Superimposing evolutionary changes upon case trends in Canada

Supplementary Material: Endemic does not mean constant as SARS-CoV-2 continues to evolve

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Evolution (2024)

Date of data download: September 23, 2023

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duotang: Lineage evolution from December 1 2021 - August 31 2022

```
####################
#Ran duotang in RStudio, adjusting dates and lineages of interest to estimate the selection coefficients and lineage frequencies for different periods of time.
#Version : 22 September 2023
#Obtained from https://github.com/CoVaRR-NET/duotang
####################

####################
#Notes to run duotang.Rmd in RStudio :
#Set directories and dates needed to run duotang.Rmd
####################
setwd ("~/Dropbox/COVID19/CoVaRRNet_Pillar6_Notebook")
params <- list ()
params$datadir <-"data_needed/"
params$datestamp <-"2023-09-02"

#Desired date range
mystartdate <-“2021-12-01”
myenddate <-“2022-08-31”
params$datestamp <- myenddate

#Enter duotang.Rmd through “meta$month” then adjust meta to trim data after the desired date
```

```
 meta <- meta %>% filter(
   sample_collection_date >= mystartdate,
   sample_collection_date <= myenddate
  )

#Use as a check for size of data set later:
nrow(meta)

#Replace startdate with
 startdate <- as.Date(mystartdate)
#Set enddate
 maxdate<-as.Date(myenddate)

#Skipping the startdate line in duotang.Rmd, continue entering commands until "## 2. LOAD epidemiological data (PHAC)"

####################
#Adjust code first in plot_selection_estimator.R and save
####################
#Hard code refdate to the middle of the time period (avoids low counts of some variants setting time to a different point)
#and allows a consistent time at which the allele frequencies are measured across provinces (here the middate
 refdate<-135

#which corresponds to April 15, 2022 for t=0

####################
#Adapting code from selection.Rmd do the following (only):
####################
source("scripts/plot_selection_estimator.R")

#define starting parameters (p,s) for making the selection estimates
startpar <- list(p=c(0.1, 0.05, 0.01), s=c(0.05, 0.05, 0.01))

#filter samples with variants of interest
setAll=getAllStrictoLineages(meta)
sublineages_BA45 <- c(getStrictoSubLineages("BA.5*",meta), getStrictoSubLineages("BA.4*",meta) )

sublineages_BA2 <- getStrictoSubLineages("BA.2*",meta)
```

```
#The rest in this period are primarily BA.1:
sublineages_BA1<-setAll[!setAll %in% c(sublineages_BA2, sublineages_BA45)] #the rest

sublineages_BA11  <- getStrictoSubLineages("BA.1.1*",meta)
sublineages_BA1 <- sublineages_BA1[!sublineages_BA1 %in% c(sublineages_BA11)] #BA.1 Other

reference <- sublineages_BA1
#define the mutants
mutants = list(sublineages_BA11, sublineages_BA2, sublineages_BA45)
#this list defines the mutants we are looking at for plotting. The order of mutants listed will be
respected on the respective plots.
#!!!last element is always the reference.
mutantNames = list("BA.1.1*",  "BA.2*", "BA.4/5*", "BA.1*")
col <- c("BA.1.1"="#CC5500","BA.2"=pal["Omicron BA.2"],"BA.4/5"=pal["Omicron BA.5"],"BA.1"=-
pal["Omicron BA.1"]) #define

#check that all lineages are present once:
nrow(setAll)-nrow(reference)-nrow(Reduce(union,mutants))

####################
#Switch to code from plot_selection_estimator.R and enter one region at a time then the following
code
####################
region<-"Ontario"
region<-"Alberta"
region<-"British Columbia"
region<-"Quebec"
method<-'BFGS'
collapseMutants<-T
sample_collection_date<-max(meta$sample_collection_date)

#Enter
 est <- .make.estimator(region, startdate, reference, mutants)
 toplot <- est$toplot
 toplot$tot <- apply(toplot[which(!is.element(names(toplot), c('time', 'date')))], 1, sum)

 fit <- .fit.model(est, startpar, method=method)
 fit

 # To visualize fits, enter code for "sub.plot.selection.estimate <- function(region,maxdate=NA){" in
selection.Rmd then enter:
```

sub.plot.selection.estimate(region, maxdate)

# Check that all sequences are accounted for
nrow(meta %>% filter(province == region))-(sum(toplot$n1)+sum(toplot$n2)+sum(toplot$n3)+sum(toplot$n4))

ONTARIO

p1	p2	p3	s1	s2	s3
0.118989176	0.872081681	0.006027493	0.037031381	0.094360512	0.168612635

In[∘]:=
```
ONML1 = ImportString[
   "0.118989176 0.872081681 0.006027493 0.037031381 0.094360512 0.168612635",
   "Table"][[1]]
```

Out[∘]=
```
{0.118989, 0.872082, 0.00602749, 0.0370314, 0.0943605, 0.168613}
```

ALBERTA

p1	p2	p3	s1	s2	s3
0.136079546	0.845212232	0.003240639	0.026057559	0.071230512	0.151728890

In[∘]:=
```
ABML1 = ImportString[
   "0.136079546 0.845212232 0.003240639 0.026057559 0.071230512 0.151728890 ",
   "Table"][[1]]
```

Out[∘]=
```
{0.13608, 0.845212, 0.00324064, 0.0260576, 0.0712305, 0.151729}
```

BRITISH COLUMBIA

p1	p2	p3	s1	s2	s3
0.062429749	0.929763426	0.002509135	0.033689743	0.095625477	0.177918711

In[∘]:=
```
BCML1 = ImportString[
   "0.062429749 0.929763426 0.002509135 0.033689743 0.095625477 0.177918711 ",
   "Table"][[1]]
```

Out[∘]=
```
{0.0624297, 0.929763, 0.00250914, 0.0336897, 0.0956255, 0.177919}
```

QUEBEC

p1	p2	p3	s1	s2	s3
0.130481532	0.848160875	0.002500278	0.028521735	0.080077145	0.167335046

In[∘]:=
```
QCML1 = ImportString[
   "0.130481532 0.848160875 0.002500278 0.028521735 0.080077145 0.167335046 ",
   "Table"][[1]]
```

Out[∘]=
```
{0.130482, 0.848161, 0.00250028, 0.0285217, 0.0800771, 0.167335}
```

duotang: Lineage evolution from September 1 2022 - May 31 2023

```
###################
#Ran duotang in RStudio, adjusting dates and lineages of interest to estimate the selection coefficients and lineage frequencies for different periods of time.
#Version : 22 September 2023
#Obtained from https://github.com/CoVaRR-NET/duotang
###################

###################
#Notes to run duotang.Rmd in RStudio :
#Set directories and dates needed to run duotang.Rmd
###################
setwd ("~/Dropbox/COVID19/CoVaRRNet_Pillar6_Notebook")
params <- list ()
params$datadir <-"data_needed/"
params$datestamp <-"2023-09-02"

#Desired date range
mystartdate <-“2022-09-01”
myenddate <-“2023-05-31”
params$datestamp <- myenddate

#Enter duotang.Rmd through “meta$month” then adjust meta to trim data after the desired date

 meta <- meta %>% filter(
   sample_collection_date >= mystartdate,
   sample_collection_date <= myenddate
  )

 #Use as a check for size of data set later:
 nrow(meta)

 #Replace startdate with
  startdate <- as.Date(mystartdate)
 #Set enddate
  maxdate<-as.Date(myenddate)

 #Skipping the startdate line in duotang.Rmd, continue entering commands until “## 2. LOAD epidemiological data (PHAC)”

###################
#Adjust code first in plot_selection_estimator.R and save
```

```
####################
#Hard code refdate to the middle of the time period (avoids low counts of some variants setting time to
a different point)
#and allows a consistent time at which the allele frequencies are measured across provinces (here the
middate
 refdate<-135

#which corresponds to Jan 14, 2023 for t=0

####################
#Adapting code from selection.Rmd do the following (only):
####################
source("scripts/plot_selection_estimator.R")

#define starting parameters (p,s) for making the selection estimates
startpar <- list(p=c(0.1, 0.05, 0.01), s=c(0.05, 0.05, 0.01))

#filter samples with variants of interest
setAll=getAllStrictoLineages(meta)
sublineages_XBB <- getStrictoSubLineages("XBB*",meta) #XBB variants

sublineages_XBB15  <- getStrictoSubLineages("XBB.1.5*",meta) #XBB1.5 variants
sublineages_XBBOther <- sublineages_XBB[!sublineages_XBB %in% c(sublineages_XBB15)] #XBB Other

sublineages_BQ <- getStrictoSubLineages("BQ*",meta)

#The rest in this period are primarily BA.5 & BA.4:
sublineages_Other<-setAll[!setAll %in% c(sublineages_BQ, sublineages_XBB15, sublineages_XB-
BOther)] #the rest

reference <- sublineages_Other
#define the mutants
mutants = list(sublineages_XBB15, sublineages_XBBOther, sublineages_BQ)
#this list defines the mutants we are looking at for plotting. The order of mutants listed will be
respected on the respective plots.
#!!!last element is always the reference.
mutantNames = list("XBB.1.5*",  "XBB.Other*", "BQ*", "BA.5*") #
col <- c("XBB.1.5*"="#00eeff","XBB.Other"=pal["XBB"],"BQ" = pal["Omicron BQ"]) #define custom color
for XBB here because otherwise it will be black cuz recombinant.

#check that all lineages are present once:
```

```
nrow(setAll)-nrow(reference)-nrow(Reduce(union,mutants))

###################
#Switch to code from plot_selection_estimator.R and enter one region at a time then the following code
###################
region<-“Ontario”
region<-“Alberta”
region<-“British Columbia”
region<-“Quebec”
method<-‘BFGS’
collapseMutants<-T
sample_collection_date<-max(meta$sample_collection_date)

#Enter
 est <- .make.estimator(region, startdate, reference, mutants)
 toplot <- est$toplot
 toplot$tot <- apply(toplot[which(!is.element(names(toplot), c(‘time’, ‘date’)))], 1, sum)

 fit <- .fit.model(est, startpar, method=method)
 fit

 # To visualize fits, enter code for “sub.plot.selection.estimate <- function(region,maxdate=NA){“ in selection.Rmd then enter:
 sub.plot.selection.estimate(region, maxdate)

 # Check that all sequences are accounted for
 nrow(meta %>% filter(province == region))-(sum(toplot$n1)+sum(toplot$n2)+sum(toplot$n3)+sum(toplot$n4))
```

```
ONTARIO
     p1       p2       p3       s1       s2       s3
0.129498579 0.007625208 0.634857867 0.074372906 0.091417510 0.032032796

$confint
     2.5 %    97.5 %
p1 0.124208973 0.134788185
p2 0.006643921 0.008606496
p3 0.627474991 0.642240743
s1 0.073088066 0.075657747
s2 0.089509689 0.093325331
```

s3 0.031330440 0.032735153

```
In[∘]:= ONML2 = ImportString[
    "0.129498579 0.007625208 0.634857867 0.074372906 0.091417510 0.032032796",
    "Table"][[1]]
Out[∘]= {0.129499, 0.00762521, 0.634858, 0.0743729, 0.0914175, 0.0320328}
```

ALBERTA
$fit
p1 p2 p3 s1 s2 s3
0.09118951 0.01216224 0.73510214 0.07422397 0.08730765 0.03323601

$confint
2.5 % 97.5 %
p1 0.082596403 0.09978262
p2 0.009555296 0.01476919
p3 0.722050410 0.74815387
s1 0.071921601 0.07652633
s2 0.084149996 0.09046531
s3 0.032005843 0.03446618

```
In[∘]:= ABML2 = ImportString[
    "0.09118951 0.01216224 0.73510214 0.07422397 0.08730765 0.03323601 ",
    "Table"][[1]]
Out[∘]= {0.0911895, 0.0121622, 0.735102, 0.074224, 0.0873077, 0.033236}
```

QUEBEC
$fit
p1 p2 p3 s1 s2 s3
0.170114876 0.005888324 0.579924511 0.063673467 0.082866917 0.023798106

$confint
2.5 % 97.5 %
p1 0.160389348 0.179840403
p2 0.004627387 0.007149262
p3 0.567772865 0.592076158
s1 0.062035976 0.065310958
s2 0.080205256 0.085528578
s3 0.022916588 0.024679624

In[∘]:=
```
QCML2 = ImportString[
   "0.170114876 0.005888324 0.579924511 0.063673467 0.082866917 0.023798106",
   "Table"][[1]]
```

Out[∘]=
```
{0.170115, 0.00588832, 0.579925, 0.0636735, 0.0828669, 0.0237981}
```

BRITISH COLUMBIA

p1	p2	p3	s1	s2	s3
0.085192517	0.005515947	0.681707601	0.075028809	0.093109572	0.028918971

$confint

	2.5 %	97.5 %
p1	0.077013733	0.093371301
p2	0.004167128	0.006864766
p3	0.668738202	0.694677000
s1	0.072886130	0.077171487
s2	0.089883560	0.096335584
s3	0.027855483	0.029982460

In[∘]:=
```
BCML2 = ImportString[
   "0.085192517 0.005515947 0.681707601 0.075028809 0.093109572 0.028918971 ",
   "Table"][[1]]
```

Out[∘]=
```
{0.0851925, 0.00551595, 0.681708, 0.0750288, 0.0931096, 0.028919}
```

Canadian age data

Canadian population size by 70+ and all ages on 1 July 2022 (from https://www150.statcan.gc.ca/n1/t-bl/csv/17100005-eng.zip):

GEO	Total	70+
Alberta	4543111	439109
British Columbia	5319324	726247
Canada	38929902	5022509
Manitoba	1409223	159565
New Brunswick	812061	125512
Newfoundland and Labrador	525972	83596
Northwest Territories	45605	2507
Nova Scotia	1019725	152435
Nunavut	40526	1076
Ontario	15109416	1918812
Prince Edward Island	170688	23926
Quebec	8695659	1250508
Saskatchewan	1194803	135543

Yukon 43789 3673

In[∘]:=
```
CanadaPop = ImportString["GEO	Total	70+
AB	4543111	439109
BC	5319324	726247
Canada	38929902	5022509
MB	1409223	159565
NB	812061	125512
NL	525972	83596
NT	45605	2507
NS	1019725	152435
NU	40526	1076
ON	15109416	1918812
PE	170688	23926
QC	8695659	1250508
SK	1194803	135543
YT	43789	3673", "Table"];
```

In[∘]:=
```
CanadaPop // MatrixForm
```

Out[∘]//MatrixForm=

GEO	Total	70+
AB	4 543 111	439 109
BC	5 319 324	726 247
Canada	38 929 902	5 022 509
MB	1 409 223	159 565
NB	812 061	125 512
NL	525 972	83 596
NT	45 605	2507
NS	1 019 725	152 435
NU	40 526	1076
ON	15 109 416	1 918 812
PE	170 688	23 926
QC	8 695 659	1 250 508
SK	1 194 803	135 543
YT	43 789	3673

BC - 70+ case counts and genomic frequencies (Dec 2021-May 2023)

http://www.bccdc.ca/Health-Info-Site/Documents/BCCDC_COVID19_Dashboard_Case_Details.csv

Processing BC Case Data [ENTER this or the next folder - uploading & processing data]

In[∘]:=
```
SetDirectory["/Users/otto/Dropbox/COVID19/BC_Data/CorrectingCaseCounts"];
```

In[∘]:=
```
startafter = "2021-11-30";
```

The two periods we'll consider:

In[∘]:=
```
mystartdate1 = "2021-12-01";
myenddate1 = "2022-08-31";
mystartdate2 = "2022-09-01";
myenddate2 = "2023-05-31";
```

In[∘]:=
```
curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

In[∘]:=
```
xaxis = {{curdate["2021-10-01"], "Oct"},
   {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
   {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
   {curdate["2022-03-01"], "Mar"}, {curdate["2022-04-01"], "Apr"},
   {curdate["2022-05-01"], "May"}, {curdate["2022-06-01"], "Jun"},
   {curdate["2022-07-01"], "Jul"}, {curdate["2022-08-01"], "Aug"},
   {curdate["2022-09-01"], "Sep"}, {curdate["2022-10-01"], "Oct"},
   {curdate["2022-11-01"], "Nov"}, {curdate["2022-12-01"], "Dec"},
   {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
   {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
   {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

Uploading the data (see below to avoid this step):

In[∘]:=
```
Drop[Import["BCCDC_COVID19_Dashboard_Case_Details11May2023.csv"], 1];
temp = %[[200 000 ;; Length[%]]]; (*Limiting data*)
counts = Transpose[{temp[[All, 1]], temp[[All, 2]], temp[[All, 4]]}];
```

In[∘]:=
```
For[i = 1, i ≤ Length[counts], i++,
 counts[[i, 1]] =
  DateString[DateObject[counts[[i, 1]]], {"Year", "-", "Month", "-", "Day"}]
]
```

Out[∘]=
```
$Aborted
```

Making sure that we've included enough of the counts (next line should be before startafter date)

In[∘]:=
```
counts[[1]]
```

Out[∘]=
```
{2021-10-20, Northern, <10}
```

In[∘]:=
```
Last[Position[counts, startafter]][[1]]
```

Out[∘]=
```
18 932
```

In[∘]:=
```
counts = counts[[% + 1 ;; Length[counts]]];
```

In[∘]:=
```
dates = DeleteDuplicates[counts[[All, 1]]]
```

Out[∘]=
```
{2021-12-01, 2021-12-02, 2021-12-03, 2021-12-04, 2021-12-05, 2021-12-06, 2021-12-07,
 2021-12-08, 2021-12-09, 2021-12-10, 2021-12-11, 2021-12-12, 2021-12-13, 2021-12-14,
 2021-12-15, 2021-12-16, 2021-12-17, 2021-12-18, 2021-12-19, 2021-12-20, 2021-12-21,
```

```
2021-12-22, 2021-12-23, 2021-12-24, 2021-12-25, 2021-12-26, 2021-12-27,
2021-12-28, 2021-12-29, 2021-12-30, 2021-12-31, 2022-01-01, 2022-01-02,
2022-01-03, 2022-01-04, 2022-01-05, 2022-01-06, 2022-01-07, 2022-01-08,
2022-01-09, 2022-01-10, 2022-01-11, 2022-01-12, 2022-01-13, 2022-01-14,
2022-01-15, 2022-01-16, 2022-01-17, 2022-01-18, 2022-01-19, 2022-01-20,
2022-01-21, 2022-01-22, 2022-01-23, 2022-01-24, 2022-01-25, 2022-01-26,
2022-01-27, 2022-01-28, 2022-01-29, 2022-01-30, 2022-01-31, 2022-02-01,
2022-02-02, 2022-02-03, 2022-02-04, 2022-02-05, 2022-02-06, 2022-02-07,
2022-02-08, 2022-02-09, 2022-02-10, 2022-02-11, 2022-02-12, 2022-02-13,
2022-02-14, 2022-02-15, 2022-02-16, 2022-02-17, 2022-02-18, 2022-02-19,
2022-02-20, 2022-02-21, 2022-02-22, 2022-02-23, 2022-02-24, 2022-02-25,
2022-02-26, 2022-02-27, 2022-02-28, 2022-03-01, 2022-03-02, 2022-03-03,
2022-03-04, 2022-03-05, 2022-03-06, 2022-03-07, 2022-03-08, 2022-03-09,
2022-03-10, 2022-03-11, 2022-03-12, 2022-03-13, 2022-03-14, 2022-03-15,
2022-03-16, 2022-03-17, 2022-03-18, 2022-03-19, 2022-03-20, 2022-03-21,
2022-03-22, 2022-03-23, 2022-03-24, 2022-03-25, 2022-03-26, 2022-03-27,
2022-03-28, 2022-03-29, 2022-03-30, 2022-03-31, 2022-04-01, 2022-04-02,
2022-04-03, 2022-04-04, 2022-04-05, 2022-04-06, 2022-04-07, 2022-04-08,
2022-04-09, 2022-04-10, 2022-04-11, 2022-04-12, 2022-04-13, 2022-04-14,
2022-04-15, 2022-04-16, 2022-04-17, 2022-04-18, 2022-04-19, 2022-04-20,
2022-04-21, 2022-04-22, 2022-04-23, 2022-04-24, 2022-04-25, 2022-04-26,
2022-04-27, 2022-04-28, 2022-04-29, 2022-04-30, 2022-05-01, 2022-05-02,
2022-05-03, 2022-05-04, 2022-05-05, 2022-05-06, 2022-05-07, 2022-05-08,
2022-05-09, 2022-05-10, 2022-05-11, 2022-05-12, 2022-05-13, 2022-05-14,
2022-05-15, 2022-05-16, 2022-05-17, 2022-05-18, 2022-05-19, 2022-05-20,
2022-05-21, 2022-05-22, 2022-05-23, 2022-05-24, 2022-05-25, 2022-05-26,
2022-05-27, 2022-05-28, 2022-05-29, 2022-05-30, 2022-05-31, 2022-06-01,
2022-06-02, 2022-06-03, 2022-06-04, 2022-06-05, 2022-06-06, 2022-06-07,
2022-06-08, 2022-06-09, 2022-06-10, 2022-06-11, 2022-06-12, 2022-06-13,
2022-06-14, 2022-06-15, 2022-06-16, 2022-06-17, 2022-06-18, 2022-06-19,
2022-06-20, 2022-06-21, 2022-06-22, 2022-06-23, 2022-06-24, 2022-06-25,
2022-06-26, 2022-06-27, 2022-06-28, 2022-06-29, 2022-06-30, 2022-07-01,
2022-07-02, 2022-07-03, 2022-07-04, 2022-07-05, 2022-07-06, 2022-07-07,
2022-07-08, 2022-07-09, 2022-07-10, 2022-07-11, 2022-07-12, 2022-07-13,
2022-07-14, 2022-07-15, 2022-07-16, 2022-07-17, 2022-07-18, 2022-07-19,
2022-07-20, 2022-07-21, 2022-07-22, 2022-07-23, 2022-07-24, 2022-07-25,
2022-07-26, 2022-07-27, 2022-07-28, 2022-07-29, 2022-07-30, 2022-07-31,
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```

Here we are going to combine the Health Authorities:

```
In[•]:= HAlist = {"Vancouver Coastal", "Vancouver Island",
    "Interior", "Fraser", "Northern", "Out of Canada"};
```

To adjust to the population size of the province:

```
In[∘]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "BC"][[1, 1]]]]
Out[∘]= {BC, 5 319 324, 726 247}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[∘]:= per100000Y = 100 000 / (popsize[[2]] - popsize[[3]])
        per100000A = 100 000 / popsize[[3]]
Out[∘]= 100 000 / 4 593 077
Out[∘]= 100 000 / 726 247
```

```
In[∘]:= Clear[datetabBC];
        datetabBC[i_] = {0, 0};
        For[i = 1, i ≤ Length[counts], i++,
         date = Position[dates, counts[[i, 1]]][[1, 1]];
         If[((counts[[i, 3]] == "70-79") ||
             (counts[[i, 3]] == "80-89") || (counts[[i, 3]] == "90+")),
          Part[datetabBC[date] = datetabBC[date] + {0, per100000A}],
          Part[datetabBC[date] = datetabBC[date] + {per100000Y, 0}]
         ]
        ]
```

Processing BC Case Data [ENTER this or the previous folder - pre-processed data]

```
In[∘]:= startafter = "2021-11-30";
```

The two periods we'll consider:

```
In[∘]:= mystartdate1 = "2021-12-01";
        myenddate1 = "2022-08-31";
        mystartdate2 = "2022-09-01";
        myenddate2 = "2023-05-31";
```

```
In[∘]:= curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

```
In[∘]:= xaxis = {{curdate["2021-10-01"], "Oct"},
    {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
    {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
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    {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
    {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
    {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

To adjust to the population size of the province:

```
In[∘]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "BC"][[1, 1]]]]
Out[∘]= {BC, 5 319 324, 726 247}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[∘]:= per100000Y = 100 000 / (popsize[[2]] - popsize[[3]])
        per100000A = 100 000 / popsize[[3]]
```

Out[∘]= $\frac{100\,000}{4\,593\,077}$

Out[∘]= $\frac{100\,000}{726\,247}$

```
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{0.4572098399395438`, 9.08781723022608`}, {0.6967007084793049`,
```

```
 7.8485694261043415`}, {0.6096131199193917`, 10.327065034347818`},
{0.6967007084793049`, 11.290924437553615`}, {0.6531569141993483`,
 10.051676633431876`}, {0.8055601941791962`, 8.399346227936226`},
{0.544297428499457`, 5.920850619692749`}, {0.63138501705937`,
 4.130826013739127`}, {0.4572098399395438`, 10.46475923480579`},
{0.6531569141993483`, 8.95012302976811`}, {0.63138501705937`,
 6.884710022898545`}, {0.39189414851960896`, 7.435486824730429`},
{0.6531569141993483`, 8.399346227936226`}, {0.6096131199193917`,
 5.232379617402895`}, {0.4789817370795221`, 7.710875225646371`},
{0.5007536342195004`, 8.95012302976811`}, {0.39189414851960896`,
 4.406214414655069`}, {0.30480655995969586`, 5.094685416944924`},
{0.3701222513796307`, 3.5800492119072436`}, {0.6531569141993483`,
 3.166966610533331`}, {0.39189414851960896`, 3.7177434123652144`},
{0.544297428499457`, 2.891578209617389`}, {0.30480655995969586`,
 1.7900246059536218`}, {0.5007536342195004`, 2.4784956082434766`},
{0.7402445027592613`, 3.304660810991302`}, {0.5660693256394351`,
 1.3769420045797092`}, {0.7402445027592613`, 2.891578209617389`},
{0.32657845709967415`, 1.9277188064115927`}, {0.30480655995969586`,
 1.3769420045797092`}, {0.63138501705937`, 2.3408014077855053`},
{0.32657845709967415`, 3.7177434123652144`}, {0.43543794279956555`,
 4.6816028155710105`}, {0.4789817370795221`, 2.6161898087014475`},
{0.30480655995969586`, 3.02927241007536`}, {0.26126276567973933`,
 3.02927241007536`}, {0.30480655995969586`, 2.7538840091594183`},
{0.43543794279956555`, 3.7177434123652144`}, {0.63138501705937`,
 2.891578209617389`}, {0.5878412227794134`, 3.02927241007536`},
{0.26126276567973933`, 5.370073817860866`}, {0.5225255313594787`,
 4.130826013739127`}, {0.4572098399395438`, 4.819297016028982`},
{0.5007536342195004`, 3.5800492119072436`}, {0.39189414851960896`,
 5.6454622187768075`}, {0.19594707425980448`, 3.7177434123652144`},
{0.4789817370795221`, 4.819297016028982`}, {0.6531569141993483`,
 6.47162742152463`}, {0.28303466281971756`, 2.7538840091594183`},
{0.41366604565958726`, 3.5800492119072436`}, {0.34835035423965244`,
 4.406214414655069`}, {0.39189414851960896`, 4.6816028155710105`},
{0.6531569141993483`, 7.5731810251884`}, {0.41366604565958726`,
 4.268520214197098`}, {0.41366604565958726`, 5.232379617402895`},
{0.39189414851960896`, 5.920850619692749`}, {0.41366604565958726`,
 4.406214414655069`}, {0.39189414851960896`, 5.783156419234778`},
{0.41366604565958726`, 3.7177434123652144`}, {0.4789817370795221`,
 5.6454622187768075`}, {0.30480655995969586`, 4.268520214197098`},
{0.5878412227794134`, 4.819297016028982`}, {0.30480655995969586`,
 2.6161898087014475`}, {0.34835035423965244`, 2.891578209617389`},
{0.5007536342195004`, 4.130826013739127`}, {0.32657845709967415`,
 4.6816028155710105`}, {0.6531569141993483`, 5.6454622187768075`},
{0.39189414851960896`, 4.819297016028982`}, {0.3701222513796307`,
```

```
 3.8554376128231853`}, {0.4572098399395438`, 3.7177434123652144`},
{0.3701222513796307`, 5.232379617402895`}, {0.32657845709967415`,
 5.370073817860866`}, {0.544297428499457`, 3.5800492119072436`},
{0.6749288113393266`, 5.6454622187768075`}, {0.5007536342195004`,
 5.6454622187768075`}, {0.4789817370795221`, 4.268520214197098`},
{0.41366604565958726`, 5.232379617402895`}, {0.39189414851960896`,
 4.956991216486953`}, {0.43543794279956555`, 6.196239020608691`},
{0.5007536342195004`, 4.406214414655069`}, {0.41366604565958726`,
 7.297792624272458`}, {0.5007536342195004`, 5.370073817860866`},
{0.3701222513796307`, 7.022404223356516`}, {0.4572098399395438`,
 4.819297016028982`}, {0.43543794279956555`, 7.8485694261043415`},
{0.41366604565958726`, 7.022404223356516`}, {0.5878412227794134`,
 6.471627421524633`}, {0.5225255313594787`, 7.5731810251884`},
{0.39189414851960896`, 5.094685416944924`}, {0.4572098399395438`,
 5.370073817860866`}, {0.43543794279956555`, 5.370073817860866`},
{0.5660693256394351`, 4.819297016028982`}, {0.4572098399395438`,
 6.196239020608691`}, {0.43543794279956555`, 5.6454622187768075`},
{0.6096131199193917`, 5.920850619692749`}, {0.7184726056192831`,
 5.6454622187768075`}, {0.43543794279956555`, 6.609321621982604`},
{0.6531569141993483`, 5.783156419234778`}, {0.4572098399395438`,
 4.956991216486953`}, {0.5225255313594787`, 5.370073817860866`},
{1.0015072684390007`, 7.022404223356516`}, {0.5878412227794134`,
 5.920850619692749`}, {0.43543794279956555`, 6.196239020608691`},
{0.63138501705937`, 5.6454622187768075`}, {0.6967007084793049`,
 7.297792624272458`}, {0.6096131199193917`, 5.6454622187768075`}};
```

Enter the following to avoid upload:

```
In[•]:= dates = tabdates;
```

```
In[•]:= For[i = 1, i <= Length[dates], i++, datetabBC[i] = tab[[i]]]
```

Overall Analysis by 70+

Cubic Spline fit (https://mathematica.stackexchange.com/questions/33206/implementation-of-smoothing-splines-function)

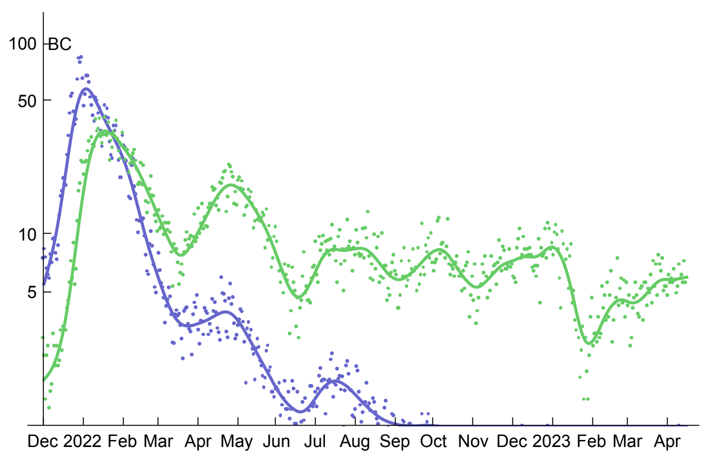
```
In[•]:= CubicSplSmooth[data_, lambda_] := Module[{M, Knots, X, Dsq, a}, M = Length@data;
   Knots = Flatten@{1, 1, 1, Range@M, M, M, M};
   X = Table[Evaluate@N@BSplineBasis[{3, Knots}, n, t], {t, 1, M}, {n, 0, M + 1}];
   Dsq = Differences[X, 2];
   a = LinearSolve[Transpose[X].X + lambda * Transpose[Dsq].Dsq,
     Transpose[X].data, Method → "Multifrontal"];
   Return[
    X.
     a]];
```

Cubic spline fit to all dates (Y is younger, A is 70+), using lambda = 4 to provide a good fit but not overfit to the data:

```
In[∘]:= modYBC = CubicSplSmooth[Table[{i, Log[Max[1, datetabBC[i][[1]]]]},
          {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
        modABC = CubicSplSmooth[Table[{i, Log[Max[1, datetabBC[i][[2]]]]},
          {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
```

```
In[∘]:= plotBC = Show[
          ListPlot[Table[{i, Log[datetabBC[i][[1]]]}, {i, 1, Length[dates]}],
           PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.4, 0.8]}],
          ListLinePlot[modYBC, PlotStyle → RGBColor[0.4, 0.4, 0.8], PlotRange → All],
          ListLinePlot[modABC, PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
          ListPlot[Table[{i, Log[datetabBC[i][[2]]]}, {i, 1, Length[dates]}],
           PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
          Graphics[Text["BC", {5, 4.6}, {-1, 0}]],
          PlotRange → {Automatic, {0, 5}}, AxesOrigin → {1, 0},
          Ticks → {xaxis, {{Log[5], "5"}, {Log[10], "10"}, {Log[50], "50"}, {Log[100], "100"},
             {Log[500], "500"}, {Log[1000], "1000"}, {Log[5000], "5000"}}}
         ]
```

Out[∘]=

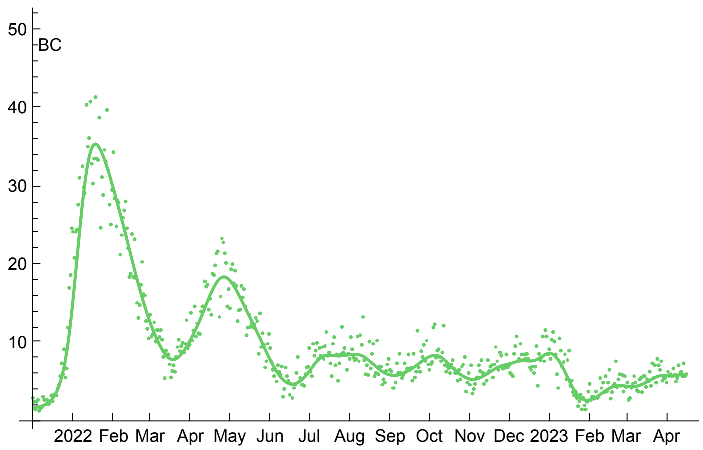


The above illustrates the major drop off in reported cases among those <70:

70+ on a non-log plot

In[∘]:=
```
Show[
 ListLinePlot[Table[{modABC[[i, 1]], Exp[modABC[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabBC[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["BC", {5, 48}, {-1, 0}]],
 PlotRange → {Automatic, {0, 50}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

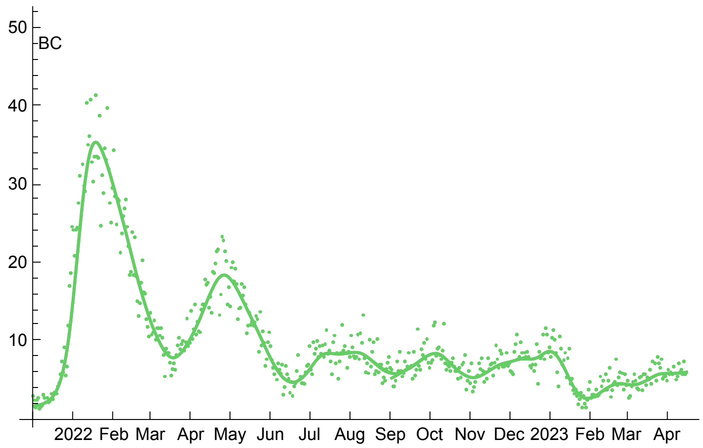
Out[∘]=



In[∘]:=
```
modABC1 = CubicSplSmooth[Table[{i, Log[Max[1, datetabBC[i][[2]]]]},
    {i, 1, Position[dates, myenddate1][[1, 1]]}], 10^lambda /. lambda → 3];
modABC2 = CubicSplSmooth[Table[{i, Log[Max[1, datetabBC[i][[2]]]]},
    {i, Position[dates, mystartdate2][[1, 1]], Length[dates]}],
   10^lambda /. lambda → 3];
```

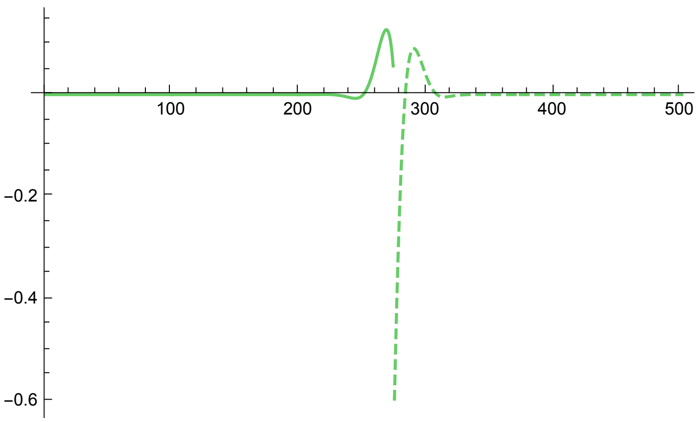
```
In[∘]:= Show[
  ListLinePlot[Table[{modABC[[i, 1]], Exp[modABC[[i, 2]]]}, {i, 1, Length[dates]}],
   PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
  ListLinePlot[Table[{modABC1[[i, 1]], Exp[modABC1[[i, 2]]]},
    {i, 1, Length[modABC1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
  ListLinePlot[Table[{modABC2[[i, 1]], Exp[modABC2[[i, 2]]]},
    {i, 1, Length[modABC2]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
  ListPlot[Table[{i, datetabBC[i][[2]]}, {i, 1, Length[dates]}],
   PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
  Graphics[Text["BC", {5, 48}, {-1, 0}]],
  PlotRange → {Automatic, {0, 50}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
 ]
```

Out[∘]=



The fit is very similar, with a slight discrepancy in numbers at the joint, so we just use the overall spline fit for the analysis:

In[ ]:=
```
Show[
 ListLinePlot[Table[{modABC1[[i, 1]], Exp[modABC1[[i, 2]]] - Exp[modABC[[i, 2]]]},
   {i, 1, Length[modABC1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modABC2[[i, 1]], Exp[modABC2[[i, 2]]] - Exp[modABC[[
      i + Position[dates, myenddate1][[1, 1]], 2]]]}, {i, 1, Length[modABC2]}],
  PlotStyle → {Dashed, RGBColor[0.4, 0.8, 0.4]}, PlotRange → All],
 PlotRange → All
]
```

Out[ ]=


Merging with Omicron subvariant frequencies

In[ ]:=
```
graphheight = 42;
```

In[ ]:=
```
colourBA1 = RGBColor[0.5, 0.1, 0.1];
colourBA11 = RGBColor[0.75, 0.1, 0.1];
colourBA2 = RGBColor[1, 0.1, 0.1];
colourBA5 = RGBColor[1, 0.5, 0.1];
colourBA45 = colourBA5;
colourBA4 = colourBA5;
colourBQ = RGBColor[1, 0.75, 0.5];
colourXBB15 = RGBColor[0.2, 0.5, 0.8];
colourXBBO = RGBColor[0.5, 0.7, 0.8];

{colourBA1, colourBA11, colourBA2, colourBA45, colourBQ, colourXBB15, colourXBBO}
```

Out[ ]=


From Omicron_VariantsGISAID.nb (selection on BA.1, BA.1.1 and BA.2 calculated from 16 May analysis [uses “2023-12-1” for t=1]; selection on BA.4&BA.5 from 24 June analysis where the initial frequency is for “2022-04-1” at t=1):

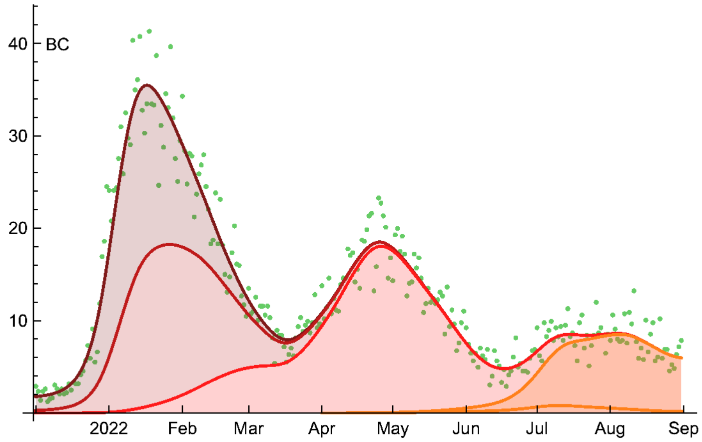
```
In[◦]:= BCML = {pBA11 → 0.15389609946813929`, pBA2 → 0.00023336006270172828`,
    sBA11 → 0.03289439606417615`, sBA2 → 0.10253826895207825`,
    pBA4 → 0.00015574461261878253`, pBA5 → 0.000047964983160236866`,
    sBA4 → 0.08125393761607246`, sBA5 → 0.11284956139460468`};

In[◦]:= endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modABC[[i, 1]],
     1 * Exp[modABC[[i, 2]]] /. t -> modABC[[i, 1]] /. BCML}, {i, 1, endtime}];
tabBA11 = Table[{modABC[[i, 1]],
     (pBA2 Exp[sBA2 t] + pBA11 Exp[sBA11 t]) / ((1 - pBA11 - pBA2) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t]) * Exp[modABC[[i, 2]]] /.
       t -> modABC[[i, 1]] /. BCML}, {i, 1, endtime}];
tabBA2 = Table[{modABC[[i, 1]],
     (pBA2 Exp[sBA2 t]) / ((1 - pBA11 - pBA2) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t]) * Exp[modABC[[i, 2]]] /.
       t -> modABC[[i, 1]] /. BCML}, {i, 1, endtime}];
tabBA4 = Table[{modABC[[i, 1]], (pBA4 Exp[sBA4 t]) / ((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
        Exp[modABC[[i, 2]]] /. t -> modABC[[i, 1]] - curdate["2022-03-31"] /.
      BCML}, {i, curdate["2022-04-1"], endtime}];
tabBA5 = Table[{modABC[[i, 1]], (pBA5 Exp[sBA5 t] + pBA4 Exp[sBA4 t]) / ((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
        Exp[modABC[[i, 2]]] /. t -> modABC[[i, 1]] - curdate["2022-03-31"] /.
      BCML}, {i, curdate["2022-04-1"], endtime}];

Show[
 ListLinePlot[Table[{modABC[[i, 1]], Exp[modABC[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabBC[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA4, tabBA5}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
      Filling → {1 → {2}, 2 → {3}, 3 → Axis, 4 → Axis, 5 → {4}}],
 Graphics[Text["BC", {5, 0.95 graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[•]=



From duotang/VirusSeq (see code above): mutantNames = list("BA.1.1*", "BA.2*", "BA.4/5*", "BA.1*")

In[•]:=
```
BCML1
```

Out[•]=
```
{0.0624297, 0.929763, 0.00250914, 0.0336897, 0.0956255, 0.177919}
```

In[•]:=
```
dataname = BCML1;
refdate = "2022-04-15"; (* t=0 date used in duotang code above *)
BCML = {pBA11 → dataname[[1]], pBA2 → dataname[[2]], pBA45 → dataname[[3]],
   sBA11 → dataname[[4]], sBA2 → dataname[[5]], sBA45 → dataname[[6]]}
```

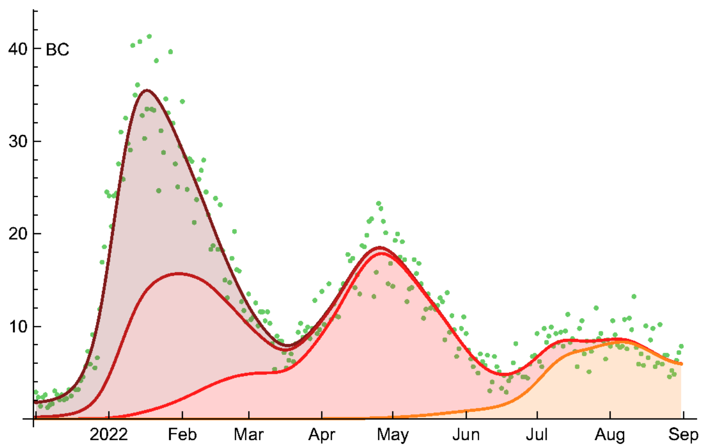
Out[•]=
```
{pBA11 → 0.0624297, pBA2 → 0.929763, pBA45 → 0.00250914,
 sBA11 → 0.0336897, sBA2 → 0.0956255, sBA45 → 0.177919}
```

In[•]:=
```
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modABC[[i, 1]],
    1 * Exp[modABC[[i, 2]]] /. t -> modABC[[i, 1]] /. BCML}, {i, 1, endtime}];
tabBA11 = Table[{modABC[[i, 1]],
    (pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modABC[[i, 2]]] /.
     t -> modABC[[i, 1]] - curdate[refdate] /. BCML}, {i, 1, endtime}];
tabBA2 = Table[{modABC[[i, 1]],
    (pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modABC[[i, 2]]] /.
     t -> modABC[[i, 1]] - curdate[refdate] /. BCML}, {i, 1, endtime}];
tabBA45 = Table[{modABC[[i, 1]],
    (pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modABC[[i, 2]]] /.
     t -> modABC[[i, 1]] - curdate[refdate] /. BCML}, {i, 1, endtime}];

Show[
 ListLinePlot[Table[{modABC[[i, 1]], Exp[modABC[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabBC[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
     Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis}],
 Graphics[Text["BC", {5, 0.95 graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[∘]=



From duotang/VirusSeq (see code above): mutantNames = list("XBB.1.5*", "XBB.Other*", "BQ*", "BA.5*")

In[∘]:=
```
BCML2
```

Out[∘]=
```
{0.0851925, 0.00551595, 0.681708, 0.0750288, 0.0931096, 0.028919}
```

In[∘]:=
```
dataname = BCML2;
refdate = "2023-01-14"; (* t=0 date used in duotang code above *)
BCML = {pXBB15 → dataname[[1]], pXBBO → dataname[[2]], pBQ → dataname[[3]],
  sXBB15 → dataname[[4]], sXBBO → dataname[[5]], sBQ → dataname[[6]]}
```

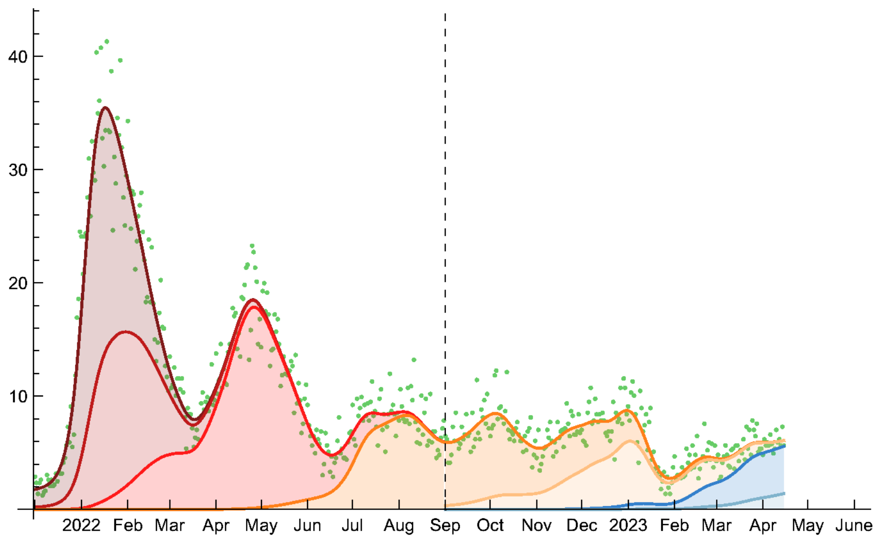
Out[∘]=
```
{pXBB15 → 0.0851925, pXBBO → 0.00551595, pBQ → 0.681708,
 sXBB15 → 0.0750288, sXBBO → 0.0931096, sBQ → 0.028919}
```

```
In[•]:= starttime = Position[dates, "2022-09-01"][[1, 1]];
endtime = Length[dates];

tabBA5 = Table[{modABC[[i, 1]], 1 * Exp[modABC[[i, 2]]] /. t -> modABC[[i, 1]] /. BCML},
   {i, starttime, endtime}];
tabBQ = Table[{modABC[[i, 1]],
     (pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
     ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
       Exp[modABC[[i, 2]]] /.
      t -> modABC[[i, 1]] - curdate[refdate] /. BCML}, {i, starttime, endtime}];
tabXBB15 = Table[{modABC[[i, 1]],
     (pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
     ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
       Exp[modABC[[i, 2]]] /.
      t -> modABC[[i, 1]] - curdate[refdate] /. BCML}, {i, starttime, endtime}];
tabXBBO = Table[{modABC[[i, 1]],
     (pXBBO Exp[sXBBO t]) /
     ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
       Exp[modABC[[i, 2]]] /.
      t -> modABC[[i, 1]] - curdate[refdate] /. BCML}, {i, starttime, endtime}];

Show[
 ListLinePlot[Table[{modABC[[i, 1]], Exp[modABC[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabBC[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45, tabBA5, tabBQ, tabXBB15, tabXBBO},
  PlotStyle → {colourBA1, colourBA11, colourBA2, colourBA45,
    colourBA45, colourBQ, colourXBB15, colourXBBO}, PlotRange → All,
      Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis,
    5 → {6}, 6 → {7}, 7 → {8}, 8 → Axis}],
 (*Graphics[Text["BC",{5,48},{-1,0}]],*)
 ListPlot[{{starttime, 0}, {starttime, 100}},
  Joined → True, PlotStyle → {Black, Thickness[0.002], Dashed}],
 PlotRange → {{1, curdate["2023-06-01"]}, {0, graphheight}},
 Ticks → {xaxis, Automatic},
 AspectRatio → 0.6,
 ImageSize → 450
]
```

Out[∘]=



QC - 70+ case counts and genomic frequencies (Dec 2021-May 2023)

https://www.inspq.qc.ca/covid-19/donnees/age-sexe/evolution-cas (1.1c - Carte thermique -> three dots -> “Télécharger les données en format CSV”.)

Processing QC Case Data [ENTER this or the next folder - uploading & processing data]

In[∘]:=
```
SetDirectory["/Users/otto/Dropbox/COVID19/BC_Data/CorrectingCaseCounts"];
```

In[∘]:=
```
SetDirectory["/Users/otto/Downloads"];
```

In[∘]:=
```
startafter = "2021-11-30";
```

The two periods we’ll consider:

In[∘]:=
```
mystartdate1 = "2021-12-01";
myenddate1 = "2022-08-31";
mystartdate2 = "2022-09-01";
myenddate2 = "2023-05-31";
```

In[∘]:=
```
curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

```
xaxis = {{curdate["2021-10-01"], "Oct"},
   {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
   {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
   {curdate["2022-03-01"], "Mar"}, {curdate["2022-04-01"], "Apr"},
   {curdate["2022-05-01"], "May"}, {curdate["2022-06-01"], "Jun"},
   {curdate["2022-07-01"], "Jul"}, {curdate["2022-08-01"], "Aug"},
   {curdate["2022-09-01"], "Sep"}, {curdate["2022-10-01"], "Oct"},
   {curdate["2022-11-01"], "Nov"}, {curdate["2022-12-01"], "Dec"},
   {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
   {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
   {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

Uploading the data (see below to avoid this step):

```
In[•]:= temp0 = Import["graph_1-1.c_page_age_et_sexe_evol_des_cas22Sep2023.csv"];
temp0[[1]]
temp = Drop[temp0, 1];
counts = Table[{DateString[
     DateObject[temp[[i, 1]], DateFormat → {"Year", "-", "Month", "-", "Day"}]],
    temp[[i, 2]], temp[[i, 3]]}, {i, 1, Length[temp]}];
Clear[temp0, temp]

Out[•]= {"Date de résultat du test", y (y), y (value), Annotations 1}

In[•]:= counts = Sort[counts];

In[•]:= Last[Position[counts, startafter]][[1]]

Out[•]= 6780

In[•]:= counts = counts[[% + 1 ;; Length[counts]]];

In[•]:= counts[[1 ;; 10]]

Out[•]= {{2021-12-01, 0-9 ans, 366}, {2021-12-01, 10-19 ans, 224},
  {2021-12-01, 20-29 ans, 109}, {2021-12-01, 30-39 ans, 199},
  {2021-12-01, 40-49 ans, 162}, {2021-12-01, 50-59 ans, 101},
  {2021-12-01, 60-69 ans, 66}, {2021-12-01, 70-79 ans, 48},
  {2021-12-01, 80-89 ans, 13}, {2021-12-01, 90 ans et plus, 2}}
```

Trim off data from Quebec after end date (this data stream keeps going):

```
In[•]:= Last[Position[counts, myenddate2]][[1]]

Out[•]= 5470

In[•]:= counts = counts[[1 ;; %]];

In[•]:= dates = DeleteDuplicates[counts[[All, 1]]]

Out[•]= {2021-12-01, 2021-12-02, 2021-12-03, 2021-12-04, 2021-12-05, 2021-12-06, 2021-12-07,
  2021-12-08, 2021-12-09, 2021-12-10, 2021-12-11, 2021-12-12, 2021-12-13, 2021-12-14,
  2021-12-15, 2021-12-16, 2021-12-17, 2021-12-18, 2021-12-19, 2021-12-20, 2021-12-21,
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2023-05-26, 2023-05-27, 2023-05-28, 2023-05-29, 2023-05-30, 2023-05-31}
```

To adjust to the population size of the province:

```
In[∘]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "QC"][[1, 1]]]]
Out[∘]= {QC, 8 695 659, 1 250 508}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[∘]:= per100000Y = 100 000 / (popsize[[2]] - popsize[[3]])
        per100000A = 100 000 / popsize[[3]]
Out[∘]= 100 000 / 7 445 151
Out[∘]= 25 000 / 312 627
```

```
In[∘]:= Clear[datetabQC];
        datetabQC[i_] = {0, 0};
        For[i = 1, i ≤ Length[counts], i++,
         date = Position[dates, counts[[i, 1]]][[1, 1]];
         If[((counts[[i, 2]] == "70-79 ans") ||
             (counts[[i, 2]] == "80-89 ans") || (counts[[i, 2]] == "90 ans et plus")),
          datetabQC[date] = datetabQC[date] + {0, per100000A * counts[[i, 3]]},
          datetabQC[date] = datetabQC[date] + {per100000Y * counts[[i, 3]], 0}
         ]
        ]
```

Processing QC Case Data [ENTER this or the previous folder - pre-processed data]

```
In[∘]:= startafter = "2021-11-30";
```

The two periods we’ll consider:

```
In[∘]:= mystartdate1 = "2021-12-01";
        myenddate1 = "2022-08-31";
        mystartdate2 = "2022-09-01";
        myenddate2 = "2023-05-31";
```

```
In[∘]:= curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

```
In[•]:= xaxis = {{curdate["2021-10-01"], "Oct"},
    {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
    {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
    {curdate["2022-03-01"], "Mar"}, {curdate["2022-04-01"], "Apr"},
    {curdate["2022-05-01"], "May"}, {curdate["2022-06-01"], "Jun"},
    {curdate["2022-07-01"], "Jul"}, {curdate["2022-08-01"], "Aug"},
    {curdate["2022-09-01"], "Sep"}, {curdate["2022-10-01"], "Oct"},
    {curdate["2022-11-01"], "Nov"}, {curdate["2022-12-01"], "Dec"},
    {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
    {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
    {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

To adjust to the population size of the province:

```
In[•]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "QC"][[1, 1]]]]
Out[•]= {QC, 8695659, 1250508}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[•]:= per100000Y = 100000 / (popsize[[2]] - popsize[[3]])
        per100000A = 100000 / popsize[[3]]
```

Out[•]= $\frac{100000}{7445151}$

Out[•]= $\frac{25000}{312627}$

```
In[•]:= tabdates = {"2021-12-01", "2021-12-02", "2021-12-03",
    "2021-12-04", "2021-12-05", "2021-12-06", "2021-12-07",
    "2021-12-08", "2021-12-09", "2021-12-10", "2021-12-11", "2021-12-12",
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    "2022-02-11", "2022-02-12", "2022-02-13", "2022-02-14", "2022-02-15",
    "2022-02-16", "2022-02-17", "2022-02-18", "2022-02-19", "2022-02-20",
    "2022-02-21", "2022-02-22", "2022-02-23", "2022-02-24", "2022-02-25",
```

```
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Overall Analysis by 70+

Cubic Spline fit (https://mathematica.stackexchange.com/questions/33206/implementation-of-smoothing-splines-function)

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    Dsq = Differences[X, 2];
    a = LinearSolve[Transpose[X].X + lambda * Transpose[Dsq].Dsq,
      Transpose[X].data, Method → "Multifrontal"];
    Return[
     X.
      a]];
```
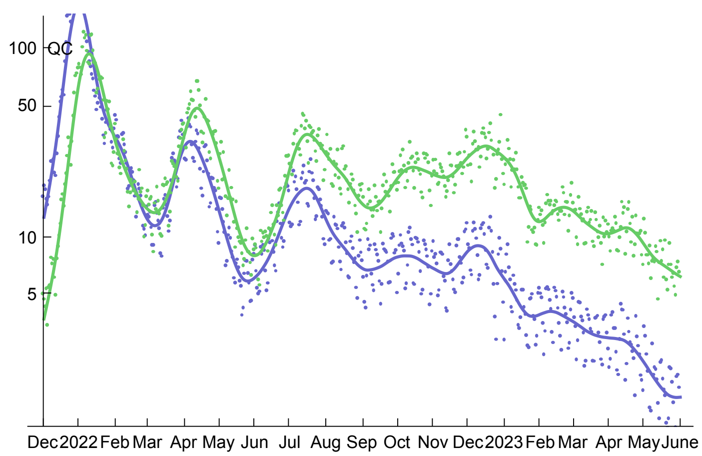

Cubic spline fit to all dates (Y is younger, A is 70+), using lambda = 3 to provide a good fit but not overfit to the data:

```
In[∘]:= modYQC = CubicSplSmooth[Table[{i, Log[Max[1, datetabQC[i][[1]]]]},
      {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
    modAQC = CubicSplSmooth[Table[{i, Log[Max[1, datetabQC[i][[2]]]]},
      {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
```

In[∘]:=
```
plotQC = Show[
  ListPlot[Table[{i, Log[datetabQC[i][[1]]]}, {i, 1, Length[dates]}],
   PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.4, 0.8]}],
  ListLinePlot[modYQC, PlotStyle → RGBColor[0.4, 0.4, 0.8], PlotRange → All],
  ListLinePlot[modAQC, PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
  ListPlot[Table[{i, Log[datetabQC[i][[2]]]}, {i, 1, Length[dates]}],
   PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
  Graphics[Text["QC", {5, 4.6}, {-1, 0}]],
  PlotRange → {Automatic, {0, 5}}, AxesOrigin → {1, 0},
  Ticks → {xaxis, {{Log[5], "5"}, {Log[10], "10"}, {Log[50], "50"}, {Log[100], "100"},
     {Log[500], "500"}, {Log[1000], "1000"}, {Log[5000], "5000"}}}
 ]
```

Out[∘]=

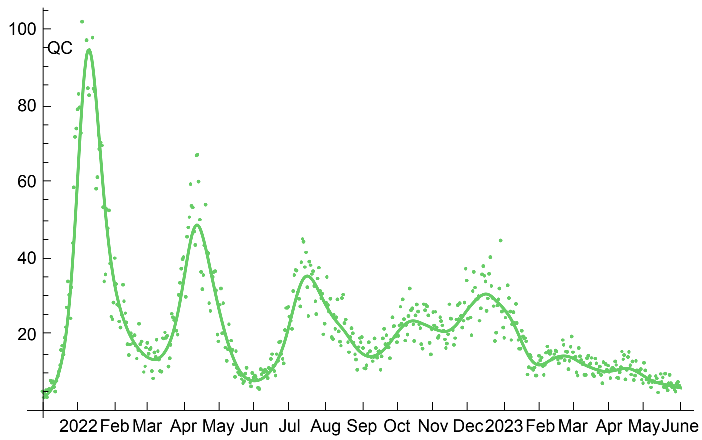


The above illustrates the major drop off in reported cases among those <70:

70+ on a non-log plot

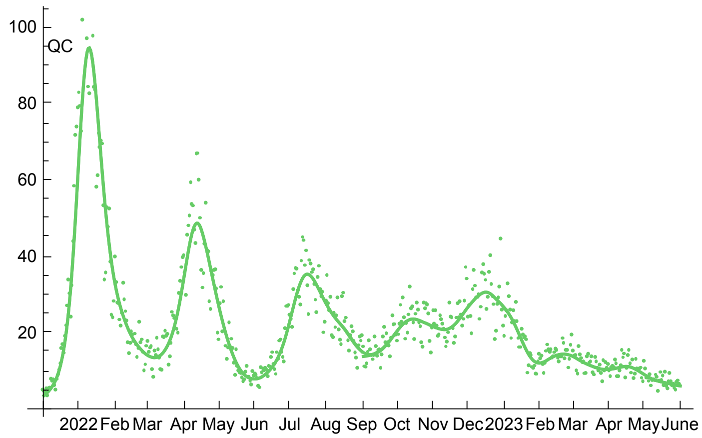
In[◦]:=
```
Show[
 ListLinePlot[Table[{modAQC[[i, 1]], Exp[modAQC[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabQC[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["QC", {5, 95}, {-1, 0}]],
 PlotRange → {Automatic, {0, 100}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

Out[◦]=



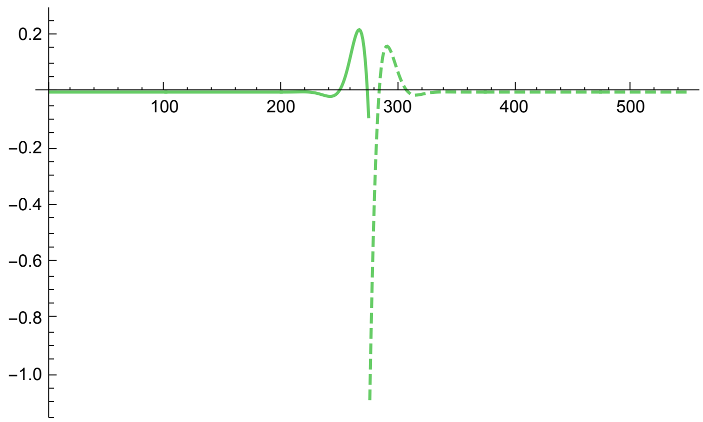
In[◦]:=
```
modAQC1 = CubicSplSmooth[Table[{i, Log[Max[1, datetabQC[i][[2]]]]},
    {i, 1, Position[dates, myenddate1][[1, 1]]}], 10^lambda /. lambda → 3];
modAQC2 = CubicSplSmooth[Table[{i, Log[Max[1, datetabQC[i][[2]]]]},
    {i, Position[dates, mystartdate2][[1, 1]], Length[dates]}],
   10^lambda /. lambda → 3];
```

In[•]:=
```
Show[
 ListLinePlot[Table[{modAQC[[i, 1]], Exp[modAQC[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAQC1[[i, 1]], Exp[modAQC1[[i, 2]]]},
   {i, 1, Length[modAQC1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAQC2[[i, 1]], Exp[modAQC2[[i, 2]]]},
   {i, 1, Length[modAQC2]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabQC[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["QC", {5, 95}, {-1, 0}]],
 PlotRange → {Automatic, {0, 100}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

Out[•]=


The fit is very similar, with a slight discrepancy in numbers at the joint, so we just use the overall spline fit for the analysis:

In[∘]:=
```
Show[
 ListLinePlot[Table[{modAQC1[[i, 1]], Exp[modAQC1[[i, 2]]] - Exp[modAQC[[i, 2]]]},
   {i, 1, Length[modAQC1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAQC2[[i, 1]], Exp[modAQC2[[i, 2]]] - Exp[modAQC[[
      i + Position[dates, myenddate1][[1, 1]], 2]]]}, {i, 1, Length[modAQC2]}],
  PlotStyle → {Dashed, RGBColor[0.4, 0.8, 0.4]}, PlotRange → All],
 PlotRange → All
]
```

Out[∘]=


Merging with Omicron subvariant frequencies

In[∘]:=
```
graphheight = 120;
```

In[∘]:=
```
colourBA1 = RGBColor[0.5, 0.1, 0.1];
colourBA11 = RGBColor[0.75, 0.1, 0.1];
colourBA2 = RGBColor[1, 0.1, 0.1];
colourBA5 = RGBColor[1, 0.5, 0.1];
colourBA45 = colourBA5;
colourBA4 = colourBA5;
colourBQ = RGBColor[1, 0.75, 0.5];
colourXBB15 = RGBColor[0.2, 0.5, 0.8];
colourXBBO = RGBColor[0.5, 0.7, 0.8];

{colourBA1, colourBA11, colourBA2, colourBA45, colourBQ, colourXBB15, colourXBBO}
```

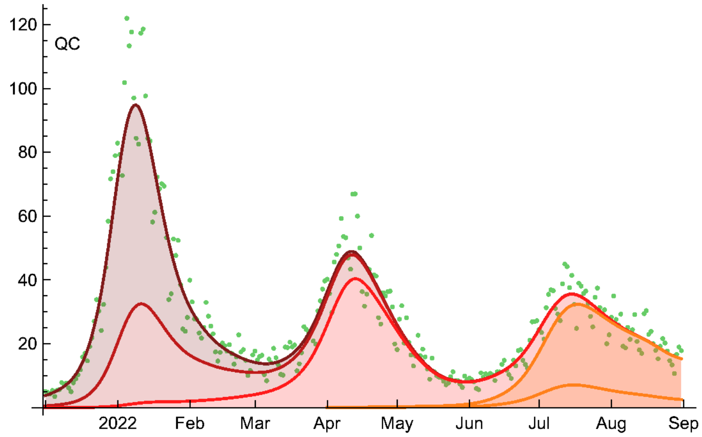
Out[∘]=


From Omicron_VariantsGISAID.nb (selection on BA.1, BA.1.1 and BA.2 calculated from 16 May analysis; selection on BA.4&BA.5 from 24 June analysis where the initial frequency is for “2022-04-1” at t=1):

In[∘]:=
```
QCML = {pBA11 → 0.1299249754084715`, pBA2 → 0.000681917154561101`,
   sBA11 → 0.029470405369802218`, sBA2 → 0.0814267906019519`,
   pBA4 → 0.00023463957846716374`, pBA5 → 0.00036479142777358456`,
   sBA4 → 0.0853074671375297`, sBA5 → 0.09303958537855452`};
```

```
In[∘]:= endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modAQC[[i, 1]],
    1 * Exp[modAQC[[i, 2]]] /. t -> modAQC[[i, 1]] /. QCML}, {i, 1, endtime}];
tabBA11 = Table[{modAQC[[i, 1]],
    (pBA2 Exp[sBA2 t] + pBA11 Exp[sBA11 t]) / ((1 - pBA11 - pBA2) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t]) * Exp[modAQC[[i, 2]]] /.
      t -> modAQC[[i, 1]] /. QCML}, {i, 1, endtime}];
tabBA2 = Table[{modAQC[[i, 1]],
    (pBA2 Exp[sBA2 t]) / ((1 - pBA11 - pBA2) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t]) * Exp[modAQC[[i, 2]]] /.
      t -> modAQC[[i, 1]] /. QCML}, {i, 1, endtime}];
tabBA4 = Table[{modAQC[[i, 1]], (pBA4 Exp[sBA4 t]) / ((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
       Exp[modAQC[[i, 2]]] /. t -> modAQC[[i, 1]] - curdate["2022-03-31"] /.
     QCML}, {i, curdate["2022-04-1"], endtime}];
tabBA5 = Table[{modAQC[[i, 1]], (pBA5 Exp[sBA5 t] + pBA4 Exp[sBA4 t]) / ((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
       Exp[modAQC[[i, 2]]] /. t -> modAQC[[i, 1]] - curdate["2022-03-31"] /.
     QCML}, {i, curdate["2022-04-1"], endtime}];

Show[
 ListLinePlot[Table[{modAQC[[i, 1]], Exp[modAQC[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabQC[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA4, tabBA5}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
     Filling → {1 → {2}, 2 → {3}, 3 → Axis, 4 → Axis, 5 → {4}}],
 Graphics[Text["QC", {5, 0.95 graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[∘]=



From duotang/VirusSeq (see code above): mutantNames = list(“BA.1.1*”, “BA.2*”, “BA.4/5*”, “BA.1*”)

In[∘]:=
```
QCML1
```

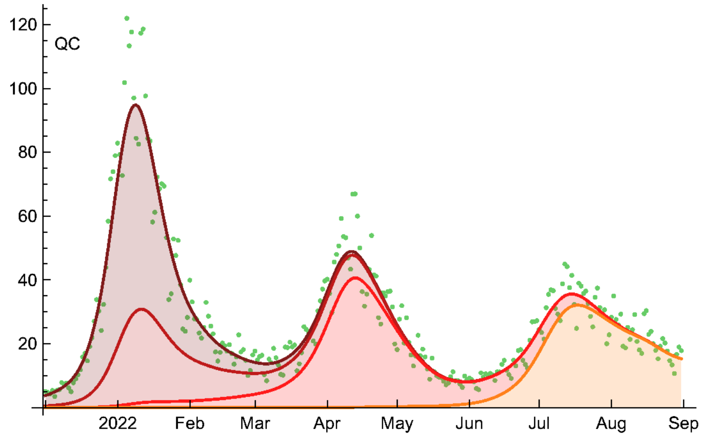
Out[∘]=
```
{0.130482, 0.848161, 0.00250028, 0.0285217, 0.0800771, 0.167335}
```

In[∘]:=
```
dataname = QCML1;
refdate = "2022-04-15"; (* t=0 date used in duotang code above *)
QCML = {pBA11 → dataname[[1]], pBA2 → dataname[[2]], pBA45 → dataname[[3]],
  sBA11 → dataname[[4]], sBA2 → dataname[[5]], sBA45 → dataname[[6]]}
```

Out[∘]=
```
{pBA11 → 0.130482, pBA2 → 0.848161, pBA45 → 0.00250028,
 sBA11 → 0.0285217, sBA2 → 0.0800771, sBA45 → 0.167335}
```

In[∘]:=
```
endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modAQC[[i, 1]],
    1 * Exp[modAQC[[i, 2]]] /. t -> modAQC[[i, 1]] /. QCML}, {i, 1, endtime}];
tabBA11 = Table[{modAQC[[i, 1]],
    (pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAQC[[i, 2]]] /.
     t -> modAQC[[i, 1]] - curdate[refdate] /. QCML}, {i, 1, endtime}];
tabBA2 = Table[{modAQC[[i, 1]],
    (pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAQC[[i, 2]]] /.
     t -> modAQC[[i, 1]] - curdate[refdate] /. QCML}, {i, 1, endtime}];
tabBA45 = Table[{modAQC[[i, 1]],
    (pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAQC[[i, 2]]] /.
     t -> modAQC[[i, 1]] - curdate[refdate] /. QCML}, {i, 1, endtime}];

Show[
 ListLinePlot[Table[{modAQC[[i, 1]], Exp[modAQC[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabQC[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
      Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis}],
 Graphics[Text["QC", {5, 0.95 graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[∘]=



From duotang/VirusSeq (see code above): mutantNames = list(“XBB.1.5*”, “XBB.Other*”, “BQ*”, “BA.5*”)

In[∘]:=
```
QCML2
```

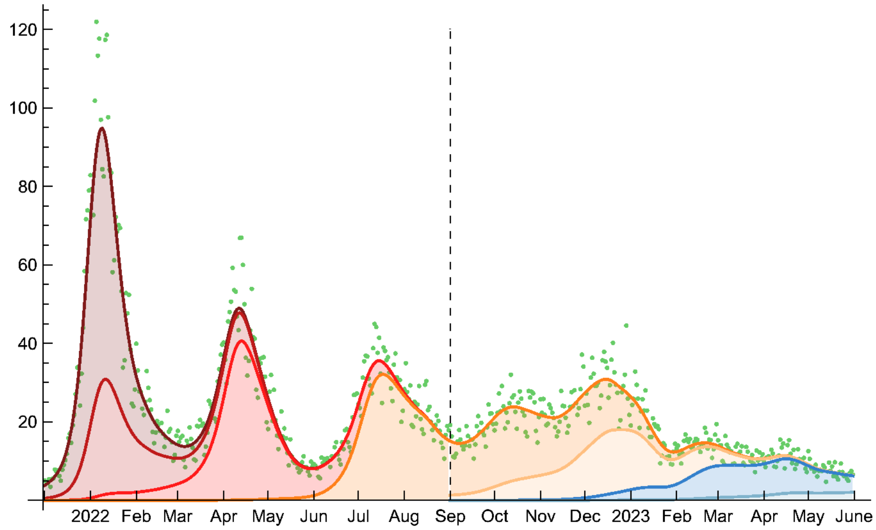
Out[∘]=
```
{0.170115, 0.00588832, 0.579925, 0.0636735, 0.0828669, 0.0237981}
```

In[∘]:=
```
dataname = QCML2;
refdate = "2023-01-14"; (* t=0 date used in duotang code above *)
QCML = {pXBB15 → dataname[[1]], pXBBO → dataname[[2]], pBQ → dataname[[3]],
   sXBB15 → dataname[[4]], sXBBO → dataname[[5]], sBQ → dataname[[6]]}
```

Out[∘]=
```
{pXBB15 → 0.170115, pXBBO → 0.00588832, pBQ → 0.579925,
 sXBB15 → 0.0636735, sXBBO → 0.0828669, sBQ → 0.0237981}
```

In[∘]:=
```
starttime = Position[dates, "2022-09-01"][[1, 1]];
endtime = Length[dates];

tabBA5 = Table[{modAQC[[i, 1]], 1 * Exp[modAQC[[i, 2]]] /. t -> modAQC[[i, 1]] /. QCML},
   {i, starttime, endtime}];
tabBQ = Table[{modAQC[[i, 1]],
     (pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
     ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
       Exp[modAQC[[i, 2]]] /.
      t -> modAQC[[i, 1]] - curdate[refdate] /. QCML}, {i, starttime, endtime}];
tabXBB15 = Table[{modAQC[[i, 1]],
     (pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
     ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
       Exp[modAQC[[i, 2]]] /.
      t -> modAQC[[i, 1]] - curdate[refdate] /. QCML}, {i, starttime, endtime}];
tabXBBO = Table[{modAQC[[i, 1]],
     (pXBBO Exp[sXBBO t]) /
     ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
       Exp[modAQC[[i, 2]]] /.
      t -> modAQC[[i, 1]] - curdate[refdate] /. QCML}, {i, starttime, endtime}];

Show[
 ListLinePlot[Table[{modAQC[[i, 1]], Exp[modAQC[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabQC[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45, tabBA5, tabBQ, tabXBB15, tabXBBO},
  PlotStyle → {colourBA1, colourBA11, colourBA2, colourBA45,
    colourBA45, colourBQ, colourXBB15, colourXBBO}, PlotRange → All,
      Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis,
    5 → {6}, 6 → {7}, 7 → {8}, 8 → Axis}],
 (*Graphics[Text["QC",{5,95},{-1,0}]],*)
 ListPlot[{{starttime, 0}, {starttime, 120}},
  Joined → True, PlotStyle → {Black, Thickness[0.002], Dashed}],
 PlotRange → {{1, curdate["2023-06-01"]}, {0, graphheight}},
 Ticks → {xaxis, Automatic},
 AspectRatio → 0.6,
 ImageSize → 450
]
```

Out[∘]=



ON - 70+ case counts and genomic frequencies (Dec 2021-May 2023)

Using “Accurate_Episode_Date” and correcting recent dates from the dashboard for ON-wide:

https://data.ontario.ca/dataset/confirmed-positive-cases-of-covid-19-in-ontario/resource/455fd63b-603d-4608-8216-7d8647f43350

Processing ON Case Data [ENTER this or the next folder - uploading & processing data]

In[∘]:=
```
SetDirectory["/Users/otto/Dropbox/COVID19/BC_Data/CorrectingCaseCounts"];
```

In[∘]:=
```
SetDirectory["/Users/otto/Downloads"];
```

In[∘]:=
```
startafter = "2021-11-30";
```

The two periods we’ll consider:

In[∘]:=
```
mystartdate1 = "2021-12-01";
myenddate1 = "2022-08-31";
mystartdate2 = "2022-09-01";
myenddate2 = "2023-05-31";
```

In[∘]:=
```
curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

In[◦]:=
```
xaxis = {{curdate["2021-10-01"], "Oct"},
   {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
   {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
   {curdate["2022-03-01"], "Mar"}, {curdate["2022-04-01"], "Apr"},
   {curdate["2022-05-01"], "May"}, {curdate["2022-06-01"], "Jun"},
   {curdate["2022-07-01"], "Jul"}, {curdate["2022-08-01"], "Aug"},
   {curdate["2022-09-01"], "Sep"}, {curdate["2022-10-01"], "Oct"},
   {curdate["2022-11-01"], "Nov"}, {curdate["2022-12-01"], "Dec"},
   {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
   {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
   {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

Uploading the data (see below to avoid this step):

In[◦]:=
```
temp0 = Import["conposcovidloc16Jun2023.csv"];
temp0[[1]]
Drop[temp0, 1];
temp = %[[588000 ;; Length[%]]]; (*Limiting data to last three months*)
counts = Transpose[{temp[[All, 2]], temp[[All, 12]], temp[[All, 6]]}];
Clear[temp0, temp]
```

Out[◦]=
```
{Row_ID, Accurate_Episode_Date, Case_Reported_Date, Test_Reported_Date,
 Specimen_Date, Age_Group, Client_Gender, Outcome1, Reporting_PHU_ID, Reporting_PHU,
 Reporting_PHU_Address, Reporting_PHU_City, Reporting_PHU_Postal_Code,
 Reporting_PHU_Website, Reporting_PHU_Latitude, Reporting_PHU_Longitude}
```

In[◦]:=
```
Last[Position[counts, startafter]][[1]]
```

Out[◦]= 35826

In[◦]:=
```
counts = counts[[% + 1 ;; Length[counts]]];
```

In[◦]:=
```
dates = DeleteDuplicates[counts[[All, 1]]]
```

Out[◦]=
```
{2021-12-01, 2021-12-02, 2021-12-03, 2021-12-04, 2021-12-05, 2021-12-06, 2021-12-07,
 2021-12-08, 2021-12-09, 2021-12-10, 2021-12-11, 2021-12-12, 2021-12-13, 2021-12-14,
 2021-12-15, 2021-12-16, 2021-12-17, 2021-12-18, 2021-12-19, 2021-12-20,
 2021-12-21, 2021-12-22, 2021-12-23, 2021-12-24, 2021-12-25, 2021-12-26,
 2021-12-27, 2021-12-28, 2021-12-29, 2021-12-30, 2021-12-31, 2022-01-01,
 2022-01-02, 2022-01-03, 2022-01-04, 2022-01-05, 2022-01-06, 2022-01-07,
 2022-01-08, 2022-01-09, 2022-01-10, 2022-01-11, 2022-01-12, 2022-01-13,
 2022-01-14, 2022-01-15, 2022-01-16, 2022-01-17, 2022-01-18, 2022-01-19,
 2022-01-20, 2022-01-21, 2022-01-22, 2022-01-23, 2022-01-24, 2022-01-25,
 2022-01-26, 2022-01-27, 2022-01-28, 2022-01-29, 2022-01-30, 2022-01-31,
 2022-02-01, 2022-02-02, 2022-02-03, 2022-02-04, 2022-02-05, 2022-02-06,
 2022-02-07, 2022-02-08, 2022-02-09, 2022-02-10, 2022-02-11, 2022-02-12,
 2022-02-13, 2022-02-14, 2022-02-15, 2022-02-16, 2022-02-17, 2022-02-18,
 2022-02-19, 2022-02-20, 2022-02-21, 2022-02-22, 2022-02-23, 2022-02-24,
```

```
2022-02-25, 2022-02-26, 2022-02-27, 2022-02-28, 2022-03-01, 2022-03-02,
2022-03-03, 2022-03-04, 2022-03-05, 2022-03-06, 2022-03-07, 2022-03-08,
2022-03-09, 2022-03-10, 2022-03-11, 2022-03-12, 2022-03-13, 2022-03-14,
2022-03-15, 2022-03-16, 2022-03-17, 2022-03-18, 2022-03-19, 2022-03-20,
2022-03-21, 2022-03-22, 2022-03-23, 2022-03-24, 2022-03-25, 2022-03-26,
2022-03-27, 2022-03-28, 2022-03-29, 2022-03-30, 2022-03-31, 2022-04-01,
2022-04-02, 2022-04-03, 2022-04-04, 2022-04-05, 2022-04-06, 2022-04-07,
2022-04-08, 2022-04-09, 2022-04-10, 2022-04-11, 2022-04-12, 2022-04-13,
2022-04-14, 2022-04-15, 2022-04-16, 2022-04-17, 2022-04-18, 2022-04-19,
2022-04-20, 2022-04-21, 2022-04-22, 2022-04-23, 2022-04-24, 2022-04-25,
2022-04-26, 2022-04-27, 2022-04-28, 2022-04-29, 2022-04-30, 2022-05-01,
2022-05-02, 2022-05-03, 2022-05-04, 2022-05-05, 2022-05-06, 2022-05-07,
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```

Age list (UNKNOWN treated as <70):

```
In[]:= DeleteDuplicates[counts[[All, 3]]]
Out[]= {50s, <20, 20s, 30s, 40s, 60s, 70s, 80s, 90+, UNKNOWN}
```

Trim off data from Quebec after end date (this data stream keeps going until June 13, 2023):

```
In[]:= Last[Position[counts, myenddate2]][[1]]
Out[]= 998 564
```

```
In[•]:= counts = counts[[1 ;; %]];

In[•]:= dates = DeleteDuplicates[counts[[All, 1]]]

Out[•]= {2021-12-01, 2021-12-02, 2021-12-03, 2021-12-04, 2021-12-05, 2021-12-06, 2021-12-07,
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```

To adjust to the population size of the province:

```
In[]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "ON"][[1, 1]]]]
Out[]= {ON, 15 109 416, 1 918 812}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[]:= per100000Y = 100 000 / (popsize[[2]] - popsize[[3]])
       per100000A = 100 000 / popsize[[3]]
```

Out[]= $\frac{25\,000}{3\,297\,651}$

Out[]= $\frac{25\,000}{479\,703}$

```
In[]:= Clear[datetabON];
       datetabON[i_] = {0, 0};
       For[i = 1, i ≤ Length[counts], i++,
        date = Position[dates, counts[[i, 1]]][[1, 1]];
        If[
          ((counts[[i, 3]] == "70s") || (counts[[i, 3]] == "80s") || (counts[[i, 3]] == "90+")),
          datetabON[date] = datetabON[date] + {0, per100000A},
          datetabON[date] = datetabON[date] + {per100000Y, 0}
        ]
       ]
```

Processing ON Case Data [ENTER this or the previous folder - pre-processed data]

```
In[]:= startafter = "2021-11-30";
```

The two periods we’ll consider:

```
In[]:= mystartdate1 = "2021-12-01";
       myenddate1 = "2022-08-31";
       mystartdate2 = "2022-09-01";
       myenddate2 = "2023-05-31";

In[]:= curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

In[∘]:=
```
xaxis = {{curdate["2021-10-01"], "Oct"},
   {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
   {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
   {curdate["2022-03-01"], "Mar"}, {curdate["2022-04-01"], "Apr"},
   {curdate["2022-05-01"], "May"}, {curdate["2022-06-01"], "Jun"},
   {curdate["2022-07-01"], "Jul"}, {curdate["2022-08-01"], "Aug"},
   {curdate["2022-09-01"], "Sep"}, {curdate["2022-10-01"], "Oct"},
   {curdate["2022-11-01"], "Nov"}, {curdate["2022-12-01"], "Dec"},
   {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
   {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
   {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

To adjust to the population size of the province:

In[∘]:=
```
popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "ON"][[1, 1]]]]
```

Out[∘]=
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The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

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{0.85667039962688 6`, 5.941176102713554`}, {0.796021167794894`,
```

```
6.149638422107012`}, {0.811183475752892`, 6.514447481045564`},
{0.5837488563829223`, 7.035603279529209`}, {0.45486923873993945`,
 4.534055446807712`}, {0.5685865484249243`, 5.1073268251397215`},
{0.6974661660679071`, 5.836944943016825`}, {0.7277907819839031`,
 7.191950019074302`}, {0.5458430864879273`, 5.732713783320096`},
{0.6292357802569162`, 5.211557984836451`}, {0.5306807785299293`,
 5.367904724381544`}, {0.4700315466979374`, 5.159442404988086`},
{0.3790576989499495`, 5.263673564684815`}, {0.796021167794894`,
 6.8271409601357504`}, {0.7050473200469061`, 5.836944943016825`},
{0.5306807785299293`, 6.097522842258647`}, {0.6368169342359152`,
 4.8467489258978995`}, {0.5837488563829223`, 5.263673564684815`},
{0.2880838512019616`, 4.794633346049535`}, {0.3866388529289485`,
 3.908668488627338`}, {0.5003561626139333`, 4.794633346049535`},
{0.758115397899899`, 6.722909800439021`}, {0.6671415501519111`,
 7.244065598922667`}, {0.6443980882149142`, 5.1073268251397215`},
{0.5079373165929324`, 4.586171026656077`}, {0.34115192905495456`,
 3.3353971102953284`}, {0.28050269722296267`, 4.429824287110983`},
{0.7429530899419011`, 5.4721358840782734`}, {0.6368169342359152`,
 5.4721358840782734`}, {0.6216546262779172`, 5.367904724381544`}};
```

Enter the following to avoid upload:

```
In[]:= dates = tabdates;
```

```
In[]:= For[i = 1, i <= Length[dates], i++, datetabON[i] = tab[[i]]]
```

Overall Analysis by 70+

Cubic Spline fit (https://mathematica.stackexchange.com/questions/33206/implementation-of-smoothing-splines-function)

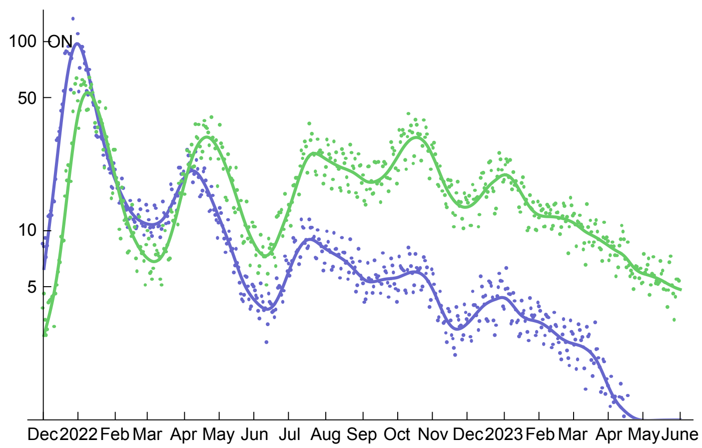
```
In[]:= CubicSplSmooth[data_, lambda_] := Module[{M, Knots, X, Dsq, a}, M = Length@data;
   Knots = Flatten@{1, 1, 1, Range@M, M, M, M};
   X = Table[Evaluate@N@BSplineBasis[{3, Knots}, n, t], {t, 1, M}, {n, 0, M + 1}];
   Dsq = Differences[X, 2];
   a = LinearSolve[Transpose[X].X + lambda * Transpose[Dsq].Dsq,
     Transpose[X].data, Method → "Multifrontal"];
   Return[
    X.
     a]];
```

Cubic spline fit to all dates (Y is younger, A is 70+), using lambda = 3 to provide a good fit but not overfit to the data:

```
In[∘]:= modYON = CubicSplSmooth[Table[{i, Log[Max[1, datetabON[i][[1]]]]},
            {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
        modAON = CubicSplSmooth[Table[{i, Log[Max[1, datetabON[i][[2]]]]},
            {i, 1, Length[dates]}], 10^lambda /. lambda → 3];

In[∘]:= plotON = Show[
          ListPlot[Table[{i, Log[datetabON[i][[1]]]}, {i, 1, Length[dates]}],
           PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.4, 0.8]}],
          ListLinePlot[modYON, PlotStyle → RGBColor[0.4, 0.4, 0.8], PlotRange → All],
          ListLinePlot[modAON, PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
          ListPlot[Table[{i, Log[datetabON[i][[2]]]}, {i, 1, Length[dates]}],
           PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
          Graphics[Text["ON", {5, 4.6}, {-1, 0}]],
          PlotRange → {Automatic, {0, 5}}, AxesOrigin → {1, 0},
          Ticks → {xaxis, {{Log[5], "5"}, {Log[10], "10"}, {Log[50], "50"}, {Log[100], "100"},
             {Log[500], "500"}, {Log[1000], "1000"}, {Log[5000], "5000"}}}
         ]
```

Out[∘]=

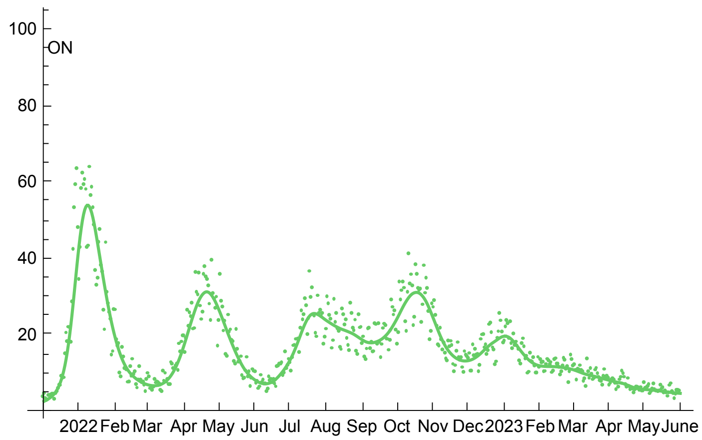


The above illustrates the major drop off in reported cases among those <70:

70+ on a non-log plot

In[∘]:=
```
Show[
 ListLinePlot[Table[{modAON[[i, 1]], Exp[modAON[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabON[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["ON", {5, 95}, {-1, 0}]],
 PlotRange → {Automatic, {0, 100}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

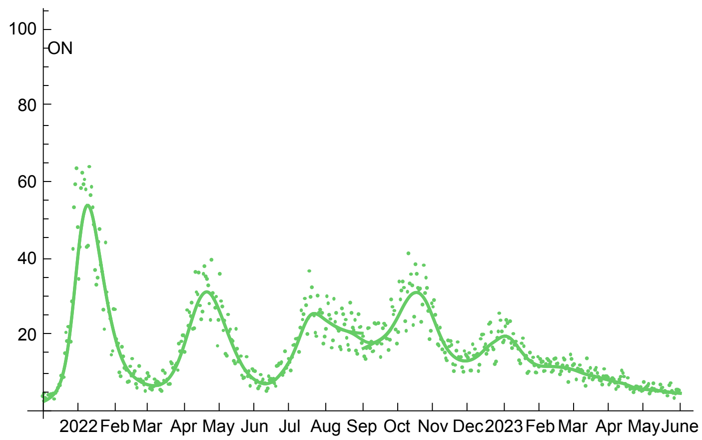
Out[∘]=



In[∘]:=
```
modAON1 = CubicSplSmooth[Table[{i, Log[Max[1, datetabON[i][[2]]]]},
    {i, 1, Position[dates, myenddate1][[1, 1]]}], 10^lambda /. lambda → 3];
modAON2 = CubicSplSmooth[Table[{i, Log[Max[1, datetabON[i][[2]]]]},
    {i, Position[dates, mystartdate2][[1, 1]], Length[dates]}],
   10^lambda /. lambda → 3];
```

In[•]:=
```
Show[
 ListLinePlot[Table[{modAON[[i, 1]], Exp[modAON[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAON1[[i, 1]], Exp[modAON1[[i, 2]]]},
   {i, 1, Length[modAON1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAON2[[i, 1]], Exp[modAON2[[i, 2]]]},
   {i, 1, Length[modAON2]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabON[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["ON", {5, 95}, {-1, 0}]],
 PlotRange → {Automatic, {0, 100}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

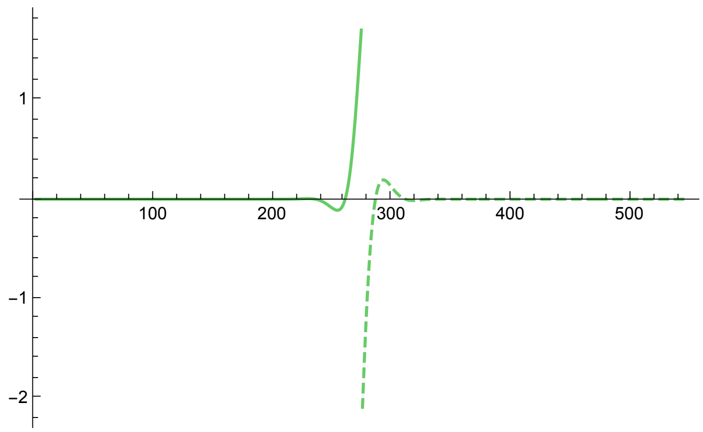
Out[•]=



The fit is very similar, with a slight discrepancy in numbers at the joint, so we just use the overall spline fit for the analysis:

In[∘]:=
```
Show[
 ListLinePlot[Table[{modAON1[[i, 1]], Exp[modAON1[[i, 2]]] - Exp[modAON[[i, 2]]]},
   {i, 1, Length[modAON1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAON2[[i, 1]], Exp[modAON2[[i, 2]]] - Exp[modAON[[
       i + Position[dates, myenddate1][[1, 1]], 2]]]}, {i, 1, Length[modAON2]}],
  PlotStyle → {Dashed, RGBColor[0.4, 0.8, 0.4]}, PlotRange → All],
 PlotRange → All
]
```

Out[∘]=



Merging with Omicron subvariant frequencies

In[∘]:=
```
graphheight = 63;
```

In[∘]:=
```
colourBA1 = RGBColor[0.5, 0.1, 0.1];
colourBA11 = RGBColor[0.75, 0.1, 0.1];
colourBA2 = RGBColor[1, 0.1, 0.1];
colourBA5 = RGBColor[1, 0.5, 0.1];
colourBA45 = colourBA5;
colourBA4 = colourBA5;
colourBQ = RGBColor[1, 0.75, 0.5];
colourXBB15 = RGBColor[0.2, 0.5, 0.8];
colourXBBO = RGBColor[0.5, 0.7, 0.8];

{colourBA1, colourBA11, colourBA2, colourBA45, colourBQ, colourXBB15, colourXBBO}
```

Out[∘]= {■, ■, ■, ■, ■, ■, ■}

From Omicron_VariantsGISAID.nb (selection on BA.1, BA.1.1 and BA.2 calculated from 16 May analysis; selection on BA.4&BA.5 from 24 June analysis where the initial frequency is for “2022-04-1” at t=1):

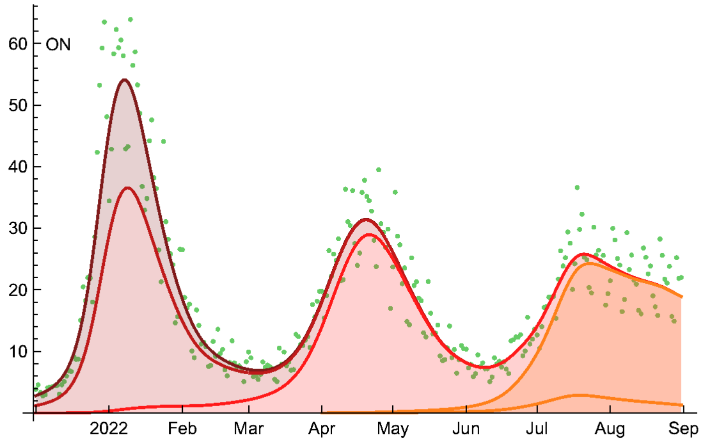
In[∘]:=
```
ONML = {pBA11 → 0.4179983246932652`, pBA2 → 0.0006274609768064037`,
   sBA11 → 0.026697737809944225`, sBA2 → 0.09026330895189581`,
   pBA4 → 0.0001836350901127891`, pBA5 → 0.0002664111940827573`,
   sBA4 → 0.08164738439327635`, sBA5 → 0.09622847239814021`};
```

In[◦]:=
```
endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modAON[[i, 1]],
    1 * Exp[modAON[[i, 2]]] /. t -> modAON[[i, 1]] /. ONML}, {i, 1, endtime}];
tabBA11 = Table[{modAON[[i, 1]],
    (pBA2 Exp[sBA2 t] + pBA11 Exp[sBA11 t])/((1 - pBA11 - pBA2) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t]) * Exp[modAON[[i, 2]]] /.
      t -> modAON[[i, 1]] /. ONML}, {i, 1, endtime}];
tabBA2 = Table[{modAON[[i, 1]],
    (pBA2 Exp[sBA2 t])/((1 - pBA11 - pBA2) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t]) * Exp[modAON[[i, 2]]] /.
      t -> modAON[[i, 1]] /. ONML}, {i, 1, endtime}];
tabBA4 = Table[{modAON[[i, 1]], (pBA4 Exp[sBA4 t])/((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
       Exp[modAON[[i, 2]]] /. t -> modAON[[i, 1]] - curdate["2022-03-31"] /.
     ONML}, {i, curdate["2022-04-1"], endtime}];
tabBA5 = Table[{modAON[[i, 1]], (pBA5 Exp[sBA5 t] + pBA4 Exp[sBA4 t])/((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
       Exp[modAON[[i, 2]]] /. t -> modAON[[i, 1]] - curdate["2022-03-31"] /.
     ONML}, {i, curdate["2022-04-1"], endtime}];

Show[
 ListLinePlot[Table[{modAON[[i, 1]], Exp[modAON[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabON[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA4, tabBA5}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
     Filling → {1 → {2}, 2 → {3}, 3 → Axis, 4 → Axis, 5 → {4}}],
 Graphics[Text["ON", {5, 0.95 * graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[•]=



From duotang/VirusSeq (see code above): mutantNames = list("BA.1.1*", "BA.2*", "BA.4/5*", "BA.1*")

In[•]:=
```
ONML1
```

Out[•]=
```
{0.118989, 0.872082, 0.00602749, 0.0370314, 0.0943605, 0.168613}
```

In[•]:=
```
dataname = ONML1;
refdate = "2022-04-15"; (* t=0 date used in duotang code above *)
ONML = {pBA11 → dataname[[1]], pBA2 → dataname[[2]], pBA45 → dataname[[3]],
   sBA11 → dataname[[4]], sBA2 → dataname[[5]], sBA45 → dataname[[6]]}
```

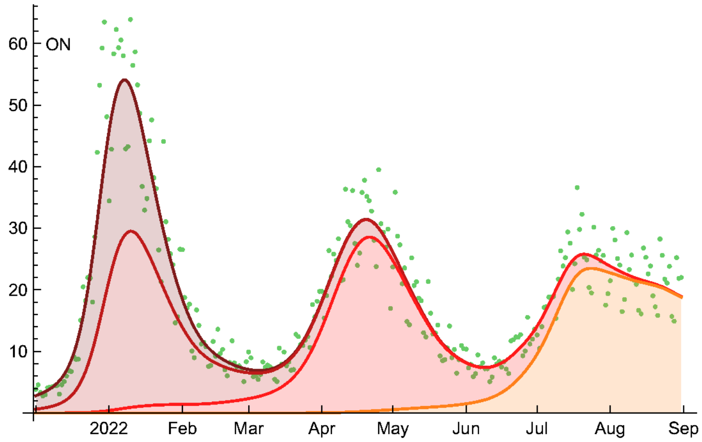
Out[•]=
```
{pBA11 → 0.118989, pBA2 → 0.872082, pBA45 → 0.00602749,
 sBA11 → 0.0370314, sBA2 → 0.0943605, sBA45 → 0.168613}
```

```
In[∘]:= endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modAON[[i, 1]],
    1 * Exp[modAON[[i, 2]]] /. t -> modAON[[i, 1]] /. ONML}, {i, 1, endtime}];
tabBA11 = Table[{modAON[[i, 1]],
    (pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAON[[i, 2]]] /.
     t -> modAON[[i, 1]] - curdate[refdate] /. ONML}, {i, 1, endtime}];
tabBA2 = Table[{modAON[[i, 1]],
    (pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAON[[i, 2]]] /.
     t -> modAON[[i, 1]] - curdate[refdate] /. ONML}, {i, 1, endtime}];
tabBA45 = Table[{modAON[[i, 1]],
    (pBA45 Exp[sBA45 t]) /
    ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAON[[i, 2]]] /.
     t -> modAON[[i, 1]] - curdate[refdate] /. ONML}, {i, 1, endtime}];

Show[
 ListLinePlot[Table[{modAON[[i, 1]], Exp[modAON[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabON[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
     Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis}],
 Graphics[Text["ON", {5, 0.95 graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[◦]=



From duotang/VirusSeq (see code above): mutantNames = list(“XBB.1.5*”, “XBB.Other*”, “BQ*”, “BA.5*”)

In[◦]:=
```
ONML2
```

Out[◦]=
```
{0.129499, 0.00762521, 0.634858, 0.0743729, 0.0914175, 0.0320328}
```

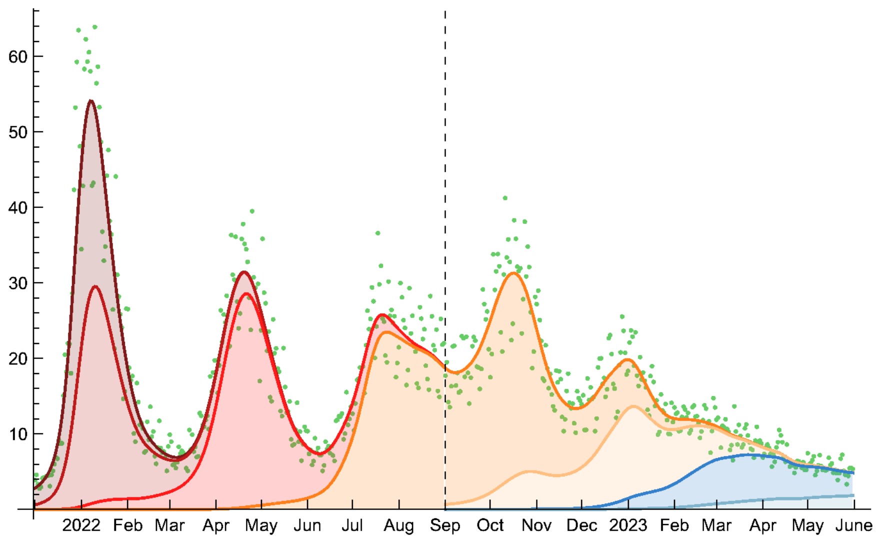
In[◦]:=
```
dataname = ONML2;
refdate = "2023-01-14"; (* t=0 date used in duotang code above *)
ONML = {pXBB15 → dataname[[1]], pXBBO → dataname[[2]], pBQ → dataname[[3]],
  sXBB15 → dataname[[4]], sXBBO → dataname[[5]], sBQ → dataname[[6]]}
```

Out[◦]=
```
{pXBB15 → 0.129499, pXBBO → 0.00762521, pBQ → 0.634858,
 sXBB15 → 0.0743729, sXBBO → 0.0914175, sBQ → 0.0320328}
```

```
In[•]:= starttime = Position[dates, "2022-09-01"][[1, 1]];
endtime = Length[dates];

tabBA5 = Table[{modAON[[i, 1]], 1 * Exp[modAON[[i, 2]]] /. t -> modAON[[i, 1]] /. ONML},
    {i, starttime, endtime}];
tabBQ = Table[{modAON[[i, 1]],
      (pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
      ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
        Exp[modAON[[i, 2]]] /.
      t -> modAON[[i, 1]] - curdate[refdate] /. ONML}, {i, starttime, endtime}];
tabXBB15 = Table[{modAON[[i, 1]],
      (pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
      ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
        Exp[modAON[[i, 2]]] /.
      t -> modAON[[i, 1]] - curdate[refdate] /. ONML}, {i, starttime, endtime}];
tabXBBO = Table[{modAON[[i, 1]],
      (pXBBO Exp[sXBBO t]) /
      ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
        Exp[modAON[[i, 2]]] /.
      t -> modAON[[i, 1]] - curdate[refdate] /. ONML}, {i, starttime, endtime}];

Show[
 ListLinePlot[Table[{modAON[[i, 1]], Exp[modAON[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabON[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45, tabBA5, tabBQ, tabXBB15, tabXBBO},
  PlotStyle → {colourBA1, colourBA11, colourBA2, colourBA45,
    colourBA45, colourBQ, colourXBB15, colourXBBO}, PlotRange → All,
      Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis,
    5 → {6}, 6 → {7}, 7 → {8}, 8 → Axis}],
 (*Graphics[Text["ON",{5,95},{-1,0}]],*)
 ListPlot[{{starttime, 0}, {starttime, 100}},
  Joined → True, PlotStyle → {Black, Thickness[0.002], Dashed}],
 PlotRange → {{1, curdate["2023-06-01"]}, {0, graphheight}},
 Ticks → {xaxis, Automatic},
 AspectRatio → 0.6,
 ImageSize → 450
]
```

Out[ ]=


AB - 70+ case counts and genomic frequencies (Dec 2021-May 2023)

https://www.alberta.ca/stats/covid-19-alberta-statistics.htm#data-export

Processing AB Case Data [ENTER this or the next folder - uploading & processing data]

In[ ]:=
```
SetDirectory["/Users/otto/Dropbox/COVID19/BC_Data/CorrectingCaseCounts"];
```

In[ ]:=
```
SetDirectory["/Users/otto/Downloads"];
```

In[ ]:=
```
startafter = "2021-11-30";
```

The two periods we’ll consider:

In[ ]:=
```
mystartdate1 = "2021-12-01";
myenddate1 = "2022-08-31";
mystartdate2 = "2022-09-01";
myenddate2 = "2023-05-31";
```

In[ ]:=
```
curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

```
xaxis = {{curdate["2021-10-01"], "Oct"},
   {curdate["2021-11-01"], "Nov"}, {curdate["2021-12-01"], "Dec"},
   {curdate["2022-01-01"], "2022"}, {curdate["2022-02-01"], "Feb"},
   {curdate["2022-03-01"], "Mar"}, {curdate["2022-04-01"], "Apr"},
   {curdate["2022-05-01"], "May"}, {curdate["2022-06-01"], "Jun"},
   {curdate["2022-07-01"], "Jul"}, {curdate["2022-08-01"], "Aug"},
   {curdate["2022-09-01"], "Sep"}, {curdate["2022-10-01"], "Oct"},
   {curdate["2022-11-01"], "Nov"}, {curdate["2022-12-01"], "Dec"},
   {curdate["2023-01-01"], "2023"}, {curdate["2023-02-01"], "Feb"},
   {curdate["2023-03-01"], "Mar"}, {curdate["2023-04-01"], "Apr"},
   {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

Uploading the data (see below to avoid this step):

```
In[∘]:= temp0 = Import["covid-19-alberta-statistics-data9June2023.csv"];
temp0[[1]]
temp = Drop[temp0, 1];
counts = Transpose[{temp[[All, 2]], temp[[All, 3]], temp[[All, 5]]}];
Clear[temp0, temp]

Out[∘]= {, Date reported, Alberta Health Services Zone,
 Gender, Age group, Death status, Case type}

In[∘]:= counts = Sort[counts];

In[∘]:= Last[Position[counts, startafter]][[1]]

Out[∘]= 335 915

In[∘]:= counts = counts[[% + 1 ;; Length[counts]]];

In[∘]:= dates = DeleteDuplicates[counts[[All, 1]]]

Out[∘]= {2021-12-01, 2021-12-02, 2021-12-03, 2021-12-04, 2021-12-05, 2021-12-06, 2021-12-07,
 2021-12-08, 2021-12-09, 2021-12-10, 2021-12-11, 2021-12-12, 2021-12-13, 2021-12-14,
 2021-12-15, 2021-12-16, 2021-12-17, 2021-12-18, 2021-12-19, 2021-12-20, 2021-12-21,
 2021-12-22, 2021-12-23, 2021-12-24, 2021-12-25, 2021-12-26, 2021-12-27, 2021-12-28,
 2021-12-29, 2021-12-30, 2021-12-31, 2022-01-01, 2022-01-02, 2022-01-03,
 2022-01-04, 2022-01-05, 2022-01-06, 2022-01-07, 2022-01-08, 2022-01-09,
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Trim off data from Alberta after end date (this data stream keeps going for a few more weeks):

```
In[∘]:= Last[Position[counts, myenddate2]][[1]]
Out[∘]= 297 334
```

```
In[∘]:= counts = counts[[1 ;; %]];
```

```
In[∘]:= dates = DeleteDuplicates[counts[[All, 1]]]
Out[∘]= {2021-12-01, 2021-12-02, 2021-12-03, 2021-12-04, 2021-12-05, 2021-12-06, 2021-12-07,
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```

To adjust to the population size of the province:

```
In[◦]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "AB"][[1, 1]]]]
Out[◦]= {AB, 4 543 111, 439 109}
```

Age list (UNKNOWN treated as <70):

```
In[◦]:= DeleteDuplicates[counts[[All, 3]]]
Out[◦]= {10-19 years, 1-4 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years,
  5-9 years, 60-69 years, 70-79 years, 80+ years, Under 1 year, Unknown}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[◦]:= per100000Y = 100 000 / (popsize[[2]] - popsize[[3]])
        per100000A = 100 000 / popsize[[3]]
```

Out[◦]= $\frac{50\,000}{2\,052\,001}$

Out[◦]= $\frac{100\,000}{439\,109}$

```
In[◦]:= Clear[datetabAB];
datetabAB[i_] = {0, 0};
For[i = 1, i ≤ Length[counts], i++,
 date = Position[dates, counts[[i, 1]]][[1, 1]];
 If[((counts[[i, 3]] == "70-79 years") || (counts[[i, 3]] == "80+ years")),
  datetabAB[date] = datetabAB[date] + {0, per100000A},
  datetabAB[date] = datetabAB[date] + {per100000Y, 0}
 ]
]
```

Processing AB Case Data [ENTER this or the previous folder - pre-processed data]

```
In[◦]:= startafter = "2021-11-30";
```

The two periods we’ll consider:

```
In[◦]:= mystartdate1 = "2021-12-01";
myenddate1 = "2022-08-31";
mystartdate2 = "2022-09-01";
myenddate2 = "2023-05-31";
```

```
In[◦]:= curdate[x_] := InputForm[DateObject[x] - DateObject[startafter]][[1, 1]];
```

```
In[∘]:= xaxis = {{curdate["2021-10-01"], "Oct"},
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    {curdate["2023-05-01"], "May"}, {curdate["2023-06-01"], "June"}};
```

To adjust to the population size of the province:

```
In[∘]:= popsize = CanadaPop[[Position[CanadaPop[[All, 1]], "AB"][[1, 1]]]]

Out[∘]= {AB, 4 543 111, 439 109}
```

The reported cases among those under and over 70+ will be reported per 100,000 for better comparison among provinces:

```
In[∘]:= per100000Y = 100 000 / (popsize[[2]] - popsize[[3]])
        per100000A = 100 000 / popsize[[3]]
```

Out[∘]= $\frac{50\,000}{2\,052\,001}$

Out[∘]= $\frac{100\,000}{439\,109}$

```
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{0.5116956570683933`, 4.3269438795378825`}, {0.7797267155327897`,
 7.0597505402986505`}, {0.5360621169287929`, 4.782411656331344`},
{1.0964906937179855`, 6.376548875108458`}, {0.6335279563703916`,
 6.832016651901919`}, {0.5847950366495923`, 5.465613321521536`},
{0.4873291972079356`, 5.921081098314997`}, {0.5360621169287929`,
 6.376548875108458`}, {0.4629627373475939`, 4.782411656331344`},
{0.682260876091191`, 9.109355535869225`}, {0.5360621169287929`,
 7.0597505402986505`}, {0.38986335776639486`, 6.832016651901919`},
{0.36549689790599516`, 5.921081098314997`}, {0.5604285767891926`,
 4.782411656331344`}, {0.4629627373475939`, 6.148814986711727`},
{0.5360621169287929`, 5.921081098314997`}, {0.4385962774871942`,
 6.604282763505189`}, {0.4142298176267945`, 6.148814986711727`},
{0.5116956570683933`, 4.0992099911411515`}, {0.4385962774871942`,
 4.3269438795378825`}, {0.5604285767891926`, 5.693347209918266`},
{0.5360621169287929`, 5.237879433124805`}, {0.609161496509992`,
 9.337089424265956`}, {0.8771925549743884`, 8.198419982282303`},
{0.7066273359515907`, 6.376548875108458`}, {0.4873291972079356`,
 6.148814986711727`}, {0.5116956570683933`, 6.148814986711727`},
{0.38986335776639486`, 7.287484428695381`}, {0.609161496509992`,
 5.465613321521536`}, {0.5604285767891926`, 6.604282763505189`},
{0.5604285767891926`, 6.376548875108458`}, {0.682260876091191`,
 4.0992099911411515`}, {0.7797267155327897`, 6.148814986711727`},
{0.4629627373475939`, 3.871476102744421`}, {0.36549689790599516`,
 3.871476102744421`}, {0.5360621169287929`, 5.237879433124805`},
{0.5847950366495923`, 6.148814986711727`}, {0.6335279563703916`,
```

```
 5.465613321521536`}, {0.5360621169287929`, 5.921081098314997`},
{0.36549689790599516`, 7.970686093885573`}, {0.24366459860399678`,
 6.832016651901919`}, {0.24366459860399678`, 4.3269438795378825`},
{0.48732919720799356`, 7.0597505402986505`}, {0.609161496509992`,
 5.465613321521536`}, {0.48732919720799356`, 4.554677767934613`},
{0.29239751832479616`, 7.0597505402986505`}, {0.5360621169287929`,
 5.237879433124805`}, {0.4142298176267945`, 5.465613321521536`},
{0.3167639781851958`, 4.3269438795378825`}, {0.3167639781851958`,
 3.4160083259509597`}, {0.5360621169287929`, 6.148814986711727`},
{0.36549689790599516`, 3.4160083259509597`}, {0.29239751832479616`,
 4.782411656331344`}, {0.36549689790599516`, 3.188274437554229`},
{0.2192981387435971`, 4.0992099911411515`}, {0.26803105846439645`,
 4.782411656331344`}, {0.17056521902279775`, 3.871476102744421`},
{0.48732919720799356`, 4.782411656331344`}, {0.26803105846439645`,
 2.2773388839673063`}, {0.4142298176267945`, 5.237879433124805`},
{0.2192981387435971`, 2.5050727723640374`}, {0.2192981387435971`,
 5.465613321521536`}, {0.36549689790599516`, 2.5050727723640374`},
{0.26803105846439645`, 2.732806660760768`}, {0.5360621169287929`,
 3.871476102744421`}, {0.3167639781851958`, 3.871476102744421`}};
```

Enter the following to avoid upload:

```
In[∘]:= dates = tabdates;
```

```
In[∘]:= For[i = 1, i <= Length[dates], i++, datetabAB[i] = tab[[i]]]
```

Overall Analysis by 70+

Cubic Spline fit (https://mathematica.stackexchange.com/questions/33206/implementation-of-smoothing-splines-function)

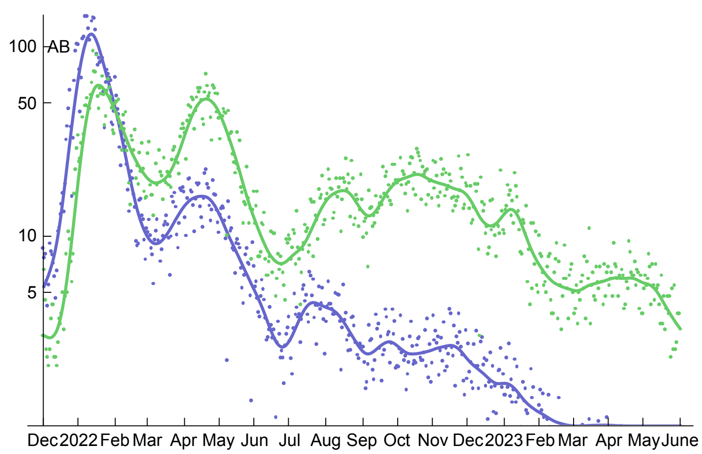
```
In[∘]:= CubicSplSmooth[data_, lambda_] := Module[{M, Knots, X, Dsq, a}, M = Length@data;
    Knots = Flatten@{1, 1, 1, Range@M, M, M, M};
    X = Table[Evaluate@N@BSplineBasis[{3, Knots}, n, t], {t, 1, M}, {n, 0, M + 1}];
    Dsq = Differences[X, 2];
    a = LinearSolve[Transpose[X].X + lambda * Transpose[Dsq].Dsq,
      Transpose[X].data, Method → "Multifrontal"];
    Return[
     X.
      a]];
```

Cubic spline fit to all dates (Y is younger, A is 70+), using lambda = 3 to provide a good fit but not overfit to the data:

In[∘]:=
```
modYAB = CubicSplSmooth[Table[{i, Log[Max[1, datetabAB[i][[1]]]]},
    {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
modAAB = CubicSplSmooth[Table[{i, Log[Max[1, datetabAB[i][[2]]]]},
    {i, 1, Length[dates]}], 10^lambda /. lambda → 3];
```

In[∘]:=
```
plotAB = Show[
  ListPlot[Table[{i, Log[datetabAB[i][[1]]]}, {i, 1, Length[dates]}],
   PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.4, 0.8]}],
  ListLinePlot[modYAB, PlotStyle → RGBColor[0.4, 0.4, 0.8], PlotRange → All],
  ListLinePlot[modAAB, PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
  ListPlot[Table[{i, Log[datetabAB[i][[2]]]}, {i, 1, Length[dates]}],
   PlotRange → {Automatic, {0, 10}}, PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
  Graphics[Text["AB", {5, 4.6}, {-1, 0}]],
  PlotRange → {Automatic, {0, 5}}, AxesOrigin → {1, 0},
  Ticks → {xaxis, {{Log[5], "5"}, {Log[10], "10"}, {Log[50], "50"}, {Log[100], "100"},
     {Log[500], "500"}, {Log[1000], "1000"}, {Log[5000], "5000"}}}
 ]
```

Out[∘]=

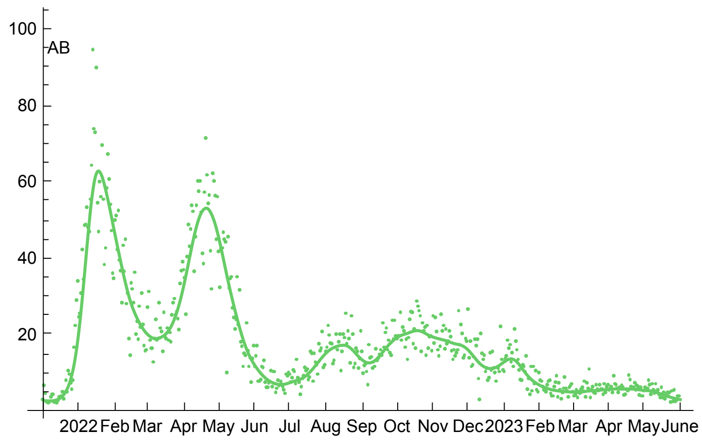


The above illustrates the major drop off in reported cases among those <70:

70+ on a non-log plot

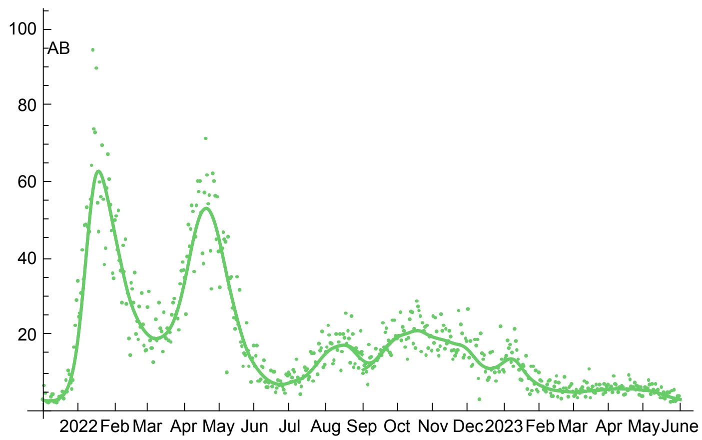
In[◦]:=
```
Show[
 ListLinePlot[Table[{modAAB[[i, 1]], Exp[modAAB[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabAB[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["AB", {5, 95}, {-1, 0}]],
 PlotRange → {Automatic, {0, 100}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

Out[◦]=



In[◦]:=
```
modAAB1 = CubicSplSmooth[Table[{i, Log[Max[1, datetabAB[i][[2]]]]},
    {i, 1, Position[dates, myenddate1][[1, 1]]}], 10^lambda /. lambda → 3];
modAAB2 = CubicSplSmooth[Table[{i, Log[Max[1, datetabAB[i][[2]]]]},
    {i, Position[dates, mystartdate2][[1, 1]], Length[dates]}],
   10^lambda /. lambda → 3];
```

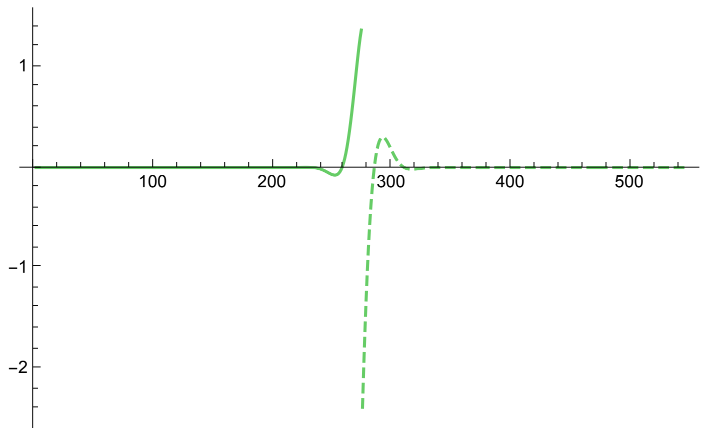
In[∘]:=
```
Show[
 ListLinePlot[Table[{modAAB[[i, 1]], Exp[modAAB[[i, 2]]]}, {i, 1, Length[dates]}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAAB1[[i, 1]], Exp[modAAB1[[i, 2]]]},
   {i, 1, Length[modAAB1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAAB2[[i, 1]], Exp[modAAB2[[i, 2]]]},
   {i, 1, Length[modAAB2]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabAB[i][[2]]}, {i, 1, Length[dates]}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 Graphics[Text["AB", {5, 95}, {-1, 0}]],
 PlotRange → {Automatic, {0, 100}}, Ticks → {xaxis, Automatic}, AxesOrigin → {1, 0}
]
```

Out[∘]=


The fit is very similar, with a slight discrepancy in numbers at the joint, so we just use the overall spline fit for the analysis:

In[◦]:=
```
Show[
 ListLinePlot[Table[{modAAB1[[i, 1]], Exp[modAAB1[[i, 2]]] - Exp[modAAB[[i, 2]]]},
   {i, 1, Length[modAAB1]}], PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListLinePlot[Table[{modAAB2[[i, 1]], Exp[modAAB2[[i, 2]]] - Exp[modAAB[[
       i + Position[dates, myenddate1][[1, 1]], 2]]]}, {i, 1, Length[modAAB2]}],
  PlotStyle → {Dashed, RGBColor[0.4, 0.8, 0.4]}, PlotRange → All],
 PlotRange → All
]
```

Out[◦]=



Merging with Omicron subvariant frequencies

In[◦]:=
```
graphheight = 95;
```

In[◦]:=
```
colourBA1 = RGBColor[0.5, 0.1, 0.1];
colourBA11 = RGBColor[0.75, 0.1, 0.1];
colourBA2 = RGBColor[1, 0.1, 0.1];
colourBA5 = RGBColor[1, 0.5, 0.1];
colourBA45 = colourBA5;
colourBA4 = colourBA5;
colourBQ = RGBColor[1, 0.75, 0.5];
colourXBB15 = RGBColor[0.2, 0.5, 0.8];
colourXBBO = RGBColor[0.5, 0.7, 0.8];

{colourBA1, colourBA11, colourBA2, colourBA45, colourBQ, colourXBB15, colourXBBO}
```

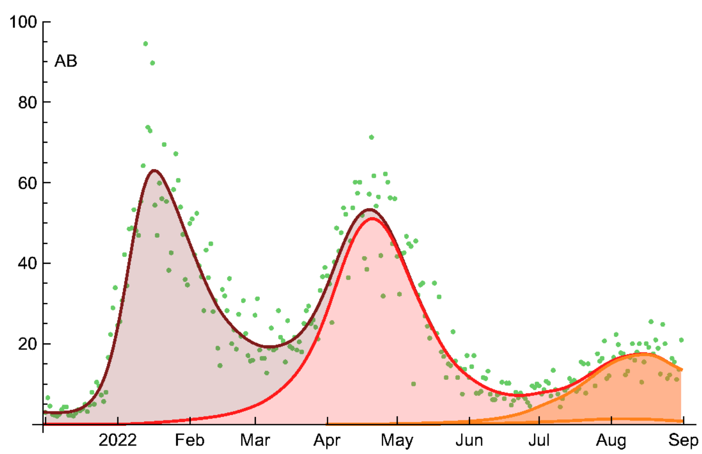
Out[◦]= 

From VariantData_AlbertaOmicron.nb (BA.5 stands for BA.4 and BA.5 and the initial frequency is at "2022-04-1" based on a separate analysis):

In[◦]:=
```
ABML = {pBA2 → 0.00011225159144028347`, sBA2 → 0.0867477034172624`,
   pBA4 → 0.000063200803465215 72`, pBA5 → 0.00011548973437613636`,
   sBA4 → 0.08609383566833843`, sBA5 → 0.10006163455695519`};
```

In[◦]:=
```
endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modAAB[[i, 1]],
    1 * Exp[modAAB[[i, 2]]] /. t -> modAAB[[i, 1]] /. ABML}, {i, 1, endtime}];
tabBA2 = Table[{modAAB[[i, 1]], pBA2 Exp[sBA2 t] / ((1 - pBA2) + pBA2 Exp[sBA2 t]) * Exp[modAAB[[i, 2]]] /.
      t -> modAAB[[i, 1]] /. ABML}, {i, 1, endtime}];
tabBA4 = Table[{modAAB[[i, 1]], pBA4 Exp[sBA4 t] / ((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
       Exp[modAAB[[i, 2]]] /. t -> modAAB[[i, 1]] - curdate["2022-03-31"] /.
     ABML}, {i, curdate["2022-04-1"], endtime}];
tabBA5 = Table[{modAAB[[i, 1]], (pBA5 Exp[sBA5 t] + pBA4 Exp[sBA4 t]) / ((1 - pBA4 - pBA5) + pBA4 Exp[sBA4 t] + pBA5 Exp[sBA5 t]) *
       Exp[modAAB[[i, 2]]] /. t -> modAAB[[i, 1]] - curdate["2022-03-31"] /.
     ABML}, {i, curdate["2022-04-1"], endtime}];

Show[
 ListLinePlot[Table[{modAAB[[i, 1]], Exp[modAAB[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabAB[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA2, tabBA4, tabBA5},
  PlotStyle → {colourBA1, colourBA2, colourBA4, colourBA5}, PlotRange → All,
      Filling → {1 → {2}, 2 → Axis, 3 → {4}, 4 → Axis}],
 Graphics[Text["AB", {5, 0.95 * graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[◦]=

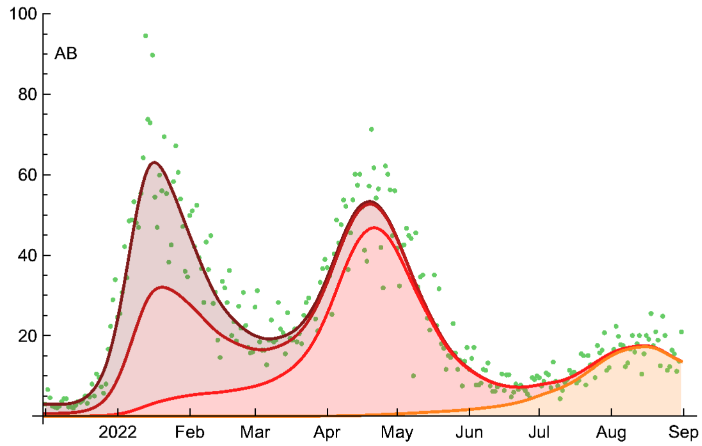


From duotang/VirusSeq (see code above): mutantNames = list(“BA.1.1*”, “BA.2*”, “BA.4/5*”, “BA.1*”)

```
In[•]:= ABML1
Out[•]= {0.13608, 0.845212, 0.00324064, 0.0260576, 0.0712305, 0.151729}

In[•]:= dataname = ABML1;
        refdate = "2022-04-15"; (* t=0 date used in duotang code above *)
        ABML = {pBA11 → dataname[[1]], pBA2 → dataname[[2]], pBA45 → dataname[[3]],
          sBA11 → dataname[[4]], sBA2 → dataname[[5]], sBA45 → dataname[[6]]}
Out[•]= {pBA11 → 0.13608, pBA2 → 0.845212, pBA45 → 0.00324064,
         sBA11 → 0.0260576, sBA2 → 0.0712305, sBA45 → 0.151729}
```

```
In[∘]:= endtime = Length[dates];
endtime = Position[dates, "2022-08-31"][[1, 1]];

tabBA1 = Table[{modAAB[[i, 1]],
    1 * Exp[modAAB[[i, 2]]] /. t -> modAAB[[i, 1]] /. ABML}, {i, 1, endtime}];
tabBA11 = Table[{modAAB[[i, 1]],
     (pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
     ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAAB[[i, 2]]] /.
     t -> modAAB[[i, 1]] - curdate[refdate] /. ABML}, {i, 1, endtime}];
tabBA2 = Table[{modAAB[[i, 1]],
     (pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) /
     ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAAB[[i, 2]]] /.
     t -> modAAB[[i, 1]] - curdate[refdate] /. ABML}, {i, 1, endtime}];
tabBA45 = Table[{modAAB[[i, 1]],
     (pBA45 Exp[sBA45 t]) /
     ((1 - pBA11 - pBA2 - pBA45) + pBA11 Exp[sBA11 t] + pBA2 Exp[sBA2 t] + pBA45 Exp[sBA45 t]) *
      Exp[modAAB[[i, 2]]] /.
     t -> modAAB[[i, 1]] - curdate[refdate] /. ABML}, {i, 1, endtime}];

Show[
 ListLinePlot[Table[{modAAB[[i, 1]], Exp[modAAB[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabAB[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45}, PlotStyle →
   {colourBA1, colourBA11, colourBA2, colourBA4, colourBA5}, PlotRange → All,
     Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis}],
 Graphics[Text["AB", {5, 0.95 * graphheight}, {-1, 0}]],
 PlotRange → {{1, endtime + 1}, {0, graphheight}}, Ticks → {xaxis, Automatic}
]
```

Out[∘]=



From duotang/VirusSeq (see code above): mutantNames = list("XBB.1.5*", "XBB.Other*", "BQ*", "BA.5*")

In[∘]:=
```
ABML2
```

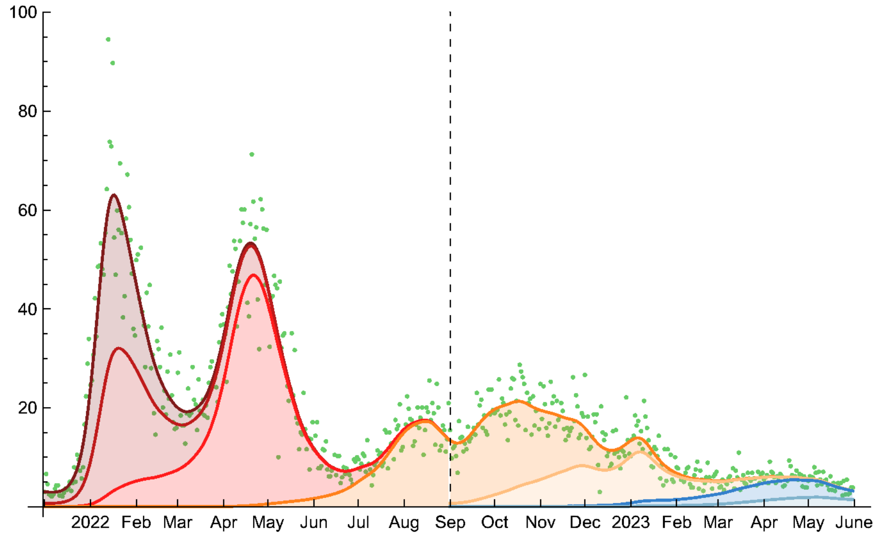
Out[∘]=
```
{0.0911895, 0.0121622, 0.735102, 0.074224, 0.0873077, 0.033236}
```

In[∘]:=
```
dataname = ABML2;
refdate = "2023-01-14"; (* t=0 date used in duotang code above *)
ABML = {pXBB15 → dataname[[1]], pXBBO → dataname[[2]], pBQ → dataname[[3]],
  sXBB15 → dataname[[4]], sXBBO → dataname[[5]], sBQ → dataname[[6]]}
```

Out[∘]=
```
{pXBB15 → 0.0911895, pXBBO → 0.0121622, pBQ → 0.735102,
 sXBB15 → 0.074224, sXBBO → 0.0873077, sBQ → 0.033236}
```

```
In[•]:= starttime = Position[dates, "2022-09-01"][[1, 1]];
endtime = Length[dates];

tabBA5 = Table[{modAAB[[i, 1]], 1 * Exp[modAAB[[i, 2]]] /. t -> modAAB[[i, 1]] /. ABML},
    {i, starttime, endtime}];
tabBQ = Table[{modAAB[[i, 1]],
      (pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
      ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
        Exp[modAAB[[i, 2]]] /.
       t -> modAAB[[i, 1]] - curdate[refdate] /. ABML}, {i, starttime, endtime}];
tabXBB15 = Table[{modAAB[[i, 1]],
      (pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) /
      ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
        Exp[modAAB[[i, 2]]] /.
       t -> modAAB[[i, 1]] - curdate[refdate] /. ABML}, {i, starttime, endtime}];
tabXBBO = Table[{modAAB[[i, 1]],
      (pXBBO Exp[sXBBO t]) /
      ((1 - pBQ - pXBB15 - pXBBO) + pBQ Exp[sBQ t] + pXBB15 Exp[sXBB15 t] + pXBBO Exp[sXBBO t]) *
        Exp[modAAB[[i, 2]]] /.
       t -> modAAB[[i, 1]] - curdate[refdate] /. ABML}, {i, starttime, endtime}];

Show[
 ListLinePlot[Table[{modAAB[[i, 1]], Exp[modAAB[[i, 2]]]}, {i, 1, endtime}],
  PlotStyle → RGBColor[0.4, 0.8, 0.4], PlotRange → All],
 ListPlot[Table[{i, datetabAB[i][[2]]}, {i, 1, endtime}],
  PlotStyle → {RGBColor[0.4, 0.8, 0.4]}],
 ListLinePlot[{tabBA1, tabBA11, tabBA2, tabBA45, tabBA5, tabBQ, tabXBB15, tabXBBO},
  PlotStyle → {colourBA1, colourBA11, colourBA2, colourBA45,
    colourBA45, colourBQ, colourXBB15, colourXBBO}, PlotRange → All,
      Filling → {1 → {2}, 2 → {3}, 3 → {4}, 4 → Axis,
    5 → {6}, 6 → {7}, 7 → {8}, 8 → Axis}],
 (*Graphics[Text["AB",{5,95},{-1,0}]],*)
 ListPlot[{{starttime, 0}, {starttime, 100}},
  Joined → True, PlotStyle → {Black, Thickness[0.002], Dashed}],
 PlotRange → {{1, curdate["2023-06-01"]}, {0, graphheight}},
 Ticks → {xaxis, Automatic},
 AspectRatio → 0.6,
 ImageSize → 450
]
```

Out[◦]=


100
80
60
40
20
2022
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2023
Feb
Mar
Apr
May
June