Estimating the effective reproduction number of COVID-19 in North Carolina

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covid-19-rt

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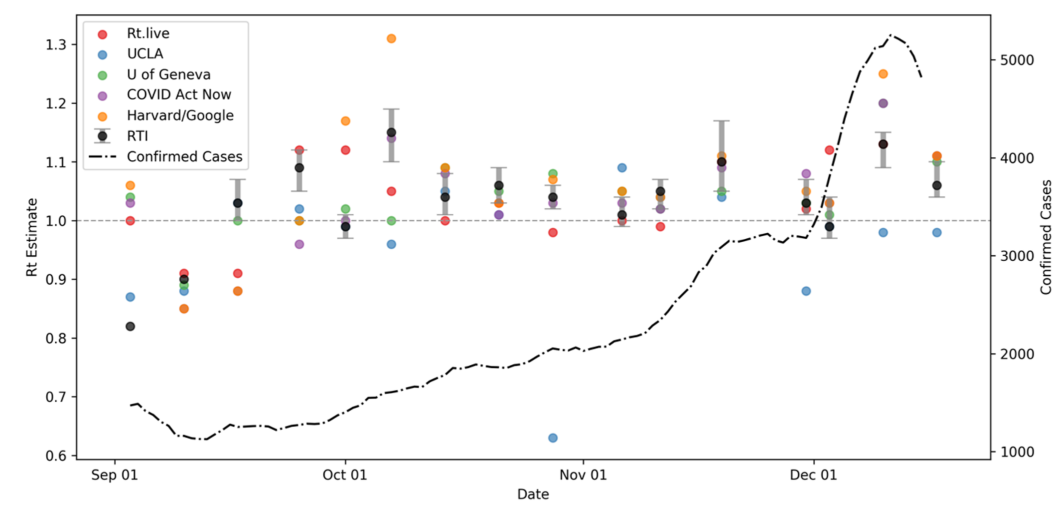
Figure 1: Rt estimates



Throughout the COVID-19 pandemic, stakeholders have used the effective reproduction number, R_t, to monitor and inform efforts to mitigate the pandemic. R_t can be defined as the estimated number of people each person with SARS-CoV-2 will infect at time t, considering the control measures in place and the proportionof the population with immunity [1]. R_t has been calculated by numerous groups using a variety of private and publicly available data sources and has been used by policy makers to monitor the trajectory of the pandemic [2].

RTI International worked with public health and healthcare stakeholders in North Carolina in 2020 to produce weekly estimates of R_t statewide and by county and sub-state region. In this publication, we focus on statewide R_t estimates [3]. Our approach to modeling evolved over time to account for more sources of uncertainty and delay. From September 3 to 10, 2020 we used a simple formula based on the growth rate of confirmed cases, derived from Wallinga and Lipsitch 2007[4]. From September 17 to November 11, 2020, we used the R package EpiEstim [5], which produces interval estimates in addition to point estimates to account for uncertainty. From November 19 to December 17, 2020, we used the R package EpiNow2 [6], which adds additional corrections for delays due to the incubation period and reporting delay in reported case counts. R_t estimates were based on confirmed cases by day of report.

We compared our weekly R_t estimates from September 3 to December 17, 2020 to public confirmed case data from theNorth Carolina Department of Health and Human Services (NC DHHS) and publicly available R_t estimates from five other modeling groups: Instagram [7], UCLA[8], University of Geneva [9], Covid Act Now [10], and Harvard [11](Figure 1). The models use slightly different methods and adjustments, as well as underlying data from various sources. The spread of R_t estimates was quantified over time by calculating the standard deviation of the five estimates each week (Figure 2). Estimates were widely distributed between September to mid-October, closer together in mid-October to mid-November, and then widely distributed again in mid-November to December when there was a sharp increase in cases in North Carolina. Our R_t estimates were most similar to estimates from other models during October to mid-November when cases maintained a steady trend.

R_t estimates based on reported case counts are affected by potential bias in the underlying data. Reported case counts are imperfect estimates of true incidence. The magnitude of under-reporting is unknown and likely varies over time, as testing availability and behavior evolve. COVID-19 tests also vary in their sensitivity and specificity. Unfortunately, no easy solution exists for this problem. Sentinel surveillance [12] and mass testing [13] programs can provide better disease monitoring, but these programs are difficult to implement and bring their own set of challenges. Reported case counts can also be adjusted to reduce bias: the Instagram team [7] used a simple adjustment by testing volume, and Boettcher et al [14] propose a more rigorous correction methodology. Ultimately, the most important response to this limitation is to ensure that all stakeholders making decisions based on R_t estimates are aware of it.

In conclusion, R_t can be a useful metric, but it is sensitive to differences between models and underlying data. In North Carolina, this was particularly evident during September to October, as well as after mid-November when the trend in cases changed dramatically. In light of these findings, R_t estimates should be presented in a way that emphasizes the uncertainty inherent in these estimates. For example, by showing a range of potential values (an interval estimate), by showing comparisons with estimates from a range of models, or by showing an ensemble estimate that combines estimates from multiple models.

The findings and conclusions in this publication are those of the author(s) and do not necessarily represent the views of the North Carolina Department of Health and Human Services, Division of Public Health.

Figure 1 legend: Figure 1: R_t estimates from RTI and 5 other groups in relation to reported COVID-19 confirmed cases by day of report from North Carolina from September 3 to December 17, 2020.

Figure 2 legend: Standard deviation of R_t estimates from RTI and 5 other groups in relation to confirmed new cases from North Carolina from September 3 to December 17, 2020

References:

1) https://doi.org/10.1001/jama.2020.7878

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3) Sandy Preiss , Kasey Jones, Emily Hadley, Stacy Endres-Dighe, Marie Stoner, Sarah Rhea.. "Pandemic Metrics: Lessons Learned from Estimating Rt." https://www.rti.org/insights/pandemic-metrics-estimating-rt

4) https://doi.org/ 10.1098/rspb.2006.3754

5) https://doi.org/10.1093/aje/kwt133

6) Epinow2 package. https://epiforecasts.io/EpiNow2/

7) Rt.live COVID-19 model. https://rt.live/

8) UCLA COVID-19 model. https://covid19.uclaml.org/

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13) Medical Device Network. https://www.medicaldevice-network.com/features/mass-testing-for-covid-19/

14) https://doi.org/10.1101/2021.05.22.21257643

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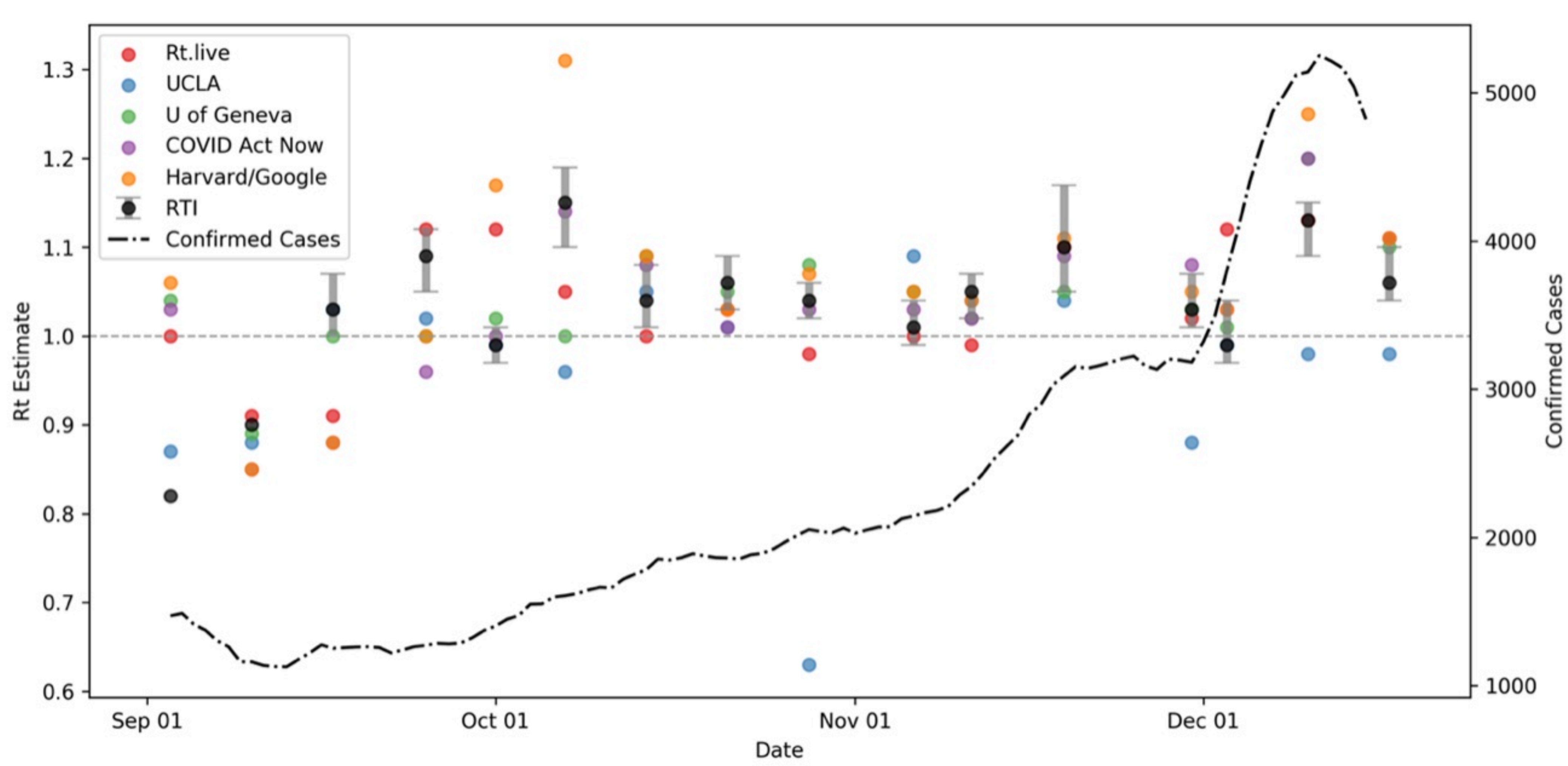

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Figure 2: Standard deviation of Rt estimates