COVID Model Projections

October 7, 2021

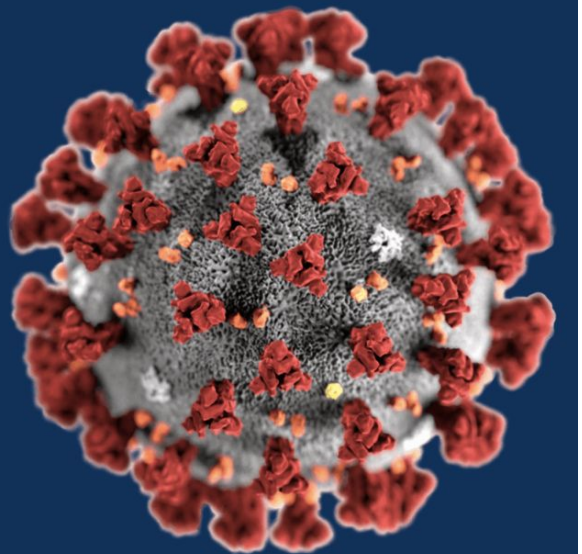
BC COVID-19 Modelling Group

@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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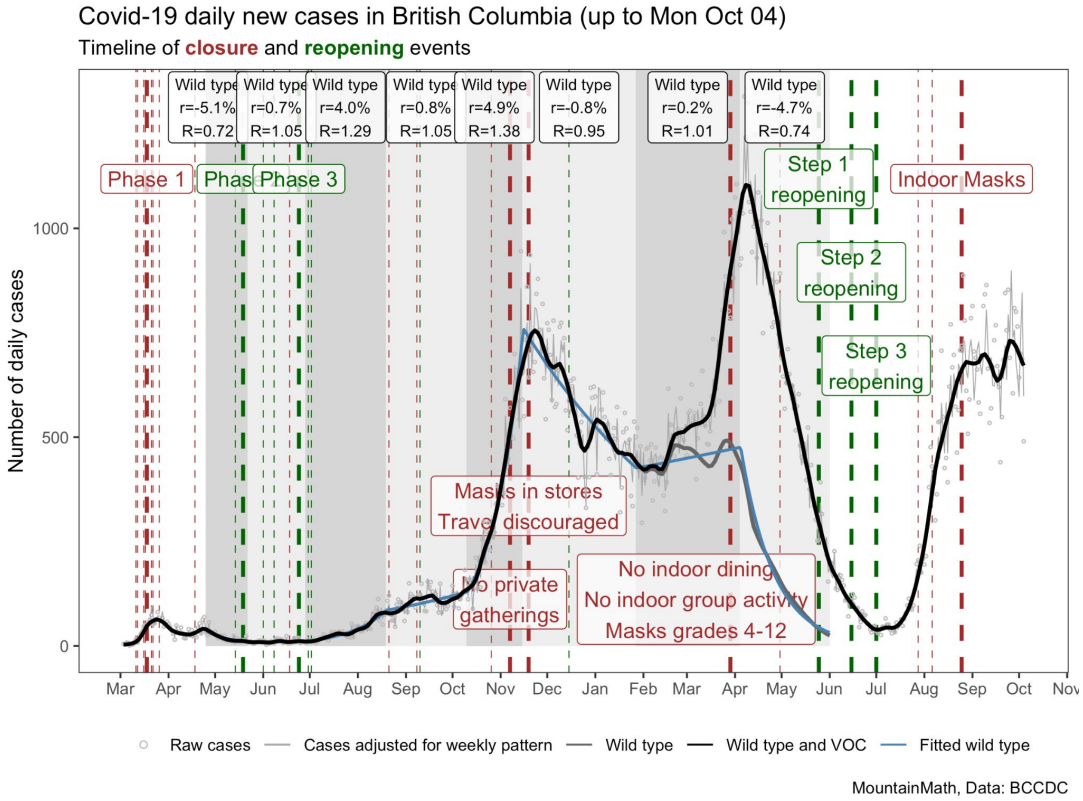
Independent and freely offered advice, using a diversity of modelling approaches.

Overview

- State of the pandemic in BC
- Diagnosed COVID-19 cases in BC: in children aged 0-9 and adults, by health authority; model projections
- A new analysis sheds light on testing rates in BC
- Hospitalizations and ICU
- Vaccination and its impact
- Vaccine uptake
- Impact of changing transmission in children
- Prospects for vaccinating children aged 5-11: direct and indirect impacts
- Situation update for Alberta: Hospital admissions declining - good news

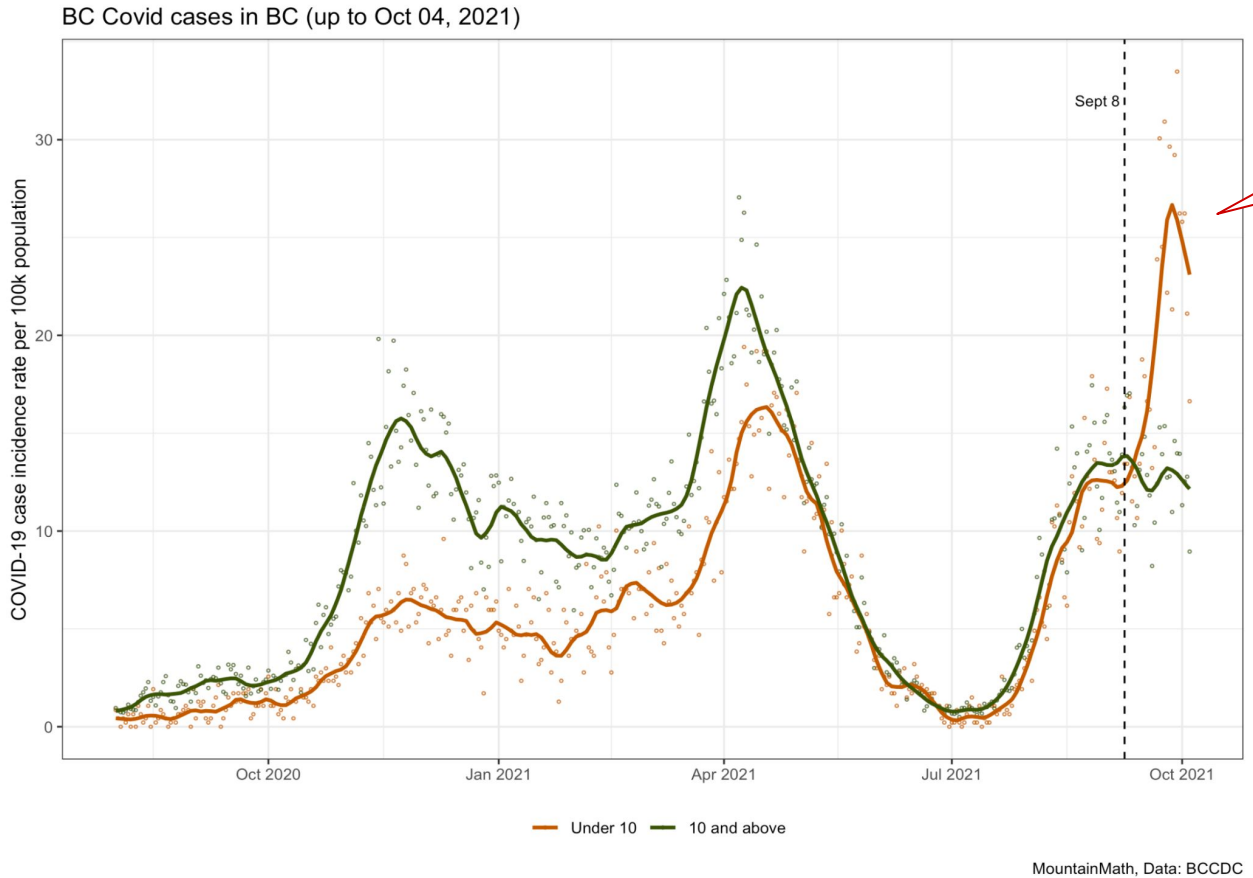
State of the COVID-19 Pandemic in BC



Indoor masking and localized measures in regions with high case counts (Interior and Northern Health Authorities) stabilized cases through September.

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)

State of the COVID-19 Pandemic in BC

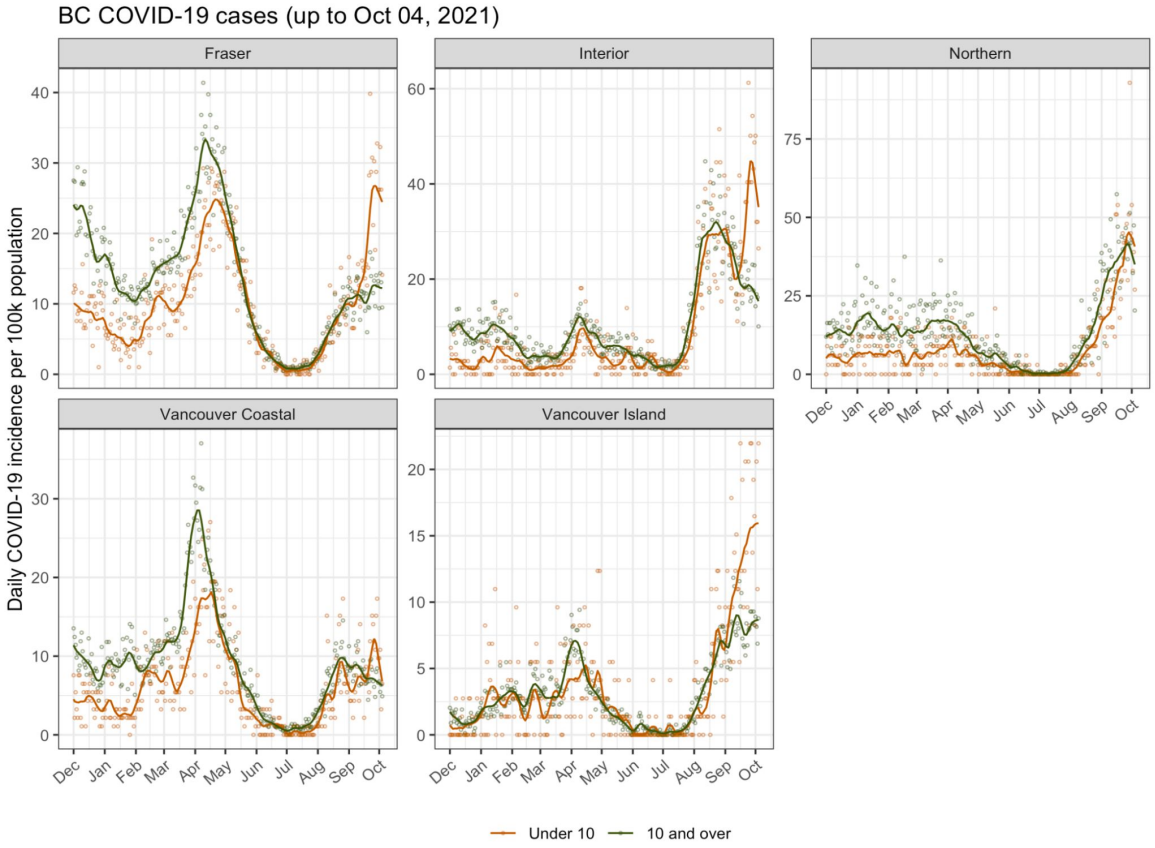


Recent uptick in cases among unvaccinated children

Case growth in children is highly volatile and needs close monitoring, ideally with data that is broken into finer age groups.

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

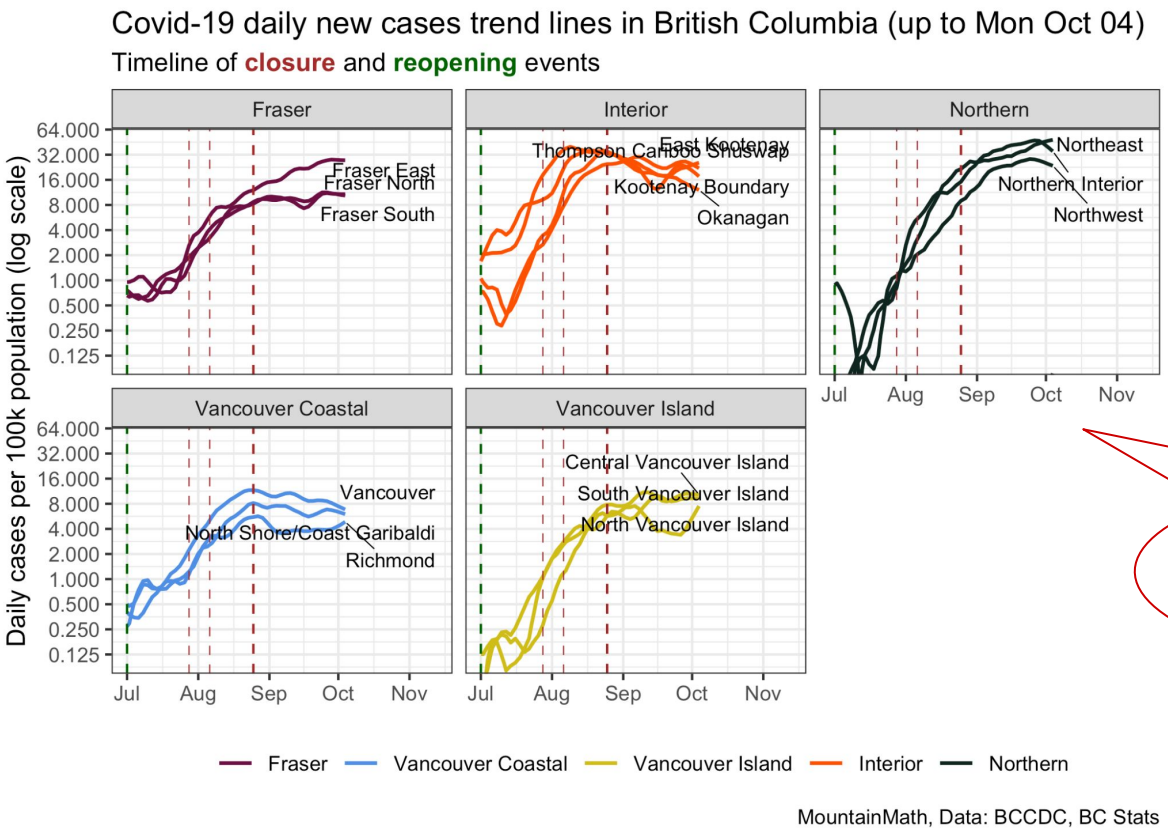
State of the COVID-19 Pandemic in BC



Not all Health Authorities show uptick among children

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

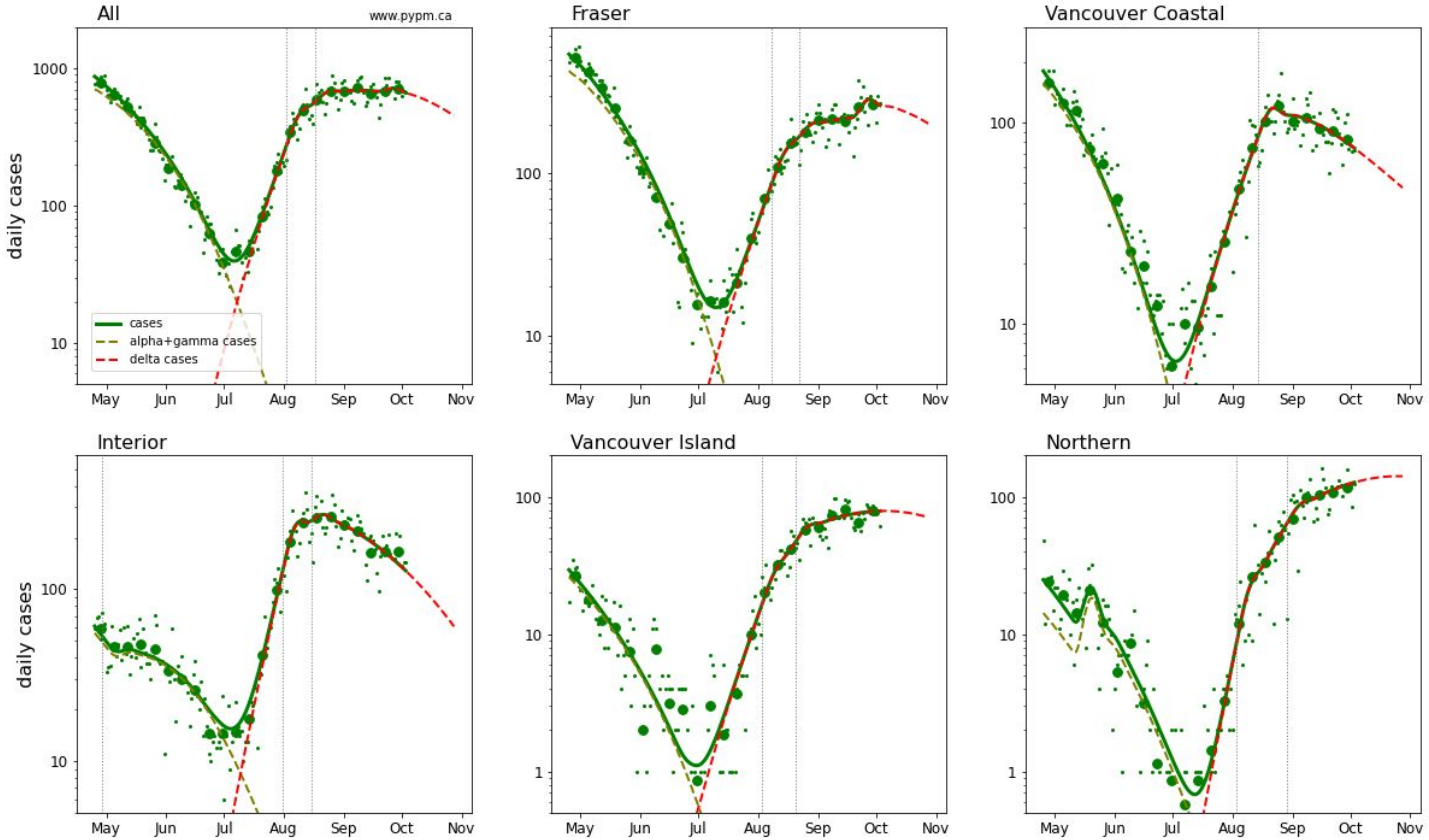
State of the COVID-19 Pandemic in BC



Health Service Delivery Areas (HSDA) follow similar trends within a Health Authority. Northern and Fraser East HSDAs show fastest 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). STL trend lines on log scale.

Model fits to BC data



The measures taken in August and the public's response significantly reduced transmission.

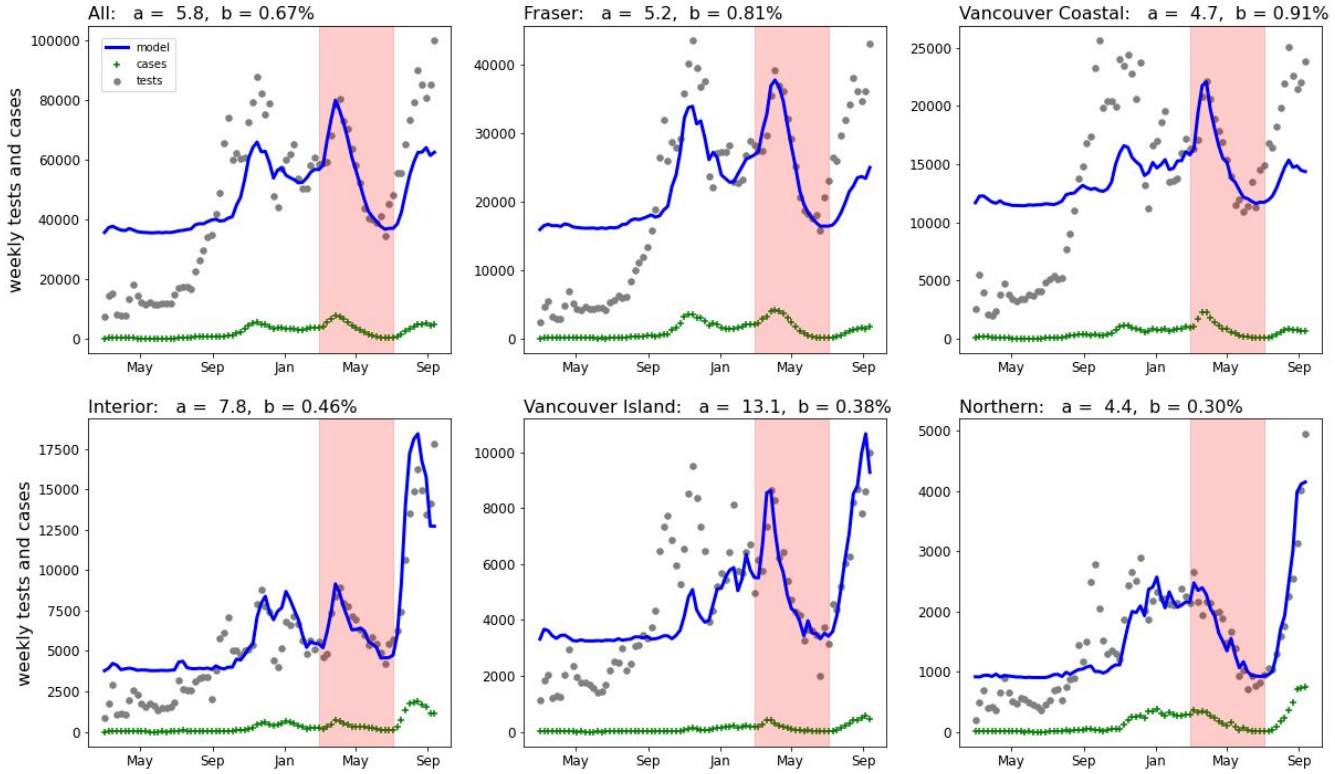
Only the Northern HA continues to experience growth, currently at about 1% per day.

Fraser HA model includes a burst of infections in early September.

Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits include past vaccination schedule. Growth in BC is currently -1% per day but seasonal effects may increase transmission, as it did in Fall 2020. Vertical lines show fitted dates for transmission rate changes. The larger dots show weekly averages.

Testing rates in BC by Health Authority

(publicly funded and private testing)



Source (D. Karlen). Case and testing data from the BCCDC public data dashboard.

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

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

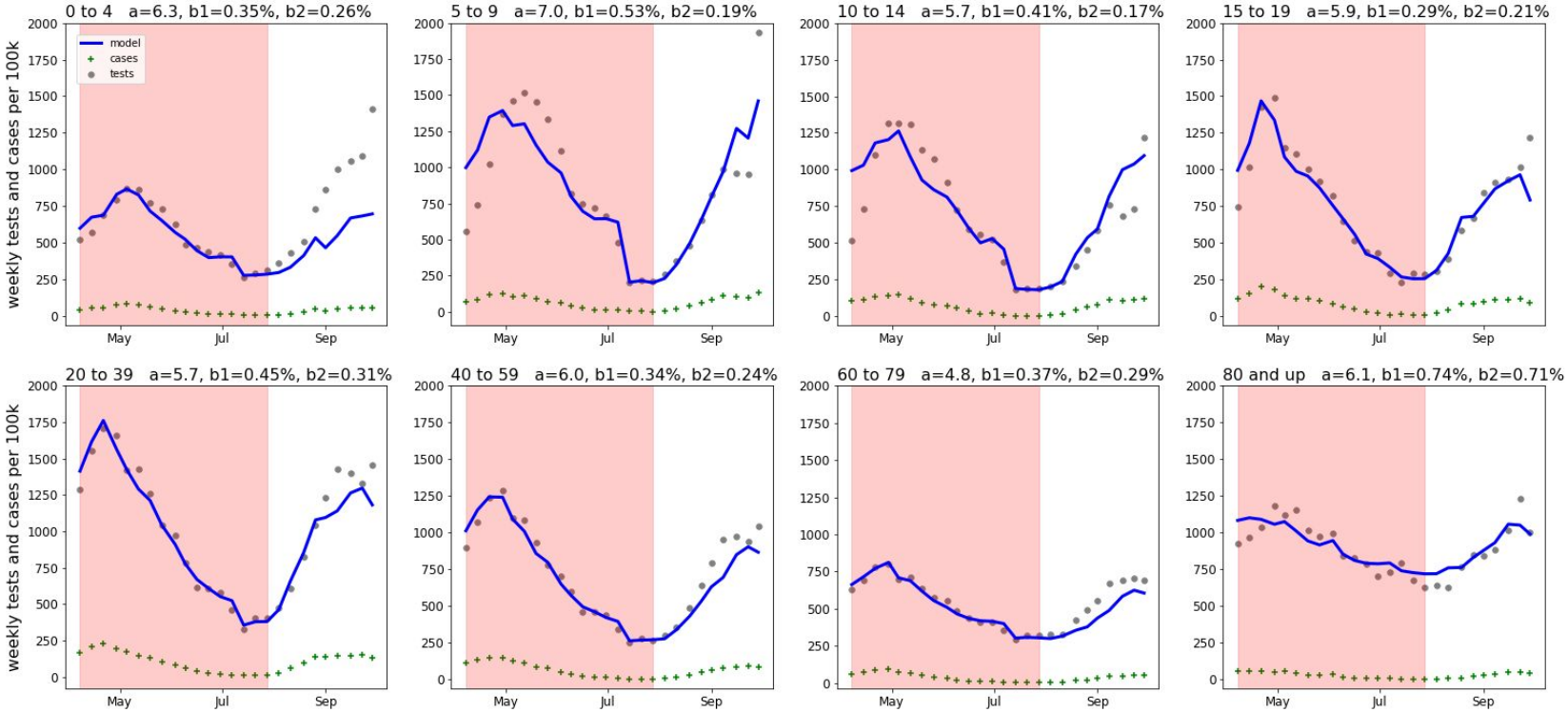
<u>Category A tests: COVID-related</u>
(infections and contacts).
Cases lead to additional tests being performed ($\mathbf{a} > 1$)

<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).

Testing in Vancouver and Fraser HAs has increased in the 4th wave (grey dots above blue model fit).

Testing rates in BC by age (publicly funded testing only)



Background testing in ages 5-14 are much higher in school months (**b1**) than during summer holiday (**b2**). Publicly funded testing rates appear to be similar for 3rd and 4th waves, except for youngest age group.

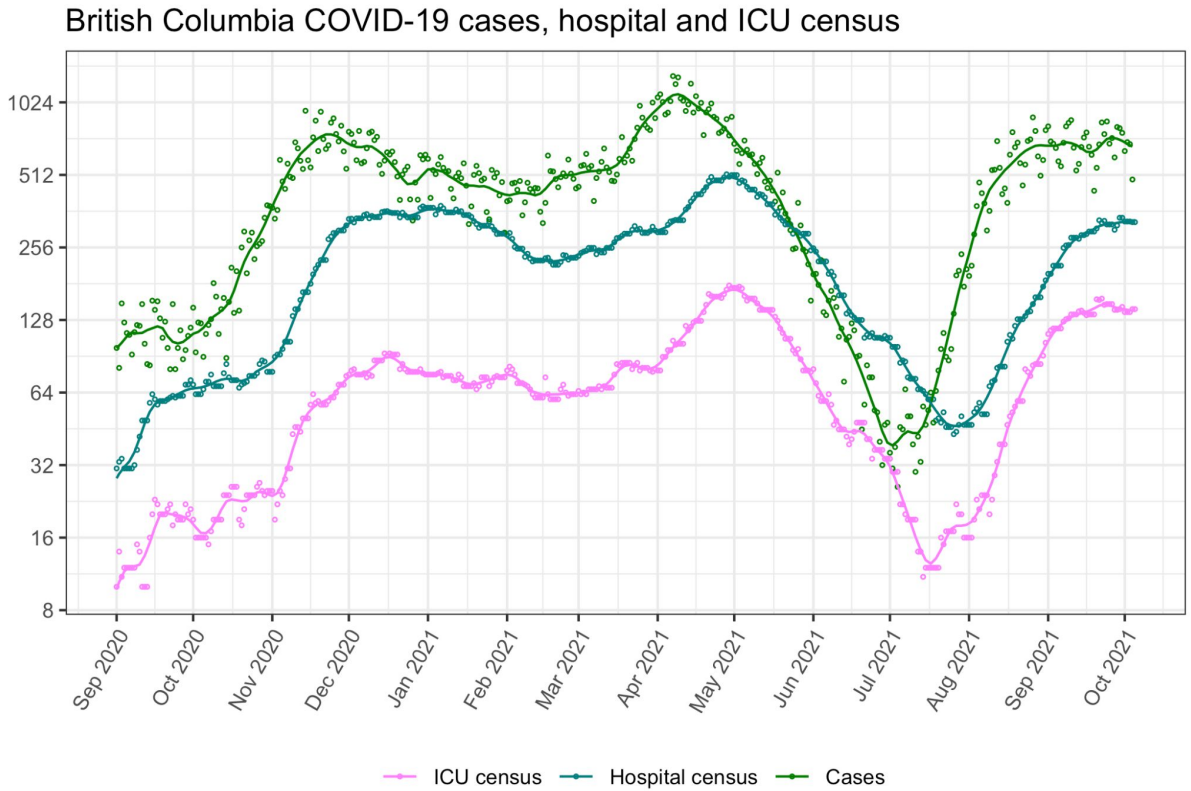
Source (D. Karlen). Data from BC CDC situation reports, collected by Brett Favaro.

Hospital and ICU occupancy over time

Hospitalization and ICU occupancy have started to plateau, tracking the plateau in COVID-19 cases (with a slight delay because cases take time to develop more severe symptoms).

Measures taken in August in BC have lowered the growth of cases, and we're now seeing the benefits of those measures on hospital demand.

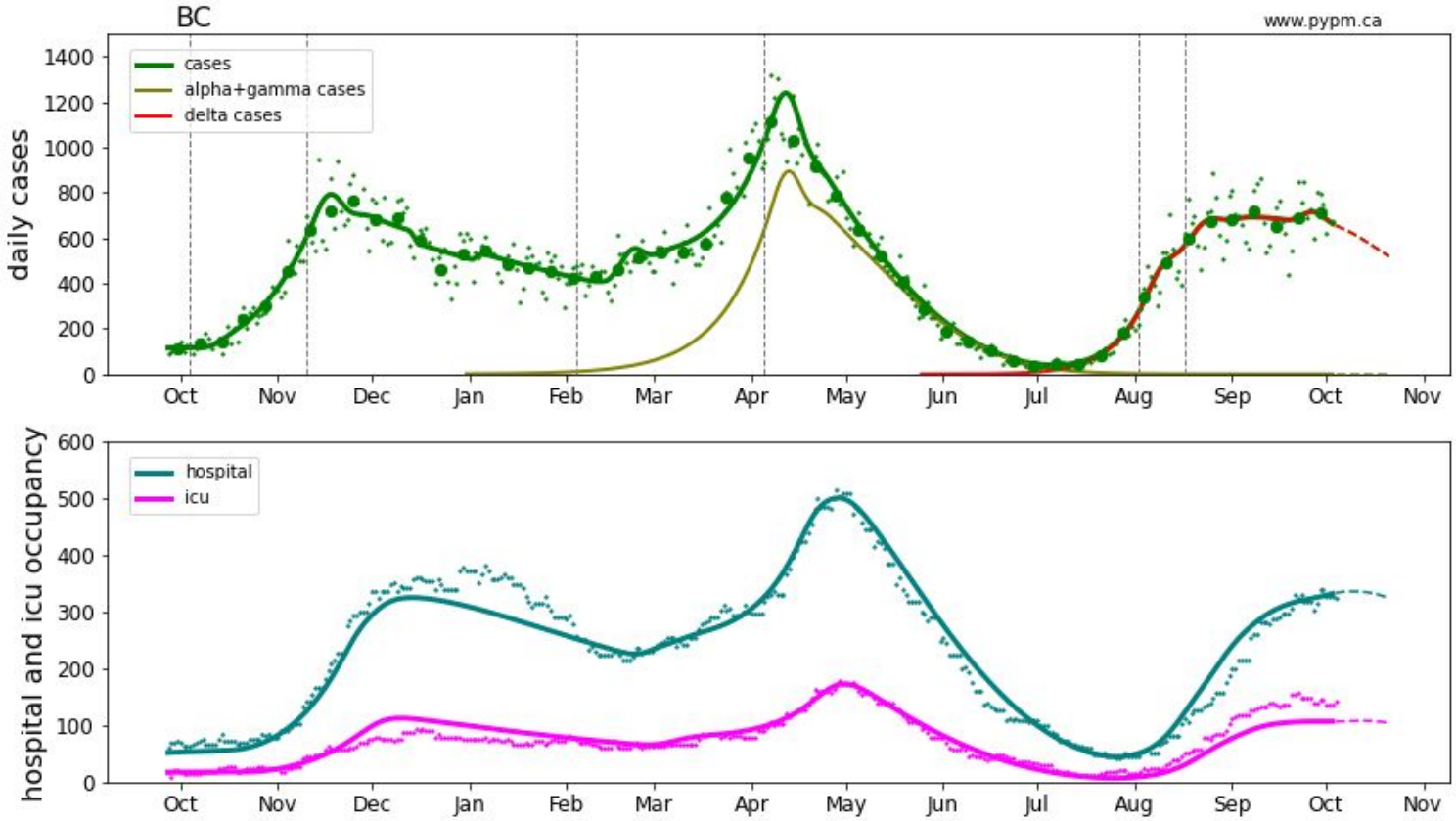
Nevertheless, ICU demand remains high, near the peak for the entire pandemic.



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

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.

Estimating demands on health care



The COVID-19 pandemic is tracked using positive tests (cases), yielding an infection model (green curve).

The infection model well describes past hospital occupancy.

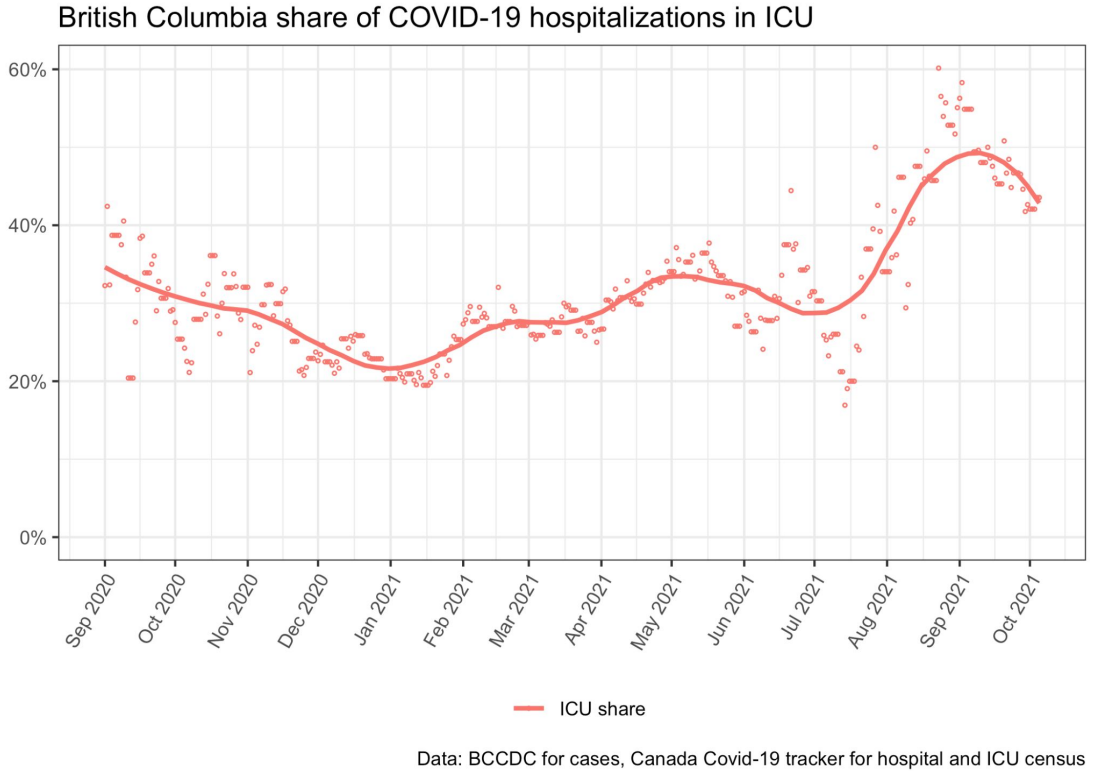
Recent hospital occupancy matches the projection, while ICU occupancy remains higher than projected.

Source (D. Karlen). See www.pypm.ca. These models have no age structure. Fits include past vaccination schedule.

Hospital and ICU occupancy over time

Of those patients in hospital, the recent increase of the fraction in ICU has stabilized.

Although many factors may contribute, the Delta variant that now predominates (98% of BC cases) has been found to be more severe in other jurisdictions*.

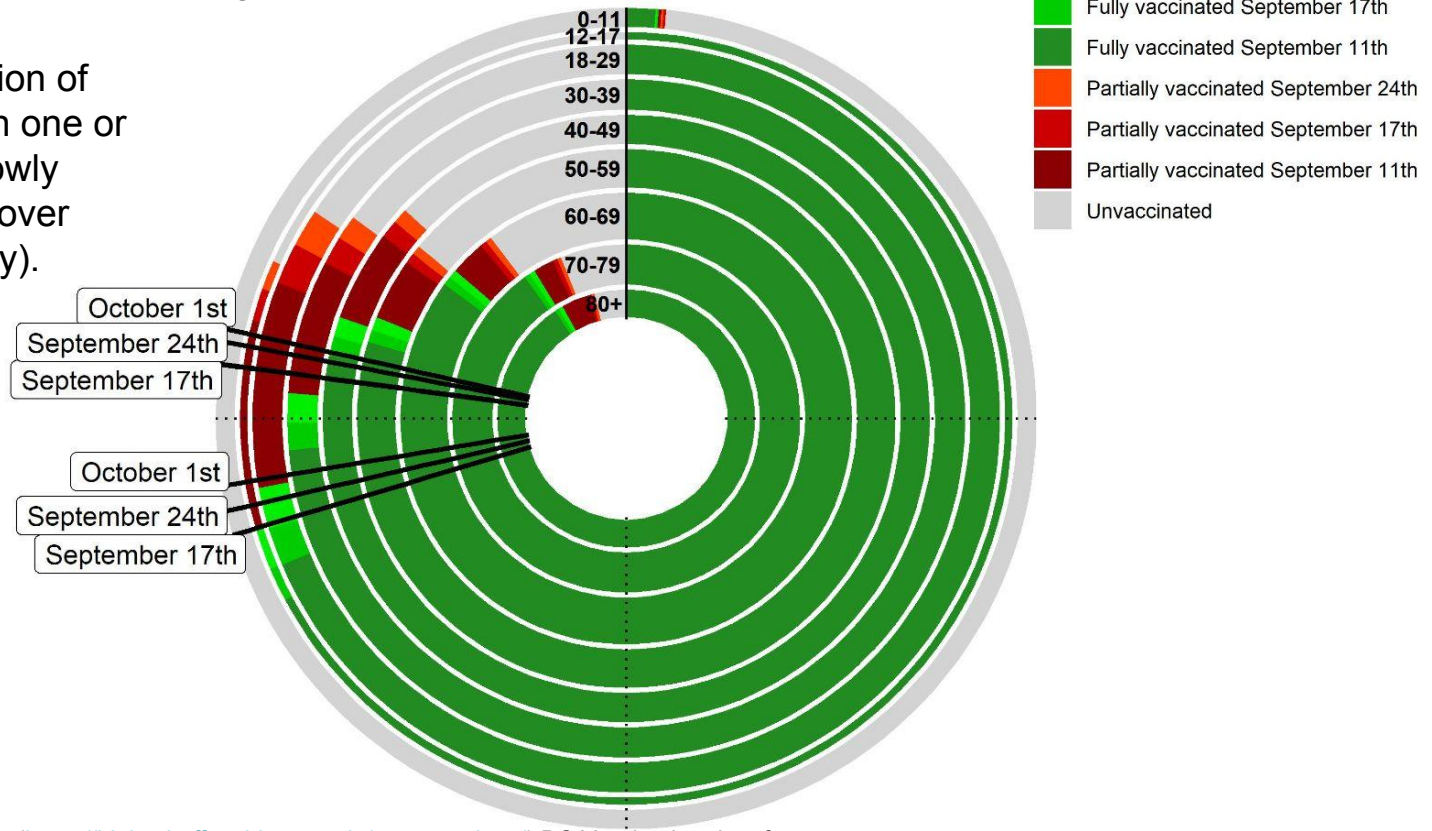


Source (J. von Bergmann) Case data from BC COVID-19 Database (http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data). STL trend lines on linear scale. *Singapore study found that Delta was 4.9 times more likely to lead to an oxygen requirement, ICU admission, or death among unvaccinated hospitalized patients; see overview of Delta severity in CBC article.

Closing the circle: Vaccination status by age

October 4th update includes data through September 24th, 2021

Slow progress: The fraction of BC's entire population with one or two doses is rising, but slowly (0.5% and 0.9% increase over the past week, respectively).

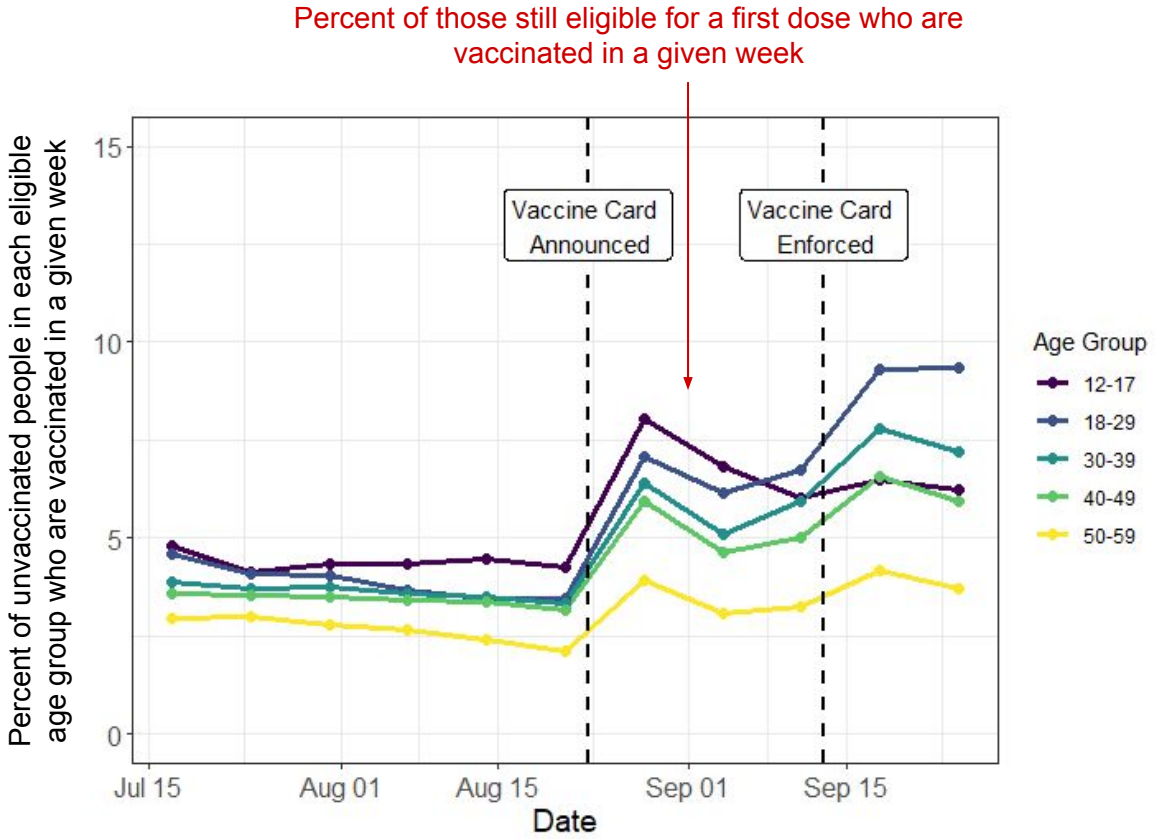


Source (B. Wiley). Design by Blake Shaffer (https://blakeshaffer.shinyapps.io/app_vaccines/) BC Vaccination data from https://health-infobase.canada.ca/covid-19/vaccination-coverage/, with area of each circle segment proportional to BC's population in that age class. BC 2021 Population projections for vaccination percentages from BC Stats: https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-projections

Slow movement on vaccinations in BC

Slow progress:

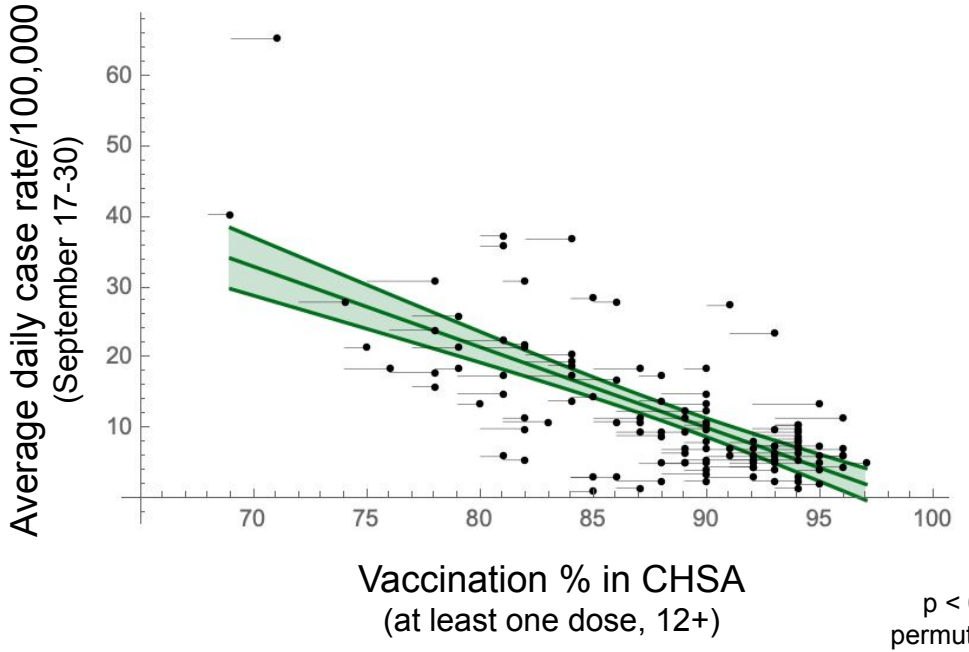
The Vaccine Card announced on August 23 (dashed line) has helped increase the rate of vaccinations, but at this rate, it would take **~14 weeks** to vaccinate half of the remaining 50-59 age group and **~6 weeks** for the 18-29 age group.



Source (B. Wiley). BC Vaccination data from https://health-infobase.canada.ca/covid-19/vaccination-coverage/. BC 2021 Population projections for vaccination percentages from BC Stats: https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-projections

A pandemic of the unvaccinated: Communities at risk

We continue to see a major effect of vaccination levels across Community Health Service Areas (CHSA). For the most recent two-weeks of cases, communities with 90% of eligible people vaccinated have **3.3 times** fewer COVID-19 cases than those with 70% vaccination.



Thin lines show vaccination progress over the past two weeks.

Vaccines show high effectiveness in BC across age groups[a]

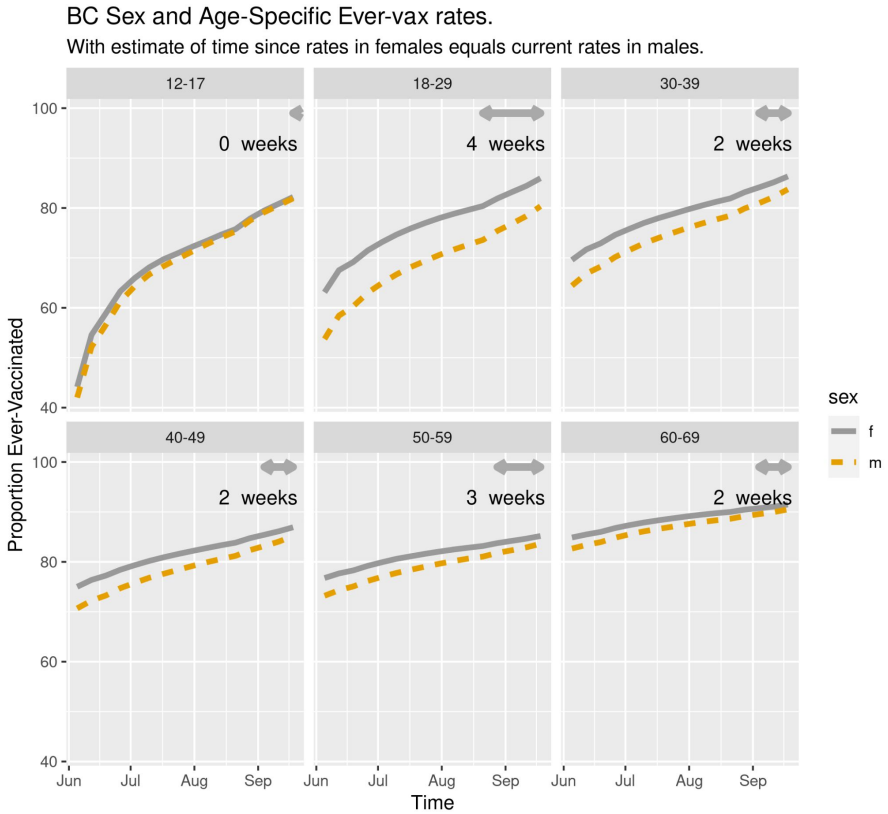
- reducing cases 12-fold
- reducing hospitalization rates 29-fold once fully vaccinated

→ **Vaccines protect people & communities**

Source (S. Otto). BCCDC data portal's surveillance dashboard data; see maps for regions that would most benefit from community vaccination drives (accessed October 4, 2021). [a]BC COVID-19 Modelling Report (September 1, 2021), consistent with BCCDC findings for age-corrected analyses.

http://www.getvaccinated.gov.bc.ca

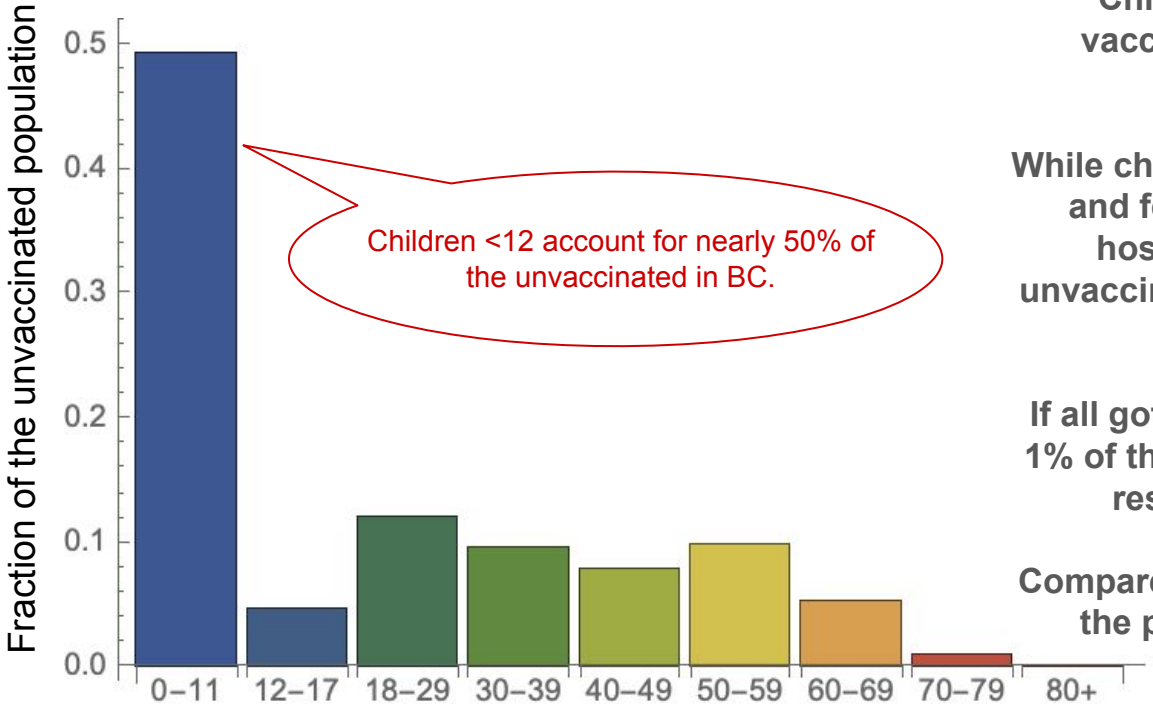
A pandemic of the unvaccinated: Males at risk



Source (R. James)

- Adolescent males and females are vaccinated at a near-identical pace
- 18-29 year old males have consistently lagged behind same-aged females
  - Current uptake of male vaccination in this age-group occurred in females 4 weeks ago.
- For subsequent age-groups: 30-39 40-49, 50-59 and 60-69, there is a consistent 2-3 week gap
- After age 69, there is no important difference (data not shown) in uptake by sex
- Comparable charts for SK and AB are available in the Appendix

A pandemic of the unvaccinated: Children under 12 at risk



Children under 12 are not yet eligible for vaccination and make up nearly half of the unvaccinated population in BC.

While children are more likely to be asymptomatic* and few with diagnosed COVID-19 end up in hospital (1% in BC), the sheer number of unvaccinated children <12 (~600,000) makes them a large risk group.

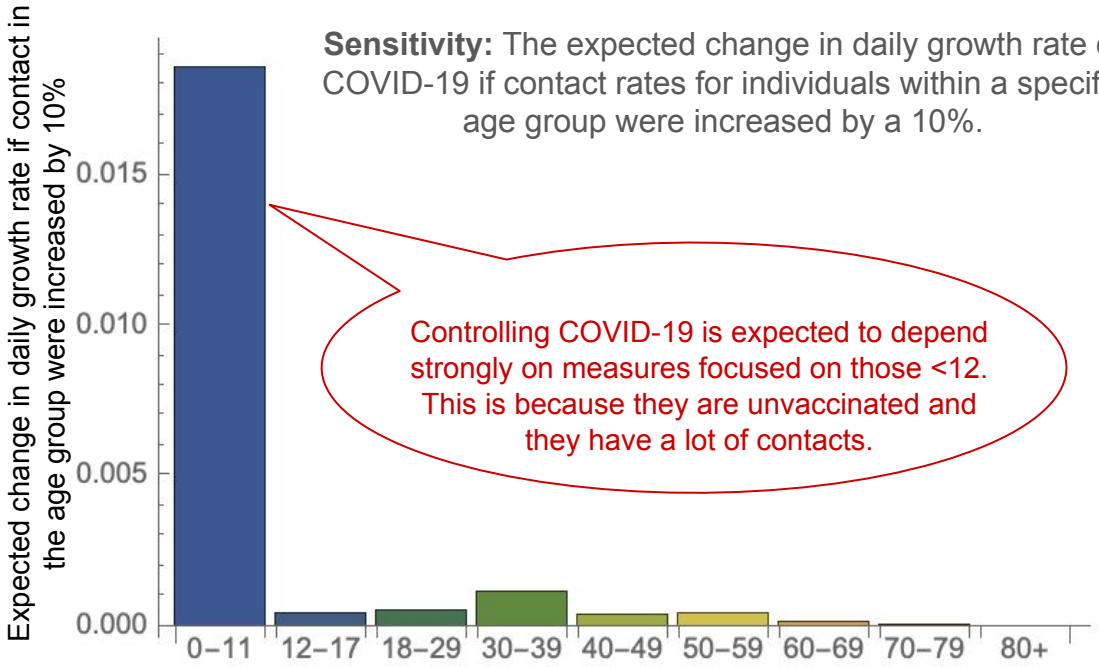
If all got COVID, half did not have symptoms and 1% of the other half were hospitalized, that would result in 3000 hospitalizations (of <12).

Compare: approximately 10000 hospitalizations in the pandemic to date in BC, all age groups

Source (S. Otto). BC Vaccination data from https://health-infobase.canada.ca/covid-19/vaccination-coverage/, with 2021 Population projections for numbers in each age class from BC Stats: https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-projections**.** Averaged across studies, youth aged 0-18 are asymptomatic in 46.7% of cases compared to 35.1% in adults (Sah et al.)

Sensitivity of growth to changes in age-based contacts

Sensitivity: The expected change in daily growth rate of COVID-19 if contact rates for individuals within a specific age group were increased by a 10%.



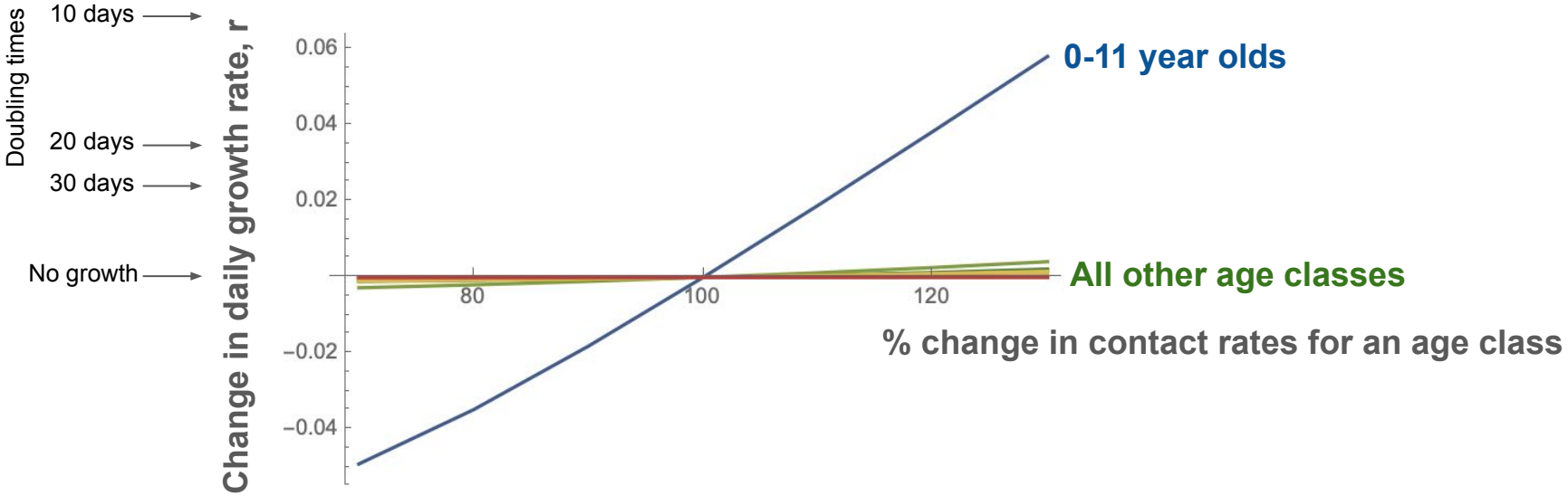
High sensitivity to NPI measures affecting the <12 year olds is mainly due to the lack of vaccinations in this age group. It is also partially due to high contact rates among children (see Appendix).

Model accounts for higher fraction of asymptomatic cases in youth (46.7% compared to 35.1% in adults; Sah et al.) and lower transmission from asymptomatic cases (58% of symptomatic transmission; Byambasuren et al.)

Source (S. Otto). Based on model in Day et al. (2020) with age-based vaccinations in BC (previous slide) and the age-based contact matrix (derived from Prem et al, PLOS CB, with BC demographic data). *See Appendix for comparison to case where contacts are all initially equal and prior to vaccination. Assumes daily growth rate, *r*, near zero, but plot is similar for other *r* values.

Sensitivity of growth to changes in age-based contacts

Until <12 year olds are vaccinated, changes to the rate at which they contact others matter disproportionately to COVID-19 spread. Thus, restricting potential transmission among this age group can help the most (left), but relaxing measures in this age group too much is expected to drive further transmission (right).



Source (S. Otto). Based on model in Day et al. (2020) with age-based vaccinations in BC (previous slide) and an age-based contact matrix (derived from Prem et al. PLOS CB, with BC demographic data). Assumes daily growth rate, *r*, near zero (but similar for other *r* values).

Vaccinating Children 5-11 years of age

- Pfizer reports their vaccine is effective and safe in this age range. Is vaccinating in this age range the best for children?
- Both COVID infection and vaccination have low risk to children. But of these low risks, which is bigger?
- Myocarditis is currently identified as the major adverse outcome for the Pfizer-BioNTech vaccine among teens.

Adverse event	**Per Million Diagnosed COVID infections**	**Per Million Pfizer-BioNTech vaccine**
Myocarditis (heart inflammation)	544 (237-1269)	63 (38-88)
Hospitalization	5000 (3000-10000)	60 (36-85)
Death	15 (7-50)	<0.2

Best estimate (and range). Numbers were estimated with data from youngest available age group (i.e. teenagers for the vaccine and for myocarditis).

All these adverse outcomes are much rarer with vaccination than with COVID, but how likely is COVID infection?

References:

https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/myocarditis.html https://www.medrxiv.org/content/10.1101/2021.08.30.21262866v1
https://www.nature.com/articles/d41586-021-01898-9 https://www.cdc.gov/mmwr/volumes/70/wr/mm7027e2.htm
https://www.medrxiv.org/content/10.1101/2021.07.23.21260998v1.full https://www.sciencedirect.com/science/article/pii/S0007091220304086
https://pubmed.ncbi.nlm.nih.gov/33289900

Source (P. Tupper)

Vaccinating Youth and Children 5-11 years of age

- If the probability of infection without the vaccine were 100%, then clearly vaccination would be much less risky.
- Likewise, if the probability of infection were 0%, risk of vaccination would be greater than not being vaccinated.
- **What probability of infection makes the risk of vaccination and the risk from infection the same?**

Adverse event	**Probability of infection with COVID that would lead to the same risk for vaccination and non-vaccination (one year interval) - Note: rare event (Pfizer) data from teens as it is not available for children**
myocarditis (heart inflammation)	12% (3%-39%) ● the risk of myocarditis from COVID is worse than from Pfizer if the chance of getting diagnosed COVID infection is 12% or higher
hospitalization	1.3% (0.3%-3.0%) ● the risk of hospitalization from COVID is worse than from Pfizer if the chance of getting diagnosed COVID infection is higher than 1.3%
death	<<3% ● the risk of death from COVID is worse than from Pfizer if the chance of getting diagnosed COVID infection is higher than ~ < 3%. Uncertain - numbers are very low.

Context: With vaccinations allowing BC to open up substantially, children <12 are getting COVID at higher rates than any other time in the pandemic (slide 5). Already ~2.4% of children under 10 have already been diagnosed with COVID-19 in BC, and at current rates, we expect >20% of children to have detected cases of COVID within two years.

Source (P. Tupper)

Vaccinating children 5-11: indirect benefits

- Children have a unique need for the adults in their lives to remain healthy and well
- Children have contact with parents, grandparents and other adults
- Preventing transmission in children has direct and **indirect benefits** for children
- Preventing transmission in children has broader indirect benefits, too

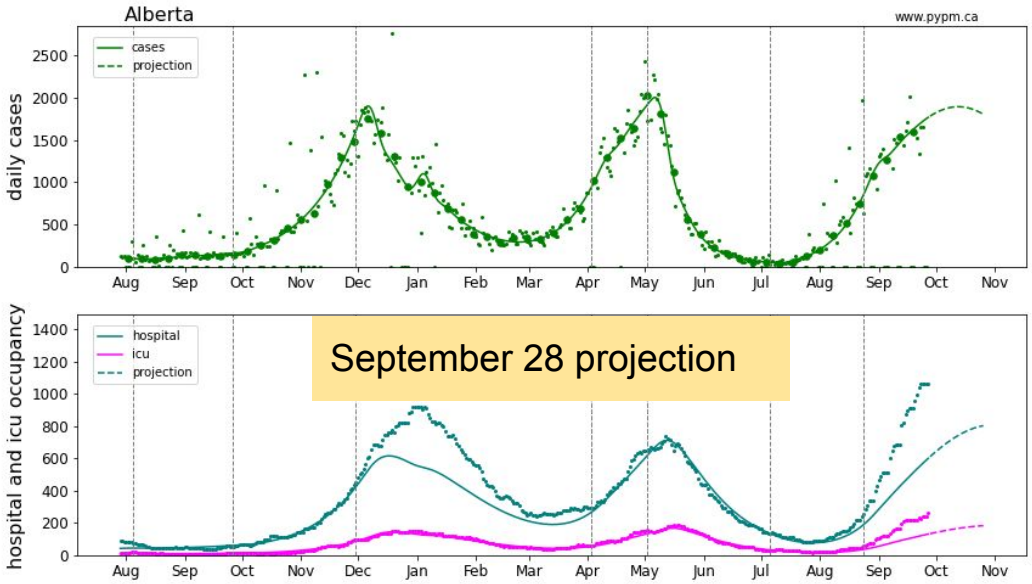
Vaccinating 5-11s prevents hospitalizations and deaths in older groups, including unvaccinated older individuals

Source (Y. Song [SFU], C. Colijn). NOTE: These are illustrative of the benefits of vaccination in this age group in a BC-like pandemic. Simulations are built upon a fit to BC's demographic and earlier pandemic data followed by growth in cases in coming weeks before child vaccination can begin. Methodology: Mulberry et al 2021

Projections for Alberta

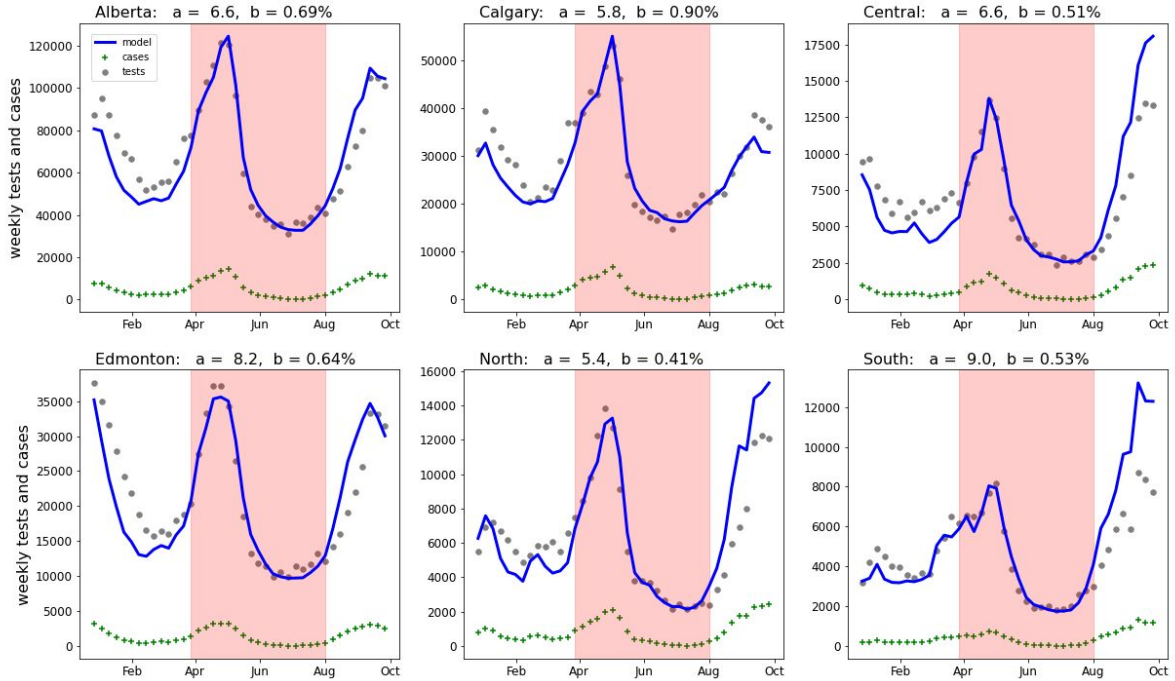
For Alberta, hospital demands in the 4th wave significantly exceed projections (Projections tuned to case and hospitalization data from 3rd wave), as shown below.

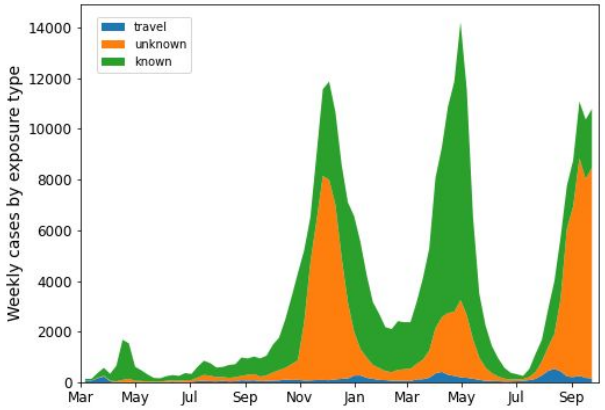
- This effect is not seen in BC and Saskatchewan data.
- A possible explanation is that changes to testing policy enacted in Alberta in early August substantially reduced the fraction of infections being reported.



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

Alberta testing rates and fraction of unknown exposures





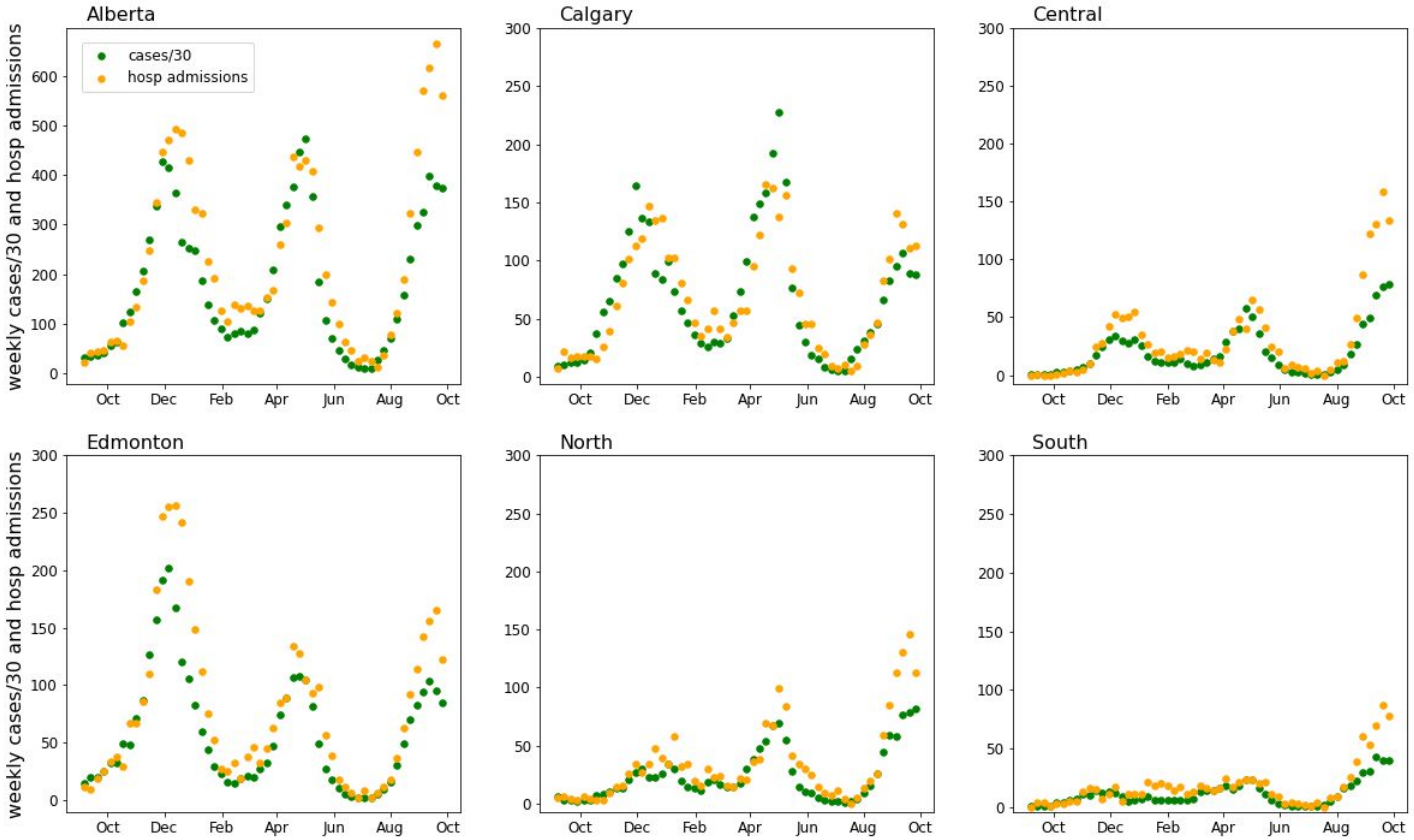
During the 3rd wave, most cases had a known exposure.

Diminished contact tracing may be responsible for most cases having an unknown exposure in the 4th wave.

During the 3rd wave (pink region), testing practice in Alberta and BC were similar (similar values for **a** and **b**: see BC testing rates page above). During the 4th wave, Alberta rural testing rates (grey points) fall well below expected level (blue curve) given the case rates (green points).

Source (D. Karlen): COVID-19 Alberta Statistics

Where are the missing 4th wave cases?



In 3rd wave, about 1 in 30 cases involved hospitalization.

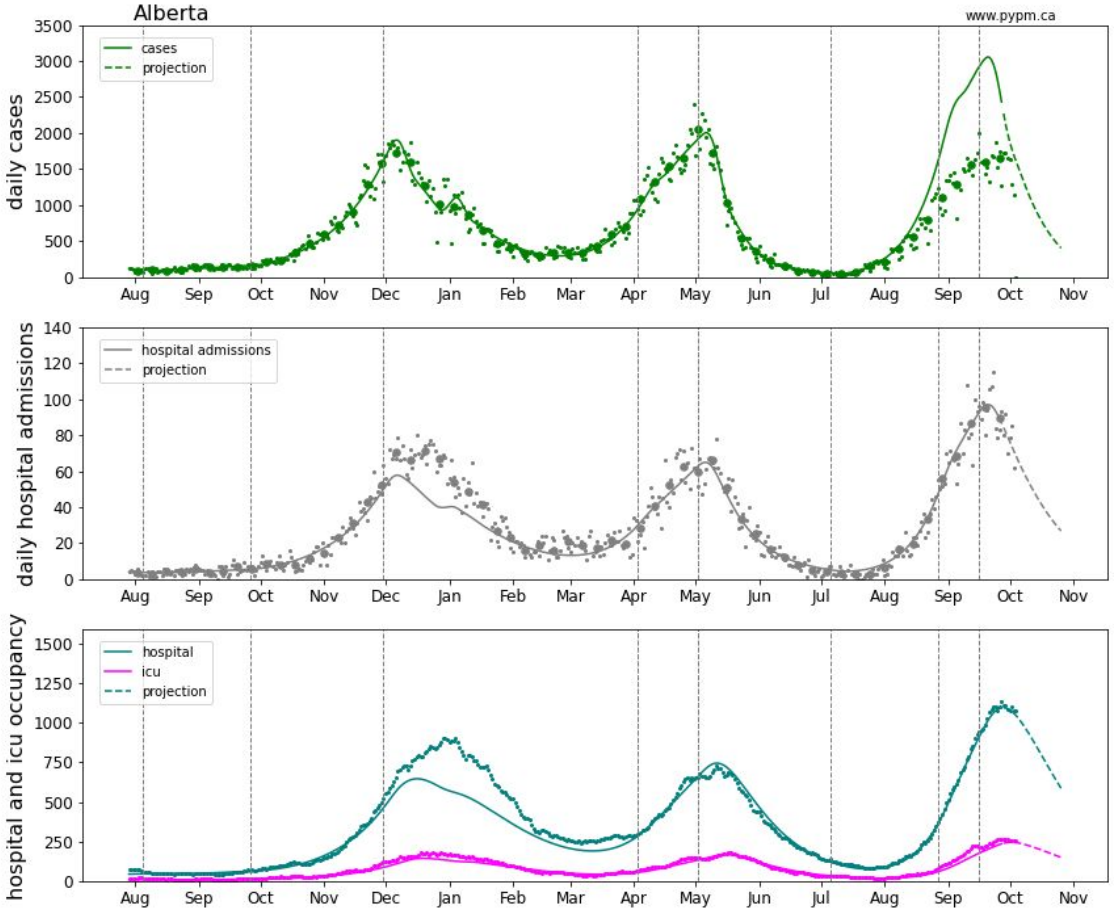
Figures compare weekly cases/30 (green points) to hospital admissions (orange points).

Cases are missing in the 4th wave when hospital admissions exceed cases/30.

The fewest missing cases are in Calgary, where testing rates appeared to be maintained in the 4th wave (previous page).

Source (D. Karlen): COVID-19 Alberta Statistics

Projections using hospital admission data



Fits hospital admission data (grey) rather than case data.

Finds that many more cases would have been reported had testing practice not changed.

Significant reversal in growth is apparent. Fitted date for change to transmission rate: Sept 15.

(Note: projections for recent changes have large uncertainty.)

Hospital and ICU occupancy data now in agreement with model for 3rd and 4th waves.

Hopeful sign for the future!

Source (D. Karlen): COVID-19 Alberta Statistics, www.pypm.ca

Key messages

State of the pandemic:

- BC's COVID-19 cases stabilized through September due to masking, other public health measures and vaccination.
- Cases in children rose steeply in Fraser Health, Interior Health and Vancouver Island.
- ICU demand remains near peak levels, but hospital and ICU occupancy have begun to stabilize.
- A new analysis reveals that the number of tests performed is a multiple of the number of cases plus a constant background number. The multiplicative factor differs by Health Authority.
- Recent testing rates in ages 0-4 are higher than expected given the number of cases.

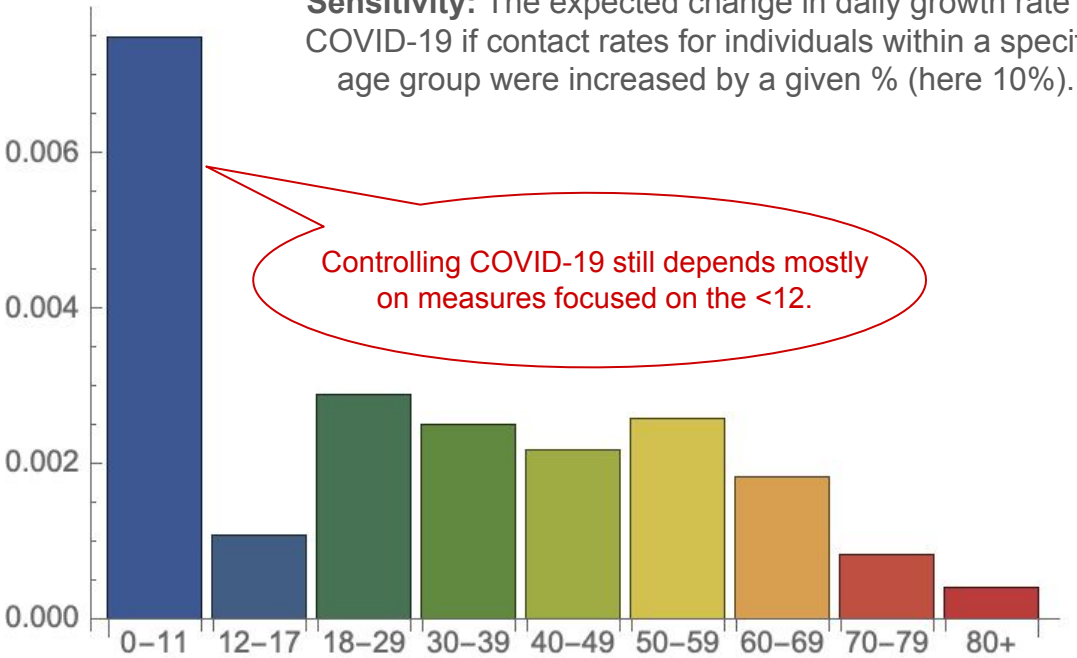
Vaccination:

- Vaccine uptake continues but at a low rate.
- Areas with high vaccination levels have lower case numbers.
- Children account for nearly 50% of the unvaccinated and are seeing rising case numbers in some health authorities in BC. Changes in transmission in children affect the cases' growth rate more than changes in other groups, because children are less vaccinated and have high contacts.
- Vaccinating children 5-11 is likely to bring benefits to children if the Pfizer vaccine is approved.
- This would have both direct benefits to children, and indirect benefits to adults.

Alberta: Hospital and case data disagreement suggests a smaller fraction of infections are being detected than previously. Cases, hospital admissions and occupancy have all begun to decline.

Appendix: Sensitivity of growth assuming equal contact

Sensitivity: The expected change in daily growth rate of COVID-19 if contact rates for individuals within a specific age group were increased by a given % (here 10%).



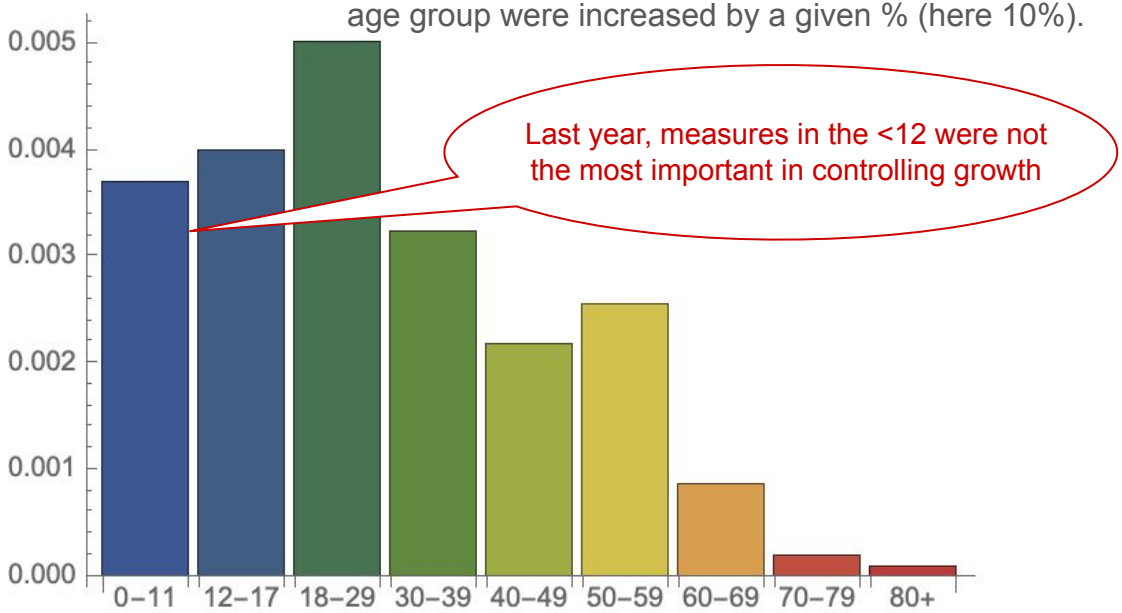
Repeats the analysis in the main report, but accounts only for the difference in vaccination rates among age groups (and the size of the group), ignoring the fact that youth are most likely to contact other youth.

Assumes that contacts are initially the same between all individuals, regardless of age.

Source: S. Otto. Based on model in Day et al. (2020) with age-based vaccinations in BC (previous slide) and a uniform contact rate matrix, regardless of age. Assumes daily growth rate, *r*, near zero, but plot is similar for other *r* values.

Appendix: Sensitivity of growth assuming no vaccination

Sensitivity: The expected change in daily growth rate of COVID-19 if contact rates for individuals within a specific age group were increased by a given % (here 10%).



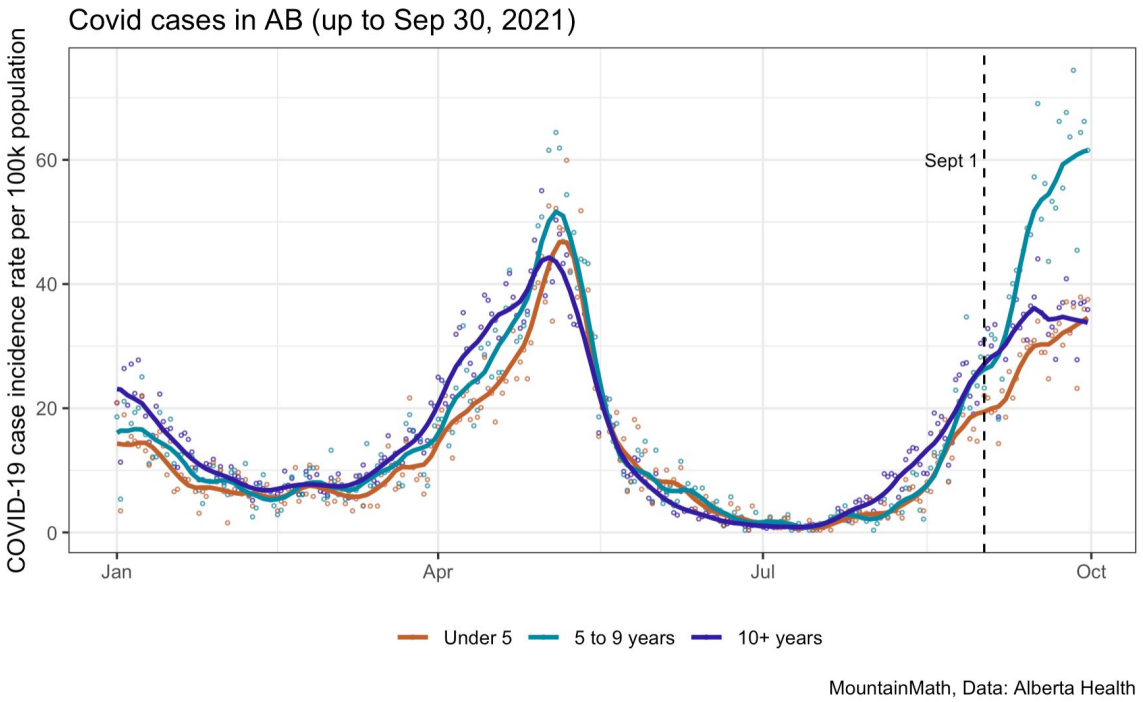
Repeats the analysis in the main report with higher contact rates among youth but without vaccination

Assumes an unvaccinated population like BC in September 2020.

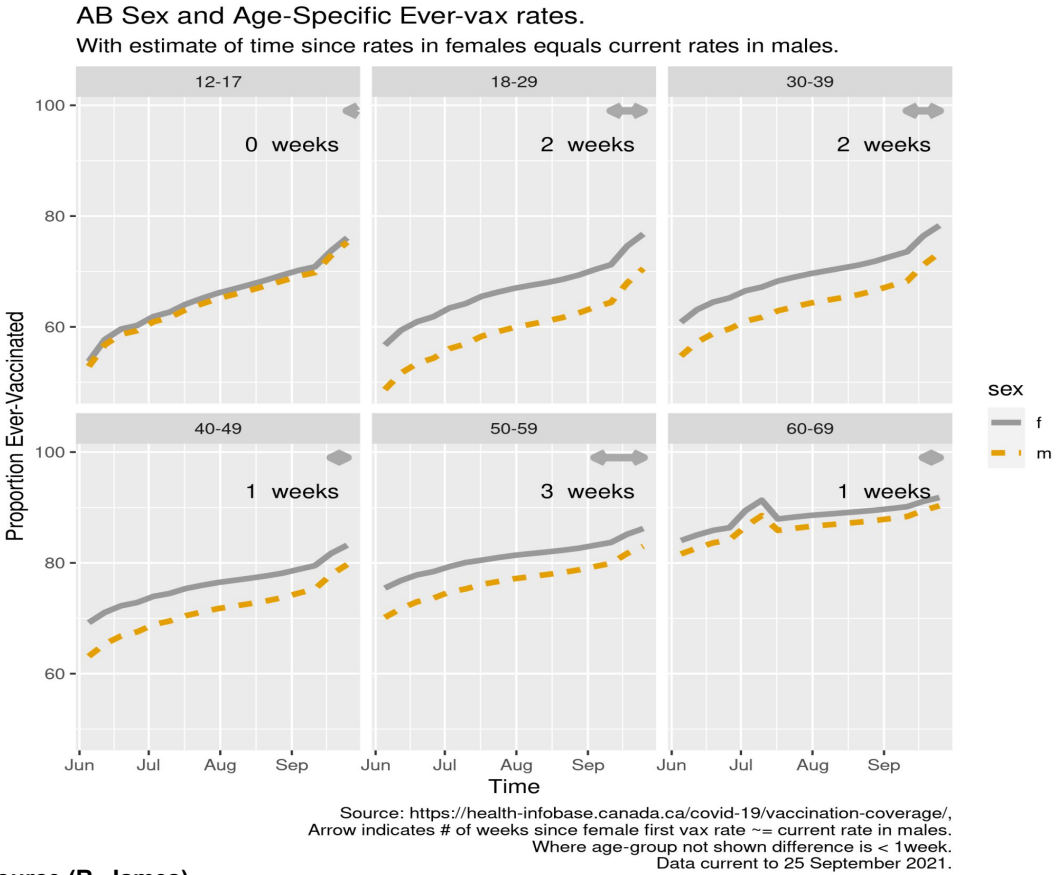
Source: S. Otto. Based on model in Day et al. (2020) with age-based vaccinations in BC (previous slide) and a uniform contact rate matrix, regardless of age. Assumes daily growth rate, *r*, near zero, but plot is similar for other *r* values.

Appendix: Childhood cases in other provinces

Alberta also shows a recent rise in cases among unvaccinated children (5-9 group).



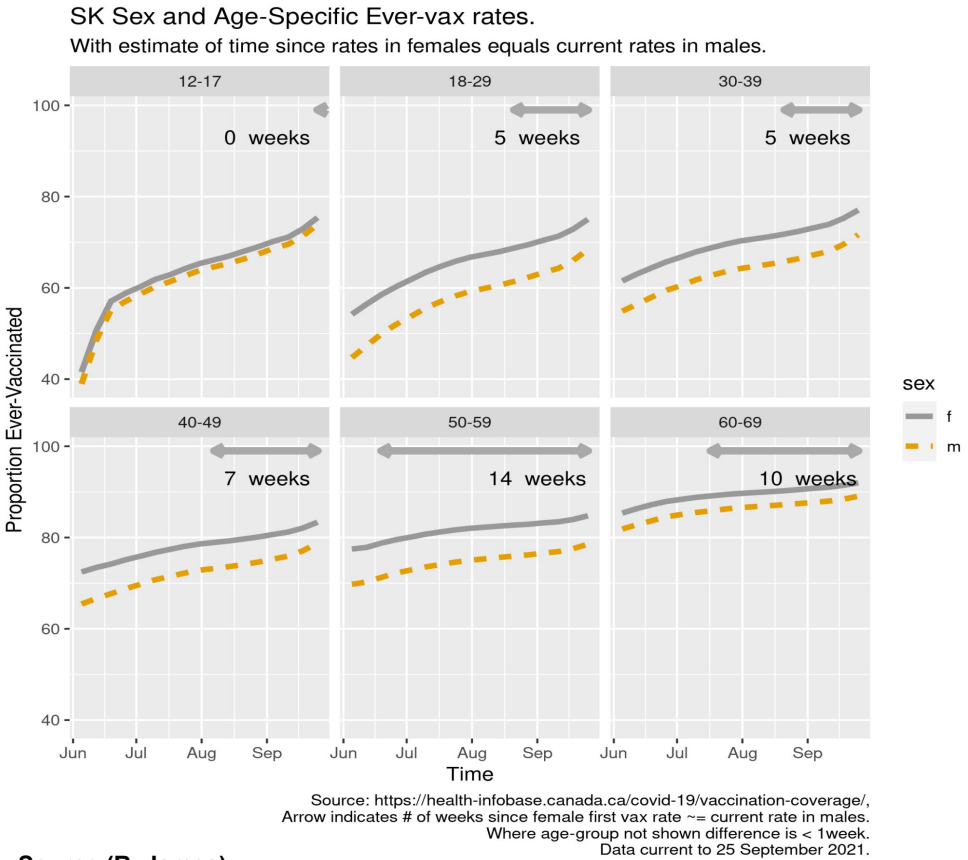
Appendix: Sex-Differences in Vaccination - AB



- Comparable rates of uptake are seen in teen males and females
- Marked uptick in vaccination is evident in 18-29 and 30-39, & 40-49 age categories in last two weeks
- Gaps of 2-3 weeks are observed across ages 18-69.
  - Males in these age-groups are uniformly vaccinated at lower rates than females.

Source (R. James)

Appendix: Sex-Differences in Vaccination - SK



- Uptake in teens shows no diferences by sex
- 18-29 year old males are vaccinated to a level seen in females 5 weeks ago
- In 30-39,40-49, & 60-69 age groups, the gap is between 5, 7 & 10 weeks
- In the 50-59 year old age group, the gap is now 14 weeks

Source (R. James)