Effectiveness_of_School_Closing

September 22, 2020

[79]:

```
from IPython.display import Image
Image("../Images/Logo.jpg")
```

[79]:

UNIVERSITY OF
CALGARY

#

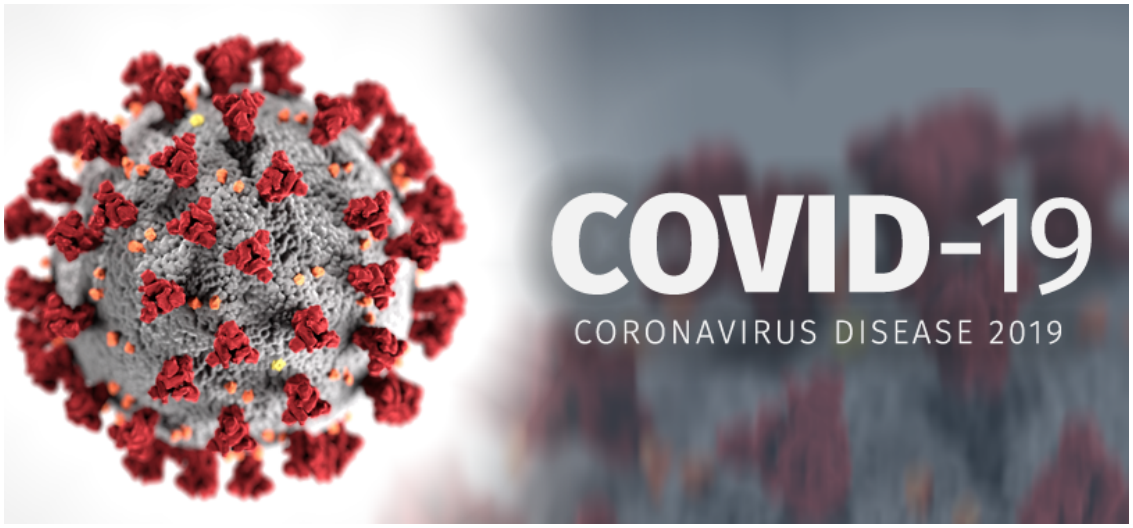
Graduate Project ENEL 698

Github Link

[81]:

```
Image("../Images/Covid-19.png")
```

[81]:



0.1 This Notebook constitues of analysis of Effectiveness of School Closures and Reopening for reducing Coronavirus Disease 2019 (COVID-19) transmission.

0.2 Objective and Scope

0.2.1 Schools have been closed all across the globe with other layers of individual and community-based public health measures to curb the spread of COVID-19. This analysis aims to assist decision-makers with evidence to support decision-making during pandemic.

- This analysis will address the following question:

1. This anlaysis will tell us what is the effectiveness of school closures on reducing transmission of COVID-19?
2. What impacts do the reopening of schools have on COVID-19 transmission?

Lets load the data to see how the world has been affected by COVID-19.

[1]:
```
#importing the necessary files required for visualization and statistical␣
 ↪analysis

import requests

import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

[2]:
```
# grabbing latest worldwide data

url = "https://ncov2019.live/data/world"

r = requests.get(url)
df_list = pd.read_html(r.text)          #this parse all html tables from a␣
 ↪webpage to alist
world_df = df_list[2]
world_df
```

[2]:
```
                                Name  Confirmed Per Million  Changes Today  \
0                              TOTAL   31740808        4082         247393
1                        Afghanistan      39096         999             22
2                            Albania      12666        4402            131
3                            Algeria      50214        1141            191
4                            Andorra       1681           0              0
..                               …          …           …             …
210                       Montserrat         13           0              0
211                 Falkland Islands         13           0              0
```

```
212    Saint Pierre and Miquelon         11           0              0
213                     Anguilla          3           0              0
214                        China      85297          59              6

    Percentage Day Change Critical Deceased Per Million.1  Changes Today.1  \
0                   0.79%    62044   973902           125             4887
1                   0.06%       93     1445            37                1
2                   1.05%       16      367           128                3
3                   0.38%       31     1689            38               10
4                      0%        4       53             0                0
..                    …      …      …           …              …
210                    0%  Unknown        1             0                0
211                    0%  Unknown  Unknown       Unknown                0
212                    0%  Unknown  Unknown       Unknown                0
213                    0%  Unknown  Unknown       Unknown                0
214                 0.01%        4     4634             3                0

    Percentage Death Change      Tests   Active Recovered Per Million.2  \
0                      0.5%  609539441  7486676  23138683          2976
1                     0.07%     109068     5075     32576           833
2                     0.82%      76965     5257      7042          2448
3                      0.6%    Unknown  Unknown     35307           802
4                        0%     137457      429      1199             0
..                      …        …      …       …           …
210                      0%        449        0        12             0
211                      0%       2261  Unknown        13             0
212                      0%       1051  Unknown         5             0
213                      0%       1020  Unknown         3             0
214                      0%  160000000      166     80497            56

     Population
0    7775221824
1      39119903
2       2877077
3      44025729
4         77293
..          …
210        4993
211        3502
212        5787
213       15033
214  1439323776

[215 rows x 15 columns]
```

[3]:

```
# We will now sort the countries based on total confirmed cases column
```

```python
world_df = world_df.sort_values("Confirmed" , ascending = False)



#Lets get top 10 affected countries

world_df.head(10)
```

[3]:

```
                 Name  Confirmed Per Million  Changes Today  \
0               TOTAL   31740808        4082         247393
169    United States    7093851       21403          31610
170            India    5640496        4078          80391
171           Brazil    4591604       21567          31521
172           Russia    1115810        7645           6215
173         Colombia     777537       15245           7102
174             Peru     772896       23369              0
175           Mexico     700580        5421           2917
176            Spain     682267       14591          10799
142     South Africa     663282       11152           1346

    Percentage Day Change Critical Deceased Per Million.1  Changes Today.1  \
0                   0.79%    62044   973902           125             4887
169                 0.45%    14076   205370           620              868
170                 1.45%     8944    90021            65             1056
171                 0.69%     8318   138108           649              758
172                 0.56%     2300    19649           135              160
173                 0.92%      863    24570           482              173
174                    0%     1415    31474           952                0
175                 0.42%     2568    73697           570              204
176                 1.61%     1417    30904           661              241
142                  0.2%      539    16118           271              126

    Percentage Death Change      Tests   Active Recovered Per Million.2  \
0                      0.5%  609539441  7486676  23138683          2976
169                   0.42%   99638458  2549361   4339120         13092
170                   1.19%   65325779   968655   4581820          3313
171                   0.55%   15011116   507869   3945627         18533
172                   0.82%   43300000   178212    917949          6290
173                   0.71%    3460714   102166    650801         12760
174                      0%    3710694   119004    622418         18819
175                   0.28%    1589975   123901    502982          3892
176                   0.79%   11820505   500987    150376          3216
142                   0.79%    4064117    54260    592904          9969

     Population
0    7775221824
169   331441624
```

```
170  1383048851
171   212900304
172   145948762
173    51004385
174    33074060
175   129236306
176    46758917
142    59475541
```

The country converter (coco) - a Python package for converting country names between different classifications schemes.¶ For more info please click here.

[4]:
```
import country_converter as coco
```

[5]:
```
# Creating a list and appending all the names from world_df column.

Names = []
for i in range(1,215):
    Names.append(world_df.iloc[i]['Name'][3:])

# Insert Total at index 0. we left that because it doesn't contain any start in␣
 ↪it.

Names.insert(0,'TOTAL')
```

[6]:
```
standard_names = coco.convert(names= Names, to='ISO3')
print(len(standard_names))
```

```
WARNING:root:TOTAL not found in regex
WARNING:root:SÃ£o TomÃ© and PrÃncipe not found in regex
WARNING:root:Channel Islands not found in regex
```

```
215
```

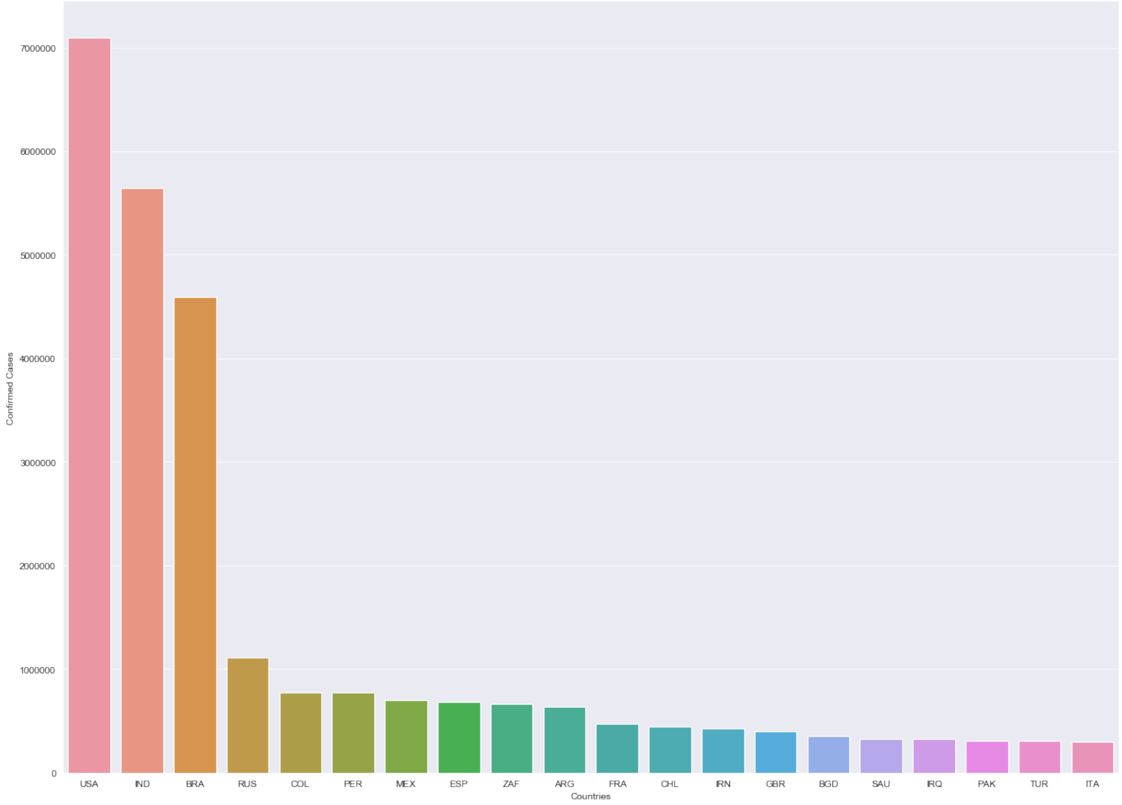
[7]:
```
# Adding the ISO3 code in a new world_df['Code'] column.

world_df['Code'] = standard_names

# Removing countries of which ISO3 code is not available

world_df = world_df[world_df['Code'] != 'not found']
```

Plot total number of confirmed cases (Top 20)

[8]:
```
# Lets plot top 20 countries based on confirmed cases

plt.figure(figsize=(20,15))
```

```
sns.set_style("darkgrid")
ax = sns.barplot(x = "Code" , y = 'Confirmed', data = world_df.head(20))
ax.set(xlabel="Countries", ylabel = "Confirmed Cases")
```

```
[8]: [Text(0, 0.5, 'Confirmed Cases'), Text(0.5, 0, 'Countries')]
```



- USA, INDIA, and BRAZIL have been affected very severely.
- The major reason being the failure of implementation of COVID-19 preventive measures by both Government and Citizens.

0.3 Global Closure of School

The following data has been provided by Namara in association with Alberta Innovates.

- Data Source - For more info please click here.

0.4 Description

The number of children, youth and adults not attending schools or universities because of COVID-19 is soaring. Governments all around the world have closed educational institutions in an attempt to contain the global pandemic.

According to UNESCO monitoring, over 100 countries have implemented nationwide closures, impacting over half of worlds student population. Several other countries have implemented localized school closures and, should these closures become nationwide, millions of additional learners will experience education disruption.

```
[9]: # load the data from the local directory

     school_closure_df = pd.read_csv("../covid_data/Data/
      ↪GlobalSchoolClosuresCOVID-19/global-school-closures-covid-19.csv.csv")
```

```
[10]: school_closure_df.head()
```

```
[10]:                        date  iso   country                  status  note
      0  2020-02-17 00:00:00+00  CHN     China          Partially open   NaN
      1  2020-02-17 00:00:00+00  MNG  Mongolia  Closed due to COVID-19   NaN
      2  2020-02-18 00:00:00+00  CHN     China          Partially open   NaN
      3  2020-02-18 00:00:00+00  MNG  Mongolia  Closed due to COVID-19   NaN
      4  2020-02-19 00:00:00+00  CHN     China          Partially open   NaN
```

Lets explore this dataset

```
[11]: school_closure_df.nunique()
```

```
[11]: date       227
      iso        210
      country    210
      status       4
      note         0
      dtype: int64
```

```
[12]: # Number of Countries

      print("This dataset contains {} number of countries.".
       ↪format(school_closure_df['iso'].nunique()))
```

```
This dataset contains 210 number of countries.
```

Lets see what are the categorical variables (policies) for each country.

```
[13]: from termcolor import colored
```

```
[14]: # Number of Categories

      print("There are {} categories in which school across the globe are divided␣
       ↪provided this dataset.". format(school_closure_df['status'].nunique()))
      print("The Categories are mentioned below:")
      print(colored(school_closure_df['status'].unique(), 'green'))
```

```
There are 4 categories in which school across the globe are divided provided
```

```
this dataset.
The Categories are mentioned below:
['Partially open' 'Closed due to COVID-19' 'Academic break' 'Fully
open']
```

I'm creating a multindex here. It will allow us to group data based on iso codes of the respective countries.

[15]:

```
# MultiIndexing to group data

print(colored(school_closure_df.set_index(['iso','country']).sort_index().
 ↪head(1000),'blue'))
```

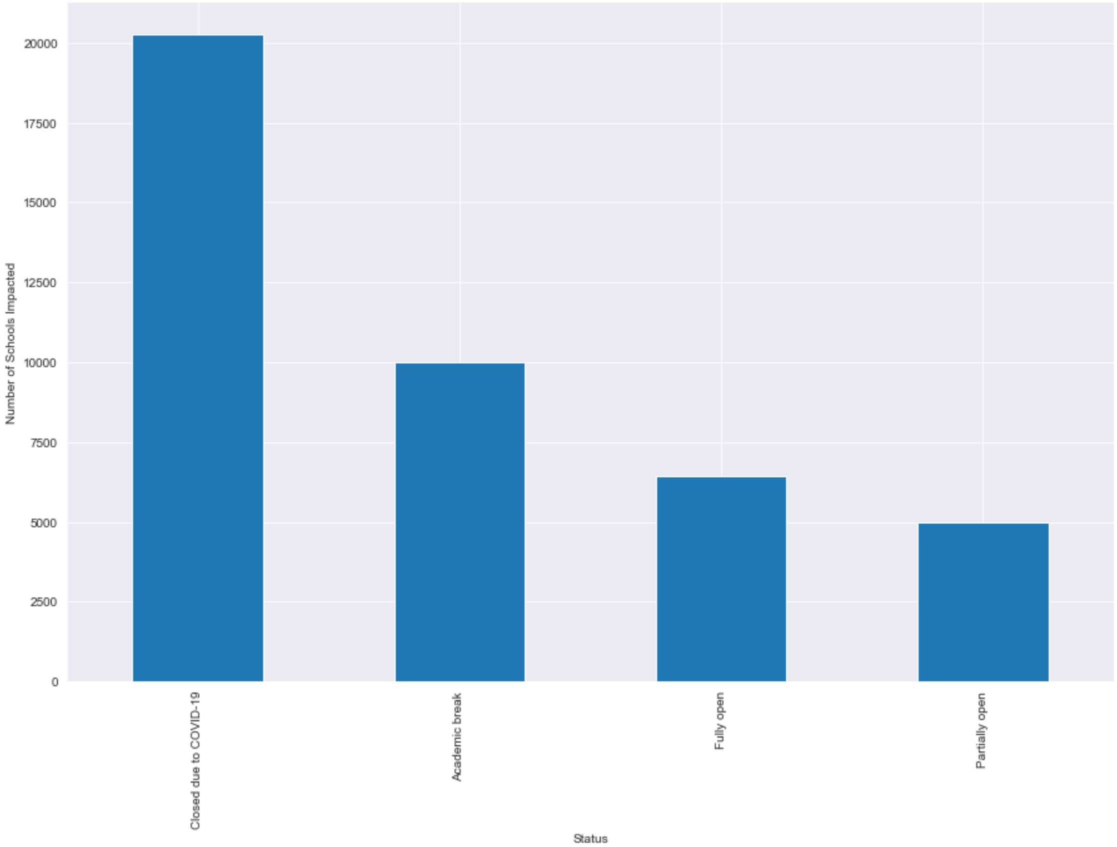
```
                                   date                  status  note
iso country
ABW Aruba    2020-03-16 00:00:00+00  Closed due to COVID-19   NaN
    Aruba    2020-03-17 00:00:00+00  Closed due to COVID-19   NaN
    Aruba    2020-03-18 00:00:00+00  Closed due to COVID-19   NaN
    Aruba    2020-03-19 00:00:00+00  Closed due to COVID-19   NaN
    Aruba    2020-03-20 00:00:00+00  Closed due to COVID-19   NaN
…                                …                     …    …
ALB Albania  2020-09-18 00:00:00+00              Fully open   NaN
    Albania  2020-09-19 00:00:00+00              Fully open   NaN
    Albania  2020-09-20 00:00:00+00              Fully open   NaN
    Albania  2020-09-21 00:00:00+00              Fully open   NaN
    Albania  2020-09-22 00:00:00+00              Fully open   NaN
[1000 rows x 3 columns]
```

[16]:

```
# How Schools are reacting to COVID-19 in various countries.

plt.figure(figsize = (15,10))
ax = school_closure_df['status'].value_counts().plot(kind='bar')
ax.set(xlabel="Status", ylabel = "Number of Schools Impacted")
```

[16]:

```
[Text(0, 0.5, 'Number of Schools Impacted'), Text(0.5, 0, 'Status')]
```



- As situation got worse, school authorities all around the world have implemented various policies.
- **More than 20,000 schools have opted to close** which was **primary** choice of the officials.
- Some authorities decided to give students **Academic break**, which was secondary choice.
- Some countries haven't decided to close the schools yet.

```
[17]: # Filtering Canada specific data.

canada_school_closure_df = school_closure_df[school_closure_df['iso']=='CAN']
print(colored(canada_school_closure_df,'magenta'))
```

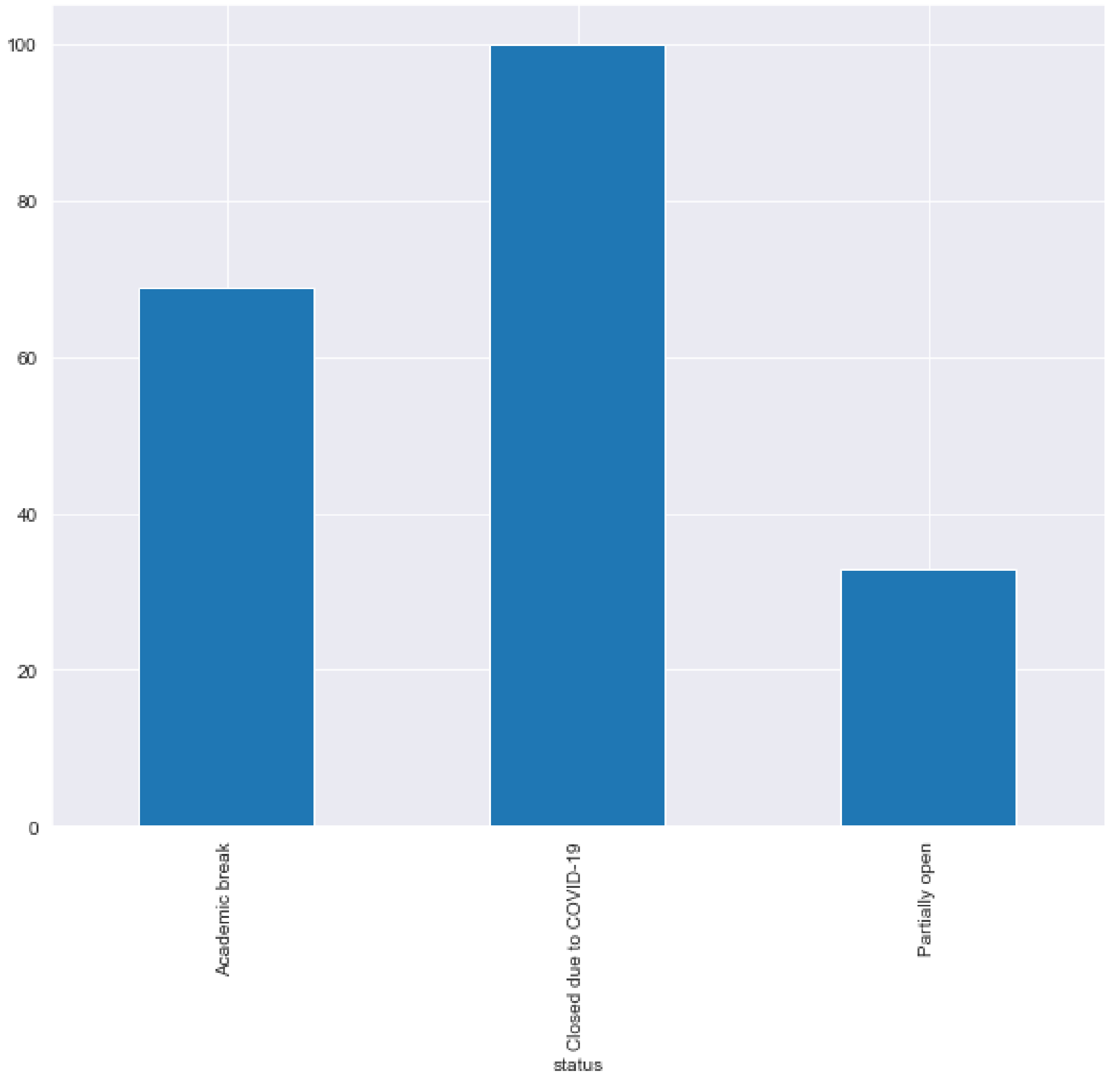
```
                        date  iso  country          status  note
423    2020-03-13 00:00:00+00  CAN   Canada  Partially open   NaN
489    2020-03-14 00:00:00+00  CAN   Canada  Partially open   NaN
557    2020-03-15 00:00:00+00  CAN   Canada  Partially open   NaN
635    2020-03-16 00:00:00+00  CAN   Canada  Partially open   NaN
761    2020-03-17 00:00:00+00  CAN   Canada  Partially open   NaN
…                         …    …      …              …    …
40696  2020-09-26 00:00:00+00  CAN   Canada  Partially open   NaN
40906  2020-09-27 00:00:00+00  CAN   Canada  Partially open   NaN
41116  2020-09-28 00:00:00+00  CAN   Canada  Partially open   NaN
41326  2020-09-29 00:00:00+00  CAN   Canada  Partially open   NaN
41536  2020-09-30 00:00:00+00  CAN   Canada  Partially open   NaN
[202 rows x 5 columns]
```

[18]:

```python
# How Canadian schools reacted?

plt.figure(figsize=(10,8))
canada_school_closure_df.groupby('status')['status'].count().plot(kind='bar')
```

[18]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16ca8ff5908>
```



- As COVID-19 outbreak became a serious issue, Majority of the **schools were closed in Canada**. Only a few were **Partially open**.

Lets see when the schools were closed all over Canada.

[19]:
```
# When Canada Decided to close the school?

canada_school_closure_df[canada_school_closure_df['status']=='Closed due to␣
↪COVID-19'].head(10).style.apply(lambda x: ['background: yellow'                                                                              ␣
↪            if (x.name == 1680)                                                                              ␣
↪            else '' for i in x], axis=1)
```

```
[19]: <pandas.io.formats.style.Styler at 0x16ca901c048>
```

1. From this we can see that schools in Canada were closed in the month of March. We will use this finding to see how effective this policy was. Based on number of reported cases before and after March.
2. Any significant drop in the number of confirmed cases by implementing this policy will be helpful to prepare for future pandemics.

```
[20]: # Partially open status of the schools in Canada.

      canada_school_closure_df[canada_school_closure_df['status']=='Partially open']
```

```
[20]:                        date  iso country          status  note
      423    2020-03-13 00:00:00+00  CAN   Canada  Partially open   NaN
      489    2020-03-14 00:00:00+00  CAN   Canada  Partially open   NaN
      557    2020-03-15 00:00:00+00  CAN   Canada  Partially open   NaN
      635    2020-03-16 00:00:00+00  CAN   Canada  Partially open   NaN
      761    2020-03-17 00:00:00+00  CAN   Canada  Partially open   NaN
      891    2020-03-18 00:00:00+00  CAN   Canada  Partially open   NaN
      1031   2020-03-19 00:00:00+00  CAN   Canada  Partially open   NaN
      1184   2020-03-20 00:00:00+00  CAN   Canada  Partially open   NaN
      1348   2020-03-21 00:00:00+00  CAN   Canada  Partially open   NaN
      1513   2020-03-22 00:00:00+00  CAN   Canada  Partially open   NaN
      36916  2020-09-08 00:00:00+00  CAN   Canada  Partially open   NaN
      37126  2020-09-09 00:00:00+00  CAN   Canada  Partially open   NaN
      37336  2020-09-10 00:00:00+00  CAN   Canada  Partially open   NaN
      37546  2020-09-11 00:00:00+00  CAN   Canada  Partially open   NaN
      37756  2020-09-12 00:00:00+00  CAN   Canada  Partially open   NaN
      37966  2020-09-13 00:00:00+00  CAN   Canada  Partially open   NaN
      38176  2020-09-14 00:00:00+00  CAN   Canada  Partially open   NaN
      38386  2020-09-15 00:00:00+00  CAN   Canada  Partially open   NaN
      38596  2020-09-16 00:00:00+00  CAN   Canada  Partially open   NaN
      38806  2020-09-17 00:00:00+00  CAN   Canada  Partially open   NaN
      39016  2020-09-18 00:00:00+00  CAN   Canada  Partially open   NaN
      39226  2020-09-19 00:00:00+00  CAN   Canada  Partially open   NaN
      39436  2020-09-20 00:00:00+00  CAN   Canada  Partially open   NaN
      39646  2020-09-21 00:00:00+00  CAN   Canada  Partially open   NaN
      39856  2020-09-22 00:00:00+00  CAN   Canada  Partially open   NaN
      40066  2020-09-23 00:00:00+00  CAN   Canada  Partially open   NaN
      40276  2020-09-24 00:00:00+00  CAN   Canada  Partially open   NaN
      40486  2020-09-25 00:00:00+00  CAN   Canada  Partially open   NaN
      40696  2020-09-26 00:00:00+00  CAN   Canada  Partially open   NaN
      40906  2020-09-27 00:00:00+00  CAN   Canada  Partially open   NaN
      41116  2020-09-28 00:00:00+00  CAN   Canada  Partially open   NaN
      41326  2020-09-29 00:00:00+00  CAN   Canada  Partially open   NaN
      41536  2020-09-30 00:00:00+00  CAN   Canada  Partially open   NaN
```

So here are some interesting facts that we might have overlooked in the above data

[21]:
```
# Partially open status of the schools in Canada.

canada_school_closure_df[canada_school_closure_df['status']=='Partially open'].
↪head(15).style.apply(lambda x: ['background: yellow'
                                                                                ␣
↪           if (x.name == 1513 or x.name == 36916)
                                                                                ␣
↪           else '' for i in x], axis=1)
```

[21]:
```
<pandas.io.formats.style.Styler at 0x16ca91fca88>
```

1. Here we can see that schools were partially open till March.
2. After that canadian government implemented school and university closure.
3. University of Calgary itself closed all its operation in the month of the March.
4. This helped Canadian government contain the spread of COVID-19.
5. The government with many public health measures decided to reopen school in September. This includes mandatory masaking, physical distancing, enhanced cleaning, daily symptom screening. If a case is confirmed, contact tracers and public health officals will be deployed to identify potential exposure and limit spread.

Lets see answer to the two questions based on the data discovered above.

1. Effectiveness of school closures on reducing transmission of COVID-19?

- Data Source - Open Timeline Canada data

[22]:
```
# Load data

canada_covid_df = pd.read_csv('../covid_data/Data/Covid-19/covid19.csv')
canada_covid_df.head(10)
```

[22]:
```
   pruid             prname                prnameFR        date  numconf  \
0     35            Ontario                 Ontario  31-01-2020        3
1     59   British Columbia  Colombie-Britannique  31-01-2020        1
2      1             Canada                  Canada  31-01-2020        4
3     35            Ontario                 Ontario  08-02-2020        3
4     59   British Columbia  Colombie-Britannique  08-02-2020        4
5      1             Canada                  Canada  08-02-2020        7
6     35            Ontario                 Ontario  16-02-2020        3
7     59   British Columbia  Colombie-Britannique  16-02-2020        5
8      1             Canada                  Canada  16-02-2020        8
9     35            Ontario                 Ontario  21-02-2020        3

   numprob  numdeaths  numtotal  numtested  numrecover  …  percentdeath  \
0        0        0.0         3        NaN         NaN  …           0.0
```

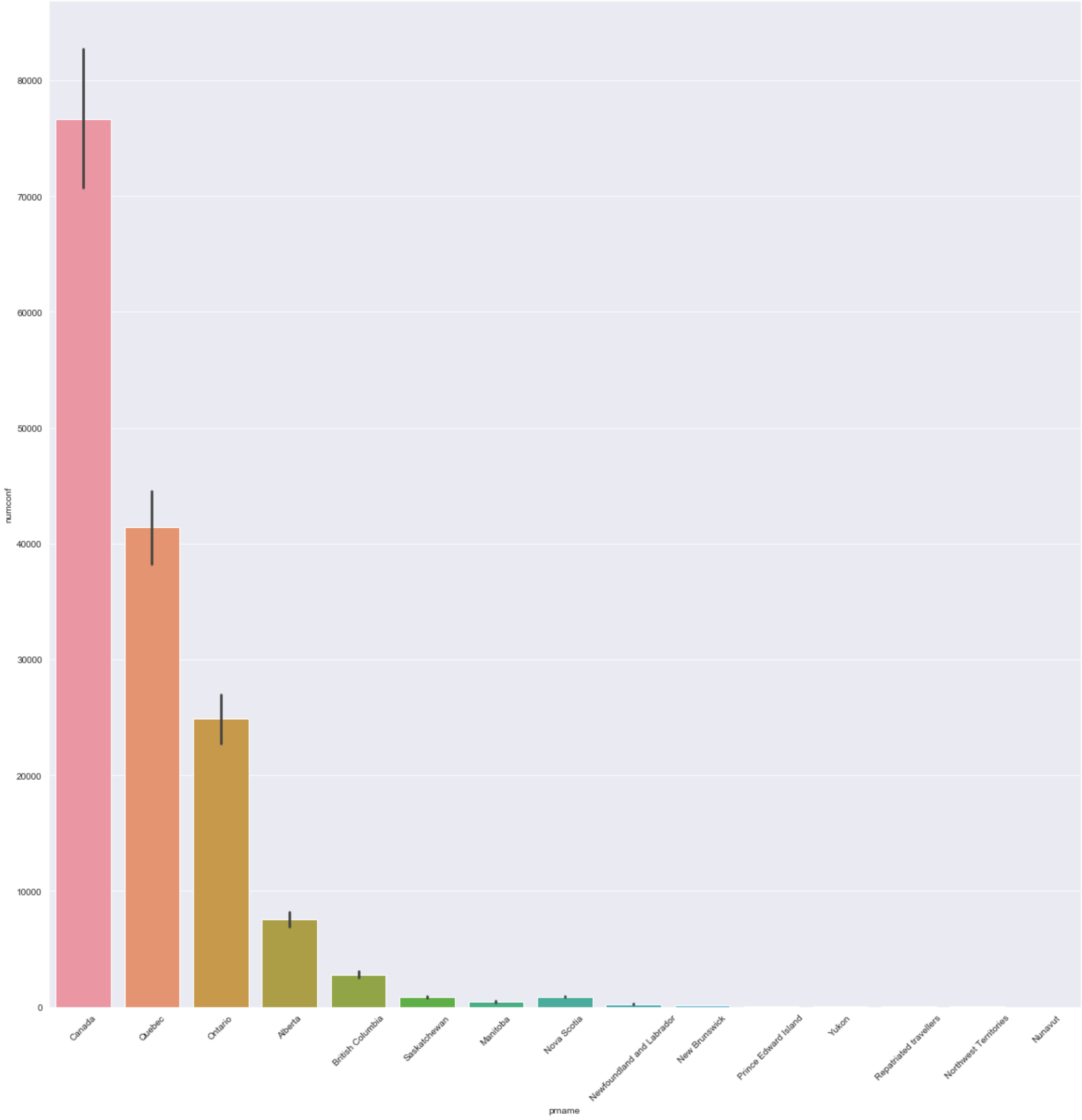
```
1         0        0.0          1        NaN         NaN  ...         0.0
2         0        0.0          4        NaN         NaN  ...         0.0
3         0        0.0          3        NaN         NaN  ...         0.0
4         0        0.0          4        NaN         NaN  ...         0.0
5         0        0.0          7        NaN         NaN  ...         0.0
6         0        0.0          3        NaN         NaN  ...         0.0
7         0        0.0          5        NaN         NaN  ...         0.0
8         0        0.0          8        NaN         NaN  ...         0.0
9         0        0.0          3        NaN         NaN  ...         0.0

   numtestedtoday  numrecoveredtoday  percentactive  numactive  rateactive  \
0             NaN                NaN          100.0        3.0        0.02
1             NaN                NaN          100.0        1.0        0.02
2             NaN                NaN          100.0        4.0        0.01
3             NaN                NaN          100.0        3.0        0.02
4             NaN                NaN          100.0        4.0        0.08
5             NaN                NaN          100.0        7.0        0.02
6             NaN                NaN          100.0        3.0        0.02
7             NaN                NaN          100.0        5.0        0.10
8             NaN                NaN          100.0        8.0        0.02
9             NaN                NaN          100.0        3.0        0.02

   numtotal_last14  ratetotal_last14  numdeaths_last14  ratedeaths_last14
0              NaN               NaN               NaN                NaN
1              NaN               NaN               NaN                NaN
2              NaN               NaN               NaN                NaN
3              NaN               NaN               NaN                NaN
4              NaN               NaN               NaN                NaN
5              NaN               NaN               NaN                NaN
6              NaN               NaN               NaN                NaN
7              NaN               NaN               NaN                NaN
8              NaN               NaN               NaN                NaN
9              NaN               NaN               NaN                NaN

[10 rows x 27 columns]
```

[23]:
```
#converting the date column to datetime format and extracting month from it.

from datetime import datetime

canada_covid_df['date'] = pd.to_datetime(canada_covid_df['date'],␣
 ↪infer_datetime_format=True)
canada_covid_df['Month'] = canada_covid_df['date'].dt.strftime('%b')
canada_covid_df['Month Number'] = canada_covid_df['date'].dt.month
```

[24]:
```
# lets see which province has been worst affected by covid-19
```

```
plt.figure(figsize=(20,20))
sns.barplot(x='prname',y='numconf', data=canada_covid_df.
 ↪sort_values('numconf',ascending=False))
plt.xticks(rotation = 45)
```

```
[24]: (array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14]),
       <a list of 15 Text xticklabel objects>)
```



- As we can see Ontario, Quebec and Alberta have been affected more in comparison to other province.

```
[25]: canada_covid_df = canada_covid_df[canada_covid_df['pruid'] != 1]
```

[26]:
```
#grouping the data based on month to get total num of active cases, num of␣
 ↪confirmed cases by month.

grouped = canada_covid_df.groupby('Month Number').sum()
grouped
```

[26]:
```
              pruid  numconf  numprob  numdeaths  numtotal    numtested  \
Month Number
1                94        4        0        0.0         4          0.0
2               752       85        0        0.0        85          0.0
3             13249    50358     1655      580.0     52013    2132606.0
4             17610   915192      412    39490.0    915602   15041059.0
5             18197  2327883      341   170408.0   2328224   38768195.0
6             17610  2969578      330   243829.0   2966043   66304217.0
7             18197  3402199      367   272939.0   3402566  105364050.0
8             18197  3794801      177   279940.0   3794978  148398825.0
9             11153  2570001       16   174134.0   2570001  114242526.0

              numrecover  percentrecover  ratetested  numtoday  ...  \
Month Number                                                    ...
1                    0.0            0.00         0.0         4  ...
2                    0.0            0.00         0.0        11  ...
3                 3833.0          686.82    878175.0      8515  ...
4               226779.0        12628.40   5979141.0     44687  ...
5              1146246.0        32015.86  11955583.0     37712  ...
6              1795740.0        34967.92  17910666.0     13257  ...
7              2608538.0        36379.41  26155620.0     12108  ...
8              3350930.0        36493.76  36044183.0     12636  ...
9              2261517.0        22620.69  27693228.0     13826  ...

              percentdeath  numtestedtoday  numrecoveredtoday  percentactive  \
Month Number
1                     0.00             0.0                0.0         200.00
2                     0.00             0.0                0.0        1600.00
3                   120.30        241214.0             1254.0       24992.87
4                   586.76        565311.0            24357.0       23684.76
5                  1035.85        859306.0            27481.0        5448.06
6                  1129.18       1104322.0            18702.0        2903.29
7                  1139.65       1280205.0            33633.0        2780.92
8                  1038.86       1454034.0            12991.0        2767.61
9                   586.63       1049755.0             9969.0        1492.66

              numactive  rateactive  numtotal_last14  ratetotal_last14  \
Month Number
1                   4.0        0.04              0.0              0.00
2                  85.0        1.22              0.0              0.00
3               47600.0     1193.98          40827.0            969.68
```

```
4              649060.0    11120.81         547037.0            8812.83
5             1011336.0    12685.37         591303.0            7324.75
6              926479.0    10913.93         240345.0            2667.96
7              521089.0     6842.93         157131.0            2582.58
8              164108.0     3314.17         175285.0            3692.10
9              134350.0     2524.67         156405.0            2848.64

              numdeaths_last14  ratedeaths_last14
Month Number
1                          0.0               0.00
2                          0.0               0.00
3                        435.0               6.57
4                      30518.0             366.01
5                      60065.0             690.36
6                      27183.0             302.14
7                       6095.0              72.74
8                       2777.0              53.04
9                       1249.0              22.25

[9 rows x 24 columns]
```

[27]:

```
#After grouping the grouping variable becomes the index so making it a label␣
 ↪again for visualization

grouped['Month Number'] = grouped.index
grouped
```

[27]:

```
              pruid  numconf  numprob  numdeaths  numtotal    numtested  \
Month Number
1                94        4        0        0.0         4          0.0
2               752       85        0        0.0        85          0.0
3             13249    50358     1655      580.0     52013    2132606.0
4             17610   915192      412    39490.0    915602   15041059.0
5             18197  2327883      341   170408.0   2328224   38768195.0
6             17610  2969578      330   243829.0   2966043   66304217.0
7             18197  3402199      367   272939.0   3402566  105364050.0
8             18197  3794801      177   279940.0   3794978  148398825.0
9             11153  2570001       16   174134.0   2570001  114242526.0

              numrecover  percentrecover  ratetested  numtoday  …  \
Month Number                                                    …
1                    0.0            0.00         0.0         4  …
2                    0.0            0.00         0.0        11  …
3                 3833.0          686.82    878175.0      8515  …
4               226779.0        12628.40   5979141.0     44687  …
5              1146246.0        32015.86  11955583.0     37712  …
6              1795740.0        34967.92  17910666.0     13257  …
```

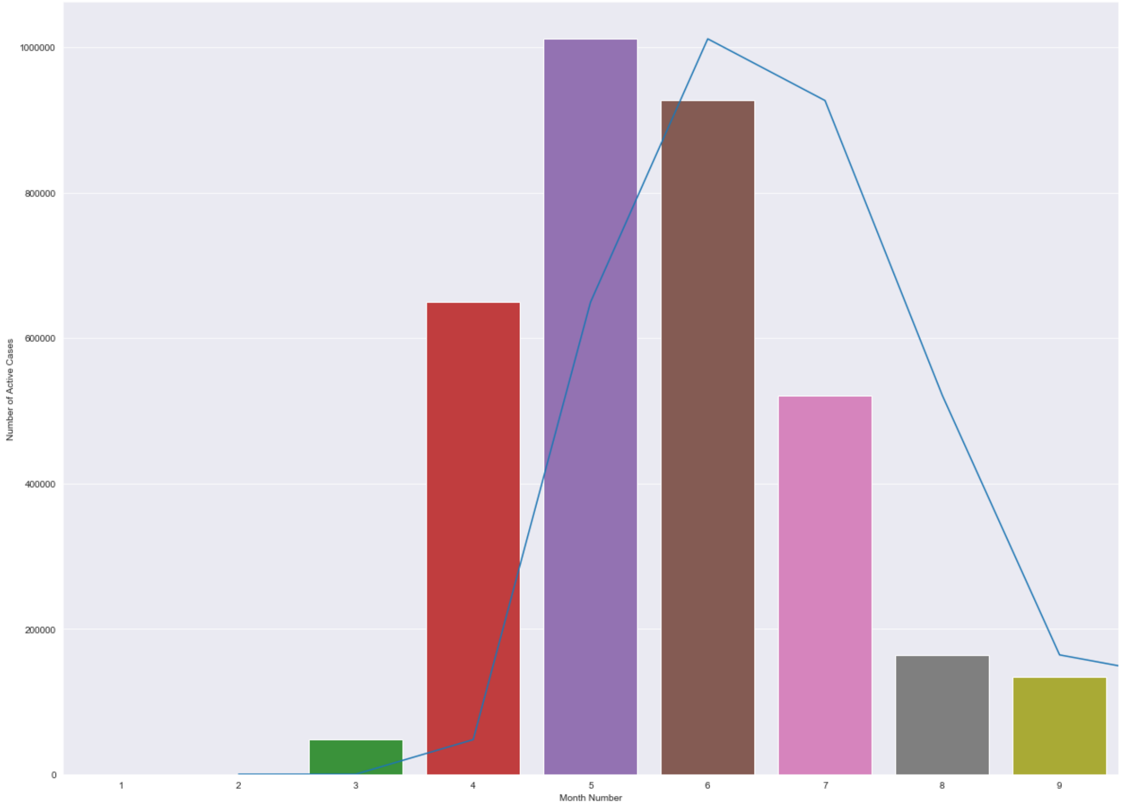
```
7              2608538.0        36379.41  26155620.0     12108  …
8              3350930.0        36493.76  36044183.0     12636  …
9              2261517.0        22620.69  27693228.0     13826  …

              numtestedtoday  numrecoveredtoday  percentactive  numactive  \
Month Number
1                        0.0                0.0         200.00        4.0
2                        0.0                0.0        1600.00       85.0
3                   241214.0             1254.0       24992.87    47600.0
4                   565311.0            24357.0       23684.76   649060.0
5                   859306.0            27481.0        5448.06  1011336.0
6                  1104322.0            18702.0        2903.29   926479.0
7                  1280205.0            33633.0        2780.92   521089.0
8                  1454034.0            12991.0        2767.61   164108.0
9                  1049755.0             9969.0        1492.66   134350.0

              rateactive  numtotal_last14  ratetotal_last14  numdeaths_last14  \
Month Number
1                   0.04              0.0              0.00               0.0
2                   1.22              0.0              0.00               0.0
3                1193.98          40827.0            969.68             435.0
4               11120.81         547037.0           8812.83           30518.0
5               12685.37         591303.0           7324.75           60065.0
6               10913.93         240345.0           2667.96           27183.0
7                6842.93         157131.0           2582.58            6095.0
8                3314.17         175285.0           3692.10            2777.0
9                2524.67         156405.0           2848.64            1249.0

              ratedeaths_last14  Month Number
Month Number
1                          0.00             1
2                          0.00             2
3                          6.57             3
4                        366.01             4
5                        690.36             5
6                        302.14             6
7                         72.74             7
8                         53.04             8
9                         22.25             9

[9 rows x 25 columns]
```

[28]:

```
#plotting the grouped data for visualization.

plt.figure(figsize = (20,15))
sns.lineplot(x = 'Month Number' , y = 'numactive', data = grouped)
sns.barplot(x = 'Month Number' , y = 'numactive', data = grouped)
```

```
plt.ylabel("Number of Active Cases")
```

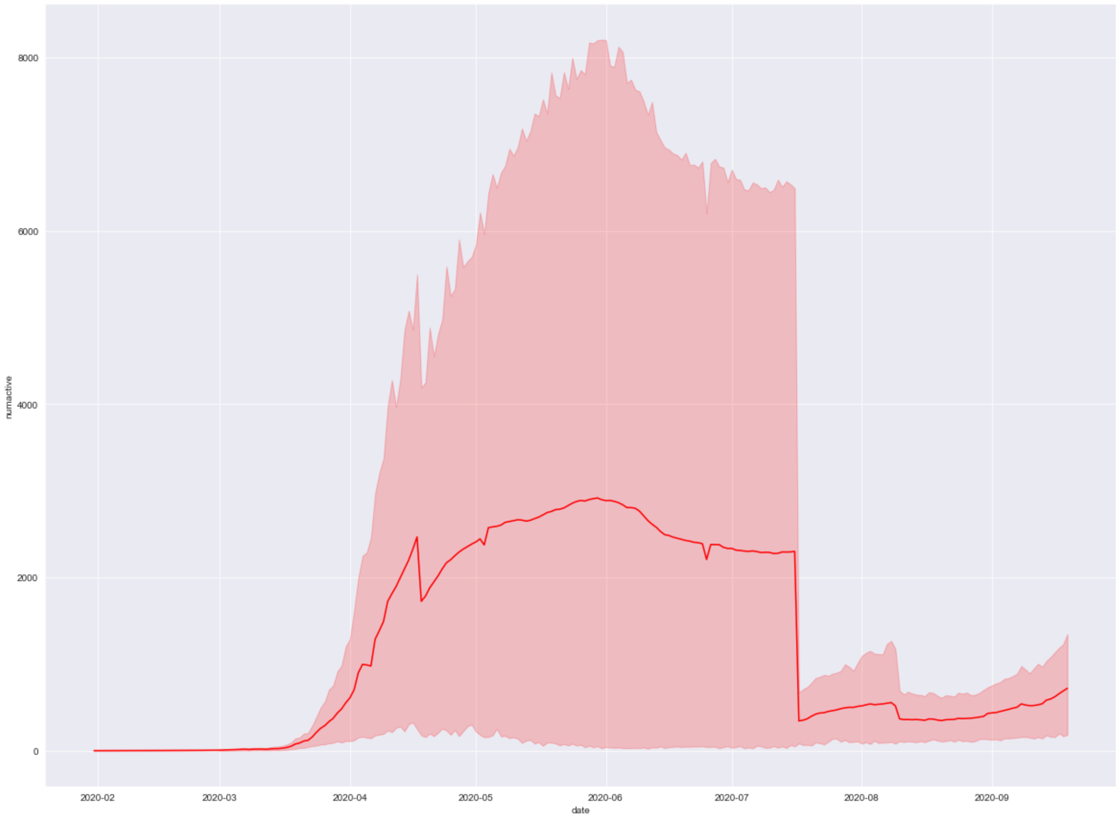
[28]:
```
Text(0, 0.5, 'Number of Active Cases')
```



- Here we can see maximum number of active cases were reported in the month **May**.
- After that we can see a decline in number of active cases. Which indicates the **effectiveness of school closing** along with other social distancing measures.
- There is a percentage drop of **~86%** in number of active cases from the Month of May to September.

[29]:
```
# New Cases by Date

plt.figure(figsize=(20,15))
sns.lineplot(y = 'numactive', x = 'date', data = canada_covid_df, color = 'red')
```

[29]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x16ca996e4c8>
```



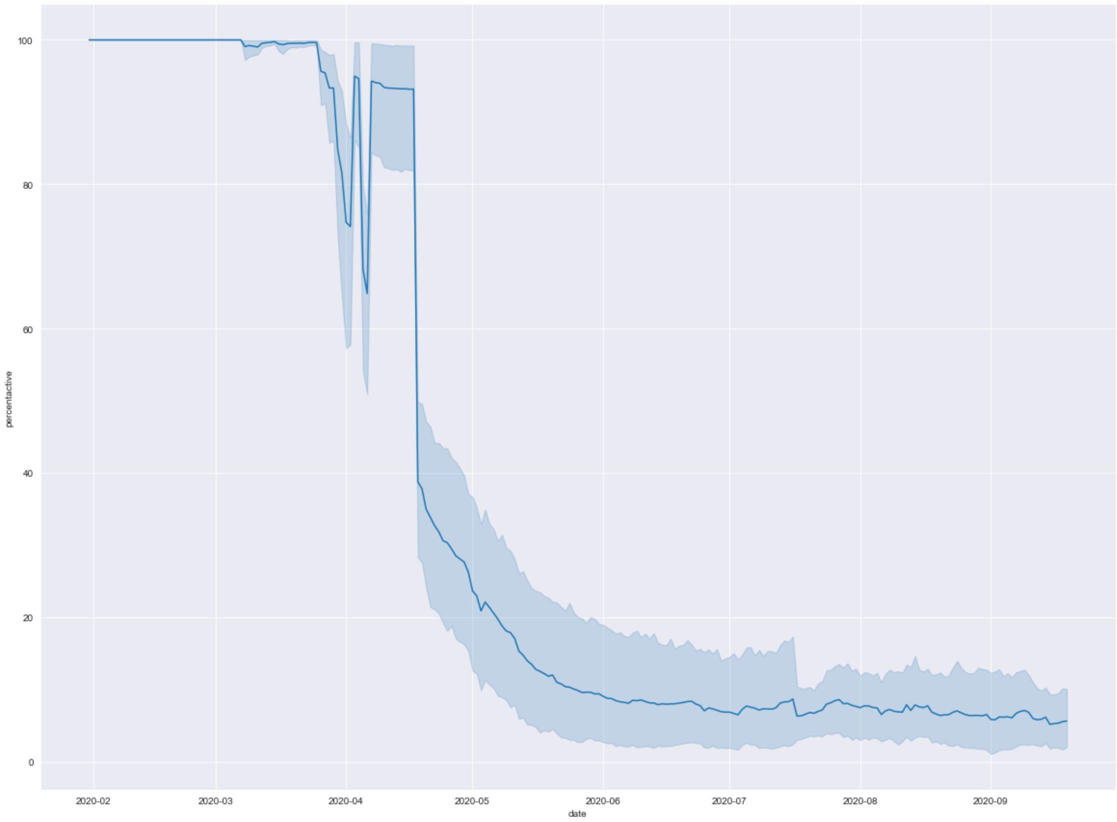
- This graph shows timeline variation of **num of active cases** in canada.

[30]:

```
# Rate of new cases by previous date

plt.figure(figsize=(20,15))
sns.lineplot(y = 'percentactive', x = 'date', data = canada_covid_df)
```

[30]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16ca99b0b88>
```

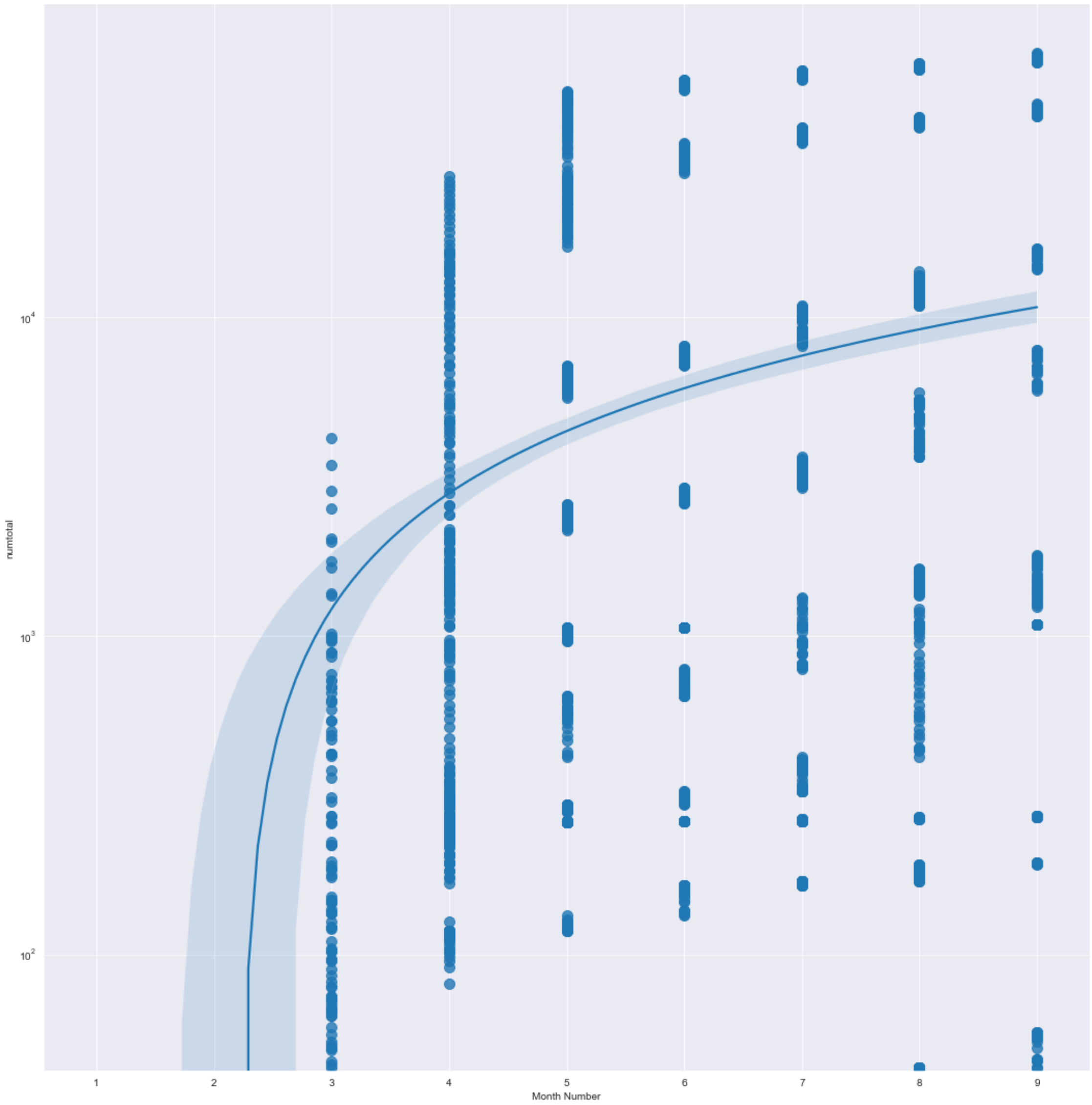


- **% of active cases** dropped significantly after **april**. This can be attributed to nationwide **Shutdown**.
- This graph also shows how **Shutdown** in Global pandemics can help nations contain the spread of the virus.

Total Confirmed cases (log-scale)

[31]:
```
# Total Confirmed cases log scale

grid = sns.lmplot('Month Number', 'numtotal', canada_covid_df, height=15,␣
 ↪truncate=True, scatter_kws={"s": 100})
grid.set(yscale="log")
```

[31]:
```
<seaborn.axisgrid.FacetGrid at 0x16ca9a48c08>
```



- why log scale graph?
- Logarithmic graph can show the **trend of COVID-19 from much earlier** because of the way the scale has been compressed. This graph helps us to understand the **trend of flatten the curve**.
- We can see that **closing of school** along with other measures have helped **CANADA** to curb the spread of virus, especially after **May**.
- It also helped **CANADA** to flatten the COVID-19 curve.

One question still remains is that how effective the closing of the school is all alone?

1. For this we will analyze data based on age groups.

We will use data provided by Alberta Innovates

1. Lets load the data which is present in Data/covid19 folder and clean it.

- Data Source - For more info please click here.

[32]:

```
# Load data

canada_age_gender_df = pd.read_csv('../covid_data/Data/Covid-19/
↪public-covid-19-cases-canada.csv.csv')
canada_age_gender_df.head(10)
```

[32]:

```
   case_id  provincial_case_id    age     sex      health_region province  \
0      NaN                   1  50-59    Male            Toronto  Ontario
1      NaN                   2  50-59  Female            Toronto  Ontario
2      NaN                   1  40-49    Male       Not Reported       BC
3      NaN                   3  20-29  Female   Middlesex-London  Ontario
4      NaN                   2  50-59  Female  Vancouver Coastal       BC
5      NaN                   3  30-39    Male       Not Reported       BC
6      NaN                   4  30-39  Female       Not Reported       BC
7      NaN                   5  30-39  Female           Interior       BC
8      NaN                   6  30-39  Female             Fraser       BC
9      NaN                   4  20-29  Female            Toronto  Ontario

  country             date_report             report_week has_travel_history  \
0  Canada  2020-01-25 00:00:00+00  2020-01-19 00:00:00+00                  t
1  Canada  2020-01-27 00:00:00+00  2020-01-26 00:00:00+00                  t
2  Canada  2020-01-28 00:00:00+00  2020-01-26 00:00:00+00                  t
3  Canada  2020-01-31 00:00:00+00  2020-01-26 00:00:00+00                  t
4  Canada  2020-02-04 00:00:00+00  2020-02-02 00:00:00+00                  f
5  Canada  2020-02-06 00:00:00+00  2020-02-02 00:00:00+00                  t
6  Canada  2020-02-06 00:00:00+00  2020-02-02 00:00:00+00                  t
7  Canada  2020-02-14 00:00:00+00  2020-02-09 00:00:00+00                  t
8  Canada  2020-02-20 00:00:00+00  2020-02-16 00:00:00+00                  t
9  Canada  2020-02-23 00:00:00+00  2020-02-23 00:00:00+00                  t

  locally_acquired                                        case_source
0              NaN  (1) https://news.ontario.ca/mohltc/en/2020/01/…
1              NaN  (1) https://news.ontario.ca/mohltc/en/2020/01/…
2              NaN  https://news.gov.bc.ca/releases/2020HLTH0015-0…
3              NaN  (1) https://news.ontario.ca/mohltc/en/2020/01/…
4    Close Contact  https://news.gov.bc.ca/releases/2020HLTH0023-0…
5              NaN  https://news.gov.bc.ca/releases/2020HLTH0025-0…
6              NaN  https://news.gov.bc.ca/releases/2020HLTH0025-0…
7              NaN  (1) https://news.gov.bc.ca/releases/2020HLTH00…
8              NaN  (1) https://news.gov.bc.ca/releases/2020HLTH00…
9              NaN  (1) https://news.ontario.ca/mohltc/en/2020/02/…
```

[33]:

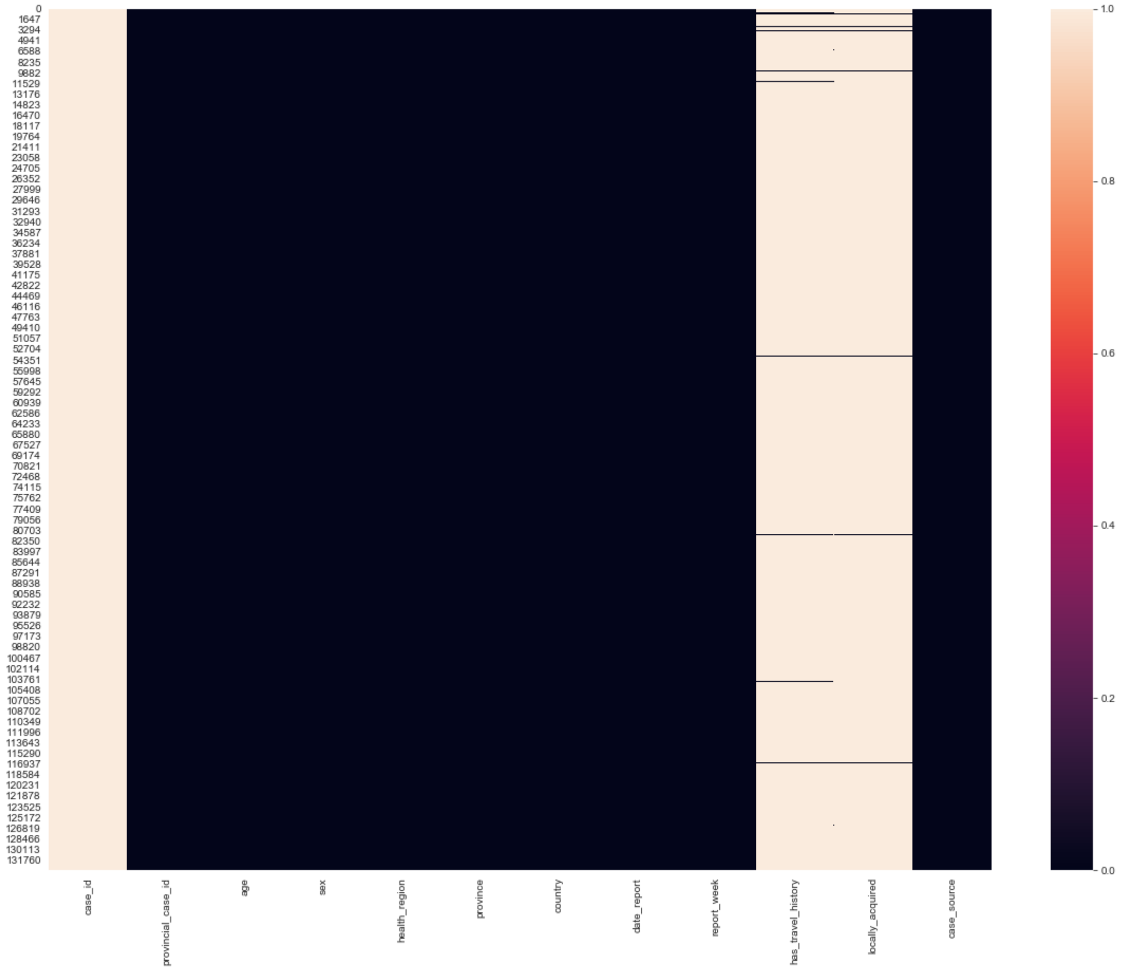
```
# Info of the data
```

```
canada_age_gender_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 133347 entries, 0 to 133346
Data columns (total 12 columns):
 #   Column               Non-Null Count   Dtype
---  ------               --------------   -----
 0   case_id              0 non-null       float64
 1   provincial_case_id   133347 non-null  int64
 2   age                  133347 non-null  object
 3   sex                  133347 non-null  object
 4   health_region        133347 non-null  object
 5   province             133347 non-null  object
 6   country              133347 non-null  object
 7   date_report          133347 non-null  object
 8   report_week          133347 non-null  object
 9   has_travel_history   1762 non-null    object
 10  locally_acquired     1099 non-null    object
 11  case_source          133347 non-null  object
dtypes: float64(1), int64(1), object(10)
memory usage: 12.2+ MB
```

[34]:
```
# Checking null variables in the dataset

plt.figure(figsize=(20,15))
sns.heatmap(canada_age_gender_df.isnull())
```

[34]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x16ca9a88dc8>
```



- Columns case_id, has_travel_history, locally_acquired have null values.

1. case_id is of no use for us, as we are focusing on answering age based question.
2. has_travel_history might help us in differentiating the case from locally_acquired cases.

[35]:
```
# Dropping case_id

canada_age_gender_df.drop('case_id',axis=1,inplace=True)
```

[36]:
```
canada_age_gender_df['has_travel_history']
```

[36]:
```
0          t
1          t
2          t
3          t
4          f
```

```
          …
133342    NaN
133343    NaN
133344    NaN
133345    NaN
133346    NaN
Name: has_travel_history, Length: 133347, dtype: object
```

[37]:

```
# how many categorical variable in column has_travel_history

canada_age_gender_df['has_travel_history'].unique()
```

[37]:

```
array(['t', 'f', nan], dtype=object)
```

[38]:

```
# Making it numerical column as it will be easier to work with numerical data.

canada_age_gender_df['has_travel_history'] =␣
 ↪(canada_age_gender_df['has_travel_history'].apply(lambda x : 1 if (x == 't')
                                                                   else 0))
```

- We changed the column based on following:

1. All the `t' which meant that the patient had a travel history are converted to 1.
2. All the `f' which meant that the patient do not have a travel history are converted to 0.

[39]:

```
# Categorical variables in locally_acquired column

canada_age_gender_df['locally_acquired'].unique()
```

[39]:

```
array([nan, 'Close Contact', 'Community', 'Close contact',
       'close contact', '1'], dtype=object)
```

[40]:

```
canada_age_gender_df[canada_age_gender_df['locally_acquired']=='1']
```

[40]:

```
        provincial_case_id   age     sex   health_region province country  \
125229               42712  0-17  Female  Simcoe Muskoka  Ontario  Canada

                     date_report               report_week  has_travel_history  \
125229  2020-08-19 00:00:00+00  2020-08-16 00:00:00+00                   0

       locally_acquired                                         case_source
125229                1  https://www.simcoemuskokahealthstats.org/topic…
```

[41]:

```
canada_age_gender_df[canada_age_gender_df['locally_acquired']=='Community']
```

[41]:

```
        provincial_case_id    age     sex   health_region province  country  \
45                      21  50-59  Female          Fraser       BC   Canada
92                      38  90-99    Male          Fraser       BC   Canada
93                      39  40-49    Male          Fraser       BC   Canada
94                      37  50-59    Male         Sudbury  Ontario   Canada
109                     41  60-69  Female          Fraser       BC   Canada
…                        …      …       …               …        …        …
123039               42173  35-44    Male  Simcoe Muskoka  Ontario   Canada
125676               42852  50-59  Female         Sudbury  Ontario   Canada
126414               43073  40-49    Male         Sudbury  Ontario   Canada
127740               43379  35-44  Female  Simcoe Muskoka  Ontario   Canada
132272               44466    >80    Male  Simcoe Muskoka  Ontario   Canada

                   date_report             report_week  has_travel_history  \
45      2020-03-05 00:00:00+00  2020-03-01 00:00:00+00                   0
92      2020-03-10 00:00:00+00  2020-03-08 00:00:00+00                   0
93      2020-03-10 00:00:00+00  2020-03-08 00:00:00+00                   0
94      2020-03-10 00:00:00+00  2020-03-08 00:00:00+00                   0
109     2020-03-11 00:00:00+00  2020-03-08 00:00:00+00                   0
…                            …                       …                  …
123039  2020-08-13 00:00:00+00  2020-08-09 00:00:00+00                   0
125676  2020-08-19 00:00:00+00  2020-08-16 00:00:00+00                   0
126414  2020-08-22 00:00:00+00  2020-08-16 00:00:00+00                   0
127740  2020-08-25 00:00:00+00  2020-08-23 00:00:00+00                   0
132272  2020-09-03 00:00:00+00  2020-08-30 00:00:00+00                   0

       locally_acquired                                        case_source
45            Community  https://news.gov.bc.ca/releases/2020HLTH0062-0…
92            Community  https://news.gov.bc.ca/releases/2020HLTH0072-0…
93            Community  https://news.gov.bc.ca/releases/2020HLTH0072-0…
94            Community  https://www.phsd.ca/news/first-case-of-covid-1…
109           Community  https://news.gov.bc.ca/releases/2020HLTH0074-0…
…                     …                                                  …
123039        Community  http://www.simcoemuskokahealthstats.org/topics…
125676        Community  https://www.phsd.ca/health-topics-programs/dis…
126414        Community  https://www.phsd.ca/news/public-service-announ…
127740        Community  https://www.simcoemuskokahealthstats.org/topic…
132272        Community  https://www.simcoemuskokahealthstats.org/topic…

[405 rows x 11 columns]
```

[42]:

```
canada_age_gender_df['locally_acquired']
```

[42]:

```
0                   NaN
1                   NaN
2                   NaN
3                   NaN
```

```
4         Close Contact
                ...
133342              NaN
133343              NaN
133344              NaN
133345              NaN
133346              NaN
Name: locally_acquired, Length: 133347, dtype: object
```

[43]:
```
# Converting the column to numerical values.

canada_age_gender_df['locally_acquired'] =␣
 ↪canada_age_gender_df['locally_acquired'].apply(lambda x: 0 if pd.isnull(x)␣
 ↪else 1)
```

[44]:
```
# We don't need case_source for this analysis, so we will drop that.

canada_age_gender_df.drop('case_source', inplace = True, axis = 1)
```

[45]:
```
canada_age_gender_df
```

[45]:
```
        provincial_case_id          age          sex      health_region  \
0                        1        50-59         Male            Toronto
1                        2        50-59       Female            Toronto
2                        1        40-49         Male       Not Reported
3                        3        20-29       Female   Middlesex-London
4                        2        50-59       Female  Vancouver Coastal
...                    ...          ...          ...                ...
133342               44851  Not Reported  Not Reported              York
133343               44852  Not Reported  Not Reported              York
133344               44853  Not Reported  Not Reported              York
133345               44854  Not Reported  Not Reported              York
133346               44855  Not Reported  Not Reported              York

       province country              date_report              report_week  \
0       Ontario  Canada  2020-01-25 00:00:00+00  2020-01-19 00:00:00+00
1       Ontario  Canada  2020-01-27 00:00:00+00  2020-01-26 00:00:00+00
2            BC  Canada  2020-01-28 00:00:00+00  2020-01-26 00:00:00+00
3       Ontario  Canada  2020-01-31 00:00:00+00  2020-01-26 00:00:00+00
4            BC  Canada  2020-02-04 00:00:00+00  2020-02-02 00:00:00+00
...         ...     ...                     ...                      ...
133342  Ontario  Canada  2020-09-05 00:00:00+00  2020-08-30 00:00:00+00
133343  Ontario  Canada  2020-09-05 00:00:00+00  2020-08-30 00:00:00+00
133344  Ontario  Canada  2020-09-05 00:00:00+00  2020-08-30 00:00:00+00
133345  Ontario  Canada  2020-09-05 00:00:00+00  2020-08-30 00:00:00+00
133346  Ontario  Canada  2020-09-05 00:00:00+00  2020-08-30 00:00:00+00
```

```
        has_travel_history  locally_acquired
0                        1                 0
1                        1                 0
2                        1                 0
3                        1                 0
4                        0                 1
…                      …                …
133342                   0                 0
133343                   0                 0
133344                   0                 0
133345                   0                 0
133346                   0                 0

[133347 rows x 10 columns]
```

[46]:
```
# Age categories

canada_age_gender_df['age'].unique()
```

[46]:
```
array(['50-59', '40-49', '20-29', '30-39', '60-69', '80-89', '70-79',
       'Not Reported', '10-19', '90-99', '<18', '<1', '2', '61', '50',
       '<10', '<20', '20-39', '60-79', '40-59', '100-109', '<19', '>90',
       '65-79', '18-34', '45-64', '35-44', '80+', '0-17', '90+', '45-65',
       '>80', '30-49', '0-9', '18-24', '0-19'], dtype=object)
```

[47]:
```
# Dropping cases where age was not reported

canada_age_gender_df = canada_age_gender_df[canada_age_gender_df['age']!='Not␣
 ↪Reported']
```

[48]:
```
canada_age_gender_df['age'].unique()
```

[48]:
```
array(['50-59', '40-49', '20-29', '30-39', '60-69', '80-89', '70-79',
       '10-19', '90-99', '<18', '<1', '2', '61', '50', '<10', '<20',
       '20-39', '60-79', '40-59', '100-109', '<19', '>90', '65-79',
       '18-34', '45-64', '35-44', '80+', '0-17', '90+', '45-65', '>80',
       '30-49', '0-9', '18-24', '0-19'], dtype=object)
```

[49]:
```
# sex categories

canada_age_gender_df['sex'].unique()
```

[49]:
```
array(['Male', 'Female', 'Not Reported'], dtype=object)
```

[50]:
```
# Dropping sex category where sex was not reported
```

```
canada_age_gender_df = canada_age_gender_df[canada_age_gender_df['sex']!='Not␣
↪Reported']
```

```
[51]: canada_age_gender_df['sex'].unique()
```

```
[51]: array(['Male', 'Female'], dtype=object)
```

```
[52]: canada_age_gender_df['date_report'] = pd.
       ↪to_datetime(canada_age_gender_df['date_report'], infer_datetime_format=True)
```

```
[53]: canada_age_gender_df.drop('report_week',inplace=True,axis=1)
```

```
[54]: # Clean Dataset

      canada_age_gender_df
```

```
[54]:         provincial_case_id    age     sex          health_region province  \
      0                        1  50-59    Male                Toronto  Ontario
      1                        2  50-59  Female                Toronto  Ontario
      2                        1  40-49    Male           Not Reported       BC
      3                        3  20-29  Female       Middlesex-London  Ontario
      4                        2  50-59  Female      Vancouver Coastal       BC
      …                        …      …      …                      …        …
      132683                  47  10-19    Male   Prince Edward Island      PEI
      132872               44583  20-29    Male              Porcupine  Ontario
      132923               44634  18-34    Male         Simcoe Muskoka  Ontario
      132924               44635  18-34    Male         Simcoe Muskoka  Ontario
      133009                 270  20-39  Female                Eastern       NL

             country date_report  has_travel_history  locally_acquired
      0       Canada  2020-01-25                   1                 0
      1       Canada  2020-01-27                   1                 0
      2       Canada  2020-01-28                   1                 0
      3       Canada  2020-01-31                   1                 0
      4       Canada  2020-02-04                   0                 1
      …          …         …                  …                 …
      132683  Canada  2020-09-04                   1                 0
      132872  Canada  2020-09-04                   1                 0
      132923  Canada  2020-09-04                   0                 0
      132924  Canada  2020-09-04                   0                 0
      133009  Canada  2020-09-05                   1                 0

      [5490 rows x 9 columns]
```

```
[55]: # Reducing age column to only 2 categorical variable namely 'under20' and '20␣
       ↪and older'
```

```
under20 =␣
↪['0-17','0-19','0-9','10-19','18-24','18-34','<1','<10','<18','<19','<20']

def convert_agegroup(x):

    if x in under20:
        return 'under20'
    else:
        return '20 and older'
```

[56]:
```
canada_age_gender_df['age'] = canada_age_gender_df['age'].apply(lambda x :␣
↪convert_agegroup(x))
```

[57]:
```
canada_age_gender_df.head(10)
```

[57]:
```
   provincial_case_id           age     sex      health_region province  \
0                   1  20 and older    Male            Toronto  Ontario
1                   2  20 and older  Female            Toronto  Ontario
2                   1  20 and older    Male       Not Reported       BC
3                   3  20 and older  Female   Middlesex-London  Ontario
4                   2  20 and older  Female  Vancouver Coastal       BC
5                   3  20 and older    Male       Not Reported       BC
6                   4  20 and older  Female       Not Reported       BC
7                   5  20 and older  Female           Interior       BC
8                   6  20 and older  Female            Fraser       BC
9                   4  20 and older  Female            Toronto  Ontario

  country date_report  has_travel_history  locally_acquired
0  Canada  2020-01-25                   1                 0
1  Canada  2020-01-27                   1                 0
2  Canada  2020-01-28                   1                 0
3  Canada  2020-01-31                   1                 0
4  Canada  2020-02-04                   0                 1
5  Canada  2020-02-06                   1                 0
6  Canada  2020-02-06                   1                 0
7  Canada  2020-02-14                   1                 0
8  Canada  2020-02-20                   1                 0
9  Canada  2020-02-23                   1                 0
```

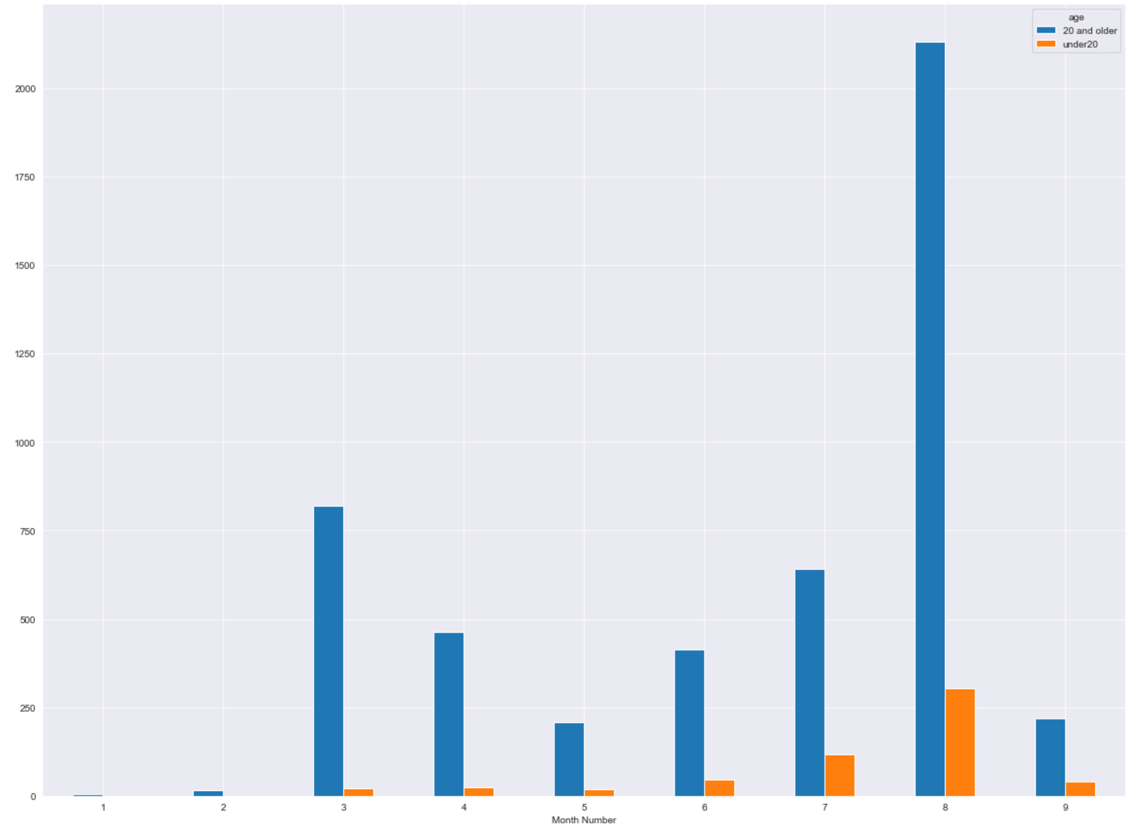
[58]:
```
# Getting Month number and month from the date report

canada_age_gender_df['Month'] = canada_age_gender_df['date_report'].dt.
↪strftime('%b')
canada_age_gender_df['Month Number'] = canada_age_gender_df['date_report'].dt.
↪month
```

[59]:
```
# grouping by age and month to see the distribution.

month_age_df = canada_age_gender_df.groupby(['Month Number','age']).size().
 ↪unstack(fill_value=0)
print(month_age_df)
```

```
age           20 and older  under20
Month Number
1                        4        0
2                       16        0
3                      820       21
4                      463       25
5                      209       18
6                      414       47
7                      640      118
8                     2130      304
9                      220       41
```

[60]:
```
#plotting the data

month_age_df.plot.bar(figsize=(20,15))
plt.xticks(rotation = 0)
```

[60]:
```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8]), <a list of 9 Text xticklabel objects>)
```



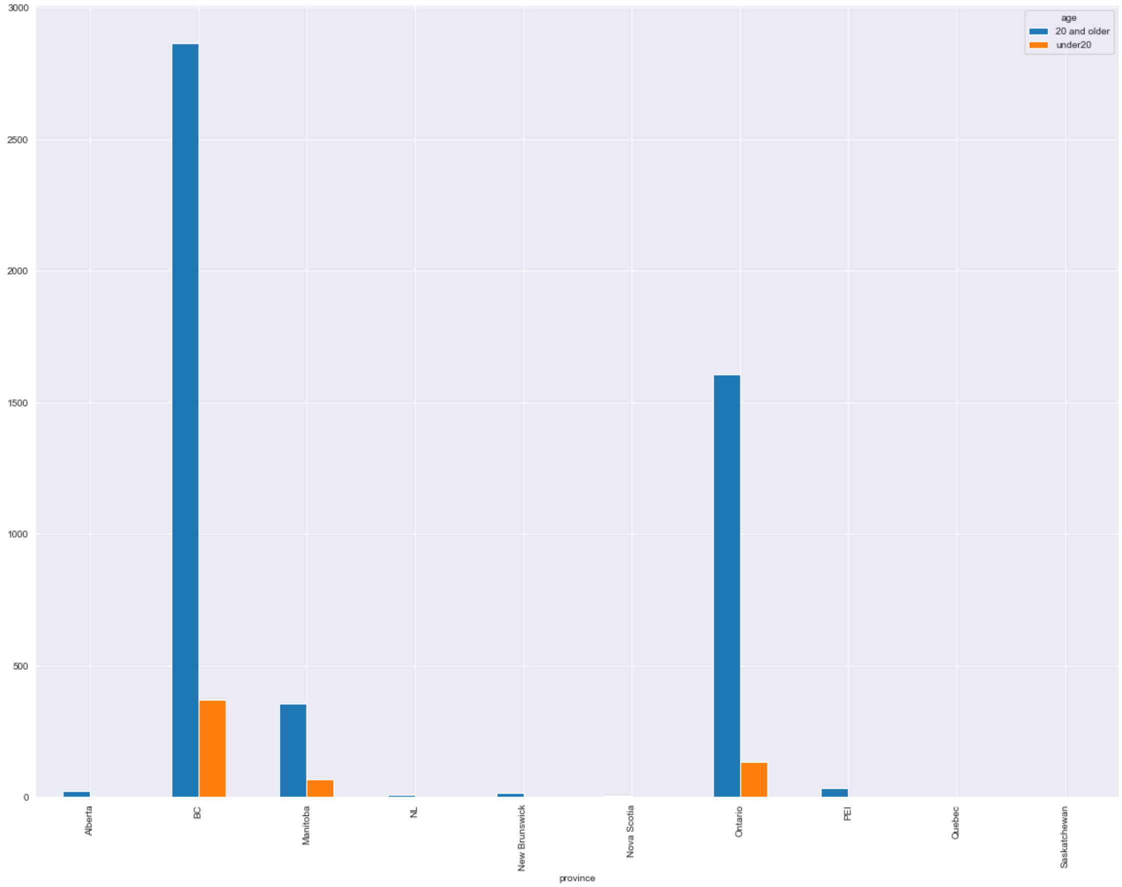
- From this graph we can see that **school closure** has helped Canadian government contain the spread of virus.
- Recent modelling studies of COVID-19 predict that school closures alone would prevent only **2-4%** of deaths only, which is much less than other social distancing interventions. Source (School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review).

[61]:
```
# provincial age distributed COVID-19 data

province_age_df = canada_age_gender_df.groupby(['province','age']).size().
↪unstack(fill_value=0)
print(province_age_df)
province_age_df.plot.bar(figsize=(20,15))
```

```
age            20 and older  under20
province
Alberta                  22        0
BC                     2865      369
Manitoba                355       67
NL                        9        1
New Brunswick            17        1
Nova Scotia               6        0
```

```
Ontario                  1605      135
PEI                        34        1
Quebec                      2        0
Saskatchewan                1        0
```

```
[61]: <matplotlib.axes._subplots.AxesSubplot at 0x16cacf15908>
```



- We can also see how province wise this distribution is. Age group of **Under20** is less affected then age group of **20 and above**.
- We can see this data doesn't give us much of information on provincial level, because there are many good sources for raw tally of cases, deaths and tests across the nation, there is no central repository in Canada for age-related COVID-19 data.
- Some provinces offer easy access to data, while some release it in press only.
- On Aug. 22, **Manitoba** suddenly stopped releasing age and public health region data for individual cases, making it impossible to easily calculate the recent share of youth cases.
- **Nova Scotia**, meanwhile, has never provided detailed age-specific information.

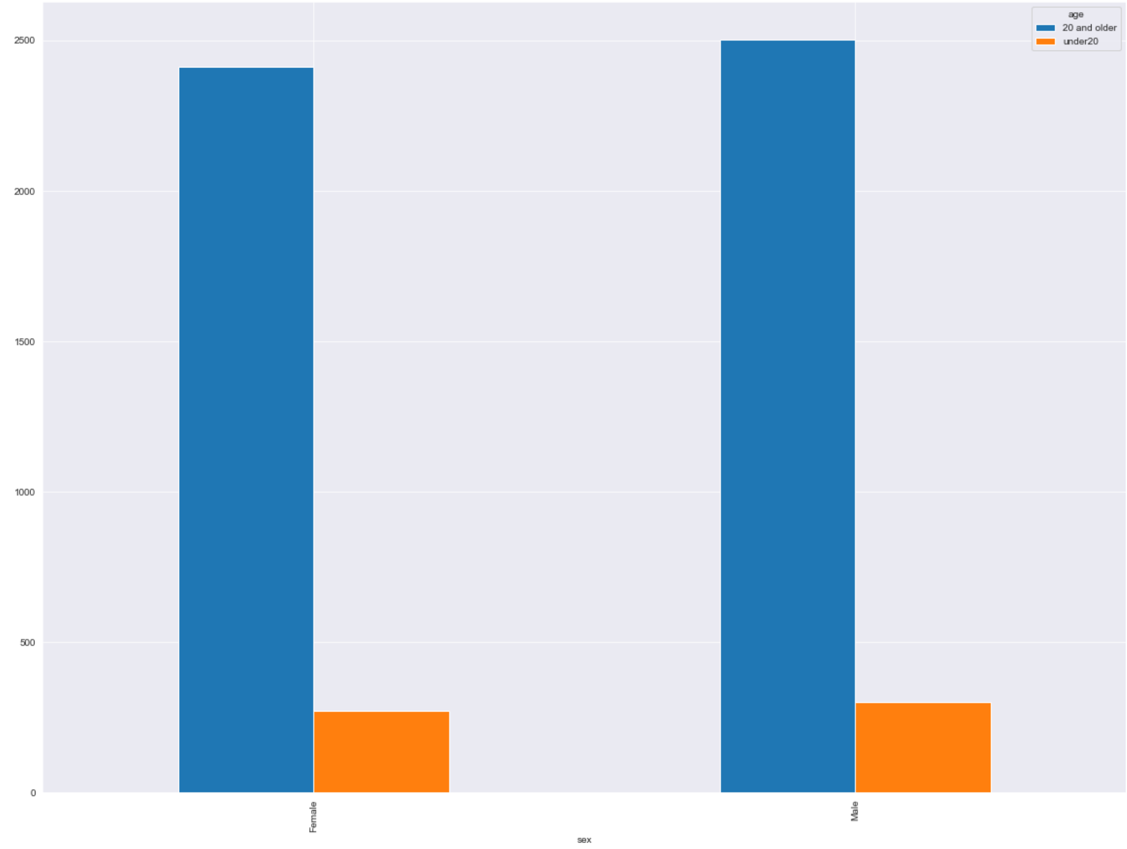
[62]:

```
# grouping of the data by sex and age

sex_age_df = canada_age_gender_df.groupby(['sex','age']).size().
 ↪unstack(fill_value=0)
print(sex_age_df)
sex_age_df.plot.bar(figsize=(20,15))
```

```
age     20 and older  under20
sex
Female          2413      272
Male            2503      302
```

[62]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x16cad3a22c8>
```



- There is not much difference in the number of males and females getting sick by COVID-19. Its almost the same.

Now we will have a more deeper look in COVID-19 Hospitalization and Death by Age

1. The data has been provided by Centers for Disease Control and Prevention.

2. This will help us further analyze which age group is more affected by COVID-19.
3. This Analysis can be used to make policies which will help prevent the more affected age group in future pandemics.

[66]:

```
# load Data

covid_by_age_df = pd.read_excel('../covid_data/Data/Covid-19/age_distribution.
 ↪xlsx', header=[0,1])
covid_by_age_df
```

[66]:

```
   Unnamed: 0_level_0 Unnamed: 1_level_0 Total  (incl. age unknown)          \
                 Week        No. of Labs                Spec Tested   # Pos
0              202010                 80                       8297     973
1              202011                 86                      35674    3484
2              202012                 87                      69707    6824
3              202013                 89                      66523   10757
4              202014                 89                      79548   14103
5              202015                 88                      83211   15090
6              202016                 87                      84676   15297
7              202017                 86                     130726   21362
8              202018                 87                     151196   19406
9              202019                 87                     165675   17665
10             202020                 89                     183690   15391
11             202021                 88                     218820   14474
12             202022                 88                     228052   12591
13             202023                 88                     249787   11867
14             202024                 89                     255468   12696
15             202025                 88                     255212   13760
16             202026                 89                     271934   17308
17             202027                 90                     279122   17203
18             202028                 90                     346571   26448
19             202029                 90                     364816   28654
20             202030                 90                     327391   27568
21             202031                 90                     309075   24461
22             202032                 89                     303096   21430
23             202033                 88                     292381   19163
24             202034                 90                     279778   16933
25             202035                 88                     261249   16085
26             202036                 88                     281940   15153
27             202037                 86                     234583   10634
28              Total                  .                    5818198  446780

           0-4 years              5-17 years              18-49 years          \
   % Pos Spec Tested # Pos % Pos Spec Tested  # Pos % Pos Spec Tested   # Pos
0   11.7         228    10   4.4         586     42   7.2        3179     318
1    9.8         975    20   2.1        1966     83   4.2       15549    1371
```

2	9.8	1576	36	2.3	2328	87	3.7	31820	2654
3	16.2	1265	47	3.7	1433	80	5.6	29896	3812
4	17.7	1128	64	5.7	1459	170	11.7	34902	4565
5	18.1	915	43	4.7	1638	168	10.3	35079	4419
6	18.1	798	66	8.3	1483	148	10.0	36425	5276
7	16.3	914	55	6.0	2545	334	13.1	59368	8618
8	12.8	1194	108	9.0	3952	478	12.1	66331	8053
9	10.7	1731	104	6.0	4412	526	11.9	73029	7731
10	8.4	1415	108	7.6	5156	516	10.0	79248	6993
11	6.6	1829	125	6.8	6247	635	10.2	97119	6754
12	5.5	1638	146	8.9	6307	637	10.1	101718	5910
13	4.8	1953	163	8.3	7129	691	9.7	115691	6091
14	5.0	2229	215	9.6	8500	904	10.6	121119	6772
15	5.4	2353	214	9.1	9866	1036	10.5	121704	7646
16	6.4	2879	274	9.5	12032	1346	11.2	136644	10101
17	6.2	3153	299	9.5	12946	1301	10.0	143309	10156
18	7.6	4427	399	9.0	17640	1932	11.0	180239	15354
19	7.9	4849	454	9.4	21391	2485	11.6	192798	16748
20	8.4	4368	513	11.7	19431	2495	12.8	175449	15881
21	7.9	3735	410	11.0	17101	2298	13.4	163996	13667
22	7.1	3532	407	11.5	15970	1967	12.3	162304	11896
23	6.6	3344	326	9.7	15582	1799	11.5	158920	10641
24	6.1	3022	284	9.4	14235	1488	10.5	155170	9444
25	6.2	3002	270	9.0	15233	1493	9.8	142126	9355
26	5.4	3076	259	8.4	17001	1355	8.0	154210	8926
27	4.5	2346	149	6.4	14098	1034	7.3	125211	6024
28	7.7	63874	5568	8.7	257667	27528	10.7	2912553	225176

		50-64 years			65+ years		
	% Pos	Spec Tested	# Pos	% Pos	Spec Tested	# Pos	% Pos
0	10.0	1973	247	12.5	2153	331	15.4
1	8.8	8379	986	11.8	7902	944	11.9
2	8.3	16115	1816	11.3	16312	2091	12.8
3	12.8	15579	2917	18.7	17640	3771	21.4
4	13.1	18865	3642	19.3	22651	5567	24.6
5	12.6	20004	3638	18.2	25135	6737	26.8
6	14.5	19294	3351	17.4	26281	6383	24.3
7	14.5	29358	4722	16.1	37785	7490	19.8
8	12.1	34592	4123	11.9	44495	6574	14.8
9	10.6	38644	3598	9.3	47233	5623	11.9
10	8.8	41972	2999	7.1	55387	4710	8.5
11	7.0	48621	2778	5.7	64354	4127	6.4
12	5.8	50807	2395	4.7	67119	3494	5.2
13	5.3	55274	2136	3.9	69154	2770	4.0
14	5.6	54489	2225	4.1	68548	2562	3.7
15	6.3	53945	2367	4.4	66738	2471	3.7
16	7.4	57332	2798	4.9	62518	2756	4.4

```
17   7.1       57137   2991   5.2       62156    2433   3.9
18   8.5       71464   4731   6.6       72422    4002   5.5
19   8.7       74907   5102   6.8       70527    3842   5.4
20   9.1       66484   4859   7.3       61362    3795   6.2
21   8.3       63408   4464   7.0       60546    3597   5.9
22   7.3       63516   3944   6.2       57489    3186   5.5
23   6.7       61033   3625   5.9       53282    2739   5.1
24   6.1       59046   3076   5.2       48056    2624   5.5
25   6.6       54118   2773   5.1       46566    2182   4.7
26   5.8       58303   2495   4.3       49168    2107   4.3
27   4.8       49966   1839   3.7       42766    1578   3.7
28   7.7     1244625  86637   7.0     1325745  100486   7.6
```

[67]:
```
covid_by_age_df.describe()
```

[67]:
```
      Total  (incl. age unknown)                               0-4 years  \
                     Spec Tested          # Pos      % Pos   Spec Tested
count               2.900000e+01      29.000000  29.000000     29.000000
mean                4.012550e+05   30812.413793   9.134483   4405.103448
std                 1.046650e+06   80255.361791   4.295536  11501.122732
min                 8.297000e+03     973.000000   4.500000    228.000000
25%                 1.307260e+05   12696.000000   6.200000   1265.000000
50%                 2.497870e+05   15391.000000   7.700000   2229.000000
75%                 2.819400e+05   19406.000000  10.700000   3153.000000
max                 5.818198e+06  446780.000000  18.100000  63874.000000

                                  5-17 years                           \
             # Pos      % Pos    Spec Tested         # Pos      % Pos
count    29.000000  29.000000      29.000000     29.000000  29.000000
mean    384.000000   7.782759   17770.137931   1898.482759  10.034483
std    1007.281206   2.538147   46595.602819   4988.563296   2.433879
min      10.000000   2.100000     586.000000     42.000000   3.700000
25%      66.000000   6.000000    2545.000000    334.000000   9.800000
50%     163.000000   8.700000    8500.000000    904.000000  10.500000
75%     299.000000   9.400000   15582.000000   1493.000000  11.600000
max    5568.000000  11.700000  257667.000000  27528.000000  13.400000

        18-49 years                                50-64 years                \
        Spec Tested          # Pos      % Pos      Spec Tested         # Pos
count  2.900000e+01      29.000000  29.000000     2.900000e+01     29.000000
mean   2.008657e+05   15529.379310   8.627586     8.583621e+04   5974.965517
std    5.245030e+05   40523.309601   2.803938     2.237746e+05  15555.449124
min    3.179000e+03     318.000000   4.800000     1.973000e+03    247.000000
25%    5.936800e+04    5910.000000   6.600000     2.935800e+04   2395.000000
50%    1.211190e+05    7731.000000   8.300000     5.394500e+04   2999.000000
75%    1.551700e+05   10156.000000  10.000000     5.904600e+04   3944.000000
max    2.912553e+06  225176.000000  14.500000     1.244625e+06  86637.000000
```

```
                         65+ years
            % Pos    Spec Tested          # Pos      % Pos
count   29.000000  2.900000e+01      29.000000  29.000000
mean     8.675862  9.143069e+04    6930.068966   9.755172
std      4.967081  2.382398e+05   18079.156185   7.213112
min      3.700000  2.153000e+03     331.000000   3.700000
25%      5.100000  3.778500e+04    2471.000000   4.700000
50%      6.800000  5.328200e+04    3494.000000   5.900000
75%     11.800000  6.435400e+04    4710.000000  12.800000
max     19.300000  1.325745e+06  100486.000000  26.800000
```

[68]:

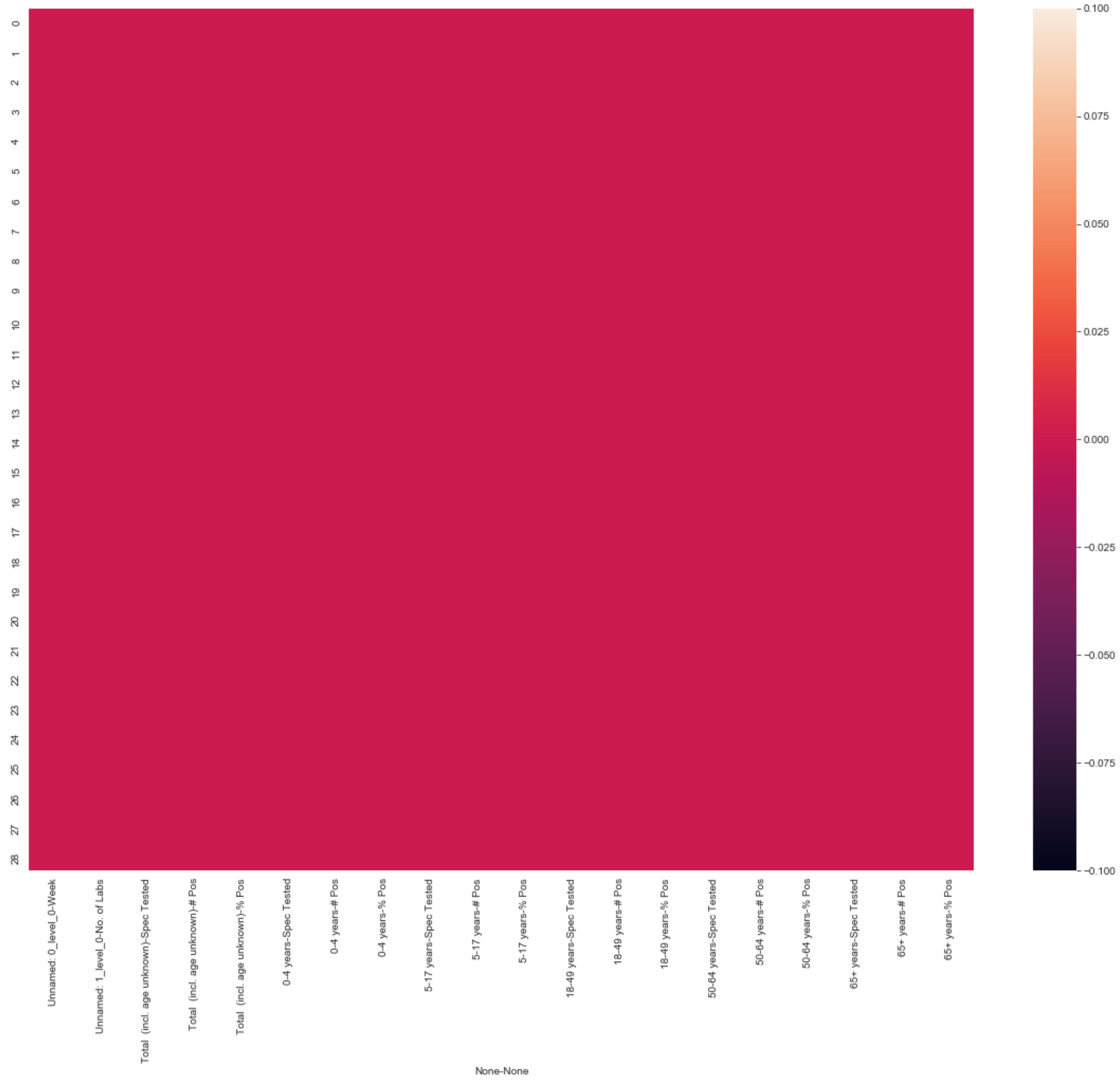
```
covid_by_age_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 29 entries, 0 to 28
Data columns (total 20 columns):
 #   Column                                        Non-Null Count  Dtype
---  ------                                        --------------  -----
 0   (Unnamed: 0_level_0, Week)                    29 non-null     object
 1   (Unnamed: 1_level_0, No. of Labs)             29 non-null     object
 2   (Total  (incl. age unknown), Spec Tested)     29 non-null     int64
 3   (Total  (incl. age unknown), # Pos)           29 non-null     int64
 4   (Total  (incl. age unknown), % Pos)           29 non-null     float64
 5   (0-4 years, Spec Tested)                      29 non-null     int64
 6   (0-4 years, # Pos)                            29 non-null     int64
 7   (0-4 years, % Pos)                            29 non-null     float64
 8   (5-17 years, Spec Tested)                     29 non-null     int64
 9   (5-17 years, # Pos)                           29 non-null     int64
 10  (5-17 years, % Pos)                           29 non-null     float64
 11  (18-49 years, Spec Tested)                    29 non-null     int64
 12  (18-49 years, # Pos)                          29 non-null     int64
 13  (18-49 years, % Pos)                          29 non-null     float64
 14  (50-64 years, Spec Tested)                    29 non-null     int64
 15  (50-64 years, # Pos)                          29 non-null     int64
 16  (50-64 years, % Pos)                          29 non-null     float64
 17  (65+ years, Spec Tested)                      29 non-null     int64
 18  (65+ years, # Pos)                            29 non-null     int64
 19  (65+ years, % Pos)                            29 non-null     float64
dtypes: float64(6), int64(12), object(2)
memory usage: 4.7+ KB
```

[69]:

```
# Checking Null values

plt.figure(figsize=(20,15))
sns.heatmap(covid_by_age_df.isnull())
```

[69]: <matplotlib.axes._subplots.AxesSubplot at 0x16cad9f6cc8>



- As we can see this dataset has been curated very well we don't have any null objects.

[70]:
```
# Dropping column which are not useful.

age_distribution_df = covid_by_age_df.drop('Total  (incl. age unknown)', axis =␣
↪1)
age_distribution_df
```

```
C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\generic.py:3936:
PerformanceWarning: dropping on a non-lexsorted multi-index without a level
parameter may impact performance.
```

```
  obj = obj._drop_axis(labels, axis, level=level, errors=errors)
```

```
[70]:   Unnamed: 0_level_0 Unnamed: 1_level_0   0-4 years             5-17 years  \
                      Week        No. of Labs Spec Tested # Pos % Pos Spec Tested
    0               202010                 80         228    10   4.4         586
    1               202011                 86         975    20   2.1        1966
    2               202012                 87        1576    36   2.3        2328
    3               202013                 89        1265    47   3.7        1433
    4               202014                 89        1128    64   5.7        1459
    5               202015                 88         915    43   4.7        1638
    6               202016                 87         798    66   8.3        1483
    7               202017                 86         914    55   6.0        2545
    8               202018                 87        1194   108   9.0        3952
    9               202019                 87        1731   104   6.0        4412
    10              202020                 89        1415   108   7.6        5156
    11              202021                 88        1829   125   6.8        6247
    12              202022                 88        1638   146   8.9        6307
    13              202023                 88        1953   163   8.3        7129
    14              202024                 89        2229   215   9.6        8500
    15              202025                 88        2353   214   9.1        9866
    16              202026                 89        2879   274   9.5       12032
    17              202027                 90        3153   299   9.5       12946
    18              202028                 90        4427   399   9.0       17640
    19              202029                 90        4849   454   9.4       21391
    20              202030                 90        4368   513  11.7       19431
    21              202031                 90        3735   410  11.0       17101
    22              202032                 89        3532   407  11.5       15970
    23              202033                 88        3344   326   9.7       15582
    24              202034                 90        3022   284   9.4       14235
    25              202035                 88        3002   270   9.0       15233
    26              202036                 88        3076   259   8.4       17001
    27              202037                 86        2346   149   6.4       14098
    28               Total                  .       63874  5568   8.7      257667

                 18-49 years             50-64 years             \
      # Pos % Pos Spec Tested  # Pos % Pos Spec Tested  # Pos % Pos
    0    42   7.2        3179    318  10.0        1973    247  12.5
    1    83   4.2       15549   1371   8.8        8379    986  11.8
    2    87   3.7       31820   2654   8.3       16115   1816  11.3
    3    80   5.6       29896   3812  12.8       15579   2917  18.7
    4   170  11.7       34902   4565  13.1       18865   3642  19.3
    5   168  10.3       35079   4419  12.6       20004   3638  18.2
    6   148  10.0       36425   5276  14.5       19294   3351  17.4
    7   334  13.1       59368   8618  14.5       29358   4722  16.1
    8   478  12.1       66331   8053  12.1       34592   4123  11.9
    9   526  11.9       73029   7731  10.6       38644   3598   9.3
    10  516  10.0       79248   6993   8.8       41972   2999   7.1
```

```
11    635  10.2       97119    6754    7.0       48621   2778    5.7
12    637  10.1      101718    5910    5.8       50807   2395    4.7
13    691   9.7      115691    6091    5.3       55274   2136    3.9
14    904  10.6      121119    6772    5.6       54489   2225    4.1
15   1036  10.5      121704    7646    6.3       53945   2367    4.4
16   1346  11.2      136644   10101    7.4       57332   2798    4.9
17   1301  10.0      143309   10156    7.1       57137   2991    5.2
18   1932  11.0      180239   15354    8.5       71464   4731    6.6
19   2485  11.6      192798   16748    8.7       74907   5102    6.8
20   2495  12.8      175449   15881    9.1       66484   4859    7.3
21   2298  13.4      163996   13667    8.3       63408   4464    7.0
22   1967  12.3      162304   11896    7.3       63516   3944    6.2
23   1799  11.5      158920   10641    6.7       61033   3625    5.9
24   1488  10.5      155170    9444    6.1       59046   3076    5.2
25   1493   9.8      142126    9355    6.6       54118   2773    5.1
26   1355   8.0      154210    8926    5.8       58303   2495    4.3
27   1034   7.3      125211    6024    4.8       49966   1839    3.7
28  27528  10.7     2912553  225176    7.7     1244625  86637    7.0

     65+ years
   Spec Tested   # Pos % Pos
0         2153     331  15.4
1         7902     944  11.9
2        16312    2091  12.8
3        17640    3771  21.4
4        22651    5567  24.6
5        25135    6737  26.8
6        26281    6383  24.3
7        37785    7490  19.8
8        44495    6574  14.8
9        47233    5623  11.9
10       55387    4710   8.5
11       64354    4127   6.4
12       67119    3494   5.2
13       69154    2770   4.0
14       68548    2562   3.7
15       66738    2471   3.7
16       62518    2756   4.4
17       62156    2433   3.9
18       72422    4002   5.5
19       70527    3842   5.4
20       61362    3795   6.2
21       60546    3597   5.9
22       57489    3186   5.5
23       53282    2739   5.1
24       48056    2624   5.5
25       46566    2182   4.7
```

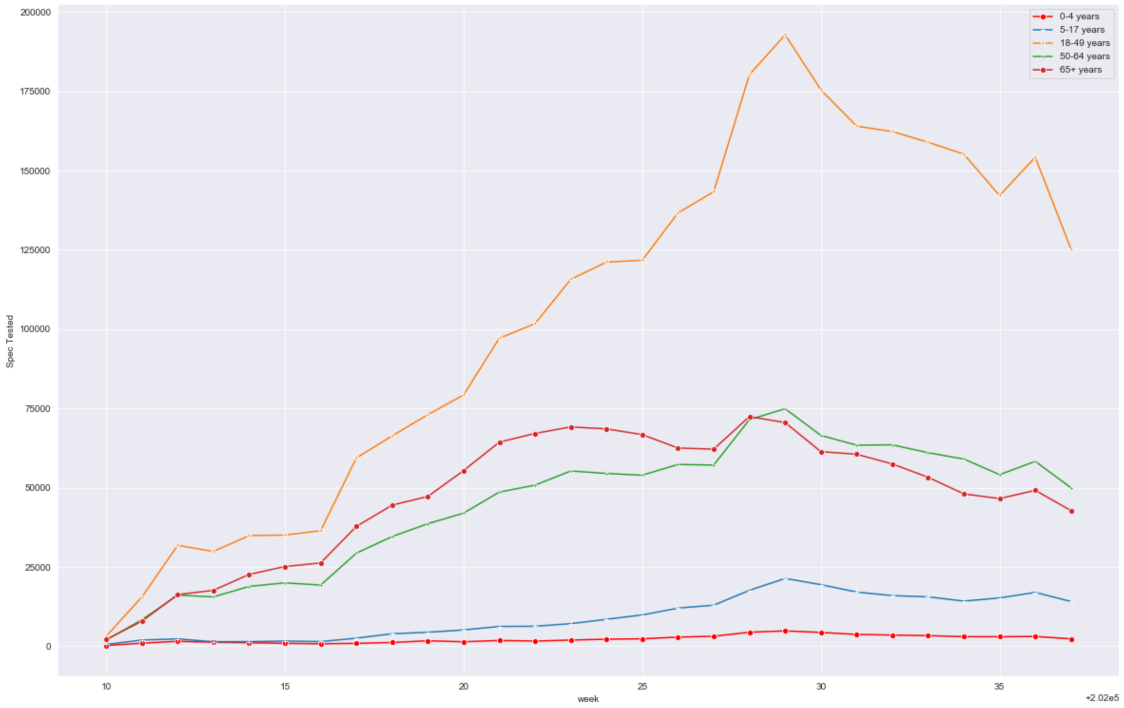
```
26       49168    2107   4.3
27       42766    1578   3.7
28     1325745  100486   7.6
```

[71]:

```
# Plot of person Tested versus number of week

plt.figure(figsize=(20,13))


sns.lineplot(y = age_distribution_df.iloc[0:28]['0-4 years', 'Spec Tested'],
                 x = age_distribution_df.iloc[0:28]['Unnamed:␣
↪0_level_0','Week'],
                 data= age_distribution_df, color = 'red', marker = 'o',␣
↪legend='brief')

sns.lineplot(y = age_distribution_df.iloc[0:28]['5-17 years', 'Spec Tested'],
                 x = age_distribution_df.iloc[0:28]['Unnamed:␣
↪0_level_0','Week'],
                 data= age_distribution_df, marker = '+', legend='brief')

sns.lineplot(y = age_distribution_df.iloc[0:28]['18-49 years', 'Spec Tested'],
                 x = age_distribution_df.iloc[0:28]['Unnamed:␣
↪0_level_0','Week'],
                 data= age_distribution_df, marker = '*', legend='brief')

sns.lineplot(y = age_distribution_df.iloc[0:28]['50-64 years', 'Spec Tested'],
                 x = age_distribution_df.iloc[0:28]['Unnamed:␣
↪0_level_0','Week'],
                 data= age_distribution_df, marker = '.', legend='brief')

sns.lineplot(y = age_distribution_df.iloc[0:28]['65+ years', 'Spec Tested'],
                 x = age_distribution_df.iloc[0:28]['Unnamed:␣
↪0_level_0','Week'],
                 data= age_distribution_df, marker = 'o', legend='brief')

plt.legend(['0-4 years', '5-17 years', '18-49 years','50-64 years','65+ years'])
plt.xlabel('week')
plt.ylabel('Spec Tested')
```

[71]:

```
Text(0, 0.5, 'Spec Tested')
```



- From this graph we can see that maximum number of persons which got tested for **COVID-19** are from age group **18-49**.
- This age group primarily includes students, and working class. Both of these class were at **high risk** because they were out and exposed to virus more than other age groups.
- After **30th week** we can see a drop in the number of people tested for COVID-19, which we can relate to **closure of the school**.
- Age group **<17** has not been affected much, as less number of persons got tested from this age group.
- Age group 50-64 and 65+ got almost same number of persons tested, but this age group has been most affected by COVID-19. As the virus causes respiratory illnes which can lead to hospitalization and even death for young and middle-aged adults.
- COVID-19 has caused most severe health issues for adults over the age of 60. This is due in no small part to the number of underlying health conditions. Diseases like diabetes, heart disease, and other chronic illness can lead to more intense symptoms and complications in the disease. Additionally as people age, their immune system gradually looses it resiliency.

[72]:
```
#Multilevel indexing sometime makes it hard to work with, here is the easy way␣
↪out.

year0_4 = age_distribution_df.iloc[0:28]['0-4 years','% Pos']
year5_17 = age_distribution_df.iloc[0:28]['5-17 years', '% Pos']
```

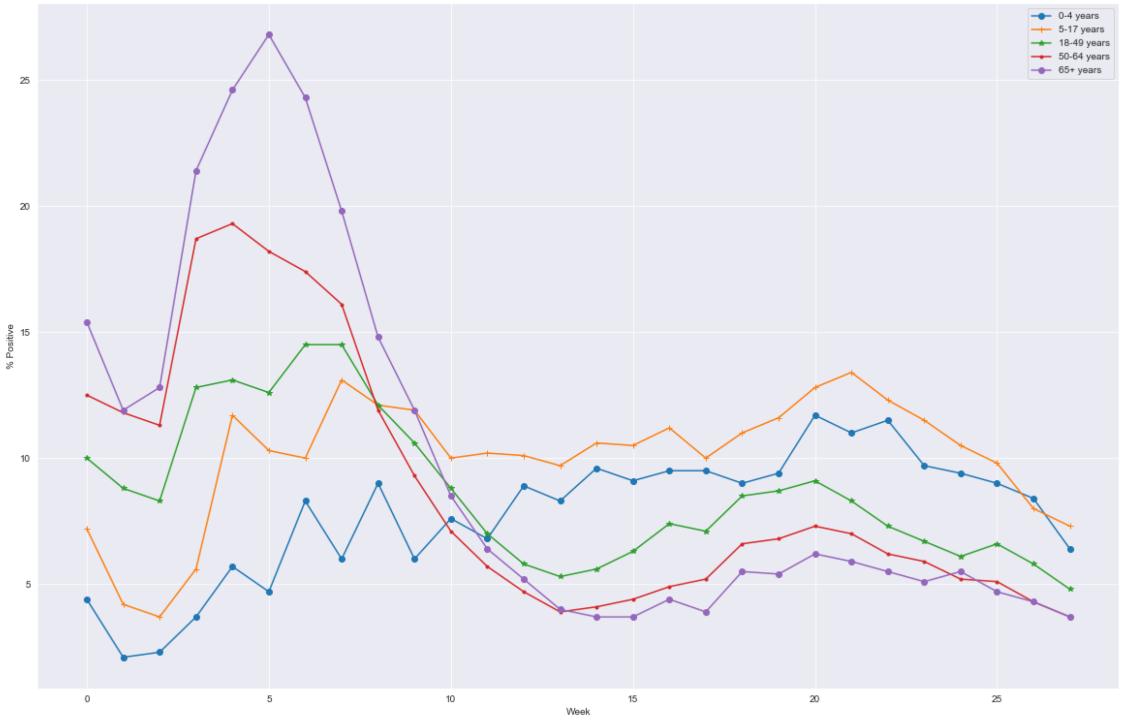
```
year18_49 = age_distribution_df.iloc[0:28]['18-49 years', '% Pos']
year50_64 = age_distribution_df.iloc[0:28]['50-64 years','% Pos']
year65plus = age_distribution_df.iloc[0:28]['65+ years', '% Pos']
```

[73]:

```
# % positive versus week

plt.figure(figsize=(20,13))

year0_4.plot(kind='line',marker='o')
year5_17.plot(kind='line',marker='+')
year18_49.plot(kind='line',marker='*')
year50_64.plot(kind='line',marker='.')
year65plus.plot(kind='line',marker='o')

plt.legend(['0-4 years', '5-17 years', '18-49 years','50-64 years','65+ years'])
plt.xlabel('Week')
plt.ylabel('% Positive')
```

[73]:

```
Text(0, 0.5, '% Positive')
```



- Here we can see that even though more number of the persons got tested from age group 18-49, yet the percentage of having corona (% positive) remains in the bottom 3. This can be attributed to **closure of school** and better immunity than the rest of the age group.

- On the other hand age group 50+ has less number of persons tested, but highest % positive cases as comapred to other 3 age groups. This can be attributed to low immunity as age increases.
- Age group < 17 has lowest number of % positive which also can be attributed to **closure of school** and better immunity.

Rate ratios compared to 18-29 year olds

1. Data source: COVID-NET (https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/in accessed 08/06/20). Numbers are unadjusted rate ratios.
2. Data source: NCHS Provisional Death Counts (https://www.cdc.gov/nchs/nvss/vsrr/COVID19/in accessed 08/06/20). Numbers are unadjusted rate ratios.

[74]:
```
# load data for ratio comparison

rate_ratio_df = pd.read_excel('../covid_data/Data/Covid-19/rate_ratio.xlsx')
rate_ratio_df
```

[74]:
```
     Age Group    Hospitalization             Death
0     0-4 years          4x lower          9x lower
1    5-17 years          9x lower         16x lower
2   18-29 years  Comparison Group  Comparison Group
3   30-39 years         2x higher         4x higher
4   40-49 years         3x higher        10x higher
5   50-64 years         4x higher        30x higher
6   65-74 years         5x higher        90x higher
7   75-84 years         8x higher       220x higher
8     85+ years        13x higher       630x higher
```

[75]:
```
# Ratio comparison based on hospitalization and Death

def highlight_rows(x):
    df = x.copy()
    df.loc[5:,] = 'background-color: red'
    df.loc[:2] = 'background-color:green'
    df.loc[2] = 'background-color:yellow'
    df.loc[3:4] = 'background-color: orange'
    return df

rate_ratio_df.style.apply(highlight_rows,axis=None)
```

[75]:
```
<pandas.io.formats.style.Styler at 0x16caf3fb308>
```

- From this table we can see that if we compare hospitalization then, **13x** more number of persons were **hospitalized from age groups > 50**.
- This data also suggest that **age group < 17** are **5x** on the lower side of the risk.
- From this we can conclude that **school closure** was an effective policy if we

combine it with other policy which focuses on higher age group. As they were the ones who are more susceptible to COVID-19.

- **Closure of schools** from the month of **March** can also be attributed to declining number of COVID-19 cases.
- Alberta is closely monitoring it schools as they have reopened them from the month of **September**.
- Public health measures are in place to ensure a safer reopening of schools. This includes mandatory masking, physical distancing, enhanced cleaning, daily symptom screening. If a case is confirmed, contact tracers and public health officials will be deployed to identify potential exposure and limit spread.

COVID-19 School Status Map (Alberta)

1. Data Source (https://www.alberta.ca/schools/covid-19-school-status-map.htm)

```
[76]: # load Alberta specific data

      school_status_map = pd.read_csv('../covid_data/Data/AlbertaSchoolClosure/
       ↪covid19dataexport-schools.csv')
      school_status_map
```

```
[76]:      Unnamed: 0         Region name              School status  \
      0             1     City Of Calgary                      Watch
      1             2     City Of Calgary  Open (Outbreak, 2-4 cases)
      2             3     City Of Calgary  Open (Outbreak, 2-4 cases)
      3             4     City Of Calgary  Open (Outbreak, 2-4 cases)
      4             5     City Of Calgary  Open (Outbreak, 2-4 cases)
      ..          …                 …                          …
      115         116       Vulcan County                       Open
      116         117    Westlock County                       Open
      117         118    Wheatland County                      Open
      118         119    Woodlands County                      Open
      119         120   Yellowhead County                      Open

                         Schools details
      0    St. Wilfrid Elementary School
      1           Notre Dame High School
      2    Lester B. Pearson High School
      3      Henry Wise Wood High School
      4                Auburn Bay School
      ..                             …
      115      No school status to report
      116      No school status to report
      117      No school status to report
      118      No school status to report
      119      No school status to report
```

```
[120 rows x 4 columns]
```

Region Classification (Alberta)

1. **Enhanced** - Risk levels require enhanced measures to control the spread at a school or school authority level. School(s) may be moved to scenario 2 (in school classes partially operating) or scenario 3 (at-home learning).
2. **Watch** - School outbreak declared with 5 or more cases where disease could have been acquired or transmitted in the school. Scenario 1 -- school is open with near normal operations with some public health measures. Province is monitoring risk and working with the school, school authority and Alberta Health Services. Additional public health measures may be in place within a school to control the spread
3. **Open** - No schools in this area have outbreaks of 5 or more cases. Scenario 1 -- school is open with near normal operations with some public health measures. Parents may have received an alert from their school. Alberta Health Services may be working with local schools, but any additional measures are localized and targeted.

```
[77]: school_status_map[school_status_map['School status']=='Watch']
```

```
[77]:    Unnamed: 0      Region name School status                  Schools details
      0           1  City Of Calgary         Watch  St. Wilfrid Elementary School
```

- Only one school in Alberta is on **Watch** which shows how effective the school closure was. As stating at home of students has helped contain the spread of virus.
- Rest of the schools are fully open and functional complying with **Public health measures for safer reopening of the school**.

- So **School Closure** which targets **5.5 million** students who are enrolled in elementary and secondary school programs. We can say that this policy is effective to contain the spread in 14% of the total population(37.6 million) in canada.
- Recent modelling from past pandemics also states that school closure only would prevent ~2-4% deaths. But its very effective for the school going age group.