# COVID19 Forecasting Report

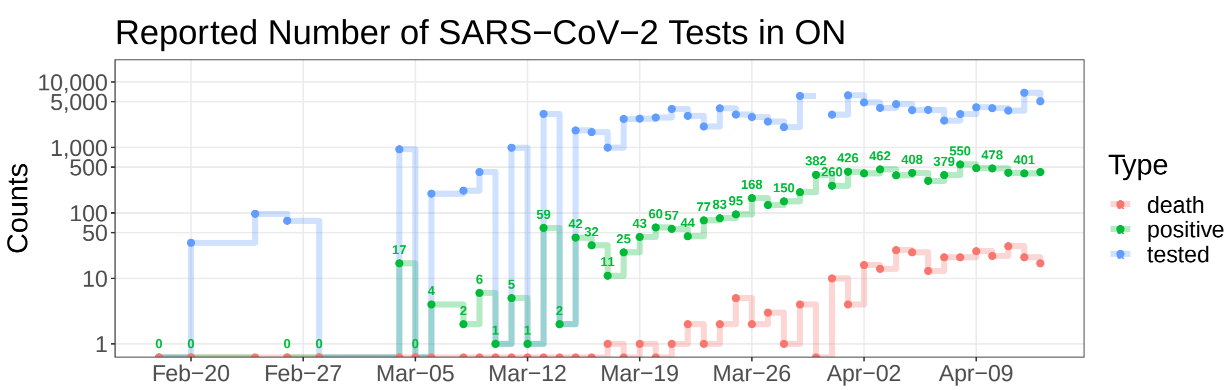

As of date : 2020-04-13
Region : ON
Contact : David Champredon (david.champredon@gmail) - Western University, London, ON


## 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)

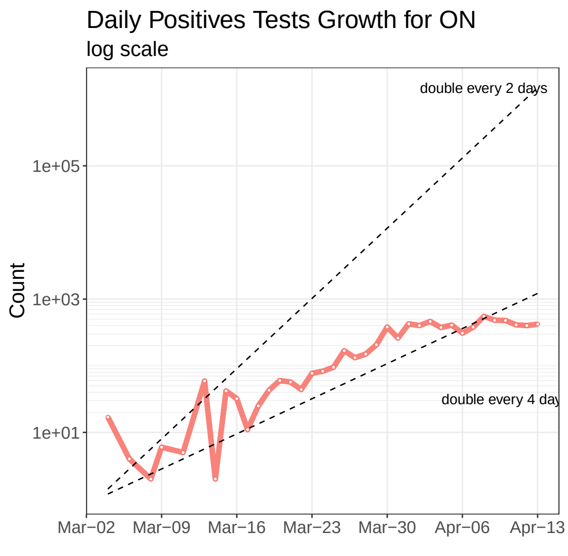
The proxy for incidence of infections used in this document are reported tests (performed and confirmed) compiled and curated by Michael Li (https://github.com/wzmli/COVID19-Canada).



# 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.



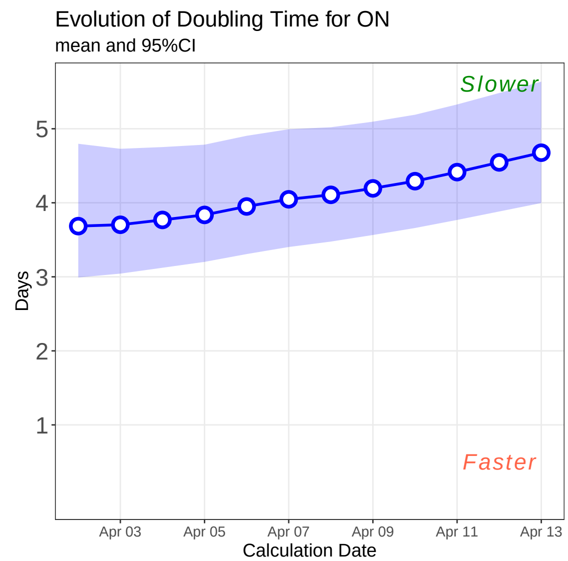




*Figure 1: Left Panel: New positive tests reported daily. The dashed line shows, for reference, the trajectories of cases doubling every 2 and 4 days. Right Panel: Doubling time (in days). The doubling times were estimated with a linear regression on the count of the log number of daily confirmed cases.*

## Estimated effect of social distancing

The effect of social distancing is estimated by fitting an epidemic model that has a discontinuity in the transmission rate on March 20 (see Table 1 for the definition of scenario **ISO1** later in this report). The size of the discontinuity is calibrated on positive tests observed after March 20 (declaration of the state of emergency in Ontario was on March 17).

| | **Mean** | **95%CI** |
|---|---|---|
| Transmission rate reduction | 36 % | ( 12 % – 53 %) |

## Effective Reproduction Numbers

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 $\mathcal{R}_t$ since the date when enough data is available for each region is shown in Figure 2.

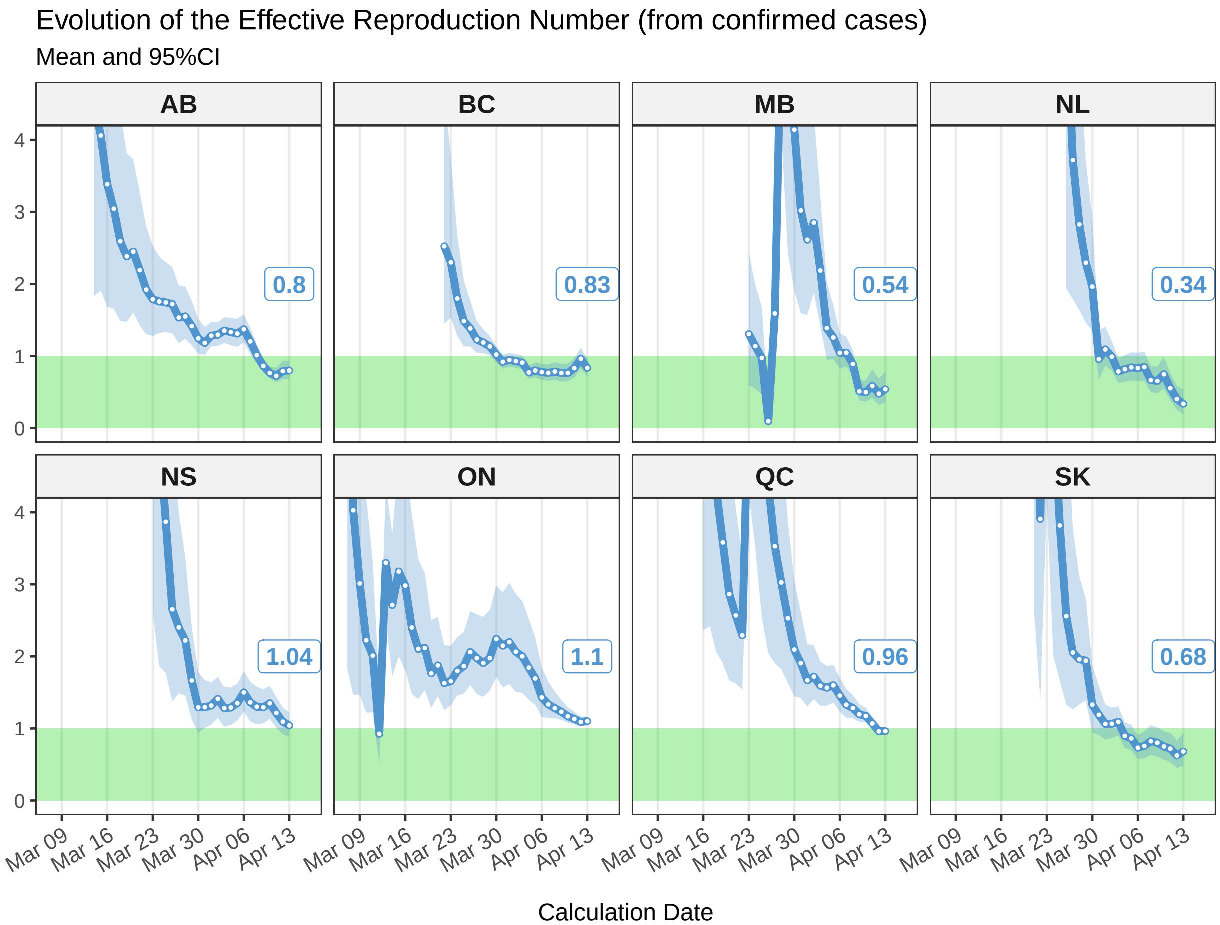



*Figure 2: Evolution of the effective reproduction number $\mathcal{R}_t$ (blue line). The green area marks the threshold level of $\mathcal{R}_t \leq 1$ where the epidemic starts to decelerate. The labelled number indicates the current mean estimate of $\mathcal{R}_t$.*

# Forecasts

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

*Table 1: Intervention scenarios used in the forecasts.*

| Name | Description |
|---|---|
| **Baseline** | This is the baseline scenario, assuming the transmission rate will remain the same as it was before the first social distancing intervention. |
| **ISO1** | This is the scenario we are currently in, where strong social distancing measures took effect after March 20th and are kept as is for 6 months. |
| **ISO2** | This is the scenario we are currently in, where strong social distancing measures took effect after March 20th. Social distancing will gradually be relaxed from May 15 until July 15. At that point, the transmission rate will return to the same value as before the social distancing measures. |

Projections are presented for three type of outcomes:

hosp : hospitalized cases

critical : hospitalized cases in critical care

death : deceased cases

## 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 | 60% | PHO daily reports |
| generation interval (mean, sd) | $m = 4.5$ days ; $\sigma = 2.6$ | various studies |
| contact heterogeneity | high ($3 \leq \alpha \leq 5$) | assumption |

## Total Burden Projections

The total burden in Figure 3 considers the cumulative number of patients that have been hospitalized, in critical and who died throughout the full duration of the simulated epidemics.

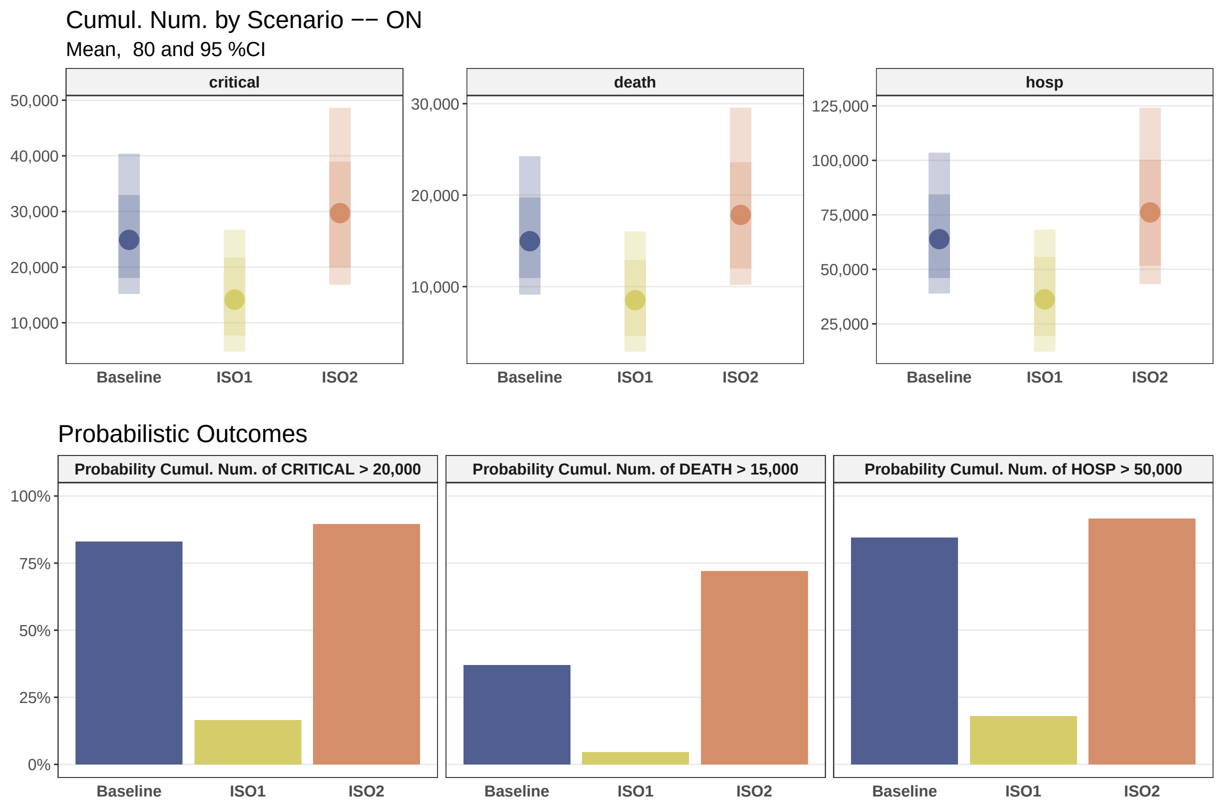



*Figure 3: hosp: hospitalized cases; critical: hospitalized cases in critical care; death: number of deaths. The lower panels is an example of a probabilistic interpretation of the upper panel.*

## Peak Timing Projections

The simulated epidemics allow to forecast the time when the daily number of hospitalization peaks. Figure 4 shows the possible peak date ranges for each scenario.

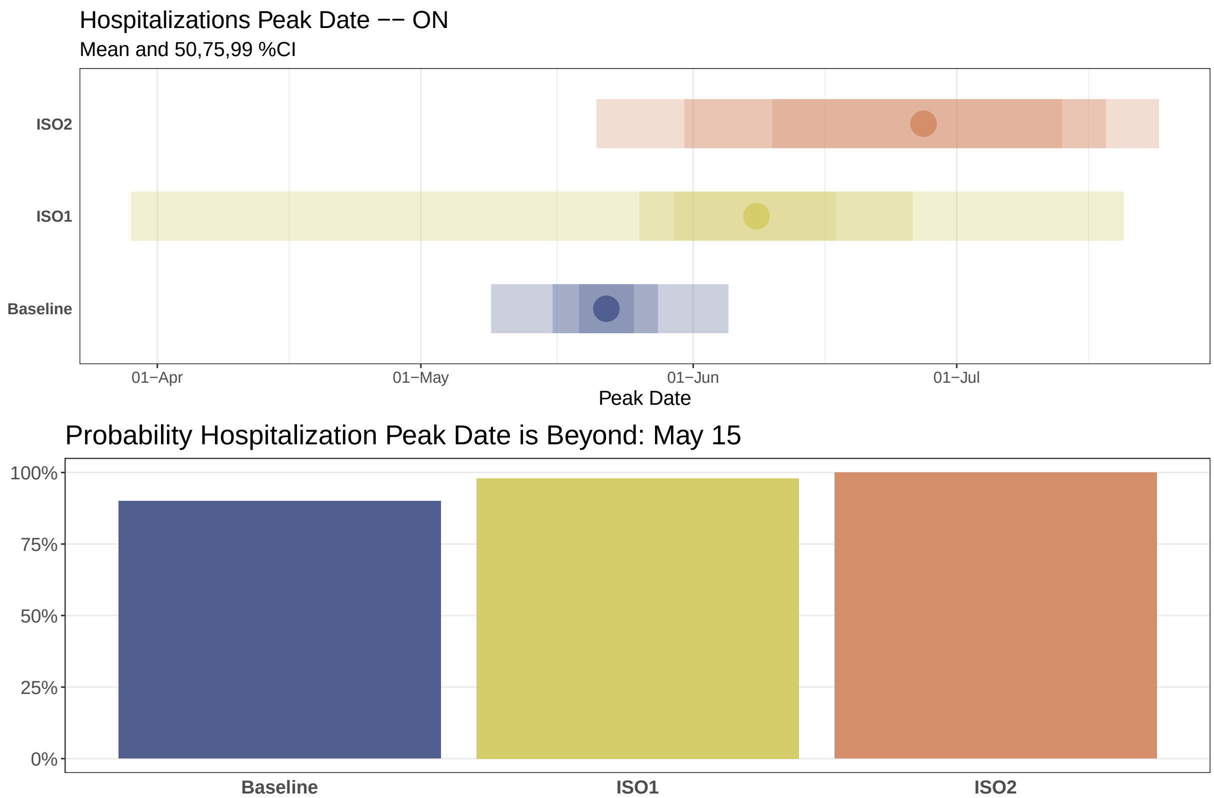



*Figure 4: Forecast for the peak time of hospitalized cases.*

## Peak Daily Intensities Projections

Similarly as the peak time forecasts, the peak intensity for the three outcomes (hospitalized, critical care and death) can be projected. Figure 5 shows the possible peak intensity ranges for each scenario and outcome.

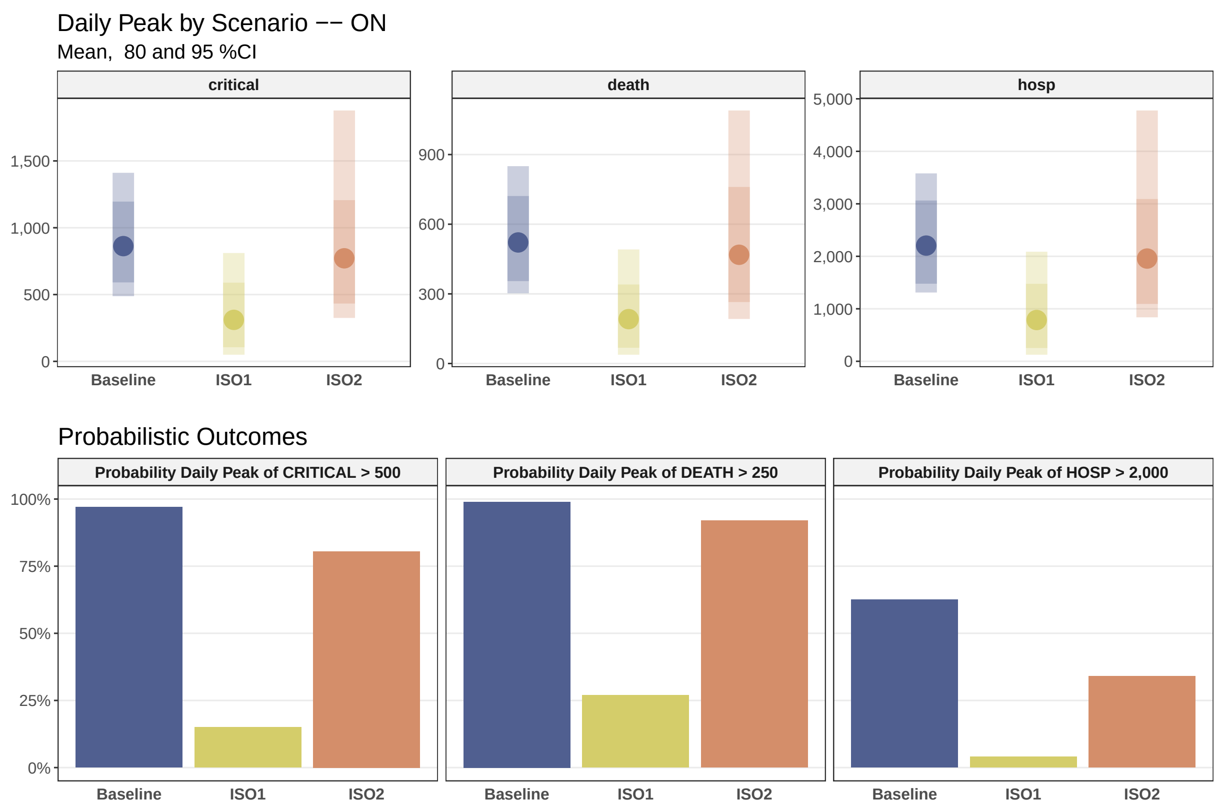



*Figure 5: hosp: hospitalized cases; critical: hospitalized cases in critical care; death: number of deaths.*

## Short-Term Projections

The probability that we will see more confirmed cases next than last week is shown in Figure 6 for each scenario.

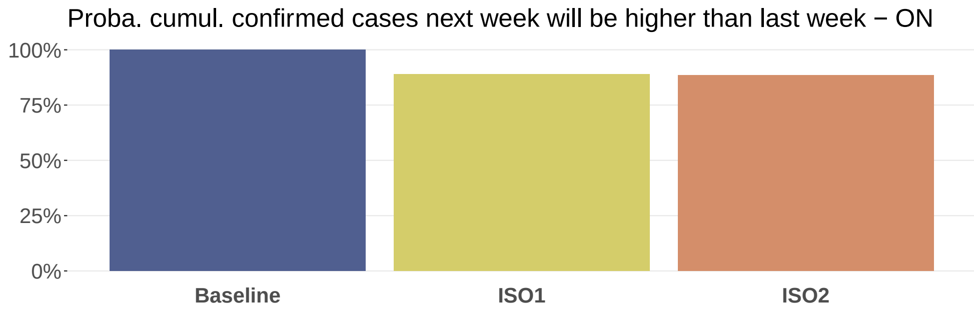



*Figure 6: For each scenario, probability that the cumulative number of confirmed cases for next week will be higher then last week.*

The projections from the Ontario Ministry of Health estimated 1,600 deaths by April 30 under the current social distancing. The mean cumulative number of deaths, as well as the probability that this number will be above 1,600 by April 30, is displayed in the Table below for each scenario. The probability distributions are shown in Figure 7.

| Scenario | Mean | Proba. Cum. Death above 1,600 by April 30 |
|---|---|---|
| BASELINE | 948 | 0 % |
| ISO1 | 614 | 0 % |
| ISO2 | 599 | 0 % |

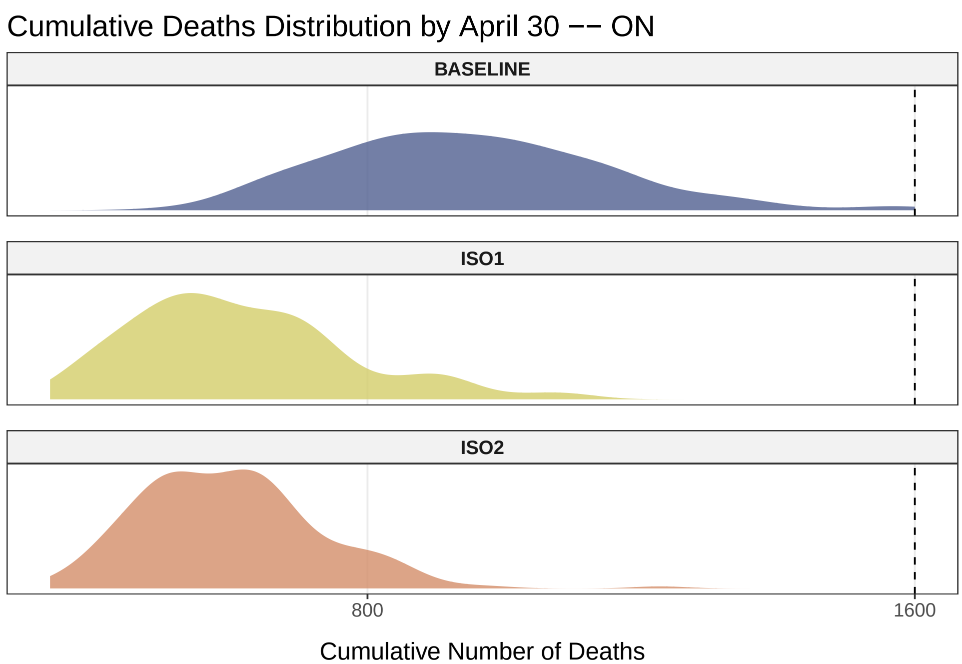



*Figure 7: For each scenario, distribution of the simulated cumulative number of deaths by April 30. The vertical dashed line indicates the Ministry's projection as of April 3rd.*