

COVID Model Projections

November 23, 2022

[BC COVID-19 Modelling Group](#)

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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

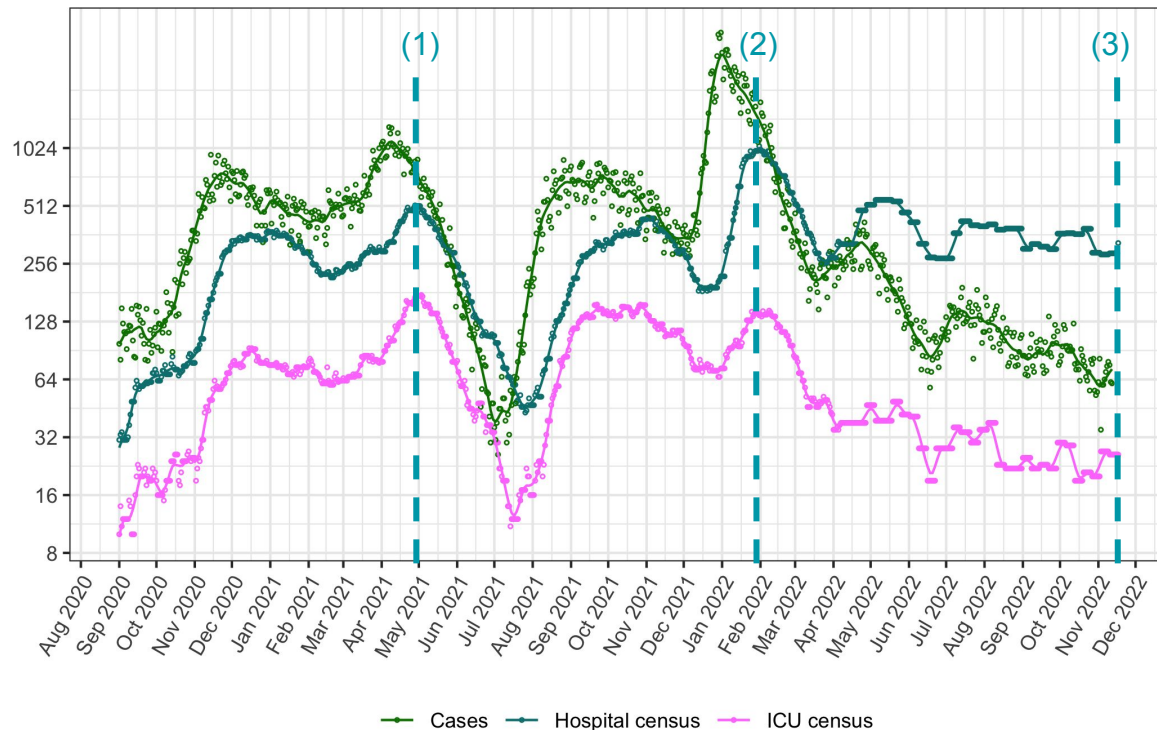
Summary: The BA.5-driven wave persists with high rates of infection. The prolonged nature of the wave is consistent with waning of immunity from infections and vaccinations early in the year. Future projections predict a rise in cases, even without new variants that are able to evade immunity. Underreporting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

OLD

Current COVID-19 trends in BC

Hospital trends in BC

British Columbia COVID-19 cases, hospital and ICU census



Data: BCCDC for cases, Canada Covid-19 tracker for hospital and ICU census

The number of people in **hospital** and the number in **ICU** have remained at similar levels for months. By contrast, **reported case numbers** have declined sharply because of limited testing*.

Number in hospital with COVID-19:

Pre-Omicron

(1) Highest = 515 (28 April 2021)

Omicron wave:

(2) Highest = 1038 (31 January 2022)

(3) Current = 328

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](#). *Reinfections with a prior lab-confirmed case are currently not counted in BC for reported case numbers, hospital admissions, or deaths, but they are included in hospital censuses as shown here.

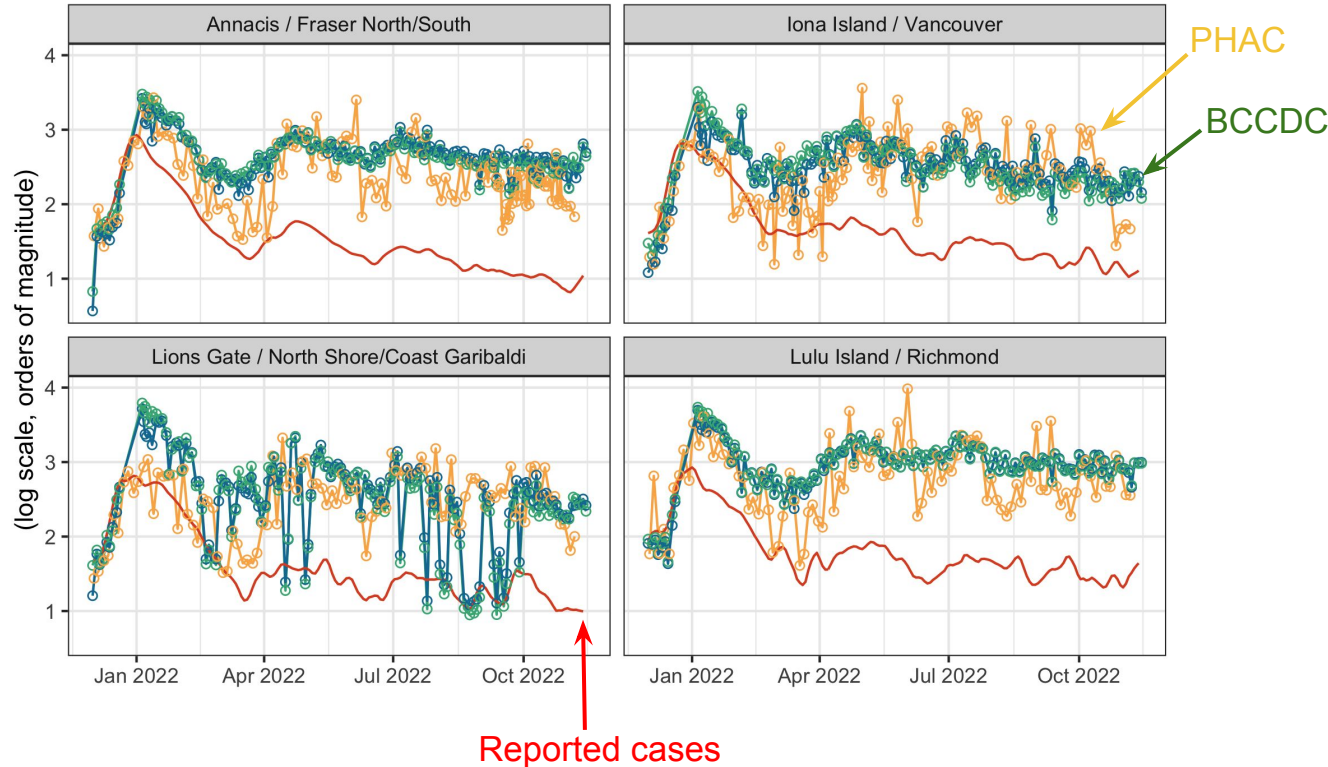
Wastewater trends in Metro Vancouver

Wastewater signals (shown on a log scale from BCCDC and PHAC) have declined much less than reported cases, with only a slight decline in COVID-19 signals in wastewater since June.

Notes:

- Heights of curves are adjusted to align in December 2021 to emphasize how trends differ across 2022.
- Y-axis shows the order of magnitude of virus copies (per liter in gold or blue or, adjusting for water flow, per day in green).
- Wastewater data are noisy and differ between the source labs for reasons that are not fully understood.

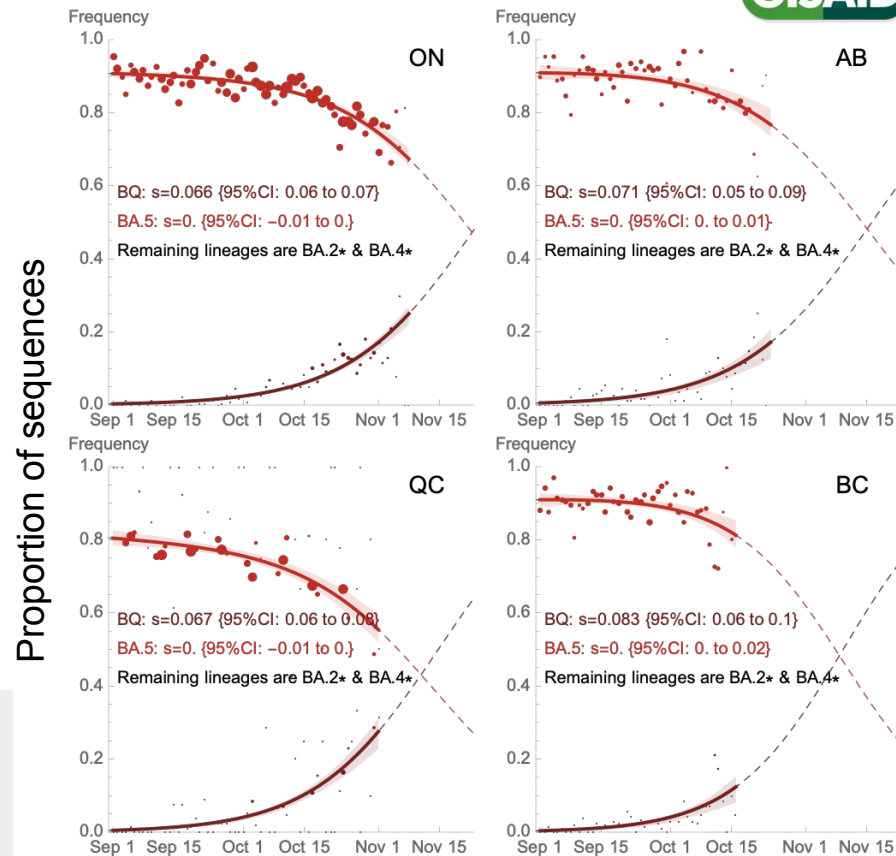
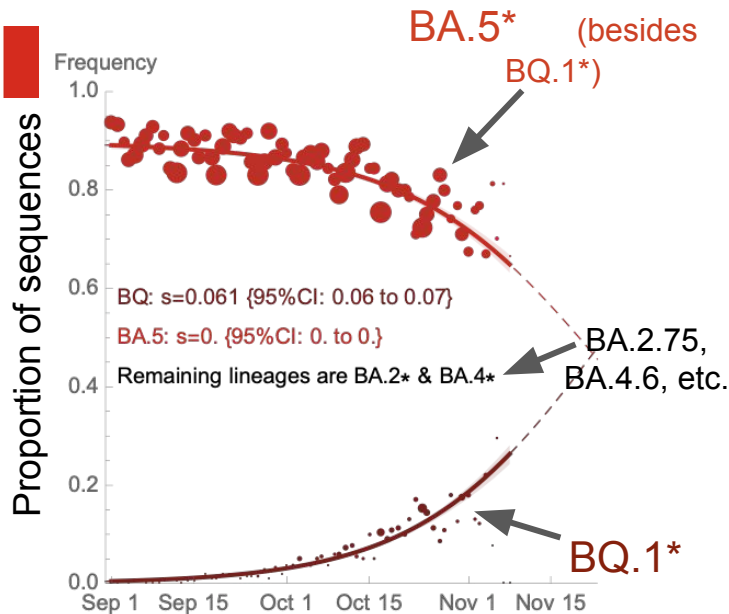
Recent wastewater COVID concentration vs case counts



The rise of BQ.1



Spread of BQ.1* sub-lineages in Canada

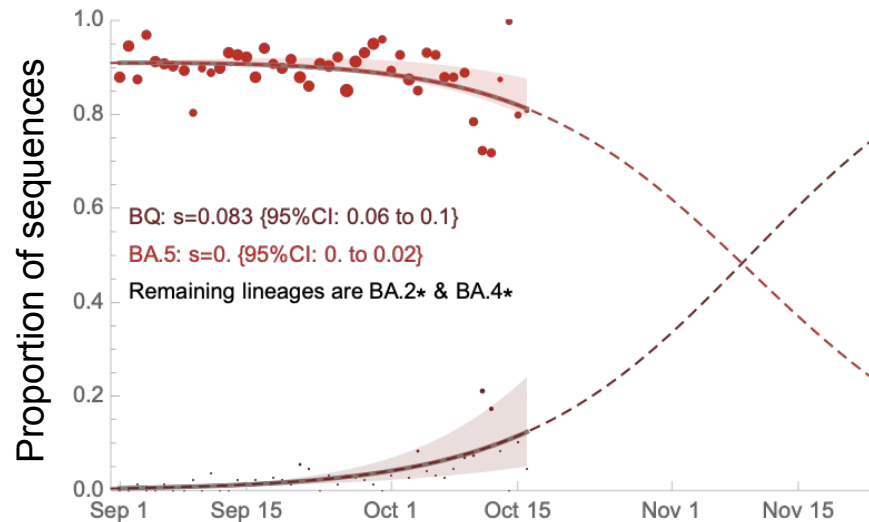


BQ.1* lineages are rising in frequency across Canada with a selective advantage of $s \sim 6\%$ relative to BA.5* or (BA.2*&BA.4*), leading to a current estimated frequency of $\sim 50\%$.

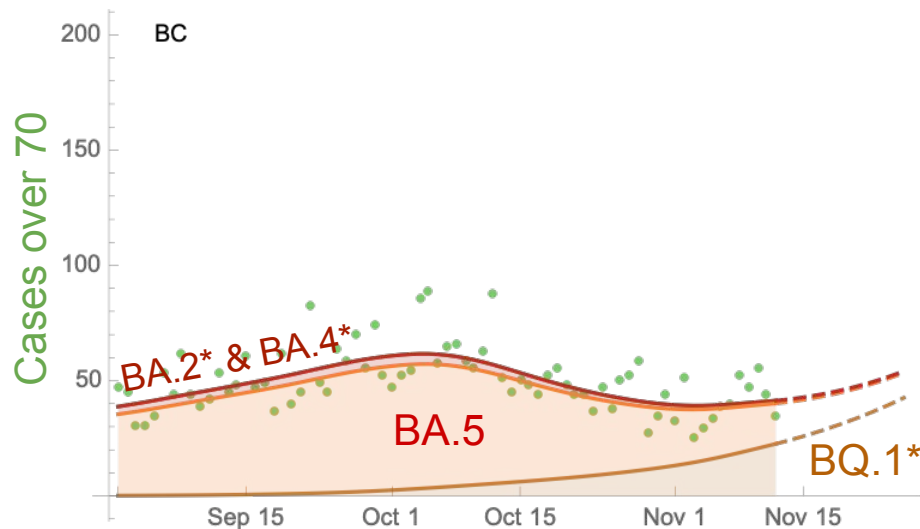
Source (S. Otto) Canadian metadata was downloaded from GISAID for the GRA clade. See Appendix for more method details.

What does this imply for case numbers?

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

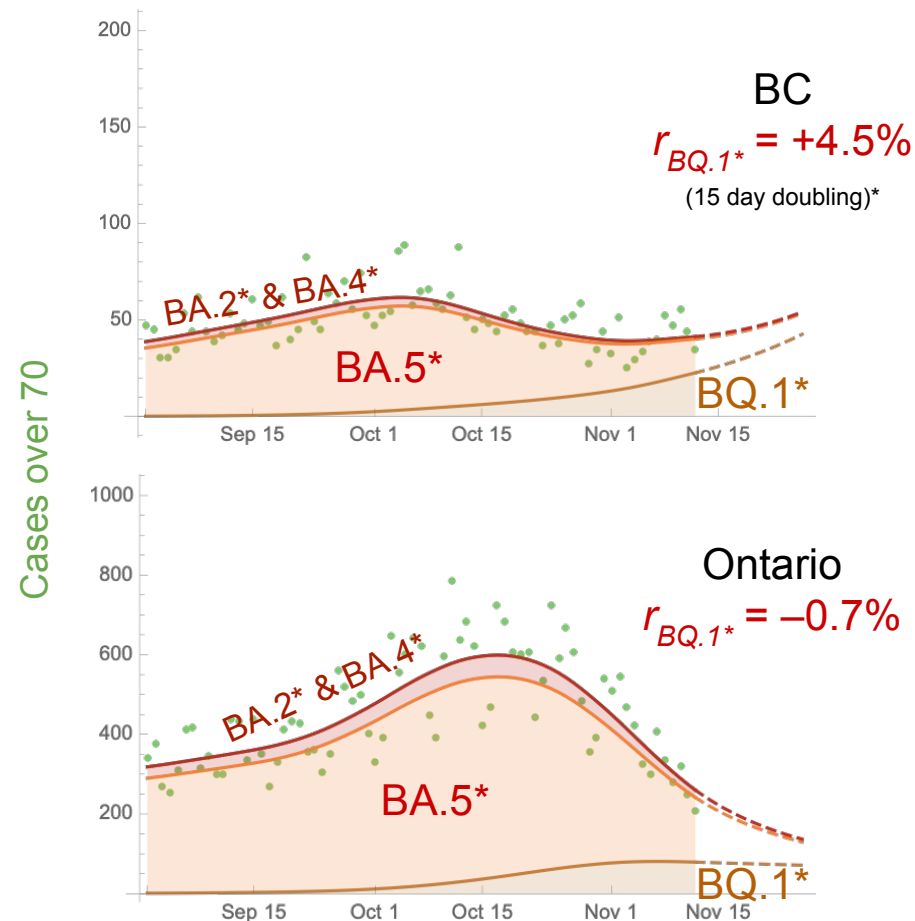


Multiplying by the # of cases in those over 70 allows us to **estimate** growth in numbers of each Omicron sublineage, while reducing extent of underreporting.



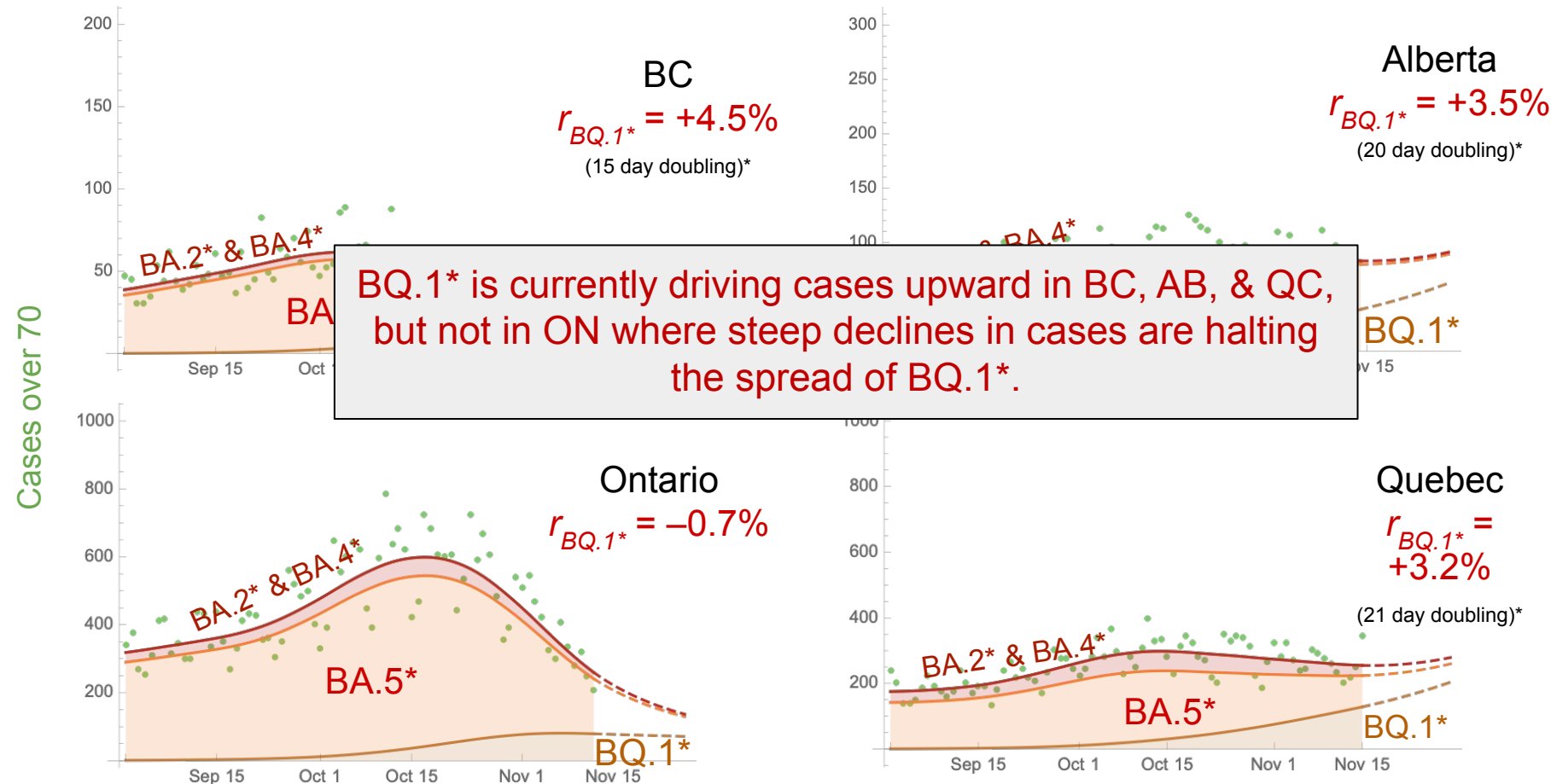
→ **BQ.1 case counts are estimated to be rising, despite overall downward trend.**

The BQ.1* Omicron Wave



* Instantaneous estimates of growth rate, r , and doubling times for BQ.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)

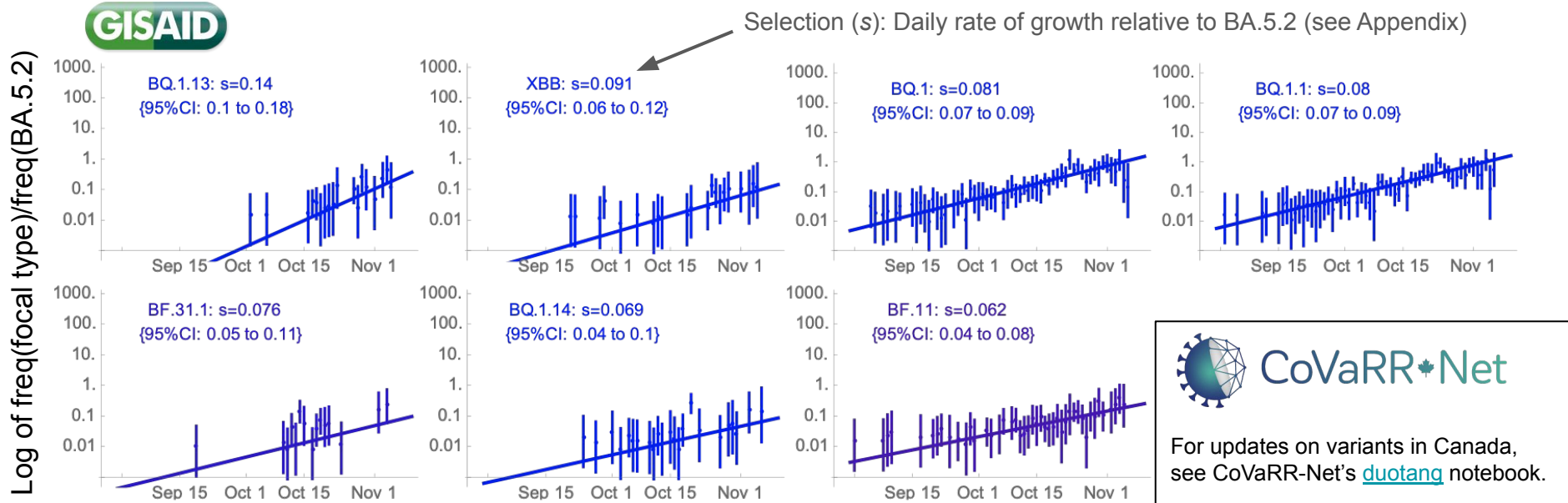
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Spread of Omicron sub-lineages in Canada

Over 200 named sub-lineages have been circulating in Canada over the last three months. Measuring the selective advantage of each, the fastest growing sub-lineages are BQ.1 sub-lineages and the XBB recombinant lineage, with selection coefficients between $s \sim 7\text{-}14\%$, which all carry mutations known to reduce recognition by antibodies ([Cao et al. 2022](#)).



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

Dynamic immunity and new variants

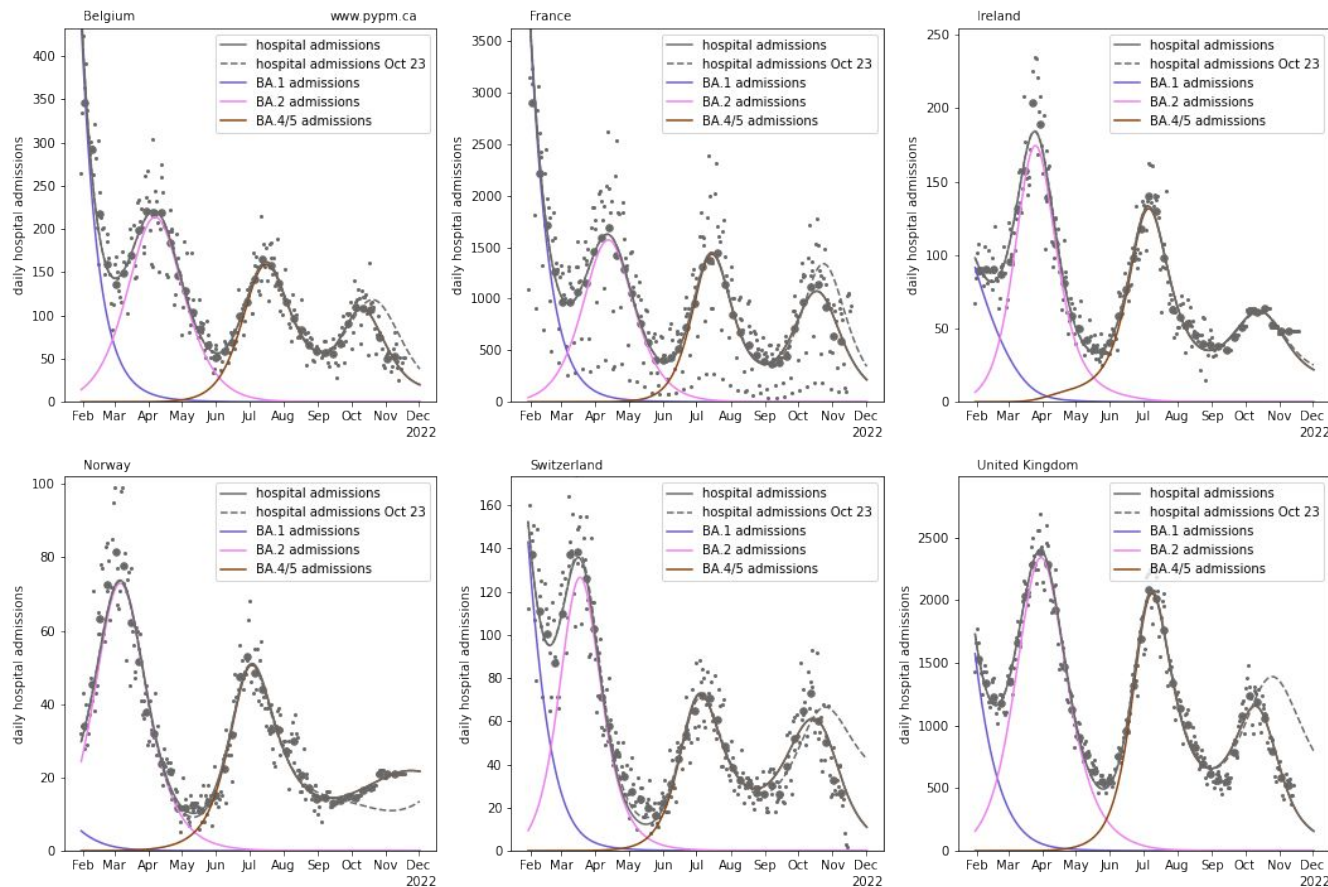
Waning immunity and vaccination

Approach: Population-level immunity dynamics can be deduced directly from data. Both the initial immunity and the rate that immunity grows are determined by the rise and fall of the BA.2 wave. Given underreporting of cases, only hospital admission data are used, and the number of new immunity-generating infections per hospital admission is inferred. Transmission is constant for each main variant.

Our last report used this approach to show that waning of immunity was causing a resurgence of COVID-19 in Europe and in Canadian provinces. This resurgence involved the same variant (BA.5) in both the 3rd (mid-summer 2022) and 4th (fall 2022) Omicron waves and so was driven by waning, not new variants.

Since our last report, the resurgence due to waning has petered out, as a result of the additional natural and vaccination immunity. The additional immunity from recent vaccinations are now included in the models.

Model fits to hospital admission data in Europe

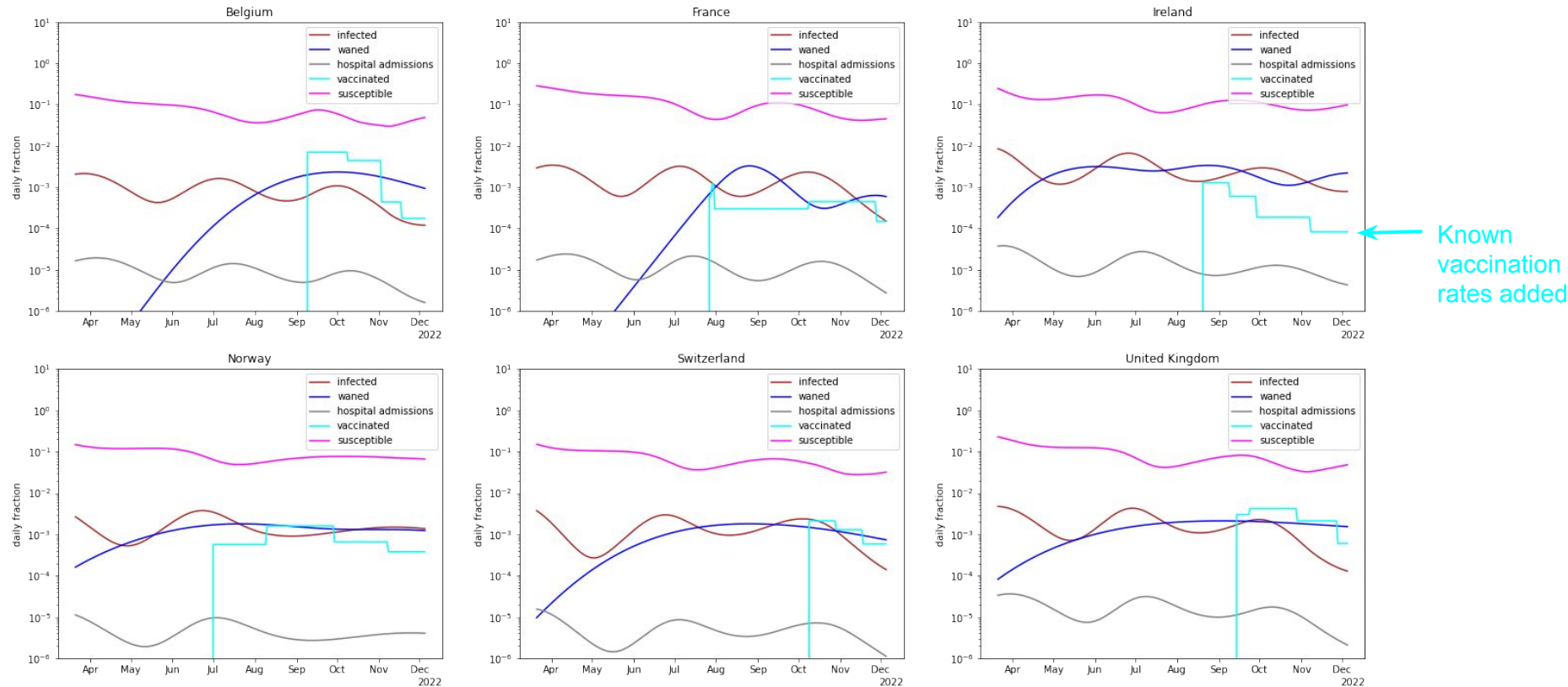


The daily (small dots) and weekly average (large dots) hospital admissions are compared to model fits (solid lines). The models have three Omicron strains (BA.1, BA.2, BA.5), each having constant transmission rate. Immunity parameters were set from the shape of the second wave (BA.2).

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 campaign in the model. To achieve good fits to Belgium, Swiss, and UK data, the model required vaccination to be included.

Recent vaccination rates, and inferred infection and waning rates



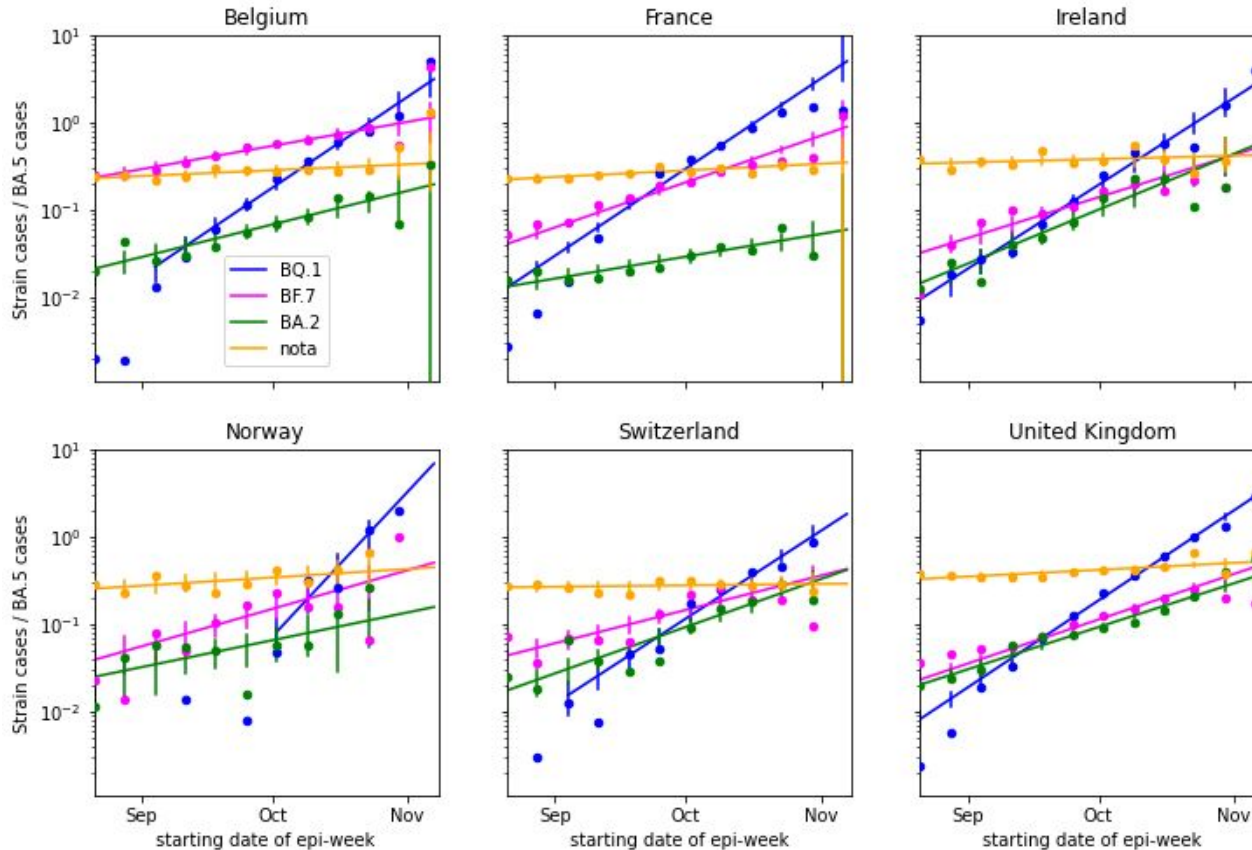
Dynamic population-level immunity and new variants

With large numbers of infections and vaccinations, the susceptible fraction is now much smaller in these European countries and in Canada (estimated by the **pink curves** at ~10-20%, compared to the largely susceptible population during the first two years of the pandemic). As immune protection wanes (**blue curves**), this generates highly dynamic population-level **susceptibility** and **infection rates**.

That is, the daily growth rate of COVID-19, r , is not constant but rises with waning and falls with infections and vaccinations.

As illustrated in the next slide, variants are rising and falling similarly over time, so that their relative frequencies change at a constant rate over time (constant selection). This suggests that the variants have similar pools of susceptible individuals and that variants like BQ.1 do not substantially evade immunity.

Selection coefficient analysis for new variants

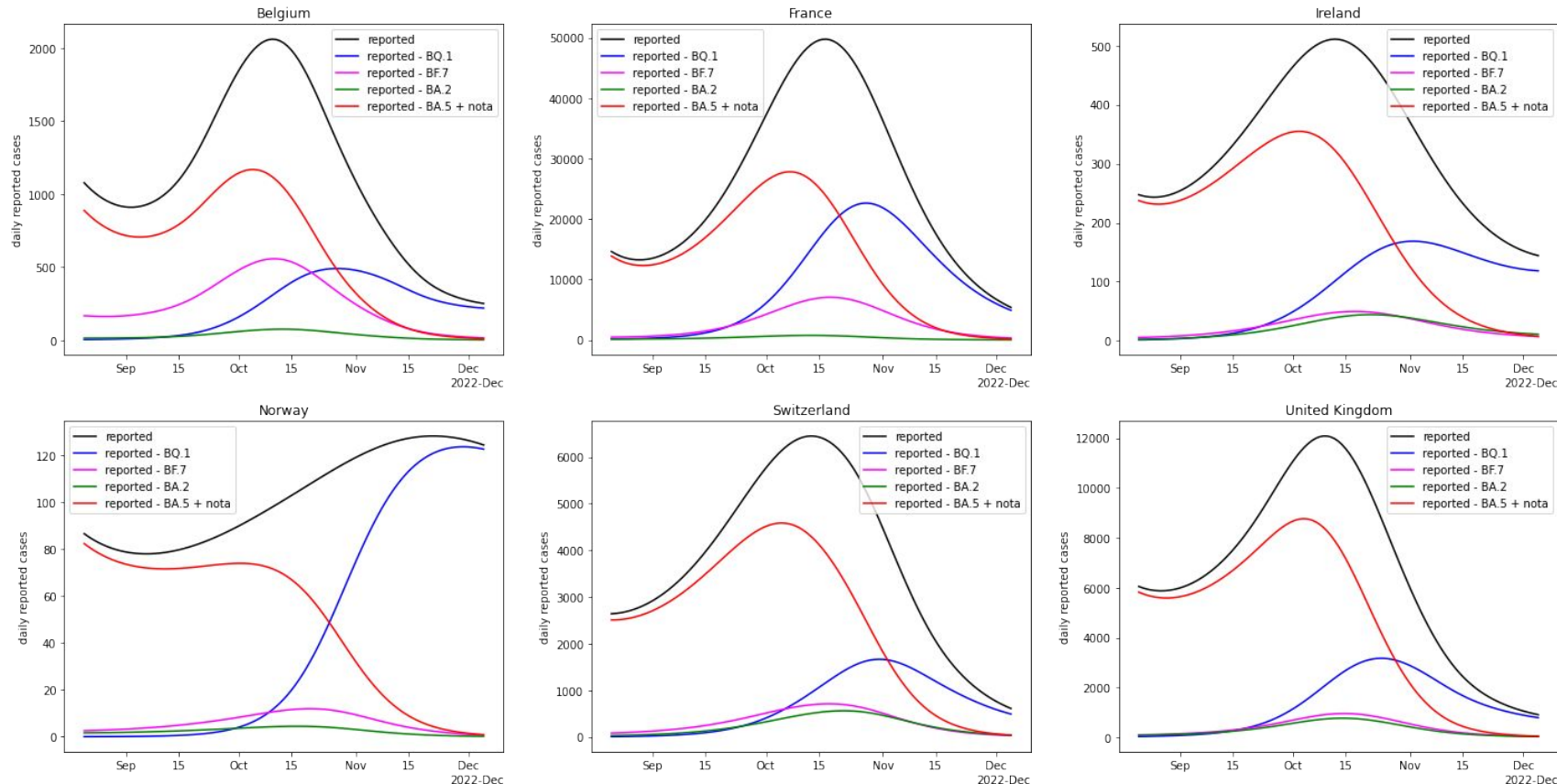


During the period from August through November, population-level immunity has been dynamic, leading to a resurgence as waning reduced the immunity followed by a decline due to additional natural and vaccine immunity.

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.

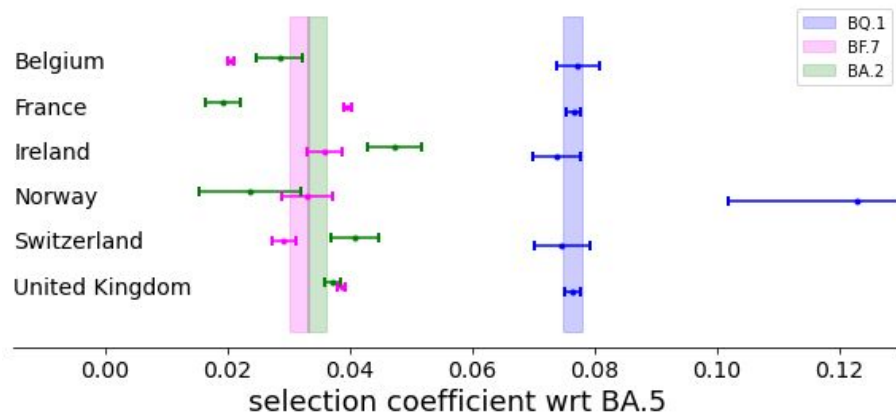
The data appear to be consistent with the hypothesis that the none of the new strains have significant immunity escape. This is further illustrated in the next slide, which breaks down the recent rates of cases into these variant groupings. The fit results on this slide are used to deduce how the fraction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

Breakdown of cases into variant groupings

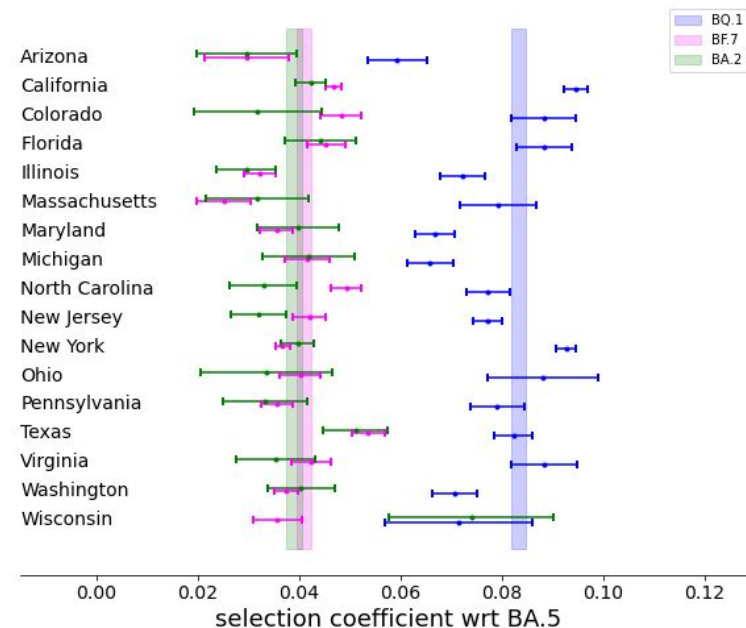


Source (D. Karlen) The BA.5* and the 'nota' variants that grow at the same rate are combined as the red curve. The rapidly growing BQ.1* strains are not seen as a separate wave as it peaked close to the peak of the BA.5* resurgence. If BQ.1* had significant immunity evasion, it would have continued to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

Selection coefficients for new variants: Europe and US

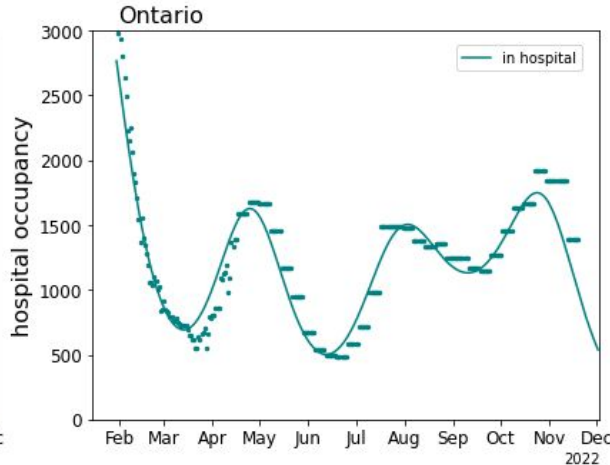
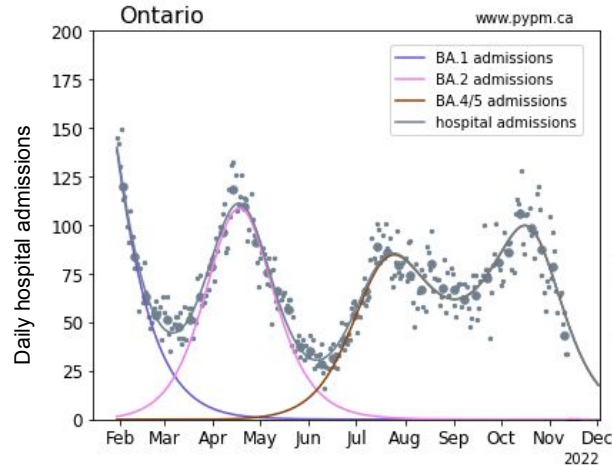
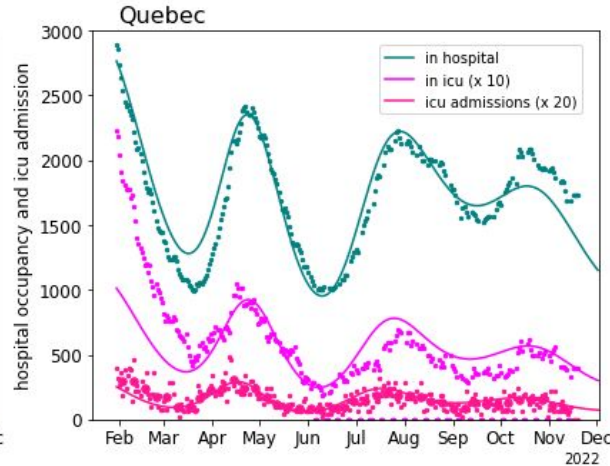
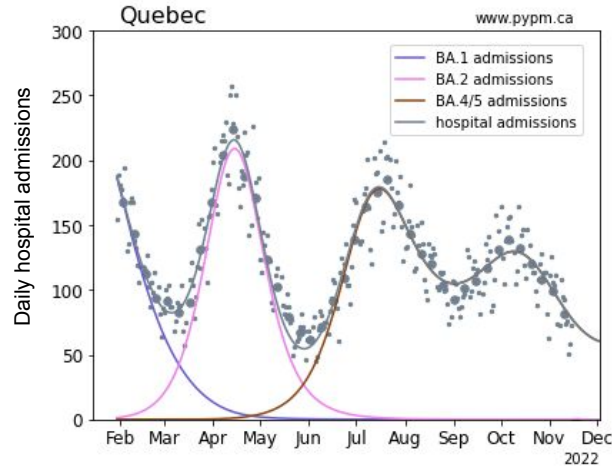


Nation	BQ.1	BF.7	BA.2	nota
Belgium	0.077 +/- 0.004	0.020 +/- 0.001	0.029 +/- 0.004	0.005 +/- 0.002
France	0.077 +/- 0.001	0.040 +/- 0.001	0.019 +/- 0.003	0.006 +/- 0.001
Ireland	0.074 +/- 0.004	0.036 +/- 0.003	0.047 +/- 0.004	0.003 +/- 0.002
Norway	0.123 +/- 0.021	0.033 +/- 0.004	0.024 +/- 0.008	0.007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

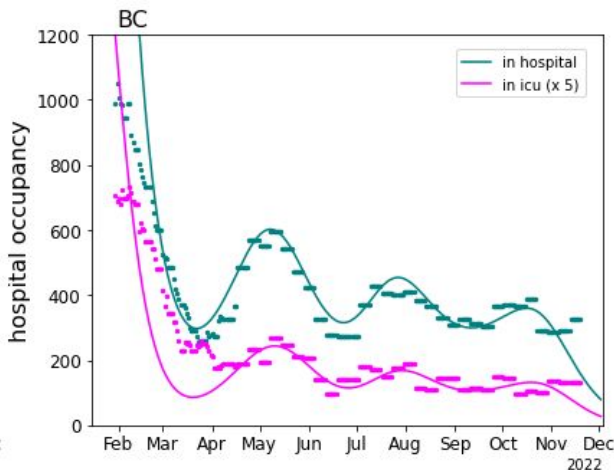
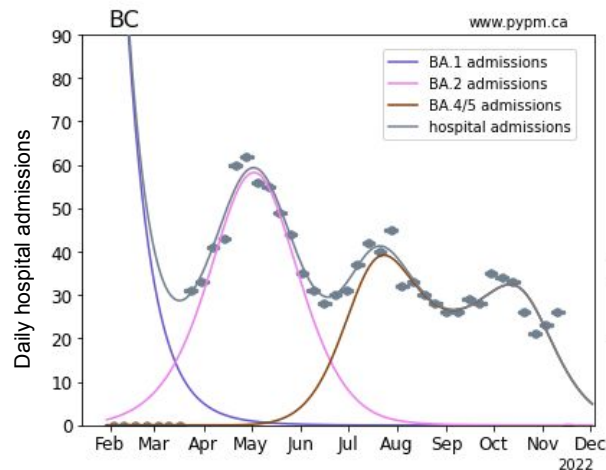
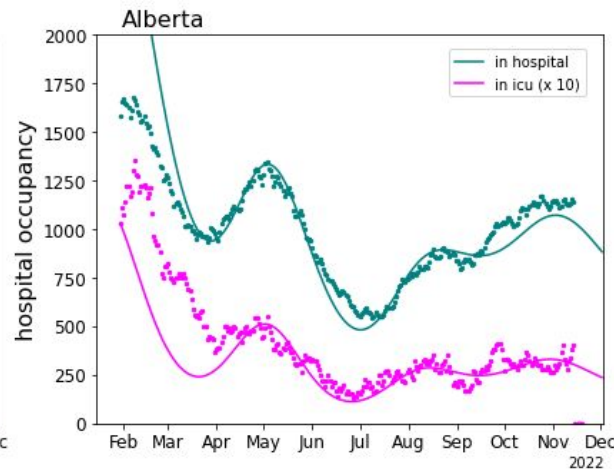
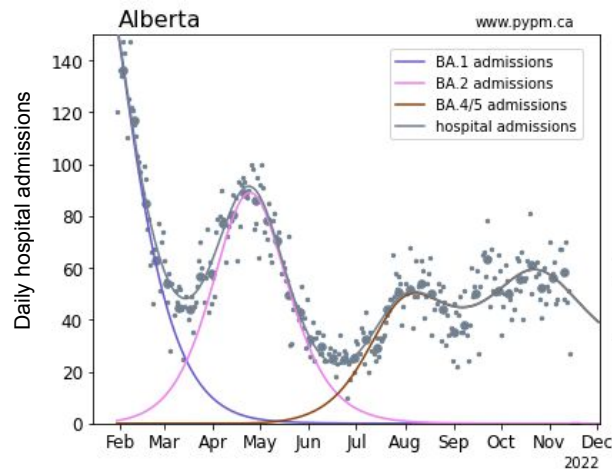
Quebec and Ontario



The same approach is applied to four provinces.

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

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.

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.2.86) and BA.4 (esp. BA.4.6), carry mutations known to better evade antibodies in blood samples. There are 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.

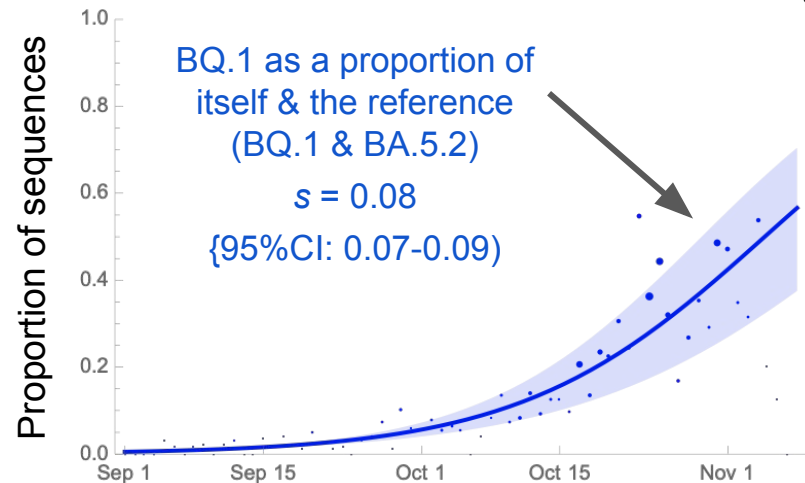
Underreporting the impact of COVID-19 make it challenging for the public to have a full understanding of the situation. Current infection rates are ~100-fold underreported based on two different serosurveys.

Appendix: Interpreting selection

What is selective (“s”) and what does it mean?

s measures the selective advantage per day of a variant relative to a reference strain (e.g., measuring the rate of spread of BQ.1 relative to BA.5.2)*.

This selective advantage may reflect a higher transmission rate or a greater ability to evade immunity or both.



* Selection per day, s , satisfies $p_T = \text{Exp}(s T) p_0 / (1 - p_0 + \text{Exp}(s T) p_0)$ where p_T is the frequency of a lineage of interest on day T , considering only itself and the reference (e.g., the # of BQ.1 divided by the # of BQ.1 and BA.5.2). s is estimated from the numbers of sequences over time by maximizing the likelihood of observing the data (see [methods](#)).

