COVID19 Forecasting Report

As of date : 2020-04-08
Region : ON
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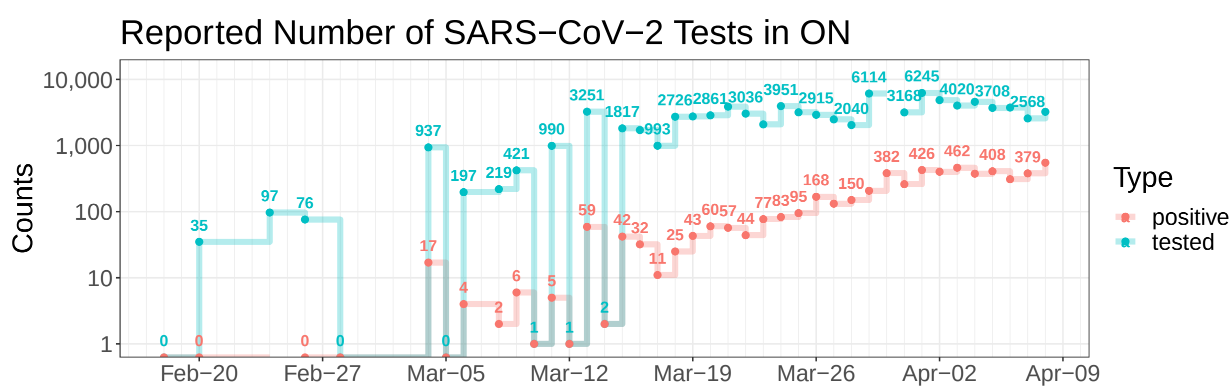
Assumptions and Caveats

- This forecast is based on a mathematical model of SARS-CoV-2 transmission. Although the model attempts to capture the overall dynamic of the epidemic, it is a simplification of the reality.
- To perform forecast, the model must be "calibrated" to observations. The quality of the forecasts is directly impacted by the quality of the observed data.
- In particular, the number of COVID-19 positive tests publicly available on Federal or Provincial websites is used as a proxy for the true, unobserved, incidence of infections. Thus, the model is impacted (among many other issues) by the saturation of tests performed, bias from the demographics tested (e.g., travellers, symptomatic and hospitalized persons), reporting delays and errors.

Incidence Curve Used (confirmed cases)

The proxy for incidence of infections used in this document are reported tests (performed and confirmed) compiled and curated by Michael Li (https://github.com/wzmli/COVID19-Canada).



Past and Current Dynamic

Doubling Time

The *daily* confirmed cases are used to estimated the doubling time of the epidemic (Figure 1). The doubling time is the expected number of days it takes for the number of daily confirmed cases to double. The higher the doubling time, the slower the epidemic progression is. The evolution of the doubling time can indicate any acceleration or deceleration of the outbreak. In particular, it can show the impact (or the lack of) of an intervention.

The implementation of social distancing measures has not had any noticeable effect at the time when the reported tests were conducted, as illustrated by the relatively constant doubling time.

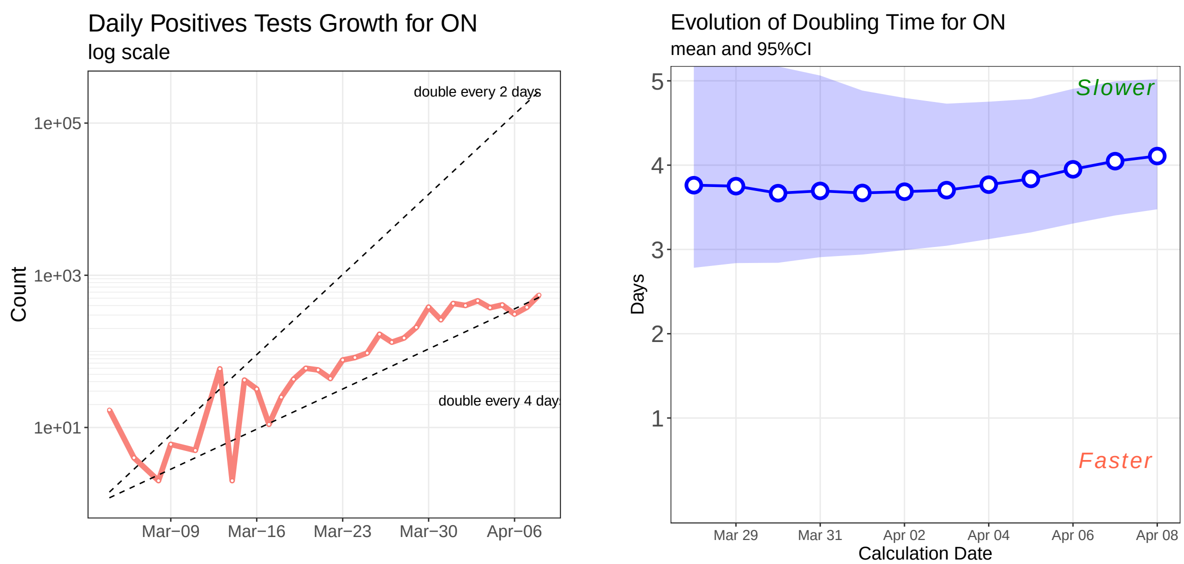


Figure 1: Left Panel: New positive tests reported daily. The dashed line shows, for reference, the trajectories of cases doubling every 2 and 4 days. Right Panel: Doubling time (in days). The doubling times were estimated with a linear regression on the count of the log number of daily confirmed cases.

Reproduction Numbers

The basic reproduction number – traditionally noted $\mathcal{R}_0$ – is defined as the average number of secondary transmissions from an infectious individual introduced in a fully susceptible population. The total number of infected individuals, as well as the effort intensity needed to control the epidemic, are directly related to the value of $\mathcal{R}_0$. The lower $\mathcal{R}_0$, the better.

Parameter	Mean	95%CI
Doubling time	4.1 days	(3.5 – 5)
Basic reproduction number $\mathcal{R}_0$	1.88	(1.71 – 2.07)

Figure 2 shows $\mathcal{R}_0$ estimates by province.

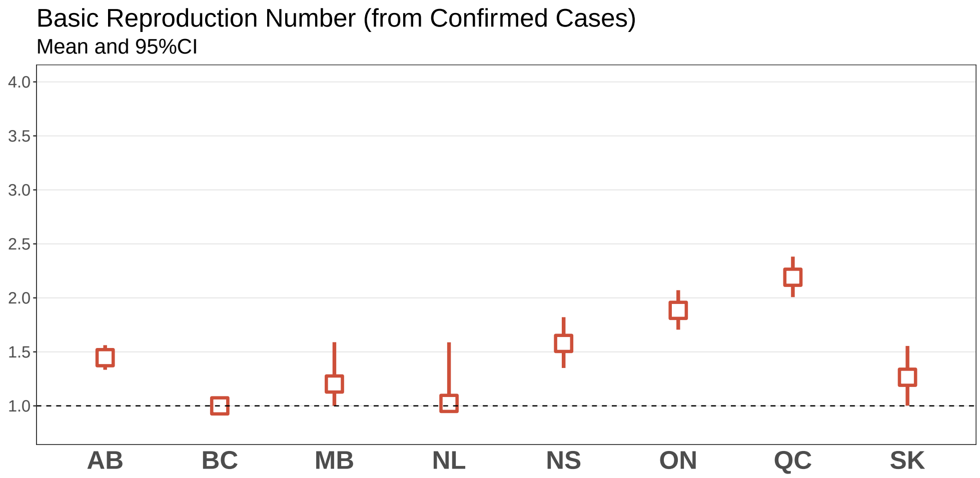


Figure 2: Basic reproduction number estimates, by province

The *effective* reproduction number – traditionally noted $\mathcal{R}_t$ – takes into account the depletion of susceptible individuals in the population: it is defined as the average number of secondary transmissions from an infectious individual (not necessarily in a fully susceptible population). The subscript t represents the time when $\mathcal{R}_t$ is calculated. When the value of $\mathcal{R}_t$ decreases below 1, this signals the epidemic is decelerating. The evolution of $\mathcal{R}_t$ during the past 6 days is shown in Figure 3. $\mathcal{R}_t$ has consistently been above 1, indicating the epidemic was probably still accelerating at the time when the tests were performed.

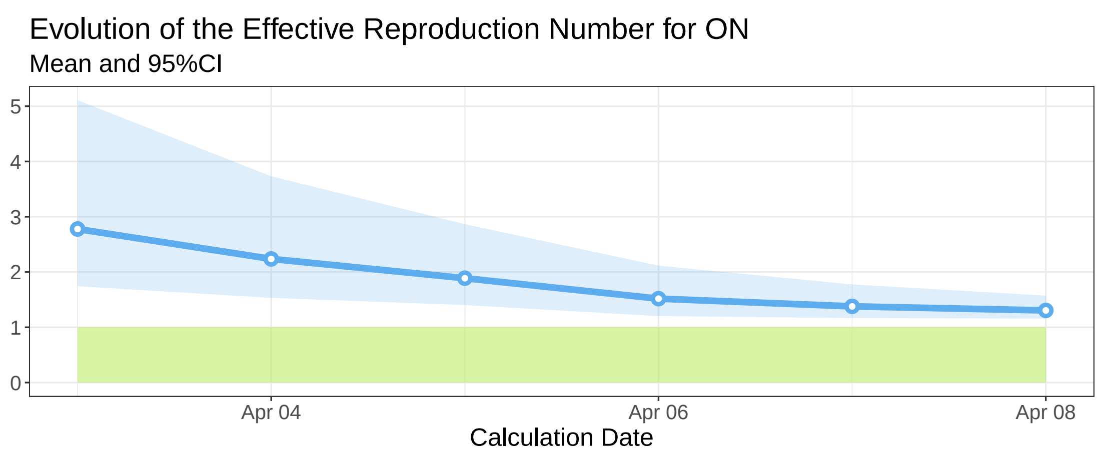


Figure 3: Evolution of the effective reproduction number $\mathcal{R}_t$ (blue line). The green area marks the threshold level of $\mathcal{R}_t \leq 1$ where the epidemic would start to decelerate.

Forecasts

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Once the mathematical model is fitted to observed data, the future trajectory of incidence is simulated. Uncertainty about the values of model parameters, as well as the transmission and reporting processes, are taken into account and propagated in the forecasts. Control measures are simulated in 3 different scenarios.

Intervention Scenario Definitions

- Baseline: This is the baseline scenario, assuming the transmission rate will remain the same as it was until today.
- Instant 30%: The transmission rate is reduced instantly by 30% starting tomorrow and will remain indefinitely at this reduced level.
- 50% in 21 days: The transmission rate continuously decreases at an exponential rate such that it is reduced by 50% after 21 days and remains constant at this reduced level thereafter.

Projections are presented for three type of outcomes:

hosp	:	hospitalized cases
critical	:	hospitalized cases in critical care
death	:	number of deaths

Model Parameters

Parameter	**Value**	**Source**
prop. susceptible	80%	assumption
prop. confirmed cases out of true incidence	25% (95%CI: 15-35%)	CMMID
prop. confirmed to hospitalized	14%	PHO daily reports
prop. hospitalized to critical care	39%	PHO daily reports
prop. critical to death	48%	PHO daily reports
generation interval (mean, sd)	$m = 4.5$ days ; $\sigma = 2.6$	various studies
contact heterogeneity	high ($\alpha = 5$)	assumption

Total Burden Projections

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The total burden in Figure 4 considers the cumulative number of patients that have been hospitalized, in critical and who died throughout the full duration of the simulated epidemics.

Figure 4: hosp: hospitalized cases; critical: hospitalized cases in critical care; death: number of deaths. The lower panels is an example of a probabilistic interpretation of the upper panel.

Peak Timing Projections

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The simulated epidemics allow to forecast the time when the daily number of hospitalization peaks. Figure 5 shows the possible peak date ranges for each scenario.

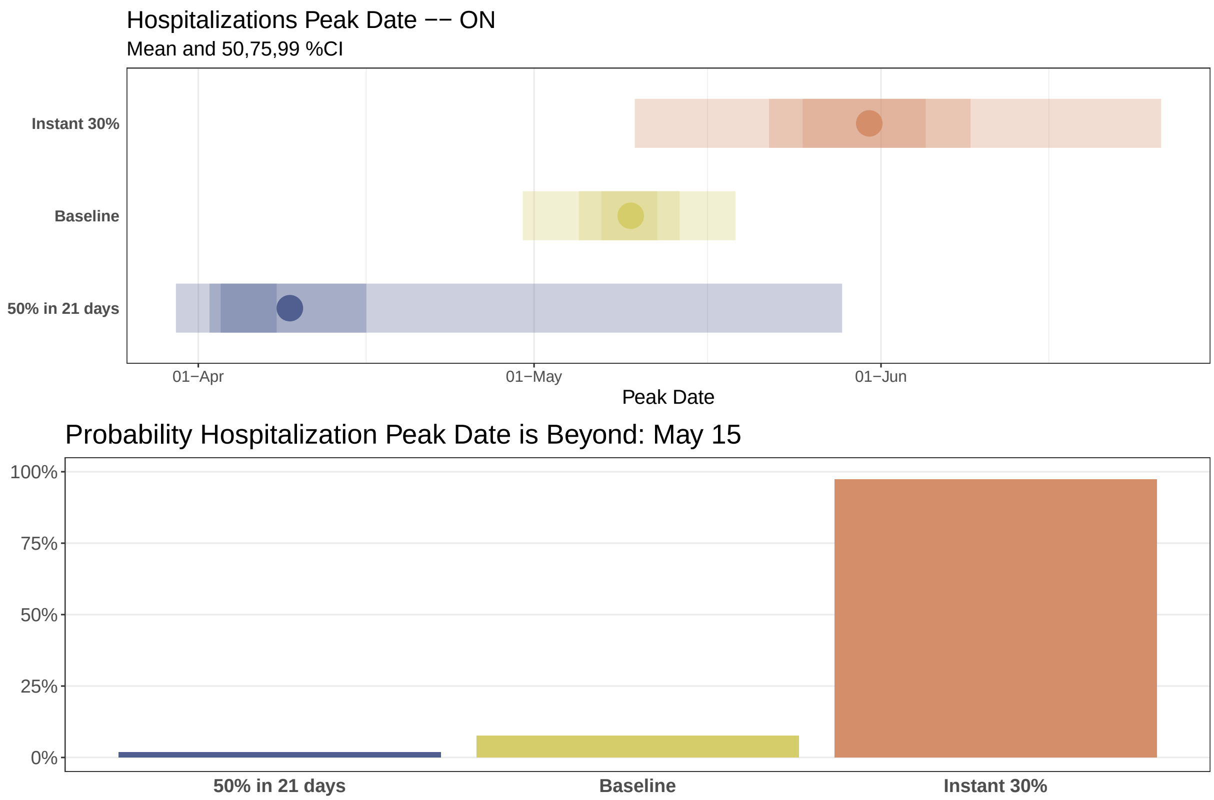

Figure 5: Forecast for the peak time of hospitalized cases.

Peak Daily Intensities Projections

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Similarly as the peak time forecasts, the peak intensity for the three outcomes (hospitalized, critical care and death) can be projected. Figure 6 shows the possible peak intensity ranges for each scenario and outcome.

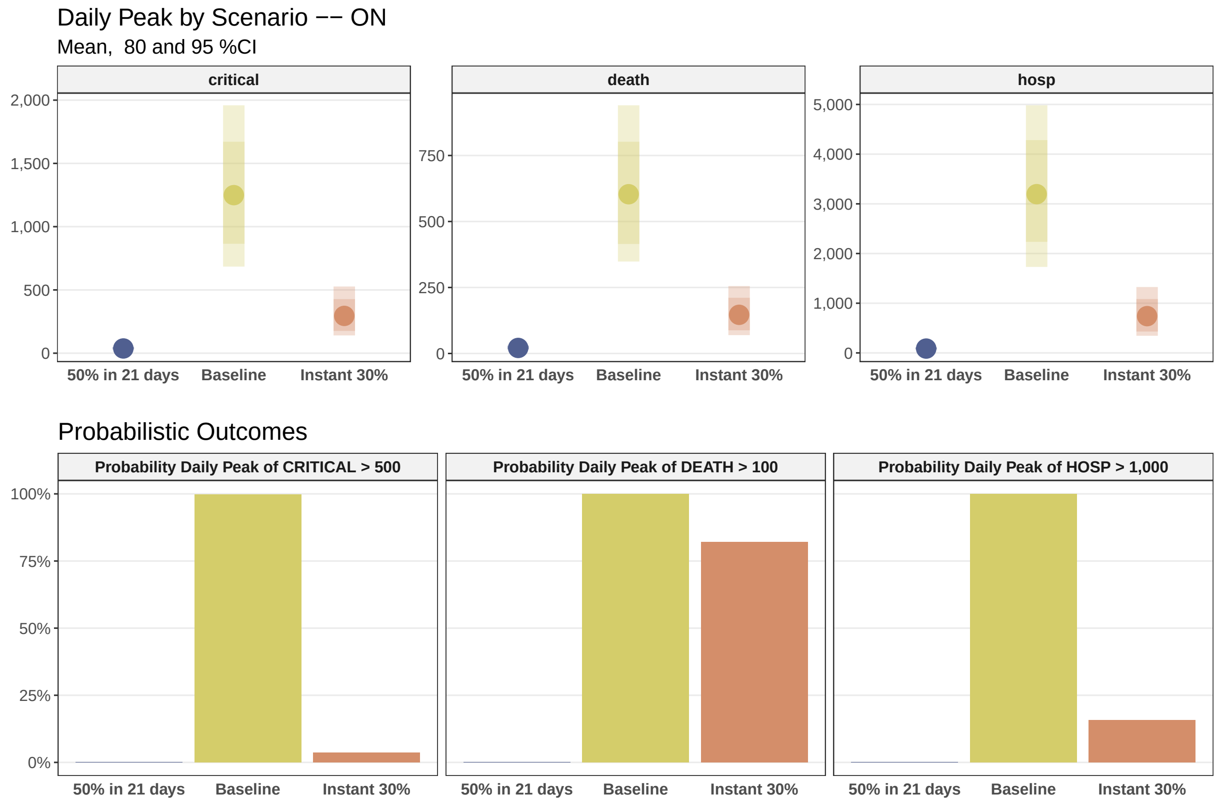

Figure 6: hosp: hospitalized cases; critical: hospitalized cases in critical care; death: number of deaths.

Short-Term Projections

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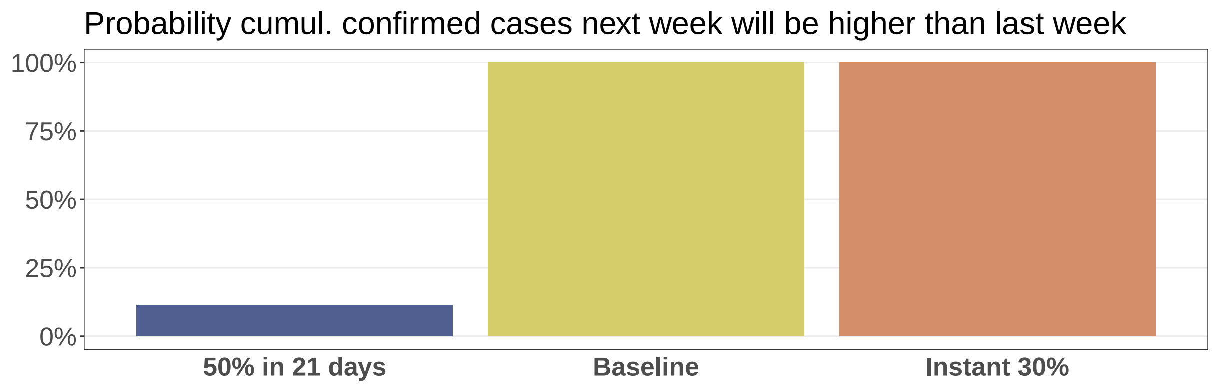

Figure 7: For each scenario, probability that the cumulative number of confirmed cases for next week will be higher then last week.