

Short report: Updated analysis of COVID-19 transmission in King County, WA

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What do we already know?

Physical distancing remains necessary to suppress COVID-19 transmission. [We previously reported](#) that the effective reproductive number in King County as of March 25 and predicted through April 7 remained near one, and that regional mobility appears to have stabilized after falling from typical late-February levels. Together, these results implied that daily case counts would likely persist at an approximate plateau if societal behavior remained unchanged, and that relaxation of social distancing would quickly lead to increased transmission.

What does this report add?

In this short-form report, we update results for King County with case data from the Washington Disease Reporting System through April 9. We estimate that the effective reproductive number remained near one (95% uncertainty interval 0.55 to 1.33, best estimate 0.94) through April 4. We include short-term forecasts under three scenarios for changes in the effective reproductive number to highlight that outcomes in May will be very sensitive to policy choices and community behavior. In contrast to previous reports, we do not include a mobility-based nowcast because the quality of fit between the reproductive number and [the mobility metric used previously](#) has declined. Research to address this issue is in progress.

What are the implications for public health practice?

Without new or strengthened interventions to further reduce the rate of transmission, COVID prevalence will likely only slowly decline and may plateau. Policy action to reduce transmission further may be required to bring daily case counts down before partial relaxation of social distancing policies can occur without substantial risks to the community and healthcare system. However, there is still a great deal of uncertainty about how to achieve further transmission reductions and how to quickly measure the impacts of policy changes before the consequences become clear in case data.

Executive summary

Throughout the month of March, physical distancing measures in King County and elsewhere in Washington State reduced the rate of COVID-19 transmission and prevented overwhelming exponential growth of infections, confirmed cases, and deaths. However, confirmed cases in King County have continued to appear at rates averaging above 100 per day since mid-March. In this short report, we update our estimates of the effective reproductive number in King County, WA through April 4, based on case data through April 9. As anticipated in our [previous report](#), **we confirm that the transmission rate has held steady with an effective reproductive number (R_e) of approximately one**, with a point estimate of 0.94 and 95% confidence interval 0.55 to 1.33 on April 4.

As the COVID-19 epidemic unfolds, we learn more both about the disease and how to model it with sufficient accuracy and proper accounting for uncertainty to responsibly inform policy. In previous reports, we included a nowcast of R_e based on the association of changes in R_e with a regional mobility metric that measures changes in population occupancy between day and night. This metric was [one of many possible metrics](#) that told similar stories in March, but it is no longer well-correlated with the most recent estimates of R_e in this report. For this reason, we do not include a nowcast here, and we are in the process of revisiting our mobility modeling to improve predictive power going forward. Furthermore, we highlight a small but important discrepancy in the previous and current estimates that reflects updates to the underlying data. **We emphasize these as they have an important message for policy: it is early in this outbreak, and we do not yet fully understand how reliable our proxies for measuring the transmission rate are.**

Our estimates of the daily R_e are consistent with 1 and no further change starting from March 22, with the best estimate of the average only slightly below one. While we cannot look past April 4 with the data available for this update, continued persistence at this transmission rate will lead to a prolonged period of slowly declining rates of daily cases and deaths, as is [currently being seen in Italy](#) and distinctly slower than [what was seen in China](#). Thus, **further policy action to reduce transmission may be required before partially relaxing physical distancing policies** to minimize the risks posed by resurgent transmission.

Key inputs, assumptions, modeling approach, and limitations

Our inputs, assumptions, modeling approach, and limitations are unchanged from the [last report](#), with the following exceptions:

- We continue to use lab testing data provided by Washington State Department of Health (WADoH) through the Washington Disease Reporting System (WDRS), compiled for this report on April 19. To hedge against incomplete reporting in WDRS, we only **include data through April 9 in the analysis**.
- We now allow for the reporting rate to change over time, with one rate prior to March 10 and a different one thereafter. This has small impacts on results reported to date but more properly accounts for the scale up in testing. Further methodological advances to handle changing testing regimes are in development as this will likely be more important in the future.
- We do not include a mobility-based nowcast for reasons discussed below.

Updated estimates of the effective reproductive number

Figure 1 shows our current estimates (black dots) of the effective reproductive number (R_e) overlain with the results (grey dots) and mobility-based model (95% confidence interval in orange) from our previous report. Our current estimate of R_e is consistent with 1 since roughly March 26, and the estimate for the most recent day, April 4, is 0.94 with 95% confidence interval from 0.55 to 1.33. These new results are consistent with our previous mobility-based nowcast (95% confidence interval in yellow), although this is partly a result biases that cancelled as described below.

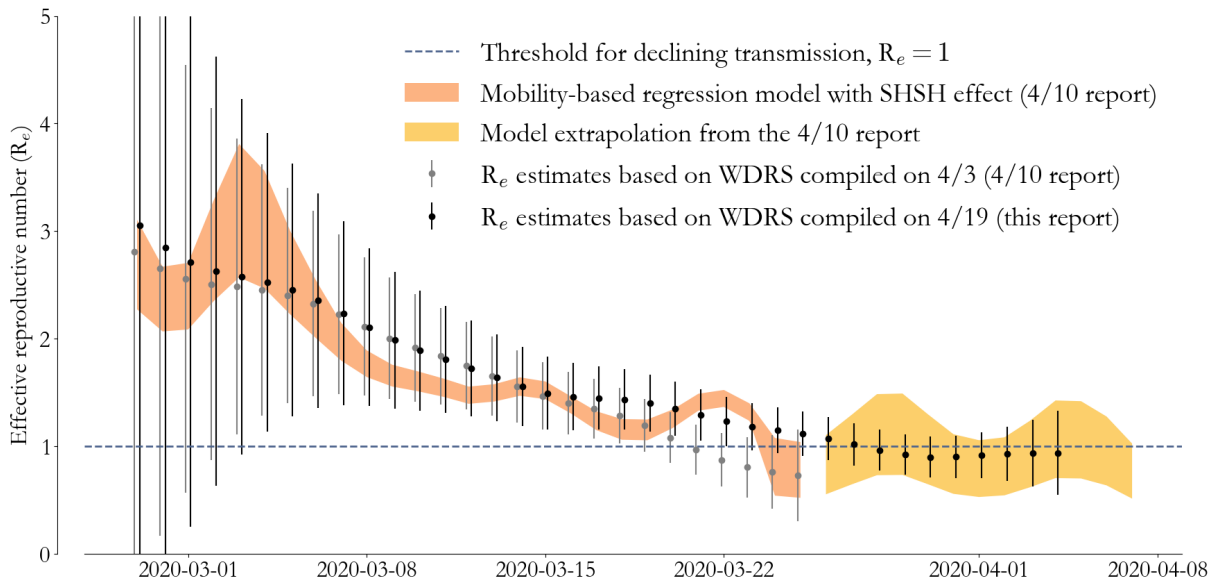


Figure 1. Comparison of updated daily estimates of the reproductive number with results in our last report. Black dots represent the current estimates of the reproductive number, and grey dots represent those from our April 10 report with 2 standard deviation error bars in both cases. Mobility-based nowcast from our previous report (orange and yellow curves) is included for reference. Since April 10, WDRS case detection data have been updated with increased case counts from March 23 to April 3, leading to retrospective increases in our reproductive number estimates from March 16 to March 25.

We observed a discrepancy with the previous estimates from roughly March 16 through March 25: the current estimates are consistently higher than the previous ones. This issue arises from a larger-than-anticipated revision to the data in WDRS, as shown in **Figure 2**. To hedge against retrospective changes in the data, our previous report assumed that King County case reporting into WDRS was typically complete within 5 days of confirmation. However, from late March to early April, lags persisted for roughly 10 days, and this led to under-estimates of R_e . In this report, we are more conservative, and we assume data within 10 days of the WDRS compilation day (April 19 in this case) are not yet reliable.

Going forward, we do not expect this particular instability to persist, as it was concordant with [specific changes to the WDRS reporting system](#). But we emphasize that future unanticipated changes will affect accuracy, and so there will remain hard-to-quantify uncertainty whenever large changes in testing and data systems occur. As a relevant example, in our previous nowcast, the mobility-covariate ran high at the same time as the case data ran low, and the resulting nowcast was successful because these two biases compensated for one another.

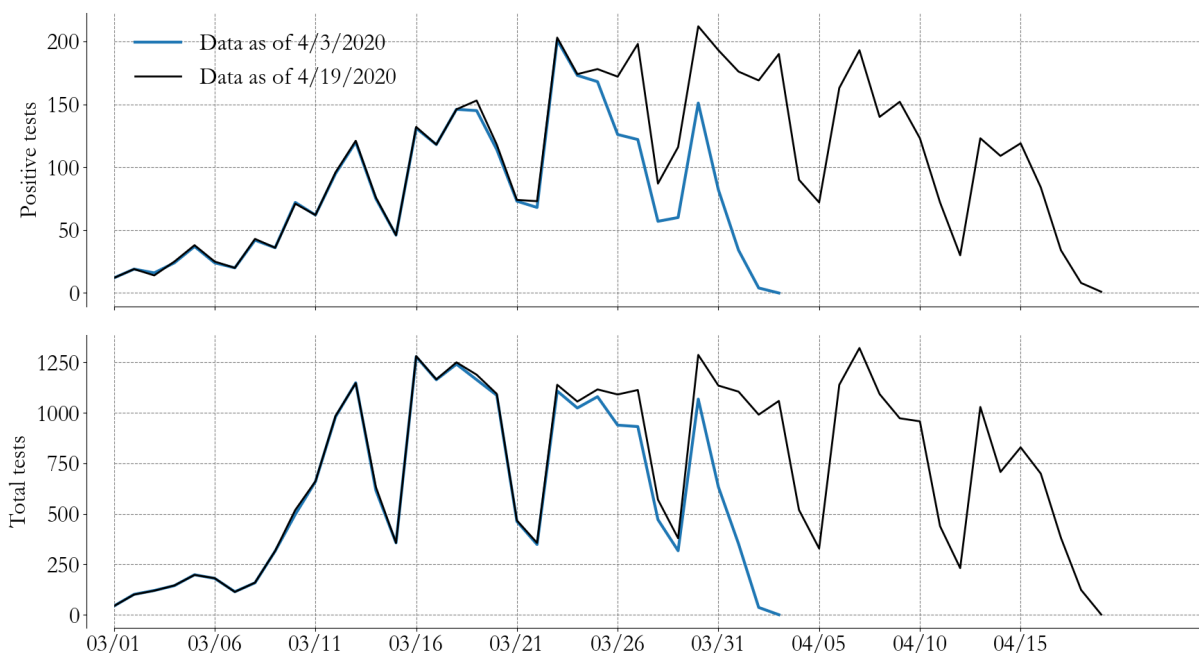


Figure 2: Showing updated WDRS case detection data. The blue line represents the data which were available for our April 10 report (WDRS compiled on April 3, used in the April 10 report), and the black line shows current available data (WDRS compiled on April 19, used in this report). There were significant revisions from March 23rd to April 3, leading to adjustments in our reproductive number estimates from March 16 to March 25.

Model based projections for King County still depend entirely on future behavior

In **Figure 3**, we show three scenarios for possible future trajectories of the daily case count through the end of May. Because there is negligible population immunity, future outcomes remain entirely dependent on societal behavior, physical distancing, and other containment policy actions. In the first scenario, we hold the transmission rate from April 4 constant through the end of May. The expected scenario is a slow decline that persists above 100 cases per day. If, starting on May 1, physical distancing partially relaxes to result in similar rates of transmission as seen in mid-March, the model predicts a rapid rise in the rate of cases that would likely exceed recent peak levels by the end of May. In contrast, if new strategies are added to current distancing measures to drop the effective reproductive number to roughly 0.5, the case rate would likely fall to near and below all levels seen since the scale up of testing in the second week of March. **We interpret these modeling scenarios to say that the situation in King County remains precarious and that further policy action in the coming weeks will dictate COVID outcomes for better or for worse.**

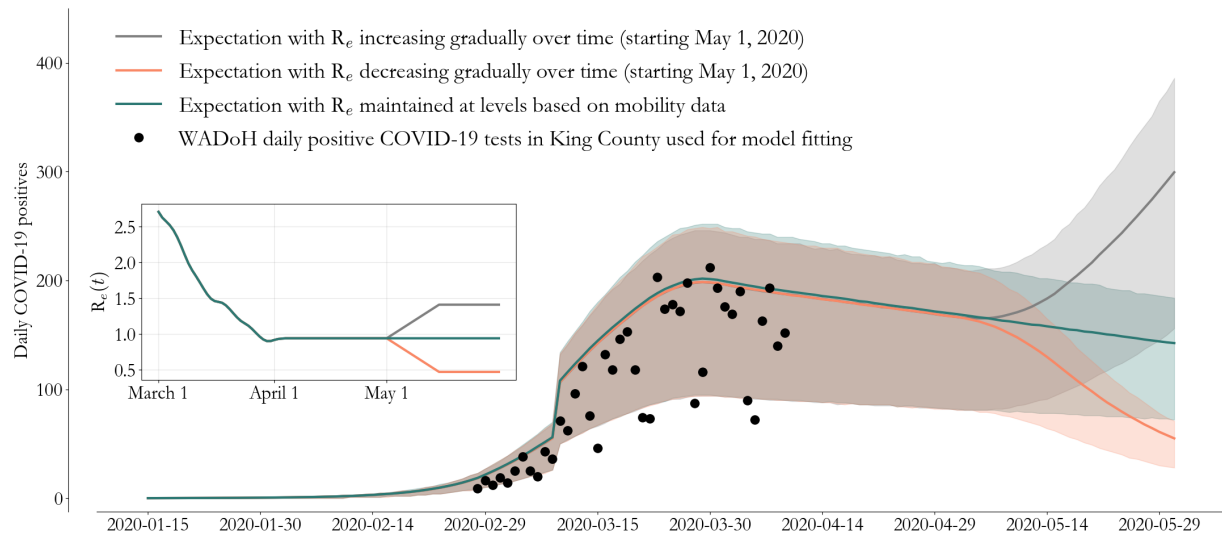


Figure 3. Updated model-based projections of cases under 3 scenarios, shown in the inset. Gradual increase in effective reproductive number (grey), maintenance (green), and gradual decrease (red) lead to dramatic changes in projections of COVID-19 cases in King County (50% confidence intervals for each scenario). In this version, R_e changes directly, without reference to a mobility covariate.

Associating digital mobility metrics with COVID-19 transmission will require more work

We do not include a mobility-based nowcast of R_e because the correlation with our previously-preferred metric has degraded, as shown in **Figure 4**. As we described [previously](#), the metric we have been using for nowcasting captures location-specific changes between day and night population occupancy. The metric captures increased rates of staying at home, but it has plateaued since roughly March 19. In contrast, our estimates of R_e declined more slowly overall and plateaued later, since roughly March 26. As a result, this metric no longer adequately captures changes in R_e on its own, and we will be re-examining multiple mobility metrics from multiple sources in the near future to assess which, if any, are more likely to be predictive going forward.

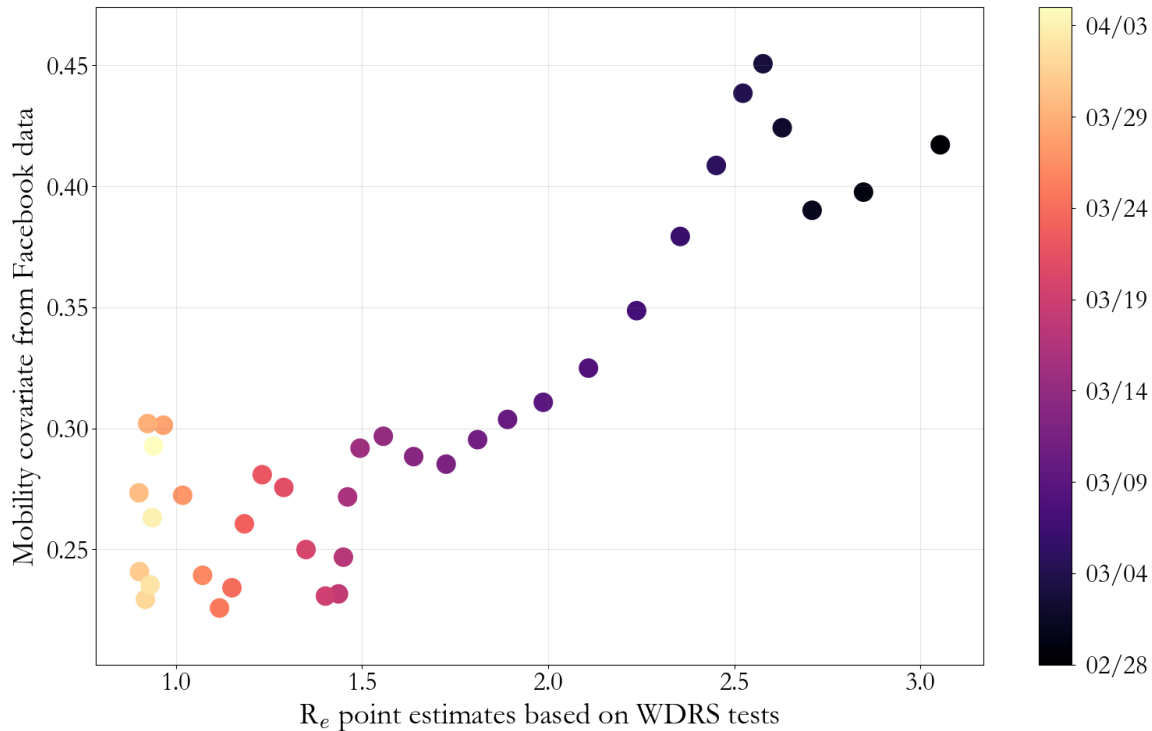


Figure 4. The correlation of the day-night occupancy mobility metric and the effective reproductive number has degraded over time. After roughly March 19, the mobility metric oscillates weekly around a new baseline while R_e continued to fall. There are many possible transmission proxy measures to use, of which this is just one, and so we will be revisiting [our mobility covariate work](#) to improve future predictive power.

Conclusions

Using WDRS case data through April 9, we infer that the effective reproductive number in King County remained stable just below 1 through April 4, and that continued persistence at this level of transmission will lead to at best a slow decline in the daily case rate through the end of May and beyond. Thus, the future outcomes in the region remain exquisitely sensitive to policy changes and public adherence to physical distancing guidelines.

The model in this report does not describe specific policies or strategies that might further reduce the transmission rate. Options may include tightened physical distancing recommendations, but also scaled up testing and contact-tracing strategies on top of current restrictions may be effective at reducing transmission prior to changing distancing policies, if feasible. We are working to quantify trade-offs among strategies with different costs, feasibilities, and benefits, but decision-making under large uncertainty will be a persistent challenge during this pandemic.

We also highlight key uncertainties that are difficult to model and are important to policy. First, as the testing and case reporting systems in Washington state continue to adapt to the needs of COVID-19 suppression, our results may be sensitive to unexpected instabilities in the data that will only be detectable with time. Furthermore, as we continue to learn about both COVID transmission and

community behavior, we need to continually assess the predictive power of transmission proxies, such as mobility metrics, as many changes in transmission may not be easily captured. Both these observations remind us that uncertainty at times can be bigger than is easily quantified, and that policy decisions should strive to be robust to reasonable errors and leave room for continual learning in this unprecedented time.

Appendix: Evaluating the quality of our previous model projections

In our previous report, we used a mobility-based transmission model to forecast 3 similar scenarios to those described above, with increasing (grey), constant (green), and decreasing (red) transmission associated with corresponding mobility changes. Here, we use the updated data to evaluate those projections.

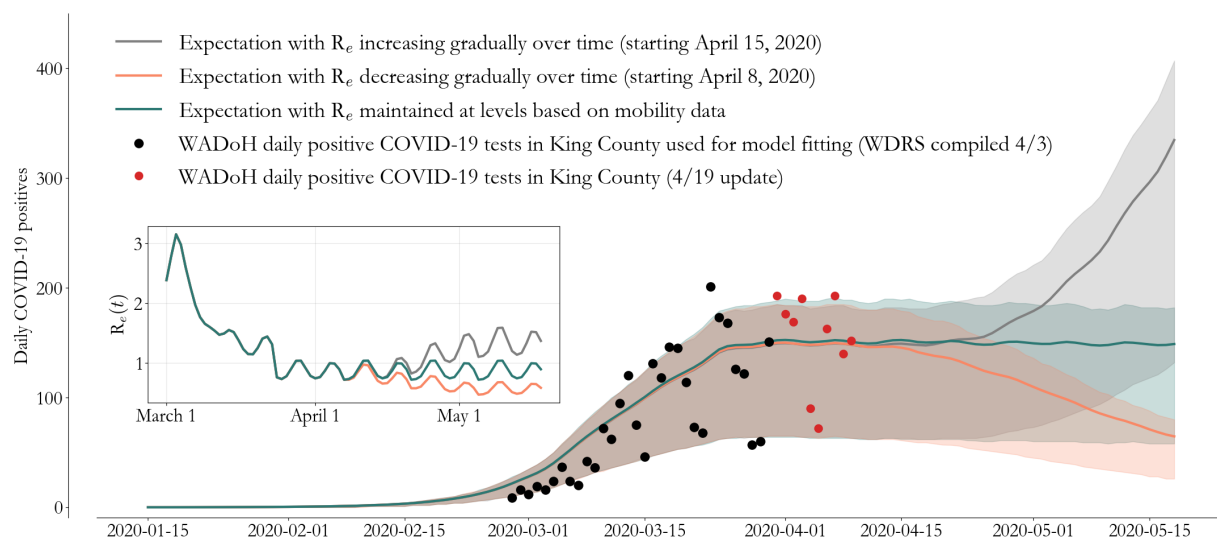


Figure S1. Previous model-based projections of cases under 3 scenarios, shown in the inset. Gradual increase in effective reproductive number (grey), maintenance (green), and gradual decrease (red) lead to dramatic changes in projections of COVID-19 cases in King County (50% confidence intervals for each scenario). This is a replication of Figure 4 from our previous report, with new data superimposed. Red dots show new daily positives from the most recent WDRS update, and indicate that current data are still consistent with any of the three scenarios.

Overall, as shown in **Figure S1**, we find that the new case data (red dots) are in line with our previous expectations. Notably, the data remain consistent with all 3 scenarios, highlighting that changes in transmission take weeks to appear unambiguously in case data.