# Pandemic dynamics in B.C.: Vaccination, reopening, and Delta variant

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## Introduction

With over 62% of the population vaccinated with the first dose (COVID-19 Tracker Canada[1], 6/6/2021), and cases and hospitalization low, B.C recently announced the reopening plan[2]. However, the Delta variant (B.1.617) has been causing a recent massive surge in India, and a significant current surge in the U.K (Johns Hopkins Coronavirus Resource Center[3]). This surge will soon come to other countries. Indeed, the Delta variant has been present in B.C since the end of April, by BCCDC report.

Therefore, we hope to project the dynamics of the pandemic in B.C when the Delta variant becomes dominant in B.C, together with the vaccination rollout and reopening plan.

In particular, we projected the daily infection cases, hospitalization, and death, for the period from May 25 to September 4.

Disclaimer: Projections have a large amount of uncertainty to them for the next couple of months.

## Key Findings

We expect the infection cases to increase when the Delta variant becomes dominant in mid-July to August.

In June and July, we see the number of projected hospitalization dips. From August, the hospitalization number by the Delta variant starts rising.

The profile of approximately half the hospitalization cases is from younger age groups, which have lower fatality rates. It agrees with the third graph in Figure 2, that the number of daily death is very low.

## Methods

Our model is an age-based SEIR[4] compartmental model (susceptible -> exposed -> infected -> recovered), following Bubar et al[5], and Mulberry et al[6]. The code is altered from Mulberry et al[7], and publicly available on Github.

Where :

$$\dot{S} = \Lambda - \mu S - \beta S \frac{I}{N},$$
$$\dot{E} = \beta S \frac{I}{N} - (\mu + \epsilon) E,$$
$$\dot{I} = \epsilon E - (\gamma + \mu + \alpha) I,$$
$$\dot{R} = \gamma I - \mu R,$$

Λ: Per-capita birth rate.

μ: Per-capita natural death rate.

α: Virus-induced average fatality rate.

β: Probability of disease transmission per contact times the number of contacts per time.

ϵ: Rate of progression from exposed to infectious (the reciprocal is the incubation period).

γ: Recovery rate of infectious individuals (the reciprocal is the infectious period).

Our model includes the concurrent vaccination rollout. We presumed the vaccination rate of Stage 1 at 73000 dose/ day, Stage 2 at 65000 dose/ day, Stage 3 and 4 at 50000 dose/ day. These numbers tentatively factor in vaccine hesitancy, based on U.S vaccination progress[8].

For one dose of Pfizer/ Moderna, we take the vaccine efficacy against symptomatic infection to be ve= 0.33 (Bernal et al[9]) and efficacy against severe symptom to be vp = 0.80 (UK data including the Alpha variant (B.1.1.7), hence we expect the actual efficacy against the Delta to be slightly lower).

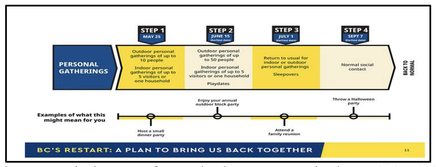
The initial number of infected cases is assumed to be the total of the previous 22 days from May 25th of daily infection cases in B.C, via BCCDC dashboard[10].

Prevalence of the Delta variant is taken as 3% of the initial infection, by BCCDC weekly report[11] on May 27. Notice that genome sequencing takes a week or more, and hence delays the data. Therefore the prevalence would in fact be higher than we assumed.

## Analyses

Data from the UK and India (GISAID) indicate that the Delta variant grows exponentially, and outcompetes other variants until it becomes the dominant variant in cases. From that time, it starts to be affected by social distancing measures. Figure 1 models the exponential growth of the Delta variant in B.C with a constant growth rate R=1.32, extracted from the U.K data. Another simulation with R=1.55, extracted from the India data, is available in our Github repository.

Our model (Figure 2) has 4 phases, corresponding to the first 3 phases of the B.C reopening plan, and the anticipation that by August 1, the Delta variant will have become the dominant variant in B.C.
Phase 1: May 25 to June 15, Phase 2: June 16 to July 1, Phase 3: July 2 to August 1, Phase 3: August 1 to Sept 4.




For the most probable scenario, we chose the transmission rate for each phase, respectively, at: R1= 1, R2 = 1.15, R3= 1.32,
R4 =1.55, basing on the reopening plan and expected dominance of the Delta variant. We also modeled with other likely transmission rate scenarios, with results available at our Github repository.

The transmission rate R is the average number an infected person infects other people.

We interpreted the current transmission rate R =1.32 in the U.K to be of both the Delta and Alpha variants, with the Delta variant outcompeting and becoming dominant, under lockdown conditions similar to those of B.C.
We interpreted the transmission rate in India from the latest surge R=1.55 to be also of both the Delta and Alpha variants, with the Delta variant outcompeting and becoming dominant, under very limited lockdown.

## Results

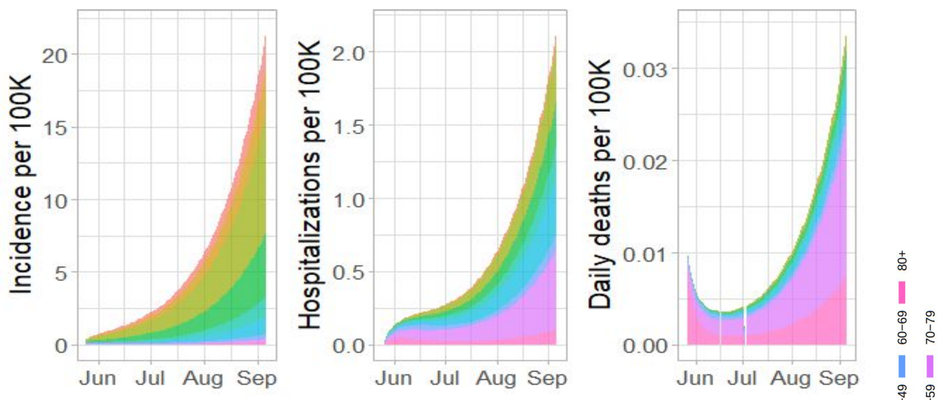



Figure 1: Delta variant growth in BC, R = 1.32

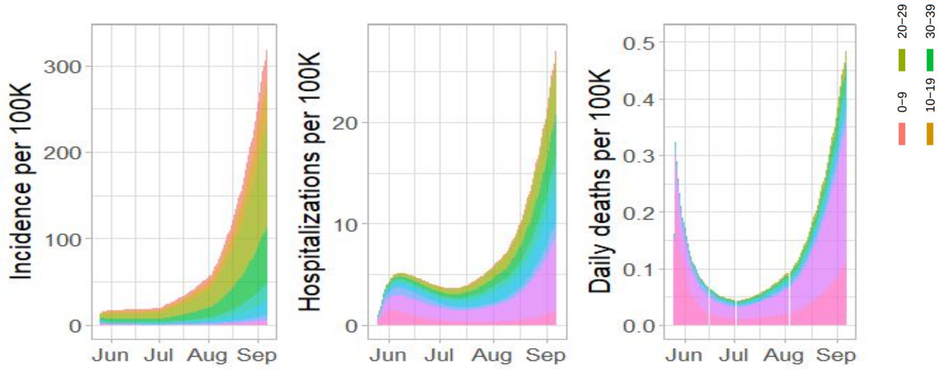



Figure 2: 4-phase BC plan, R1= 1, R2= 1.15, R3= 1.32, R4= 1.55

## Conclusions

Notice in both cases, the number of daily cases exceeds the current rate of 13 people/ 100k daily in mid-July, and becomes dominant at the beginning of August (R=1.55 gives almost ten times the daily hospitalization and death number compared to R=1.32).

It takes until August 1st, for the daily hospitalization to significantly increase to 40 cases per day, due to cases from the Delta variant. Please note that this is based on the hospitalization rate of the 2020 variants data. The Delta variant is estimated to be 20-46% more severe.

The profile of approximately half the hospitalization cases are younger age groups, which have a lower fatality rate. Therefore, this agrees with the observation that the projected number of death is meager.

The majority of projected death cases are still from the older population. This can either comes from the unvaccinated group due to vaccine hesitancy, or the vaccine efficacy of one dose is only 80% and not 100% [12].

These optimistic numbers are due to the effect of vaccination. Therefore, we should keep vaccinating the population with one dose. Also we should prioritize the older population in rolling out the second dose.

Request for future data: daily age-stratified hospitalization, ICU, and death data for B.C (and other countries). This would help bring better projections.

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