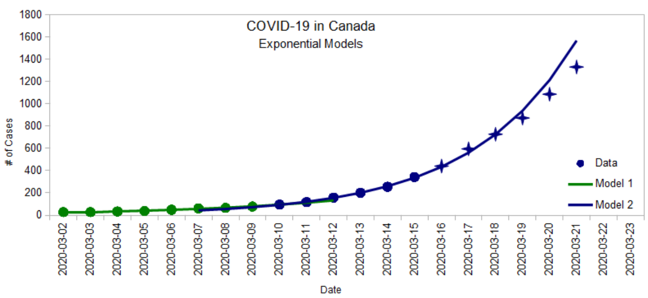
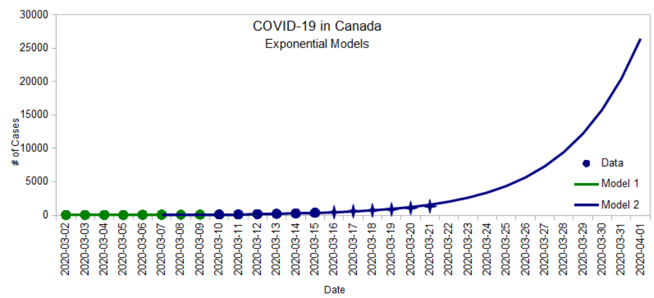
COVID-19 Spread (Part II)

- 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 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.

Day	# of Cases	New Cases	Growth Factor
Day2	110	10	
Day3	130	20	2

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:

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

Date	# of Cases	New Cases	Growth Factor
2020-03-16	441	99	1.33
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[1]			
2020-03-23	2091	380	1.56
2020-03-24	2792	701	1.84
2020-03-25	3409	617	0.88
2020-03-26			
2020-03-27			
2020-03-28			
2020-03-29			
2020-03-30			

There's a lot of variation in the growth factor or because real life is messy. It's also worth kee ping in min d that the num bers we see are cont inge nt on how muc h testi ng we do. It's easy to ima gine that testi ng labs are lagg ing a few day s behi nd and that they 'll som etim es be able to repo rt 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. Never-the-less, 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 is the very best case scenario 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.
- 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 25th Update

A lot happened at the beginning of the week:

- BC seems to be dropping the ball on testing. Their reported numbers are proportionally much lower than Quebec and Ontario, which indicates we are simply not testing enough.
- Quebec went the opposite way, increasing their testing.

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 no longer seems to be 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 15 days behind Italy (with now has over 74,000 cases). Whatever we have been doing is either not working or we are not seeing the effects yet.

According to the CBC:

> “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.”

The numbers disagree. Country-wide, we have consistently been two weeks behind Italy. Province-wide, we are doing less testing than others so the numbers we have are underestimates. There are no reasons to be optimistic about being on a different path. I guess we'll see in a week or two – when it's too late.

[1] BC did not report its numbers on March 22 so I excluded this data point.