COVID Model Projections

April 6, 2022

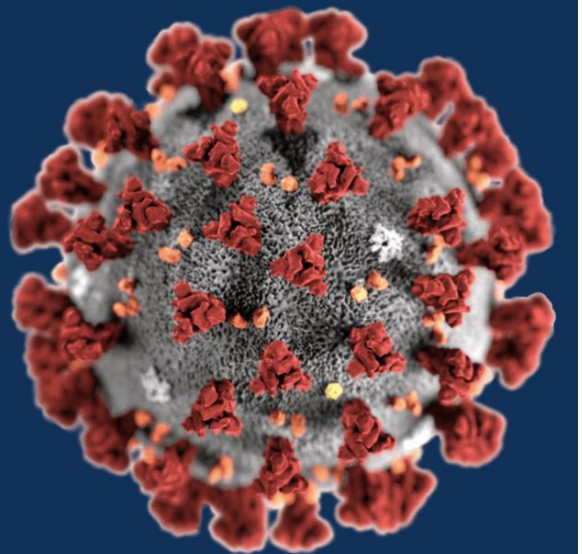
BC COVID-19 Modelling Group

@bcCOVID19group

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, working independently from Government, includes experts in epidemiology, mathematics, and data analysis from UBC, SFU, UVic, and the private sector, 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.

Overview

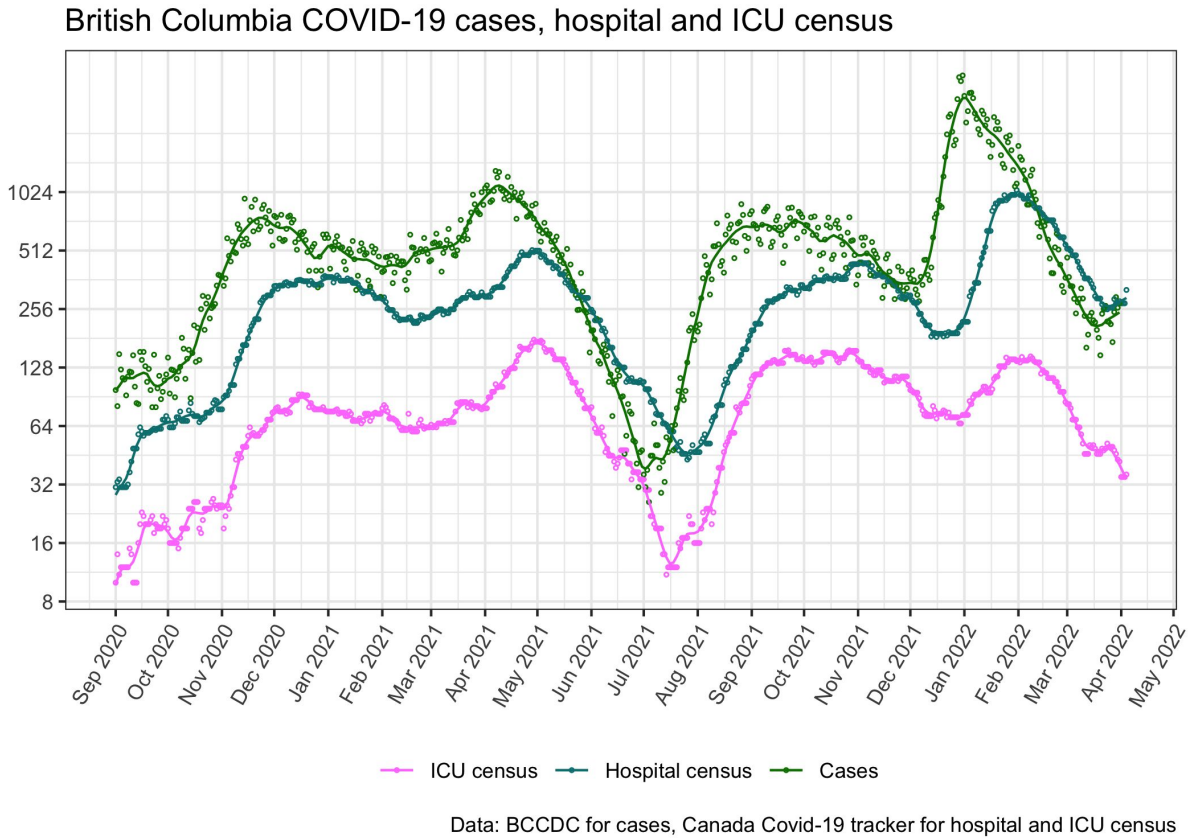
The start of a second Omicron wave in BC

- Reported cases, cases among those aged 70+, and number of people in hospital are now rising.
- Omicron sub-variant BA.2 continues to rise in frequency in BC and is **estimated** to comprise roughly 80% of cases this week, with selection favouring BA.2 by s = 9.1% [95CI: 8.7-9.5%] per day in BC.
- The number of **BA.2 cases is now rising,** using cases among 70+ to gauge infection rates (slide 9) or using estimated hospital admissions data (slide 13).

Risks of the second Omicron wave are hard to gauge

- The first line of immune protection from antibodies rises with boosters, as well as following infection, but the extent of this protection wanes over time, making it challenging to know how protected BC is during this second Omicron wave.
- The most vulnerable and the most exposed (e.g., health care workers) were boosted first and so now face the lowest level of protection as we enter the second Omicron wave.

Hospital trends in BC



The numbers of reported cases and people in hospital (but not ICU) are now showing upward trends in BC.

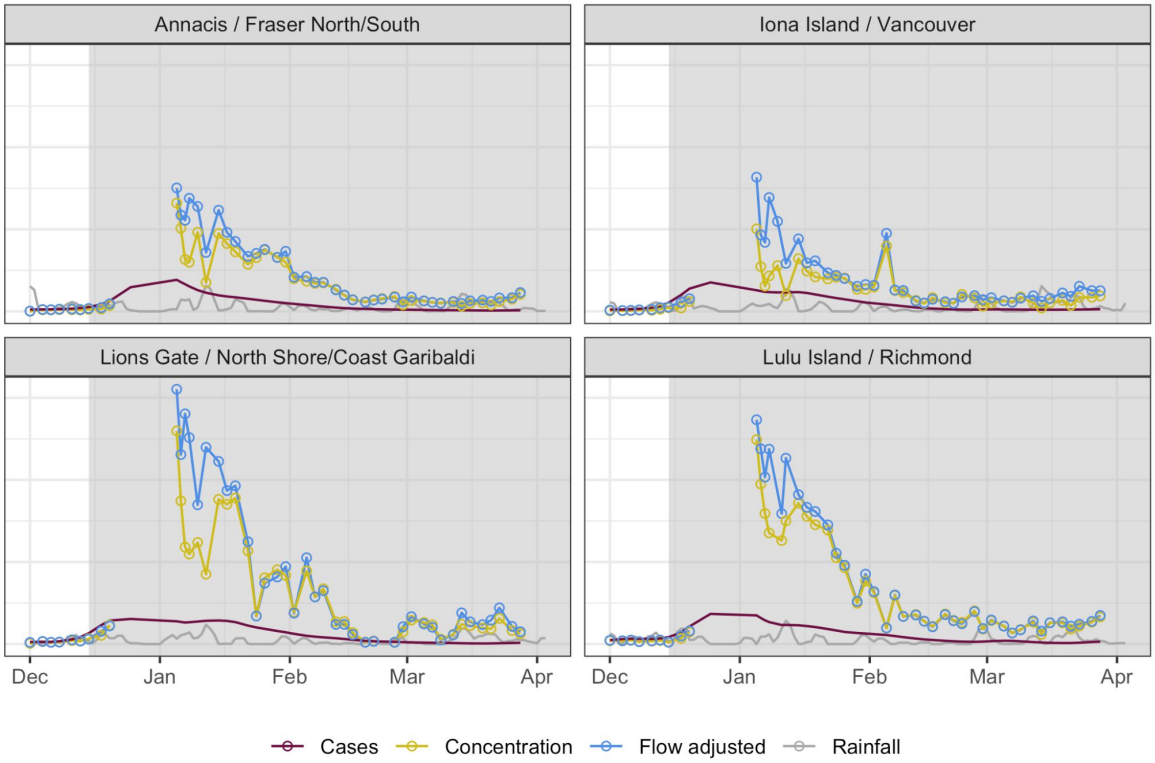
Source (J. von Bergmann) Case data from BC COVID-19 Database (http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data). STL trend lines on log scale.

Wastewater trends in Metro Vancouver

Clear trends are difficult to discern, with several regions showing an uptick in wastewater signals.

Increasing collection frequency, expanding coverage, reducing data lag, and adding covariates to help with modelling are important steps toward an alternative surveillance program based on wastewater.

Recent wastewater COVID concentration vs case counts



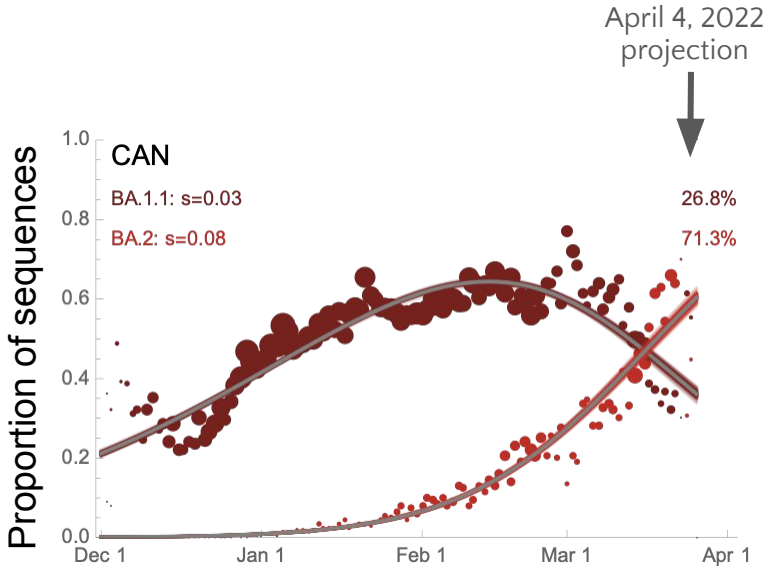
Source (J. Bergmann) Data from Metro Vancouver's [Testing for the COVID-19 VIrus in Wastewater]

Spread of Omicron sub-lineages in Canada

Data shared by Public Health labs across Canada allow us to track the spread of Omicron sub-lineages over time.

→ BA.1.1 is spreading slightly faster than BA.1 at a rate of s=3% per day (dark red).

→ BA.2 is spreading much faster than BA.1 at a rate of s=8% per day (this is similar to selective spread of Alpha). Proportion of BA.2 cases estimated this week at **71%.**



How does this vary across Canada?

What does this imply for case numbers?

Source (S. Otto) Canadian sequences were downloaded from GISAID for BA.1, BA.1.1, and BA.2 (Alberta sequences were removed as AB first identifies variants and preferentially sequences BA.2). A model of selection was fit to the numbers of each type using maximum likelihood based on a trinomial distribution given the expected frequencies on each day. Hessian matrix used to show plausible trajectories, accounting for uncertainty in the parameters.

Spread of Omicron sub-lineages in Canada

April 6 2022
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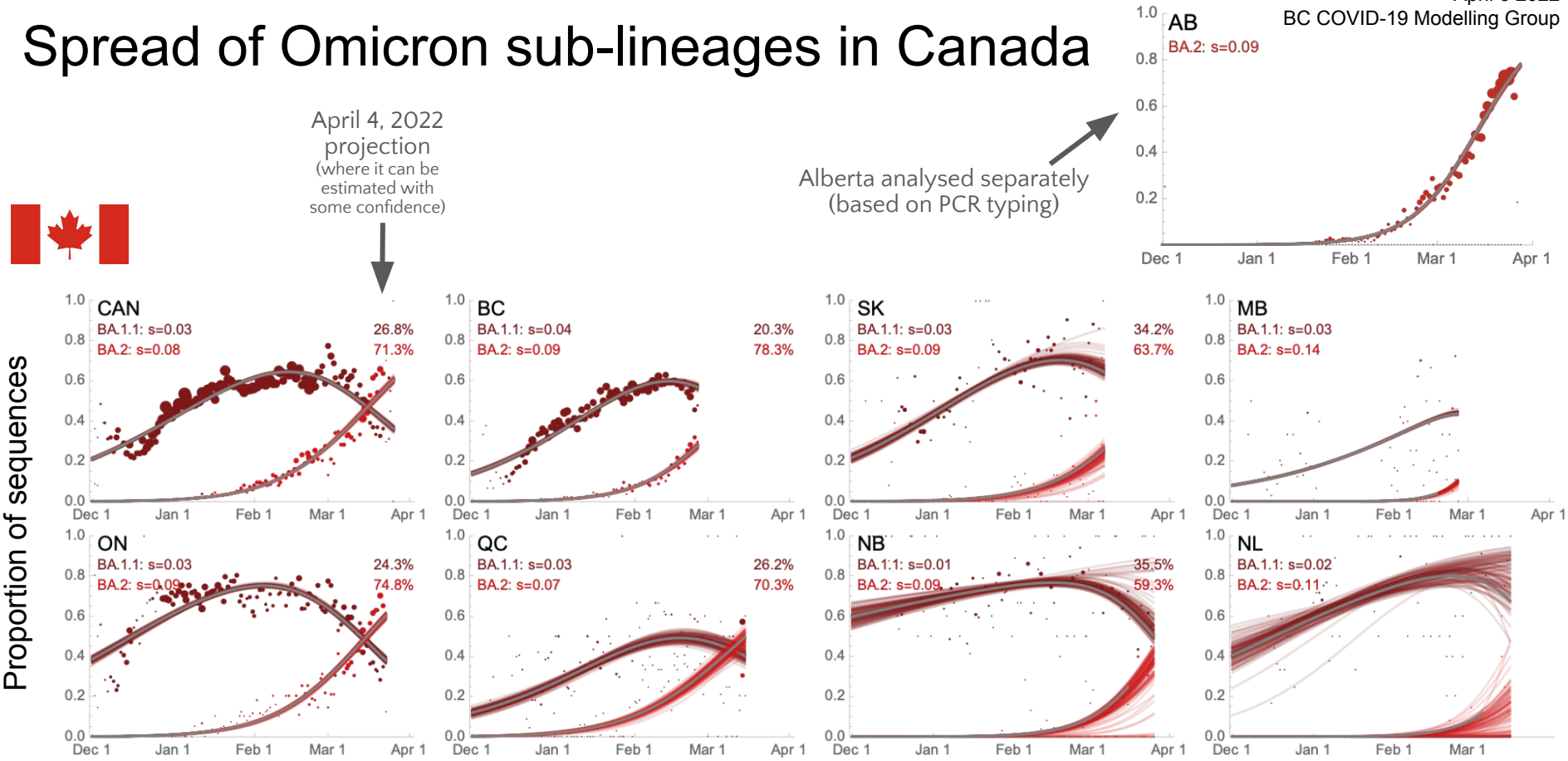
April 4, 2022 projection (where it can be estimated with some confidence)

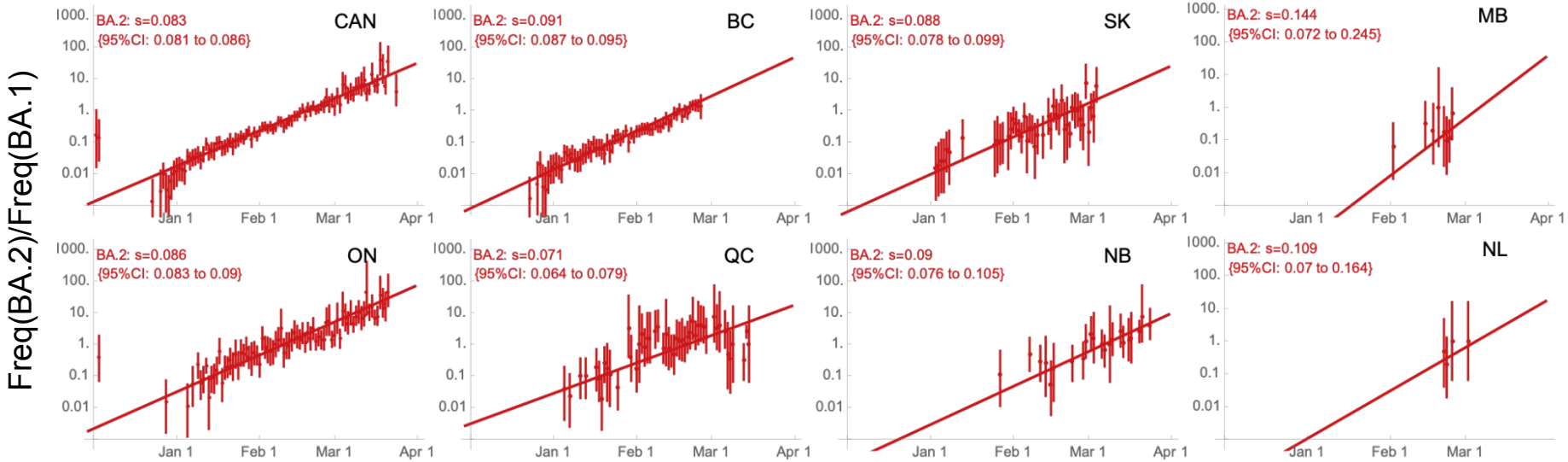
Alberta analysed separately (based on PCR typing)



Source (S. Otto) Canadian sequences were downloaded from GISAID for BA.1, BA.1.1, and BA.2 (Alberta sequences were removed as AB first identifies variants and preferentially sequences BA.2). A model of selection was fit to the numbers of each type using maximum likelihood based on a trinomial distribution given the expected frequencies on each day. Hessian matrix used to illustrate plausible trajectories, accounting for uncertainty in the parameters. Alberta data obtained based on PCR typing.

Spread of Omicron sub-lineages in Canada

The same data, plotted on a log-scale as the frequency of BA.2 versus BA.1, shows a linear rise with a slope equal to the strength of selection. **The strength of selection favoring BA.2 has remained constant** (no appreciable change in slope).

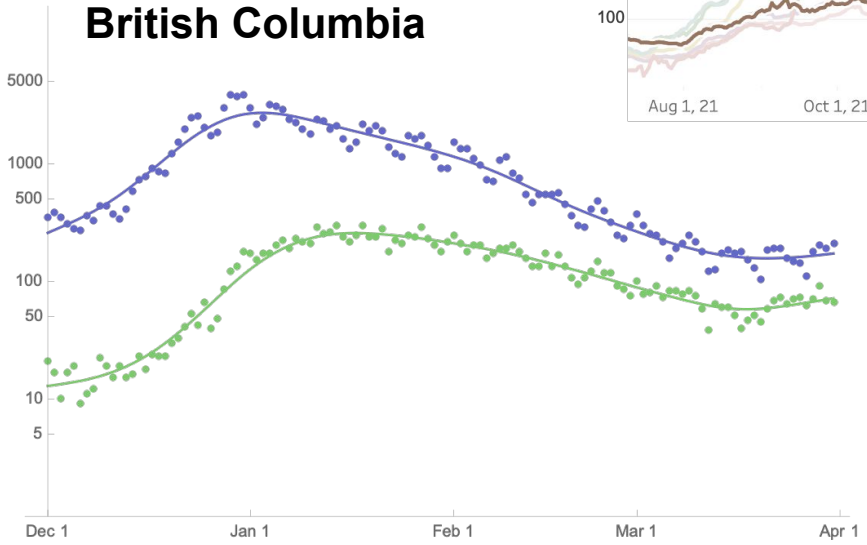


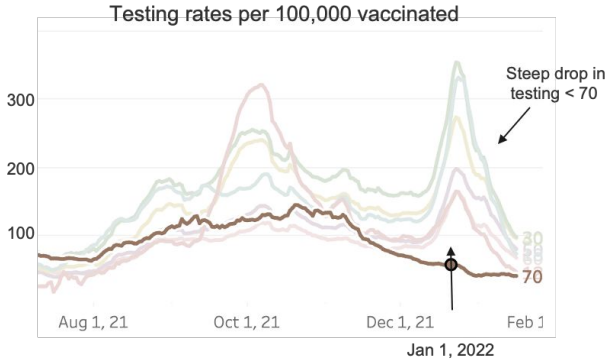
Source (S. Otto) Canadian sequences were downloaded from GISAID for BA.1, BA.1.1, and BA.2 (Alberta sequences were removed as AB first identifies variants and preferentially sequences BA.2). A model of selection was fit to the numbers of each type using maximum likelihood based on a trinomial distribution given the expected frequencies on each day. Profile likelihood used to obtain 95% confidence intervals. Alberta data obtained based on PCR typing.

What does this imply for case numbers?

We'll use case numbers observed in individuals aged 70+, who have been more consistently tested.

While cases <70 (blue) have dropped precipitously (15.7-fold), cases among the 70+ age group have dropped less (3.6-fold), because of the change in testing.



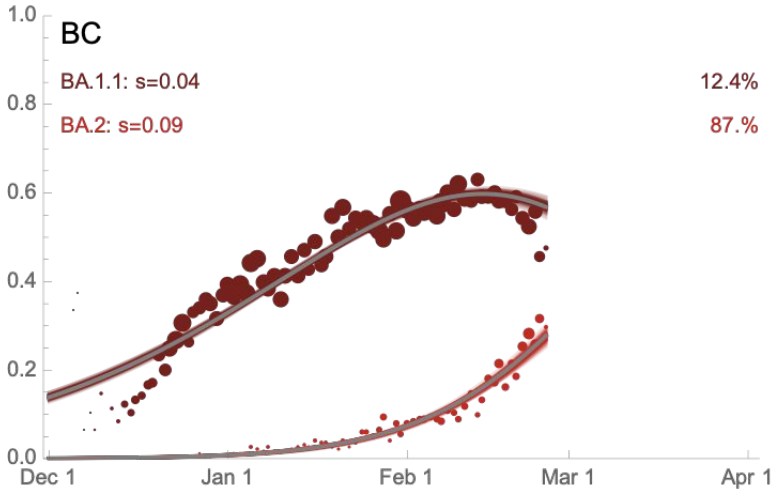


Cases among the 70+ age group are now **significantly increasing*** (see Health Authority data in Appendix).

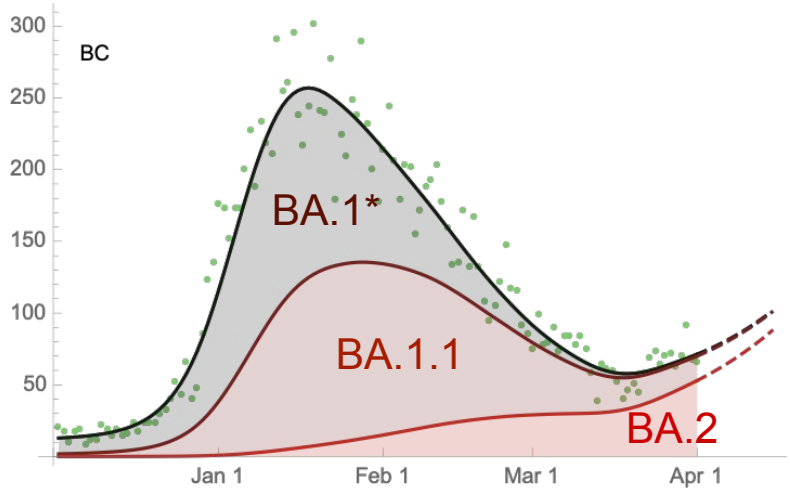
Source (S. Otto) New cases per day in 10-year age groups were downloaded from the **BCCDC COVID-19 data portal**. Cubic spline fits to log-case data were obtained (curves) for those 70+ (green) or <70 (blue). *Linear regression through log case counts among 70+ from last 14 days of data.

What does this imply for case numbers?

Fitting models of selection allows us to estimate rate of spread of BA.1.1 and BA.2, relative to BA1 in BC.



Multiplying by the # of cases in those over 70 allows us to **estimate** growth in numbers of each Omicron sublineage.

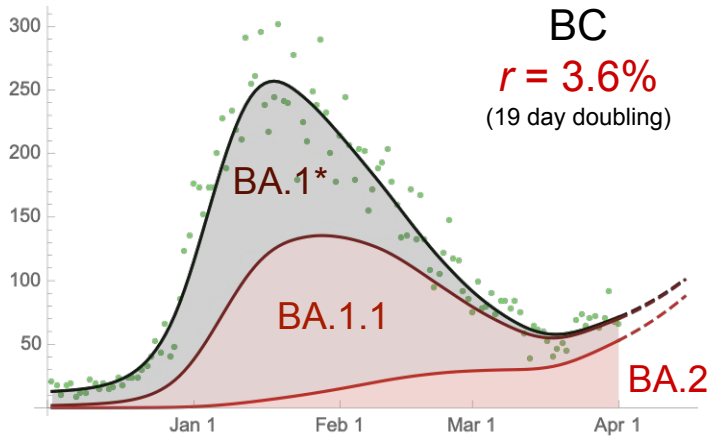


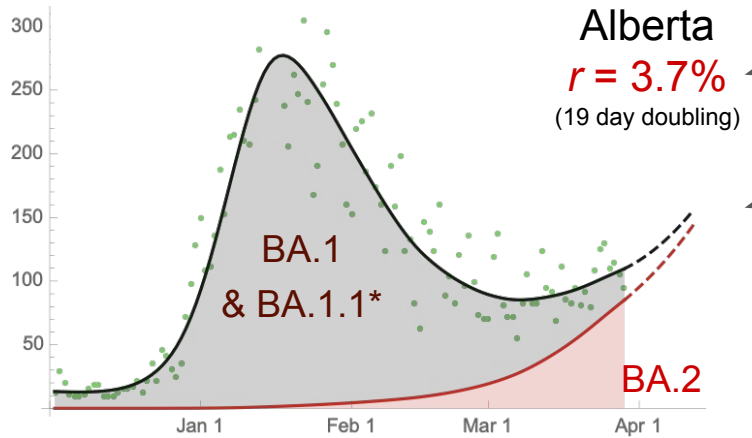
→ While numbers of BA.1 (daily growth rate r = –5.4%) and BA.1.1 (r = –1.9%) are declining, **estimated numbers of BA.2 are slowly rising (r = +3.6%) in British Columbia.**

Source (S. Otto) Canadian sequences were downloaded from GISAID for BA.1, BA.1.1, and BA.2. A model of selection was fit to the numbers of each type using maximum likelihood based on a trinomial distribution given the expected frequencies on each day. Hessian matrix used to obtain confidence regions. *Grey includes other variants.

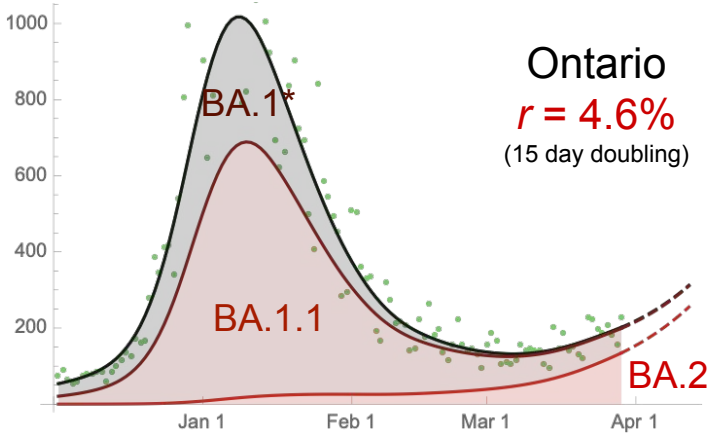
Daily growth rates

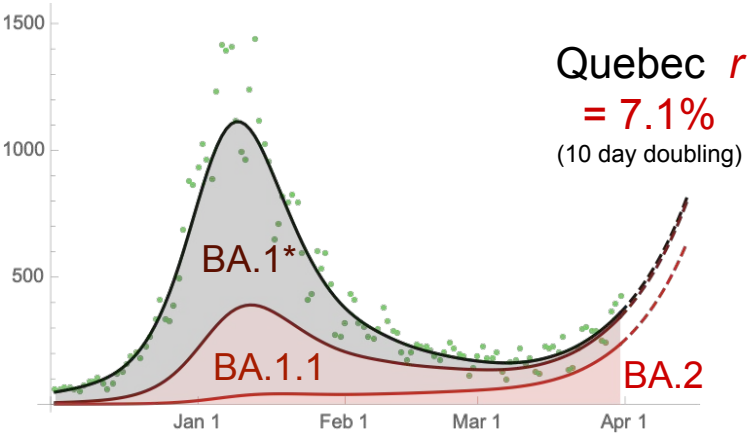
BA.2 is driving a rise in cases across Canada.





Daily growth rates estimated on April 4th and projected forward two weeks, but subject to change!

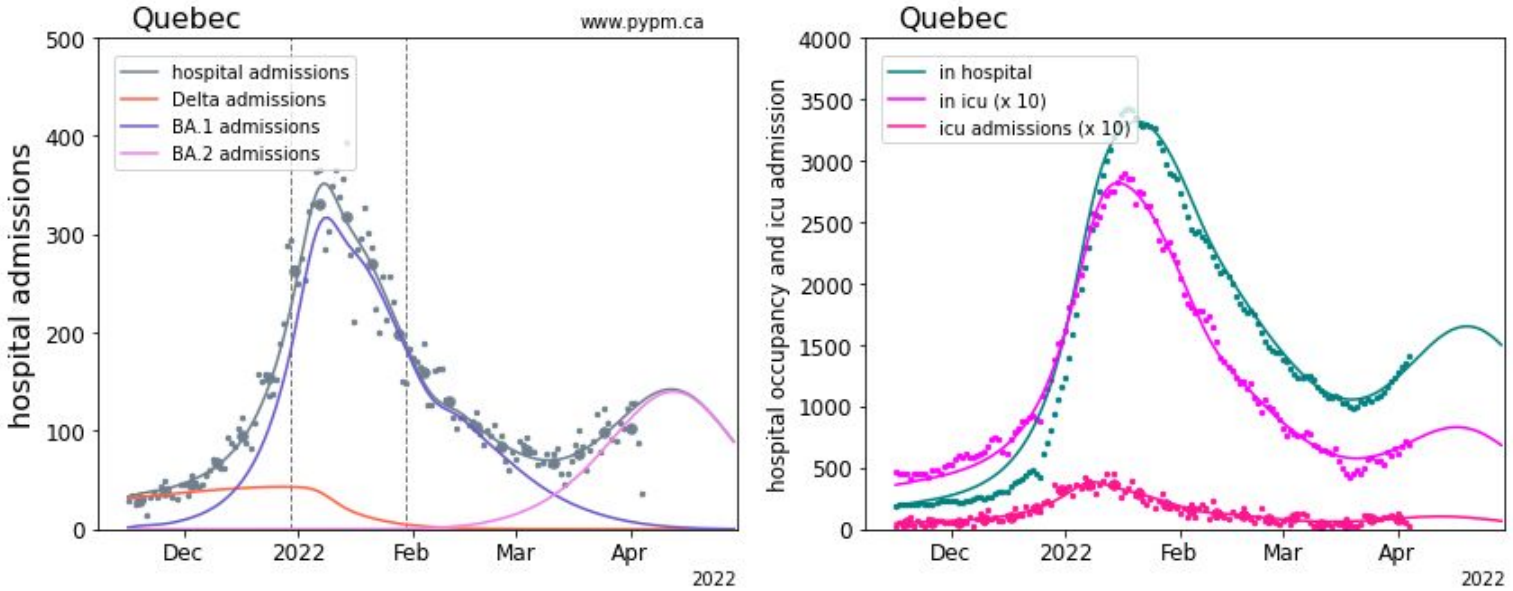




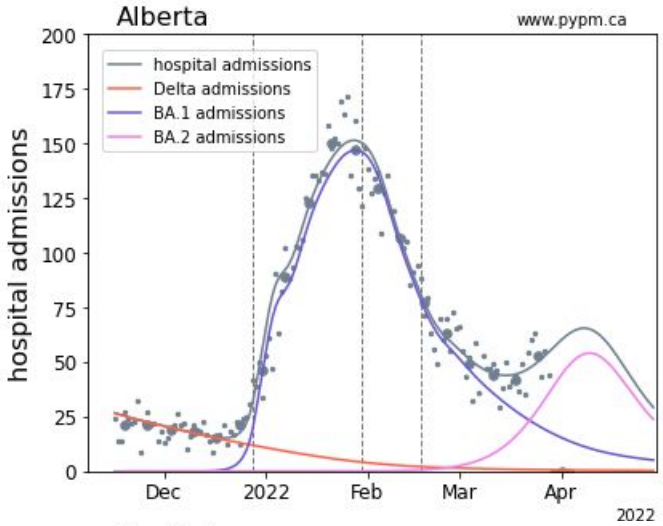
*Grey includes other variants.

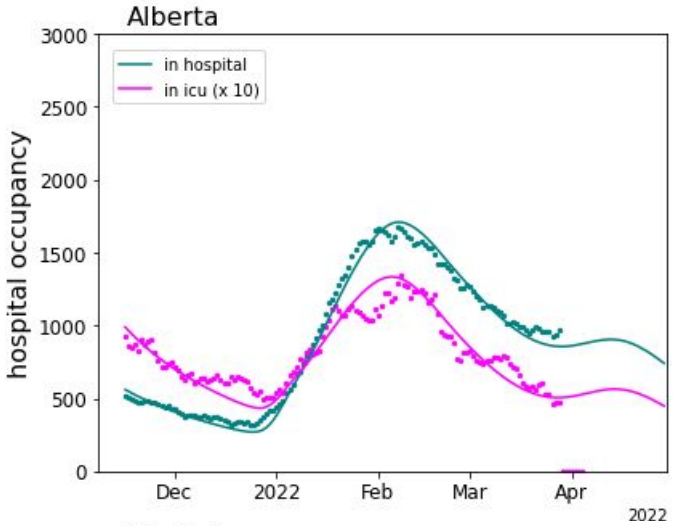
Hospital projections for Provinces

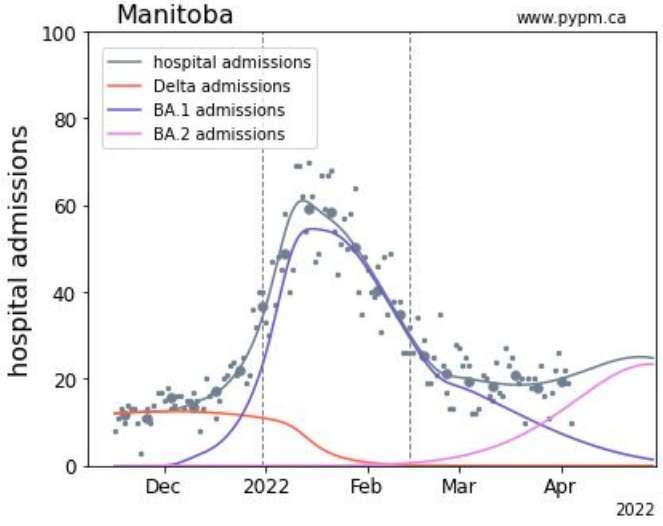
- In place of case data, hospital admission data are used to define the infection model.
- The immunity model is not well established. As a result, **projections are very uncertain**.

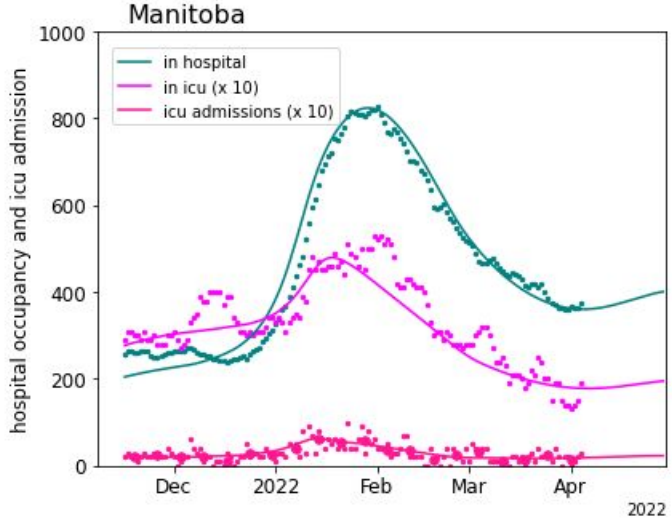


Source (D. Karlen) As in previous reports, the model has no age structure. Two Omicron strains are included (BA.1 includes BA.1.1) with both evading 80% of natural immunity from previous strains and 80% of 2 dose vaccinations. Booster doses are assumed to provide 80% effectiveness against infection. Omicron infections are assumed to produce symptoms with a probability of 60% of that for previous strains. The probability that symptoms lead to hospitalization is 35% of that for previous strains. Vertical lines show fitted dates for transmission rate changes. The larger dots show weekly averages.





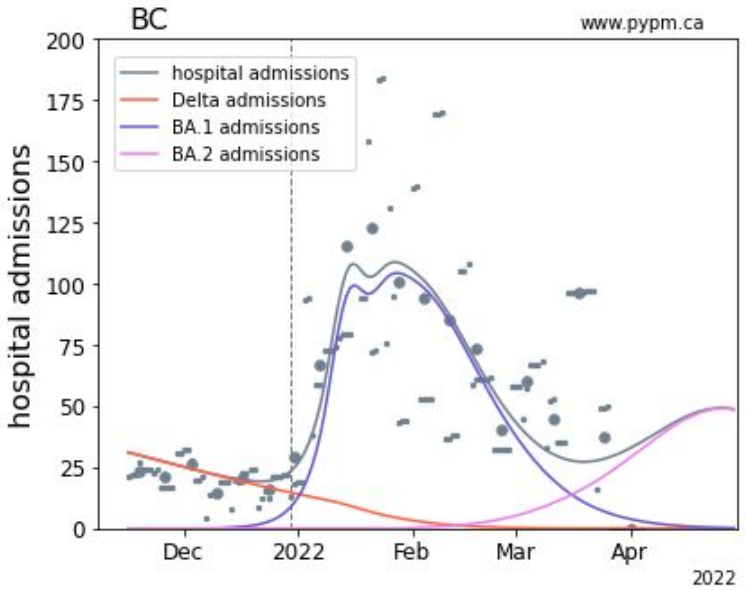


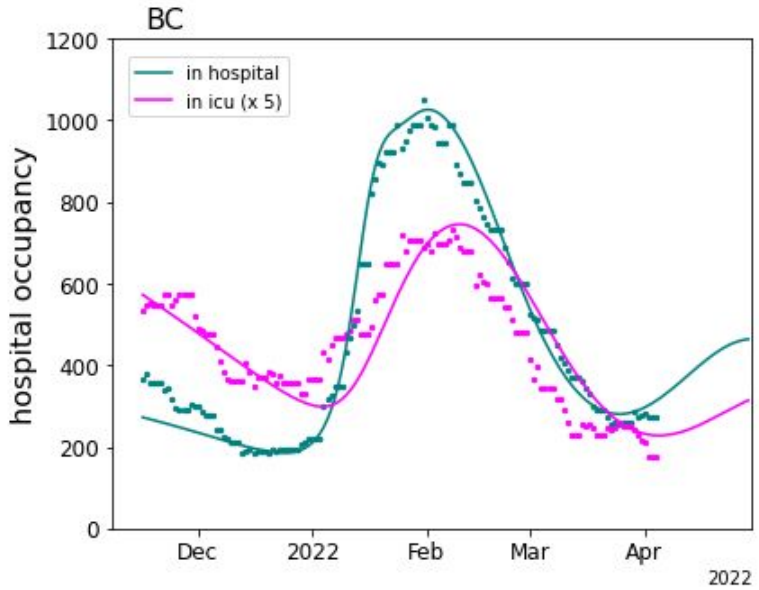


While these projections suggest that BA.2 might produce a smaller wave, that depends crucially on the level of immunity building up in the population.

BC hospital data issue

- Poor quality hospital admission data*: large variance





* Based on the change in reported total number of COVID cases ever in hospital (BCCDC Dashboard), which is updated irregularly across Health Authorities, leading to large under- and over-estimation of new admissions by day.

BA.2 Projections - Modelling

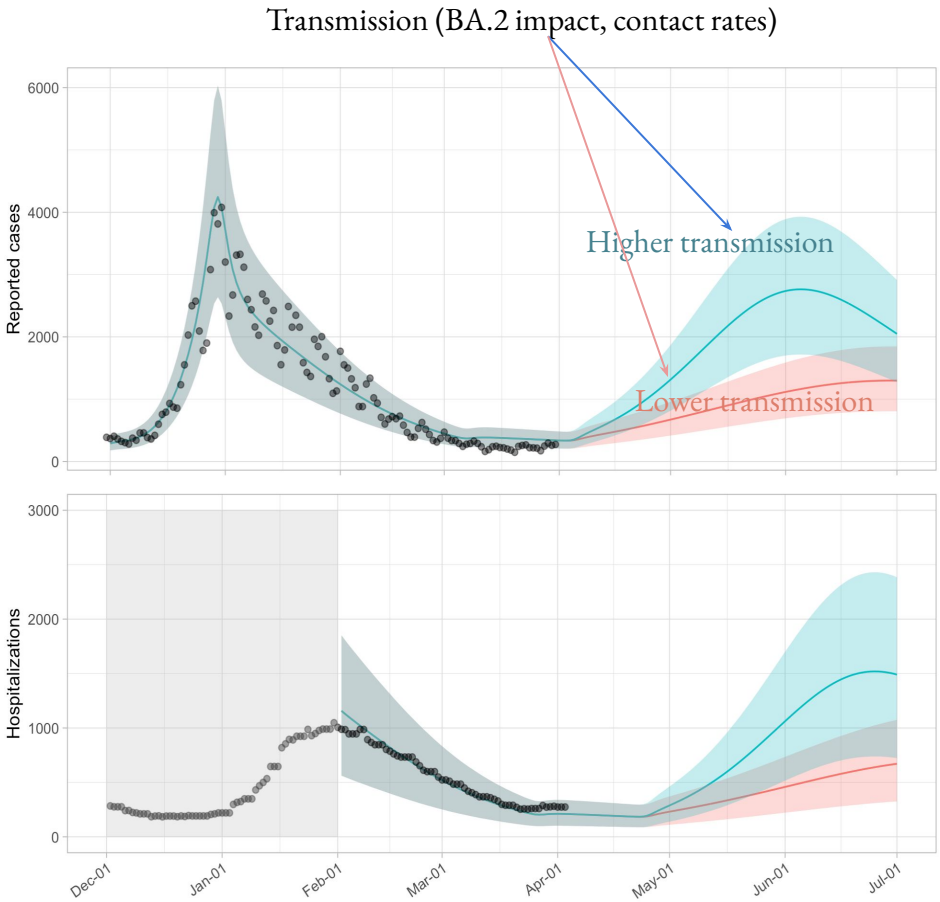
How high will the second Omicron wave be?

Most uncertain point so far in the pandemic for modelling!

Models have many sources of uncertainty. Here we explore just one: how much the combination of BA.2 and population contact patterns (activities, reduced mask use, summer) will affect transmission.

Other uncertainties (variation not shown) include:

- **Immunity** in the population, shaped by:
  - past infection
  - protection from reinfection
  - booster uptake and waning
  - booster efficacy against infection
- Workplace and business measures
- Community contact patterns



[Source: SFU Magpie group]

Key information to project risk, economic, and health care burden

Information	Underlying need and value	Challenges
Serology: how many people had Omicron during the Omicron wave?	Understand **immunity** and interpret reported cases. **Long-term prevalence**: economic and health care burden.	Data exist but recent estimates are not available. (See CITF data.)
Population prevalence: how many Canadians have COVID-19 infection today?	Understand **current risk, transmission** and **immunity**, interpret wastewater and reported cases (now and over time).	Limited testing, making it challenging to scale up from data available (outpatient, workplace, private sector, etc.) to the general population.
Age-specific **efficacy against *infection*** of vaccination and boosters (and its waning)	Understand **transmission, immunity**, future immunity, and **selection** (e.g. emergence of new VOC)	Depends on testing sufficiently to know the numbers of *infections* in boosted and other groups, ideally by time since booster.
Susceptibility to reinfection following breakthrough and non-breakthrough infection	Understand **immunity**, **transmission** - speed & strength of new waves, **long-term prevalence**, **selection** (new VOC)	Relies on knowledge of past infection, which requires testing broadly.
Age-specific **vaccine efficacy against *hospitalization***	Informs projections of **hospitalization** and healthcare use. A small change from 90% to 80% efficacy ~doubles the population at risk.	Data exists in Canada but estimates are not yet available. Available from international sources.

How bad will the BA.2 wave be?

We have little information about the total number of recent infections and the extent of immunity going into the second Omicron wave, making it **challenging to predict the height of the BA.2 wave**.

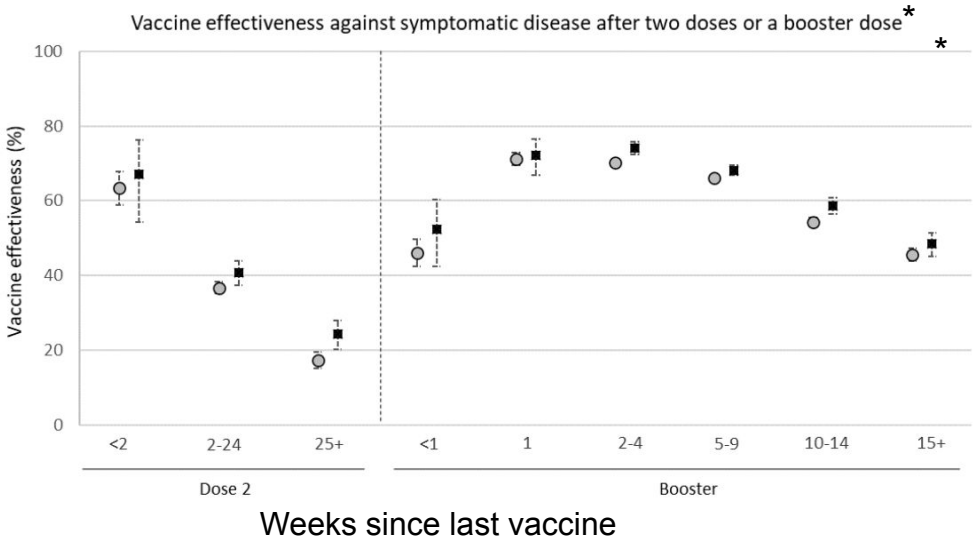
Some jurisdictions like South Africa have seen a much more modest BA.2 wave, while others like the United Kingdom are seeing similar levels of hospitalization as in the BA.1 wave.

Much of this difference depends on the level of immunity that people have when exposed to BA.2, especially in the first line of immune defense (antibodies protecting against infection).

A recent study from England shows that boosters elevate protection against infection but then wane over 3-4 months, with **BA.1 and BA.2 showing very similar trends**.

BREAKING NEWS: BC is now making fourth doses of the COVID-19 vaccine available for seniors over 70, long-term care residents and Indigenous people aged 55 and older, allowing these groups to regain high levels of antibody protection from infection.

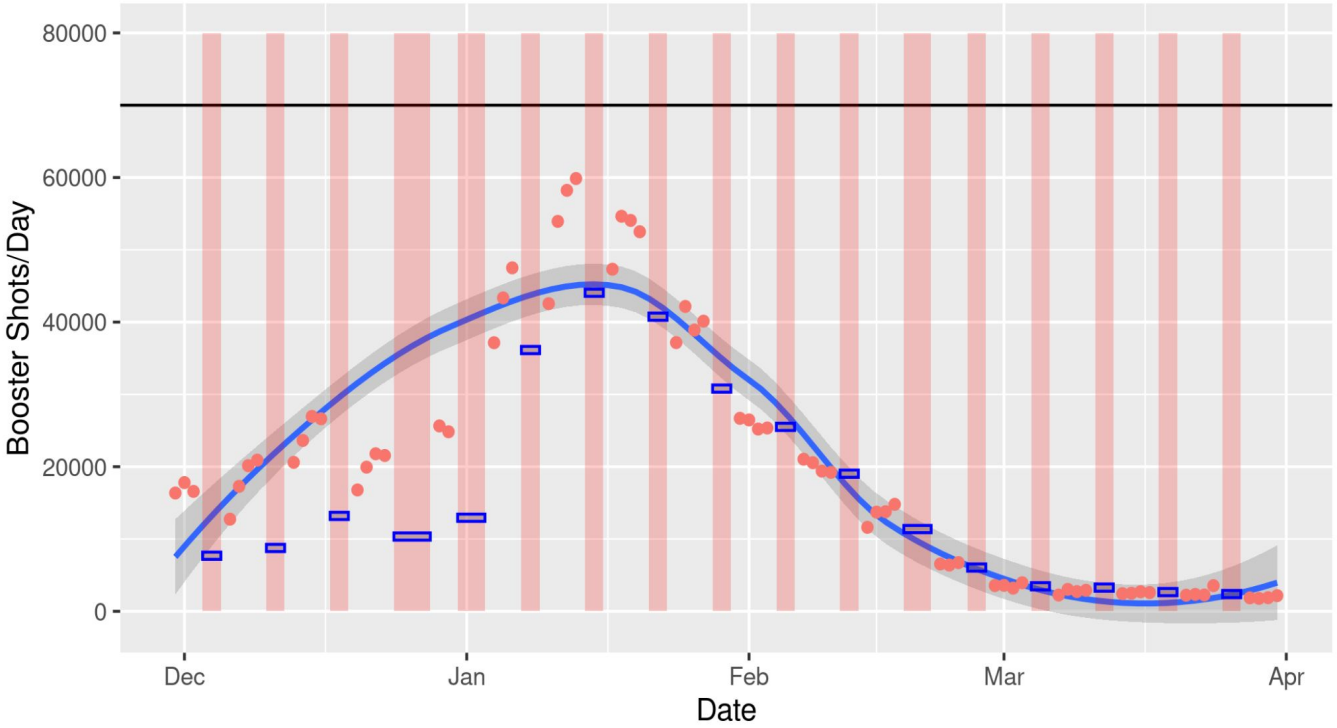
Vaccine effectiveness against symptomatic infection (Kirsebom et al.)



* Reporting mRNA (primarily Pfizer) data

Booster Shot Progress

As reported by day and estimated for weekends and holidays



Data via R Dumont from daily briefings.
Salmon coloured columns are periods where day-specific booster are not available: e.g. weekends & holidays.
Red dots are reported single-day booster #s.
Blue bars are per day mean boosters where number was reported for multiple days (total/# of days).
Horizontal line is 70K/day, the value assumed in 14 Jan 2022 Epi Modelling.

Booster shots are now about ~2100/day

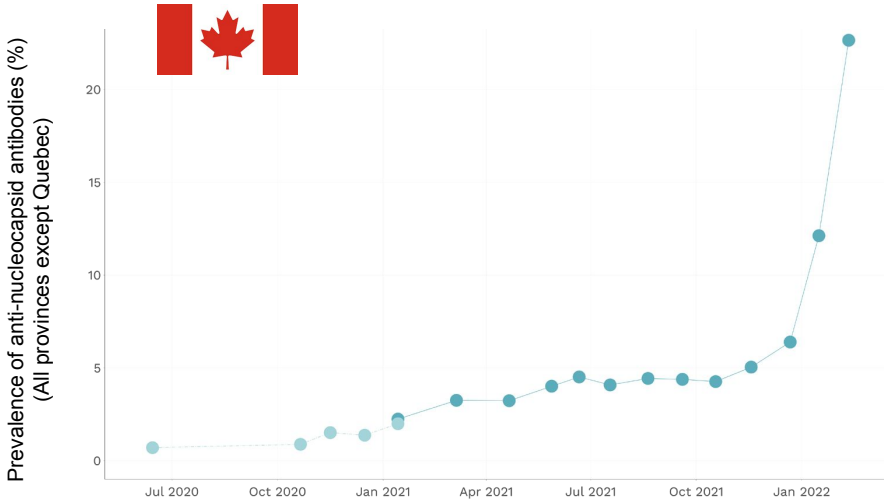
BCCDC data suggests ~52% of adults (18+) are **not boosted**, with less coverage in younger populations (33% boosted in 12-17 y/o)

Variable BC booster uptake is concerning; important inequalities by age, location, etc.

Israel and Germany reports ⬇️benefit in months after booster.

Estimating the number of infections occurring during the omicron wave

- Serological surveys measure anti-COVID antibodies in the blood.
- Current vaccinations target only the spike protein of the virus, so people who have been vaccinated but not infected have antibodies to spike only. On the other hand, people who have been infected have antibodies to spike **and** nucleocapsid proteins of the virus.
- The Canadian Immunity Task Force (CITF) and Canadian Blood Services routinely test blood from donors to estimate the prevalence of antibodies and thus estimate the prevalence of prior infection.



- Across Canada, nearly 20% of all blood donors were newly infected between December 2021 and mid-February 2022.
- This catches the start of the Omicron wave, but excludes people who first developed antibodies after February 15.
- Seroprevalence in BC increased from around 5% in Oct-Nov 2021 to 25-30% in mid-February 2022.

Source: CITF February report on blood donors
https://www.covid19immunitytaskforce.ca/results-blood-donation-organizations/

Estimating the number of infections occurring during the omicron wave

Taking these changes in serology at face value, approximately 1 million people in BC were infected within a short (~2 month) period, but there are caveats with this data:

- Children under 17 are not eligible to donate blood. Other serology studies from 2020-21 (pre-Omicron) generally showed lower prevalence for this age group compared to adults.
- Blood donors are generally representative of urban rather than rural populations. Related: Metro Vancouver usually shows a slightly higher prevalence of antibodies than the province as a whole.
- Because blood donations can only be made at 56-day intervals, each week of data in January/February is from a different group of donors. Because of this, the estimated prevalence does not increase smoothly from week to week. As more weeks of data are released from the Canadian Blood Services / Canadian Immunity Task Force project, we will get a clearer picture.

The CITF website contains a lot more information about how infection and vaccination have changed the prevalence of antibodies to SARS-CoV-2 in Canada. Recommended!

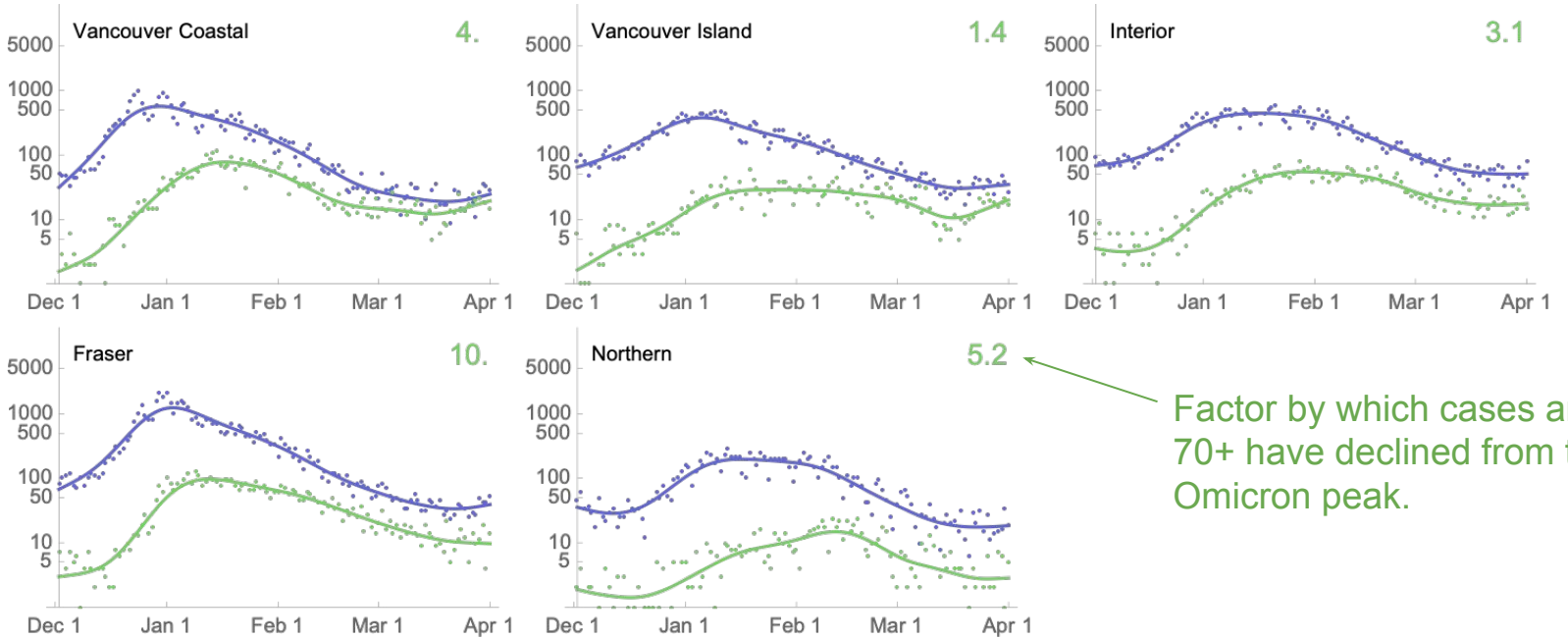
Source: CITF February report on blood donors
https://www.covid19immunitytaskforce.ca/results-blood-donation-organizations/

Key messages

State of the Omicron wave in BC:

- While BA.1 is receding, **BA.2 is on the rise, with recent upticks in reported cases among 70+ and the number of people in hospital.**
- BC faces a great deal of uncertainty about the height of the second Omicron wave, depending on:
  - Unknown number of recent infections – **uncertain immunity**
  - Unknown strength and time frame of waning of Omicron-based immunity – **uncertain immunity**
  - Unknown risks of severe and long-term COVID, especially with different individual histories of vaccination, infections, and risk factors – **uncertain severity**
  - Unknown responses to lifting of public health measures – **uncertain contact rates**
  - Changing and inconsistent data streams – **uncertain infection rates**
- Modelling suggests, however, that given current high levels of immunity, the BA.2 wave has started, but its height and duration are highly uncertain.
- New announcement of further booster shots for potentially vulnerable populations should reduce health impacts of the second Omicron wave

APPENDIX: Age-corrected case counts by Health Authority



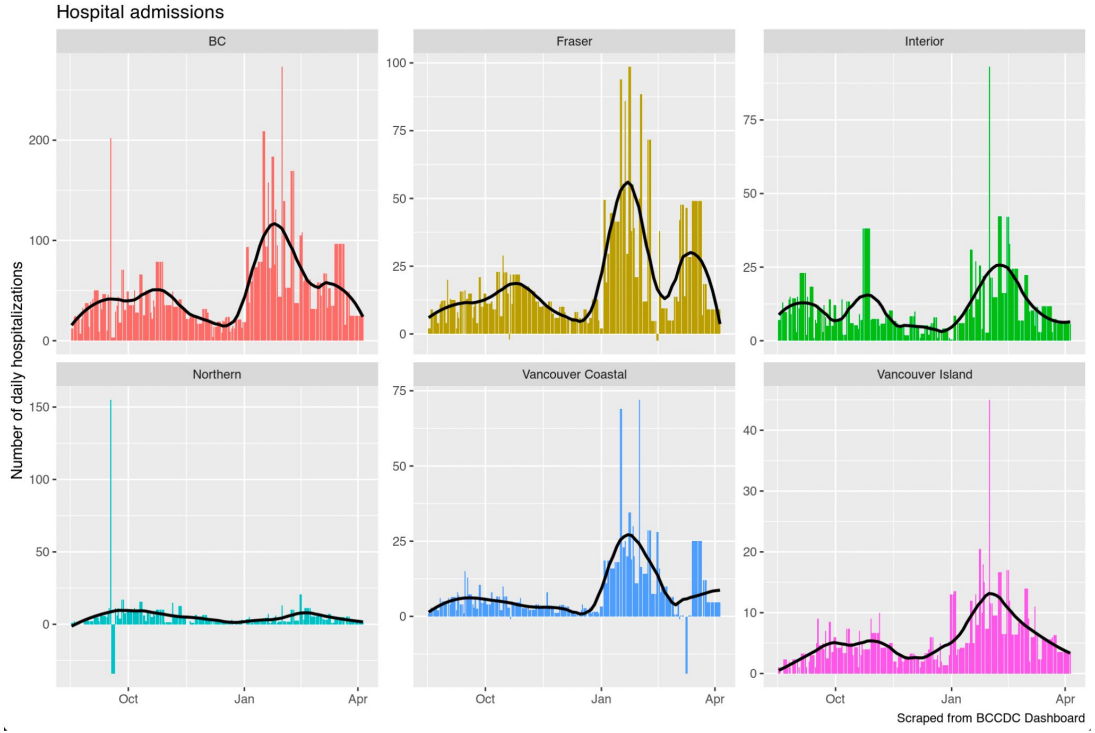
<70 (blue)
70+ (green)

Factor by which cases among 70+ have declined from the Omicron peak.

→ Significant rise in cases among those 70+ in age seen in Vancouver Coastal and Vancouver Island Health Authority, with other Health Authorities showing no clear trend.

Source (S. Otto) New cases per day in 10-year age groups were downloaded from the BCCDC COVID-19 data portal (17 March). Cubic spline fits to log-case data were obtained (curve) and estimates for those <70 obtained by applying the fits for those 70+, shifted up to match the projection for that age class on 21 December 2022 when testing limits were initially reached in many parts of the province (black curve). *Linear regression through log case counts among 70+ from last 14 days of data.

APPENDIX: Hospital admissions



Hospital admissions data is an important near real-time measurable, especially when reliable case information are lacking.

Clean and back-corrected hospital admissions data is not publicly available, and scraped admissions data is very noisy, as shown here.

Providing updated and historically-corrected admissions data is an important component for long-term surveillance and modelling.

Source (J. Bergmann) Data from BCCDC Dashboard.