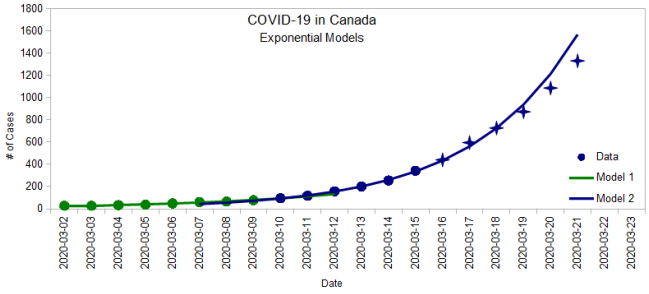
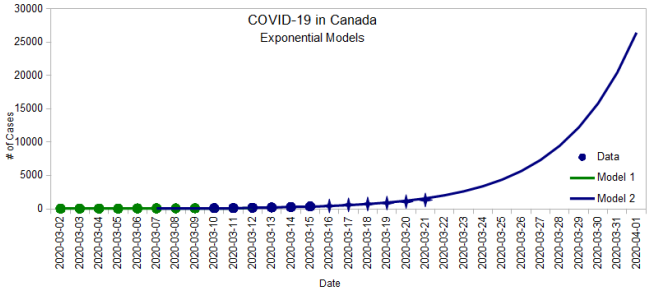
COVID-19 Spread (Part II)

- I'm not an epidemiologist, doctor, or any kind of expert on the subject. I just look at the numbers.
- This was originally written on Sunday March 22nd. Since then, I've updated the numbers and added updates at the end of the post.

In Part I, I built an exponential model using data between March 2 and March 15, then continued to add daily numbers to see how that model tracked:





Initially, the number of cases doubled every 2.7 days, predicting almost 160 cases by the end of Saturday March 21, but since Thursday, the

infection rate seems to have slowed down a bit and we got about 1331 cases instead. This deviation from the exponential model is what I explore below.

Growth Factor

There's a ratio involving three data points that's useful to track how “fast” the exponential grows. It's easier to explain with an example, so suppose we had three days like this:

Day	# of Cases	New Cases	Growth Factor
Day1	100		

- If the **growth factor** > **1**, the number of new cases is itself increasing each day, which means we are still in

Day	# of Cases	New Cases	Growth Factor
Day 2	110	10	2
Day 3	130	20	

the exponential phase.

- If the **growth factor = 1**, then the number of cases is growing at a constant rate (same amount each day). This is the middle of the Logistic Curve (more on that soon).
- If the **growth factor < 1**, then the infection rate is levelling off.

To calculate the growth factor:

- Take the number of new cases from one day to the next (10 new cases from Day 1 to Day 2, 20 new cases from Day 2 to Day 3)
- Then, take the ratio between new cases (20 ÷ 10 = 2)

Here are the number of cases in Canada with the calculated growth factors:

March

Date	# of Cases	New Cases	Growth Factor
2020-03-01	?		
2020-03-02	27		
2020-03-03	27	0	
2020-03-04	33	6	
2020-03-05	37	4	0.67
2020-03-06	48	11	2.75
2020-03-07	60	12	1.09
2020-03-08	64	4	0.33
2020-03-09	77	14	3.25
2020-03-10	95	18	1.38
2020-03-11	117	22	1.22
2020-03-12	157	40	1.82
2020-03-13	201	44	1.10
2020-03-14	254	53	1.20
2020-03-15	342	88	1.66
2020-03-16	441	99	1.33

Date	# of Cases	New Cases	Growth Factor
2020-03-17	596	155	1.57
2020-03-18	727	131	0.85
2020-03-19	873	146	1.11
2020-03-20	1087	214	1.47
2020-03-21	1331	244	1.14
2020-03-22	BC did not report its numbers on March 22.		
2020-03-23	2091	380	1.56
2020-03-24	2792	701	1.84
2020-03-25	3409	617	0.88
2020-03-26	4043	634	1.03
2020-03-27	4757	714	1.13
2020-03-28	5655	898	1.26
2020-03-29	BC did not report its numbers on March 22.		
2020-03-30	7448	897	1.00
2020-03-31	8591	1143	1.27

April

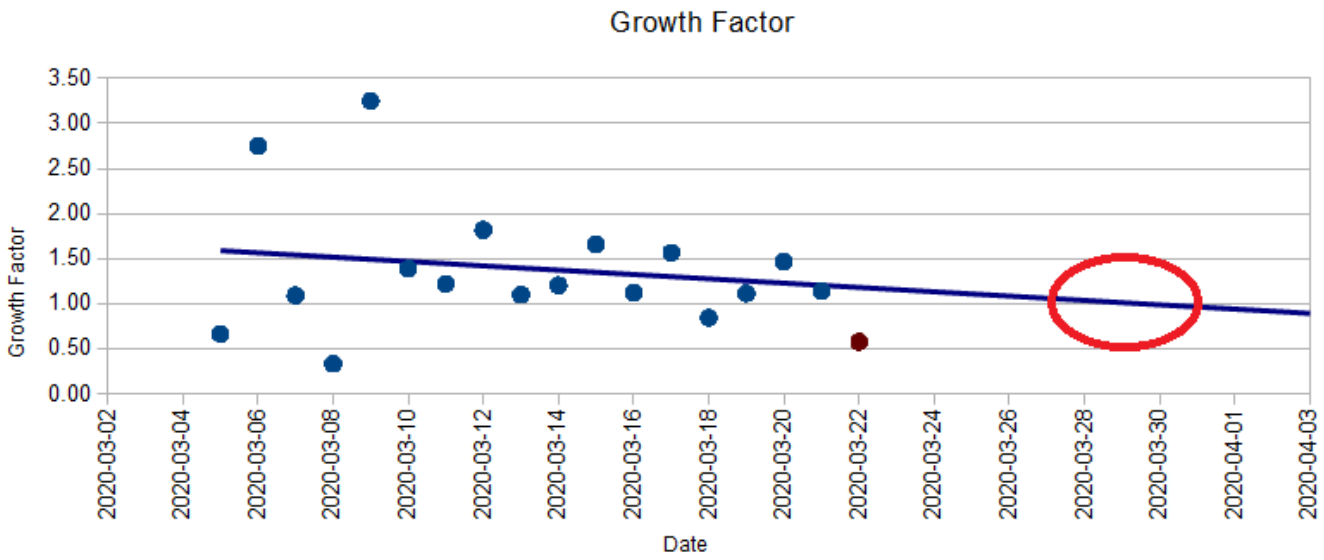
Date	# of Cases	New Cases	Growth Factor
2020-04-01	9730	1139	1.00
2020-04-02	11283	1553	1.36
2020-04-03	12549	1266	0.82

Date	# of Cases	New Cases	Growth Factor

There's a lot of variation in the growth factor because real life is messy. It's also worth keeping in mind that the numbers we see are contingent on how much testing we do. It's easy

to imagine that testing labs are lagging a few days behind and that they'll sometimes be able to report more results one day and less the next.

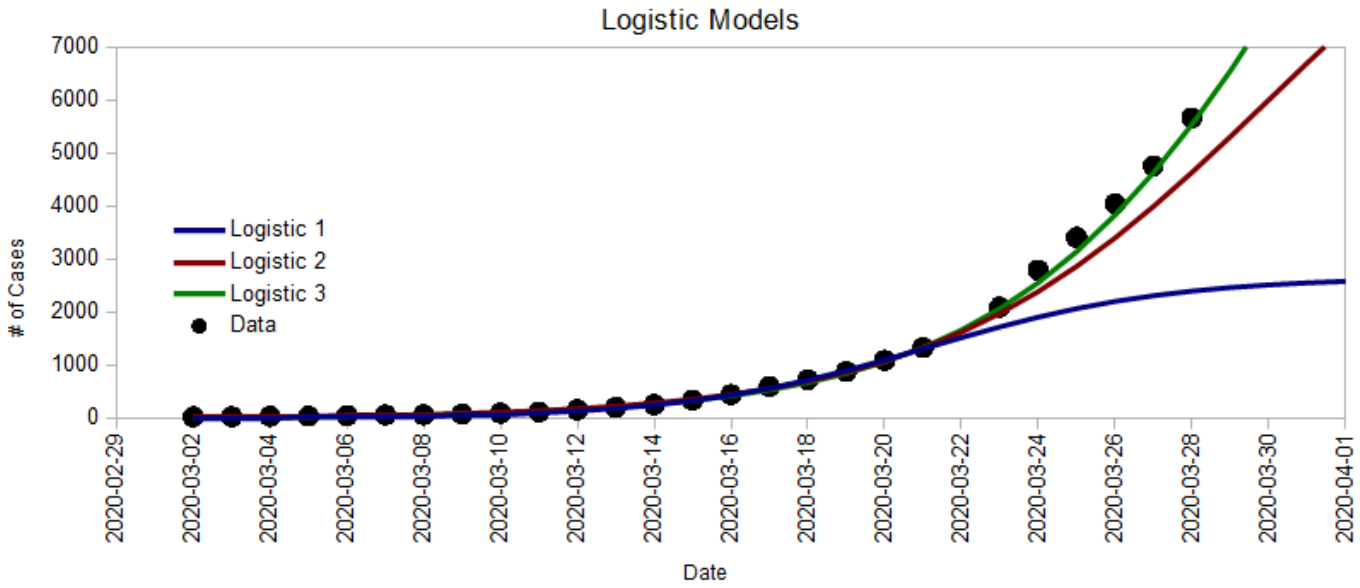
We don't have an accurate picture of the world here so it's hard to make any kind of hard predictions. Nevertheless, as of March 21, there seemed to be a loosely decreasing pattern:

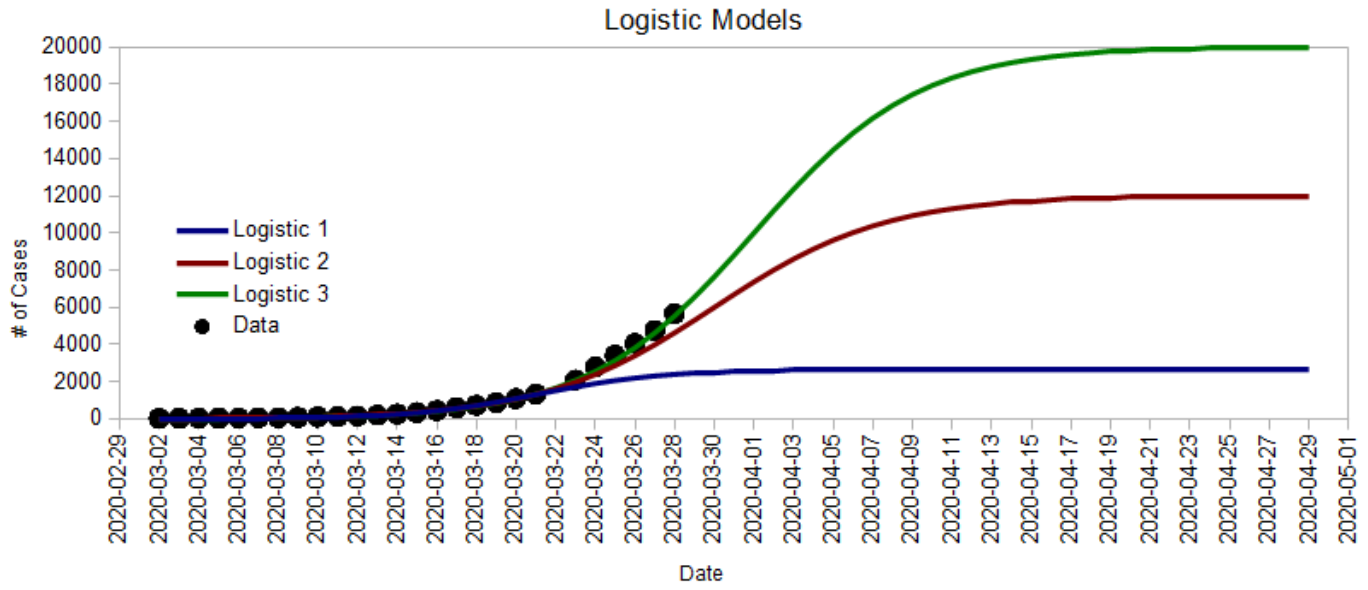


Overall, the growth factor is mostly above 1 (in the exponential phase), but it looks like we might be on track to reach 1 by the end of the month (end of exponential phase). If that's the case, and if we continue to implement measures to slow the down the spread, then we'll be in a better position to estimate the final outcome by the end of the month. Here's why.

The Logistic Curve

In Part I, we saw that very different Logistic Curves can fit the current data, and that there's really no way of knowing which path we're on yet. Here they are again:





- Logistic 1 was the very best case scenario (as of March 22) where the total number will be double of what it is today. This assumes that the growth factor reached 1 yesterday (March 21), which it hasn't. But we're way passed that now.
- Logistic 2 is an optimistic scenario where the total number reaches 12,000 and the growth factor reaches 1 on March 30st.
- Logistic 3 is a very likely scenario where the total number reaches 20,000 and the growth factor reaches 1 on April 1st. This is **not** a worst case scenario. Things could be much worse (look at Italy).

Logistic 1	Logistic 2	Logistic 3
$$N = \frac{2660}{1 + e^{-0.32(t - 21.1)}}$$	$$N = \frac{12000}{1 + e^{-0.232(t - 30)}}$$	$$N = \frac{20000}{1 + e^{-0.24(t - 32)}}$$

Here are a few things to know about the Logistic Curve. In the middle:

- The curve is flat like a straight line, which indicates that the growth rate is constant.
- This means that the growth factor is 1 (by definition)
- It also happens that this is the halfway point in terms of total number of cases.

So once we reach that point, we'll be able to get a better estimate of where we'll end up. Until then, things are still very much in the air.

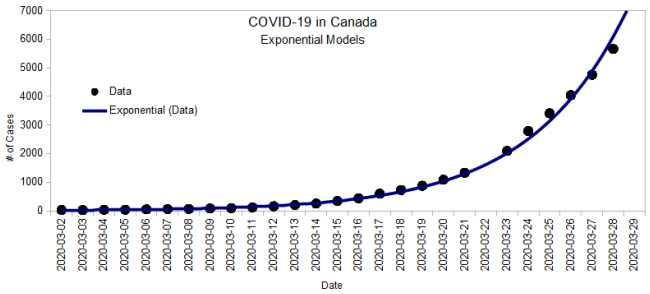
March 28th Update

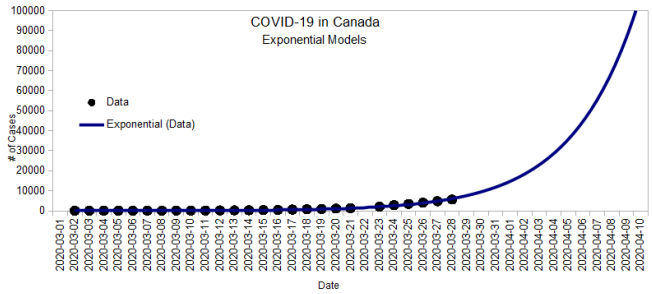
A lot happened this week:

- BC seems to be dropping the ball on testing. Their reported numbers are proportionally much lower than Quebec and Ontario and the messaging is that we might finally be “flattening the curve”. However, it could simply be that we are not testing enough and are way behind on reporting results. On a personal note, I finally got my result yesterday (negative): three weeks after getting tested!

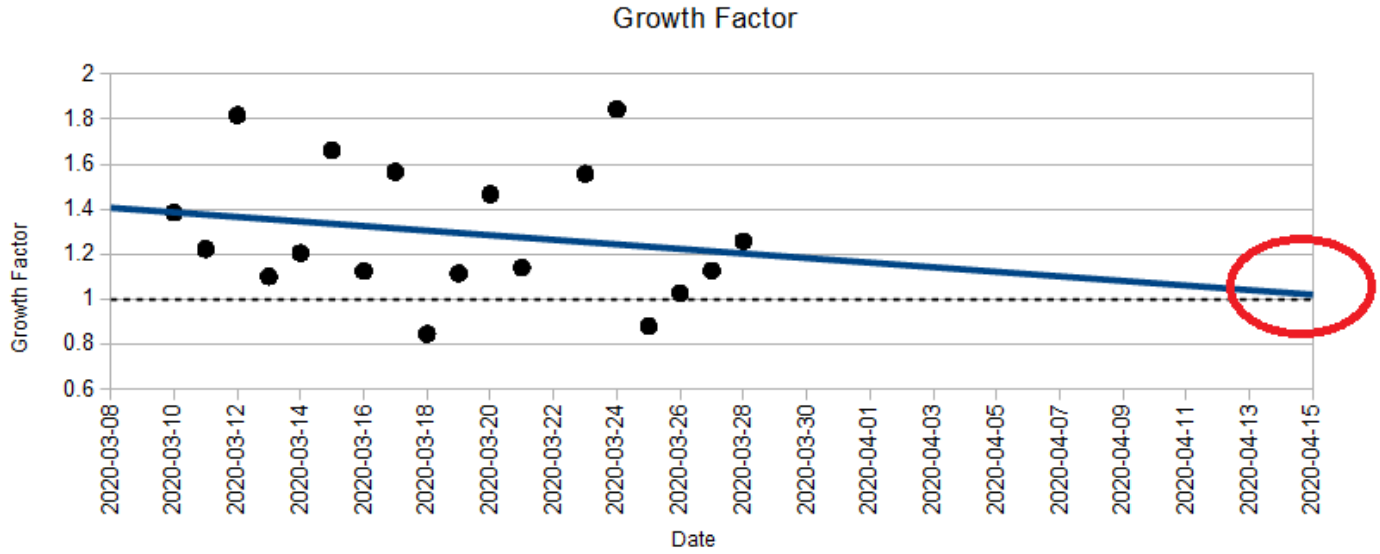
- Quebec went the opposite way, increasing their testing and finding a lot more cases.

Over all, it looks like we are back on the exponential curve with an overall doubling time of 3.1 days:





The Growth Factor also seems to support this as it is barely decreasing.



Over a week ago, back when we only had 342 cases, the model (at the time) predicted we were about two weeks behind Italy (which had 26,000 then).

The updated model (doubling every 3.1 days) predicts that we are about 12 days behind Italy (with now has over 92,000 cases). Whatever we have been doing is either not working or we are not seeing the effects yet.

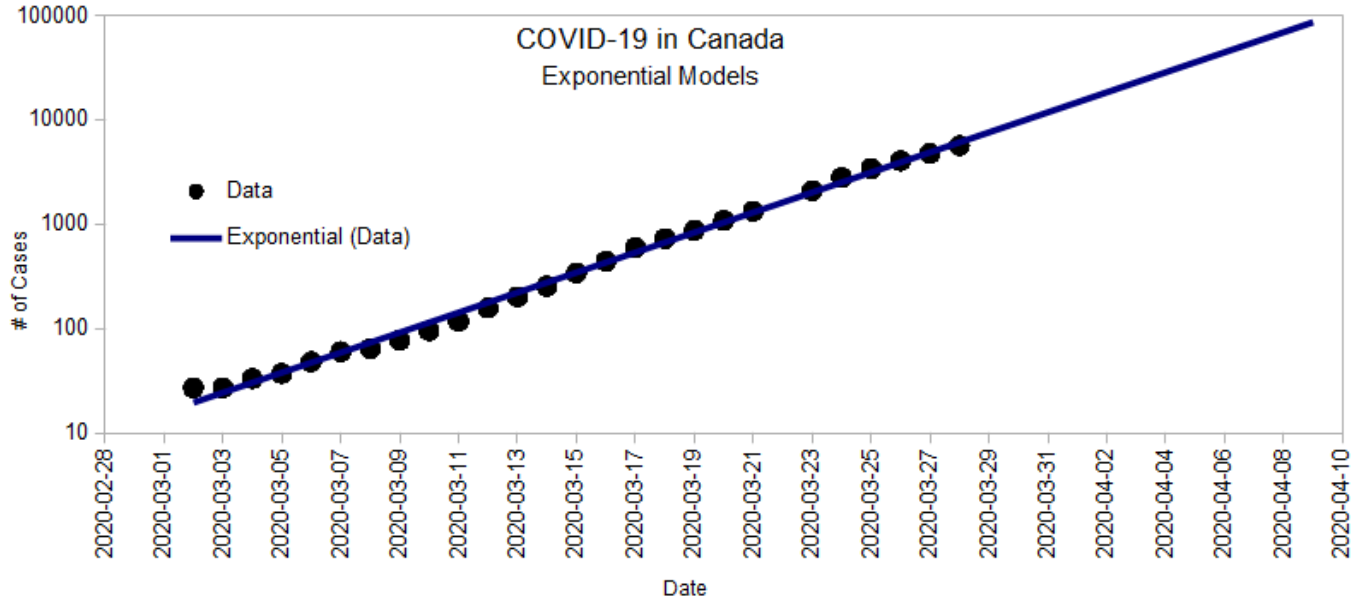
According to the CBC from March 25th:

> “Dix and provincial health officer Dr. Bonnie Henry both said they are optimistic B.C. isn't following the same

path as countries like Italy that have seen their healthcare systems overwhelmed by huge spikes in hospitalizations and deaths."

Country-wide, the numbers disagree. We have about two weeks behind Italy since the beginning of March. Province-wide, the numbers do look better, but it could well be because we are not testing as much as other provinces like Quebec and Ontario. There are no reasons to be optimistic about being on a different path.

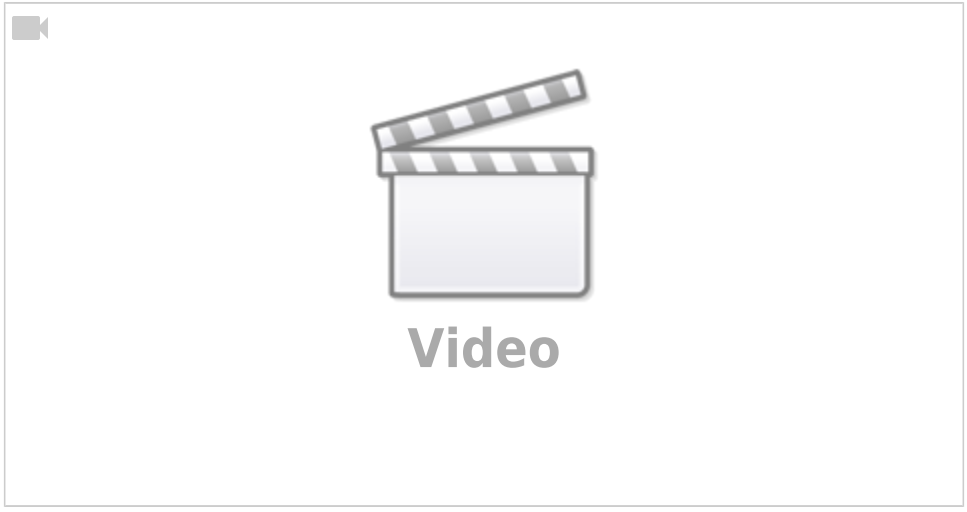
Here's a different way to look at the exponential curve when the number of cases is presented as a multiple of 10 on the vertical axis (called a logarithmic scale):



If we stay on that line, we'll reach 100,000 cases by April 10th!

Cleaning Groceries

Here's a video shared by the Mid Island Radio Group:



Other Models

Compartmental Models are popular such as the SEIR (Susceptible, Exposed, Infected, Recovered) Model. https://en.wikipedia.org/wiki/Compartmental_models_in_epidemiology#The_SEIR_model

Kaggle has a modelling competition which has some good data sets. You need to use a Google ID to access this (I think since Google brought Kaggle a few years ago). https://www.kaggle.com/c/covid19-global-forecasting-week-3