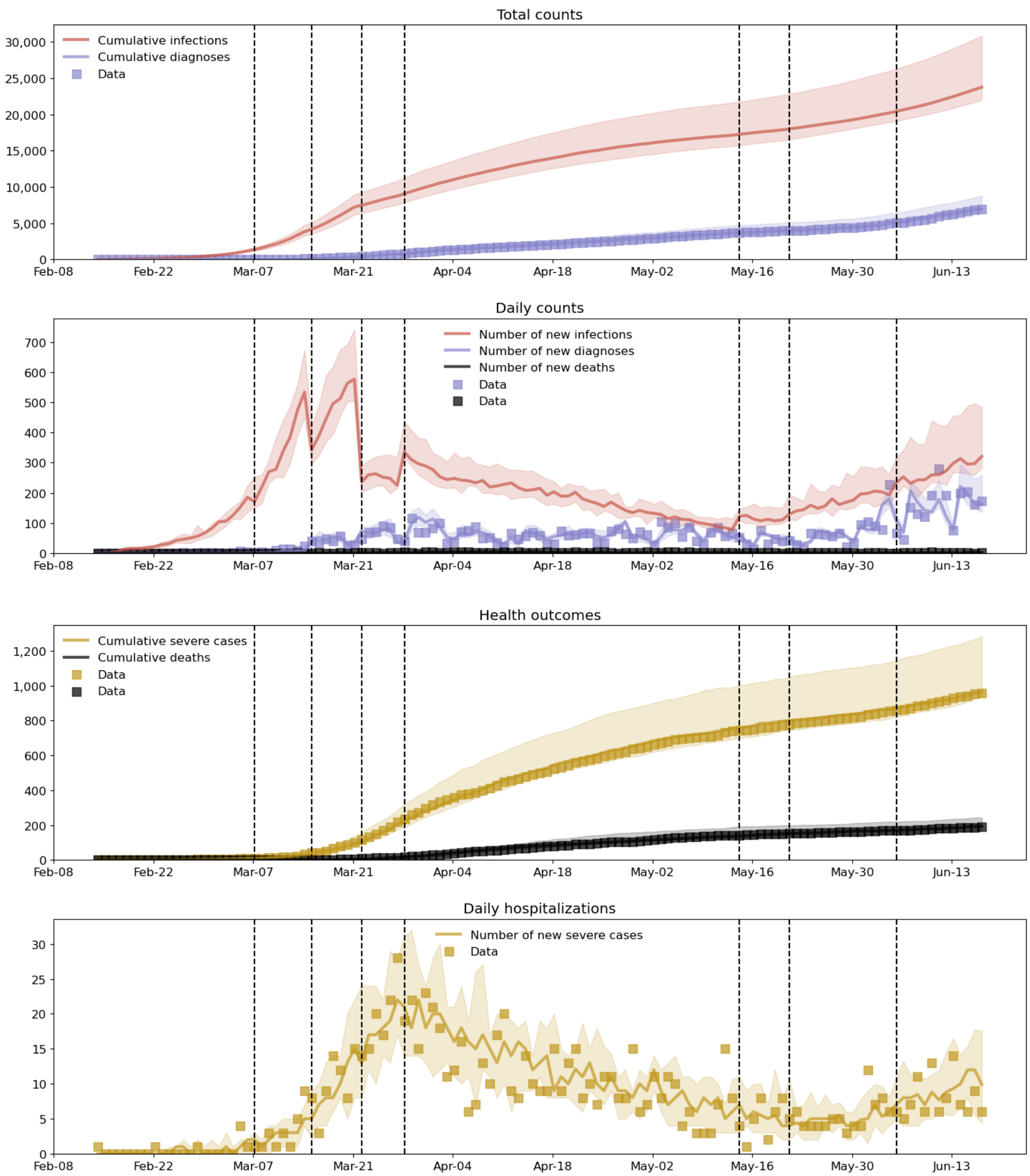

Figure 1: Model calibration with Oregon case data. Dotted vertical lines correspond, from left to right, to estimated reductions in transmission relative to baseline of 5% (March 8th), 55% (March 16th), 80% (March 23rd), 70% (March 29th), 55% (May 15th), 45% (May 22nd), and 35% (June 6th). Raw data are 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 16th based on the three different calibration assumptions described above (which diverged starting June 6th). For all scenarios, we assumed 4,000 tests per day to reflect current testing levels (June 19th Testing Summary). We ran the forecast model 11 times to simulate the epidemic and produce forecast intervals.

Optimistic scenario: We assumed no increase in transmission in June.

- If this trend were to continue over the next month, the estimated number of new infections would remain relatively stable at around 180 (Figure 2). The effective reproduction number (Re) – the expected number of secondary cases that a single case generates – was projected to drop from 1.4 to 1 by June 10th and remain there (Figure 4). Re was reduced because we assumed in this scenario that a higher proportion of new infections were diagnosed starting June 4th (and by being diagnosed, those individuals were assumed to be less likely to transmit the infection to others).

Moderate scenario: We assumed a 10 percentage point increase in transmission after June 6th.

- If this trend were to continue over the next month, the estimated number of new infections per day would currently be 310 and would triple over the next month (Figure 2). Specifically, the model projected about 10,800 more cumulative infections (38,300 vs. 27,500), 730 more new infections per day (910 vs. 180), and 19 more new severe (i.e., hospitalized) cases per day (27 vs. 8) by July 16th than the optimistic scenario. The Re was estimated to be about 1.4 (Figure 4).

Pessimistic scenario: We assumed a 20 percentage point increase in transmission after June 6th.

- If this trend were to continue over the next month, the estimated number of new infections per day would increase dramatically (Figure 3).[5] Specifically, the model projected about 50,600 more cumulative infections (78,100 vs. 27,500), 4,850 more new infections per day (5,030 vs. 180), and 74 more new severe cases per day (82 vs. 8) by July 16th than the optimistic scenario. [4] The Re was estimated to increase to about 2 (Figure 4).

[5] Figure 3 projections for the "optimistic" and "moderate" scenarios are identical to those in Figure 2; these scenarios were first presented separately to show differences at the smaller y-axis scale.

Summary of Results

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.[6]

Nevertheless, the results suggest that transmission has increased since reopening. The Re was at 1 only in our optimistic scenario, in which increases in recent diagnoses were assumed to be entirely due to more effective testing practices, rather than to increases in transmission. While this is possible, it is unlikely. The other scenarios demonstrate that increases in transmission, if maintained, would lead to exponential growth in new infections. The scenarios did not estimate possible future reductions in transmission from increased use of face coverings after the Governor's requirements.

Comparison with other model results[7]

The latest results from CovidActNow (https://covidactnow.org/us/or?s=54069) and RT Live (https://rt.live/) estimate the Re for Oregon to be about 1.2 to 1.3, which is in between the current report's findings for the optimistic and moderate scenarios. Columbia University's projections of new infections in Oregon are in between the current report's projections for moderate and pessimistic scenarios. The Imperial College London estimates have not been updated since May 29, 2020.

[6] "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)

[7] These websites accessed 6/23/2020.

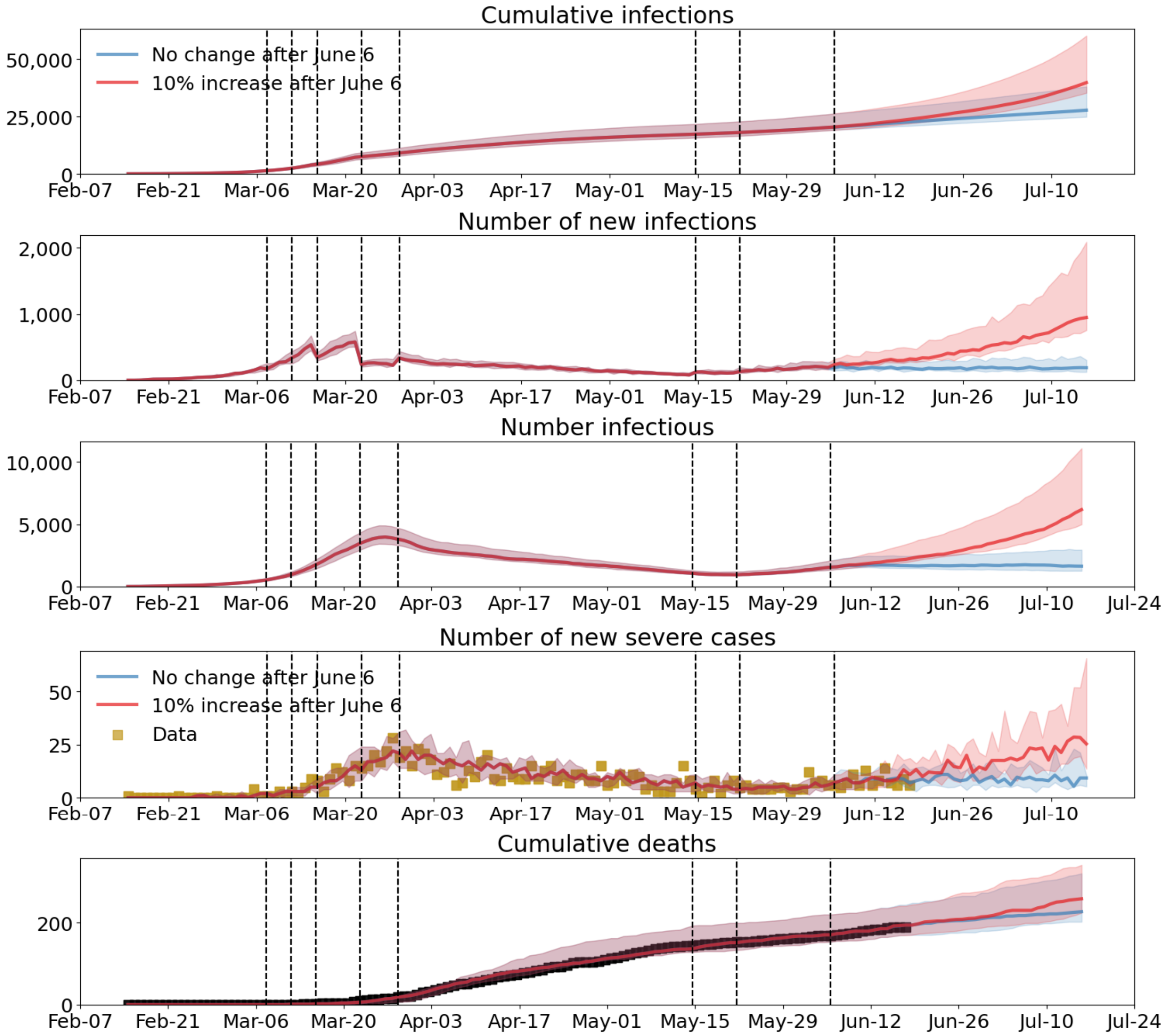

Figure 2: Model projections for the next 4 weeks, assuming that after June 6th: 1) transmission did not change (blue line, "optimistic" scenario), and 2) transmission increased by 10 percentage points (red line, "moderate" scenario). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection).

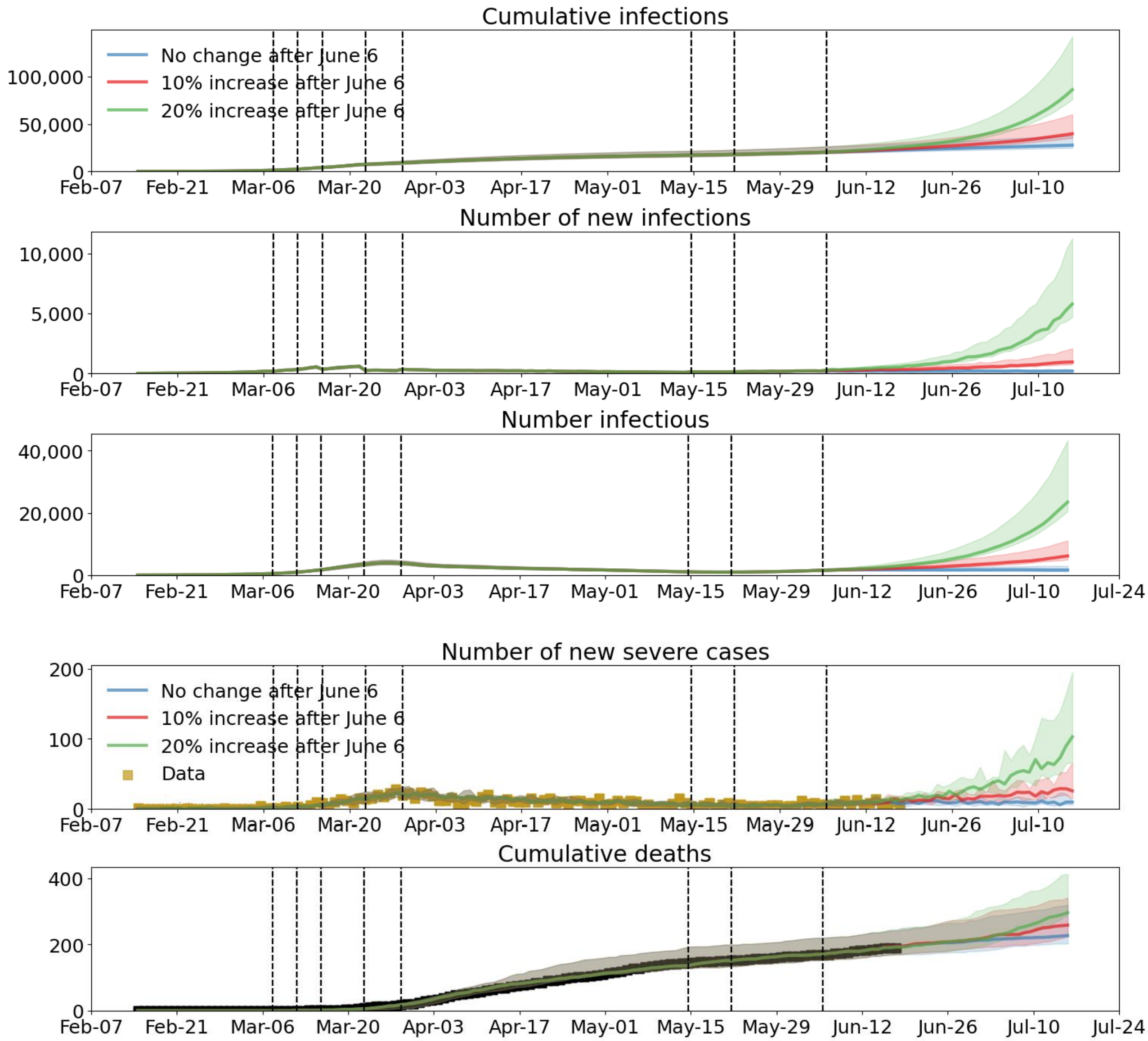

Figure 3: Model projections for the next 4 weeks, assuming that after June 6th: 1) transmission did not change (blue line, "optimistic" scenario), 2) transmission increased by 10 percentage points (red line, "moderate" scenario), and 3) transmission increased by 20 percentage points (green line, "pessimistic" scenario). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection).

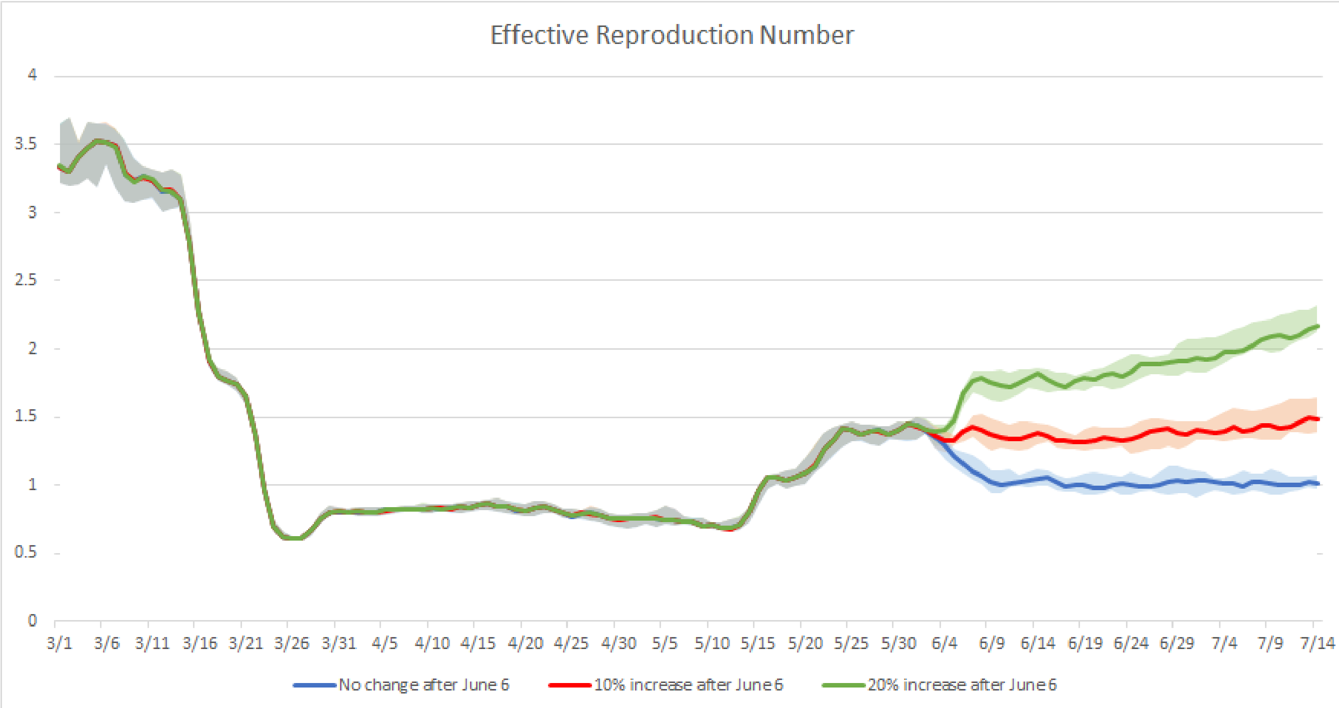

Figure 4: Projected effective reproduction number (Re) through July 14th, assuming that starting June 6th: 1) no change in transmission (blue line), 2) transmission increased by 10 percentage points (red line), and 3) transmission increased by 20 percentage points (green line). The lighter shaded areas 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 1.4.7, 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 1.4.7, 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).[8]
3) Disease parameters were updated to match recent CDC best estimates for pandemic planning scenarios (CDC Planning Scenarios as of May 20, 2020) 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. The susceptibility odds ratios used were: 0.25 for age 0-9, 0.50 for age 10-19, 1.70 for age 20-29, 1.42 for age 30-39, 1.25 for age 40-59, 0.60 for age 60-69, 0.71 for age 70-79, and 1.06 for age 80 and higher. These ratios may partially correspond to biological susceptibility by age but are also a reflection of social behavior and testing activity. For consistency, we kept these assumptions the same as in our last report. However, diagnosed cases in Oregon do appear to be getting younger; if the infected population is younger than we are assuming, our models (calibrated based on hospitalizations) would be underestimating the total number of infections.
5) We determined transmission levels through May based on hospitalization levels and adjusted the assumptions about testing practices to reflect the observed test positivity rates. Specifically, the relative probability of symptomatic individuals being tested was adjusted to match actual diagnoses counts given our inputted number of tests,[9] with

[8] 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.
[9] Since the previous report, we now have data on how the current, increased level of testing relates to diagnoses and have adjusted testing probability accordingly.

changes in relative odds occurring on April 28th and June 4th We modified the testing probability as of June 4th differently for each of the three calibrations, as described in the report.

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

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. The report uses the best available local data as of June 22, 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 in Oregon from imported cases are included in the data used for model calibration.
- 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 are continuing to explore those and other modeling options.
- Estimated reductions in transmission over time are imprecise and not necessarily due to any particular action (e.g., policy or event); some are based on few data points and sometimes multiple actions co-occurred.
- 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 numbers of tests and diagnoses, it assumed both occurred entirely among symptomatic individuals. It also 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 the age distribution (and therefore prognosis) are sensitive to a single outbreak or super spreader event, such as the recent Union County church outbreak with over 200 cases. Such outbreaks would be expected to affect a younger population than outbreaks in nursing homes, which occurred early in Oregon's epidemic (OHA Weekly COVID-19 Report)
- 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. However, the demographics of cases diagnosed over time in Oregon have been changing, as documented in OHA's weekly COVID-19 report found here.

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

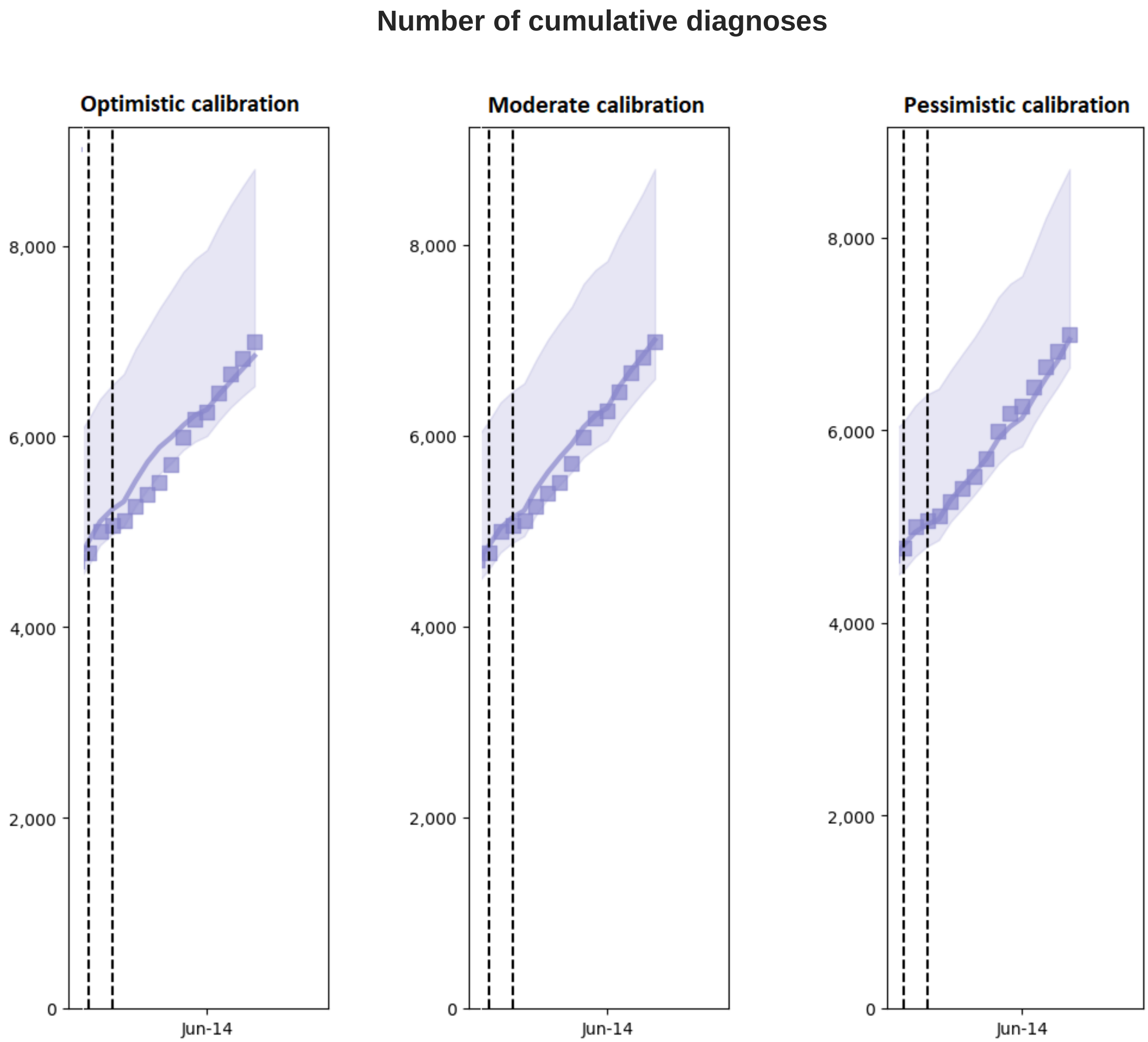

Figure A-1: Cumulative diagnoses by model calibration. Raw data are presented as squares; estimates from the calibration are presented as lines. Note: scale varies among calibrations.