COVID Model Projections

November 23, 2022

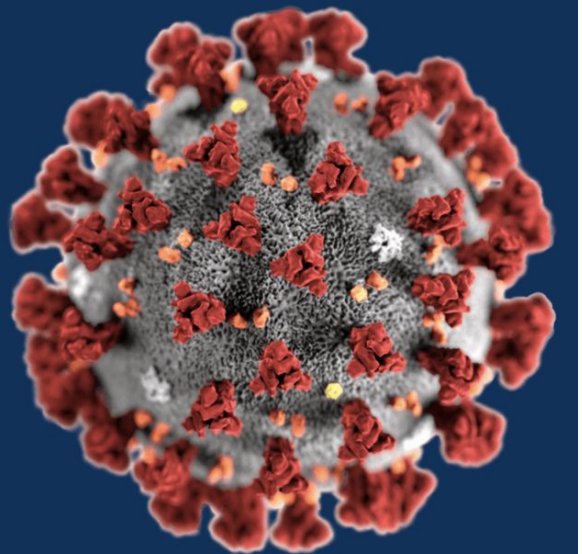
BC COVID-19 Modelling Group

@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

Contents of this report:

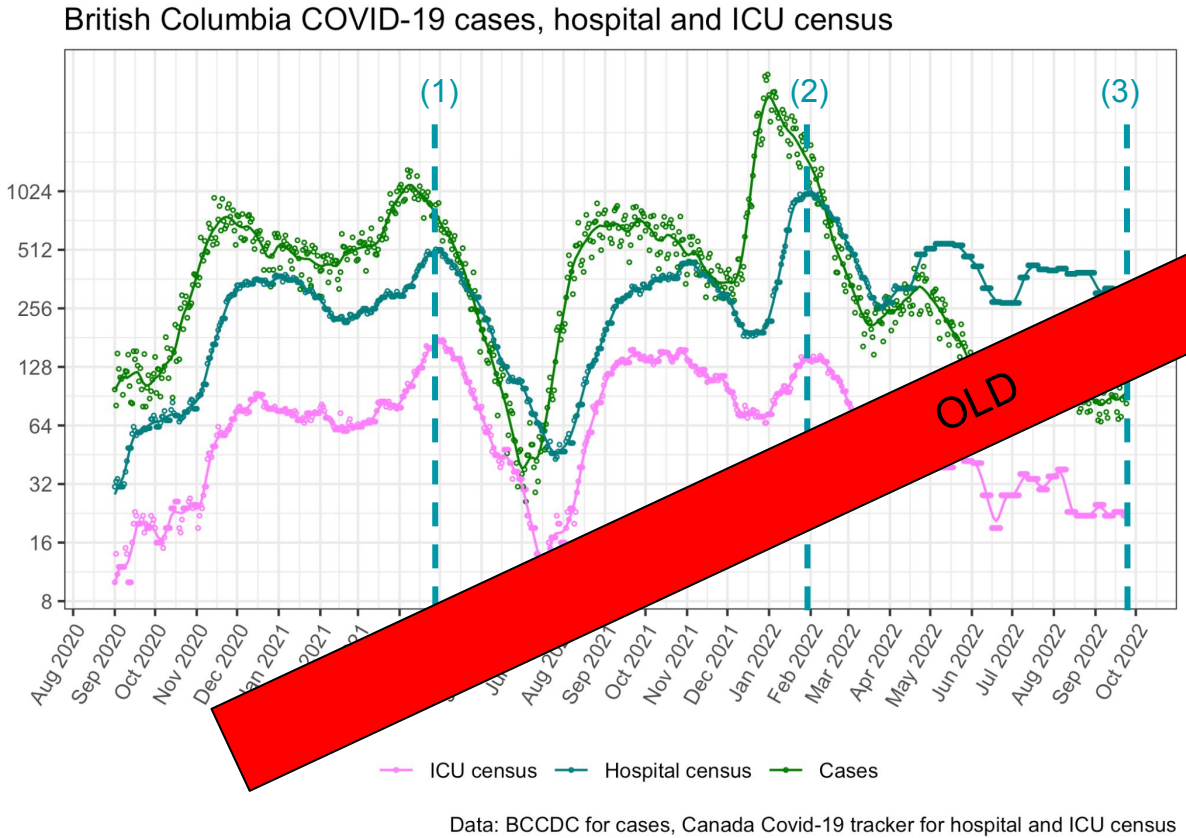
- Current COVID-19 trends in BC
- The persistent Omicron BA.5 wave
- Interpretation of COVID-19 hospital admission data:
  - Evidence for waning of immunity
  - Short-term projections

OLD

Summary: The BA.5-driven [illegible]wave persists with high rates of infection. The prolonged nature of the [illegible]ve is consistent with waning of immunity from infections and vaccinations early [illegible]ar. Future projections predict a rise in cases, even without new variants that [illegible]r able to evade immunity. Underreporting of cases is extremely high, with ~100 [illegible]more infections currently than reported cases.

Current COVID-19 trends in BC

Hospital trends in BC



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Reported cas… the number of… hospital and the n… have remained …evels for three months …ppendix for data on admissions and deaths).

Number in hospital with COVID-19:

Pre-Omicron
- (1) Highest = 515 (28 April 2021)

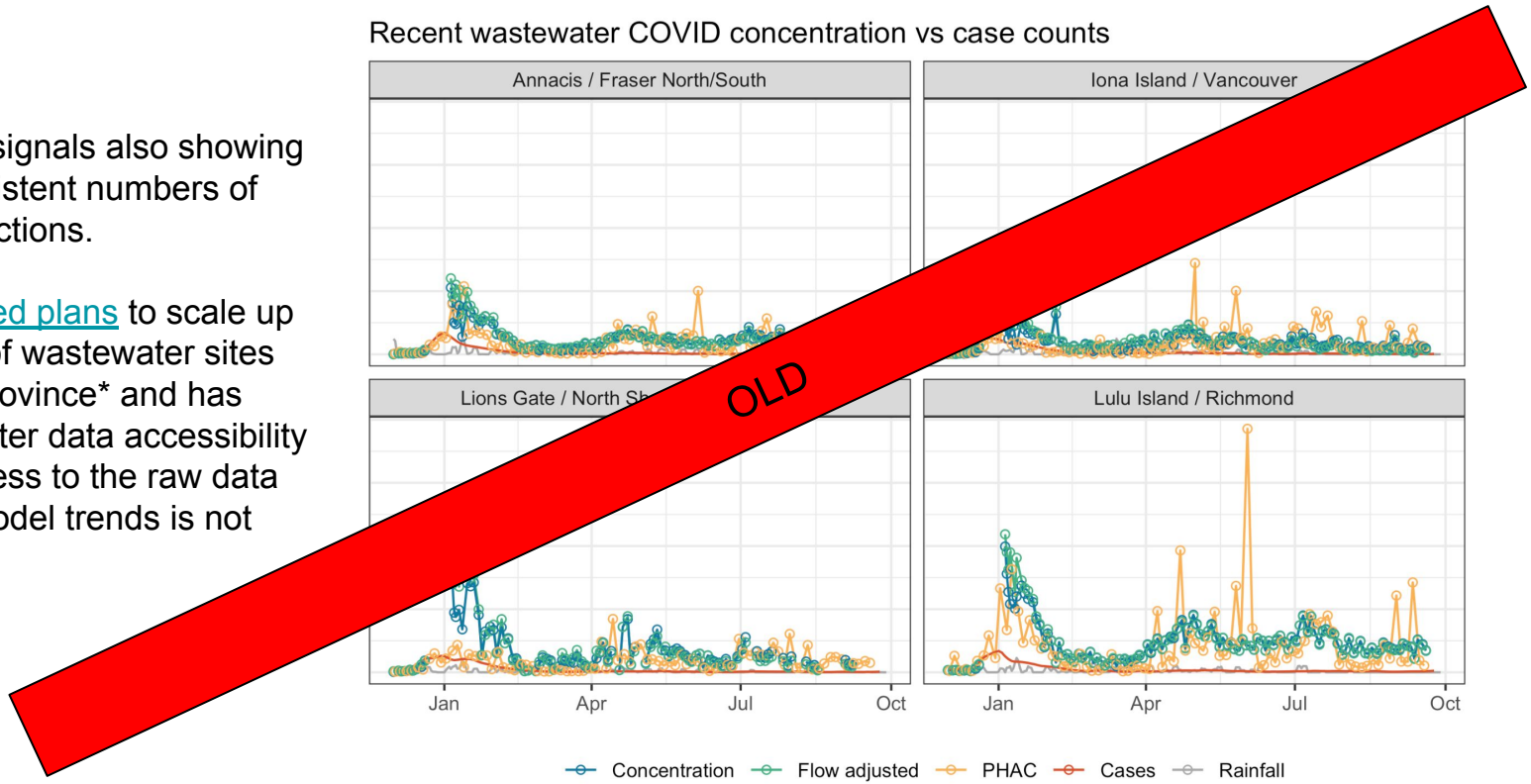
Omicron wave:
- (2) Highest = 1038 (31 January 2022)
- (3) Current = 367

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. How hospitalizations and deaths are attributed to COVID-19 changed in BC on April 2, 2022.

Wastewater trends in Metro Vancouver

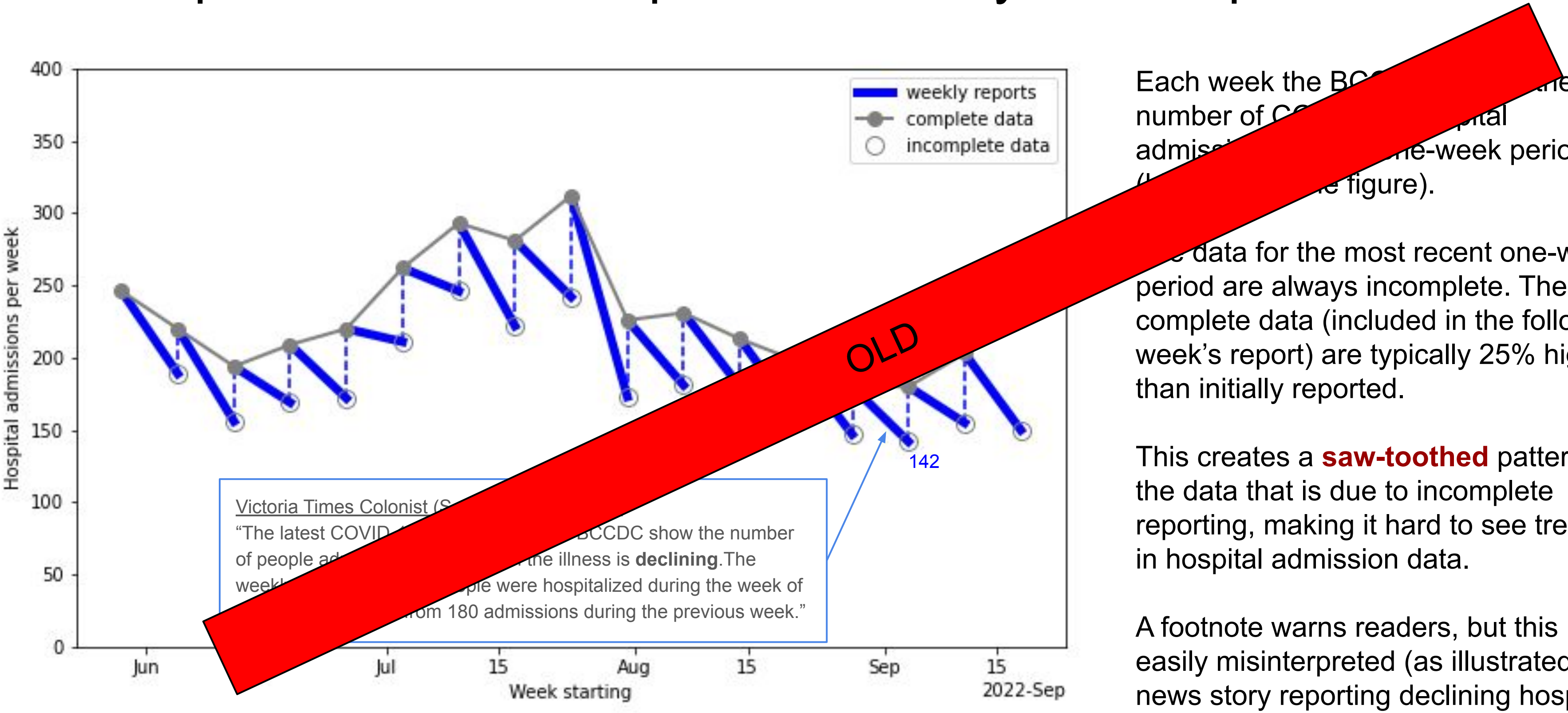
Wastewater signals also showing signs of persistent numbers of Omicron infections.

BC announced plans to scale up the number of wastewater sites across the province* and has promised better data accessibility (to date, access to the raw data needed to model trends is not available).



Source (J. Bergmann) Data from Metro Vancouver's Testing for the COVID-19 VIrus in Wastewater. *Adding Comox, Victoria, Nanaimo (VIHA), Kelowna, Nelson, Kamloops (IHA), and Prince George, Terrace, Fort St John, Prince Rupert (pending ongoing discussions, NHA)

BC hospital admissions reports are easily misinterpreted



Each week the BC… the number of C… pital admis… e-week periods (… e figure).

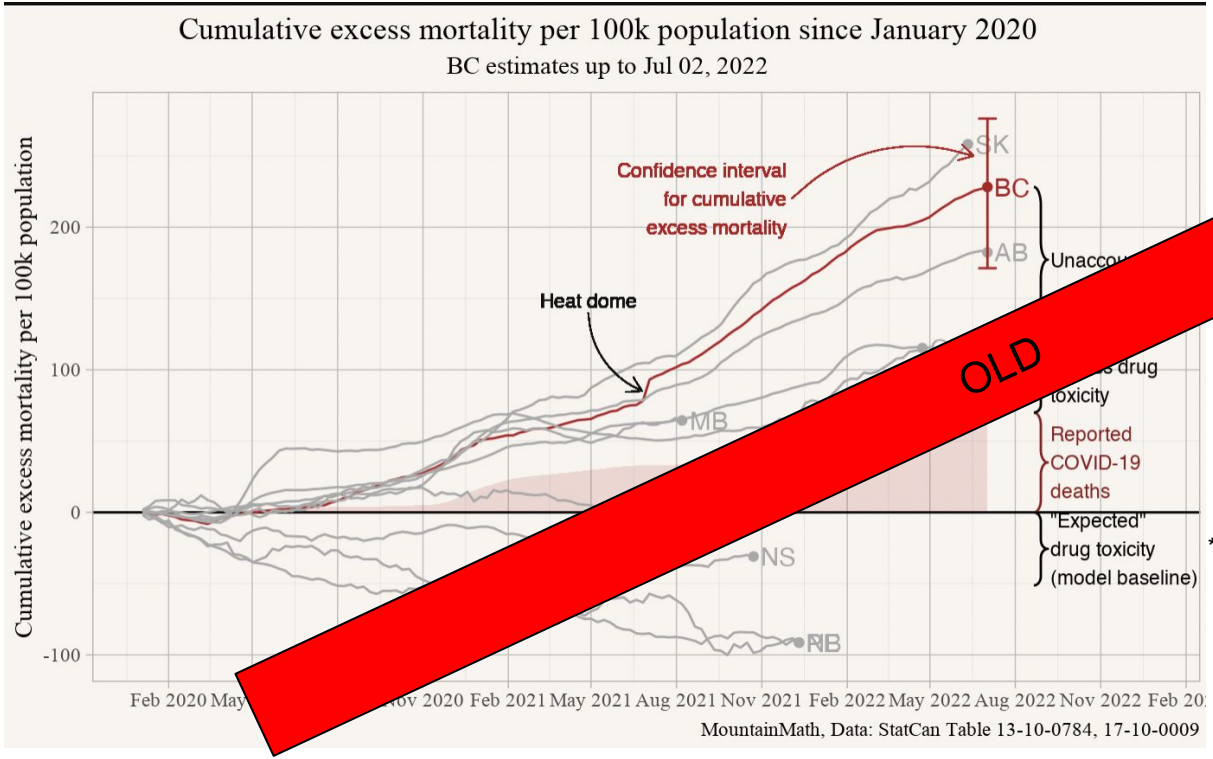
… data for the most recent one-week period are always incomplete. The complete data (included in the following week's report) are typically 25% higher than initially reported.

This creates a **saw-toothed** pattern in the data that is due to incomplete reporting, making it hard to see trends in hospital admission data.

A footnote warns readers, but this is easily misinterpreted (as illustrated in a news story reporting declining hospital admissions when they were steady).

Source: BCCDC COVID-19 Data: http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data

Excess mortality update



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Excess mortality accounts for all causes of mortality above the expected based on previous years.

Only half of excess mortality since the start of the pandemic is accounted for in COVID statistics.

What about the unaccounted deaths?

COVID-19 can cause a heightened health risk long after the 30-days currently used in BC to define COVID-related deaths.

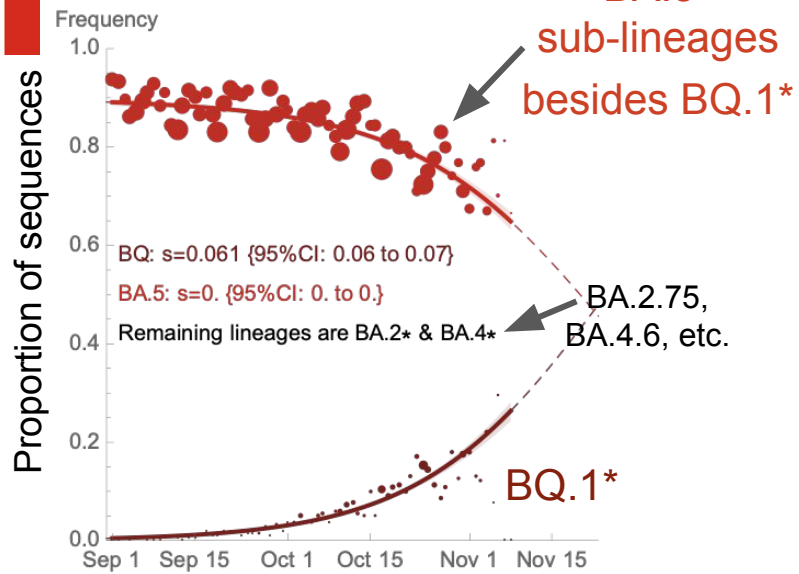
For example, Xie et al. studied US veterans and found a 55% higher risk of a major cardiovascular event (e.g., heart attack) in the year after COVID.

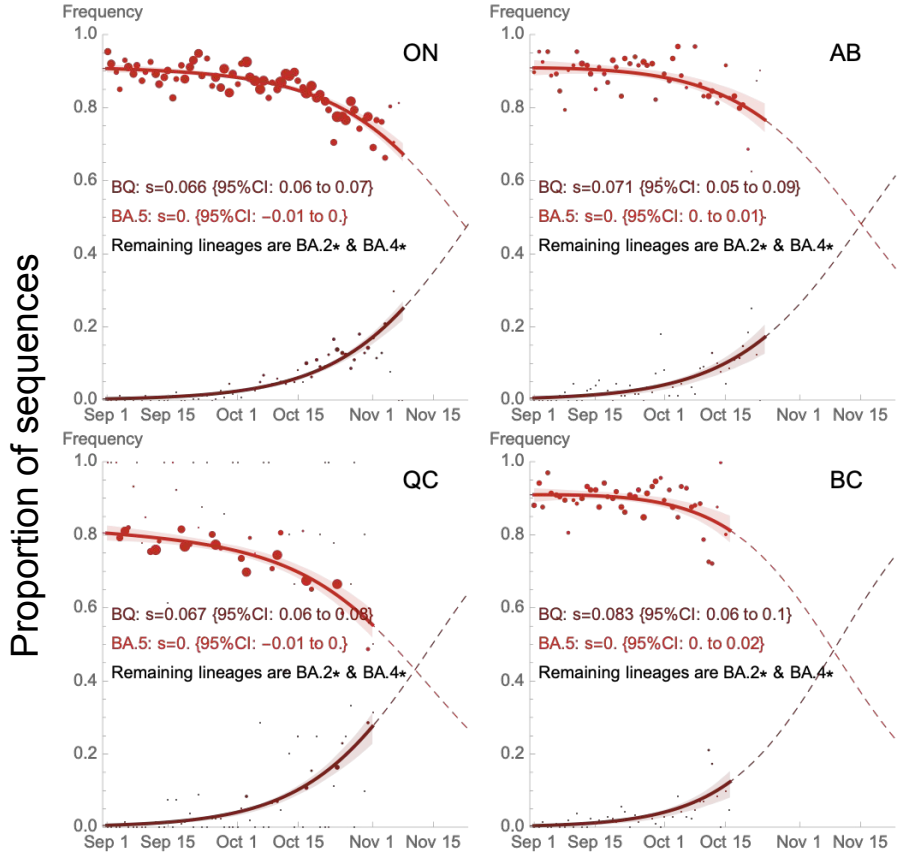
BC is likely substantially undercounting total deaths due to COVID.

Source (J. Bergmann) Data from StatCan. The model baseline consists of "expected" deaths based on the previous four years, including drug toxicity and other causes (* indicates the levels of mortality due to drug toxicity in the four previous years). See May 19 2022 report (slide 9) for more details on excess deaths.

The rise of BQ.1

Spread of BQ.1* sub-lineages in Canada



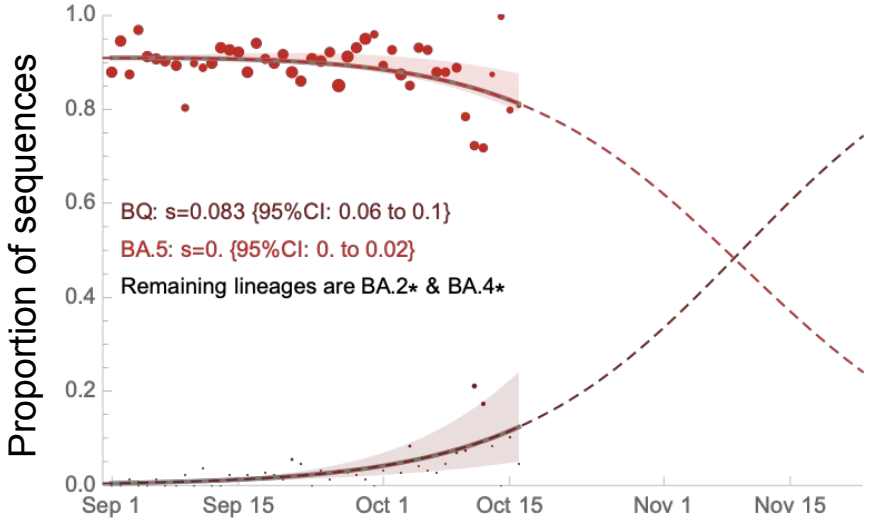


BQ.1* lineages (particularly, BQ.1 and BQ.1.1) are rising in frequency across Canada, with a current estimated frequency of ~50%.

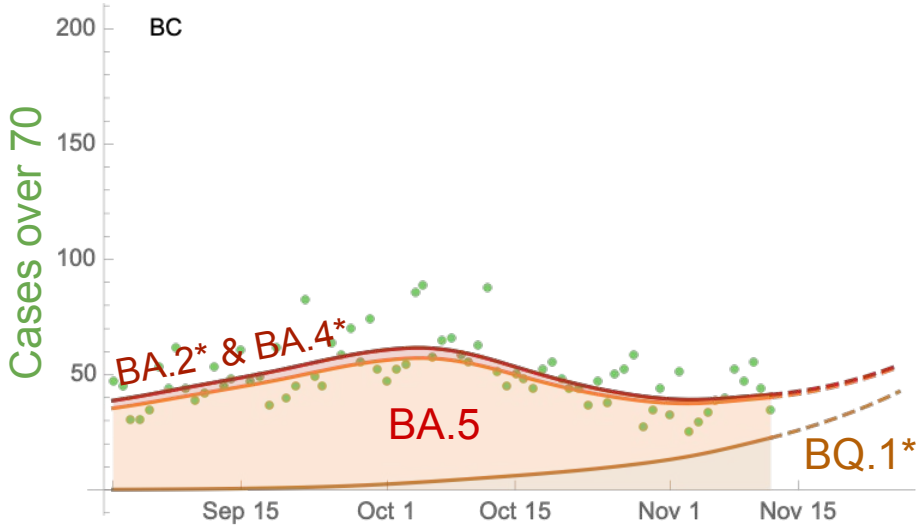
Source (S. Otto) Canadian metadata was downloaded from GISAID for the GRA clade.

What does this imply for case numbers?

Fitting models of selection allows us to estimate frequency changes among variants.



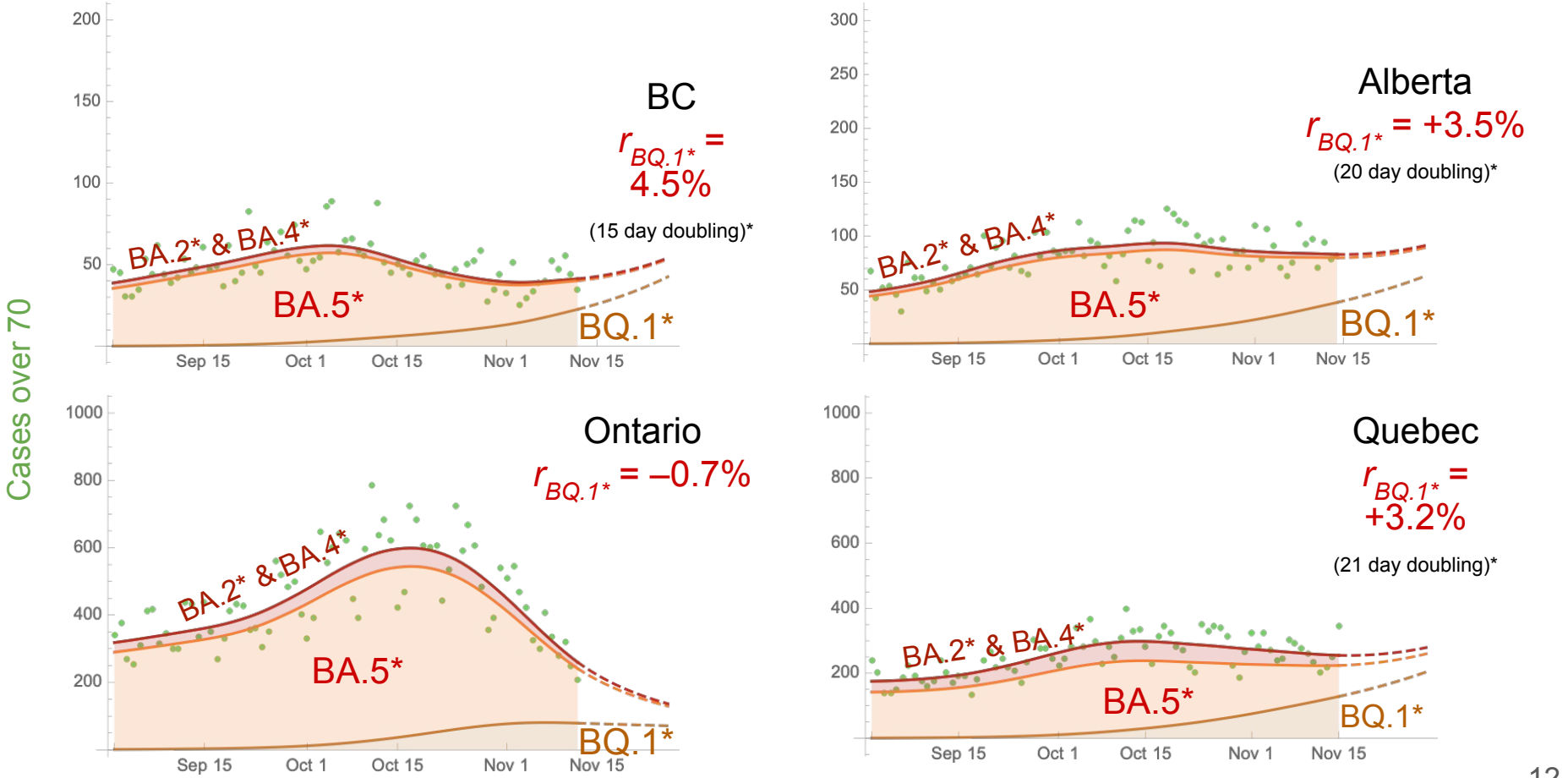
Multiplying by the # of cases in those over 70 allows us to **estimate** growth in numbers of each Omicron sublineage, while reducing extent of underreporting.



→ BQ.1 rising in frequency in BC while remaining lineages are on the decline.

Source (S. Otto) Canadian metadata was downloaded from GISAID for the Omicron GRA clades. 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 intervals.

The BQ.1* Omicron Wave



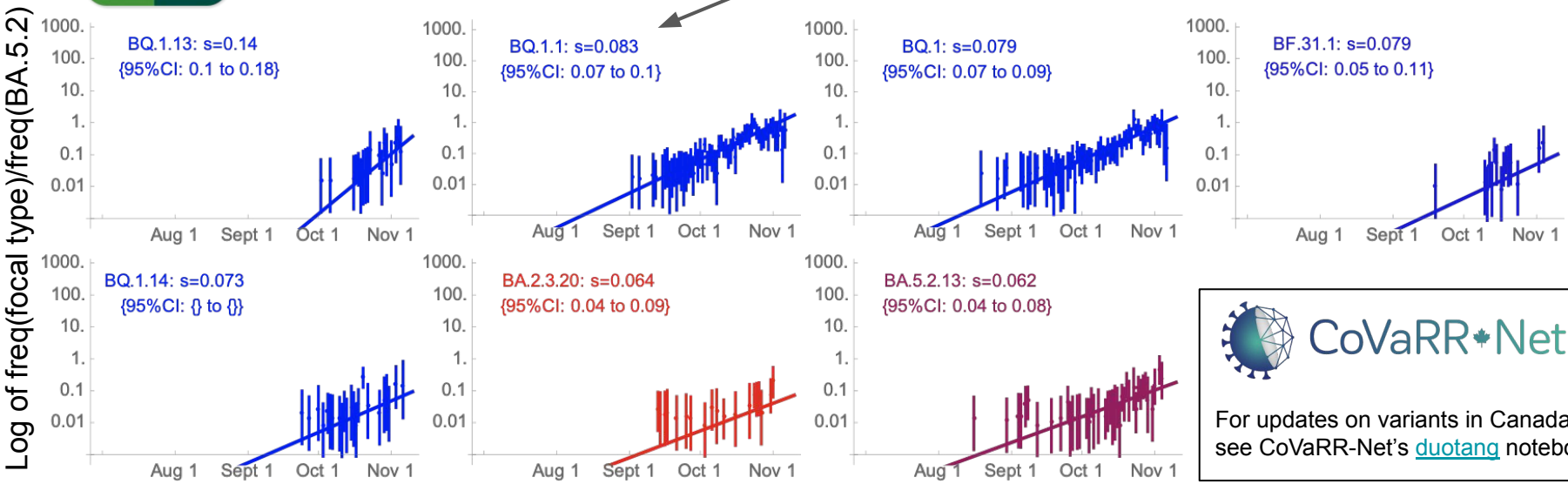
* Instantaneous estimates of growth rate, *r*, and doubling times for BQ.1* (mainly BQ.1 and BQ.1.1). These rates change with changing immunity and with protective health measures, both mandated and voluntary, to reduce transmission (e.g., wearing effective masks, increasing ventilation, and avoiding crowded indoor spaces)

Spread of Omicron sub-lineages in Canada

Looking at the many different sub-variants separately, the three fastest growing lineages are BQ.1* sub-lineages, with selection coefficients between *s* ~ 8-14%. Other lineages showing rapid growth of also carry mutations at sites known to reduce the efficacy of neutralizing antibodies (next slide) [BA.5* sub-lineages: BF.31.1 and BA.5.2.13; BA.2* sub-lineage: BA.2.3.20].

GISAID

Selection (*s*): Daily rate of growth relative to BA.5.2



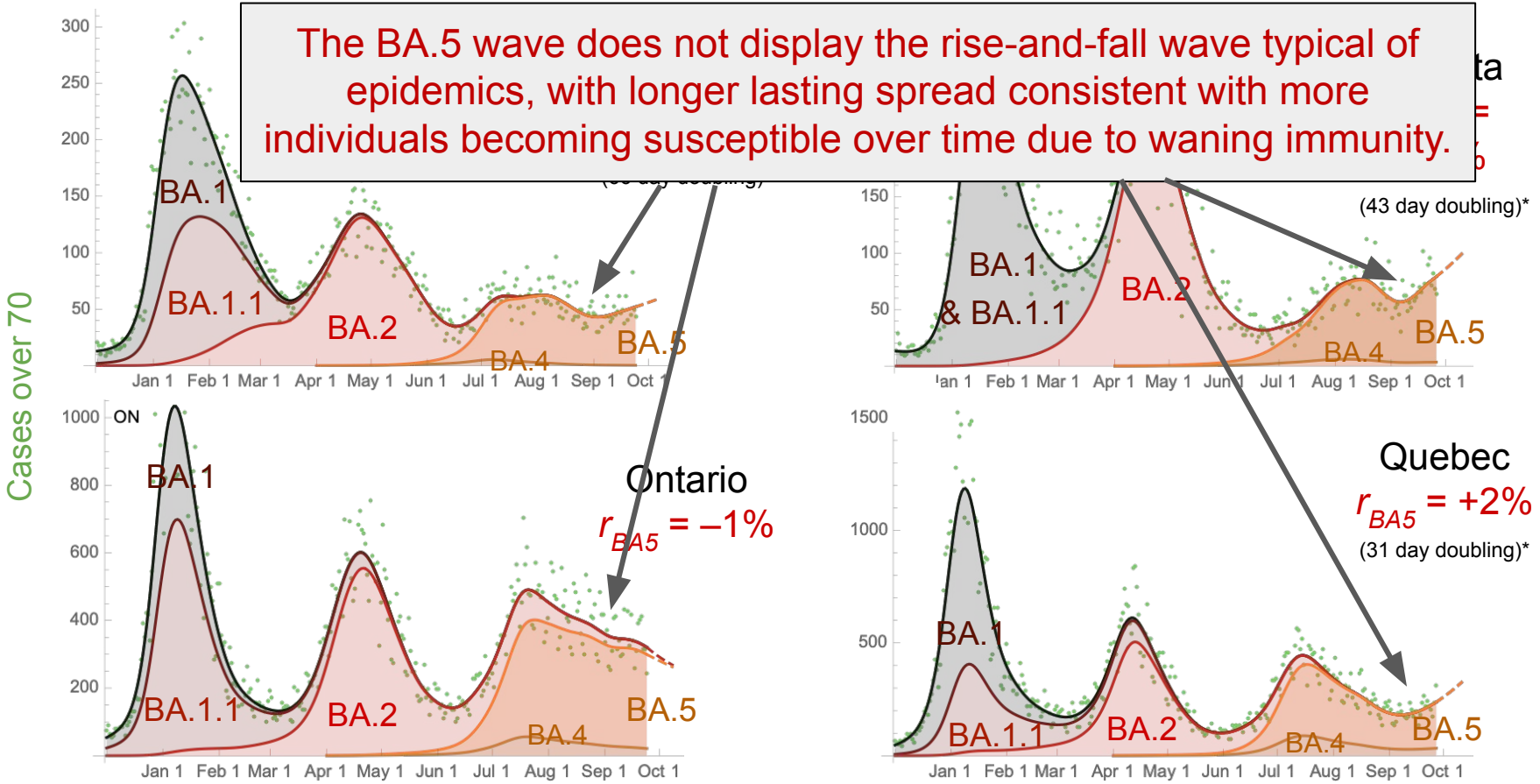
CoVaRR-Net

For updates on variants in Canada, see CoVaRR-Net's duotang notebook.

Source (S. Otto) See previous page. Each lineage is plotted separately relative to BA.5.2 on a log scale. On this logit plot, the slope measures selection for a variant relative to BA.5.2.

The Third Omicron Wave

The BA.5 wave does not display the rise-and-fall wave typical of epidemics, with longer lasting spread consistent with more individuals becoming susceptible over time due to waning immunity.



* Instantaneous estimates of growth rate, *r*, and doubling times for BA.4 & BA.5 (mainly BA.5). These rates change with changing immunity and with protective health measures, both mandated and voluntary, to reduce transmission (e.g., wearing effective masks, increasing ventilation, and avoiding crowded indoor spaces)

Dynamic immunity and new variants

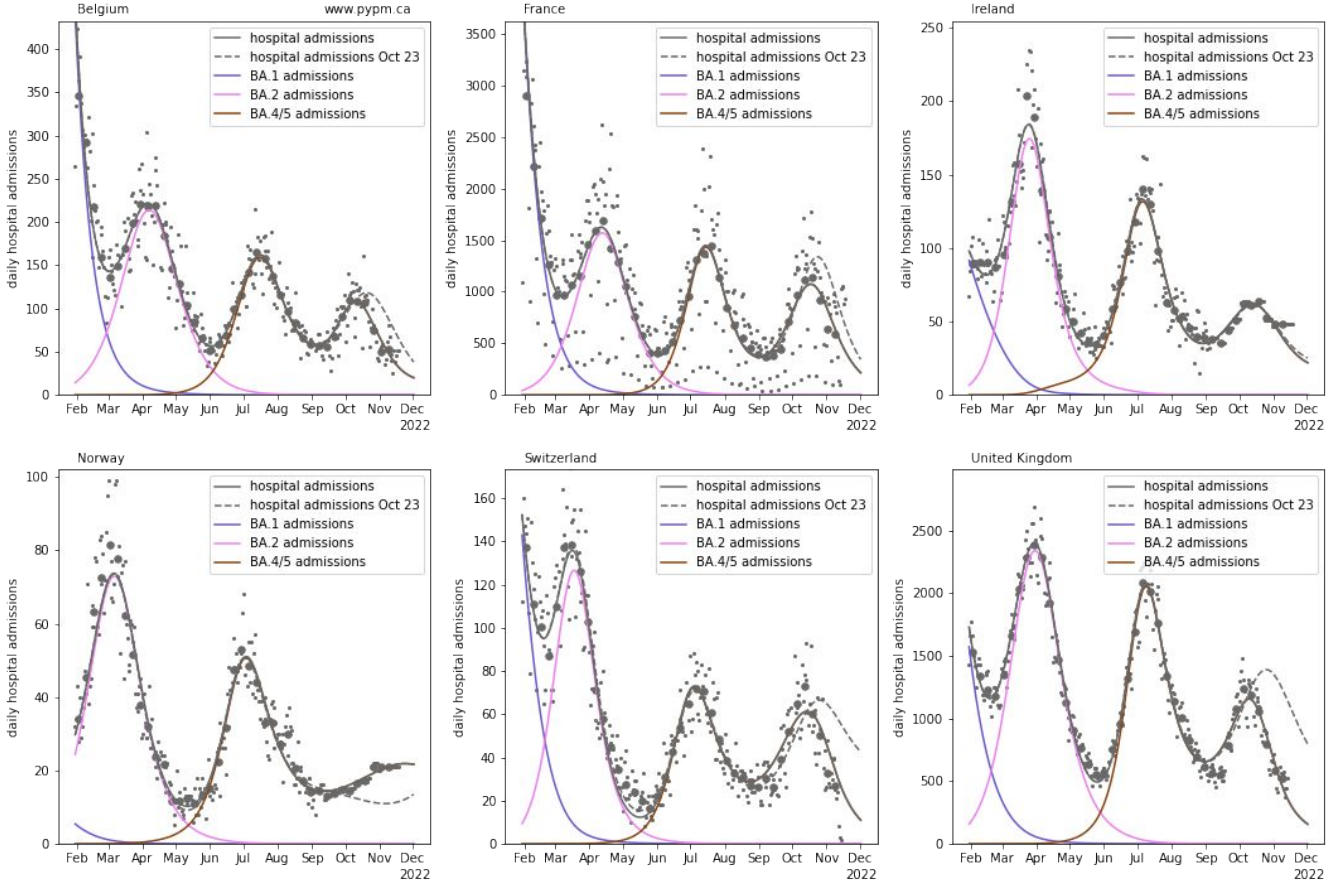
Waning immunity and vaccination

As introduced in our previous reports, population immunity dynamics can be deduced directly from population-level data. Both the initial immunity and the rate that immunity grows are determined by the rise and fall of the spring/summer BA.2 wave. Since hospital admission data are used, the number of new immunity-generating infections for every hospital admission is inferred. Transmission rates are assumed to be constant.

Our last report used this analysis to show that waning of immunity was causing a resurgence of COVID-19 in Europe, and the same effect was seen in Canadian provinces. As a result, BA.5 was the dominant strain for both the 3rd and 4th omicron waves in 2022.

Since our last report, the resurgence due to waning has turned around, as a result of additional natural and vaccination immunity. In Belgium, Switzerland, and the UK, recent rates of vaccinations have exceeded the rate of infections inferred from the model. The additional immunity from recent vaccinations are now included in the models.

Model fits to hospital admission data in Europe



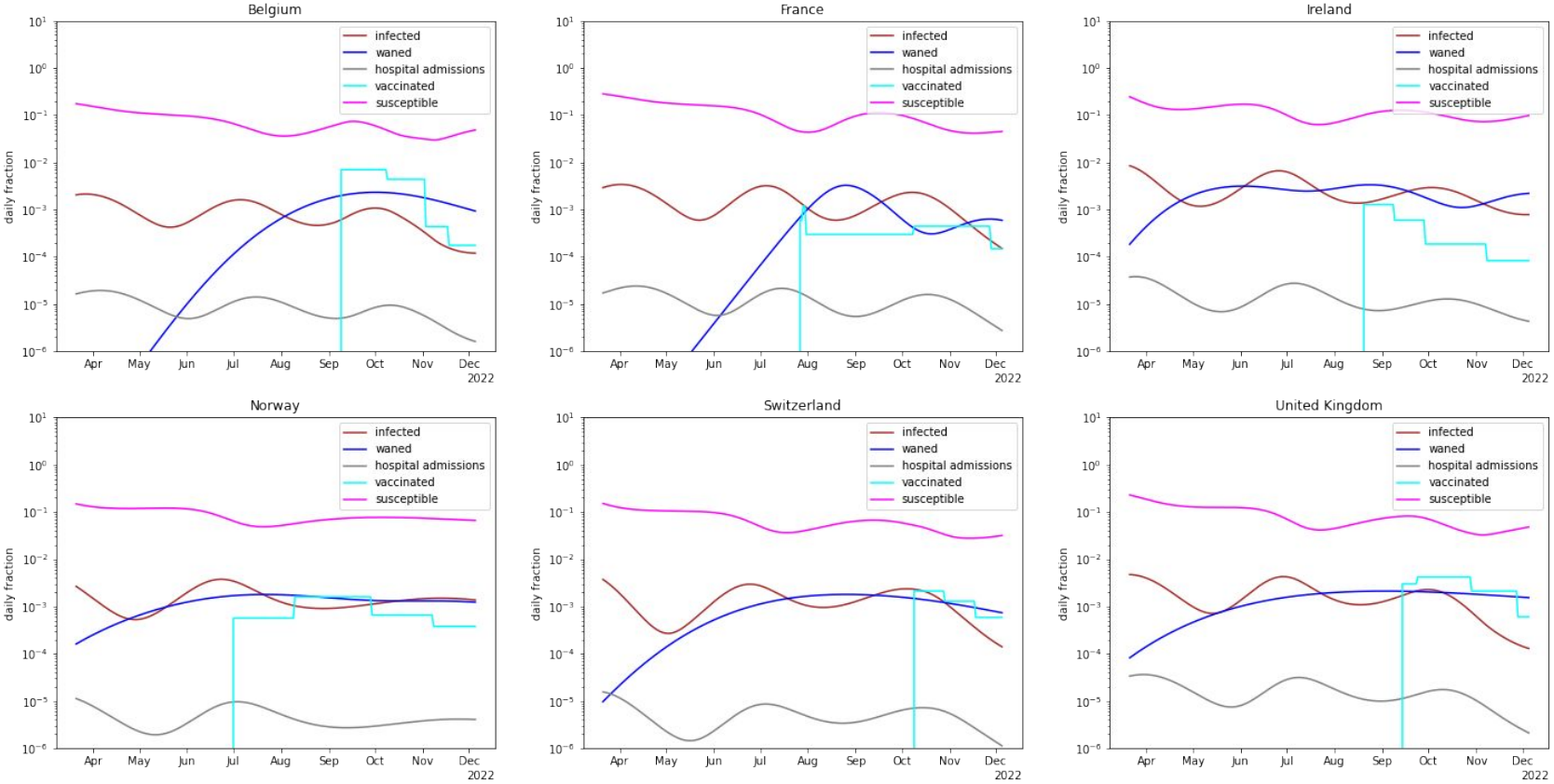
The daily (small dots) and weekly average (large dots) hospital admissions are compared to model fits (solid lines). The models have three omicron strains, each having constant transmission rate. Immunity parameters were set from the shape of the second wave (BA.2).

Waning is implemented as a gamma delay function, with three free parameters in the fits.

The model shown by the dashed curve was produced on October 23, prior to including the recent vaccination immunity in the model. To achieve good fits to Belgium, Swiss, and UK data, the model requires vaccination to be included.

Source (D. Karlen) See www.pypm.ca. Data from European COVID-19 Forecast Hub and Our World in Data

Recent vaccination rates, and inferred infection and waning rates



Source (D. Karlen) See www.pypm.ca. Data from ECDC vaccine tracker.

Dynamic population-level immunity and new variants

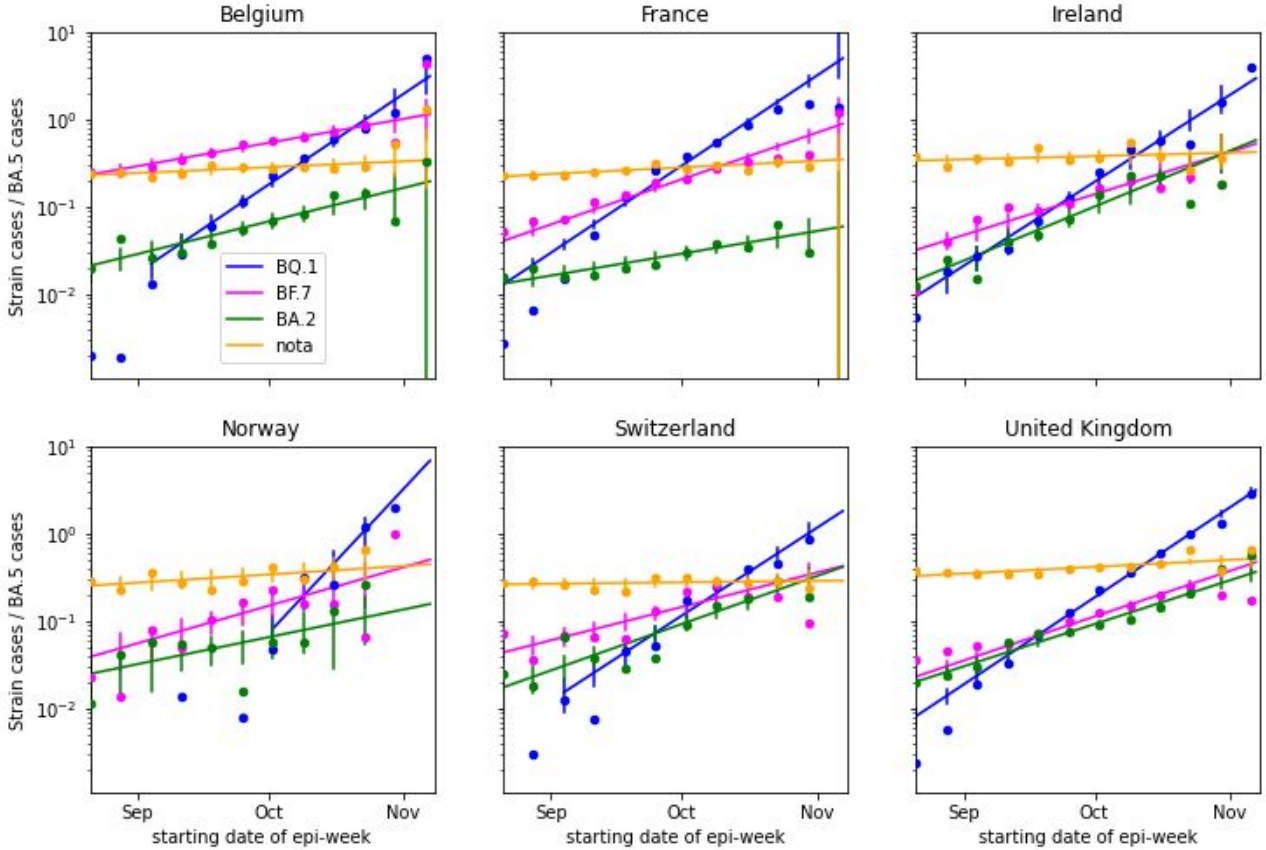
In 2020 and 2021, the susceptible fraction was large and roughly constant. With this static population-level immunity, cases in a given region would grow or decline exponentially at a constant rate over substantial periods of time, corresponding to a constant growth rate, r (% per day).

- Variants of concern emerged with a faster growth rate. The ratio of new variant to original strain cases would grow exponentially with a rate given by the selection coefficient, s (% per day), being the difference of the two growth rates.

With continued vaccinations and large number of infections, the susceptible fraction is now much smaller. This leads to highly dynamic population-level immunity, and as a result the growth rate is no longer constant. In absence of waning, the growth rate, r, reduces each day thanks to recent infections. Immunity waning causes the growth rate to increase.

- A variant that even partially evades immunity would have a growth rate that is affected less by population-level immunity dynamics. A constant selection coefficient would be a sign that population immunity is robust against the new variant.

Selection coefficient analysis for new variants

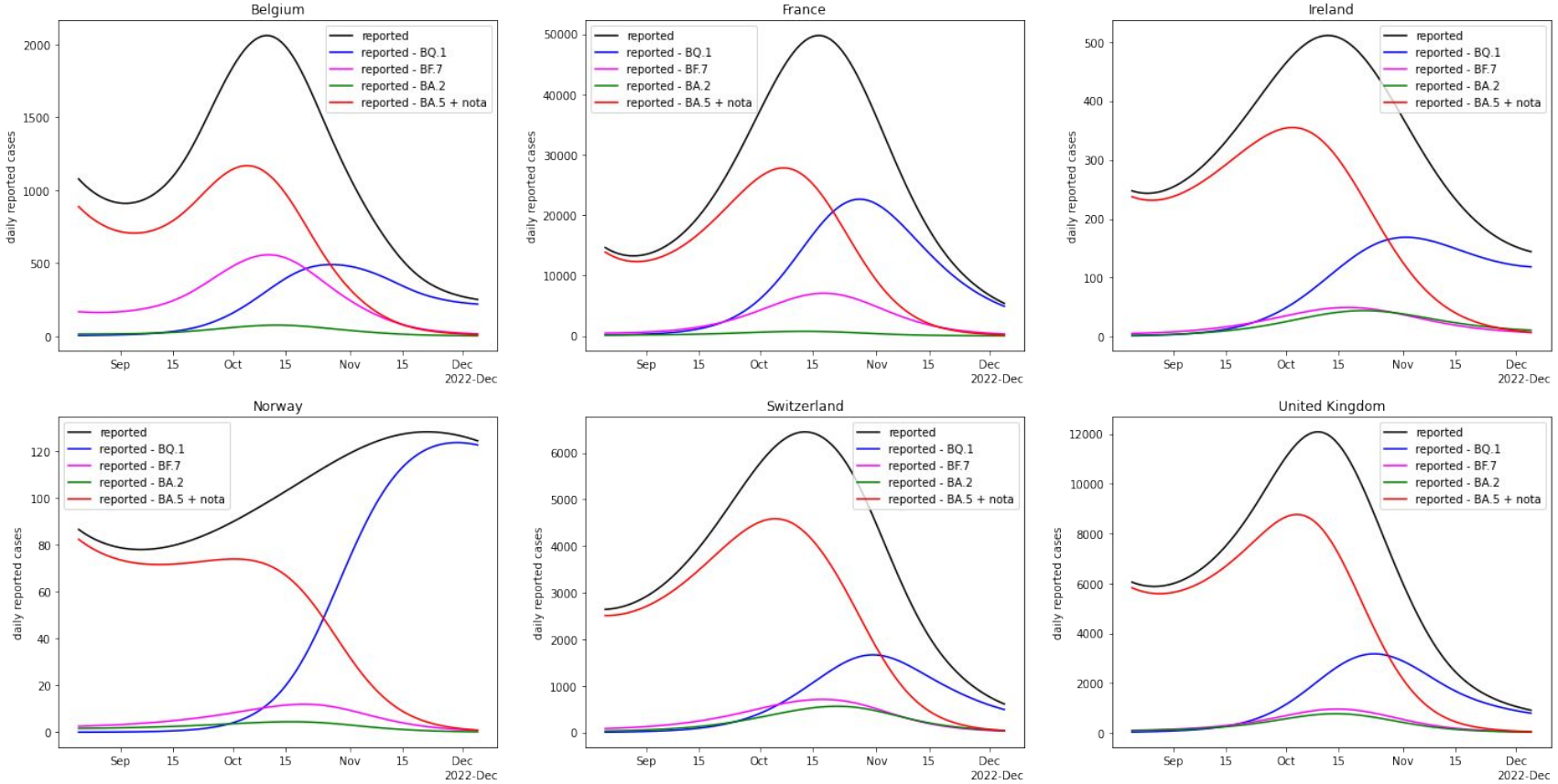


During the period from August through November, population-level immunity has been dynamic, leading to a resurgence as waning reduced the immunity followed by a decline due to additional natural and vaccine immunity.

The points show the ratio of cases identified as BQ.1*, BF.7*, BA.2* and none of the above ('nota') with respect to BA.5* cases.

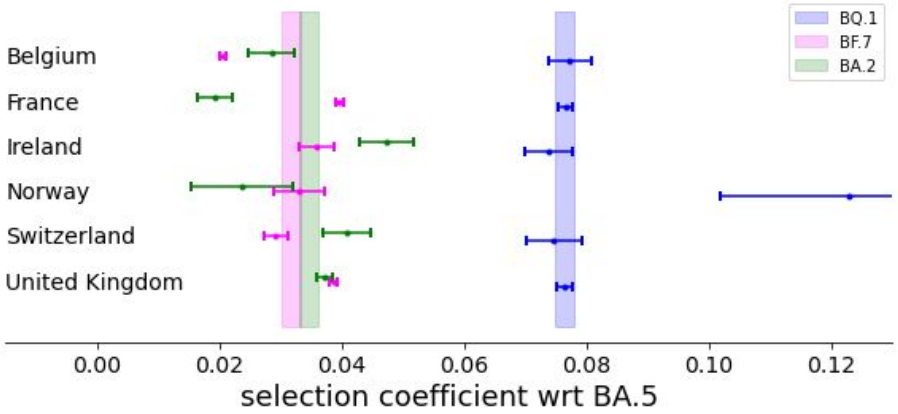
The data appear to be consistent with the hypothesis that the none of the new strains have significant immunity escape. This is further illustrated in the next slide, which breaks down the recent rates of cases into these variant groupings. The fit results on this slide are used to deduce how the fraction of cases evolved with time, shown on the next slide.

Breakdown of cases into variant groupings

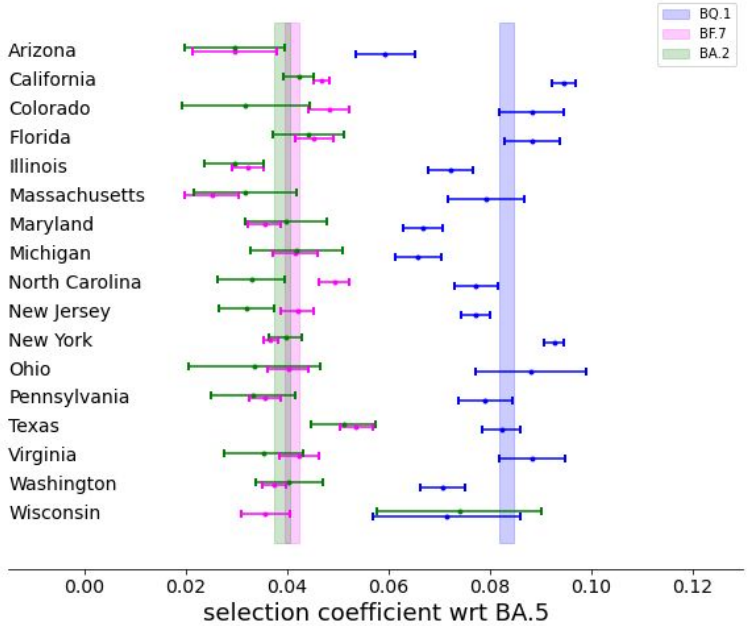


Source (D. Karlen) The BA.5* and the 'nota' variants that grow at the same rate are combined as the red curve. The rapidly growing BQ.1* strains are not seen as a separate wave as it peaked close to the peak of the BA.5* resurgence. If BQ.1* had significant immunity evasion, it would have continued to grow, rather than peak.

Selection coefficients for new variants: Europe and US



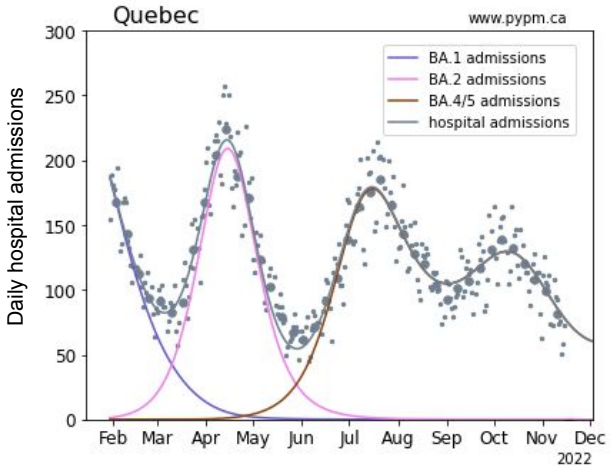
Nation	BQ.1	BF.7	BA.2	nota
Belgium	0.077 +/- 0.004	0.020 +/- 0.001	0.029 +/- 0.004	0.005 +/- 0.002
France	0.077 +/- 0.001	0.040 +/- 0.001	0.019 +/- 0.003	0.006 +/- 0.001
Ireland	0.074 +/- 0.004	0.036 +/- 0.003	0.047 +/- 0.004	0.003 +/- 0.002
Norway	0.123 +/- 0.021	0.033 +/- 0.004	0.024 +/- 0.008	0.007 +/- 0.004
Switzerland	0.075 +/- 0.005	0.029 +/- 0.002	0.041 +/- 0.004	0.001 +/- 0.002
UK	0.076 +/- 0.001	0.039 +/- 0.001	0.037 +/- 0.001	0.006 +/- 0.001

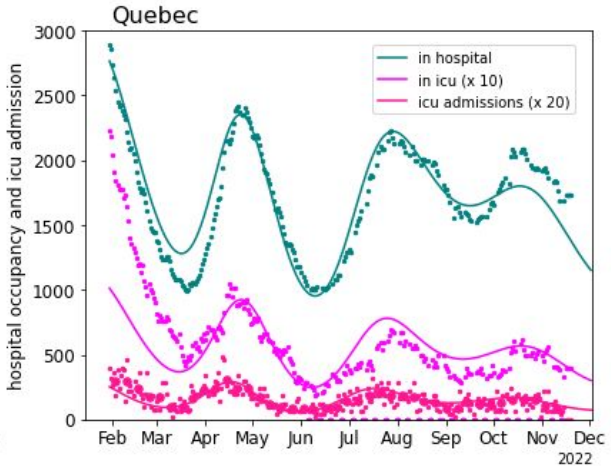


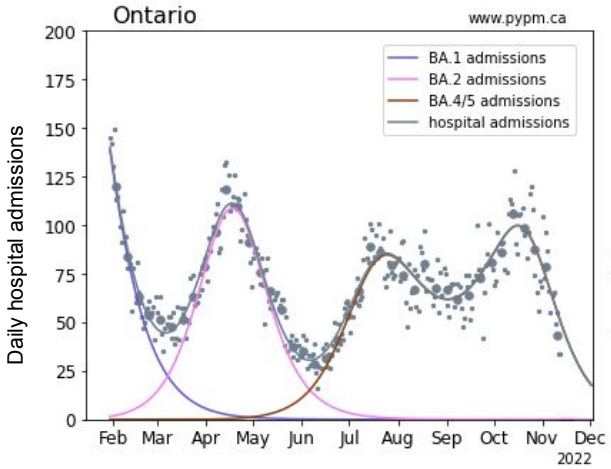
Consistent selection coefficients for Europe and US

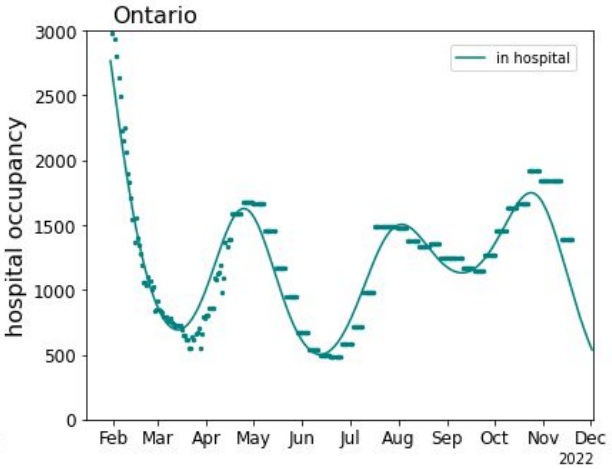
Source (D. Karlen) See www.pypm.ca. Data from ??

Quebec and Ontario







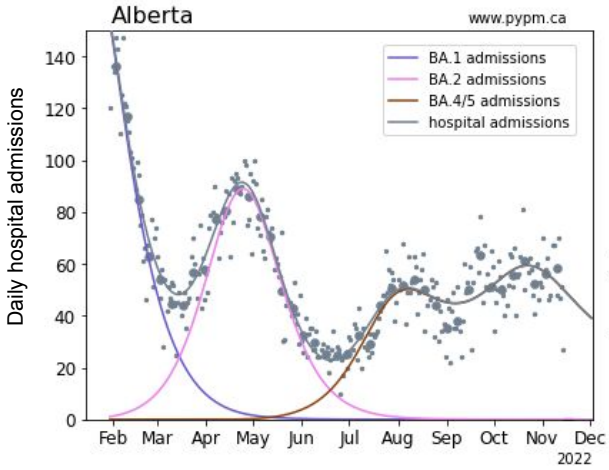


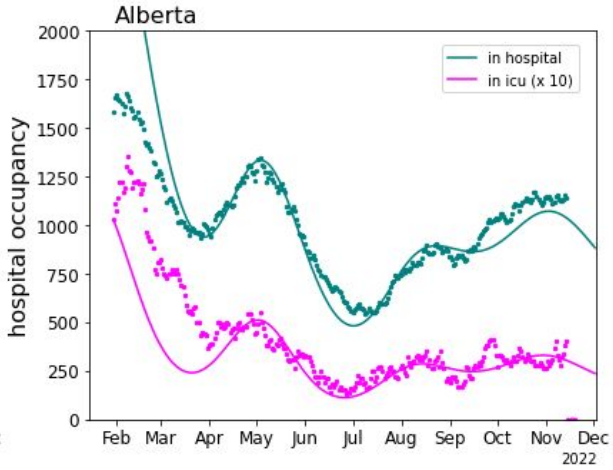
The same approach is applied to four provinces.

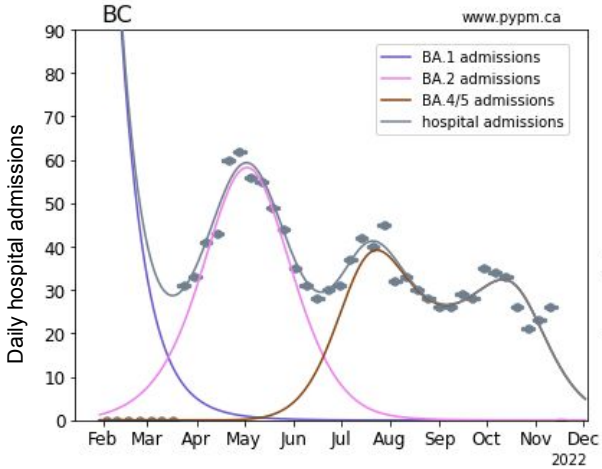
Quebec and Ontario show rapidly falling infection rates, due to additional immunity.

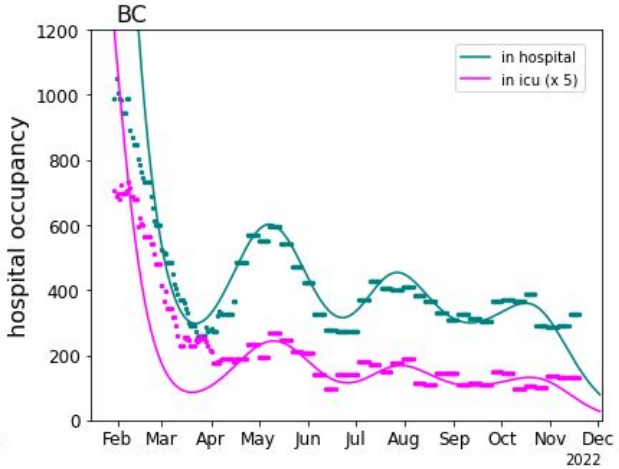
Source (D. Karlen) See www.pypm.ca.

Alberta and BC









The situation in Alberta and BC is less certain. The model predicts declining infection rates, but there is significant uncertainty in understanding waning immunity and the current situation with new variants.

Source (D. Karlen) See www.pypm.ca.

Getting booster vaccines can re[illegible] the rising wave

by countering wa[illegible]unity

OLD

W[illegible]unity will drive another [illegible] of infections, even without the spread of new variants, unless there is substantial uptake of vaccinations.

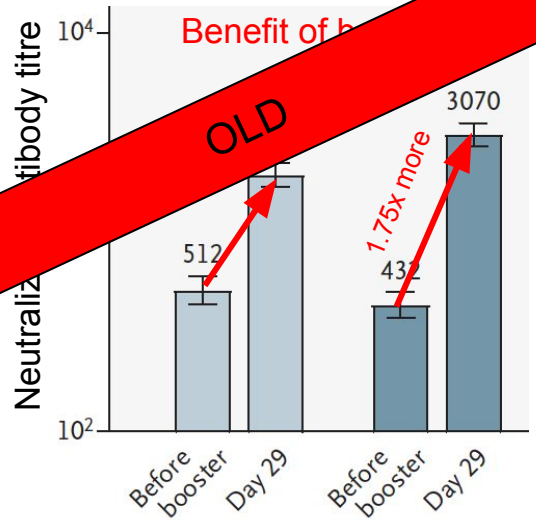
What is the bivalent vaccine used in Canada?

"Bivalent" refers to having two types: the current Moderna bivalent vaccine available in Canada encodes the spike protein from both the original (Wuhan) and Omicron (BA.1) variants.

Getting the bivalent vaccine boosts immunity and broadens the diversity of antibodies in your bloodstream to better recognize Omicron, priming your immune system to neutralize the virus and avoid infection*.

Moderna's bivalent (Wuhan & BA.1) boosts neutralizing antibodies that recognize BA.1 by a geometric mean factor of 1.75 more than boosting with the original vaccine (see plot).

Neutralizing antibodies that rec… BA.5 are also raised by … 6, indicating a benef… tiple Omicron lineag… Arias et al. 2022).



Moderna vaccine: Original Bivalent

Both the original vaccine and the bivalent help, but the bivalent helps more against Omicron.

Note: The BA.5 & Wuhan bivalent approved in the United States has been tested in mice but not yet in humans (learn more from CoVaRR-Net).

*These neutralizing antibodies wane over the course of months. Once a person is infected, memory cells that recognize SARS-CoV-2 are stimulated, allowing vaccinated and previously infected people to clear infections more efficiently, reducing (but not eliminating) the risk of severe disease.

Key messages

BC appears on the brink of another wave, driven by Omicron BA.5 and waning immunity.

- BA.5, and specifically BA.5.2, is the predominant variant across Canada.
- Some sub-variants of BA.5 (e.g., BF.7), as well as sub-variants of BA.2 (esp. BA.2.75) and BA.4 (esp. BA.4.6), carry mutations known to better evade antibodies in blood samples, and show signs of rising in frequency, but the growth advantages of these sub-variants over BA.5 are currently small in Canada.
- Population immunity can be estimated based on the shape of epidemic curves, providing a way to estimate immune evasion and waning and to predict future infection and hospitalization rates.

The growth in COVID-19 will reverse once immunity lost through waning is offset by new immunity, gained by vaccination or new infections.

Underreporting the impact of COVID make it challenging for the public to have a full understanding of current levels. Current infection rates are ~100-fold underreported based on two different serological datasets.

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