# COVID Model Projections

July 7, 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
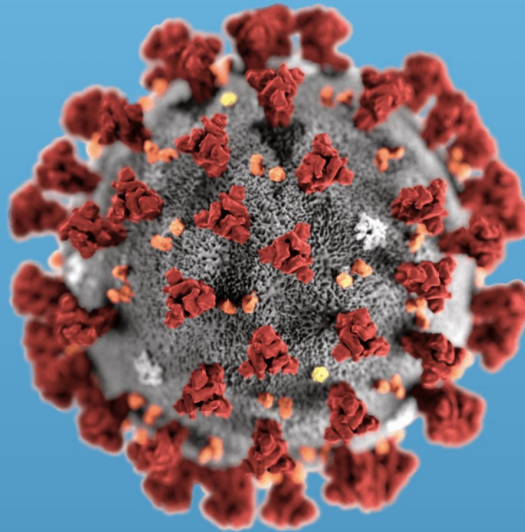
Contributors to report
Eric Cytrynbaum (UBC, co-editor)
Sarah Otto (UBC, co-editor)
Dean Karlen (UVic and TRIUMF)
Caroline Colijn (SFU)
Jens von Bergmann (MountainMath)
Rob James (evidently.ca)
James Colliander (UBC and PIMS)
Daniel McDonald (UBC)
Paul Tupper (SFU)
Daniel Coombs (UBC)
Elisha Are (SFU)
Bryn Wiley (UBC)

Independent and freely offered advice,
using a diversity of modelling approaches.
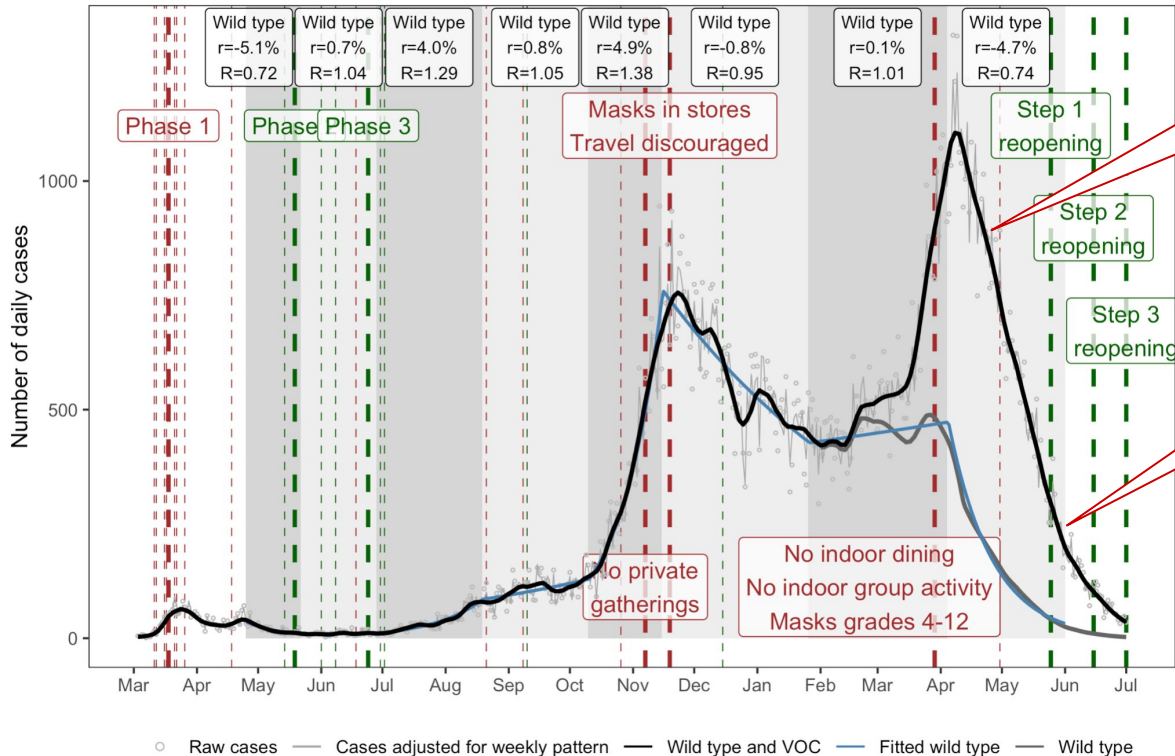
BC: Facing old and new variants of concern

Key messages

- The Step 2 reopening on June 15 did not cause daily cases to grow.
- Delta (B.1.617.2) cases remain roughly constant or are declining slightly in BC, but Delta continues to rise in frequency relative to other variants.
- With Delta numbers stable in June, the Step 3 reopening on July 1 leaves the future trajectory of Delta wide open. Increased transmission risks must be balanced by increasing vaccination to keep Delta numbers stable.
- Projections are uncertain without knowing how much people will change their behaviours.
- The vaccination campaign continues to make great progress and is showing measurable signs of having an impact across communities in BC.

State of the COVID-19 Pandemic in BC

Covid-19 daily new cases in British Columbia (up to Thu Jul 01)

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=0.1% 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

No private gatherings

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

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

Continued decline in cases.

Number of daily cases

1000

500

0

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

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

MountainMath, Data: BCCDC

Declines have continued but slowed in June.

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.

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Case data by Health Authority: June 16 model fit
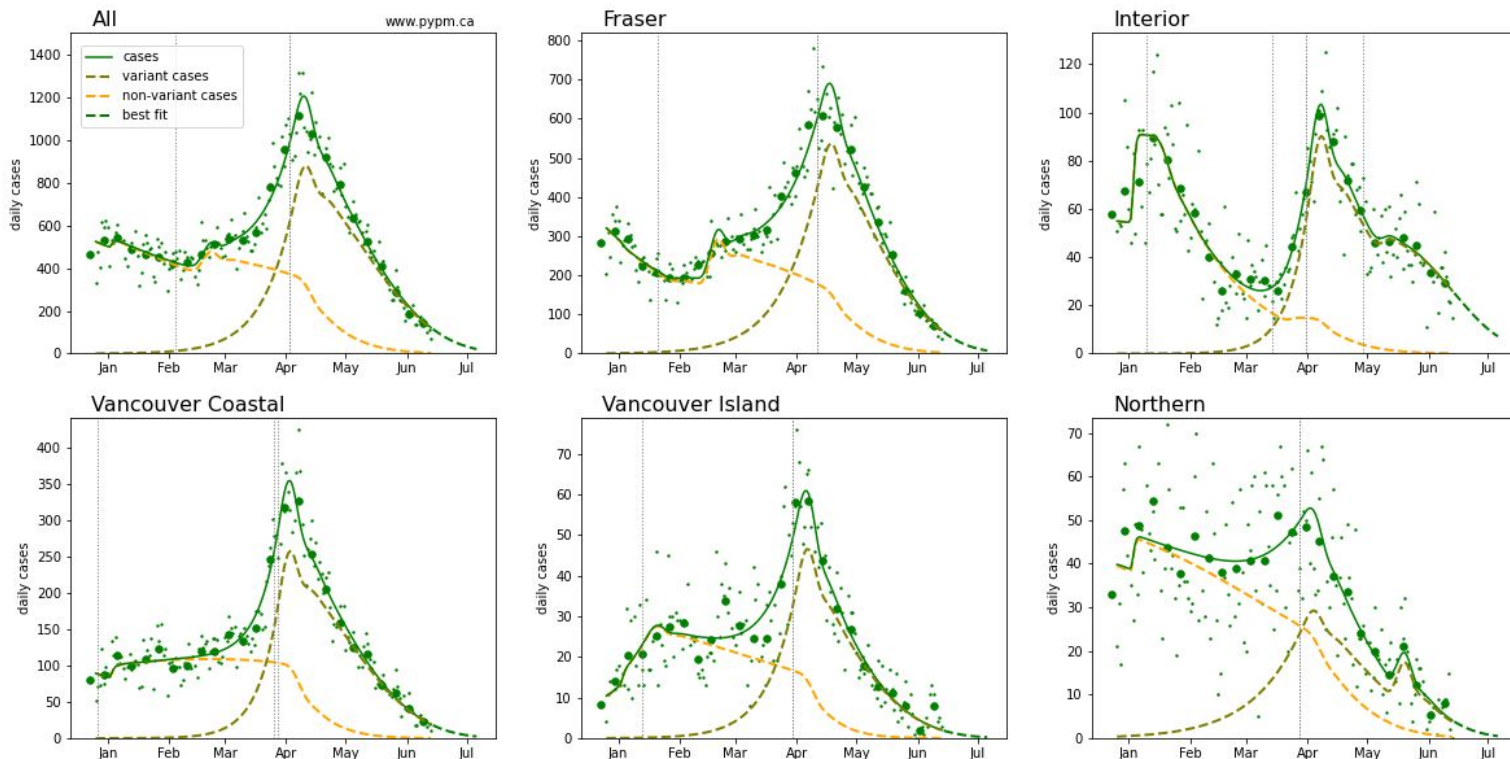
Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits past vaccination schedule and sets future vaccination rate of 1st doses to 45,000/day (given to all ages in proportion to HA population size until 75% of the population is vaccinated). Assumes 1st+2nd dose effectiveness rises over time to 90% (see May 14 report for details). Vaccination model benchmarked with data from Israel: see link. Assumes current public health measures remain in place in June.

June 16 model fit with recent data (and delta)
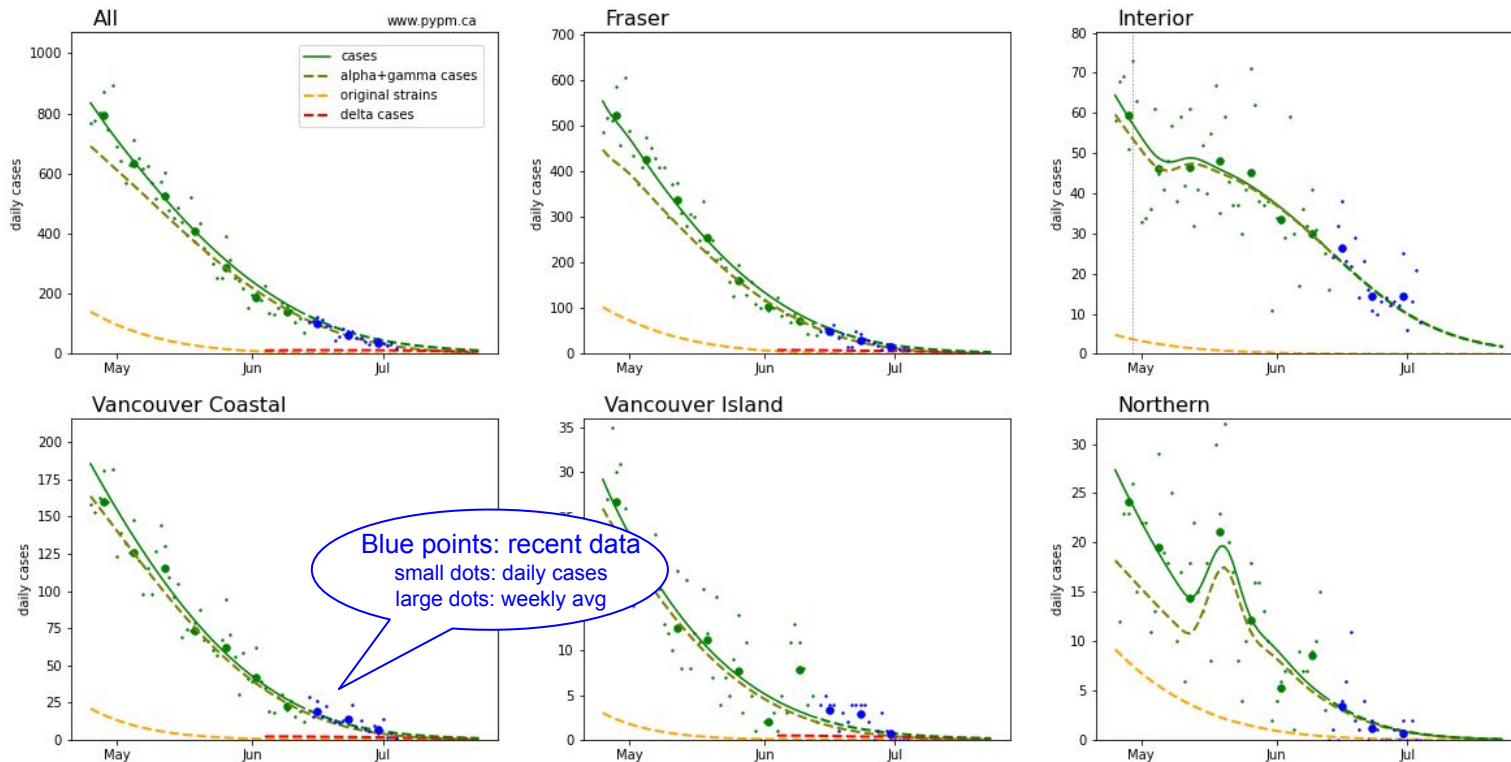
Declining case rates have followed model projections.
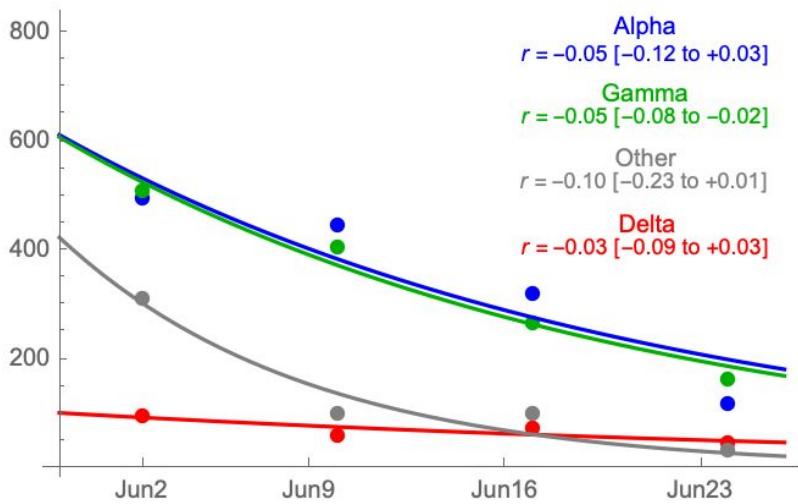
- Delta variant added to model

Transmission rates have remained roughly constant after Steps 1 and 2 of reopening, but Step 3 on July 1 was larger and is not included.

Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits past vaccination schedule and sets future vaccination rate of 1st doses to 17,000/day, following recent trends (given to all ages in proportion to HA population size until 75% of population is vaccinated, ~mid-July). 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.
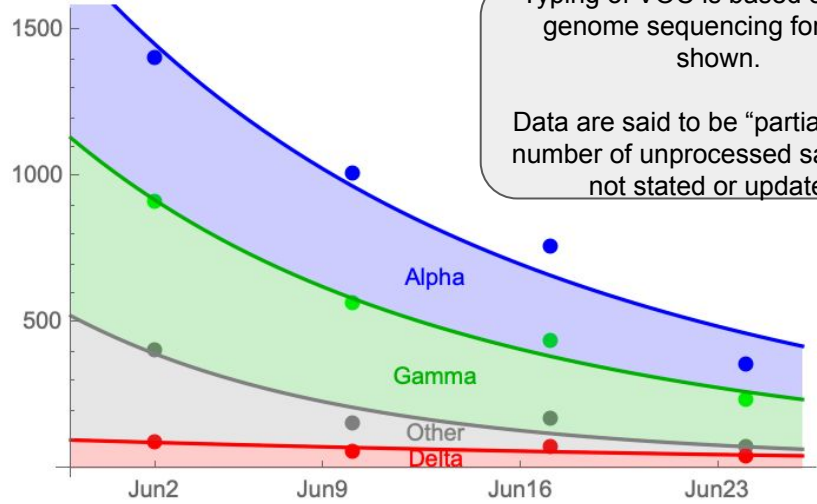
Variants in BC

Variant cases have declined in number over the past month (shown separately on the left and added together on the right), but this decline is weak for Delta, providing only a small buffer against growth after the Step 3 reopening on July 1.

Number of variant cases

Alpha
$r = -0.05$ [-0.12 to $+0.03$]
Gamma
$r = -0.05$ [-0.08 to -0.02]
Other
$r = -0.10$ [-0.23 to $+0.01$]
Delta
$r = -0.03$ [-0.09 to $+0.03$]

New weekly cases

Alpha

Gamma

Other

Delta

Typing of VOC is based on whole genome sequencing for dates shown.

Data are said to be "partial" but the number of unprocessed samples is not stated or updated.

Source (S. Otto). Number of cases per week from BCCDC's Variant report. Uses cumulative 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 daily growth rate, r. Note that r estimates are highly uncertain with so few data points [95% CI in square brackets] and may be biased because only "partial" data are

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Delta trends in Alberta

While case numbers have fallen in Alberta from a daily high of 2409 to less than 100 for the past 12 days, this decline has masked the rise of Delta variants in frequency (left) and, more slowly, in numbers (right).
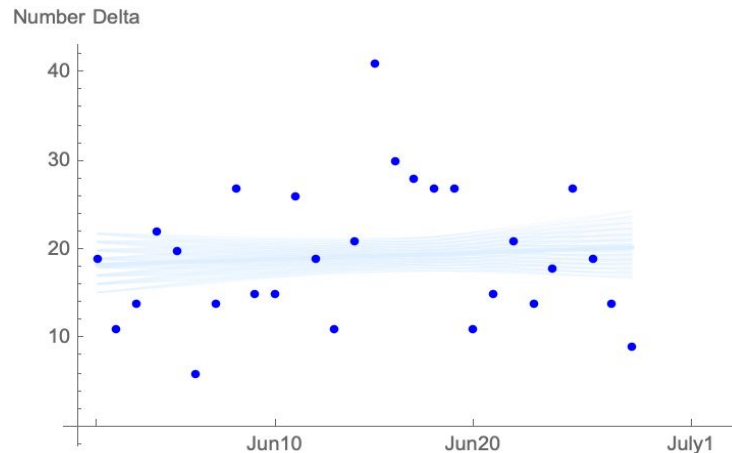
Daily selective advantage of Delta
s = 0.104 {95% CI: 0.092, 0.116}
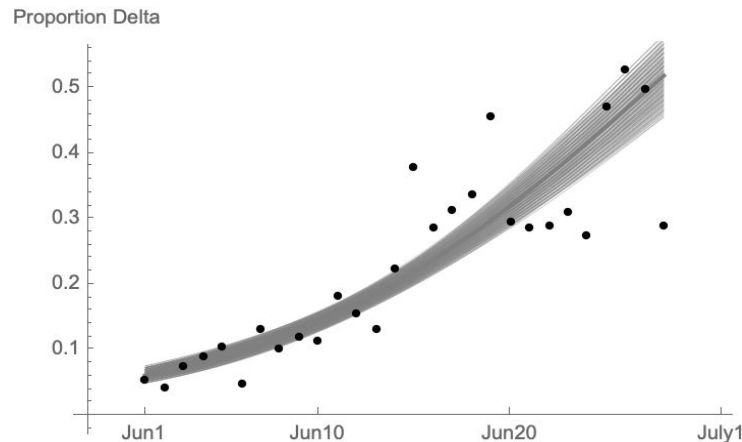
Daily growth rate of Delta
r = 0.004 {95%CI: -0.006, 0.014}

With the rising percentage of Albertans vaccinated, growth in Delta case numbers has slowed relative to previous report (no longer significant), but this leaves no buffer for reopening. Alberta lifted most public health restrictions on July 1.

Source (S. Otto). Data from source file https://www.alberta.ca/stats/covid-19-alberta-statistics.htm#variants-of-concern (accessed July 5, using data through June 28). 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). The estimate of the growth rate (r) depends on an inference of sampling fraction in May, which was based on a fit of the total proportion of all VOC from April 10 to June 28, 2021.

BC incidence projections: contact and reopening

Incidence continues to decline, with vaccinations[§] driving that decline. The decline is robust to some but not a major increase in contact rates* among those distancing (coloured curves).

This model takes increased transmission and somewhat decreased vaccine efficacy for Delta into account.

Uncertainty in: (1) transmission in a reopened population, (2) efficacy against infection with Delta, and especially (3) changes in behaviour.

> Rising cases may not be followed by rises in hospitalizations, due to strong efficacy of vaccines against severe COVID-19.
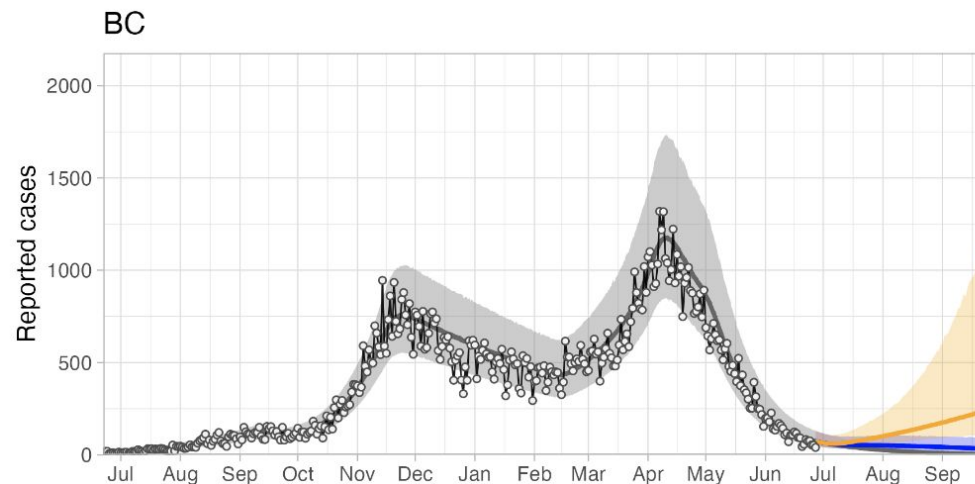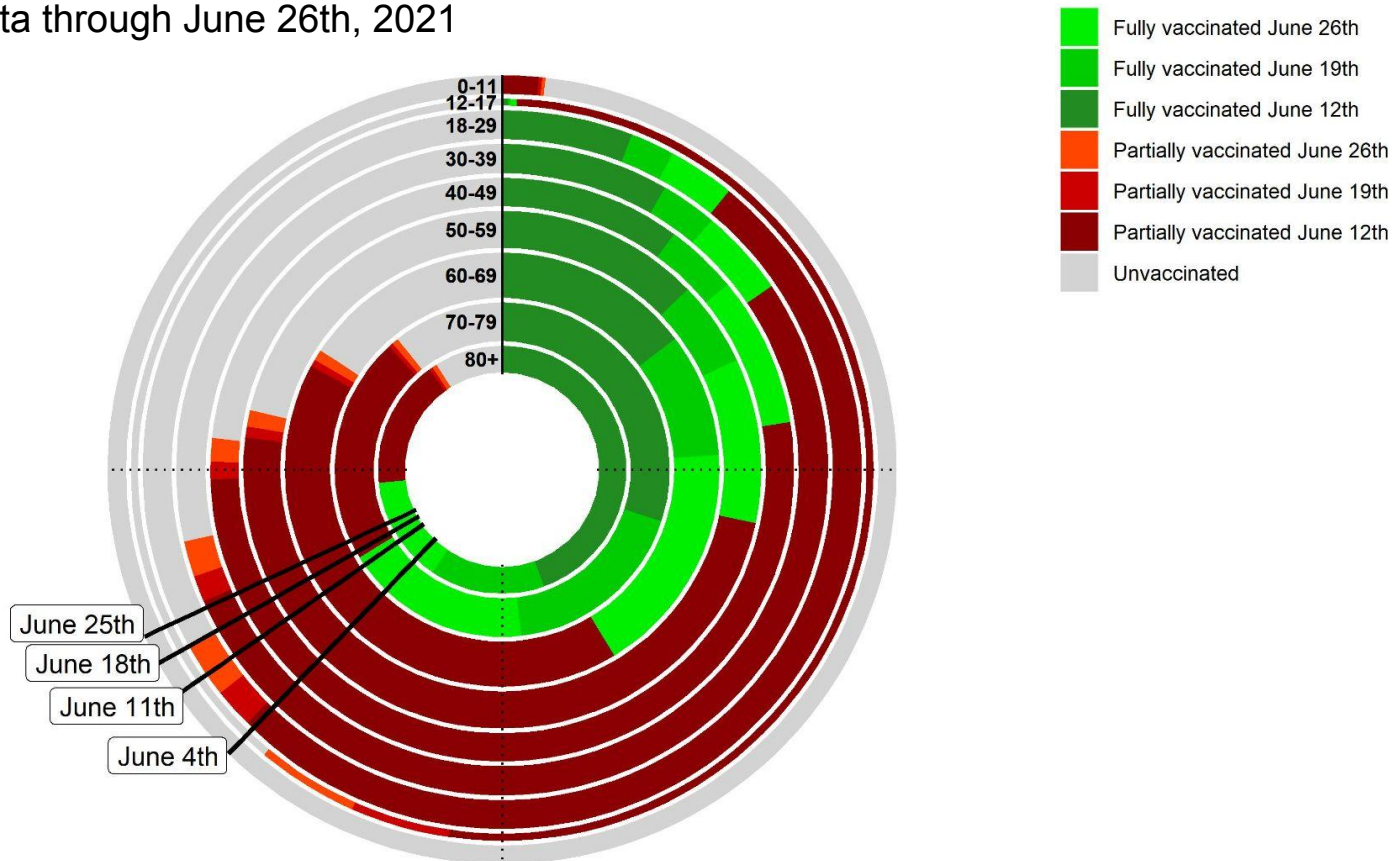

Orange: 50% increase in contact* (from June levels).
Blue: 25% increase in contact (from June levels).

Source (E. Are, C. Colijn). Daily case numbers projected forward, accounting for variants of concerns (VoC). Data on VoC from weekly BCCDC variant reports were fit by a logistic function to estimate percent VoC by day (see Appendix of April 14 report). Assuming a 40% increase in transmissibility for B.1.1.7 and P.1 (consistent with the estimated selection s in the Appendix of April 14 report), the percent VoC is used to create an overall reproduction number R for the virus population. R changes in time as the VoC rises in frequency. The same process is repeated for Delta. The social distancing parameter (among others) is estimated using the 'covidseir' R package (M. Irvine, S. Anderson). §Vaccination is incorporated by removing susceptibles at a rate accounting for contact by age, vaccination by age and susceptibility of contacts. *Measured as f, the relative contact rate among those willing and able to distance.

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Closing the circle: Vaccination status by age

July 5th update includes data through June 26th, 2021

Legend:
- Fully vaccinated June 26th
- Fully vaccinated June 19th
- Fully vaccinated June 12th
- Partially vaccinated June 26th
- Partially vaccinated June 19th
- Partially vaccinated June 12th
- Unvaccinated

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

Labels: June 25th, June 18th, June 11th, June 4th

Slowing progress:
Fraction of BC's population vaccinated per week has slowed substantially, as focus has shifted to second doses.

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Closing the circle: Vaccination status by age

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If vaccines were 100% effective:

Herd immunity if R_0 ~5-6

Herd immunity if R_0 ~4-5

R_0 for B.1.617.2 unknown but may be ~4 to 7 given an R_0 for B.1.1.7 of ~2.8 to 5.4* without control measures
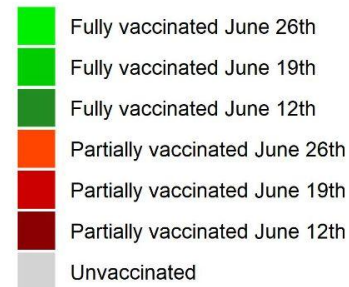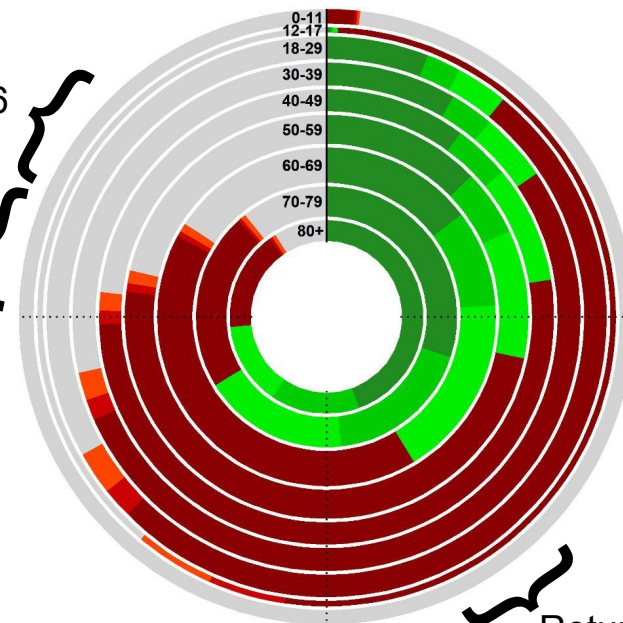
Herd immunity: the level of immunity in a population at which a disease starts to decline*

$\rightarrow$ $(1-f)$ $R < 1$ 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.
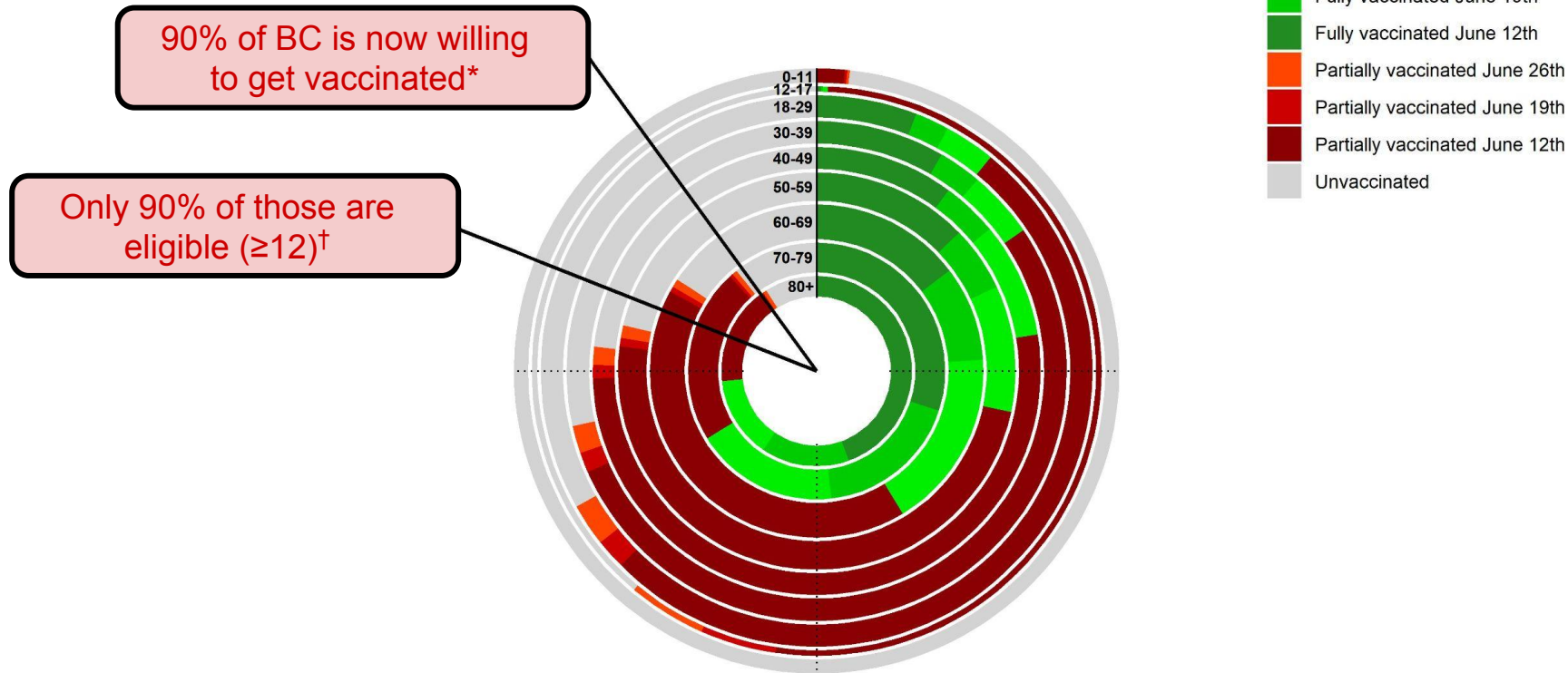
Return to Feb/March 2021 activities when R~1.7 for B.1.1.7 & P.1 in BC[†]

Source (B. Wiley). Design by Blake Shaffer (https://blakeshaffer.shinyapps.io/app_vaccines/) [†]https://bccovid-19group.ca/post/april-2021-report/
*Public Health Ontario: https://www.publichealthontario.ca/-/media/documents/ncov/covid-wwksf/2021/02/wwksf-herd-immunity.pdf, assuming B.1.617.2 has a selective advantage of s=0.05 and using a 6.5 day generation time to translate to reproductive numbers (as in Volz et al.). *Typically assumes no or minimal control measures.

Closing the circle: Vaccination status by age

July 5th update includes data through June 26th, 2021

90% of BC is now willing to get vaccinated*

Only 90% of those are eligible (≥12)†

Fully vaccinated June 26th
Fully vaccinated June 19th
Fully vaccinated June 12th
Partially vaccinated June 26th
Partially vaccinated June 19th
Partially vaccinated June 12th
Unvaccinated

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

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90% of BC is now willing to get vaccinated*

Only 90% of those are eligible (≥12)[†]

&

First dose only partially effective against symptomatic infection[‡]

Pfizer
Moderna
AstraZeneca

Age groups: 0-11, 12-17, 18-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+
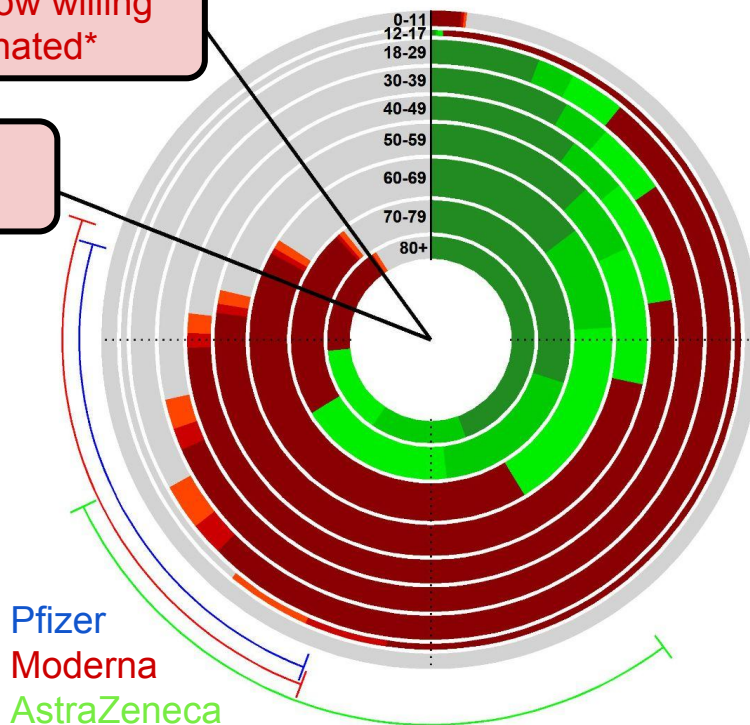
Herd immunity with no control measures will not be achieved until more of BC is fully vaccinated.

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

Vaccination status by age group
Last age-based BC data update June 26

British Columbia
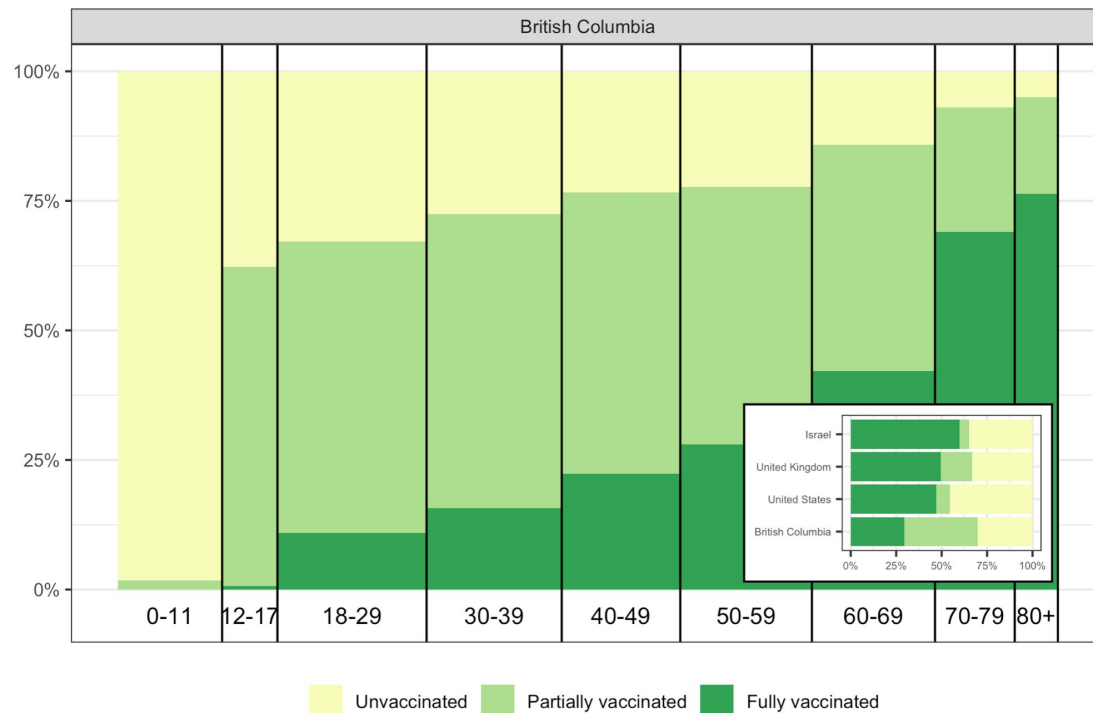
Data: PHAC, StatCan Table 17-10-0005, Our World in Data

Israel: 65% vaccinated (at least one dose, 60% fully vaccinated). Uses a traffic light model that opens up regionally depending on local infection levels. Israel *reimposed indoor mask mandate* because of rising Delta cases.

UK: 67% vaccinated (at least one dose, 50% fully vaccinated). Schools fully open with optional rapid testing available and masks for secondary students; indoor dining open with safety protocols; outdoor socializing up to 30, indoor up to 6 people. *Step 4 reopening has been postponed because of Delta*.

Countries with high vaccination levels are seeing upticks in cases and have slowed reopening due to Delta

Source (J. von Bergmann). Vaccination data https://health-infobase.canada.ca/covid-19/vaccination-coverage/
Benchmarks from Israel and UK: https://ourworldindata.org

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Vaccination helps

Community Health Service Areas (CHSA) with higher vaccination rates have significantly lower daily case counts in BC. Increasing vaccination coverage from 70% to 83% halves the average case count.

p = 0.0001
permutation test

Vaccination % in CHSA
(at least one dose, 12+)

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

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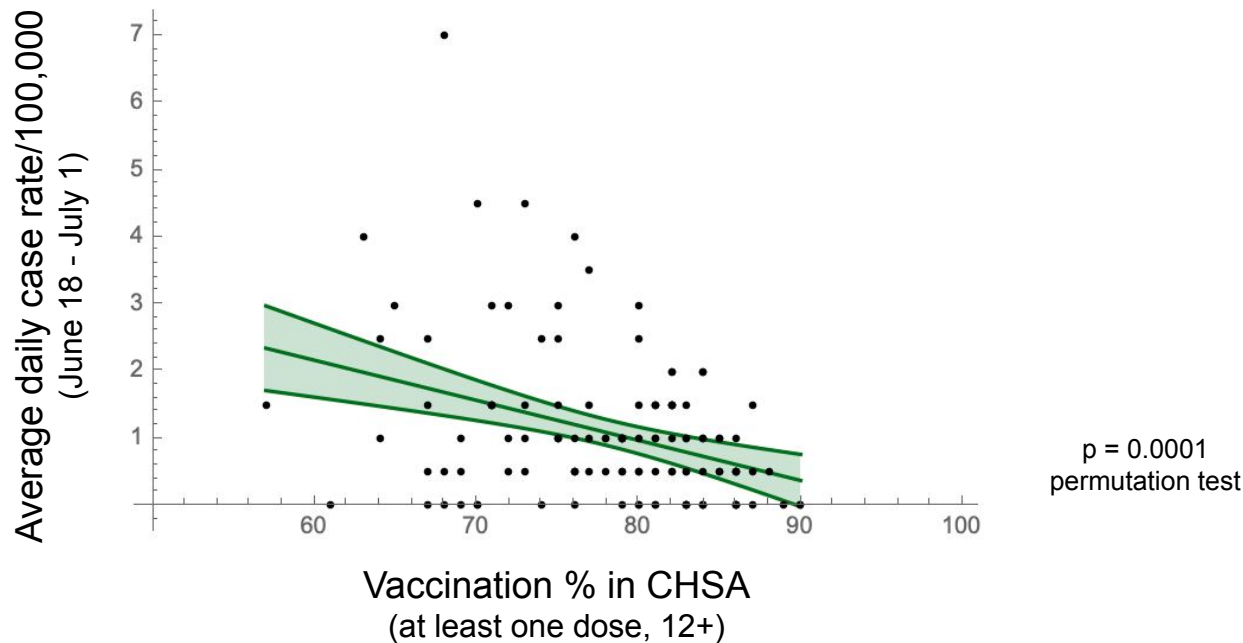
Protect others, even when vaccinated

The projected fraction of people in BC who have been partially or fully vaccinated for ≥14 days is plotted on the left. While the majority of new cases are expected to originate from unvaccinated people (on the right), a large fraction of cases will continue to originate from vaccinated people because there are more of them.
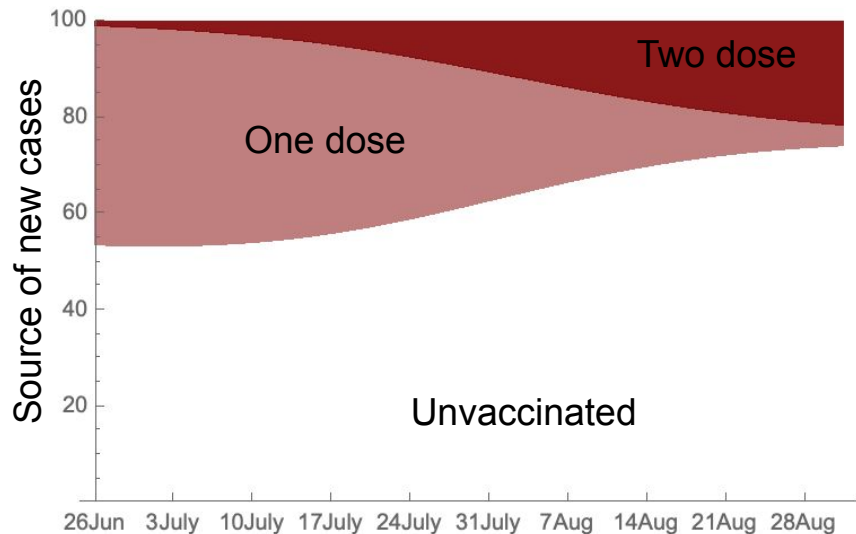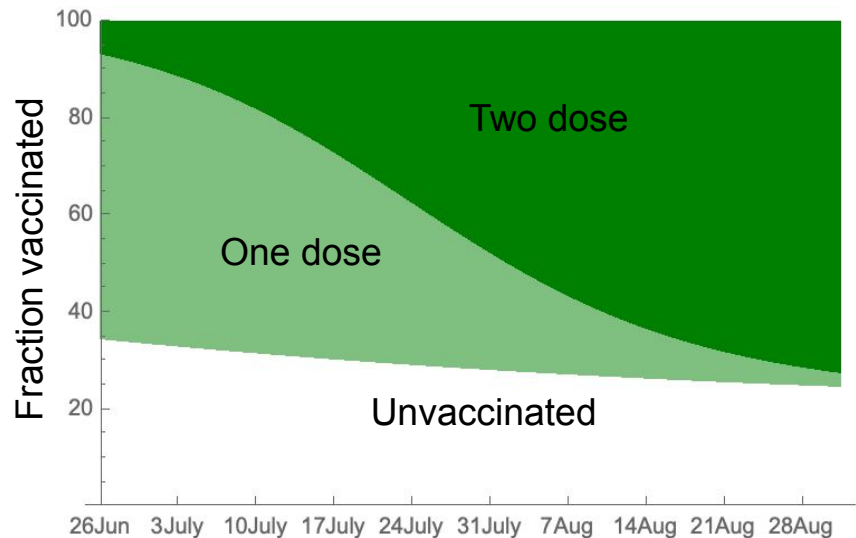
Each of us, even those fully vaccinated, can help protect others by keeping up the good behaviour! Get tested when exposed, stay home when sick, mask indoors in public & return slowly to normal while cases remain.

Source (S. Otto). Uses weekly vaccination data from June to project vaccination levels forward, assuming 80% maximum uptake rate (roughly 90% of 12+) and assuming that all who are singly vaccinated will become fully vaccinated. Vaccine efficacy against transmission (VE) remains unmeasured and differs among variants; right graph assumes 90% VE for fully vaccinated (80% effective against infection and half the transmissions if infected) and 50% VE for singly vaccinated (between ref 1 and 2).

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Solid projections require solid data

The public, including the BC COVID-19 Modelling Group, has repeatedly had troubles accessing accurate and updated information about variants of concern.

BCCDC's variant reports are partial, contain errors, and are not updated as more data are gathered and corrected*.

Genome sequencing data will eventually provide fuller information, but the delays are too lengthy to be used in projections.
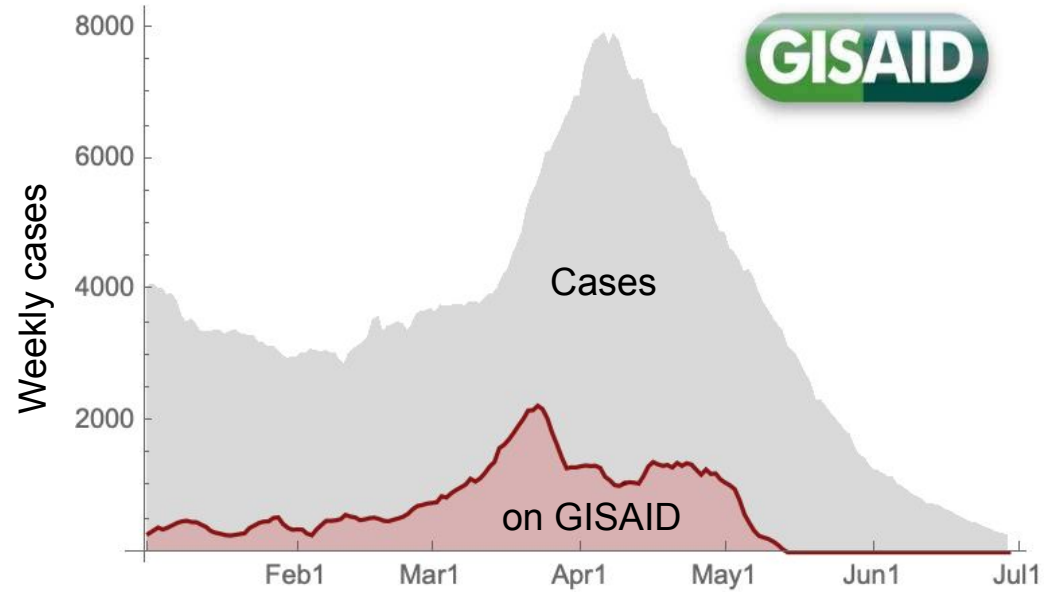
Starting in late May, all cases in BC have been sequenced, but none are publicly available.

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Final messages

Slow changes in transmission following Step 1 and 2 reopenings on May 25 and June 15 have not led to a rise in cases, being balanced by the rise in vaccinations.

We must pay attention to growth of the fastest rising variant (currently Delta) in order to predict future trends.

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

A near zero growth rate leaves little buffer for reopening. Increased transmission must be balanced by further increases in vaccination to prevent a rise in Delta.

Data inconsistencies in the reporting of variants of concern (detailed in link) have hampered external modelling and have contributed to substantial uncertainty in their spread over time, with their extent regularly underestimated in the past 6 months.