COVID Model Projections

February 3, 2022

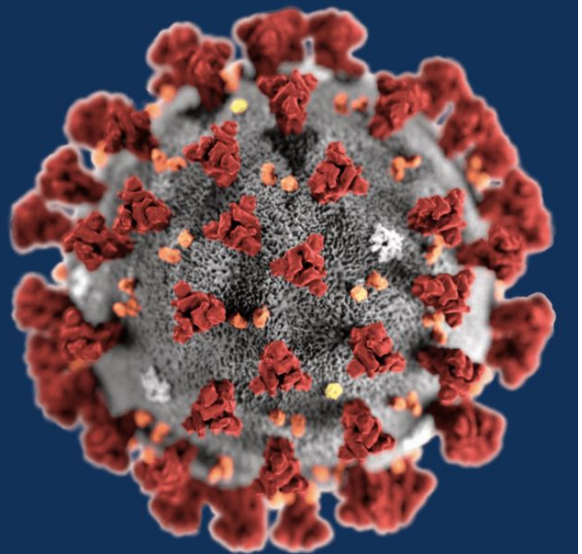
BC COVID-19 Modelling Group

@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

Contributors to report

Sarah Otto (UBC, co-editor)
Eric Cytrynbaum (UBC, co-editor)
Dean Karlen (UVic and TRIUMF)
Jens von Bergmann (MountainMath)
Caroline Colijn (SFU)
Rob James (evidently.ca)
Rob Dumont
Ailene MacPherson (SFU)
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.

Overview

Omicron in flux

- Inferring the likely trajectory of Omicron cases and the demands that COVID-19 will place on communities and hospitals in the near future is hampered by substantial data gaps in BC.
  - There is a lack of consistent data on cases and hospital admissions.
- Omicron sub-variant BA.2 is spreading in many other jurisdictions, with selection favouring BA.2 by s~0.1 per day relative to BA.1.
  - Genomic data is not available from BC to measure the spread of BA.2 relative to BA.1 and assess the risk that it poses here.
- Case counts among those aged 70+ have plateaued in BC but are only showing signs of a significant decline in Fraser Health.
- The number of individuals admitted to hospital and the number hospitalized have leveled off.

Reliable data is essential for risk assessment

All data streams publicly available in BC to monitor the Omicron pandemic are unreliable, as a result of changing data standards and missing or inaccessible data.

➔ **Case counts:**

- Eligibility for testing has shifted repeatedly (no group is consistently monitored)
- Testing rates by age have plummeted for most age groups (data not downloadable)
- Rapid Antigen Tests have replaced PCR testing (data not shared)

➔ **Hospitalization data:**

- With testing limitation, another early and reliable data stream in many jurisdictions is timely data on hospital admissions (not shared on a daily basis and corrections are not publicly available)
- Criteria for hospital admissions and occupancy are unclear and differ among Health Authorities
- Criteria have shifted during the Omicron pandemic, including more incidental cases but testing less in hospitals (no consistent data stream)

➔ **Wastewater data:**

- Monitoring is narrowly confined to the Lower Mainland (lack of data)
- Publicly available data is not normalized by flow rate (data only shared for viral concentration per liter)
- Data for non-COVID viruses (e.g., PMMoV), which provide a standard of comparison in many other jurisdictions, is not available (data not shared)

➔ **Genetic data:**

- BA.2 is replacing BA.1 in many jurisdictions, but rates of spread in BC and Canada cannot be assessed (majority of BC data not shared in a timely fashion)
- Virus sequencing depends on testing. Testing limitations are preventing a broad sample of viruses from being sequenced, limiting information about variants and vaccine effectiveness (limited data).

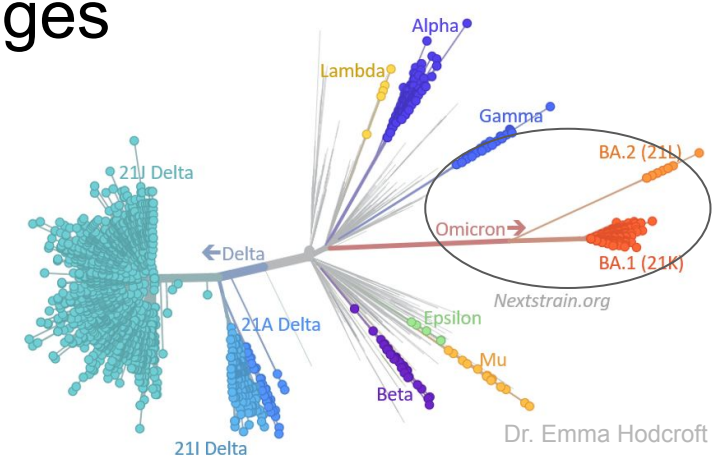
Keeping an Eye on Omicron Sub-Lineages

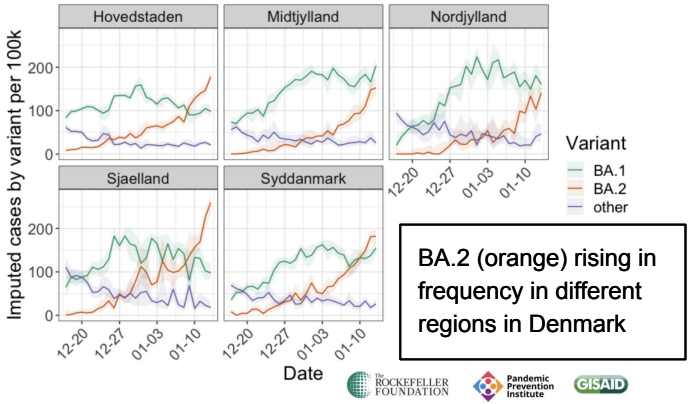
Omicron describes two major lineages, BA.1 and BA.2, that first diverged over a year ago (see evolutionary tree). BA.1 and BA.2 differ at a number of sites but share 21 changes in the spike protein.

While a relatively old lineage, BA.2 has recently started to spread in several countries, showing signs that it has gained a selective advantage over the more common BA.1.

Early data suggests that the advantage of BA.2 might come from a higher inherent transmissibility, rather than a greater ability to evade immunity, but reinfection rates with BA.2 are not yet known:

- Risk of infection to a household member is slightly higher in UK: 13.4% for BA.2 vs 10.3% for BA1.
- Viral load is higher for BA.2 than BA.1 among unvaccinated individuals.
- Our analysis (see appendix) finds that BA.2 is spreading faster than BA.1 at a rate of s=11%/day in Denmark and s=15%/day in the UK.





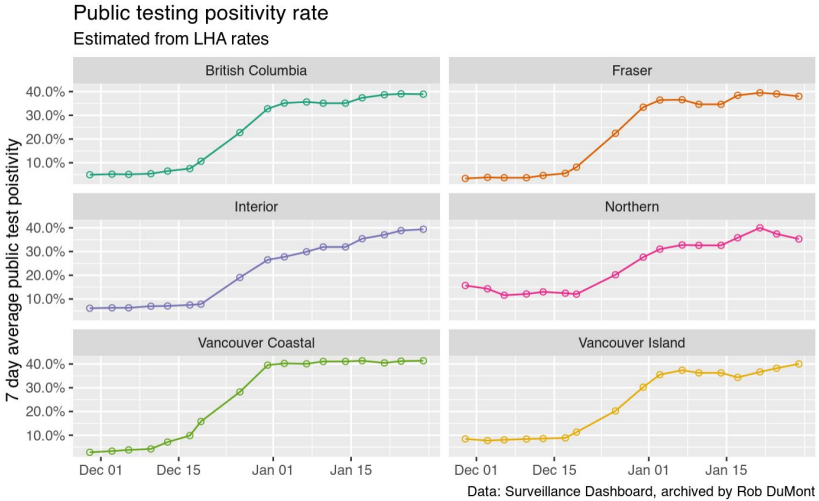
BA.2 (orange) rising in frequency in different regions in Denmark

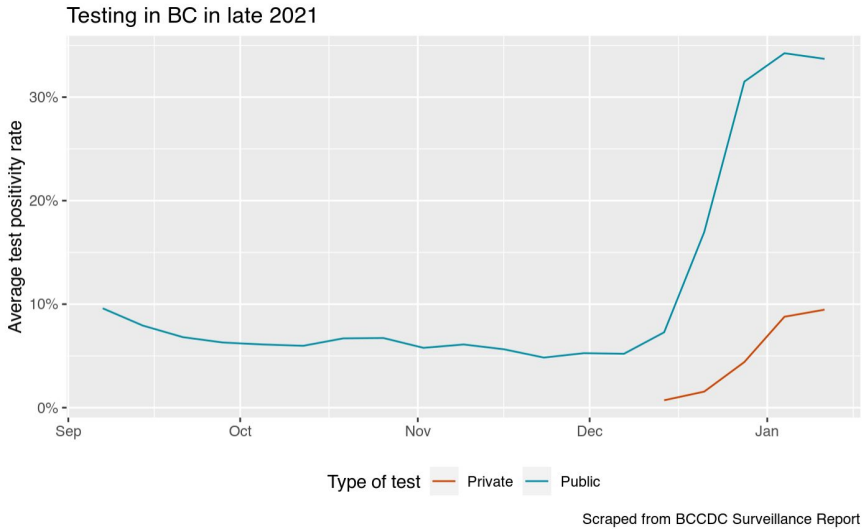
In Canada, few BA.2 sequences have been publicly shared on GISAID (55 in total). BC has submitted only 8 sequences, all from last year, making it impossible to assess if BA.2 is spreading.

Test positivity

Public testing positivity has remained at very high levels.

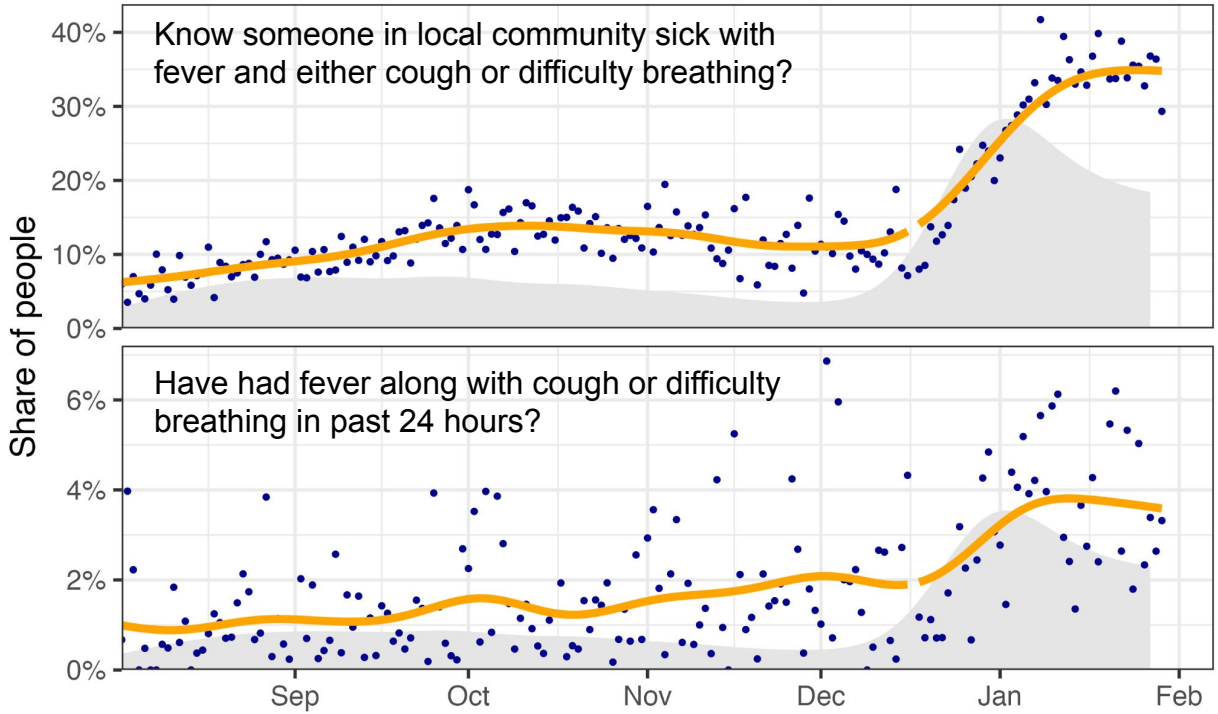
Test positivity of private testing comes with considerable time lag and uncertainty because it has to be manually scraped out of images. It shows an increasing trend suggesting high community prevalence.





Survey Data on COVID Prevalence

U of Maryland Global Covid-19 Trends and Impact Survey (UMD CTIS)



In the past UMD CTIS Survey data has correlated reasonably well with COVID cases in BC. It's a noisy measure, but can help add information in the absence of better data.

The survey is administered on Facebook with a daily sample size of about 300 people in BC (over 200K internationally).

In contrast to the drop in reported cases, the survey suggests a flattening in infections, but not yet a marked decline.

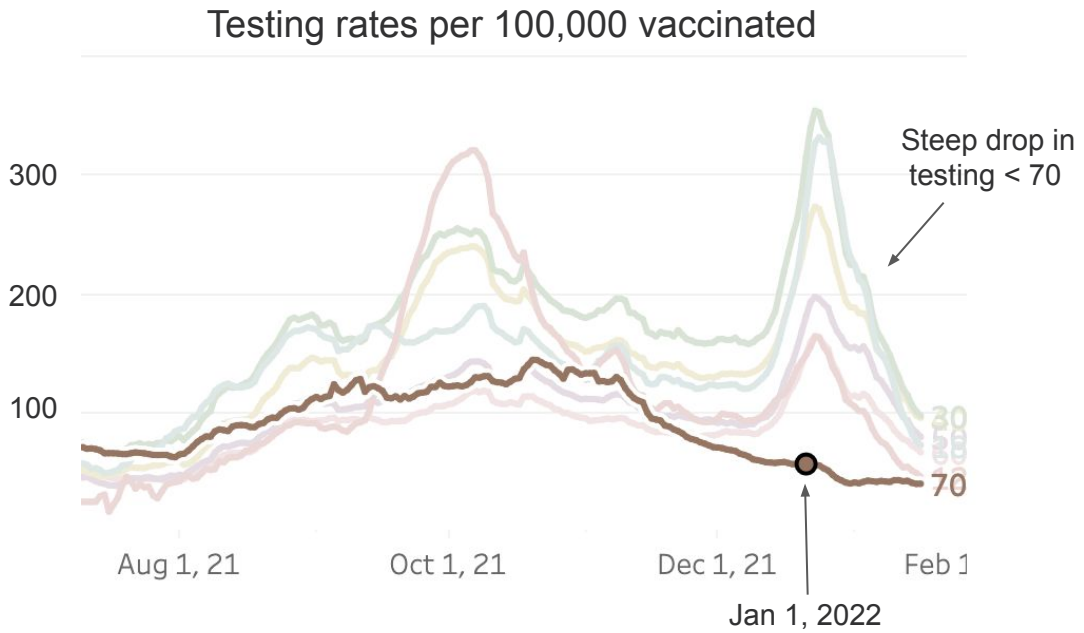
Data: UMD Global CTIS (survey) and BCCDC (cases)

Age-corrected case counts: British Columbia

Official COVID-19 case counts in BC are based on PCR testing.

PCR testing rates have plummeted in the last month among individuals under 70, because BC recommends testing only for those at risk of more severe disease (including unvaccinated adults).

[See testing guidelines here.]



→ Testing rates have been more stable among individuals 70+ (brown curve), providing a more reliable group to track COVID-19 cases over time.

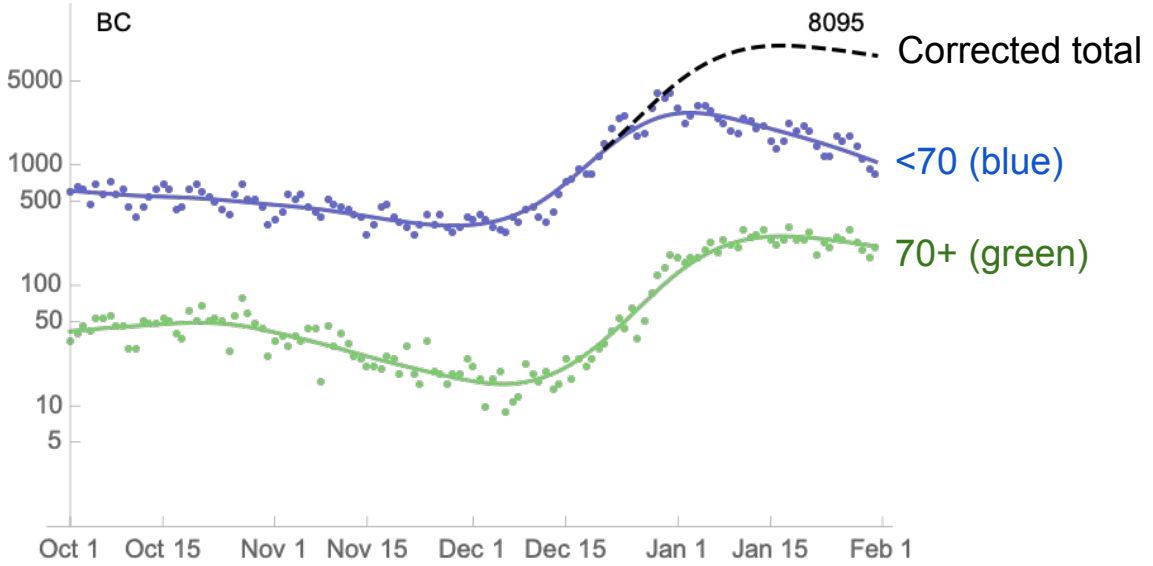
Source: COVID-19 Regional Surveillance Dashboard, "Outcomes by Vax 1" tab, "Testing rate" metric in third graph.

Age-corrected case counts: British Columbia

The black dashed curve gives the expected total number of cases, applying growth in older age cohorts (green) to correct for limited testing in younger groups (blue).

This correction suggests ~8000 cases on January 31 compared to the 1236* reported.

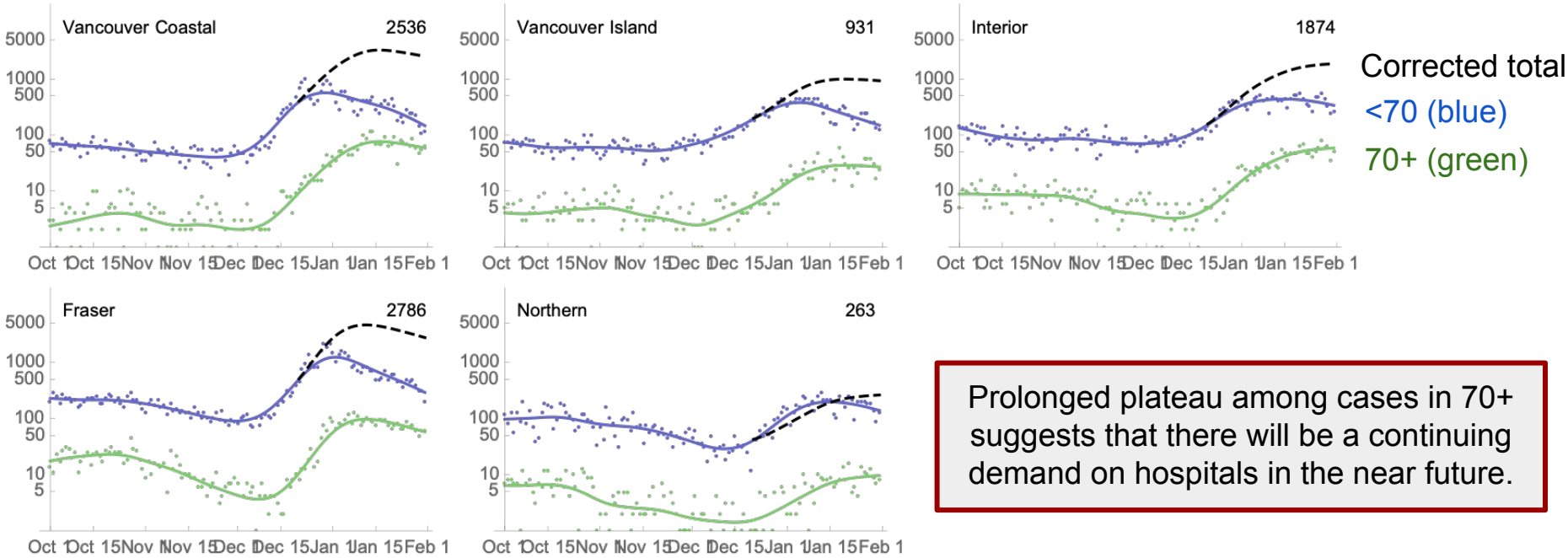
The age distribution is, however, likely to have shifted over the last month, so this total is increasingly unreliable.



→ The 70+ age group continues to suffer very high case counts**, which have not yet started to decline significantly**.**

Source (S. Otto; BC COVID-19 Modelling Group) 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 (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 BC. *From the daily BC Gov News reports. **Linear regression through log case counts among 70+ from last 14 days of data.

Age-corrected case counts: Health Authority



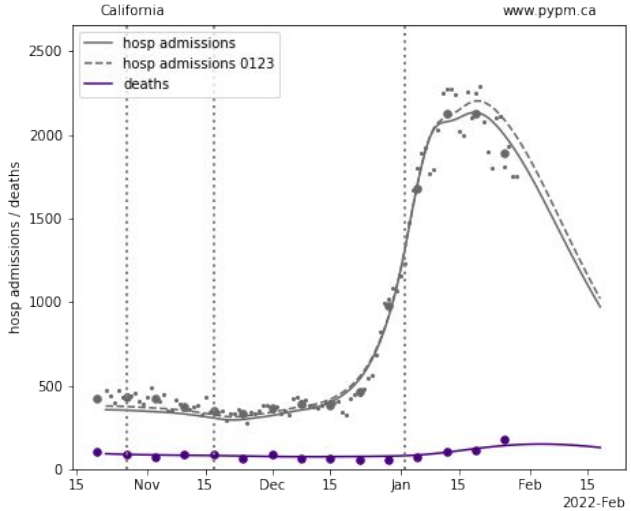
Prolonged plateau among cases in 70+ suggests that there will be a continuing demand on hospitals in the near future.

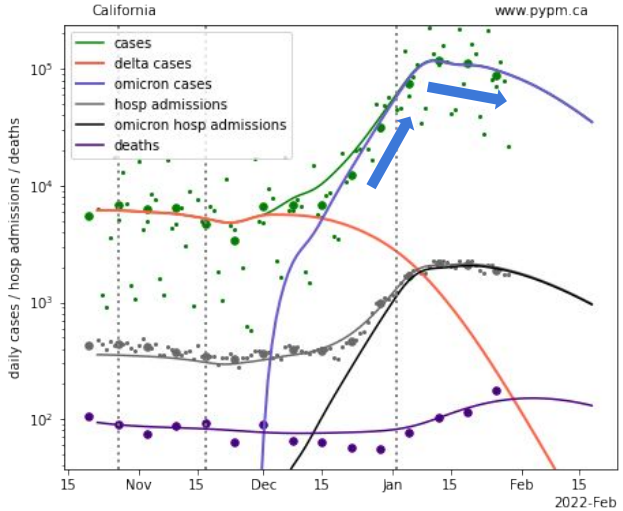
→ Cases among those aged 70+, while declining significantly* in Fraser Health, are persisting at high levels in the remaining Health Authorities.

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 (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. *Linear regression through log case counts among 70+ from last 14 days of data.

Omicron infection trajectory

- In all US states, growth rates for cases and hospital admissions reduced significantly near the start of 2022. **As a result, hospital demands have been significantly lower than earlier projections**.



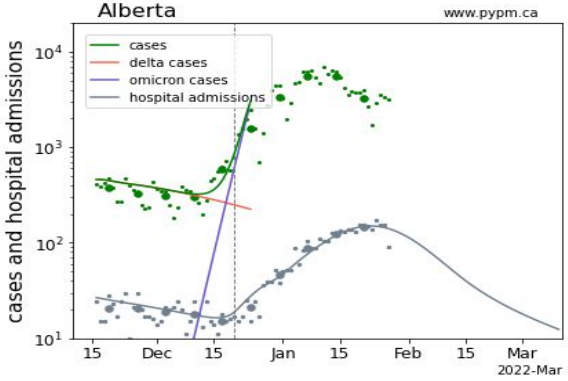


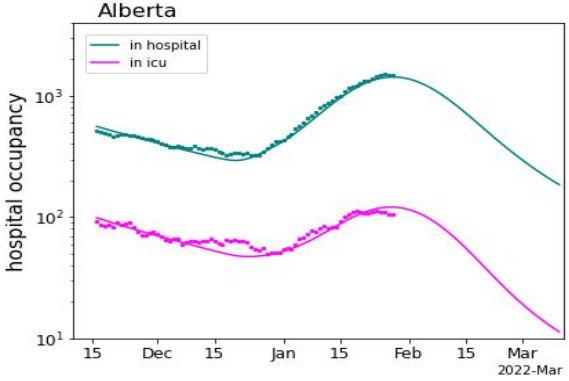
- The left plot shows the rapid rise in hospital admissions in California followed by decline. The curves show model fits to these data. The models include a significant reduction in transmission rate near January 1 (vertical dashed line).
  - the dashed curve shows the model fit from previous week: the projected decline was observed
- The right plot shows data in log scale. Exponential growth appears as straight lines.
  - the sudden change in slope is characteristic of a change in transmission rate
  - the smooth downward bending is characteristic of growing population immunity

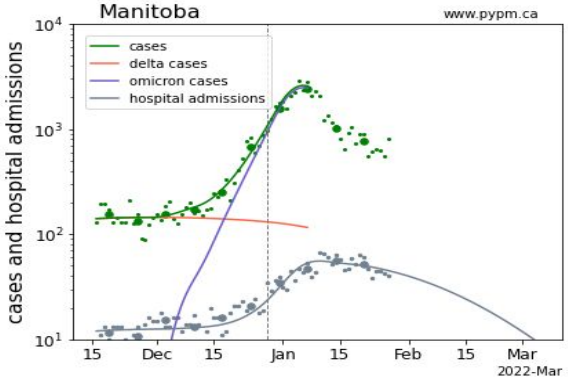
Source (D. Karlen). See www.pypm.ca. The larger dots show weekly averages.

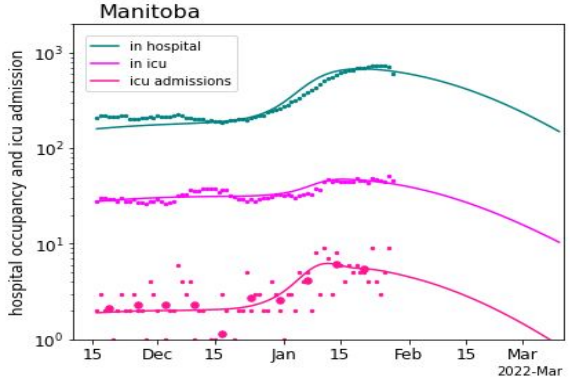
Omicron infection trajectory in Canada

A similar drop in growth rate is also seen in Canadian provinces (dashed vertical lines).





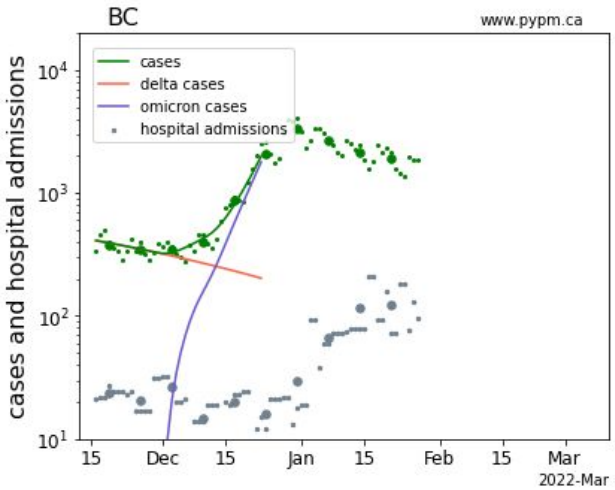


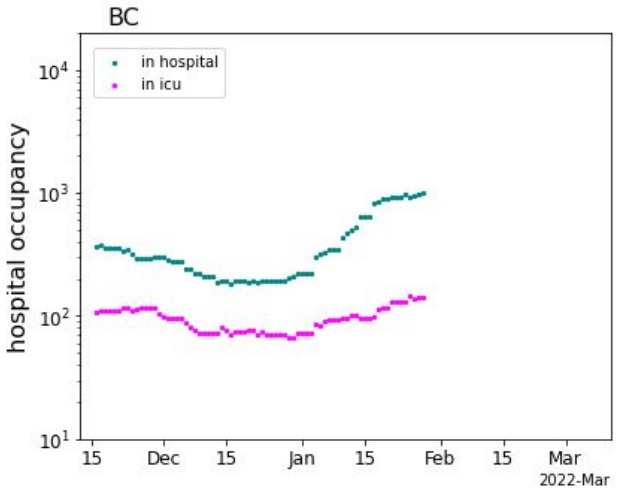


- As a result of changes to testing policy and testing capacity limits, cases can no longer be used in Canada to track the infection trajectory (green dots).
- Omicron growth rates can be monitored in provinces that provide reliable hospital admission data, in place of case data (left plots).
- With admission data to estimate Omicron growth rates, projections for hospital and ICU occupancy can be made (right plots).

Omicron infection trajectory in BC

Without reliable data, we cannot make projections for health care demands in BC





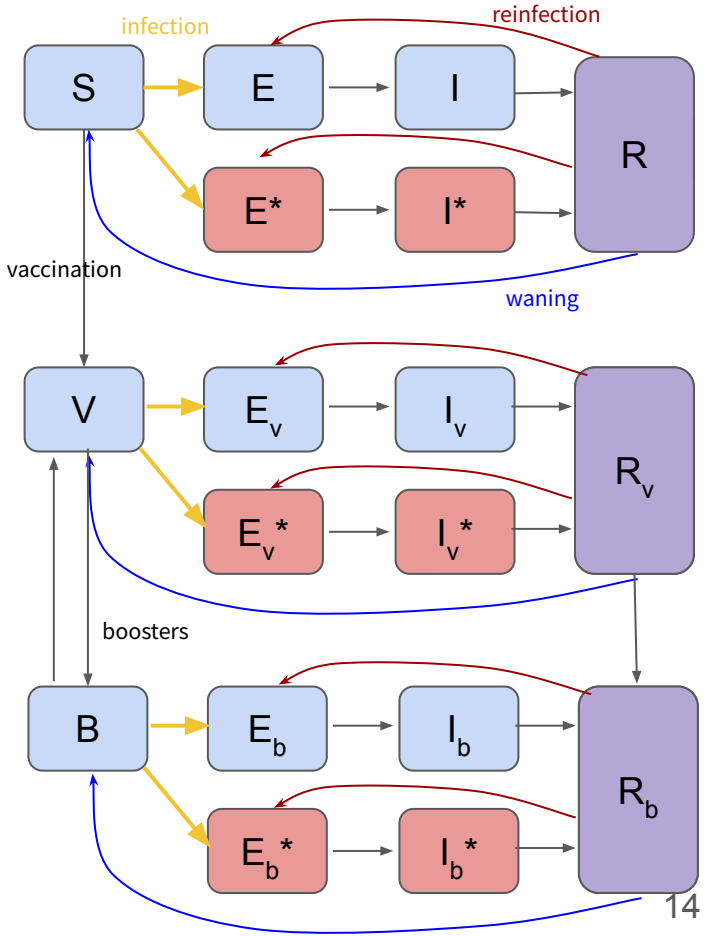
- Hospital admission data are posted irregularly and of poor quality (grey dots with large scatter).
- The province changed its definition for counting COVID hospital admissions in mid-January.
- Hospital occupancy appears to be leveling off (right panel).

Projections in a multi-strain model

This is a model with unvaccinated, vaccinated and boosted individuals, with two strains: blue (Delta) and red (Omicron).

The model allows for reinfection, different transmissibility and efficacy for Omicron, and waning of immunity.

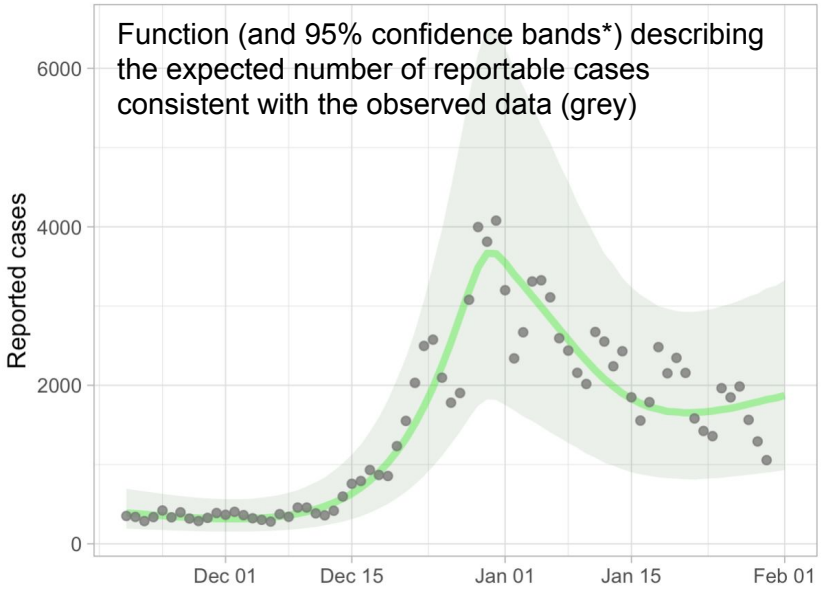
Approach: Fit to reported cases, but adjust the fraction of infections that are reported to mirror changes in testing, using those aged over 70 as a baseline.

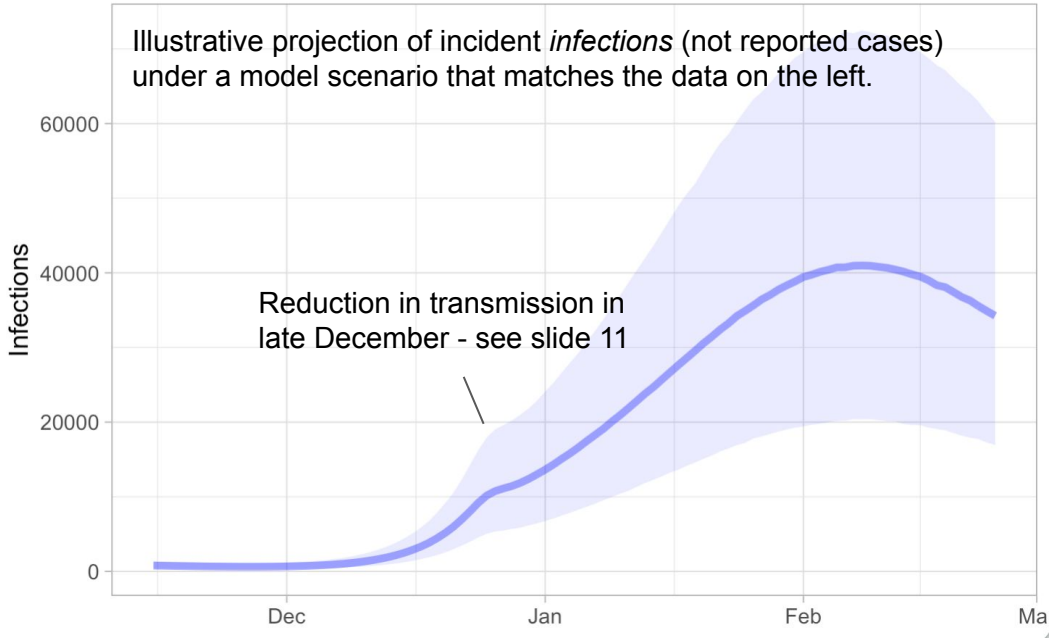


Source: SFU MAGPIE group. Boosters are ongoing in the model at a rate matching BC's reported levels in late December.

Reported cases and infections

Reported cases declined in January, but inferred infections are only now peaking.
There is considerable uncertainty about the peak size and timing.

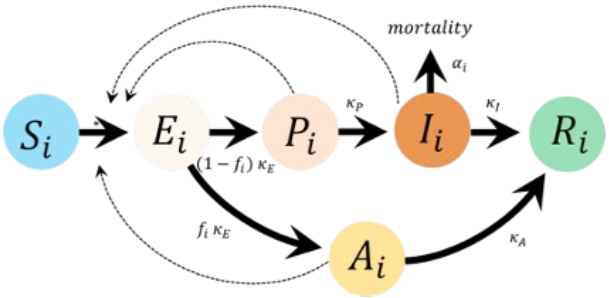


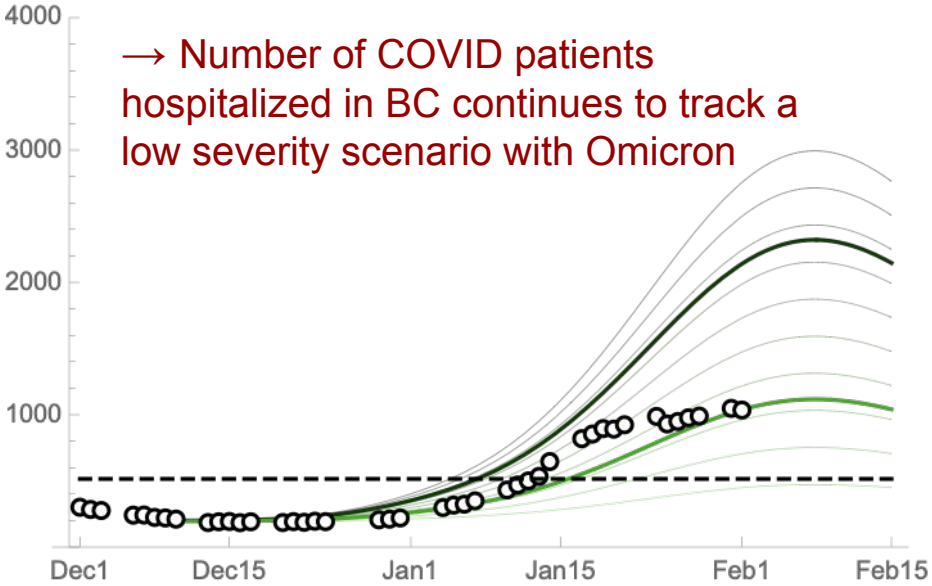


Source (SFU MAGPIE group; C. Colijn). Data used: reported cases; 50% Omicron by Dec 12; early growth advantage of Omicron 20% per day; test positivity in the private sector (slide 6); reporting in <70 and 70+ (slide 9). Fitted parameters: transmission parameters for the strains, strength of transmission reduction in late December.
*Assuming case data is distributed according to a negative binomial.

Age-based model: Hospital projections with Omicron

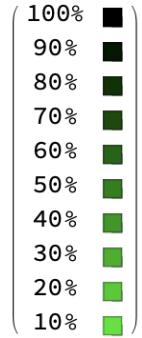
Scenario from January 2022 report: Reduced growth of Omicron





→ Number of COVID patients hospitalized in BC continues to track a low severity scenario with Omicron

Omicron severity



Severity: Varied from 0.1 (light green) to 0.9 (light black) for the risk of hospitalization per case for Omicron relative to previous variants for unvaccinated individuals. Estimated of 76% from Ferguson et al. is thicker black curve; estimate of 33% from UK Technical Briefing is thicker green curve.

Source (S. Otto). See details in 19 January 2022 report. Only the scenario #2 where Omicron growth rate was reduced for everyone from 20% to 12% per day on December 24 is shown. No further adjustments have been made.

Sources of uncertainty

There are many sources of uncertainty in modelling COVID-19 infections, in addition to data limitations. These include:

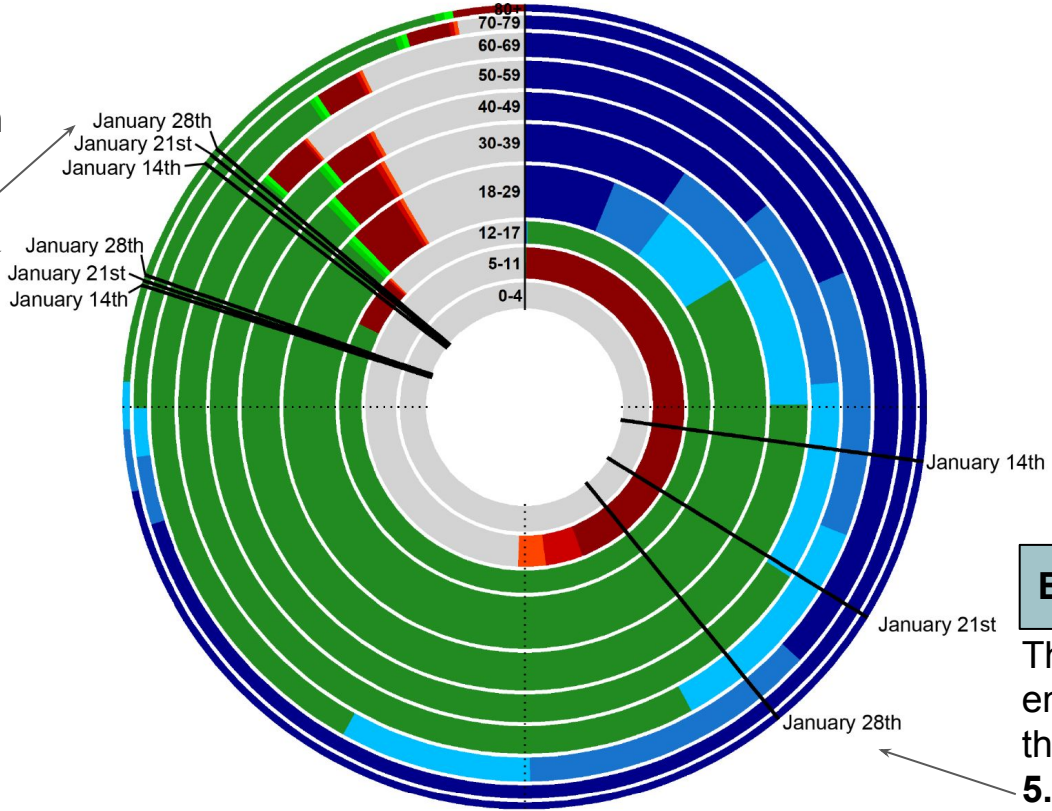
- The fraction of infections that have been tested/reported in the past - this impacts the estimated amount of immunity in the population, which impacts the peak projection
- Changing age distribution of infections
- Impact of school and university reopening
- Variation among regions (health authorities, finer-scale differences):
  - In vaccination levels, in contact patterns, potential variation in test-seeking and test access, in immunity from past COVID-19 infection, etc
- Uncertain duration for which people remain infectious (and circulating in public), and how this may differ for Omicron
- Uncertain protection from near-term reinfection (protection against severe disease is believed to be very good, but infection and infectiousness impact model projections)
- Impact of BA.2, including whether BA.2's growth advantage results from increased transmissibility, and whether it will be similar in BC to other places.

Vaccination status by age

January 28th update includes data through January 22nd

February 3 2022
BC COVID-19 Modelling Group

The fraction of BC's entire population with one or two doses increased **0.3%** and **0.2%** respectively over the past week



Single vaccinated before:
- January 22nd
- January 15th
- January 8th

Double vaccinated before:
- January 22nd
- January 15th
- January 8th

Triple vaccinated before:
- January 22nd
- January 15th
- January 8th

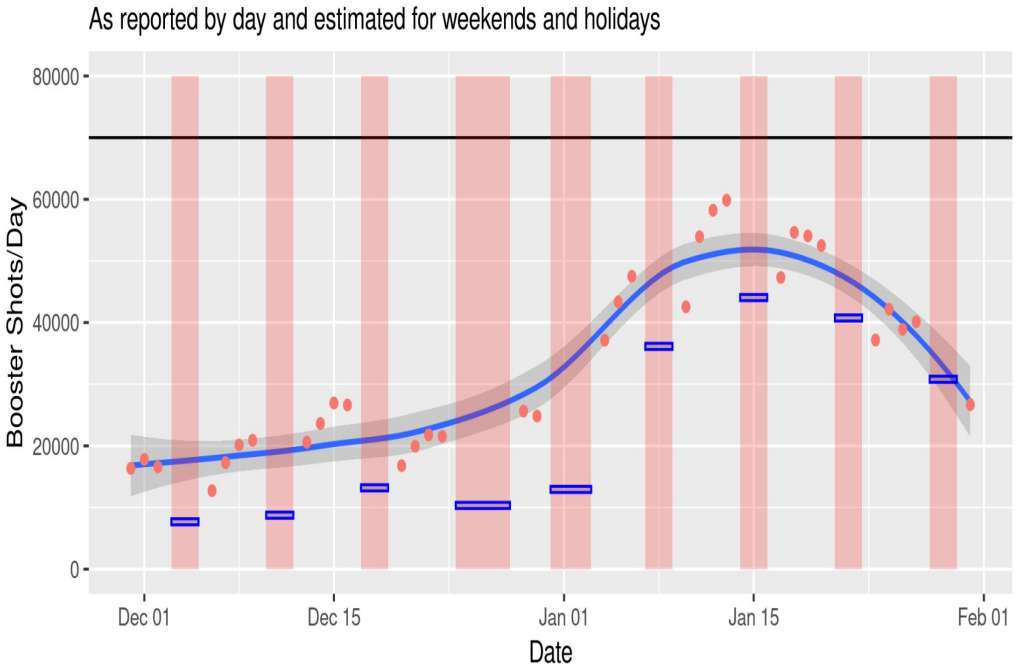
Unvaccinated

Booster Progress

The fraction of BC's entire population with three doses increased **5.4%** over the past week

Source (B. Wiley). Design by Blake Shaffer (https://blakeshaffer.shinyapps.io/app_vaccines/) BC Vaccination data for first and second doses from https://health-infobase.canada.ca/covid-19/vaccination-coverage/, with area of each circle segment proportional to BC's population in that age class. BC 2022 Population projections for vaccination percentages from BC Stats: https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-projections

Booster Shot Progress



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.

Boosters have been found to substantially increase protection against severe disease and hospitalization from Omicron.

BC PHO goal for boosters was 70K/day (see report) (here: black horizontal line).

Red dots show reported boosters/day.

Blue curve shows smoothed trend in boosters/day. Now trending down and <30K/day.

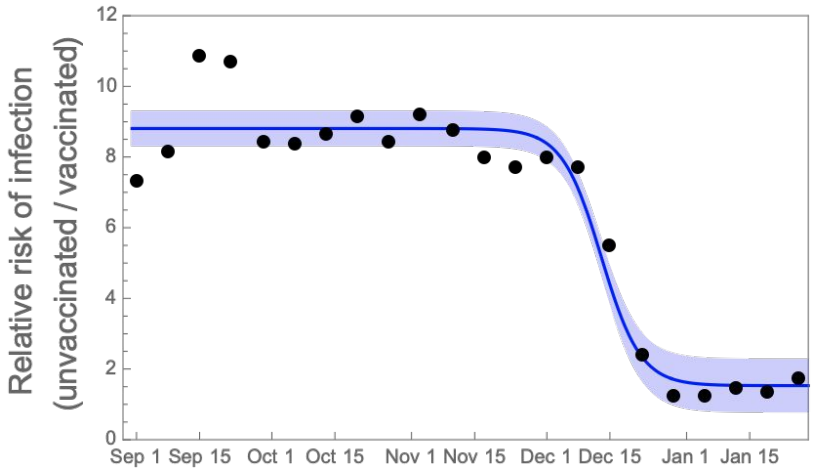
Blue horizontal bars are estimated boosters/day for days when booster #s are reported for a period of several days rather than a single day. Estimate gives boosters provided over period /# days in period.

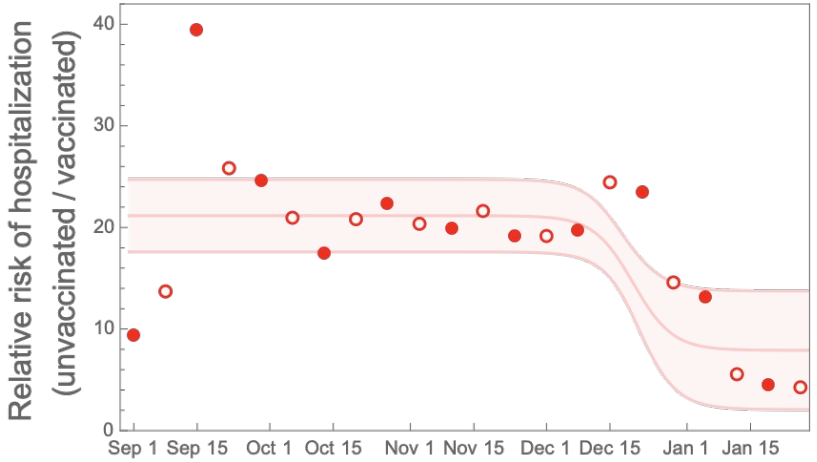
Note that weekend boosters are typically less than adjacent weekdays (red dots).

Changing immunity with Omicron

The risk of COVID-19 for an unvaccinated person relative to a fully vaccinated person has declined rapidly with the spread of Omicron in BC. Being unvaccinated increased the relative risk of infection by an average of 8.8-fold before Omicron, but this has declined to only 1.5-fold with Omicron (left). The risk of hospitalization has fallen less, from 21.1-fold before Omicron to 7.9 (right).

[Relative risks are for an average person (age corrected) and do not reflect patterns in specific ages or given specific types and dates of vaccination.]





Source (S. Otto) Risks for an unvaccinated person relative to a fully vaccinated person (age corrected) were obtained from the daily BC Gov News reports. Because risk of infection is calculated across the past week, we use data from only one day per week (Wednesday) and fit $a\,(1–p_t) + b\,p_t$, where p_t is the frequency of Omicron (inferred by D. Karlen in Dec 22 report, slide 7). Risk of hospitalization is calculated over the past two weeks of data, so we fit to a model of Omicron frequency seven days ago $a\,(1–p_{t-7}) + b\,p_{t-7}$ to account for the lag in hospitalizations, using data from every other week (analysing solid and hollow points separately) and averaging the results.

What can we learn from surveillance efforts for other respiratory infections?

Influenza-like illness (ILI) and lab-confirmed infections are monitored across Canada (see Appendix for recent data):

- Network of hospitals, labs, doctor's offices and provincial health ministries
- National "Fluwatchers" volunteer network report symptoms
  - Sentinel surveillance of a targeted group over time provides data collected from the same group of people over time (e.g., the UK SIREN study)
- Analysis of severe disease outcomes and flu strain characterization, including monitoring for drug resistance
- Statistics on vaccination levels are kept
- Weekly reports produced by PHAC (national) and BCCDC (local)

Influenza monitoring benefits from consistent data collection and case characterization, although data accessibility remains an issue.

Sources: https://www.canada.ca/en/public-health/services/diseases/flu-influenza/influenza-surveillance/about-fluwatch.html
https://www.canada.ca/en/public-health/services/publications/diseases-conditions/fluwatch/2021-2022/week-3-january-16-january-22-2022.html

Implications for reporting on SARS-CoV-2

- During the omicron wave, BC has transitioned away from symptomatic testing for SARS-CoV-2 for most people. This changes the data that is available and makes modelling more uncertain.
- Routine surveillance through hospitals and doctor's offices could be used to monitor symptomatic and severe SARS-CoV-2 in the community, as PHAC and BCCDC do with influenza.
- Rates of SARS-CoV-2 infection, especially in infants and children, should be presented alongside data for other respiratory viruses such as RSV and influenza (Appendix).
- An ongoing study cohort of people who undergo regular testing, regardless of symptoms, would give detailed information on current rates of infection in different groups (age, economic status, etc) across BC (e.g. UK ONS study). This would go beyond the current strategy for influenza.

Sources: https://www.gov.uk/government/statistics/coronavirus-covid-19-infection-survey-uk-14-january-2022

Key messages

State of the Omicron wave in BC:

- Cases in individuals >70 in age have plateaued and are starting to show significant declines in Fraser Health.
- Until cases in this age group drop more broadly, we do not predict hospital demand will drop.
- In general, hospital burden remains low, much lower than the worst case scenarios considered in previous reports. This success is likely due to a combination of individual actions to reduce transmission, BC's booster program, with 50% of adults having now received a booster, and the low severity of Omicron.
- We may be at the peak number of Omicron infections, but there is substantial uncertainty due to substantial gaps in all potential data sources about COVID-19: cases, hospitalizations, wastewater surveys, and genomic data.

Accurate, timely and consistent data is needed to understand the progress of the pandemic and the impacts of public health measures. Sharing high quality, anonymized data with the public can build trust and supports a less-polarized discussion around policy.

High quality data does not need to be in the form of daily case counts. Monitoring programs for asymptomatic and symptomatic disease, wastewater surveillance, and genomic surveillance of variants can all support decision making and mathematical modelling.

Our group will continue to **call for sharing of anonymized public health data**, for SARS-CoV-2, as well as other infectious, non-infectious, environmental and mental health conditions.

Appendix: Selection coefficient for BA.2 wrt BA.1

Selection coefficient analysis

For an exponential process, the expected number of cases reported over a period of $m = 7$ days commencing on day d is

$$E[N(d)] = \int_d^{d+m} n_0 e^{rt}\, dt = \frac{n_0}{r} e^{rd}(e^{rm} - 1)$$

For two exponential processes (1 and 2), the ratio of the daily cases is given by

$$r(d, s, d_0) = \frac{E[N_2(d)]}{E[N_1(d)]} = a \exp(r_2 - r_1)d = a \exp(sd) = \exp s(d - d_0)$$

where a is a constant, d is an integer day number, and s is the selection coefficient $s = r_2 - r_1$. The constant a defines the relative prevalence for the period commencing on day 0. A more suitable parameterization specifies the time d_0 for which the two have equal prevalence.

There are other strains in the samples and the sampling fraction can change with time. The problem can be considered to be a binomial problem, only considering the omicron samples.

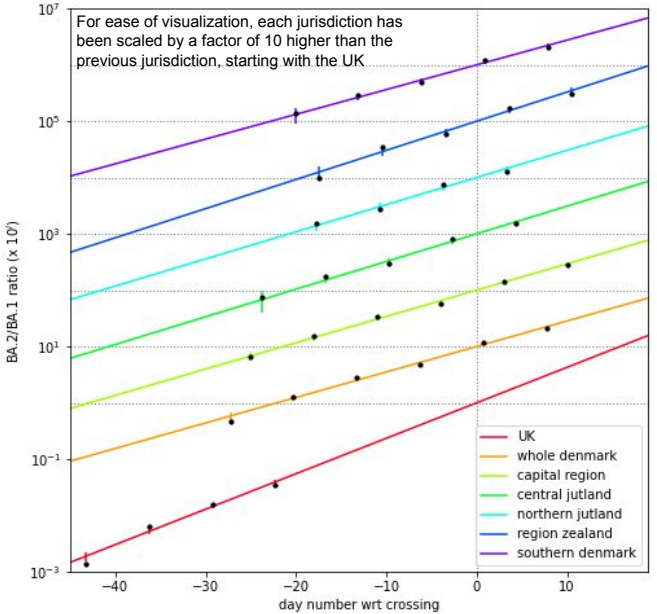
The probability for an omicron case to be type 2 is:

$$p_2(d, s, d_0) = \frac{E[N_2(d)]}{E[N_1(d) + N_2(d)]} = \frac{1}{1 + 1/r(d, s, d_0)}$$

To estimate s, use maximum likelihood. This is a binomial problem, with $n = n_1 + n_2$ trials each day.

$$\ln \mathcal{L}(s, d_0) = c + \sum_d [n_2(d) \ln p_2(d, s, d_0) + n_1(d) \ln(1 - p_2(d, s, d_0))]$$

No analytic solution, so find the estimates and uncertainty numerically.



Data from UK and regions of Denmark analyzed:

- s: selection coefficient
- d0: days after 12/5/2021 when BA.2 becomes the dominant Omicron lineage

68% statistical uncertainties shown

region	s	d0
UK	0.145 ± 0.001	64.3 ± 0.2
whole denmark	0.104 ± 0.001	34.3 ± 0.1
capital region	0.108 ± 0.007	32.0 ± 0.0
central jutland	0.113 ± 0.003	37.8 ± 0.0
northern jutland	0.111 ± 0.002	38.7 ± 0.4
region zealand	0.119 ± 0.004	31.5 ± 0.1
southern denmark	0.101 ± 0.003	34.1 ± 0.2

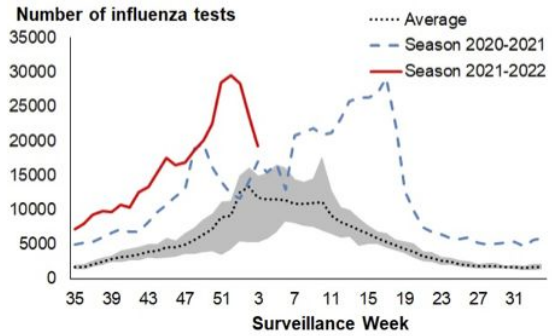
Selection coefficient of BA.2 relative to BA.1 is consistent across Denmark and somewhat smaller than in UK.

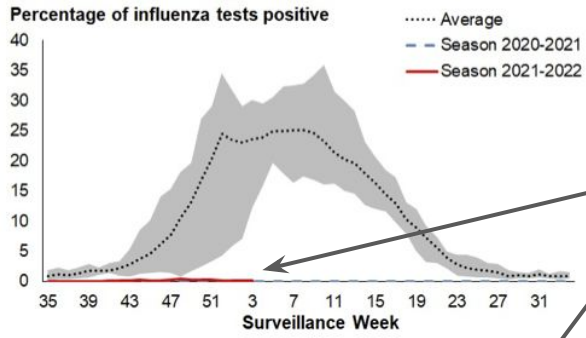
BA.2 will become the dominant Omicron lineage in the UK about 30 days later than in Denmark.

Source: D. Karlen

Appendix: Tracking influenza

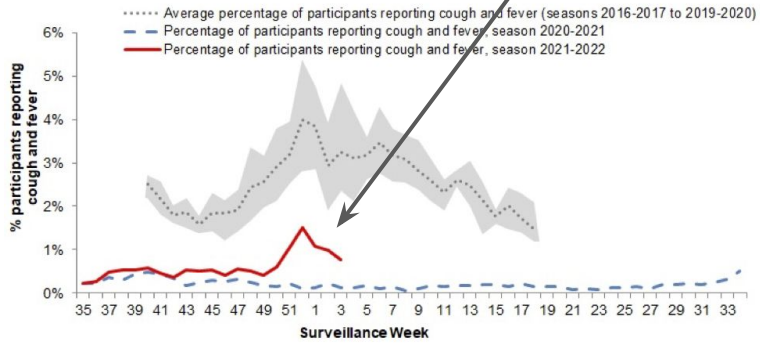
BC network of medical practitioners





Despite high testing rates, there have been very few influenza cases in the past two years (9 this week)

Fluwatcher



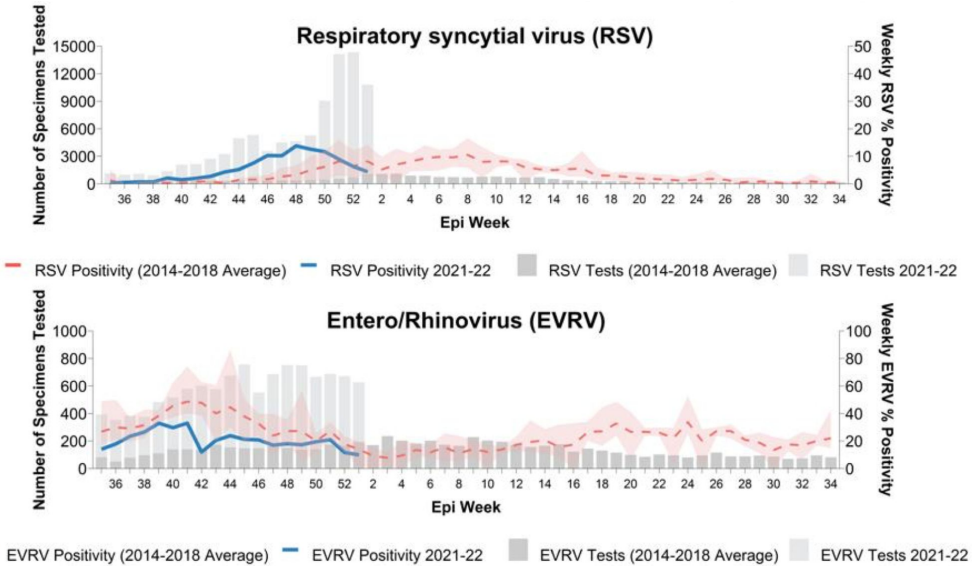
- 98/12711 Fluwatcher volunteers reported ILI symptoms last week but *"The percentage of participants reporting cough and fever in recent weeks has been at the highest level seen in the past two seasons."*
- Rates of reported ILI are much higher than last year, but much lower than in pre-pandemic years.

Sources: https://www.canada.ca/en/public-health/services/diseases/flu-influenza/influenza-surveillance/about-fluwatch.html
https://www.canada.ca/en/public-health/services/publications/diseases-conditions/fluwatch/2021-2022/week-3-january-16-january-22-2022.html

What might we see in the future if SARS-CoV-2 is treated similarly to other respiratory infections?

BCCDC also produces a weekly report on influenza and influenza-like-illness (ILI)

- There are many other circulating viruses that can cause ILI. Two of the most common are respiratory syncytial virus (RSV) and entero/rhinovirus. Similar to influenza, these viruses can be serious for infants and for older adults.
- Hospital (especially BC Children's) and lab data for these viruses is reported by the BCCDC.
- The whole-province, and BC Children's, test positivity rates for RSV were a bit higher than usual for RSV in the fall of 2021, while test positivity rates for entero/rhinovirus were a bit lower than usual. Changes in testing due to the pandemic make it difficult to interpret details.
- SARS-CoV-2 is not included in the BCCDC report



Sources: http://www.bccdc.ca/health-professionals/data-reports/communicable-diseases/influenza-surveillance-reports