COVID Model Projections

January 6, 2022

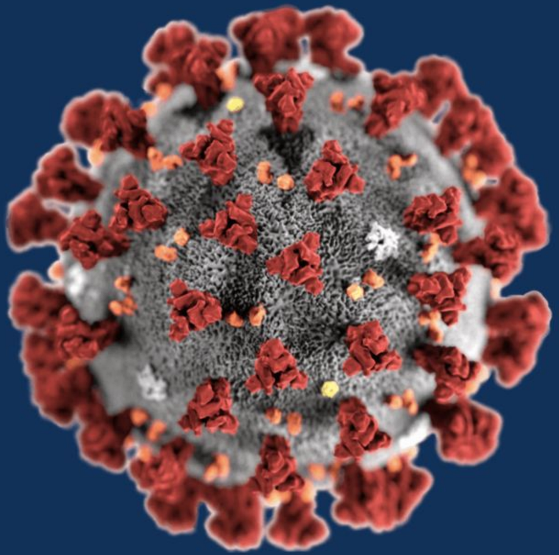
BC COVID-19 Modelling Group

@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

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)
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.

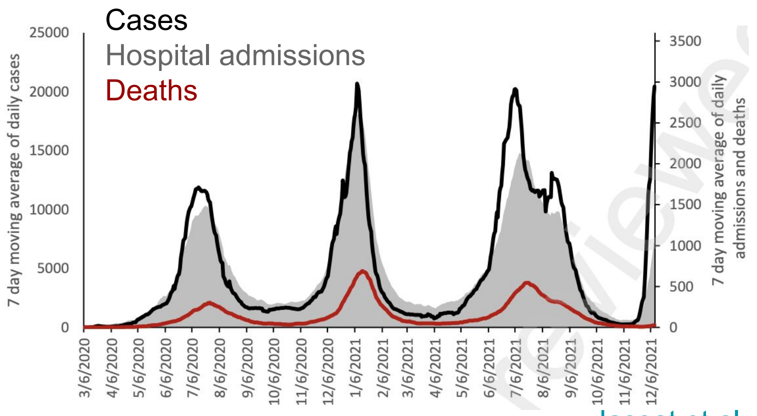
Overview

Omicron is now established and spreading within BC

- Case rates have risen rapidly to the **highest levels seen during the pandemic**, with spiking case numbers in every health authority.
- Models estimate that prior to Christmas, Omicron cases in BC were growing 21-26% per day, doubling every 3.0-3.6 days. With testing limitations, current growth rate is unknown.
- Testing capacity limits have now been breached in BC, with the province prioritizing use of PCR tests for those “people 65 years and older, as well as those with underlying medical conditions”. While rapid antigen testing expands capacity, results are not available publicly. We call on BC to share this information.
- Models continue to predict that demand on hospitals will be extreme in January, reaching much higher levels than witnessed to date, even if Omicron is less severe.
- Rapid spread means we have little time to act, but we can protect ourselves and slow the spread of Omicron in BC as we did with previous variants: **getting vaccinated, wearing tight fitting masks, improving ventilation, avoiding large indoor gatherings, and improving rapid testing and isolation**

Omicron: Updates from around the world

Highlighting large studies and studies most relevant to BC



Jassat et al.

Severity:

- South Africa summary found that hospitalization rates dropped from 16.6% of cases in previous two waves to 4.9% for Omicron; patients admitted with Omicron were 73% less likely to have severe disease[1] and were released in half the time (median of 4 days vs 7-8 days), reflected a combination of higher immunity in the population and/or lower severity of Omicron (Jassat et al.).

- UK study controlled for immunity (vaccination or prior exposure), finding 35% fewer admissions to hospital per Omicron case than Delta case (Ferguson et al.). Vaccinated cases (Pfizer two-dose) were much less likely to visit hospital (74% less for Omicron vs Delta), while unvaccinated cases were only slightly less likely (24% less).

- Ontario study found 54% lower risk of hospitalization for Omicron versus Delta cases [95% CI:23-73%]), matched by age and onset date and adjusting for vaccine status (Ulloa et al.).

→ Omicron cases less often require hospitalization, especially for vaccinated individuals, and more often result in shorter and less intensive care in hospital.

[1]Including cases needing supplemental oxygen or ICU care, exhibiting respiratory distress, or dying.

Omicron: Updates from around the world

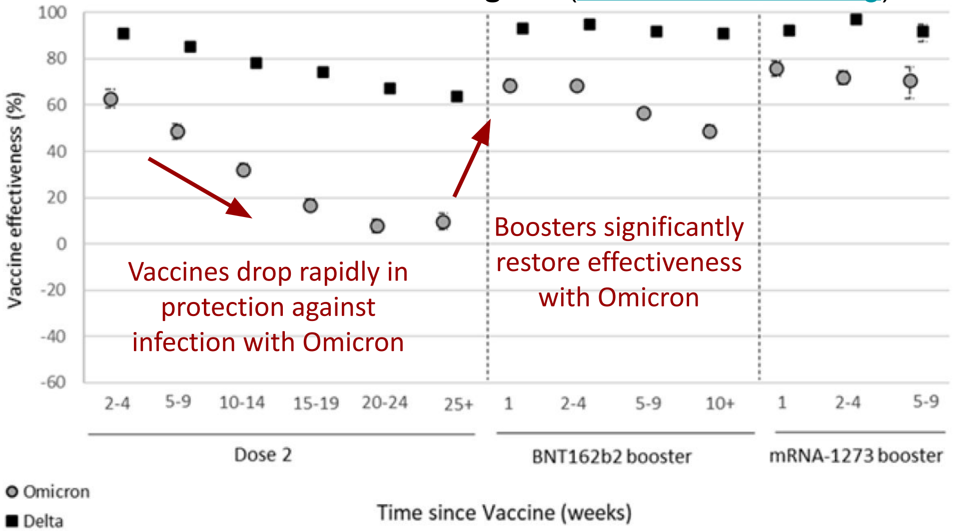
Highlighting large studies and studies most relevant to BC

Vaccine Effectiveness:

- UK study found vaccine protection against infection with Omicron plummets to near zero by 15 weeks but is regained to high levels within a week following boosting (UK Technical Briefing).

→ Higher antibody levels are needed to prevent infection with Omicron, because of its many genetic differences.

Pfizer two-dose regime (UK Technical Briefing)

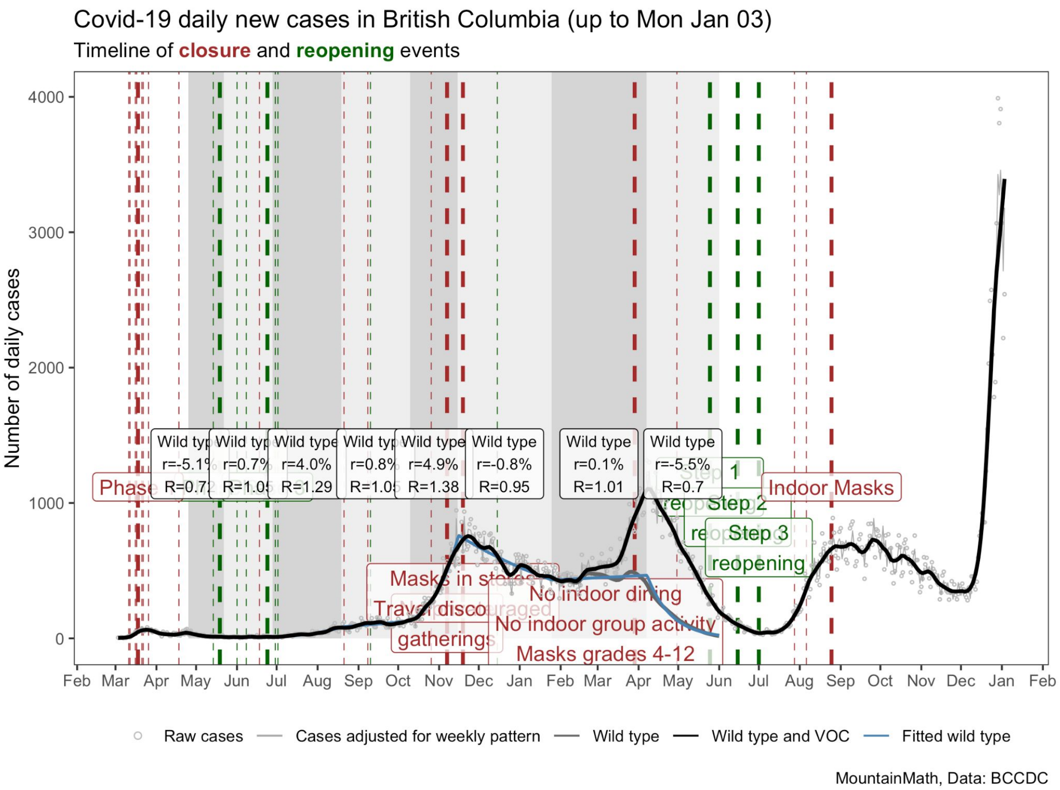


Transmissibility:

- Danish study found Omicron to be only slightly more transmissible among unvaccinated households (1.17x relative to Delta [95% CI:0.99-1.38]) and attributed Omicron's rapid spread primarily to its ability to infect vaccinated individuals (Lyngse et al.).
- Tissue-based study found that Omicron replicated 70x faster in bronchial tubes and 10x slower in lung tissue

→ Omicron may replicate less well in lungs and more in airways, potentially accounting for lower severity and slightly higher transmissibility.

State of the COVID-19 Pandemic in BC

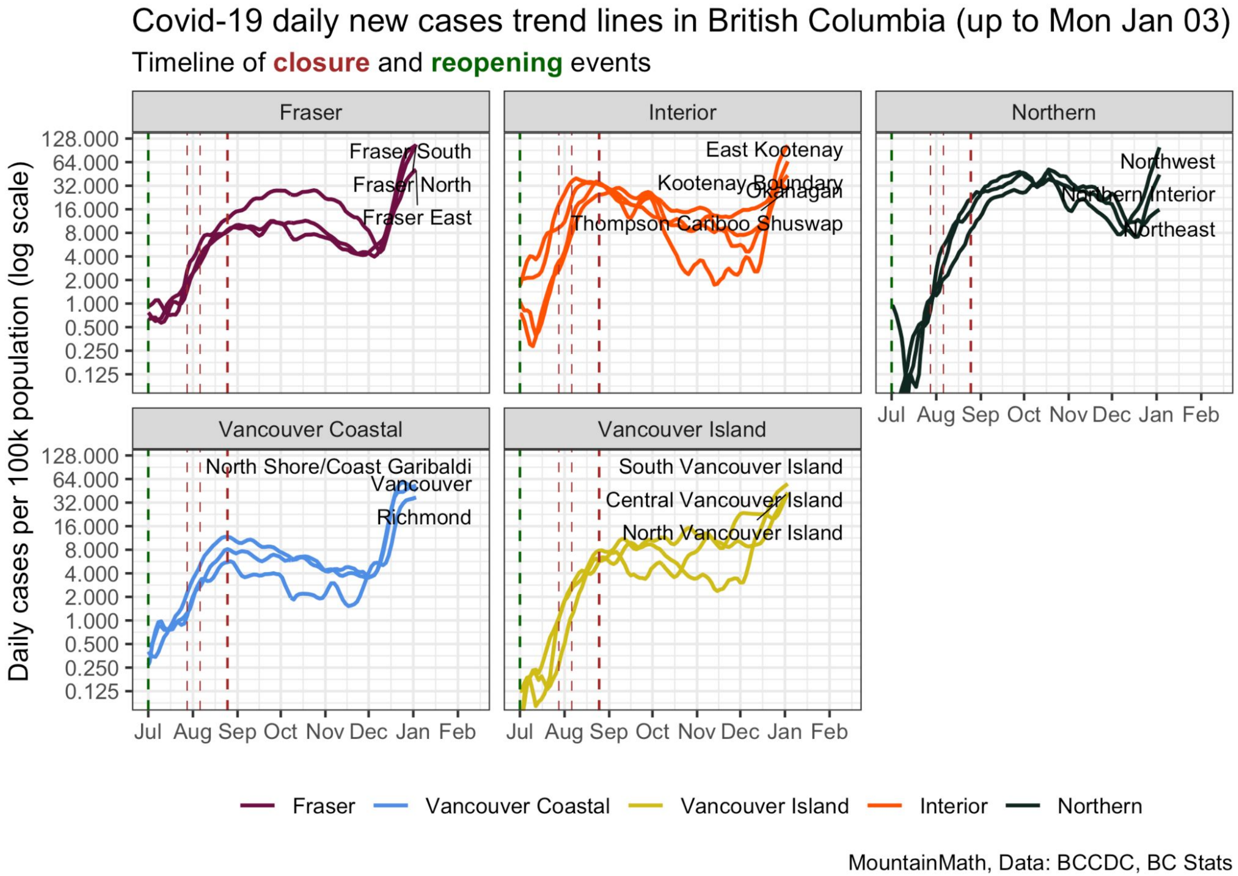


After the long decline in cases seen since September, the establishment of Omicron has lead to a dramatic rise in cases, reaching the highest levels yet seen in BC.

As testing is hitting capacity limits and people are diverted to self-report rapid test results, the PCR test results are understating current case growth.

Source (J. von Bergmann) Case data from BC COVID-19 Database (http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data). Vertical lines give dates of public health measures (major as thick lines, minor as thin lines). Grey dots are raw case counts, grey lines is cases abused for weekly pattern, black STL trend line and blue fitted periods of constant exponential growth. *Central Okanagan – July 29: masks, August 6: restrictions on group gatherings; Interior – August 21: masks; August 23: some restrictions on group gatherings. BC – August 25 mask mandate; BC's Vaccine Card to come into effect on September 13 (first dose) and October 24 (second dose)

COVID-19 in BC Health Regions



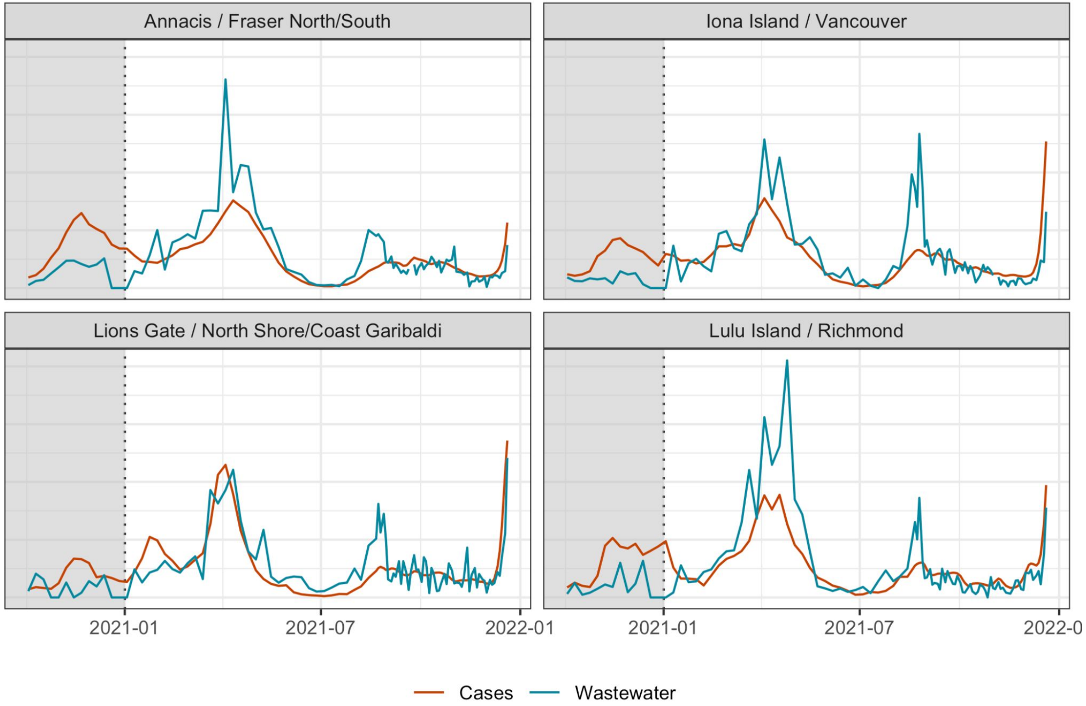
We now see steep increases in all heath regions, indicating that Omicron has become established everywhere throughout BC.

With cases so high that testing limits have been reached in BC, these graphs don't show the full picture of recent case growth.

Data Gaps

There are significant data gaps that make it difficult to assess the current status of Omicron in BC.

Wastewater COVID concentration vs case counts



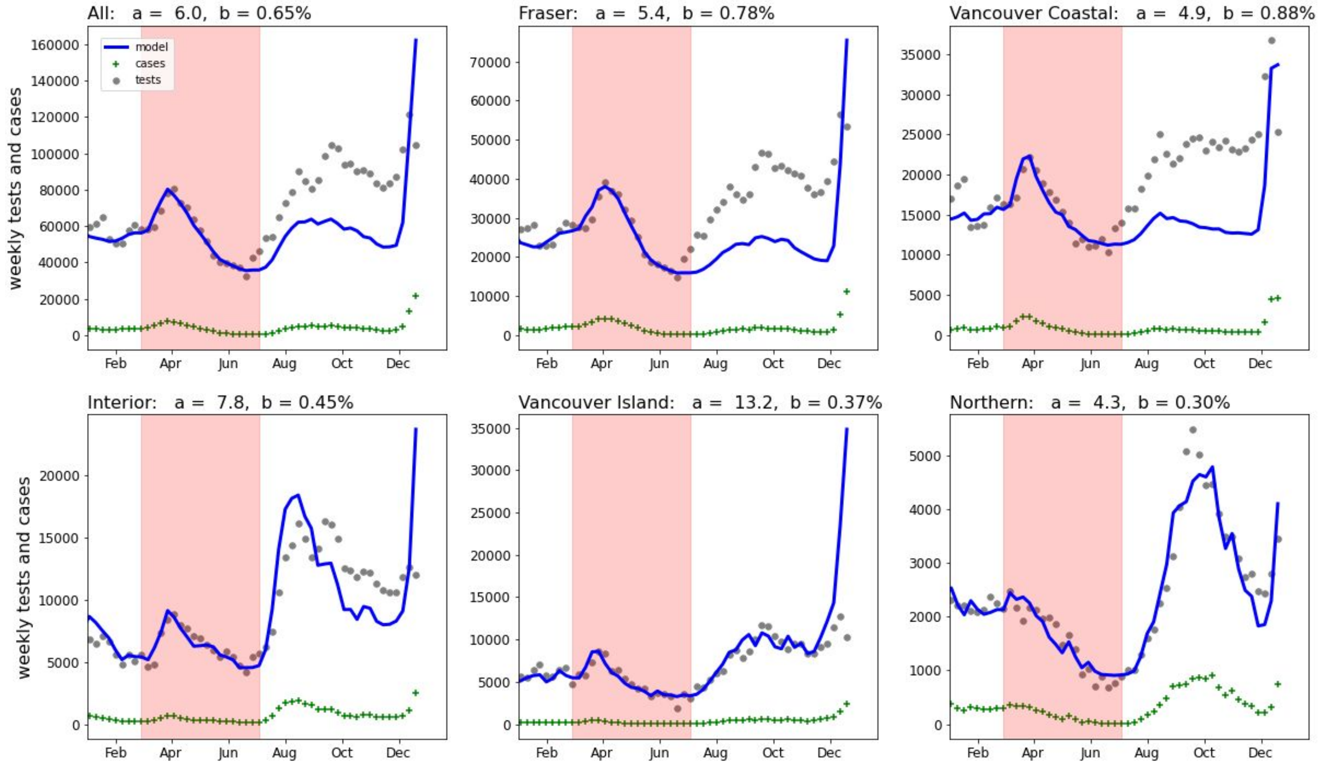
- As expected, testing capacity is unable to keep up with the growth of Omicron, leading to an unknown level of underreporting.
- People are being diverted away from PCR toward rapid antigen testing (RATs). While RATs increase capacity, the results are not publicly shared in BC, worsening the data gap.
- Wastewater surveillance data is in principle a good tool to estimate underreporting, but the Metro Vancouver wastewater surveillance data has not been updated since Dec 20.

Had a positive rapid antigen test?
Report results here and call on BC to share:
https://reportcovidresults.bccdc.ca/

→ COVID-19 infection rates are now highly uncertain

Testing rates in BC by Health Authority

Fraser and Coastal had additional testing during 4th wave



A consistent testing policy (starting Jan 2021) yielded a simple relation between number of tests and number of cases each week:

tests = $\mathbf{a} \times$ cases + $\mathbf{b} \times$ population

<u>Category A tests: COVID-related</u> (infections and contacts).
Cases lead to additional tests being performed ($\mathbf{a} > 1$)

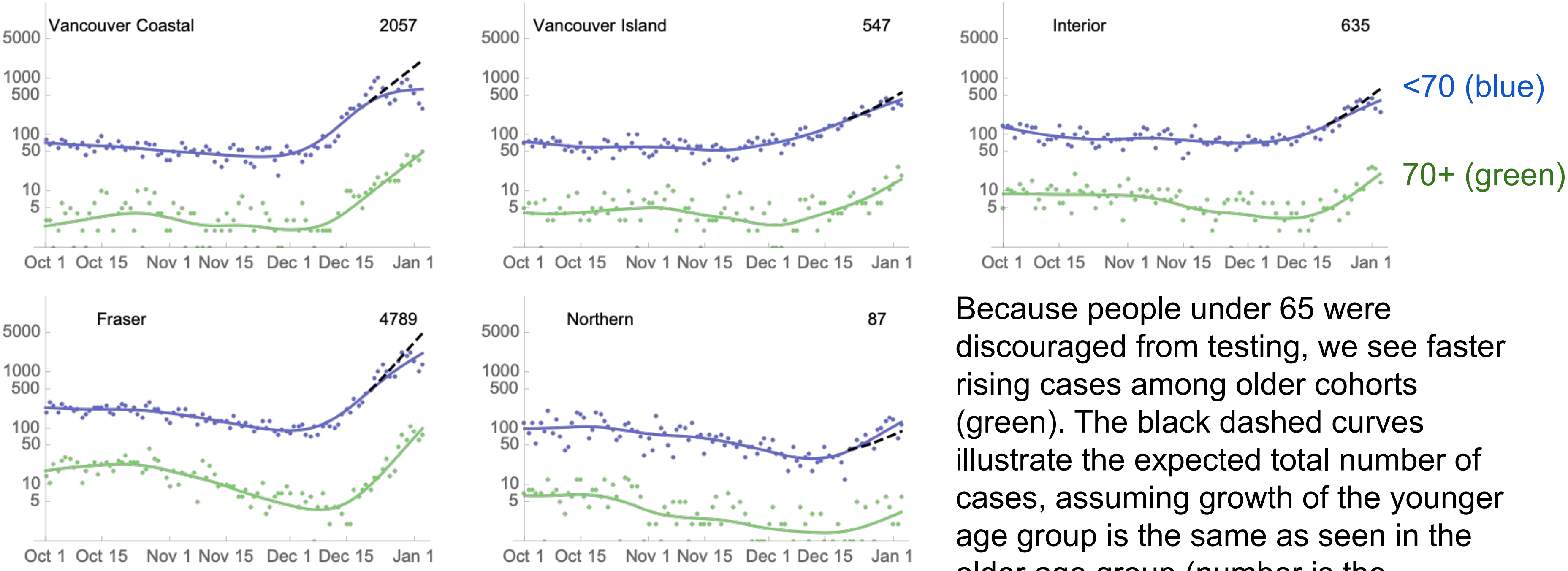
<u>Category B tests: background</u> (unrelated to a COVID infection)
b: fraction of the population per week who get a test for reasons unrelated to an actual COVID infection

The blue curves show the relations using **a** and **b** estimated from the 3rd wave (shaded in pink).

→ Current testing rates fall below expectation, given case numbers.

Source (D. Karlen). Case and testing data from the BCCDC public data dashboard. See the October 7, 2021 report.

How large is this data gap?



Because people under 65 were discouraged from testing, we see faster rising cases among older cohorts (green). The black dashed curves illustrate the expected total number of cases, assuming growth of the younger age group is the same as seen in the older age group (number is the projected total for January 3).

→ Using this age correction, the estimated number of cases that would have been detected on January 3 is **8115** had testing limits not been exceeded: **3.6 times more than the 2230 reported.**

Data Gaps

There are significant data gaps that make it difficult to assess the current status of Omicron in BC.

→ These data gaps matter!

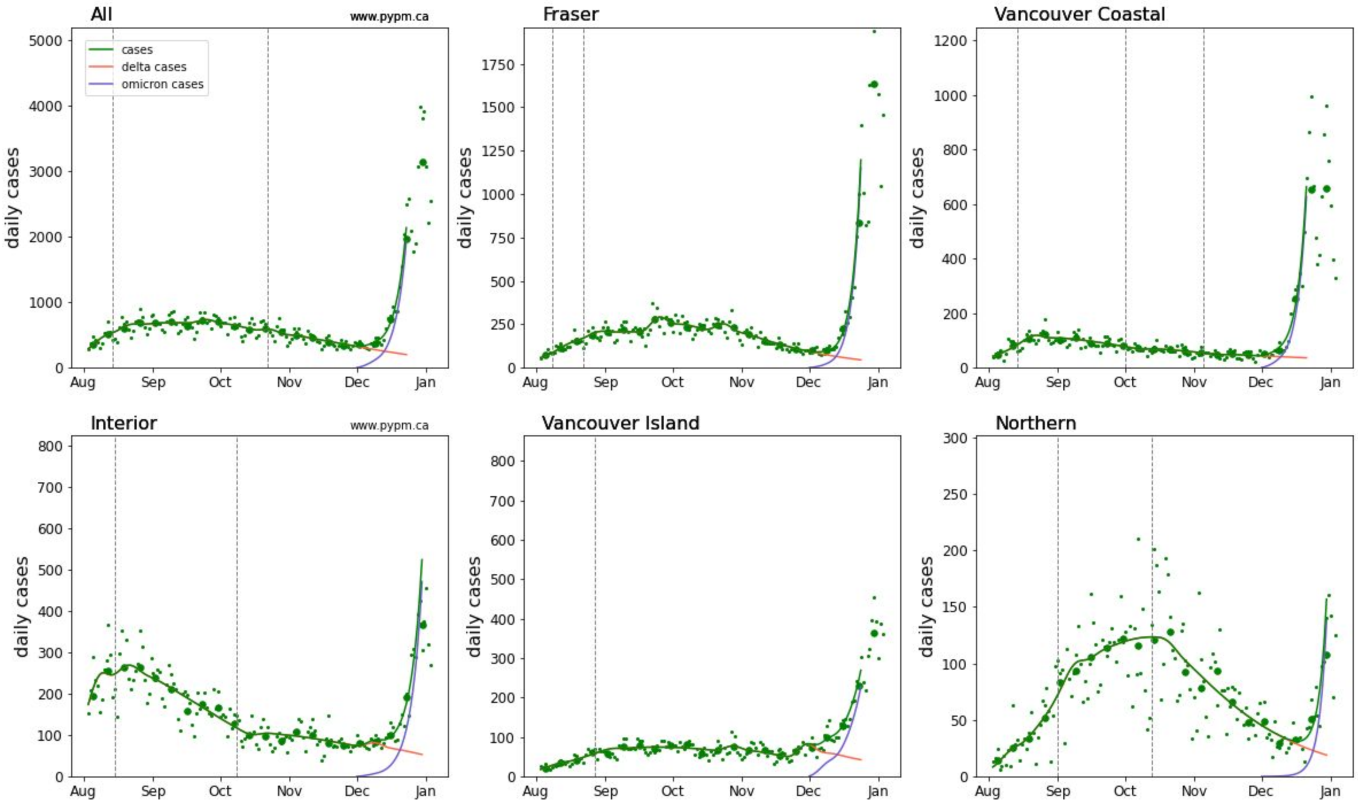
The lack of accurate estimates of Omicron infections means:

- Individuals cannot assess the risks they face (see table)
- The effect of recent public health measures cannot be determined
- Projections of the height and timing of peak cases and hospital demand become more uncertain, making it hard to develop the right contingency plans

Active cases	Chance of at least one infected person in a group of 10	Chance of at least one infected person in a group of 50	Chance that at least 2 employees are sick out of 10 workers
0.5% of people in BC (reported number*)	5%	22%	0.1%
5% of people in BC (10x higher**)	40%	92%	8.6%

*27,106 active cases in BC reported on January 4, 2022; **Potential level of underreporting because of testing limits, asymptomatic & mild infections, etc.

Omicron model fits to BC data



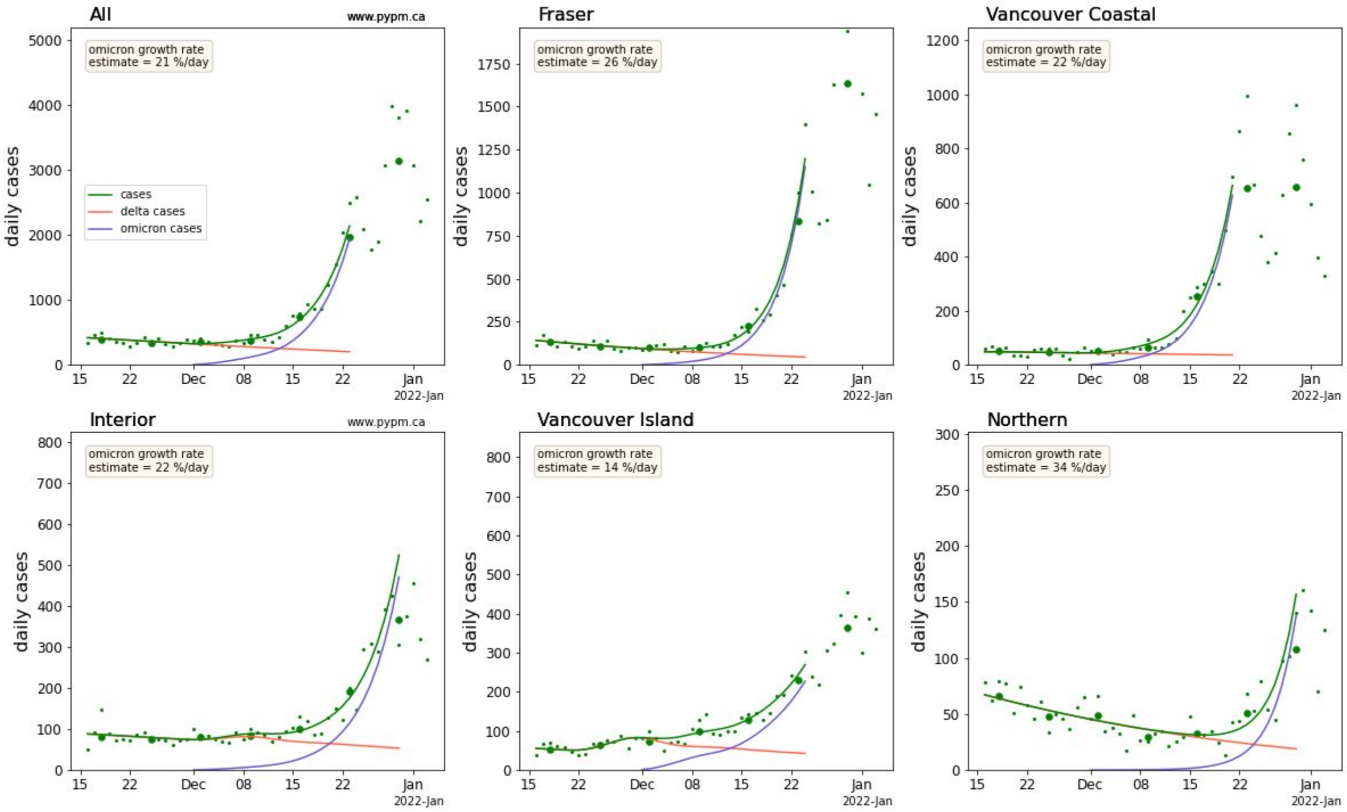
Maximum in each panel corresponds to 1 case per day per 1000 people in the region.

Model fits use case data until the date where it becomes apparent that holiday or testing policy/capacity cause a unusual drop in cases.

All HA clearly show growth in cases arising from Omicron

Source (D. Karlen). See www.pypm.ca. These models include vaccination but have no age structure. Vertical lines show fitted dates for transmission rate changes. The larger dots show weekly averages.

Omicron model fits to BC data (zoomed in)



Maximum in each panel corresponds to 1 case per day per 2000 people in the region.

Reliable Omicron growth rates estimates are 21 - 26% per day. (doubling times: 3.0 - 3.6 days)

Source (D. Karlen). See www.pypm.ca. These models include vaccination but have no age structure. The larger dots show weekly averages.

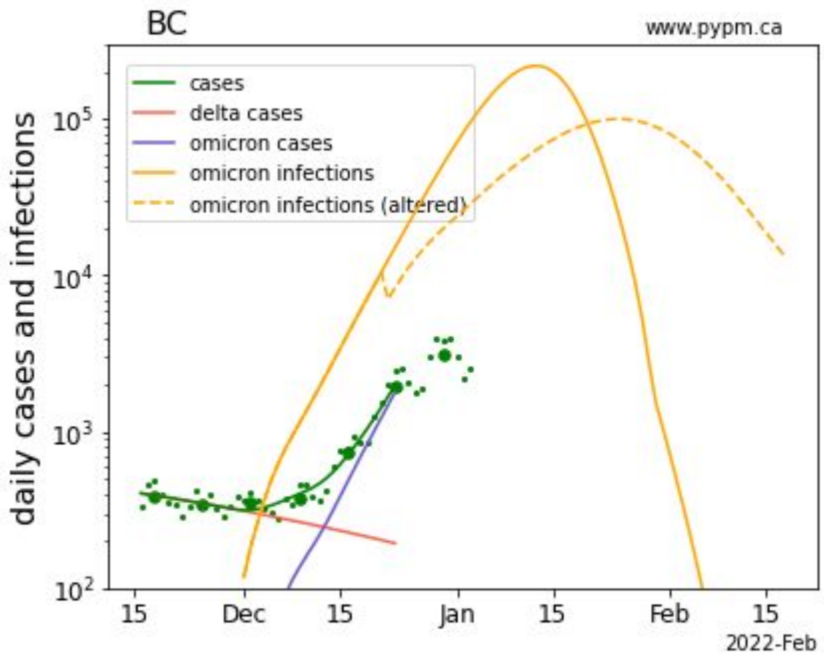
Longer term projections for BC

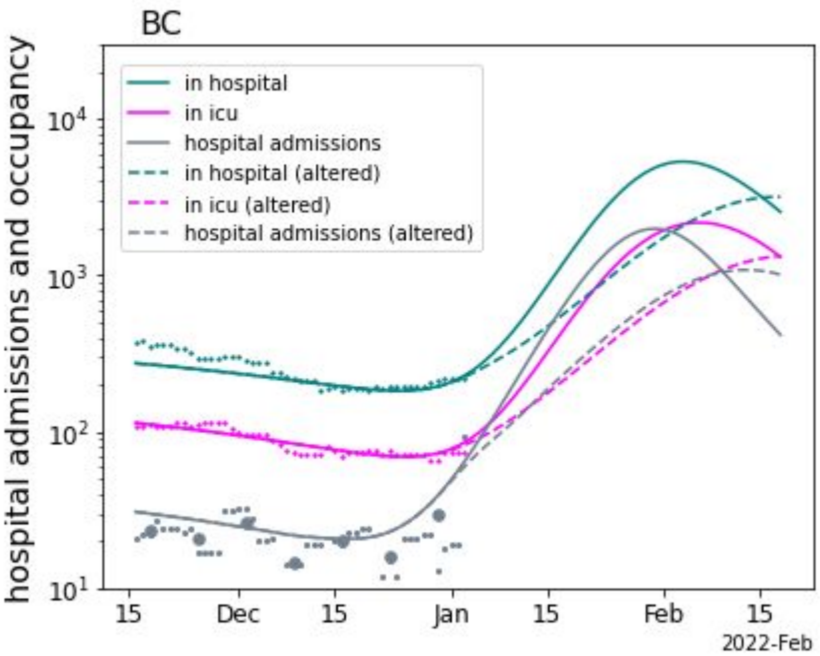
The following slides show 6-week projections for a set of nominal assumptions and for adjustments to those assumptions, to indicate sensitivity to the assumptions:

Model Parameter	Nominal	Altered
transmission rate	constant	50% reduction in December or January
2-dose vaccine effectiveness against Omicron	20%	50%
fraction of Omicron infections reported	same as earlier variants	0.3 times the reporting fraction for earlier variants
fraction of Omicron infections requiring hospitalization	0.3 times the hospitalization fraction of earlier variants	0.1 or 0.5 times the hospitalization fraction of earlier variants

- Projections show infections instead of cases, since the reporting fraction is unknown and likely to change in the future, due to capacity limitations.
- Projections do not include hospitalization capacity limits or changes to admission policies.
- Heterogeneity (not present in these homogeneous models) may result in earlier onset of herd immunity.

Reduction in transmission rate (December 21)



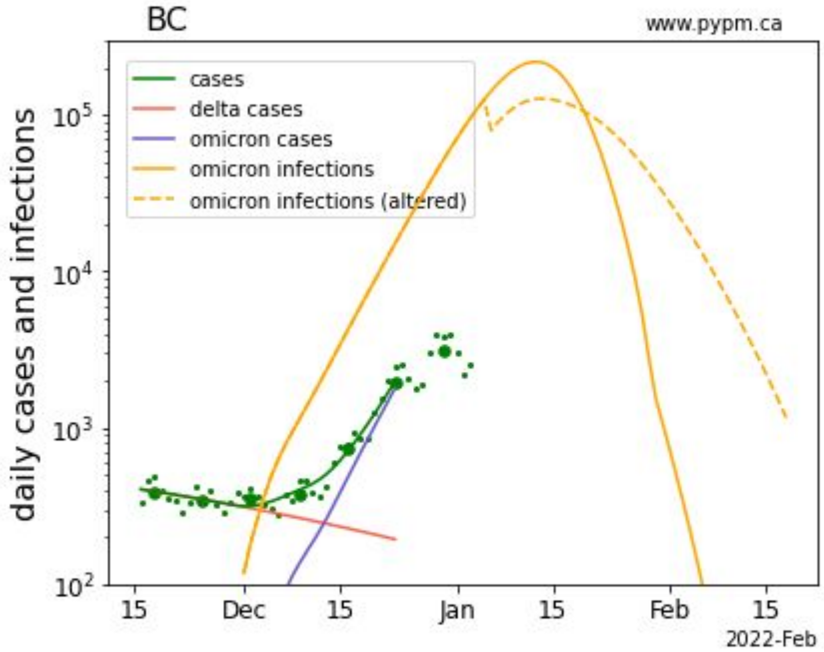


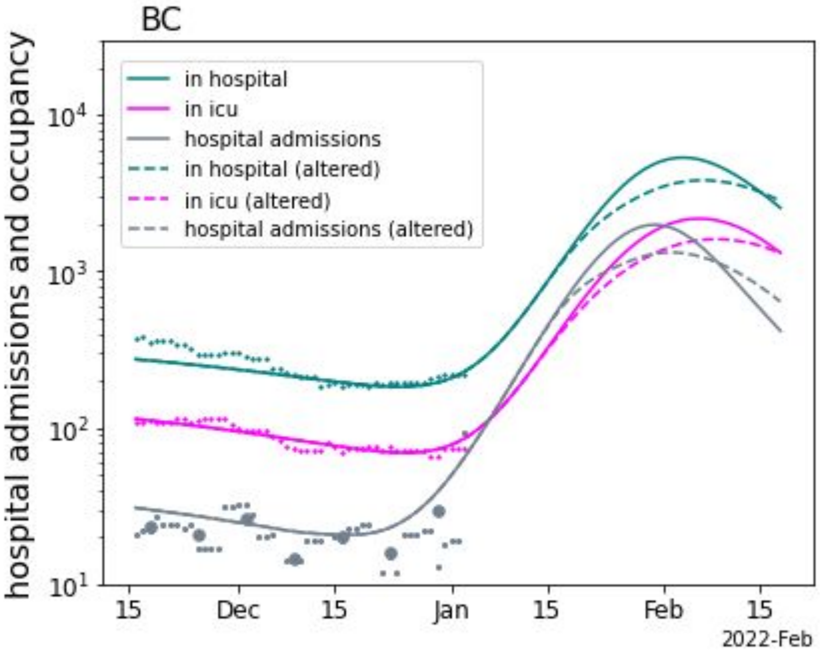
- Solid yellow curve: Omicron daily infections that led to the observed cases (after a delay). With a constant transmission rate, infections begin to decline in mid-January due to the herd effect.
- Dashed yellow curve: Had transmission reduced on December 21, reducing growth rate from 20% to 10% per day, infection and hospitalization peaks reduced by about 50%, but capacity limits are still exceeded.

→ Peak hospital demand would be lower and later, but peak remains very high.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Reduction in transmission rate (January 5)



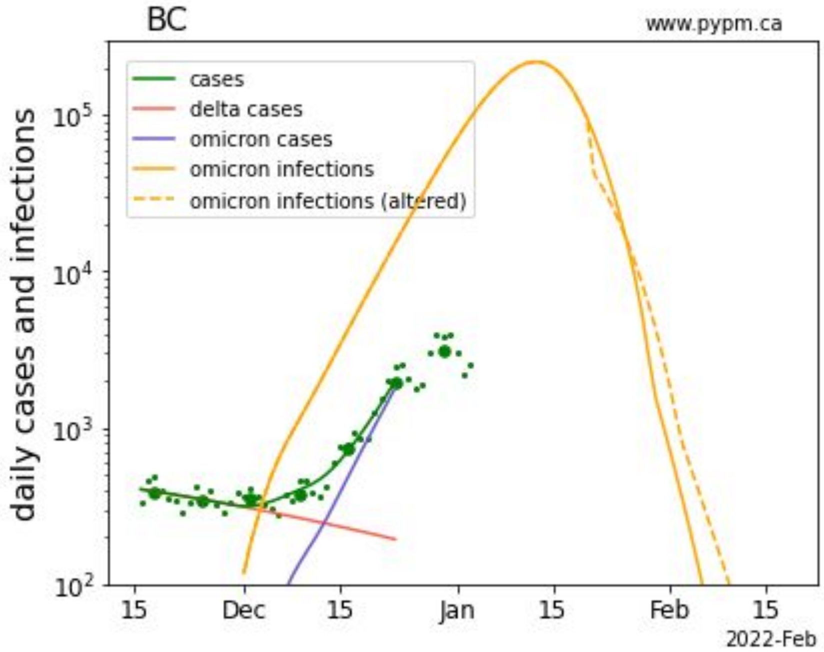


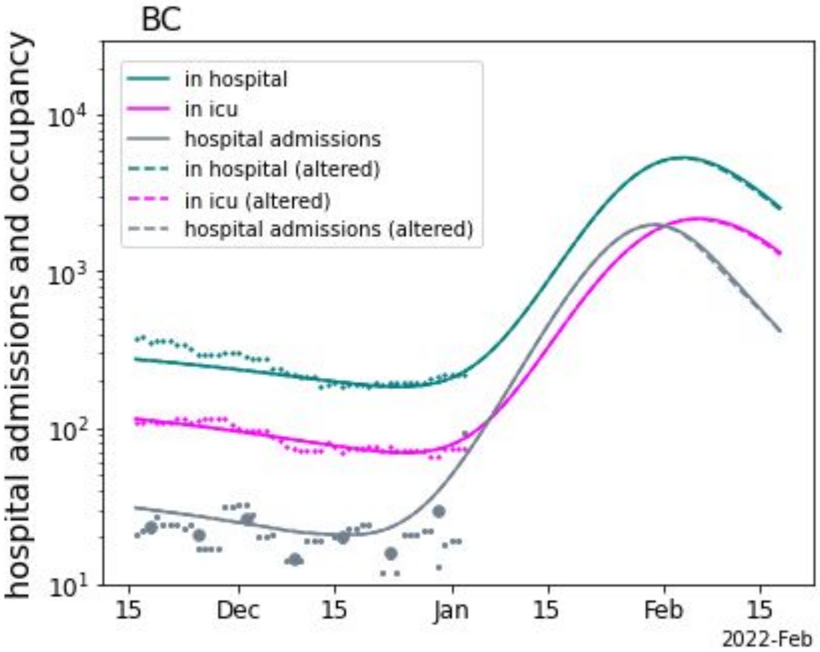
- Dashed yellow curve: The same reduction in transmission rate, but on January 5, has a smaller effect.

→ Peak hospital demand would be lowered by 30%, but peak remains very high.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Reduction in transmission rate (January 20)



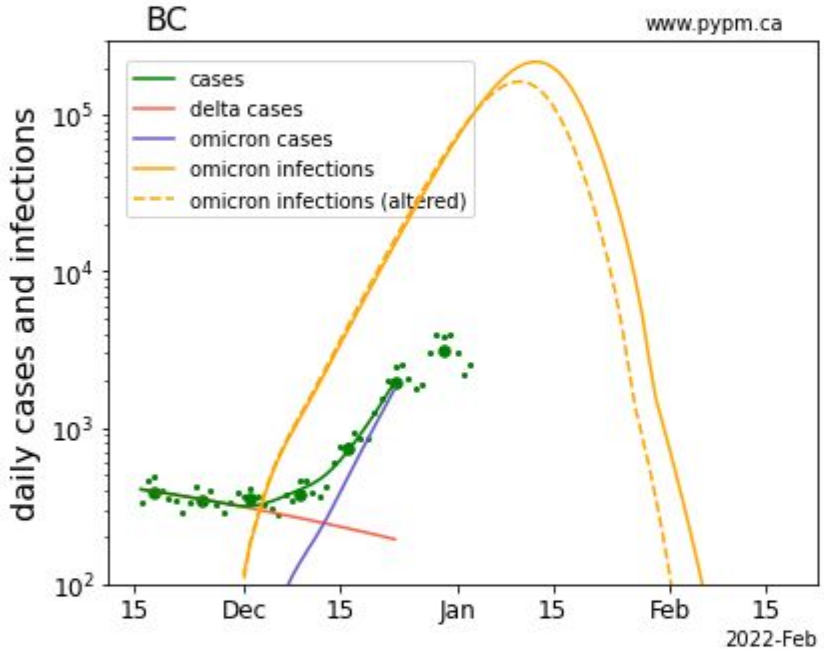


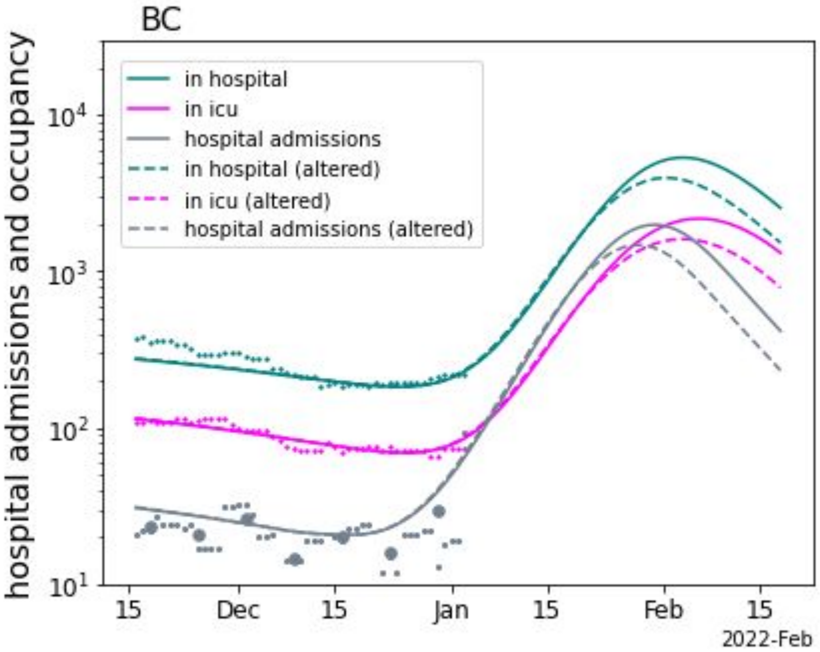
- Dashed yellow curve: The same reduction in transmission rate, but delayed until January 20, midway through the rise in hospital demand. The reduced transmission rate comes too late to have any substantial effect.

→ Transition would be too late to affect peak hospital demand

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Increased vaccine effectiveness against omicron



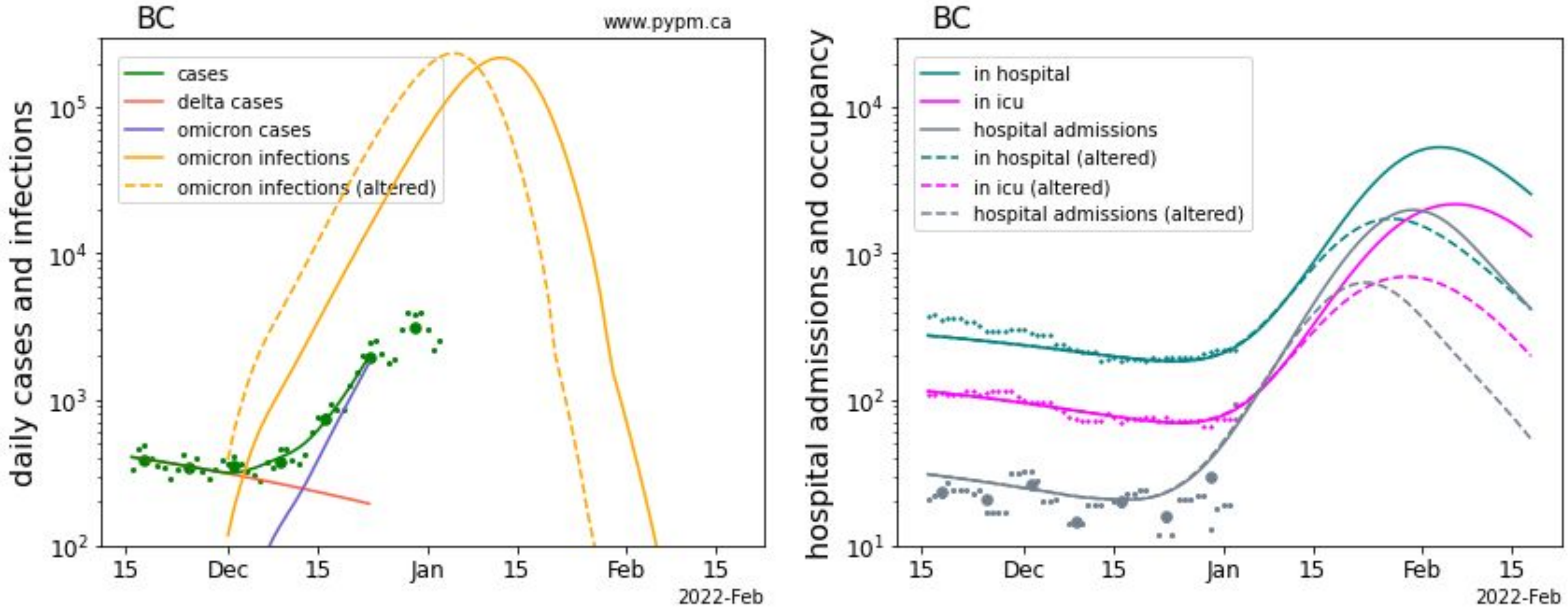


- Solid yellow curve: The effectiveness of 2-dose vaccination against Omicron is assumed to be 20%.
- Dashed yellow curve: The effectiveness is adjusted to be 50% and the transmission rate is adjusted to fit case data. Since a larger fraction of the population is immunized against Omicron, herd immunity is reached earlier and peak hospital demands are reduced, but still exceed capacity.

→ Peak hospital demand would be lowered by 30%, but peak remains very high.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Reduced fraction of Omicron infections reported

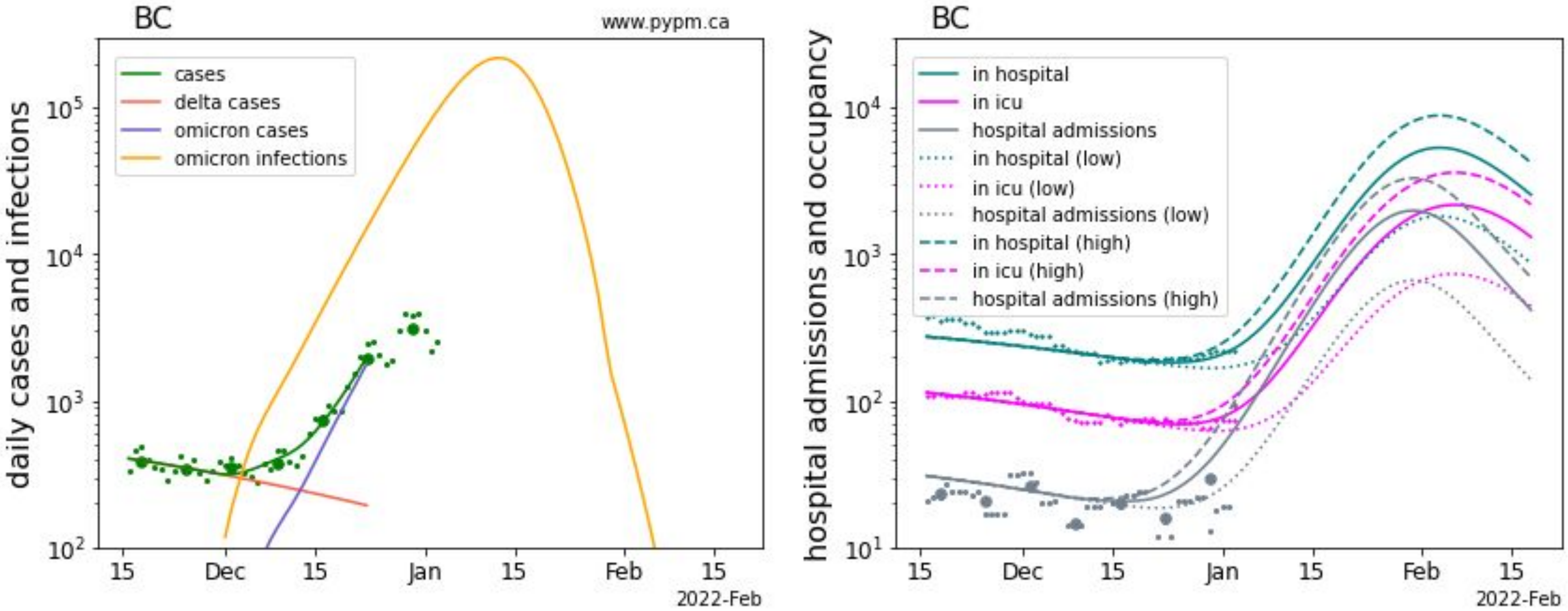


- Solid yellow curve: The fraction of Omicron infections reported is the same as for other variants.
- Dashed yellow curve: The fraction of Omicron infections reported is 0.3 times the reporting fraction for other variants. In this scenario, we are further along the infection trajectory than we realized. As a result, herd immunity comes earlier than expected and Omicron severity is lower than estimated from data.

→ If many more cases are mild and went undetected, peak could be 3 fold lower.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Omicron severity

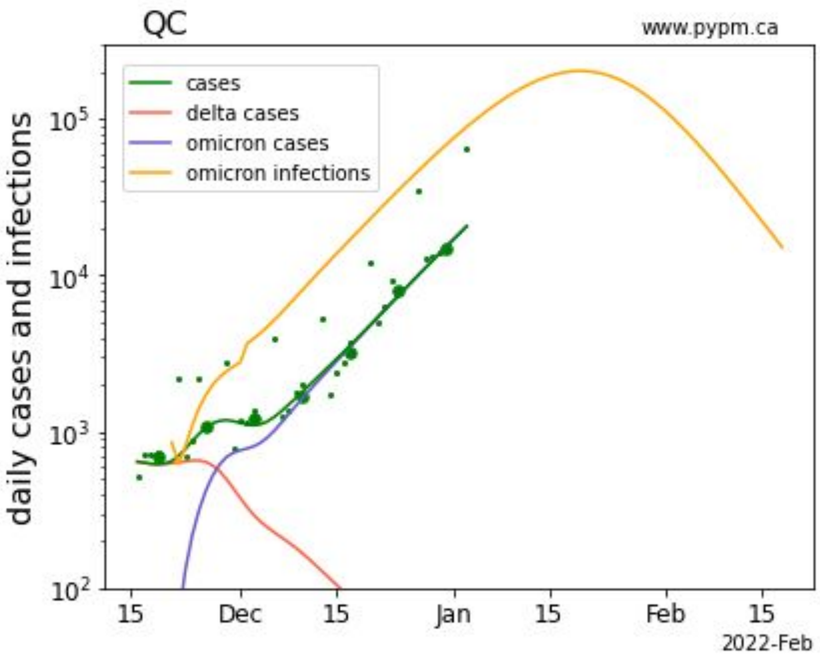


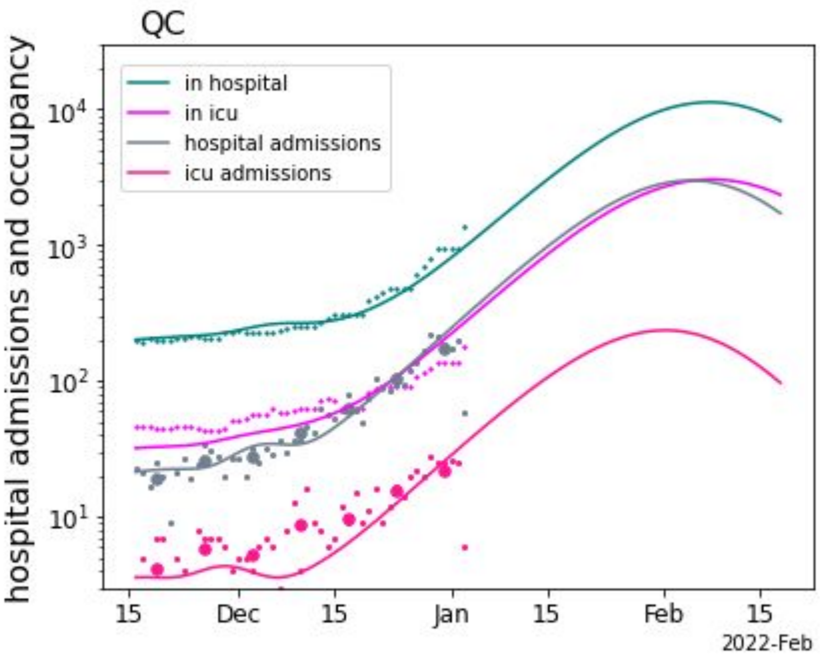
- Solid hospital curves: The fraction of Omicron infections requiring hospitalization is 0.3 times the hospitalization fraction for other variants. The duration for hospital stay is 0.4 times that for other variants. These values are estimated from a study of US states where Omicron has been dominant for weeks.
- Alternative Omicron hospitalization scale factors: low (0.1) high (0.5). Duration scale factor is kept at 0.4.

→ If cases are much less severe than already assumed, peak could be significantly lower.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Comparison with Quebec

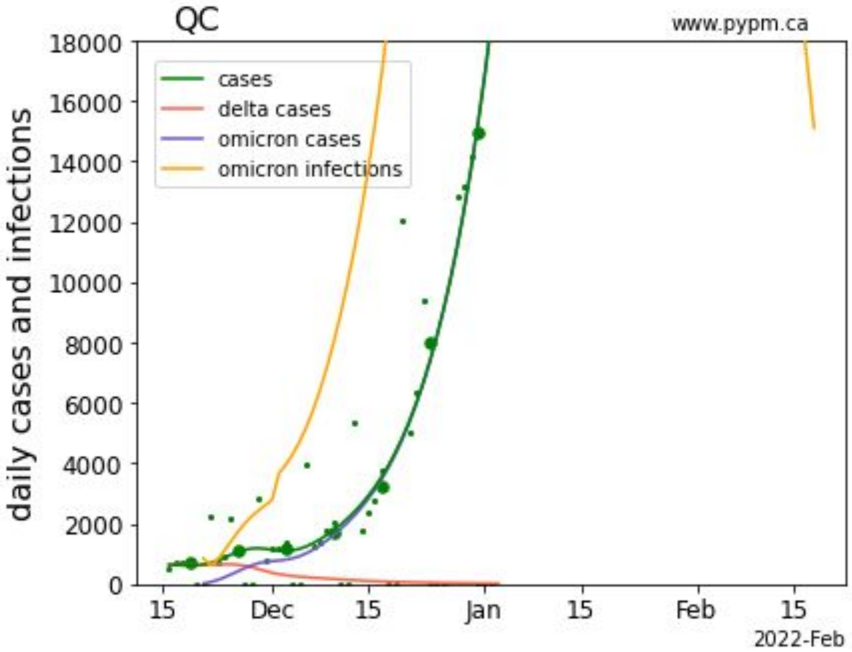


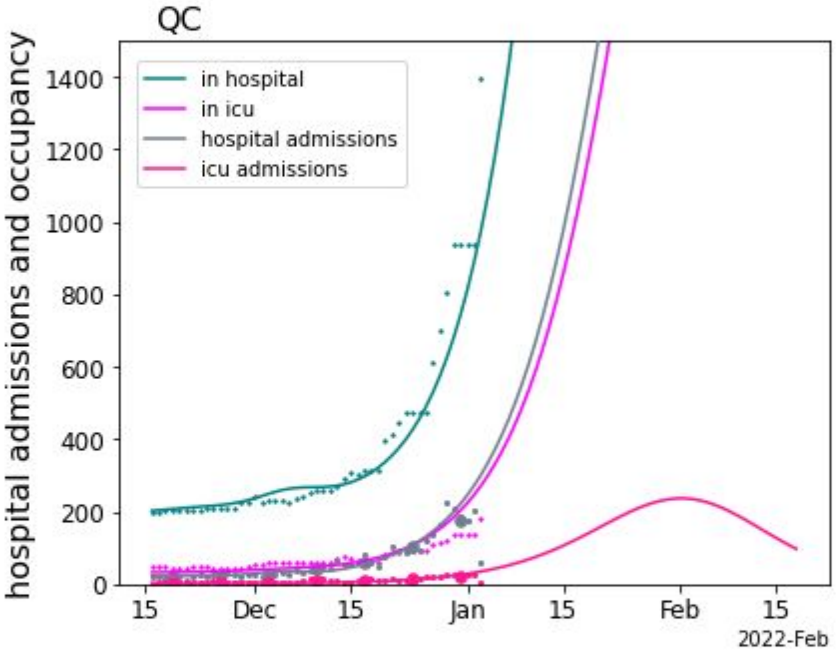


- Because Omicron has been dominant for a longer period of time, hospital demand is now growing rapidly.
- Case data follows exponential growth. Case rates appear to be less affected by holiday and testing capacity.
- Growth rate substantially lower: 11%/day. Hospital growth consistent with case growth.
- Omicron hospitalization scale factor higher than other jurisdictions: 0.85. ICU scale factor 0.4.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Comparison with Quebec (linear scale)





- Same data as on previous slide, but using a linear scale. Rapid growth in hospitalization demand is apparent.
- Projections shown in this report indicate that similar rapid growth in hospitalization in BC will begin soon.

Source (D. Karlen). See www.pypm.ca. These models include vaccination (including boosters) but have no age structure.

Age-based model projections with Omicron

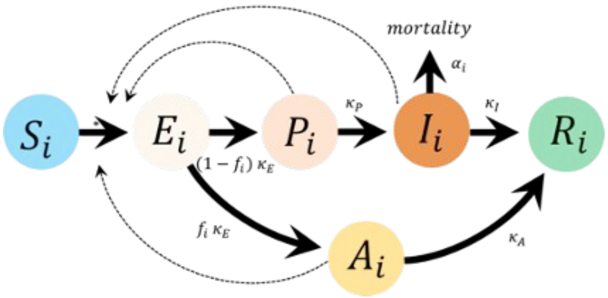
The following slides show model projections for the daily number of cases and number in hospital due to Omicron, using BC data for vaccination status and hospitalization rates by age.

Here we use the best current estimates for data for Omicron:

- **VE$_{infection}$**: Vaccine Effectiveness against infection set to 10% for unboosted individuals and 75% for boosted individuals (UK Technical Briefing 33).
- **Severity**: Omicron is 76% as severe among unvaccinated (Ferguson et al.).
- **P$_{severe}$** (Hazard Ratio): Omicron is 34% as severe among vaccinated relative to unvaccinated infected individuals (Ferguson et al.)

(See previous report for projections that **account for uncertainty** in these values.)

The growth rate of Omicron was set to 20% per day, matching case numbers in December. Length of stay in hospital was set to 12 days (typical for COVID in Canada) or halved to 6 days for Omicron.



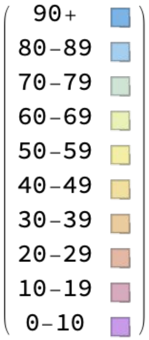
SEAPIR Model (Day et al. 2020)

10 age classes

{0-9,10-19,...80-89,90+}

2 immune classes

- Vaccinated (or recovered)
- Susceptible



Slides assume ~1/4 of all infections in BC were detected (Hamadeh et al.) up until December 21 (see Appendix if 3/4 were detected). After this date, cases will represent a smaller fraction of infections due to testing limits.

Source (S. Otto). Modified from model analyses reported by CoVaRR-Net Pillar 6, modified to focus on predictions for the population of BC and adjusting the initial number of cases to account for an observed incidence of ~1000 Omicron cases on December 21, alongside 300 cases and 192 hospitalizations for Delta (not modeled explicitly).
Data from Ferguson et al. use their corrected numbers (P$_{severe}$ =26/76, assuming two doses of Pfizer vs unvaccinated, Table 3).

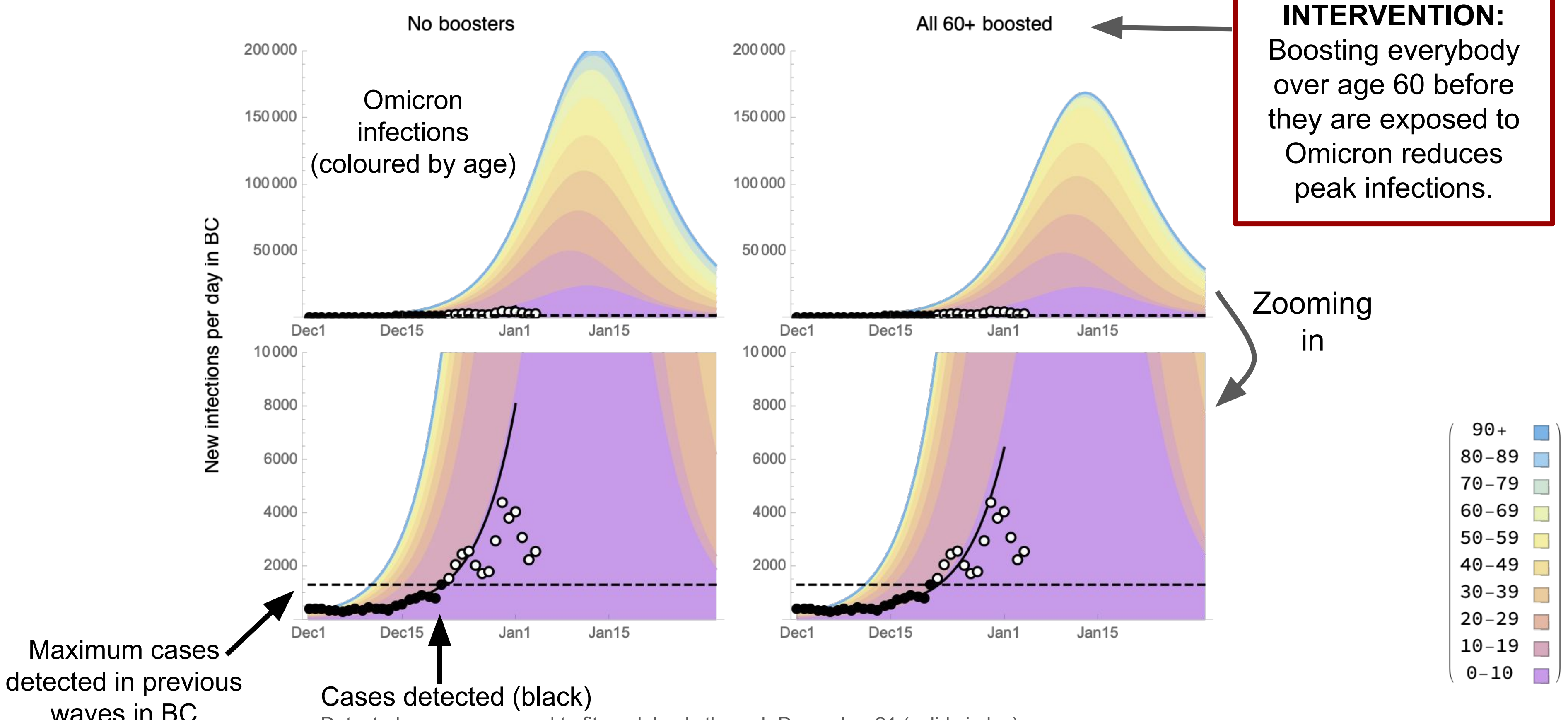
Projected Omicron infections by age

Doubling every 3.5 days (reduced by boosting)

FEW INFECTIONS DETECTED (25%)
Only infections with moderate symptoms

January 6, 2022
BC COVID-19 Modelling Group

INTERVENTION: Boosting everybody over age 60 before they are exposed to Omicron reduces peak infections.



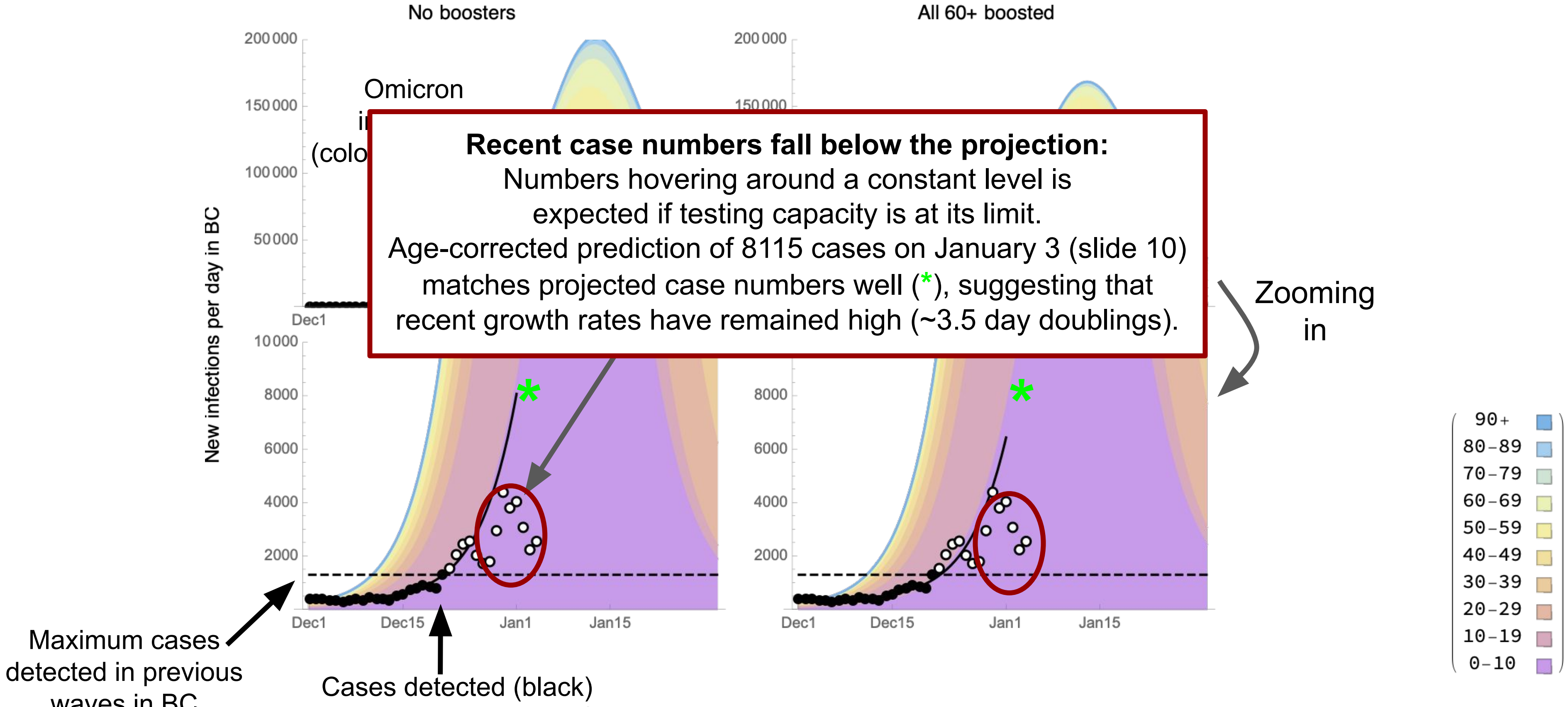
Detected cases were used to fit model only through December 21 (solid circles)

Projected infections by age

Doubling every 3.5 days (reduced by boosting)

FEW INFECTIONS DETECTED (25%)
Only infections with moderate symptoms

January 6, 2022
BC COVID-19 Modelling Group



Detected cases were used to fit model only through December 21 (solid circles), assumes ~300 Delta cases (constant)

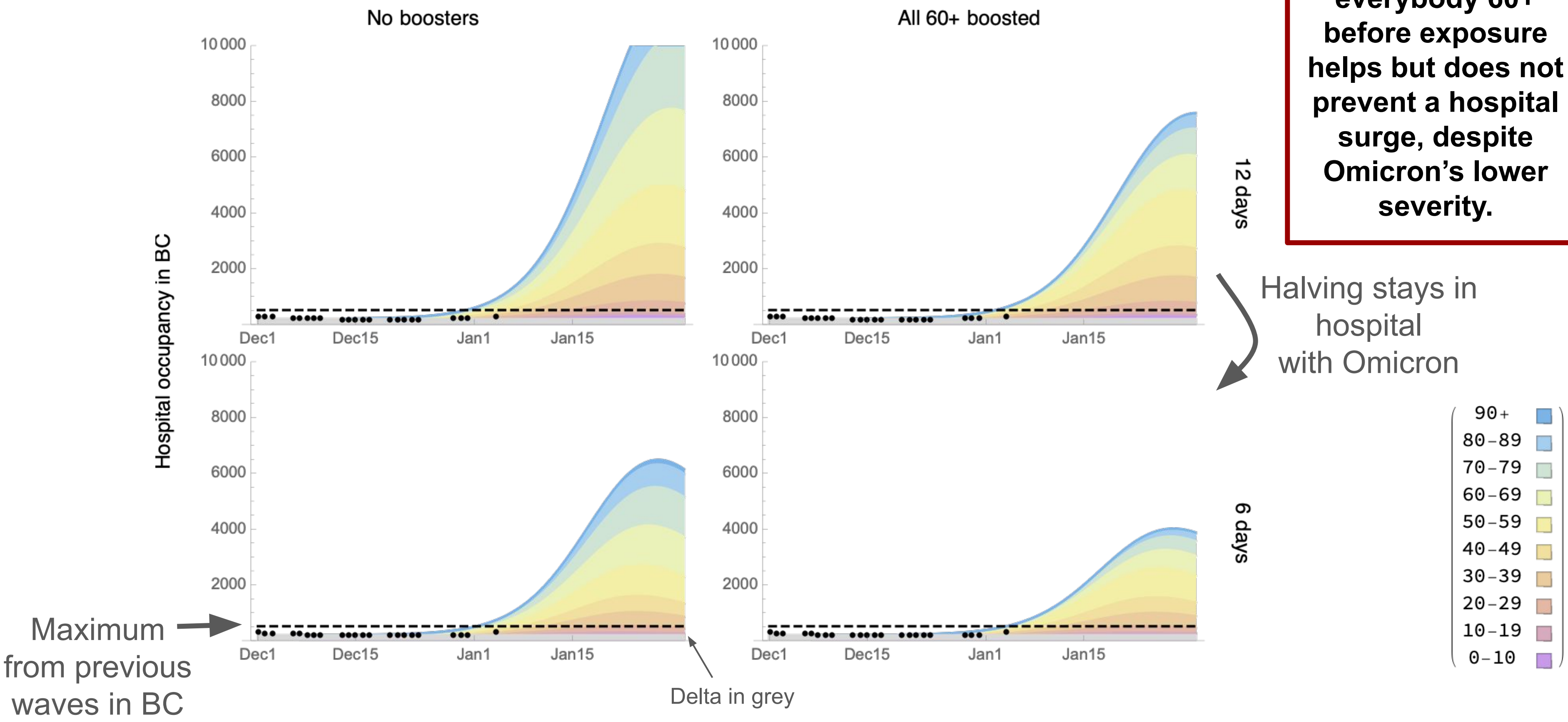
Projected number in hospital by age

Doubling every 3.5 days (reduced by boosting)

FEW INFECTIONS DETECTED (25%)
Only infections with moderate symptoms

January 6, 2022
BC COVID-19 Modelling Group

Boosting everybody 60+ before exposure helps but does not prevent a hospital surge, despite Omicron's lower severity.



Uncertainties in these projections

Might these projections about hospital demand be wrong?

There remains substantial uncertainty and the following possibilities would lead to lower surges:

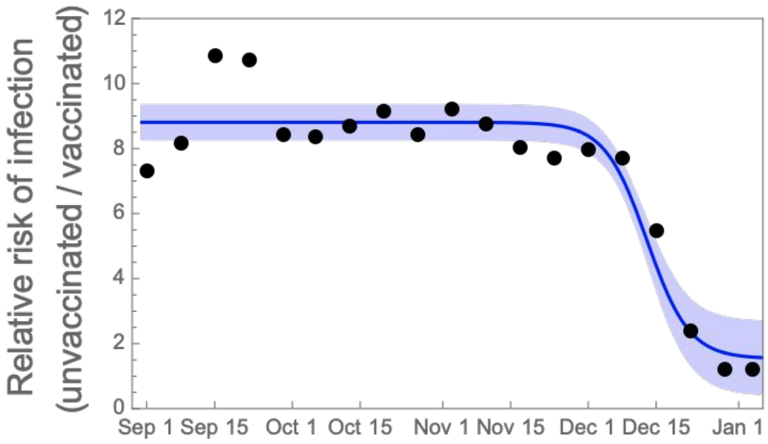
- While data suggest some reduction in severity relative to Delta (incorporated above), the uncertainty in these estimates is substantial. If Omicron is much less severe than reported, especially among the unvaccinated who make up a large proportion of those requiring hospitalization, then peak hospital demand could be reduced.
- We assumed shorter hospital stays (down 50% from an average of 12 days in Canada on slide 26, and down 60% for the other projections), but if stays are reduced even further, that could help.
- Similarly, if Omicron often leads to such mild symptoms that more people are unaware that they are infected, the peak hospital demand could be lower. [Slide 19 explores a scenario where only 30% of infections are reported for Omicron relative to previous variants; slide 26 assumes that 25% of Omicron infections are reported (when testing capacity is available).]

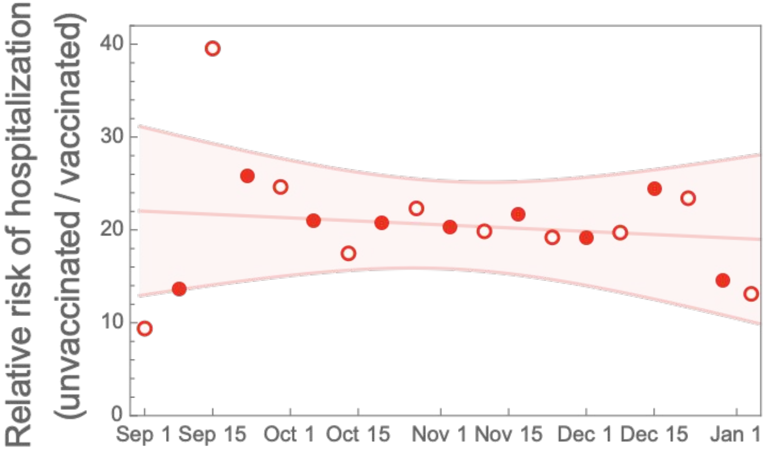
As more data on Omicron emerges, the plausibility of these more hopeful scenarios can be evaluated, but with the data available, two independently derived models predict a severe demand on hospitals.

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 is declining to only 1.5-fold with Omicron (left). The risk of hospitalization has so far remained stable at 20.5-fold (right).

[Relative risks are for an average person (age corrected) and do not reflect patterns in specific ages. Impact of Omicron on risk of hospitalization is expected to lag by about a week and may require more time to detect.]





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 [Tuesday for the week of the report]) and fit $a\,(1 - p_t) + b\,p_t$, where p_t is the frequency of Omicron (inferred by D. Karlen in previous report, slide 7). Risk of hospitalization is calculated over the past two weeks of data, so we fit the data from every other week using a linear model (analysing solid and hollow points separately) and average the results.

Key messages

State of the Omicron wave in BC:

- The Omicron wave is clearly underway in BC, with Omicron infections doubling every 3-3.5 days.
- Different models agree that demand on the health care system will likely become extreme in January.
- Even under optimistic scenarios about Omicron severity, the need for expanded hospital bed space is strongly indicated by independent model projections; urgent consideration of options for expanding hospital capacity over the next month are strongly recommended.
- Information from elsewhere does indicate that the Omicron wave is likely to lead to better outcomes for hospitalized patients (reduced need for ICU and mechanical ventilation) than a Delta wave of similar size.
- Testing capacity has been exceeded, making the daily case count figures almost useless for projections. To fill this gap, data on rapid antigen results, sick days, and wastewater sampling could be used to improve estimates of case rates. A representative sampling strategy to estimate prevalence in the community would be useful to have but would need to be established extremely rapidly to yield results relevant for the Omicron wave.

Uncertainty:

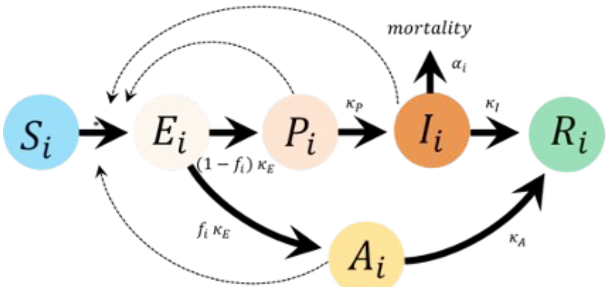
- **There is a great deal of uncertainty in current infection rates in BC. Estimates of severity and immune protection vary, making it challenging to forecast the impact of the Omicron wave. Most projections have infections peaking in January, unless growth rates are substantially slowed. The height of the ensuing hospitalization wave is hard to estimate at present. We will carefully follow severity estimates from the UK and elsewhere, as they come out, and update our projections.**
- **Based on the information we have, two different models currently project a hospitalization peak that exceeds previous peak levels by a factor of between 4 and 10.**

APPENDIX: Adjusting fraction of cases detected

In the age-based model, two cases were explored:

- **Main slides:** Cases detected in BC were assumed to exclude most infections that were asymptomatic or mild (70% of infections in adults, 90% of infections in youth). These undetected cases were, on average, half as transmissible.

- **Appendix slides:** Cases detected in BC were assumed to exclude only asymptomatic infections (20% of infections in adults, 40% of infections in youth). These undetected cases were, on average, half as transmissible.



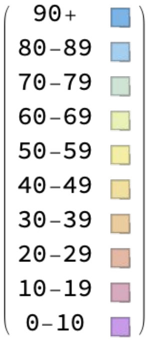
SEAPIR Model (Day et al. 2020)

10 age classes

{0-9,10-19,...80-89,90+}

2 immune classes

- Vaccinated (or recovered)
- Susceptible



Source (S. Otto). Modified from model analyses reported by CoVaRR-Net Pillar 6, modified to focus on predictions for the population of BC and adjusting the initial number of cases to account for an observed incidence of ~1000 Omicron cases on December 21, alongside 300 cases and 192 hospitalizations for Delta growing at ~0% daily (gray). Data from Ferguson et al. use their corrected numbers (P_{severe} =26/76, assuming two doses of Pfizer vs unvaccinated, Table 3).

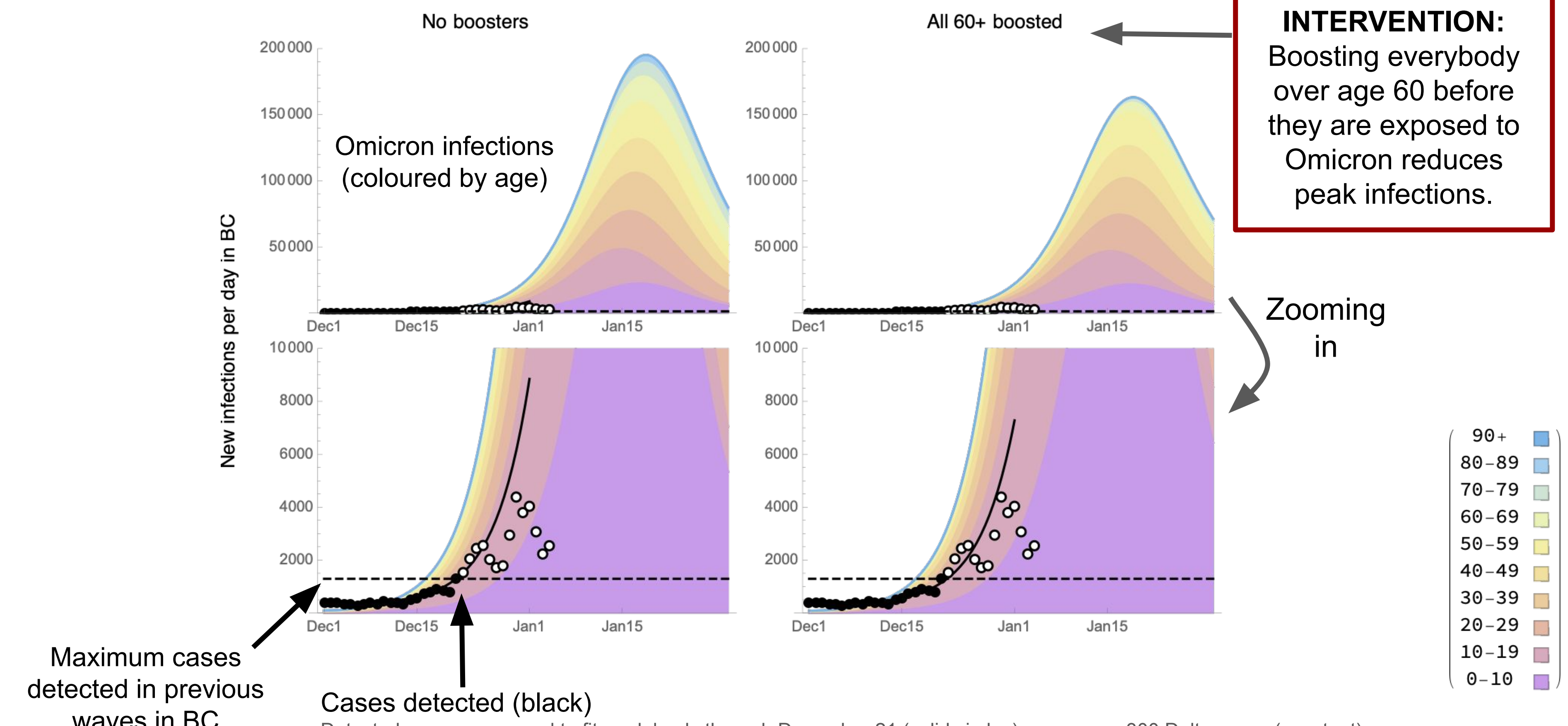
APPENDIX: Projected infections by age

Doubling every 3.5 days (reduced by boosting)

MOST INFECTIONS DETECTED (75%)
Cases are all infections with any symptoms

January 6, 2022
COVID-19 Modelling Group

INTERVENTION:
Boosting everybody over age 60 before they are exposed to Omicron reduces peak infections.



Detected cases were used to fit model only through December 21 (solid circles), assumes ~300 Delta cases (constant)

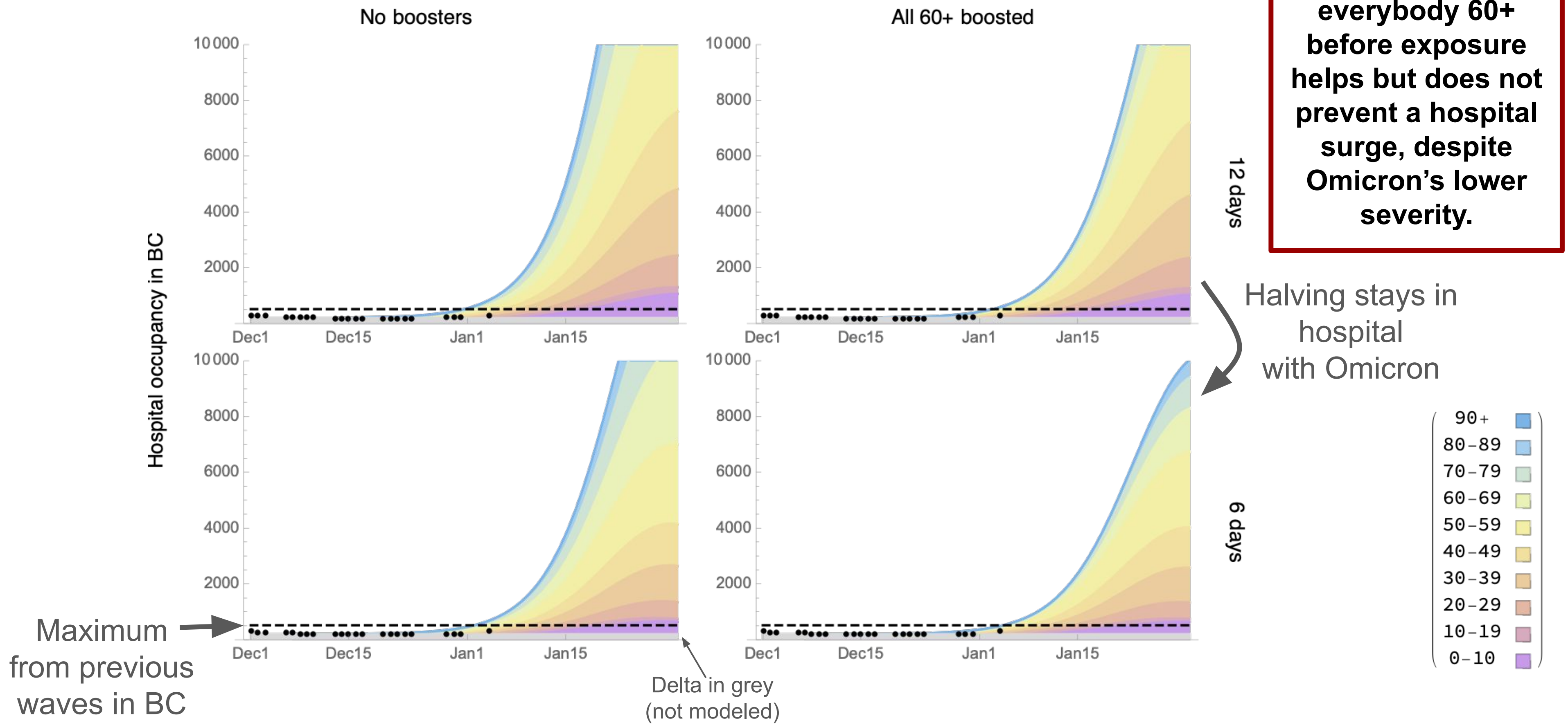
January 6, 2022
BC COVID-19 Modelling Group

Projected number in hospital by age

Doubling every 3.5 days (reduced by boosting)

MOST INFECTIONS DETECTED (75%)
Cases are all infections with any symptoms

Boosting everybody 60+ before exposure helps but does not prevent a hospital surge, despite Omicron's lower severity.



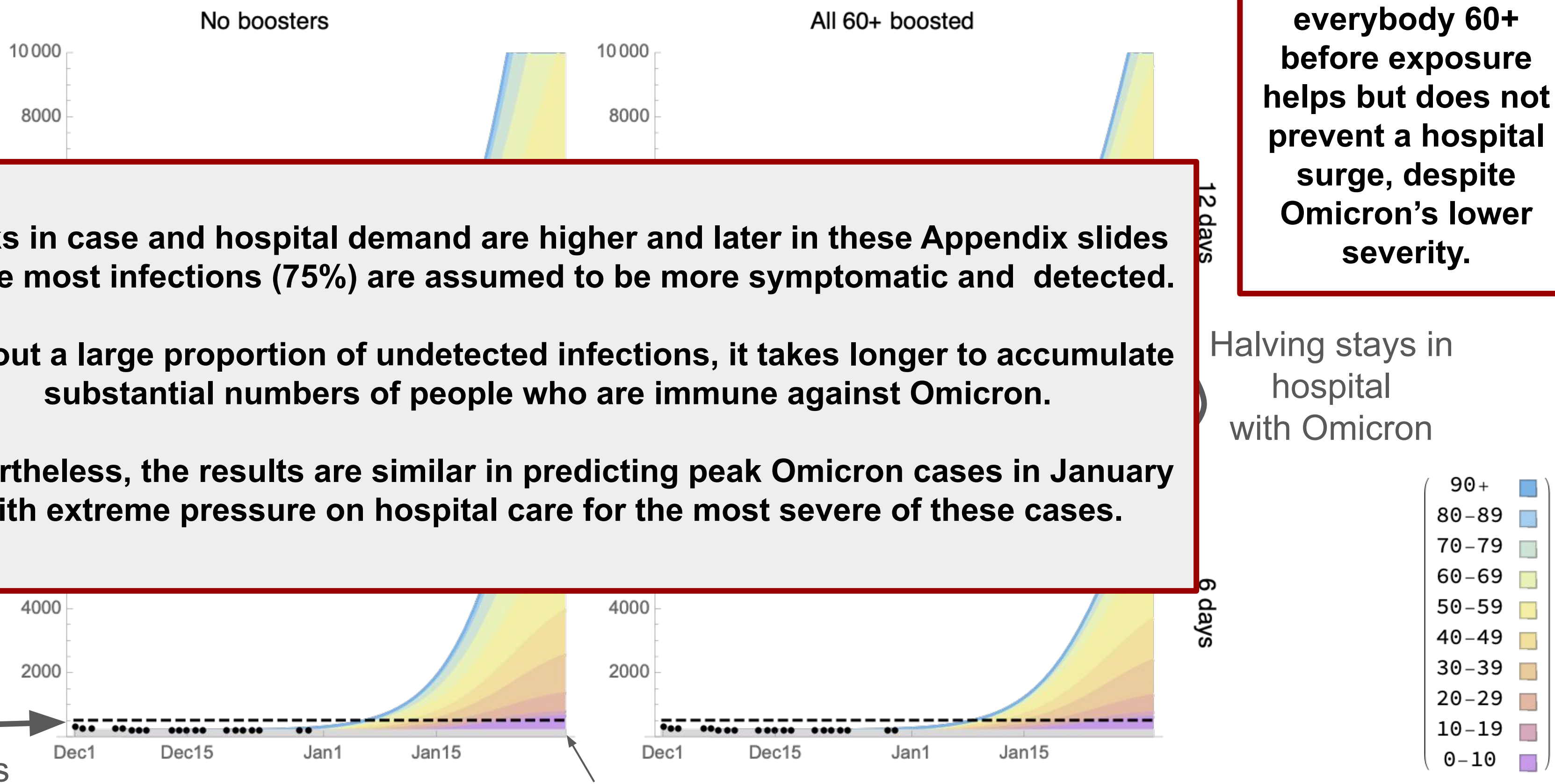
Projected number in hospital by age

Doubling every 3.5 days (reduced by boosting)

MOST INFECTIONS DETECTED (75%)
Cases are all infections with any symptoms

January 6, 2022
BC COVID-19 Modelling Group

Boosting everybody 60+ before exposure helps but does not prevent a hospital surge, despite Omicron's lower severity.



Peaks in case and hospital demand are higher and later in these Appendix slides where most infections (75%) are assumed to be more symptomatic and detected.

Without a large proportion of undetected infections, it takes longer to accumulate substantial numbers of people who are immune against Omicron.

Nevertheless, the results are similar in predicting peak Omicron cases in January with extreme pressure on hospital care for the most severe of these cases.

Halving stays in hospital with Omicron

Maximum from previous waves in BC

Delta in grey