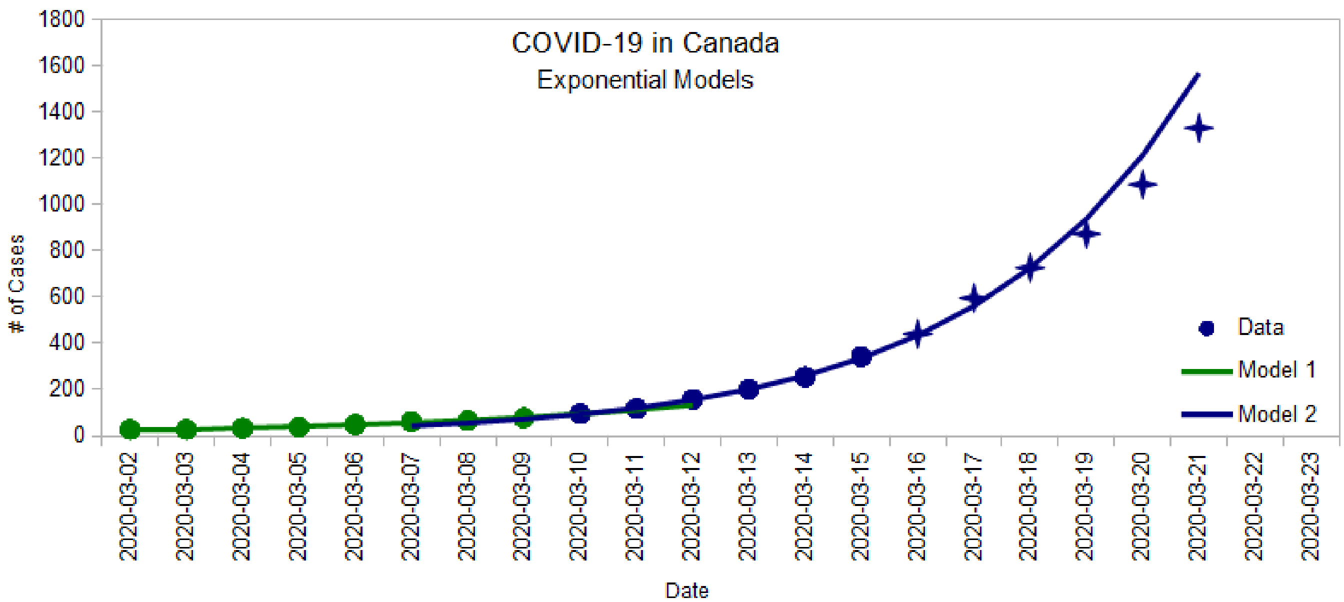
COVID-19 Spread

- I'm not an epidemiologist, doctor, or any kind of expert on the subject. I just look at the numbers.
- The original post was written on March 16. Since then, I've updated the graphs with daily numbers, and added another section at the end.

One of the key messages from today's PM announcement is that things will get worse before they get better. I wanted to have a sense of the rate at which COVID-19 is spreading in Canada, so I made a graph, and did some math.[1)]

First, I got the data from https://www.covid-19canada.com, plotted them on a graph, and tried to use a basic exponential model to extract some key information.

Date	Count	Date	Count	Date	Count
2020-03-01	?	2020-03-08	64	2020-03-15	342
2020-03-02	27	2020-03-09	77	2020-03-16	441[†]
2020-03-03	27	2020-03-10	95	2020-03-17	596[†]
2020-03-04	33	2020-03-11	117	2020-03-18	727[†]
2020-03-05	37	2020-03-12	157	2020-03-19	873[†]
2020-03-06	48	2020-03-13	201	2020-03-20	
2020-03-07	60	2020-03-14	254	2020-03-21	



† Data from March 16 onward has been added to the original model without modifications.

There seems to be two different patterns in this two-week period:

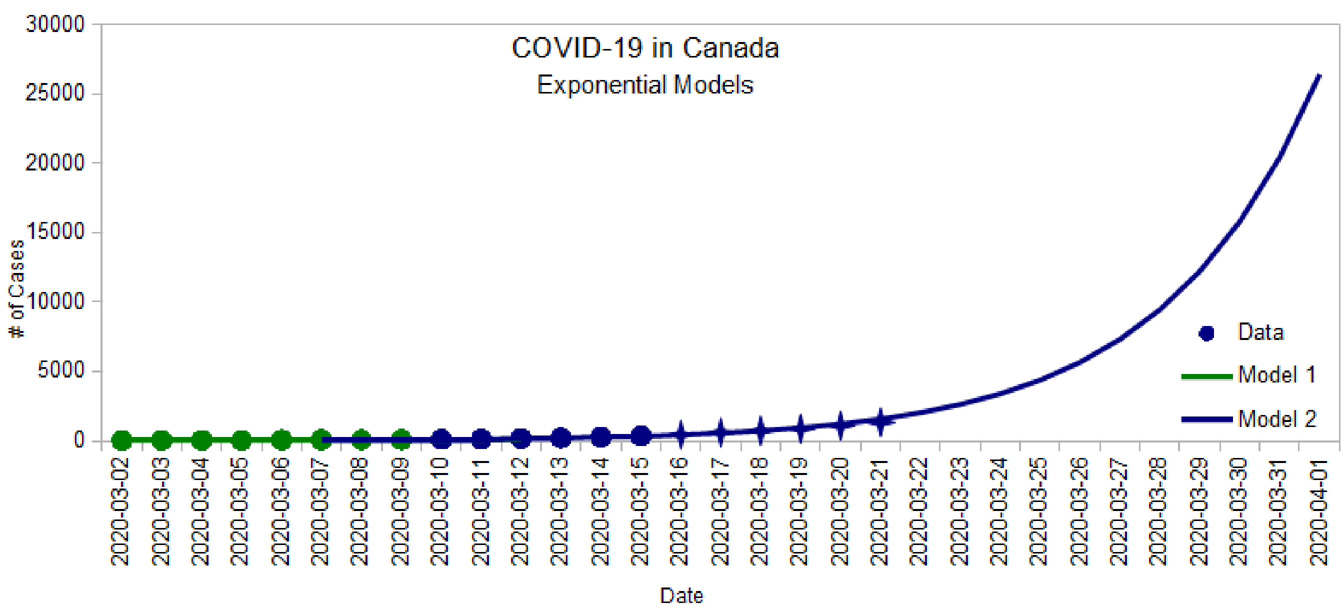
- Between March 2 and March 10 (ish) (green line), the number of cases was **doubling every 4.1 days**.
- But since March 10 (ish) (blue line), the number of cases has been **doubling every 2.7 days**.

The formulae for the exponential curves are:

- $P = 24.5 \times 2^{(\frac{t}{4.1})}$ for the green line (where *t* is the number of days since March 2)
- $P = 93.1 \times 2^{(\frac{t}{2.7})}$ for the blue line (where *t* is the number of days since March 10)

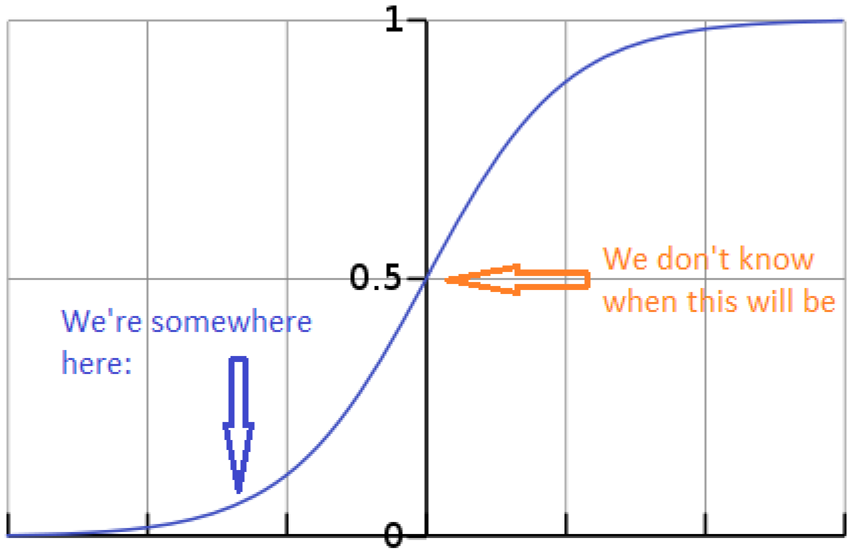
If the blue exponential pattern continues:

- We should have close to 1600 cases by the end of Saturday (from 342 on Sunday)
- A week after that: over 9000 cases
- By the end of April 1: 26,000 cases (similar to Italy today)



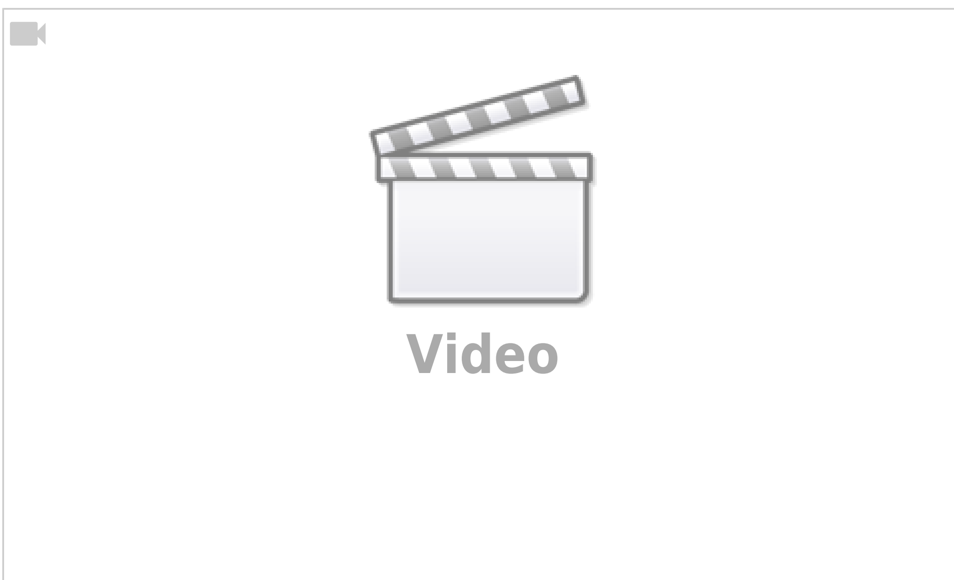
So there's a very real sense in which, if we don't do anything different, we could simply be about 15 days behind Italy…

But doing the right things can change that future. In reality, the spread of the infection follows more of a Logistic Function. At the beginning, it looks like an exponential, but then it flattens out. This is what the news keeps referring to when they say that social distancing and proper hand washing can help “flattening the curve” more quickly.

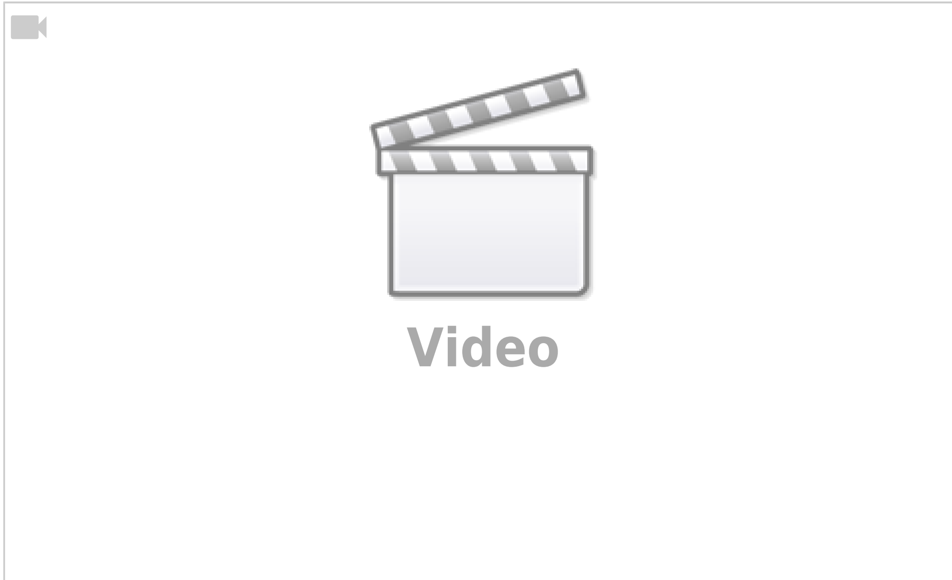


The real question is how soon will we reach that middle point, and at what height.

Here's a good video that explains this sort of math and why being able to think in exponential term is important for non-linear systems such as this one.



And here's another one with different animations that complements it very nicely.

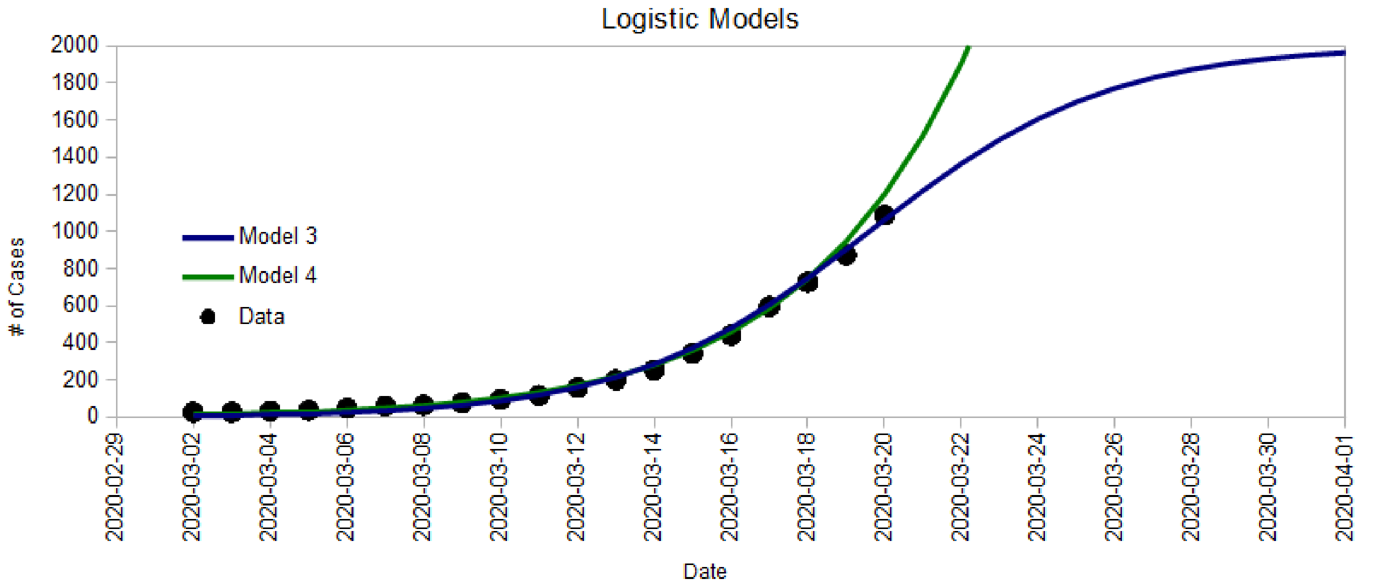


Here's an interesting article from The Washington Post showing basic random simulations for four different cases (free-for-all, attempted quarantine, mild moderate distancing, extensive social distancing).

More on the Logistics Function

This is an update from March 19th.

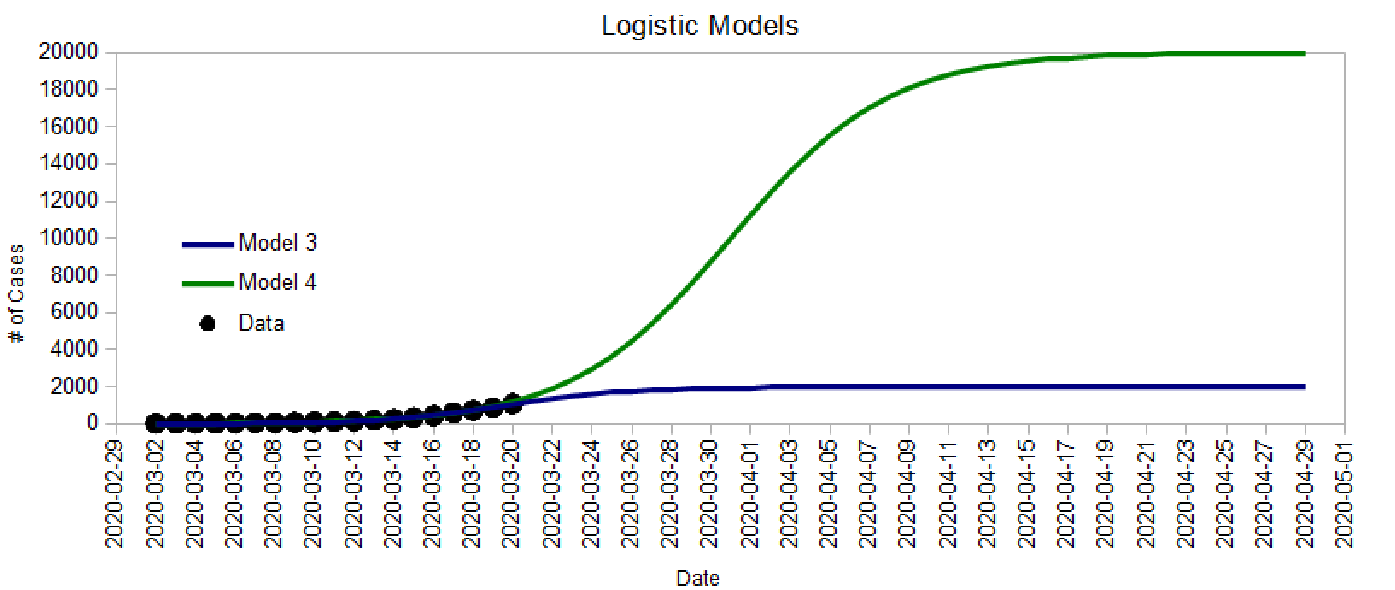
Here, I want to illustrate that even though the infection follows a Logistic Function, that fact alone doesn't help us predict the future in any way. Here are two very different examples that fit the current data pretty well:



The equation "Model 3" is:

$$P = \frac{2000}{1 + e^{-0.32(t - 17.6)}}$$

It reaches its halfway point around March 18 and peaks at 2000 people infected. Unfortunately, "Model 4" fits the data just as well:



Its equation is:

$$P = \frac{20000}{1 + e^{-0.25(t - 29)}}$$

It reaches its halfway point at the end of the month and peaks at 20,000 people.

Reality could be anywhere in between, lower, or even higher. I could have created a curve that fits the data just as well and peaks at 2 million people. The point is that right now, we just don't know. But more importantly, which of these we end up on depends on what we do.

1)
If you like this sort of thing, I did something similar in 2011 about the atmospheric CO_2 levels, and then updated the data seven years later to see how my model stacked up. It might be time for a new update soon...