# COVID Model Projections

July 28, 2021

BC COVID-19 Modelling Group

About BC COVID-19 Modelling Group

The BC COVID-19 Modelling Group works on rapid response modelling of the COVID-19 pandemic, with a special focus on British Columbia and Canada.

The interdisciplinary Group was convened by Caroline Colijn (SFU) and Dan Coombs (UBC) with support from the Pacific Institute for the Mathematical Sciences.

https://bccovid-19group.ca
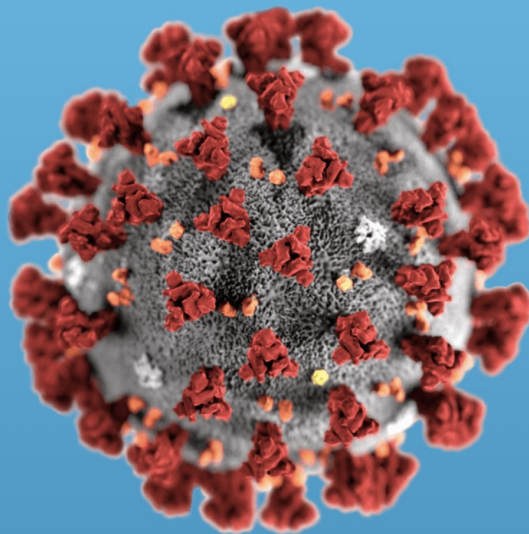
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*Independent and freely offered advice,
using a diversity of modelling approaches.*
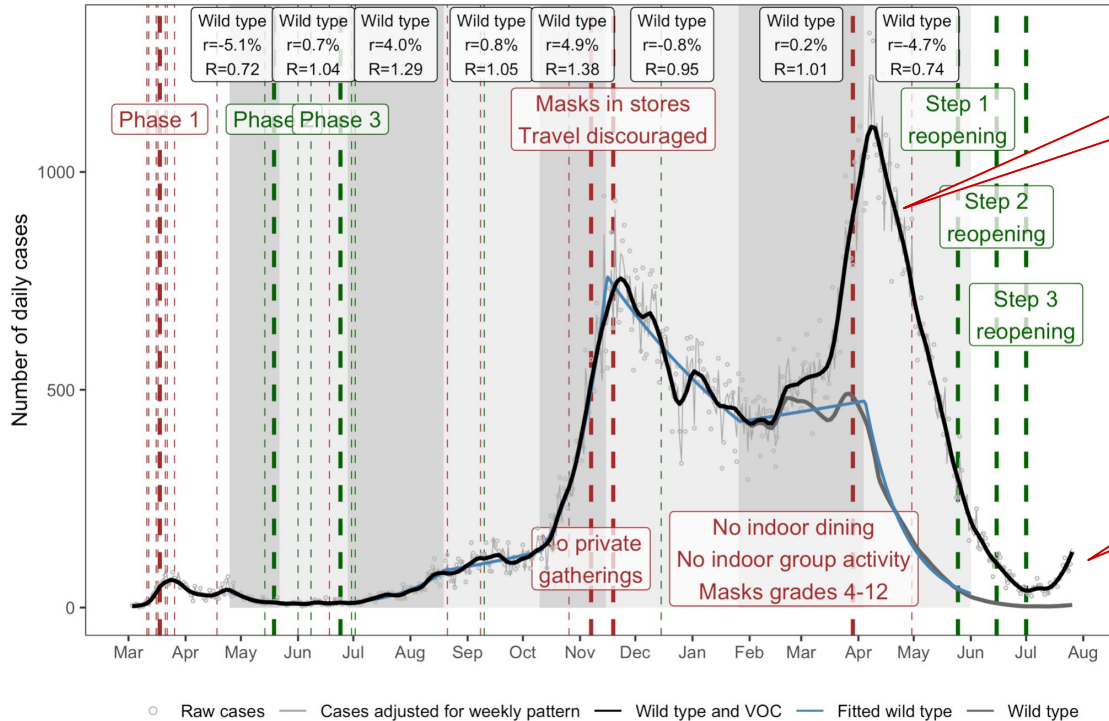
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BC: Early signs of growth

Key messages

- COVID-19 cases are now rising in British Columbia as a whole, and most concerningly, in the Interior Health region.
- There are signs that we may be entering a rapid growth phase, and case numbers need to be watched carefully.
- Delta (B.1.617.2) continues to rise in frequency relative to other variants.
- Communities with lower vaccination rates are seeing five times as many cases as those with higher levels of vaccination.
- First dose vaccination rates are inching up slowly, by about 1% per week.
- Vaccinated individuals can still catch and transmit the virus, although their risk of doing so is about ten times lower.
- Increasing evidence shows that COVID-19 cases are often asymptomatic among vaccinated individuals, making the source of a COVID-19 infection increasingly hard to determine.

State of the COVID-19 Pandemic in BC

Covid-19 daily new cases in British Columbia (up to Mon Jul 26)
Timeline of **closure** and **reopening** events

| Wild type r=-5.1% R=0.72 | Wild type r=0.7% R=1.04 | Wild type r=4.0% R=1.29 | Wild type r=0.8% R=1.05 | Wild type r=4.9% R=1.38 | Wild type r=-0.8% R=0.95 | Wild type r=0.2% R=1.01 | Wild type r=-4.7% R=0.74 |

Phase 1   Phase   Phase 3

Masks in stores
Travel discouraged

Step 1 reopening

Step 2 reopening

Step 3 reopening

April 2021: BC bent down the COVID-19 curve following March 30 "circuit breaker"

Cases are showing clear growth after Step 3 reopening. The exact nature of the growth is unclear because of inadequate data on VOC, in particular Delta.

No private gatherings

No indoor dining
No indoor group activity
Masks grades 4-12

Number of daily cases

1000

500

0

Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

○ Raw cases — Cases adjusted for weekly pattern — Wild type and VOC — Fitted wild type — Wild type

MountainMath, Data: BCCDC

COVID-19 is now spreading rapidly in BC, echoing growth of Delta in other regions.

Source (J. von Bergmann) Case data from BC COVID-19 Database (http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data). Vertical lines give dates of public health measures (major as thick lines, minor as thin lines). Grey dots are raw case counts, grey lines is cases abused for weekly pattern, black STL trend line and blue fitted periods of constant exponential growth.

State of the COVID-19 Pandemic in BC

Covid-19 daily new cases in British Columbia (up to Mon Jul 26)

Timeline of **closure** and **reopening** events
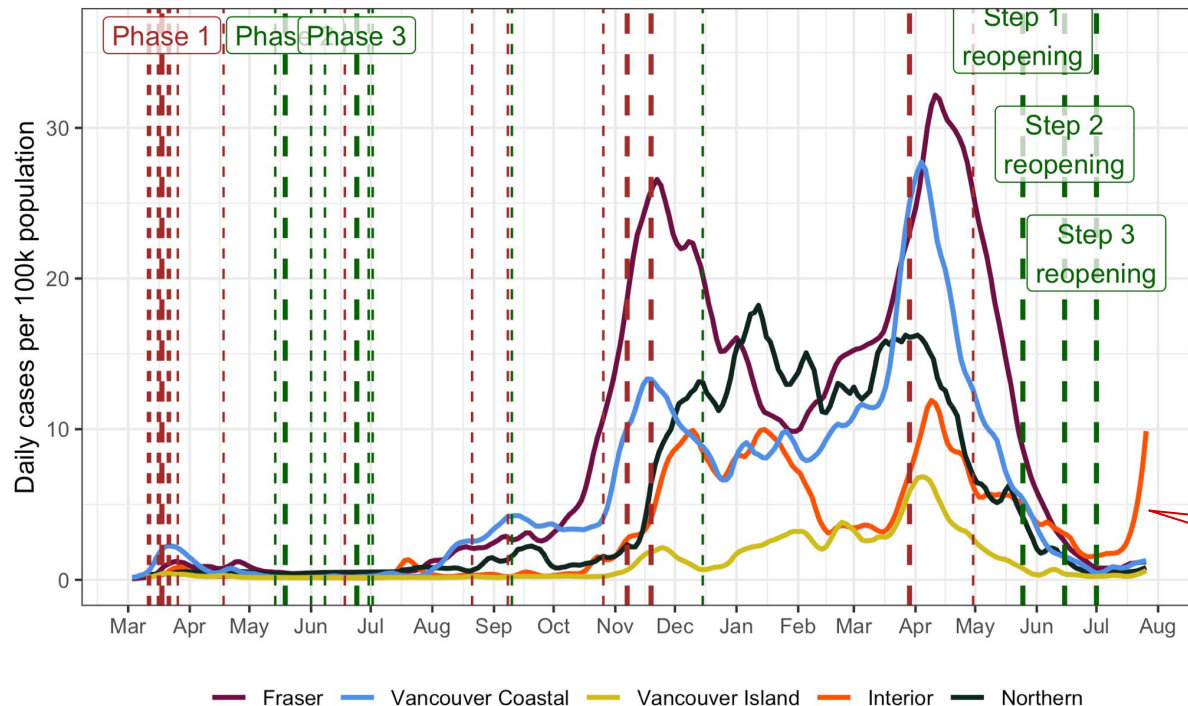
First-dose vaccination % of total population:
Interior Health: 65.2%
Northern Health: 57.4%
Fraser Health: 69.4%
Vancouver Coastal: 79.9%
BC: 72.0%

Health Authorities are not equally protected by vaccination

Recent rise in case numbers is primarily in Interior Health Authority
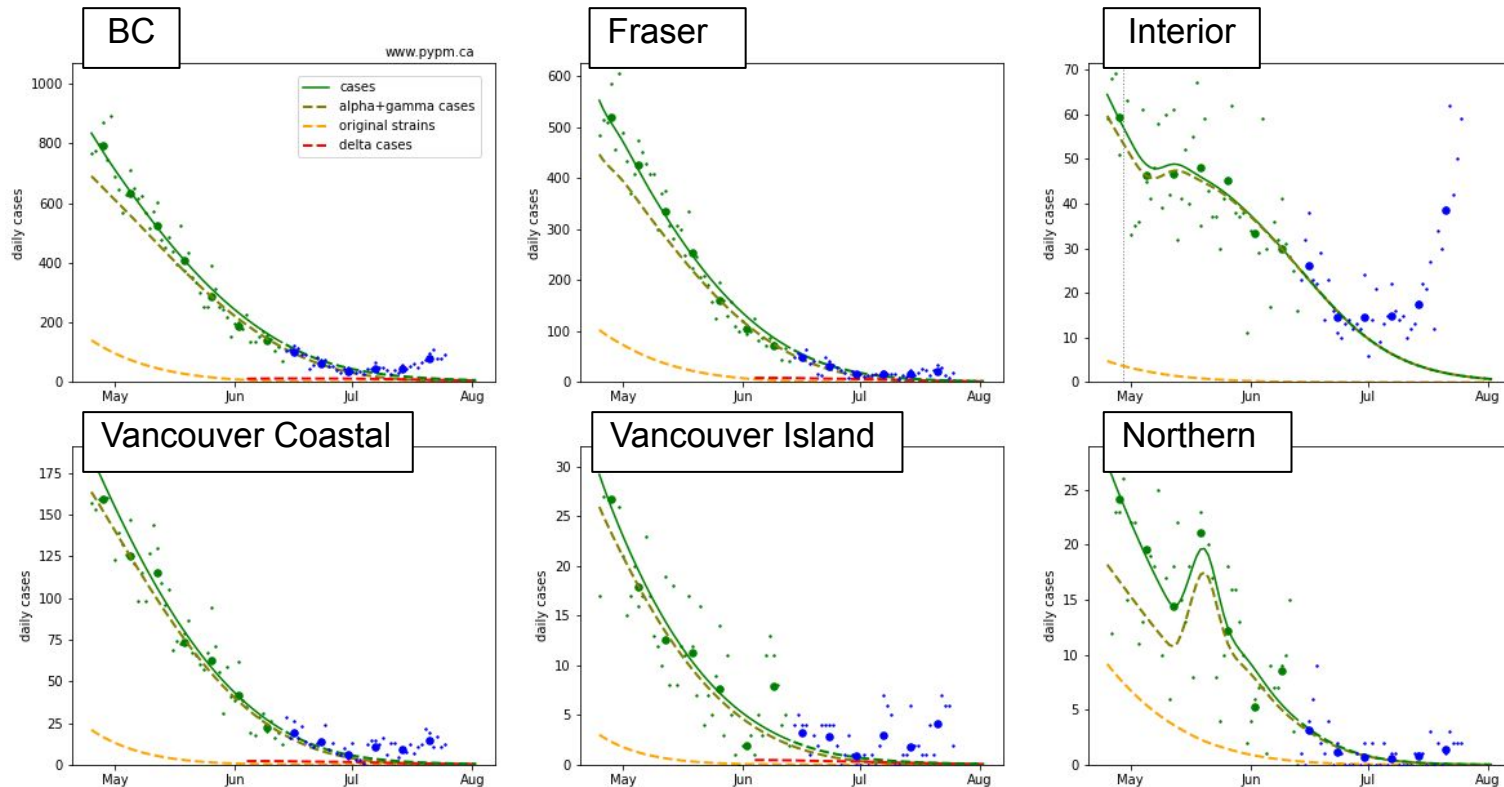
MountainMath, Data: BCCDC, BC Stats

Source (J. von Bergmann) Case data from BC COVID-19 Database (http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data). Vertical lines give dates of public health measures (major as thick lines, minor as thin lines). Grey dots are raw case counts, grey lines is cases abused for weekly pattern, black STL trend line and blue fitted periods of constant exponential growth. Vaccination % by Health Authority from the BCCDC Dashboard, with BC population projections.

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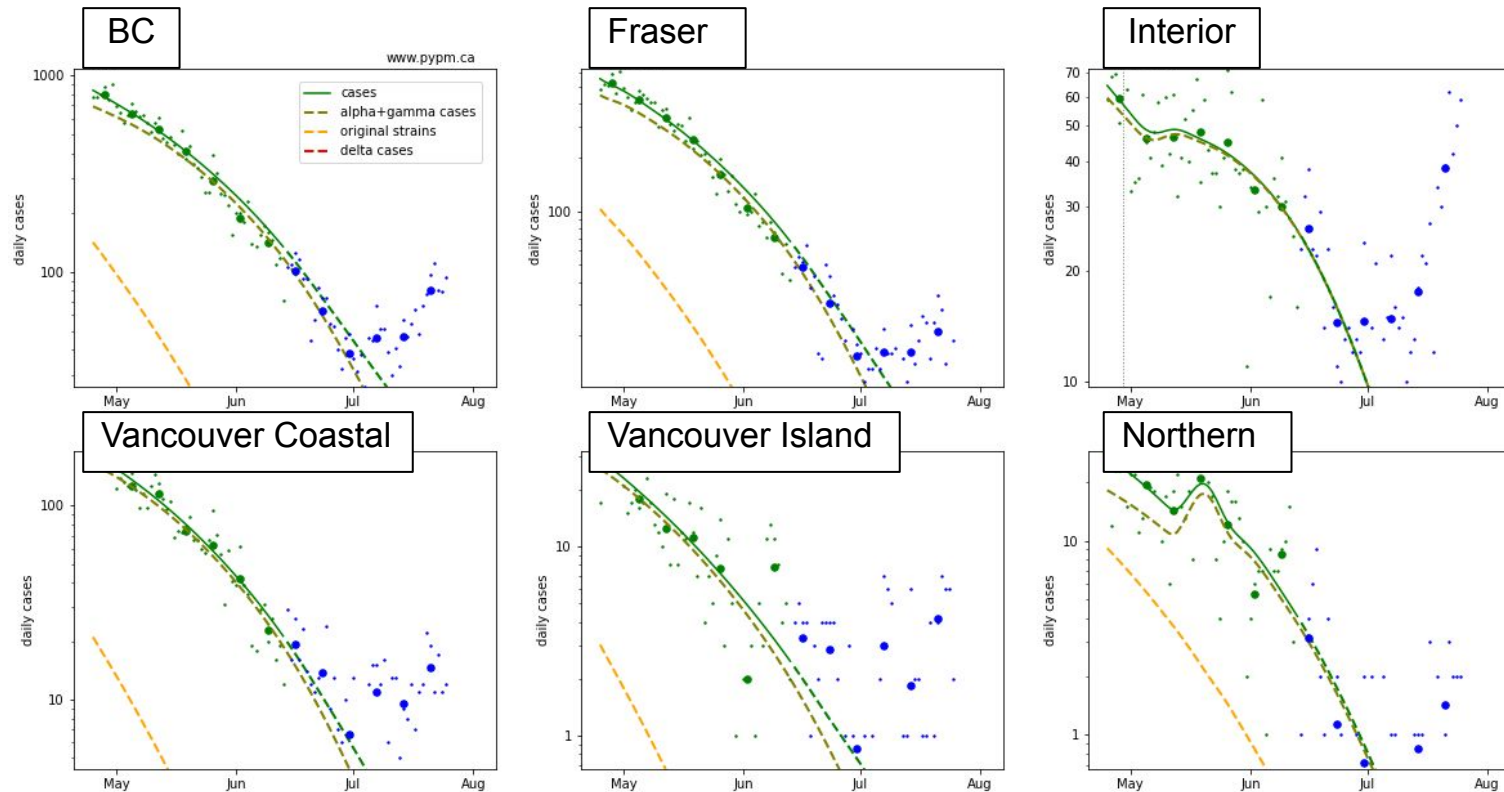# Case data by Health Authority: June 16 model fit
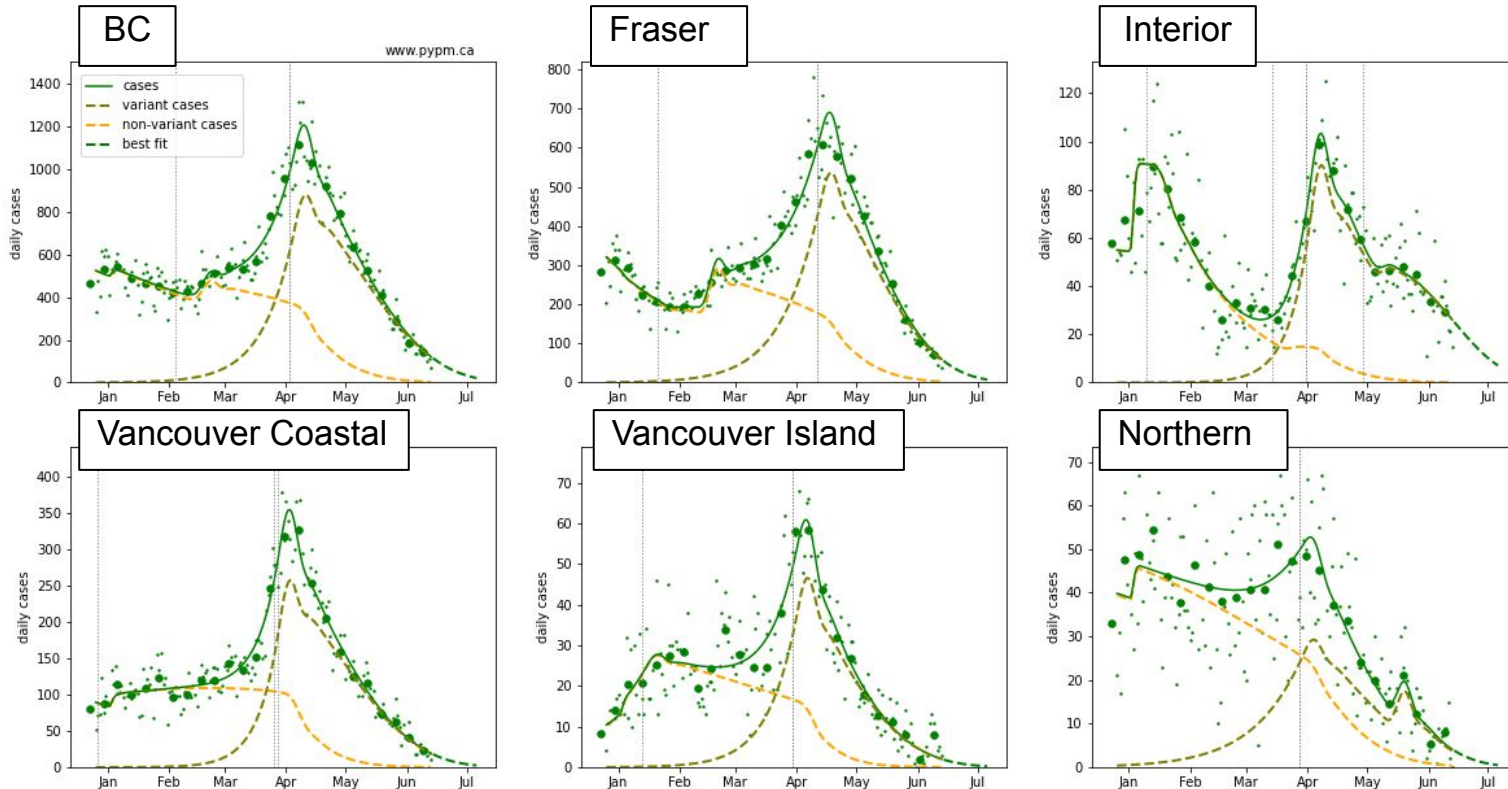
June 16 model fit, showing recent data

Soon after Step 3 of reopening (July 1), case rates began to rise above June 16 model projections.

Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits include past vaccination schedule. Assumes 1st+2nd dose effectiveness rises over time to 90% (see May 14 report for details). Vaccination model benchmarked with data from Israel: see link. Assumes transmission rates are constant May-August.

June 16 model fit, showing recent data (log scale)

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Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits include past vaccination schedule. Assumes 1st+2nd dose effectiveness rises over time to 90% (see May 14 report for details). Vaccination model benchmarked with data from Israel: see link. Assumes transmission rates are constant May-August.
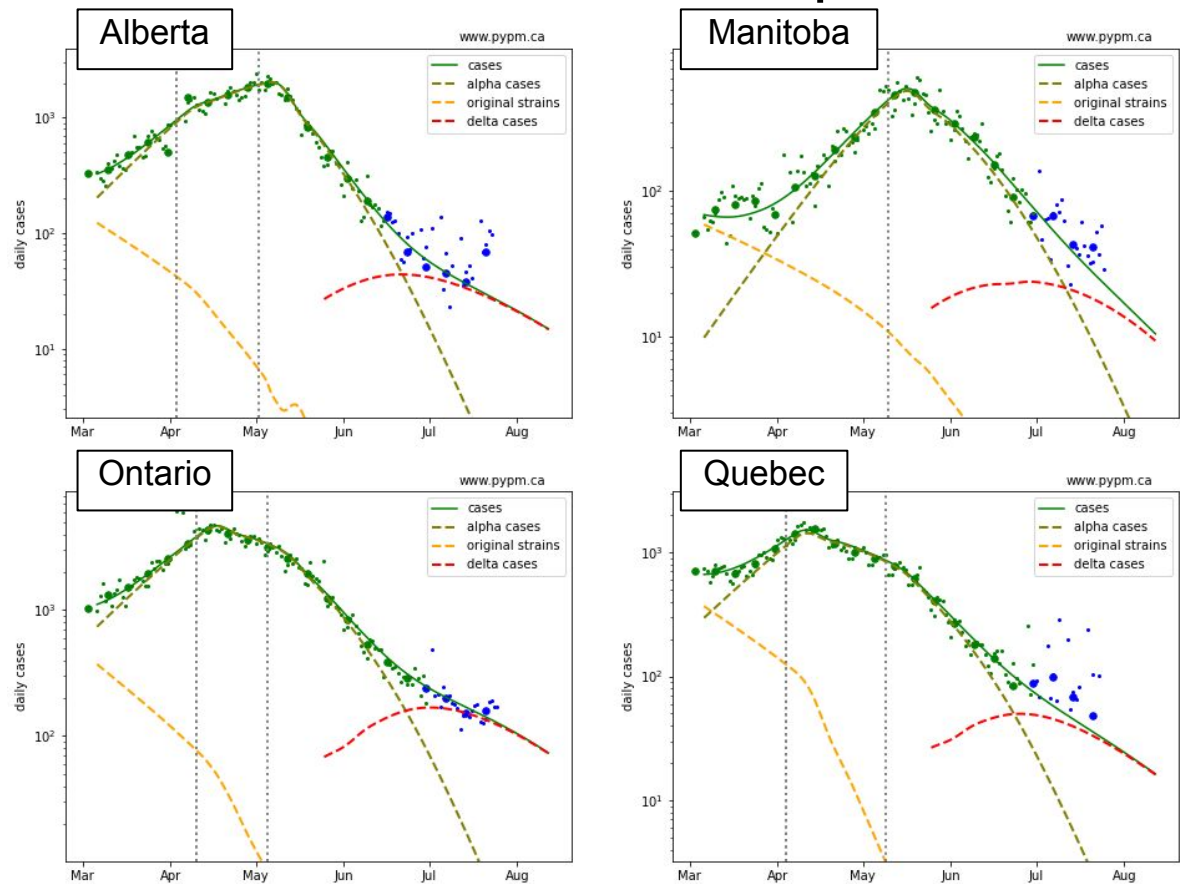
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Earlier model fits for other provinces, showing recent data
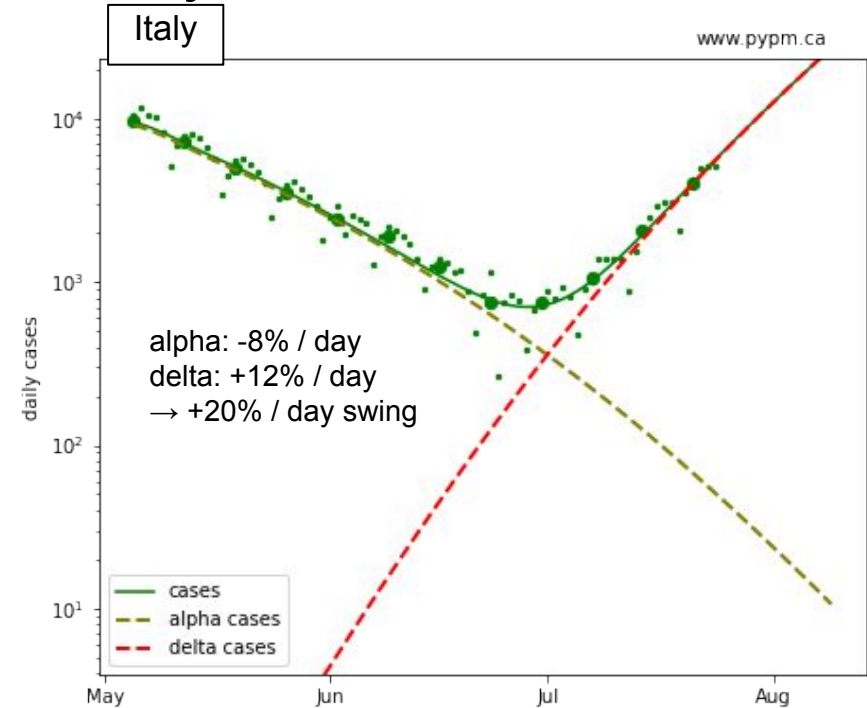

Recent data are compared to earlier model projections for 4 provinces.

The decline in case rates agree with the projections from a month earlier, with the exception of Alberta, where a significant uptick in case rate is seen in the past week.

Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits include past vaccination schedule.

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Example of current rapid growth: Italy

alpha: -8% / day
delta: +12% / day
→ +20% / day swing

Source (D. Karlen). See www.pypm.ca for model fits to US state and EU nation case data. These models have no age structure. Fits include past vaccination schedules.
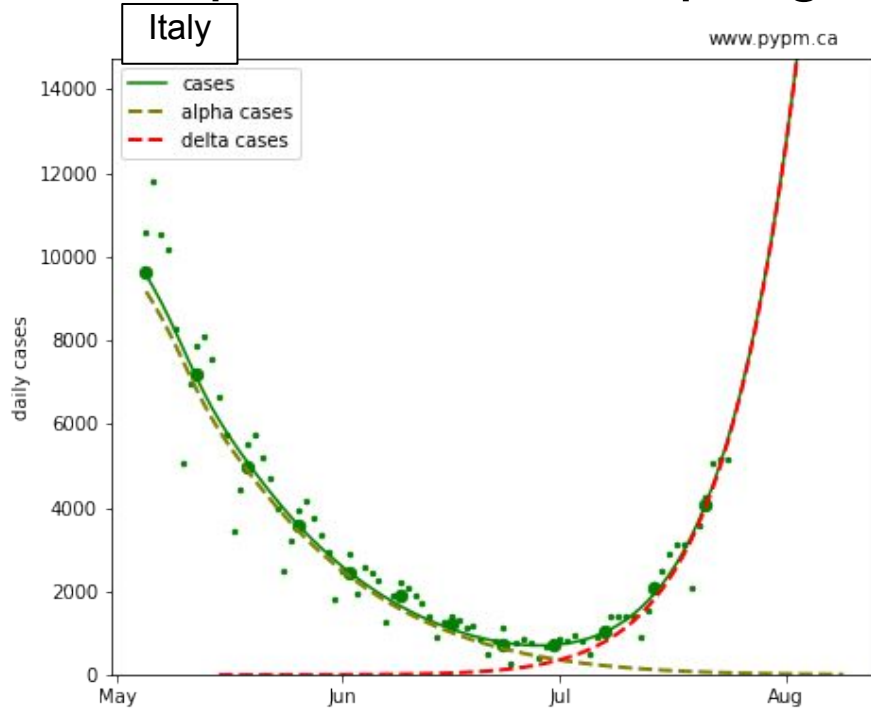
Model fits with recent BC data

BC

cases
alpha+gamma cases
delta cases

www.pypm.ca

alpha+gamma: -9% / day
delta: +9% / day
→ +18% / day swing

Fraser

alpha+gamma: -11% / day
delta: +8% / day
→ +19% / day swing

Interior

alpha+gamma: -8% / day
delta: +12% / day
→ +20% / day swing

Vancouver Coastal

alpha+gamma: -11% / day
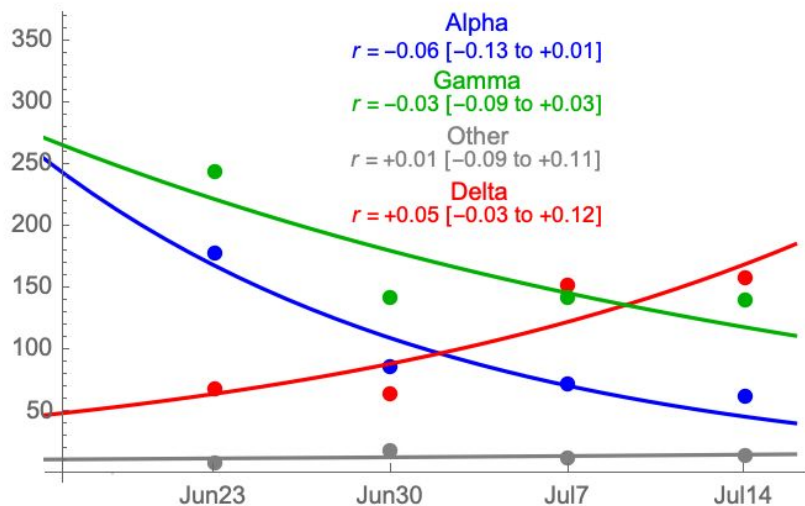delta: +6% / day
→ +17% /day swing
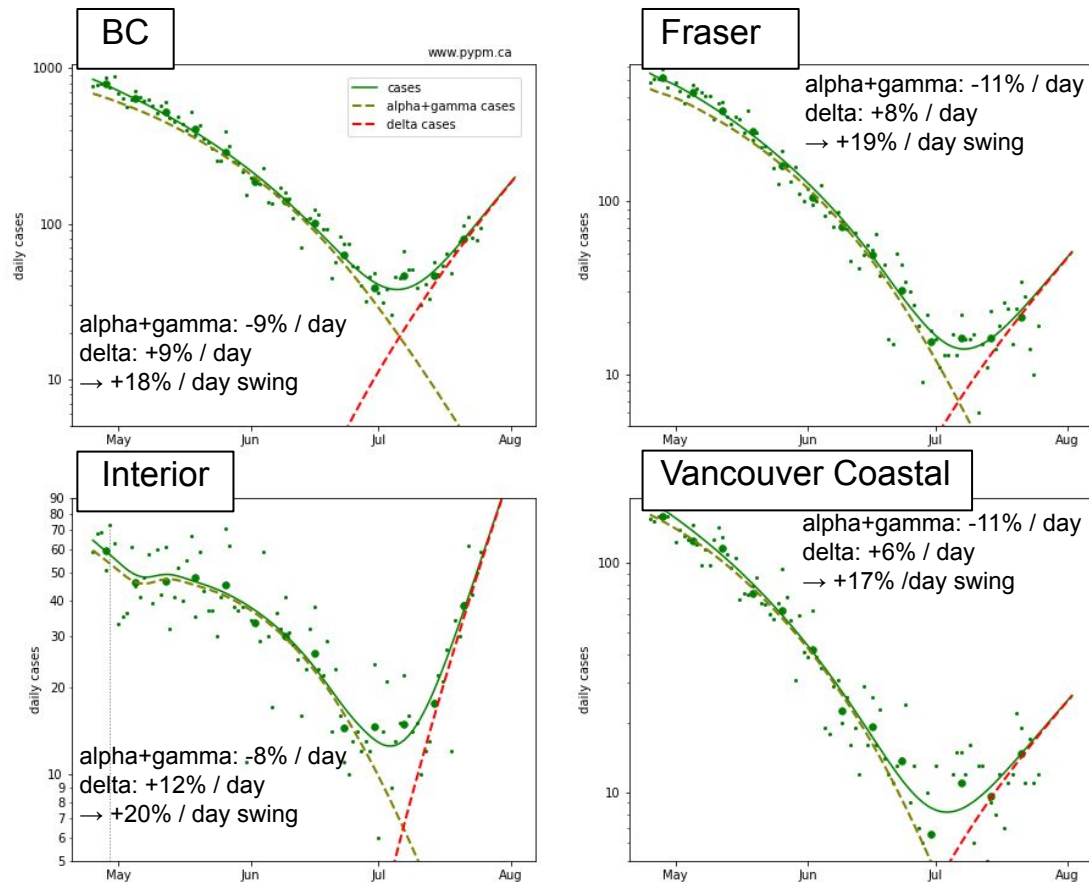
BC data fits are consistent with the pattern seen in Europe and US states, where the combination of relaxation and the emergence of delta has produced large swings in daily growth rates.

The proportion of cases due to delta may differ from these fits since the fits assume constant behaviour.

Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits include past vaccination schedule.
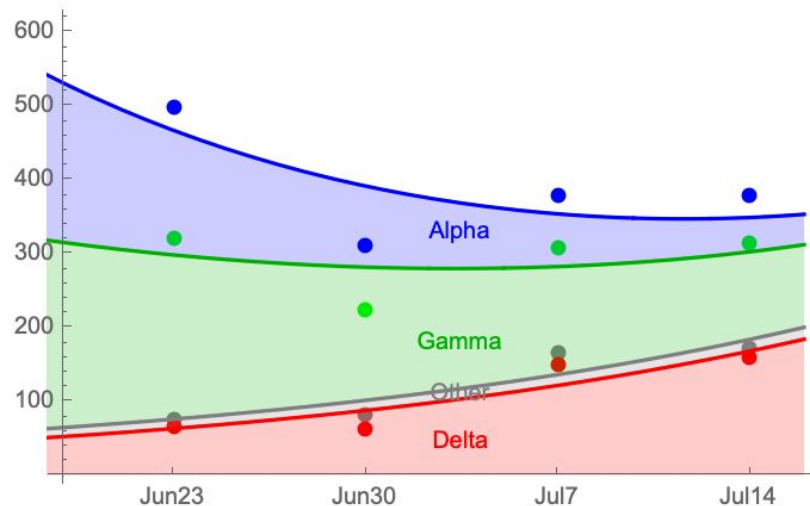
Variants in BC

Besides Delta, COVID-19 variants have declined substantially over the past month
(shown separately on the left and added together on the right),
but Delta cases are rising.

Number of variant cases

Alpha
$r = -0.06$ [−0.13 to +0.01]
Gamma
$r = -0.03$ [−0.09 to +0.03]
Other
$r = +0.01$ [−0.09 to +0.11]
Delta
$r = +0.05$ [−0.03 to +0.12]

New weekly cases

Alpha
Gamma
Other
Delta

Source (S. Otto). Number of cases per week from Figure 2 of BCCDC's July 23 Variant report. Uses total case numbers for each epiweek (mid-date of epiweek shown on x axis) and multiplies by the "Sample prevalence VOCs" to estimate number of each variant in each week. An exponential model fit is used to estimate average daily growth rate, r. 13
Estimates of growth r are highly uncertain with so few data points [95% CI in square brackets] & may be biased downwards because recent points report only "partial" VOC data.
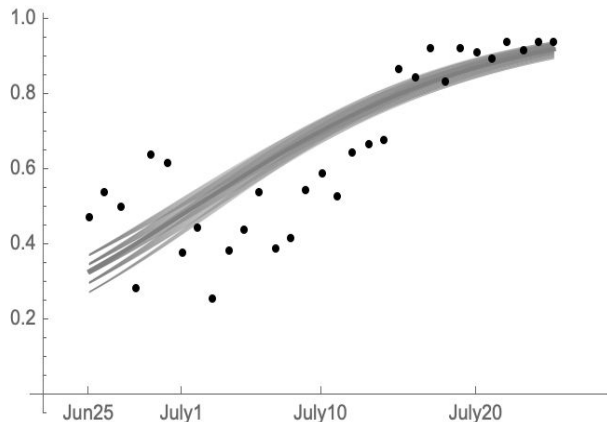
Delta trends in Alberta

Delta is now the most common Variant of Concern in Alberta (left), making up 94% of the variants and 71% of all cases (projections for July 28th). The seven-day average case number has recently risen above 100, after a month averaging <60 cases per day (right). Delta cases have recently risen rapidly (blue), underlying the rise in overall case numbers.

Daily selective advantage of Delta
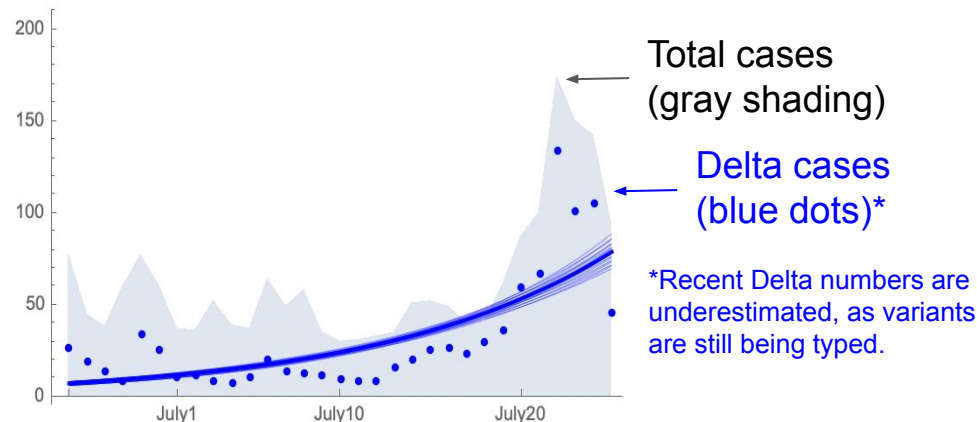*s* = 0.105 {95% CI: 0.091–0.119}

Daily growth rate of Delta
r = +0.078 {95%CI: 0.070–0.085}

Total cases
(gray shading)

Delta cases
(blue dots)*

*Recent Delta numbers are underestimated, as variants are still being typed.

Source (S. Otto). Data from source file https://www.alberta.ca/stats/covid-19-alberta-statistics.htm#variants-of-concern (accessed July 26, using data through July 25).
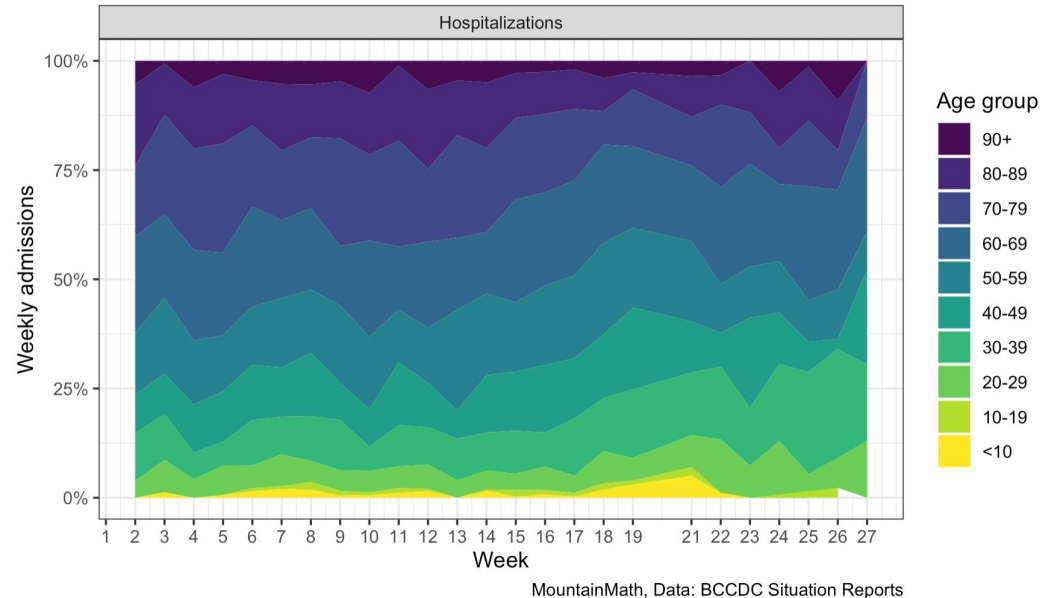Uses a maximum likelihood approach, with binomial sampling among VOC to estimate *s* for Delta relative to other VOC (mainly Alpha) and with Poisson sampling to estimate *r* for Delta. Curves are fits within the 95% CI for *s* and initial proportion (left) or for *r* and initial number (right). *r* and *s* change over time and their averages shown.

Who is at risk?

High rates of vaccination among the elderly are protecting them from hospitalization.
People under 50 now make up the majority of COVID-19 patients in hospital.
(<25% of hospitalized patients were under 50 years old early in 2021 but that has risen to >50% recently)

The number of people in hospital and ICU is currently very low in BC, at the lowest levels observed since September 2020.

If we see consistently rising case counts, however, we expect hospitalized patients will be largely younger and less vaccinated patients, in line with experiences in other countries.

MountainMath, Data: BCCDC Situation Reports

Source (J. von Bergmann) Age-based hospitalization data taken from the Situation reports in the BC COVID-19 Database
(http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data).

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What are the projected hospital numbers?

If cases continue to rise, hospitalization and ICU are expected to follow suit with a short delay. More people are in the hospital now than current case numbers predict, potentially due to long-term hospitalizations and underreporting of cases.
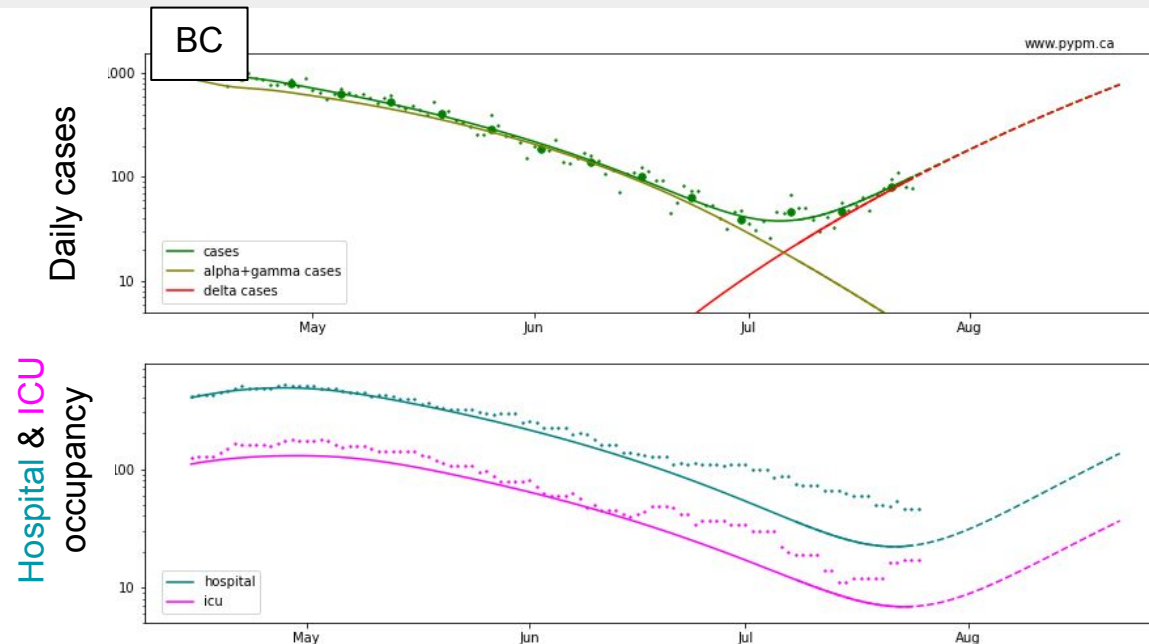
Source (D. Karlen). See www.pypm.ca. This model has no age structure and use a constant rate of infections entering hospital (teal) and ICU (magenta), fitted in early 2021.

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Closing the circle: Vaccination status by age

July 24th update includes data through July 17th, 2021

Legend:
- Fully vaccinated July 17th
- Fully vaccinated July 10th
- Fully vaccinated July 3rd
- Partially vaccinated July 17th
- Partially vaccinated July 10th
- Partially vaccinated July 3rd
- Unvaccinated

Age groups: 0-11, 12-17, 18-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+

July 23rd, July 16th, July 9th
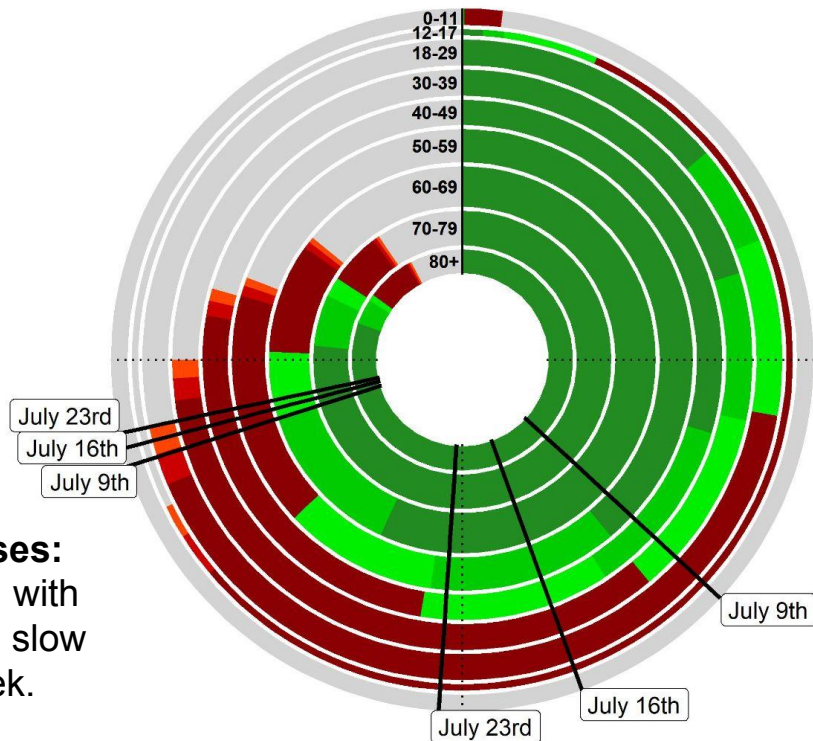
Slow progress on 1st doses: Fraction of BC's population with at least one vaccine shows slow growth, rising ~1% per week.

Fast progress on 2nd doses: Fraction of BC's population who are fully vaccinated has been rising ~8% per week.

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Closing the circle: Vaccination status by age

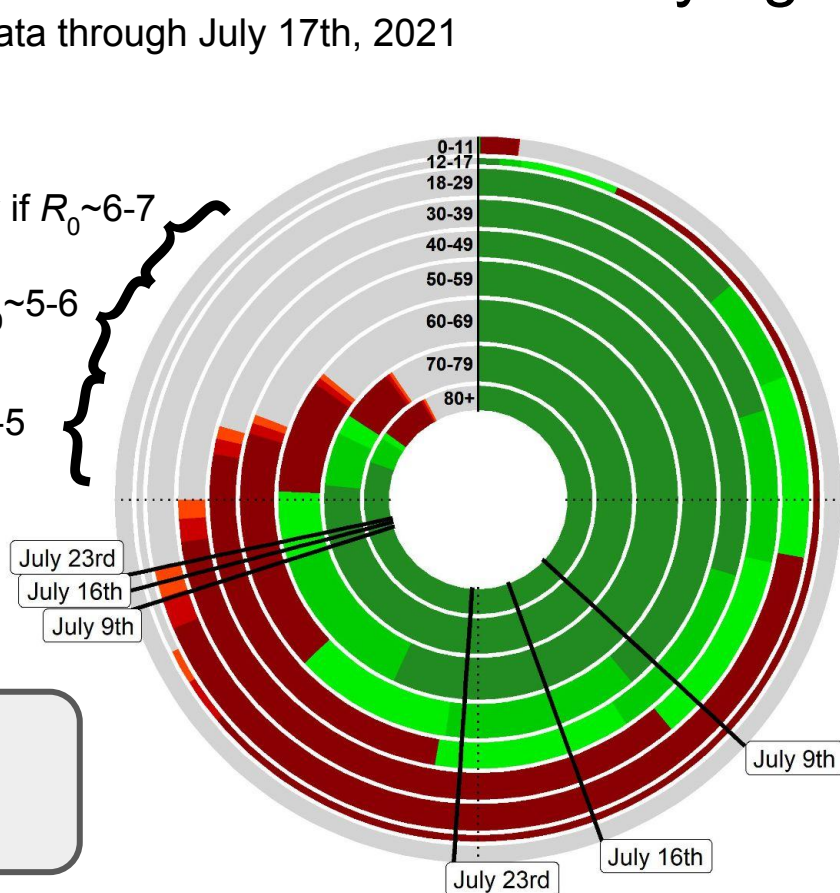July 24th update includes data through July 17th, 2021

If vaccines were 100% effective:

Herd immunity if $R_0 \sim 6\text{-}7$

Herd immunity if $R_0 \sim 5\text{-}6$

Herd immunity if $R_0 \sim 4\text{-}5$

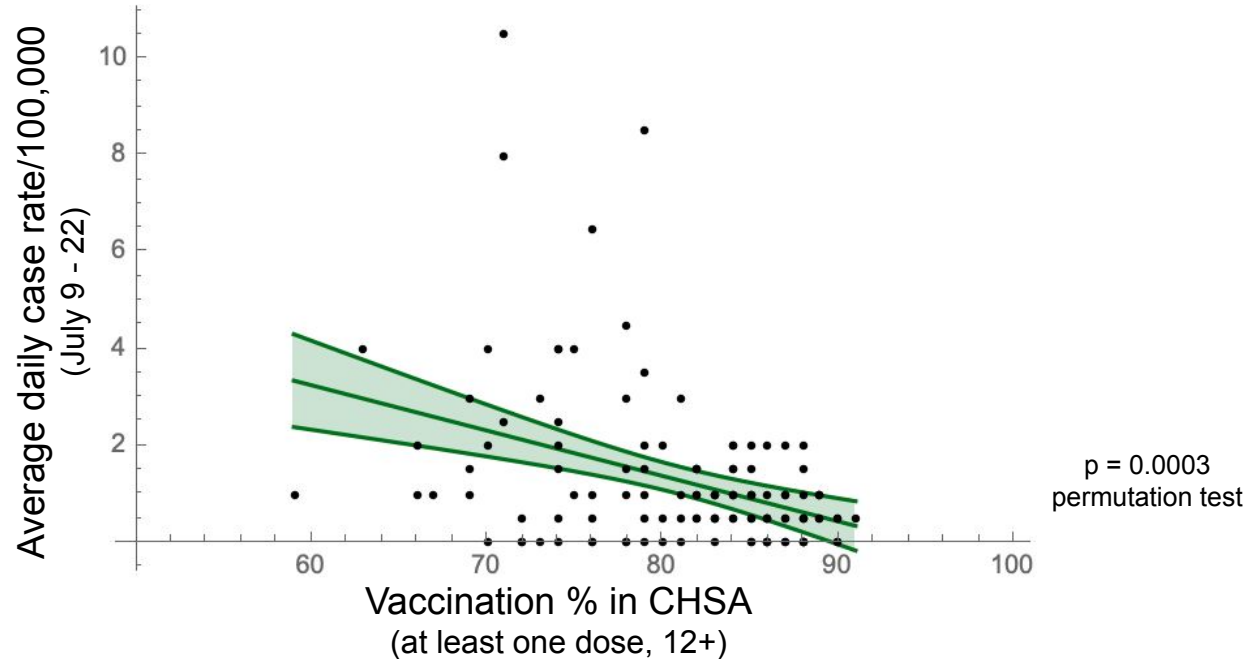R_0 for B.1.617.2 (Delta) unknown but has been estimated to be ~7*.

Legend:
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July 23rd, July 16th, July 9th

Herd immunity: the level of immunity in a population at which a disease starts to decline*

$\rightarrow (1\text{-}f)\, R < 1$ where f is level of immunity

Reproductive number (R): number of new cases per case, called R_0 in the absence of any control measures.

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Vaccination helps

Community Health Service Areas (CHSA) with higher vaccination rates have significantly lower daily case counts in BC. Communities that are 70% vaccinated have **five** times higher rates of COVID-19 cases than those with 90% vaccination.

$p = 0.0003$
permutation test

http://www.getvaccinated.gov.bc.ca

Source (S. Otto). BCCDC data portal's surveillance dashboard data; see maps for regions that would most benefit from community vaccination drives (accessed July 27, 2021)

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More cases have unknown sources

The likely source of cases is now more often "unknown" in BC, rising by 36% from January 1 to July 1, 2021. This trend tracks the rise in vaccinations and is consistent with **vaccinated individuals being more likely to be asymptomatic*, if they do get infected, but still transmitting to others**✧.

Fraction unknown source

Case counts/100,000
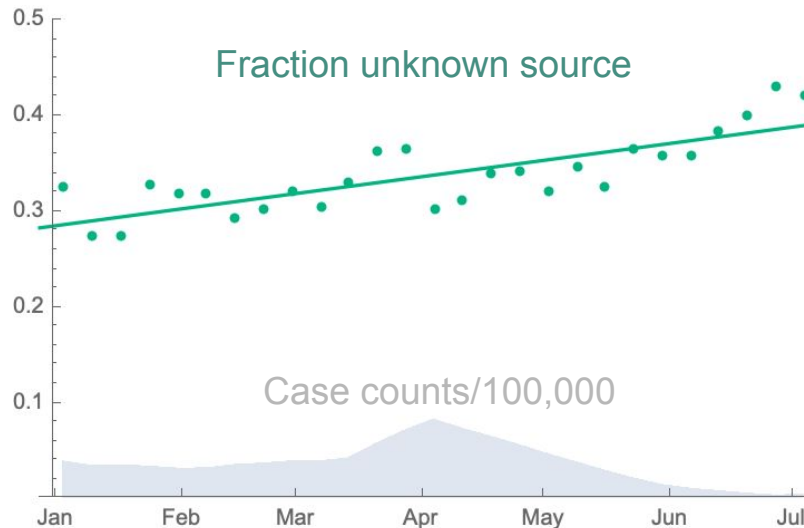
Cases among the vaccinated are more often asymptomatic*, making it harder to know if you are infected and reducing the efficacy of contact tracing.

Continuing to mask, even when fully vaccinated, can help protect others by reducing transmission from those who are asymptomatic.

Source (S. Otto). Uses Table 2 data from the weekly Situation Reports from the BCCDC through epi week 27. From the fraction "pending/missing", contact tracing appeared to improve in January 2021 and then has remained stable. "Fraction unknown source" excludes travellers and is (Domestic-unknown)/(Domestic-case/cluster + Domestic-unknown). *Asymptomatic rate rose from 27% among unvaccinated to 39% among fully vaccinated (Regev-Yochay 2021 Lancet). ✧ Estimated risk of infection and transmission among the vaccinated has been estimated as 11.5% that of unvaccinated individuals in (Prunas et al. 2021).; Israel pre-March 2021 (pre-Delta)

Final messages

Recent growth in cases is predominantly in communities with lower vaccination rates, with many communities in the Interior Health Authority at higher risk.

Delta (B.1.617.2) has been rising relative to other variants, consistent with a ~10% growth advantage *per day* compared to Alpha.

Delta case growth has been extremely rapid in many other jurisdictions. There are early signs of similar growth in BC.

While the risk of catching and transmitting COVID-19 is lower among those who are fully vaccinated (~10 times lower), there is still a risk.

To reduce the growth of cases, we encourage continued use of masks in indoor public settings, reduced exposure to poorly ventilated and crowded indoor environments, and vaccination by all those who are able.

Appendix: Tracking variants in US states
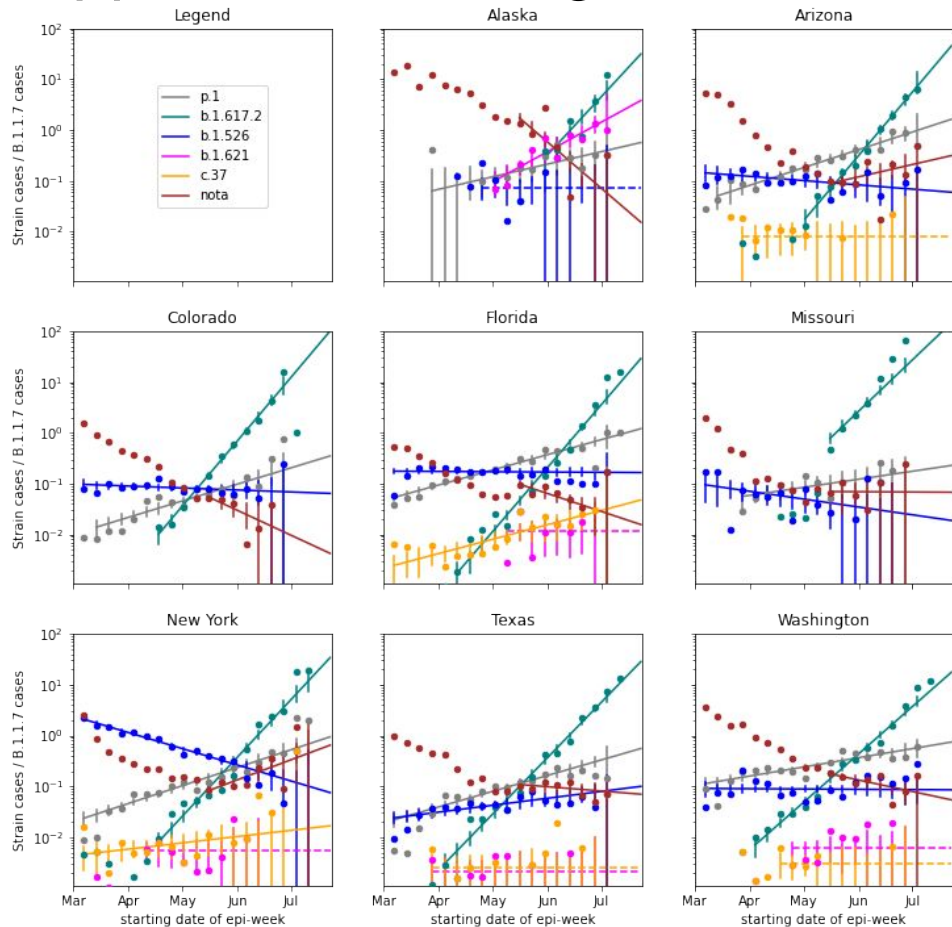
Genomic data from the United States allows estimation of growth for each variant (coloured trajectories)

Tracking variants in BC
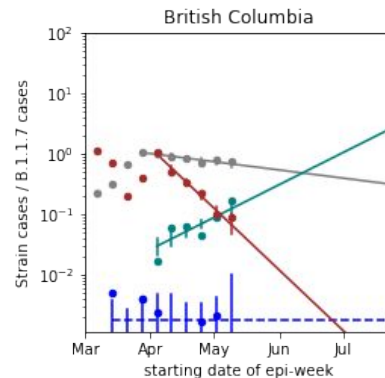
Data lacking in BC from recent months.

Gamma and Delta selection coefficients

Selection coefficients for P.1 (Gamma in gray) and B.1.617.2 (Delta in teal) relative to B.1.1.7 (Alpha) in the United States.

The selection coefficient measures the relative rise in frequency per day of a variant.