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

Results as of 7/8/2020 – 11:00pm

ACKNOWLEDGEMENTS

This is an update to the Oregon Health Authority's (OHA's) previous modeling reports. This report was based on Covasim modeling software, developed by The Institute for Disease Modeling (IDM). IDM provided OHA with initial programming scripts for the models, and has 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 COVID-19 data used for the modeling are continually being updated. (For daily up-to-date information, visit the OHA COVID-19 webpage.) The results in this brief will be updated 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

Changes after Oregon has begun to reopen

- Based on data through July 2nd, the models indicate that transmission has increased since reopening began on May 15th. Specifically, trends in new hospitalizations are consistent with an increase in transmission of 20 percentage points after May 15th, an additional 10 percentage points after May 22nd, followed by a slight waning around June 6th (but still 25 percentage points higher than before May 15th).

Future scenarios

- We modeled three future scenarios by making different assumptions about transmission.

    - Transmission continues as-is: If we assume transmission continues at the current level over the next month, the estimated number of new daily infections more than triples over the next 4 weeks (from 1,100 to 3,600), and the number of daily new severe (i.e., hospitalized) cases similarly increases (from 17 to 49). The model projects 110,600 cumulative infections by July 30th. The effective reproduction number (Re) – the expected number of secondary cases that a single case generates – is projected to be approximately 1.4.

    - Transmission decreases: If we assume that transmission decreases by 10 percentage points starting July 3rd and continues at that level over the next month, the estimated number of new infections per day increases more slowly. The model projects approximately 23,600 fewer cumulative infections (87,000 vs. 110,600), 2,000 fewer new infections per day (1,600 vs. 3,600), and 25 fewer new severe (i.e., hospitalized) cases per day (24 vs. 49) by July 30th than the continued as-is scenario. The Re is estimated to decrease to around 1.2 after July 2nd.

    - Transmission increases: If we assume that transmission increases by 10 percentage points starting July 3rd and continues at that level over the next month, the estimated number of new infections per day increases more dramatically. Compared to the continued as-is scenario, the model projects about 42,000 more cumulative infections (152,600 vs. 110,600), 3,700 more new infections per day (7,300 vs. 3,600), and 27 more new severe cases per day (76 vs. 49) by July 30th. The Re is estimated to be about 1.7 after July 2nd.

Conclusions

The results indicate that transmission has increased since reopening. If transmission remains at current levels, we expect continued exponential growth in infections. The other model scenarios suggest that increasing or decreasing transmission by only ten percentage points would have a large effect on the number of infections. However, a reduction by ten percentage points appears insufficient to stop growth, with the Re staying above 1.

PURPOSE OF THIS REPORT

This report describes epidemic trends in COVID-19 since Oregon began to re-open, and projects trends over the next month assuming different scenarios. This report complements the extensive epidemiology data (e.g., demographic trends in cases, testing patterns) available at the OHA COVID-19 webpage.

METHODS

This report presents analyses conducted using methods consistent with the previous June 25, 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 July 6th, but data after July 2nd were considered incomplete because of lags in reporting and were not used.
- The age-specific hospitalization estimates were lowered for the current report, in part, because the model appeared to be under-predicting total infections (diagnosed and undiagnosed). This began to cause issues with model fit, as evidenced by the "optimistic scenario" in the previous report. In addition, recent Centers for Disease Control and Prevention (CDC) seroprevalence studies suggest that there may be a significant number of undiagnosed infections in the U.S. (CDC Seroprevalence Studies). Lowering the parameter assumptions for the age-specific hospitalization rates among all infections results in more estimated infections per observed hospitalization.
- Because hospitalized cases have been getting younger, we adjusted the age-specific susceptibility ratio parameters to reflect the changing age distribution of hospitalized cases over time.

NOTE: Given the updates to the parameter assumptions, results presented in this report are not directly comparable to past reports. The changes affected how the model fit to the data; thus, some of the estimated transmission changes over time are different from past reports.

More information about the methods is in Appendix 1.

INTERVENTIONS

Oregon has 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 21, 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.
- 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 began of a new plan for testing at long-term care facilities, as described here.
- On June 25th, the Governor required people living in Oregon's 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), as described here. This requirement extended to all Oregon counties on July 1st, as described here.

RESULTS

As with previous modeling reports, the results in this brief report will be updated 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, and hospitalizations (referred to as "severe cases" below) for Oregon. The dates on which model transmission levels change were selected based on key policy enactment dates, with the following exceptions: 4/6/2020 (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 for calibration.

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 maximum 75% decrease in transmission after March 23rd.[1] 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 early-April, but the number of new daily infections was still declining through mid-May.

Consistent with the previous report, the current calibration provides evidence that transmission has increased since reopening began on May 15th.

- As seen in Figure 1, hospitalizations increased starting 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 20 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). Transmission appeared to then decrease slightly around June 6th -- as reflected by the growth in hospitalizations slowing somewhat after mid-June -- but was still 25 percentage points higher than before May 15th. Of note, the last several days of observed hospitalization data suggest a possible flattening in the trends (Figure 1), but more data are needed to assess this, given the day-to-day variability in the data.
- Average daily diagnoses increased in late June (Figure 1), but this change was consistent with the existing (hospitalization-based) level of transmission, increased levels of testing, and expected positive test rates.

In the last report, we calibrated the model three different ways to take into account differences between the recent diagnosis trends and the hospitalization trends. In the current report, we were able to calibrate the model to the hospitalization data (reflecting transmission through June 20th), and the diagnoses afterward were consistent with the previous patterns.

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

The model estimates that, as of July 2nd, there have been a total of 52,400 cumulative infections in Oregon (80% forecast interval: 44,800 – 73,000), but only 10,200 have been diagnosed according to our local data. This estimate is considerably higher than our last report, in part, because of newer cases over the two-week period, but also because of changes in our parameter assumptions, as mentioned earlier. For example, the model from the current report estimates the number of cumulative infections on June 6th was 31,900, while the last report estimated only 20,400.

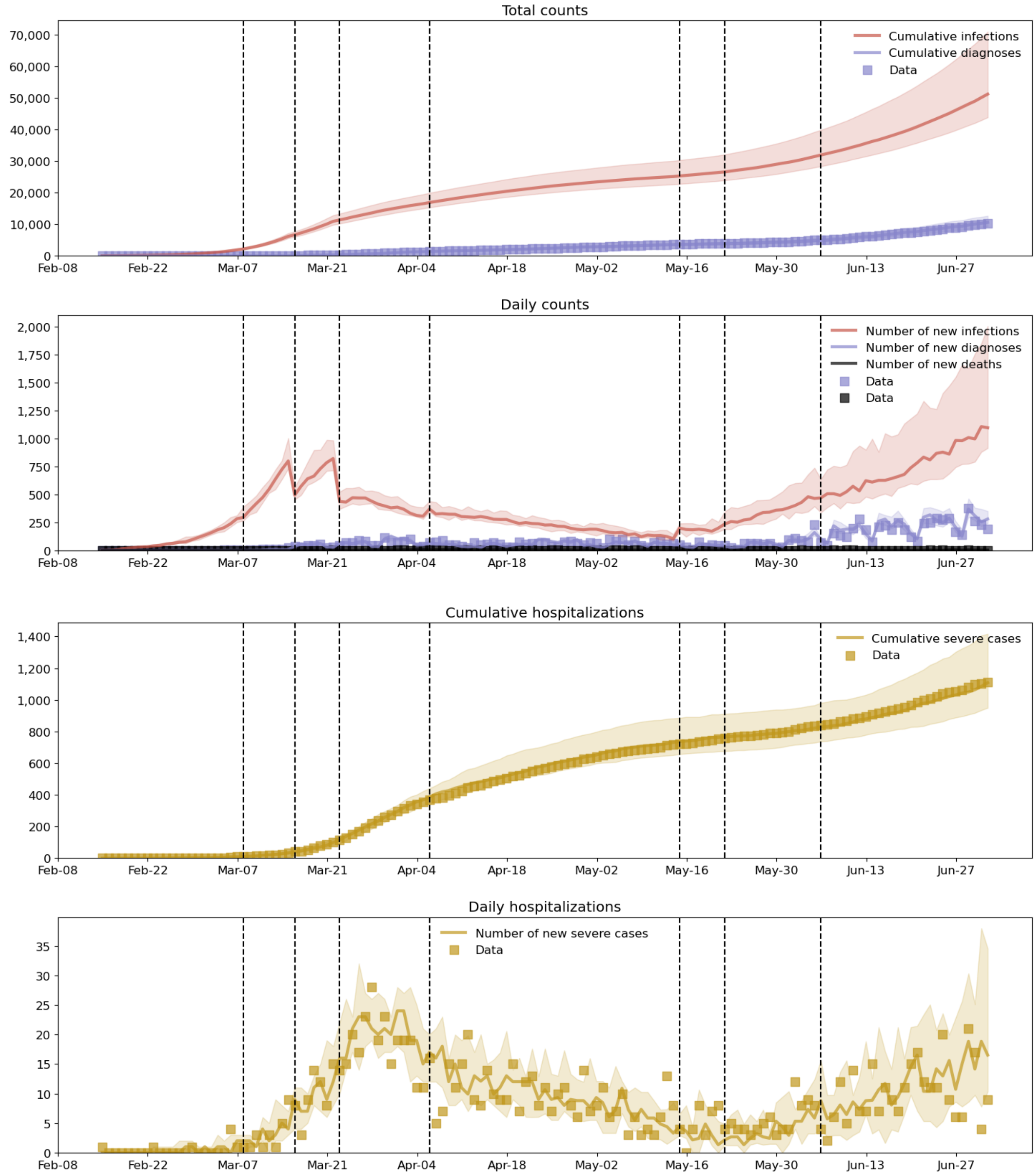

Figure 1: Model calibration with Oregon case data. Dotted vertical lines correspond, from left to right, to estimated reductions in transmission relative to baseline of 5% (March 8th), 50% (March 16th), 75% (March 23rd), 70% (April 6th), 50% (May 15th), 40% (May 22nd), and 45% (June 6th). Raw data are 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

Because we do not know how adherence to the physical distancing, face covering, and hygiene recommendations will change over time, it is not possible to confidently predict future transmission levels. Recent data points also suggest some amount of uncertainty: while average daily diagnoses continue to increase, new hospitalization growth may be slowing. Therefore, we modeled three future scenarios through July 30th by making different assumptions about future transmission.

For all scenarios, we assumed 4,500 tests per day to reflect recent testing levels (July 7 Testing Summary). We ran the forecast model 11 times to simulate the epidemic and produce forecast intervals.

- Transmission continues as-is: If we assume transmission continues at the current estimated level over the next month, the predicted number of new daily infections more than triples over the next 4 weeks, from 1,100 to 3,600 (Figure 2). The model projects 110,600 cumulative infections, 3,600 new infections per day, and 49 new severe (i.e., hospitalized) cases per day by July 30th. The effective reproduction number (Re) – the expected number of secondary cases that a single case generates – is projected to be about 1.4 (Figure 3).[2]

- Transmission decreases: If we assume that transmission decreases by 10 percentage points starting July 3rd and continues at that level over the next month, the estimated number of new infections per day increases more slowly over the next month (Figure 2). The model projects about 23,600 fewer cumulative infections (87,000 vs. 110,600), 2,000 fewer new infections per day (1,600 vs. 3,600), and 25 fewer new severe (i.e., hospitalized) cases per day (24 vs. 49) by July 30th than the continued as-is scenario. The Re is estimated to decrease to around 1.2 after July 2nd (Figure 3).

- Transmission increases: If we assume that transmission increases by 10 percentage points starting July 3rd and continues at that level over the next month, the estimated number of new infections per day increases more dramatically (Figure 2). Compared to the continued as-is scenario, the model projects about 42,000 more cumulative infections (152,600 vs. 110,600), 3,700 more new infections per day (7,300 vs. 3,600), and 27 more new severe cases per day (76 vs. 49) by July 30th. The Re is estimated to be about 1.7 after July 2nd (Figure 3).

[2] Re increased slightly over time in this and other scenarios because, as new infections increase, a gradually smaller proportion are assumed to be diagnosed and to subsequently reduce their transmission, since testing is assumed to stay at the same level.

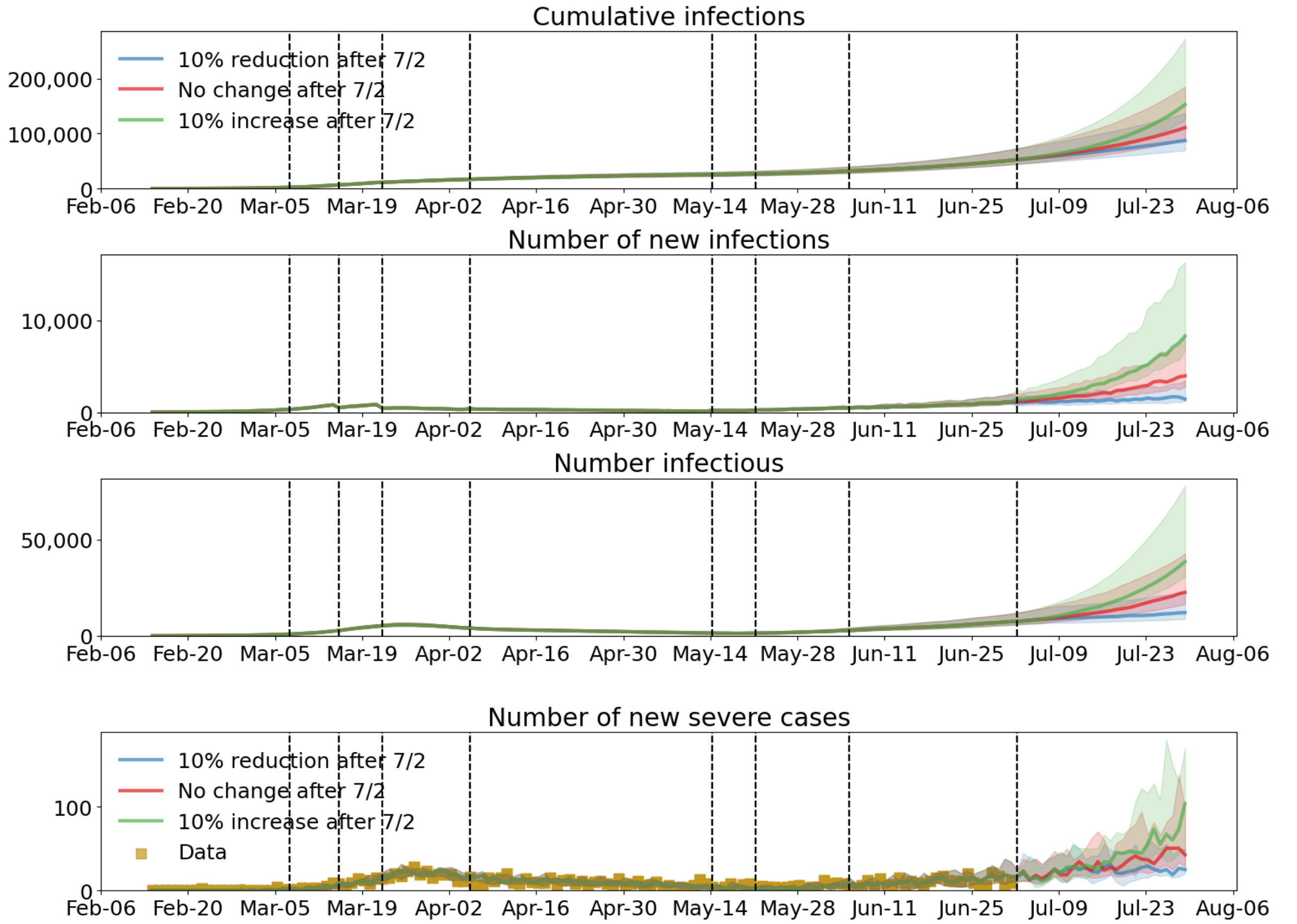

Figure 2: Model projections for the next 4 weeks, assuming that after July 2nd: 1) transmission does not change (red line), 2) transmission decreases by 10 percentage points (blue line), and 3) transmission increases by 10 percentage points (green line). The lighter shaded areas correspond to 80% forecast intervals (i.e., 10th and 90th percentiles of the projection).

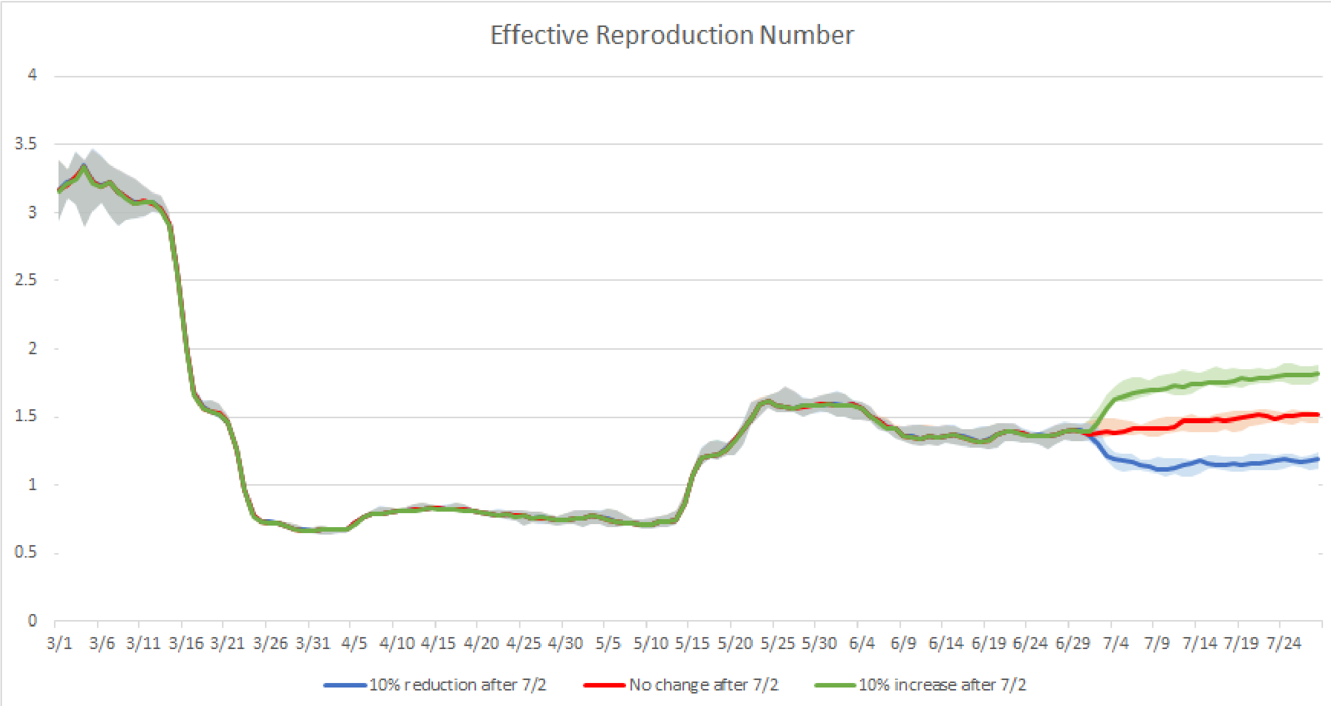

Figure 3: Projected effective reproduction number (Re) through July 28th, assuming that starting July 3rd: 1) no change in transmission (red line), 2) transmission decreased by 10 percentage points (blue line), and 3) transmission increased by 10 percentage points (green line). The lighter shaded areas 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.

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.[3]

Nevertheless, the results indicate that transmission has increased since reopening. If transmission remains at current levels, we expect continued exponential growth in infections. The other model scenarios suggest that increasing or decreasing transmission by only ten percentage points would have a large effect on the number of infections. However, a reduction by ten percentage points appears insufficient to stop growth, with the Re staying above 1.

Even with testing, treatment, and contract tracing, transmission levels are still dependent on adherence to the recommendations regarding physical distancing, face coverings, hygiene,

[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)

self-quarantining of contacts, and self-isolation of cases. Understanding the system, workplace, social network, and individual-level barriers to adherence to those recommendations and addressing those barriers is essential to reducing transmission.

Comparison with other model results

The latest results from Imperial College (https://mrc-ide.github.io/covid19usa/#/details/OR), CovidActNow (https://covidactnow.org/us/or?s=54069) and RT Live (https://rt.live/)[4] estimate the Re for Oregon to be lower than we did: their estimates were 1.23, 1.13 and 1.10, respectively.

CDC compiles hospital forecasts from numerous modelers. Our scenario that assumed transmission continues as-is most closely resembles the forecasts from GT-DeepCOVID and Covid19Sim (Figure 4).

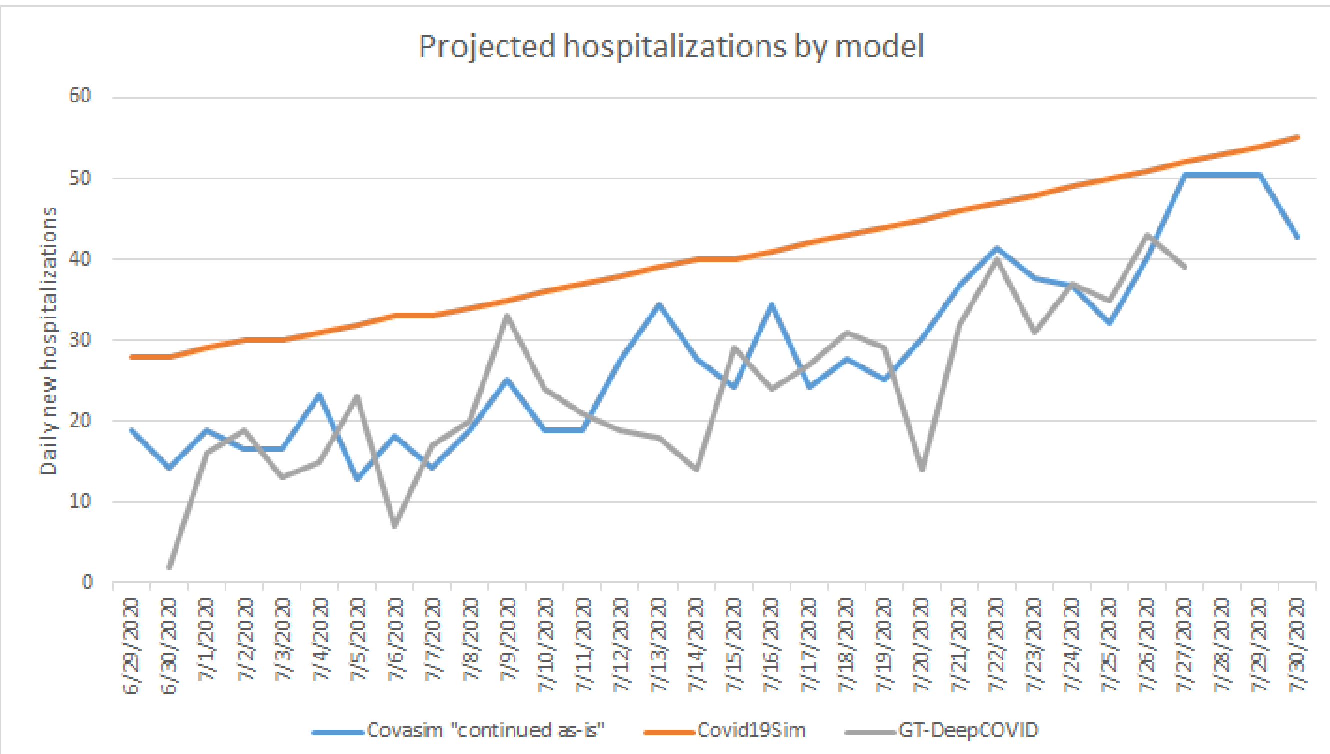

Figure 4: Projected daily new hospitalizations in Oregon through July 30th for the current report's scenario that assumed estimated transmission "continues as-is" (Covasim) and for two models included in CDC's hospital forecast compilation, as of June 30th (Covid19Sim and GT-DeepCOVID).

[4] These websites accessed 7/9/2020.

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, and hospitalizations (referred to as severe cases below) 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 of 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).[5]
3) We lowered our age-specific hospitalization estimates for the current report, in part, because our model appeared to be under-predicting total infections. This began to cause issues with model fit. In addition, recent CDC seroprevalence studies suggest that there have been many undiagnosed infections in the US (CDC Seroprevalence Studies). We adjusted Covasim's age-specific severe probability parameters among all infections to be consistent with CDC's suggested parameter values for pandemic planning scenarios (CDC Planning Scenarios as of May 20, 2020). Specifically, we used the CDC parameter values for age-specific hospitalization probabilities among symptomatic infections, and adjusted them based on Covasim's age-specific symptomatic probability parameters. With Oregon's age distribution, the resulting parameter values for age-specific severe probabilities among all infections for our model were 1.7% for ages 0-49, 4.3% for ages 50-64, and 8.6% for ages 65 and older. These rates are lower than in recent reports due to the incorporation of Covasim symptomatic assumptions and a change in the age-adjustment methodology.
4) Parameter assumptions were modified to vary susceptibility by age and time, such that the age distribution of severe cases in the model follows that of cases diagnosed and subsequently hospitalized in Oregon over two time periods: February-April and May-June. The susceptibility odds ratios used in these respective time periods were: [2.42, 3.05] for age 0-9, [0.51, 1.28] for age 10-19, [1.08, 1.05] for age 20-29, [0.48, 0.55] for age 30-39, [0.63, 0.51] for age 40-49, [1.05, 0.80] for age 50-59, [0.93, 0.46] for age 60-69, [1.02, 0.49] for age 70-79, and [1.19, 0.62] for age 80 and higher. These ratios may

[5] 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.

partially correspond to biological susceptibility by age but are also a reflection of social behavior and testing activity. Both the diagnosed and hospitalized population has become younger over time in Oregon, implying a lower overall hospitalization rate and more total infections per hospitalization in recent months.

5) To assess our new parameter assumptions, we compared our model estimates of cumulative infections with what we might expect from seroprevalence studies. CDC's study in Western Washington State of people seeking medical care suggests that only about 9% of infections as of April 1st had been reported (CDC Seroprevalence Studies). Our current model had similar results: cumulative diagnoses on April 1st in Oregon made up about 7% of the estimated cumulative infections on that date (1,070 cumulative diagnoses /15,300 estimated cumulative infections).
6) We determined transmission levels through mid-June 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, with changes in relative odds occurring on April 23rd and June 4th.

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 75 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 report are will be updated 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 July 6, 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.
- Our parameter assumption for the proportion of all infections (diagnosed or not) that are hospitalized was based on CDC's hospitalization-among-symptomatic estimates and Covasim default symptomatic-among-infection estimates, then adjusted to observed local hospitalizations by age. However, there is considerable variability in this estimate in the literature. Underestimating (overestimating) this proportion would inflate (deflate) our estimates of total number of infections.
- 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 and hospitalizations 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).
- 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 adherence to recommendations (e.g., physical distancing, face coverings, hygiene), the disease dynamics, and treatment. 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.”