Effectiveness_of_School_Closing

December 6, 2020

[11]:
```
from IPython.display import Image
Image("../Images/Logo.jpg")
```

[11]:

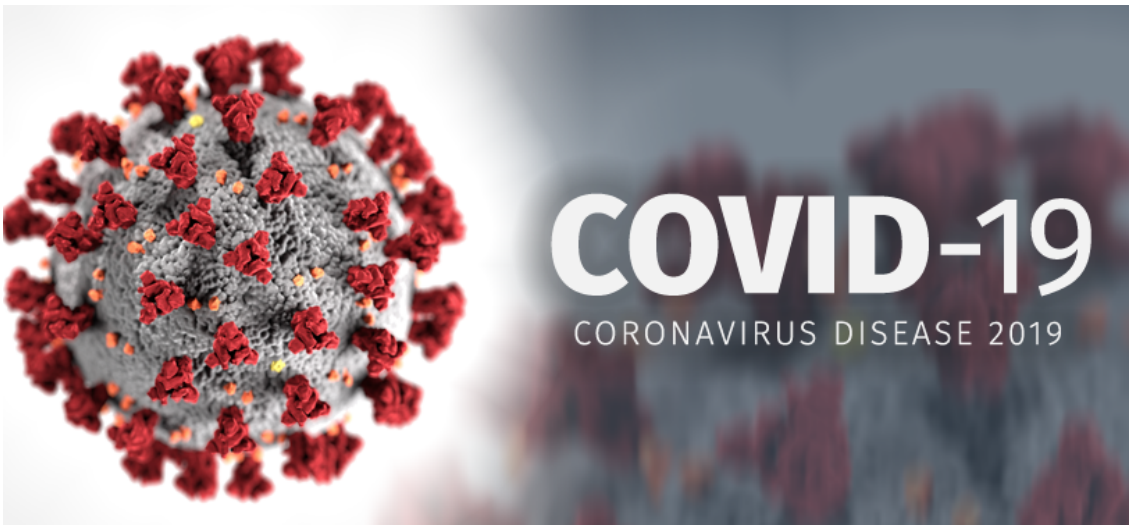
#

Graduate Project ENEL 698

Github Link

[12]:
```
Image("../Images/Covid-19.png")
```

[12]:



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.

[13]:
```
#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
```

[14]:
```
import plotly.io as pio
pio.renderers.default = 'jupyterlab'
```

[15]:
```
# 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.to_csv("ncov2019_data.csv", sep= '\t')
```

[16]:
```
# We will now sort the countries based on total confirmed cases column

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

```
#Lets get top 10 affected countries

world_df.head(10)
```

[16]:

	Name	Confirmed	Per Million	Changes Today
0	TOTAL	43761843	5623	402759
170	United States	8959376	27017	66515
171	India	7945888	5740	36838
172	Brazil	5411550	25402	17422
173	Russia	1531224	10491	17347
58	France	1165278	17840	26771
7	Argentina	1102301	24319	11712
174	Spain	1098320	23488	17396
175	Colombia	1025052	20078	9167
176	United Kingdom	894690	13157	20890

	Percentage Day Change	Critical	Deceased	Per Million.1	Changes Today.1
0	0.93%	78877	1164185	150	5059
170	0.75%	16470	231026	697	510
171	0.47%	8944	119535	86	505
172	0.32%	8318	157451	739	288
173	1.15%	2300	26269	180	219
58	2.35%	2770	35018	536	257
7	1.07%	5038	29301	646	405
174	1.61%	2163	35031	749	93
175	0.9%	2365	30348	594	194
176	2.39%	743	44998	662	102

	Percentage Death Change	Tests	Active	Recovered	Per Million.2
0	0.44%	786902572	10721306	31669921	4069
170	0.22%	134349235	2906299	5822051	17556
171	0.42%	103462778	627638	7198715	5200
172	0.18%	21900000	388169	4865930	22840
173	0.84%	57821260	358859	1146096	7852
58	0.74%	14880040	1018913	111347	1705
7	1.4%	2850102	163414	909586	20067
174	0.27%	16690076	912913	150376	3216
175	0.64%	4789625	70660	924044	18099
176	0.23%	32151242	Unknown	Unknown	Unknown

	Population
0	7782884635
170	331621597
171	1384308221
172	213040452
173	145954555
58	65319785

```
7      45327446
174    46760593
175    51054737
176    67999816
```

- 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.

[17]:
```
# load the data from the local directory

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

[18]:
```
school_closure_df.head()
```

[18]:
```
                       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

[19]:
```
school_closure_df.nunique()
```

[19]:
```
date       227
iso        210
country    210
status       4
```

```
note          0
dtype: int64
```

[20]:
```
# 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.

[21]:
```
from termcolor import colored
```

[22]:
```
# 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']
```

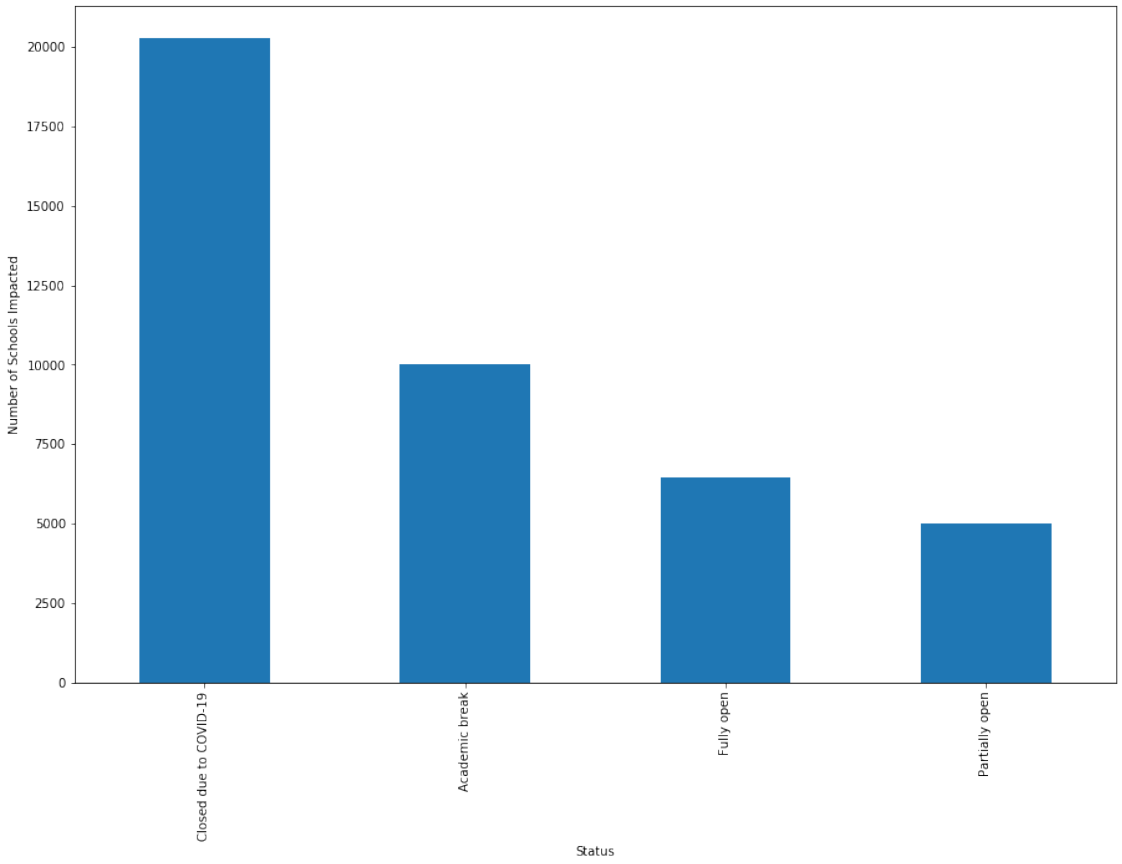
I'm creating a multindex here. It will allow us to group data based on iso codes of the respective countries.

[23]:
```
# 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]
```

[24]:
```
# 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")
```

[24]:
```
[Text(0, 0.5, 'Number of Schools Impacted'), Text(0.5, 0, 'Status')]
```



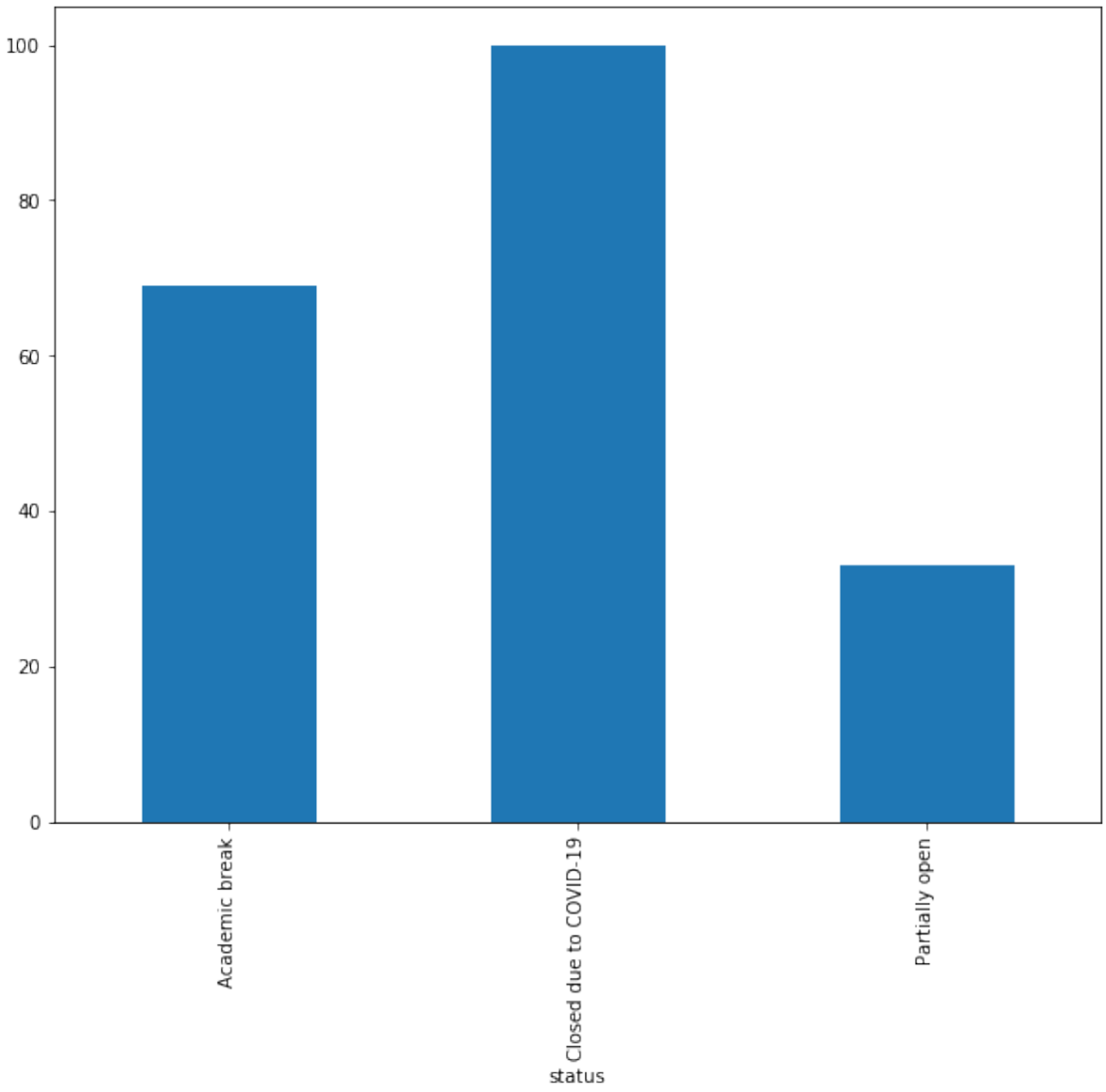
- As situation got worse, school authorities all around the world have implemented various policies.
- **More than 20,000 schools have opted to close** which was **primary** choice of the officials.
- Some authorities decided to give students **Academic break**, which was secondary choice.
- Some countries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

[25]:
```
# 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]
```

[26]:
```
# How Canadian schools reacted?

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

[26]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2162b89b788>
```



- 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.

[27]:
```
# 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)
```

[27]: <pandas.io.formats.style.Styler at 0x2162b8d4208>

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.

[28]:
```
# Partially open status of the schools in Canada.

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

[28]:

	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

[29]:
```
# 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)
```

[29]:
```
<pandas.io.formats.style.Styler at 0x2162b8ab588>
```

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

[30]:
```
# Load data

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

[30]:

	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	

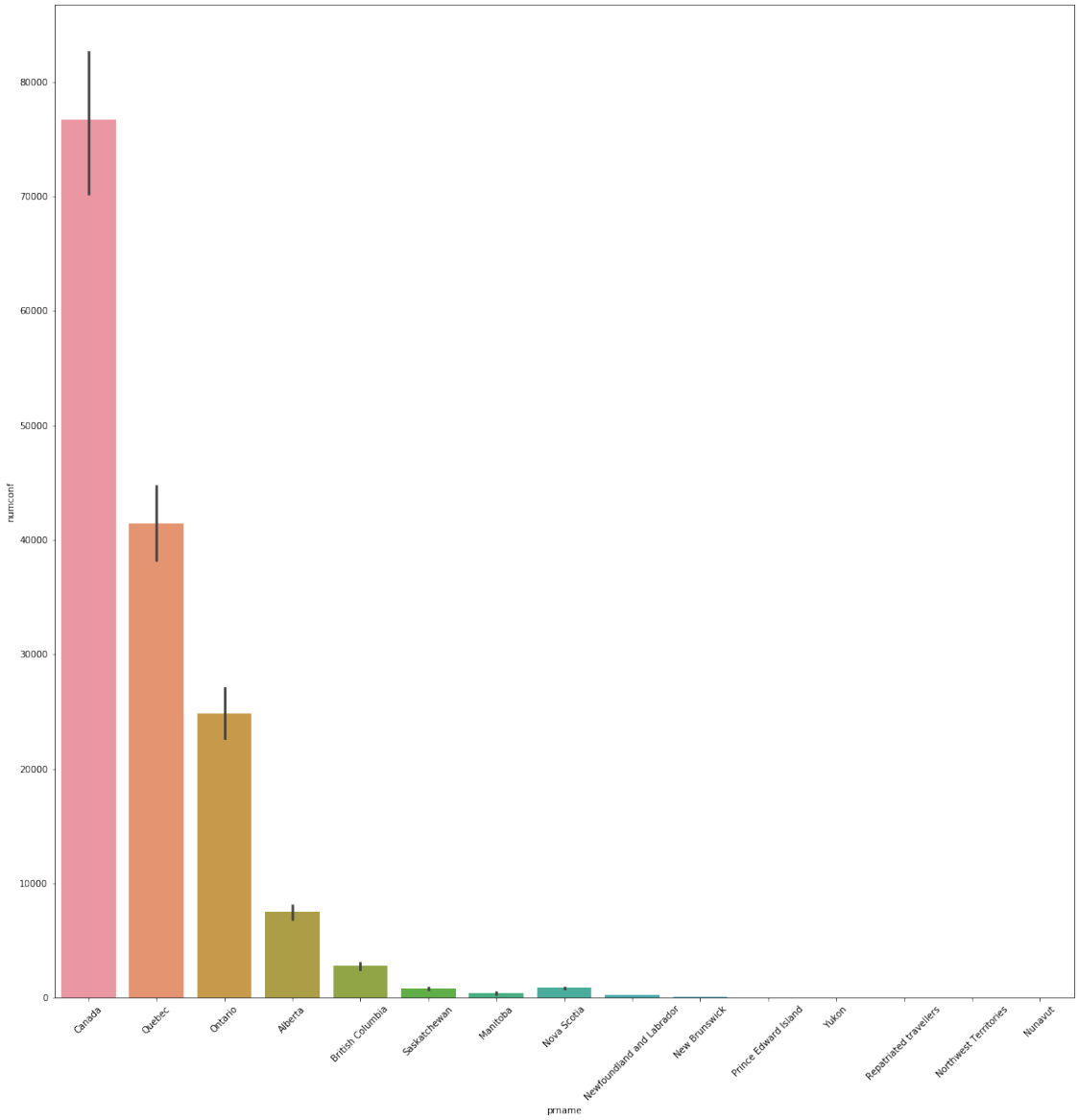
```
1        0        0.0         1        NaN         NaN  …           0.0
2        0        0.0         4        NaN         NaN  …           0.0
3        0        0.0         3        NaN         NaN  …           0.0
4        0        0.0         4        NaN         NaN  …           0.0
5        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]
```

[31]:
```
#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
```

[32]:
```
# 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)
```

[32]:
```
(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.

[33]:
```
canada_covid_df = canada_covid_df[canada_covid_df['pruid'] != 1]
```

[34]:
```
#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
```

[34]:

Month Number	pruid	numconf	numprob	numdeaths	numtotal	numtested	\
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	

Month Number	numrecover	percentrecover	ratetested	numtoday	…	\
					…	
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	…	

Month Number	percentdeath	numtestedtoday	numrecoveredtoday	percentactive	\
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	

Month Number	numactive	rateactive	numtotal_last14	ratetotal_last14	\
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]
```

[35]:
```
#After grouping the grouping variable becomes the index so making it a label␣
↪again for visualization

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

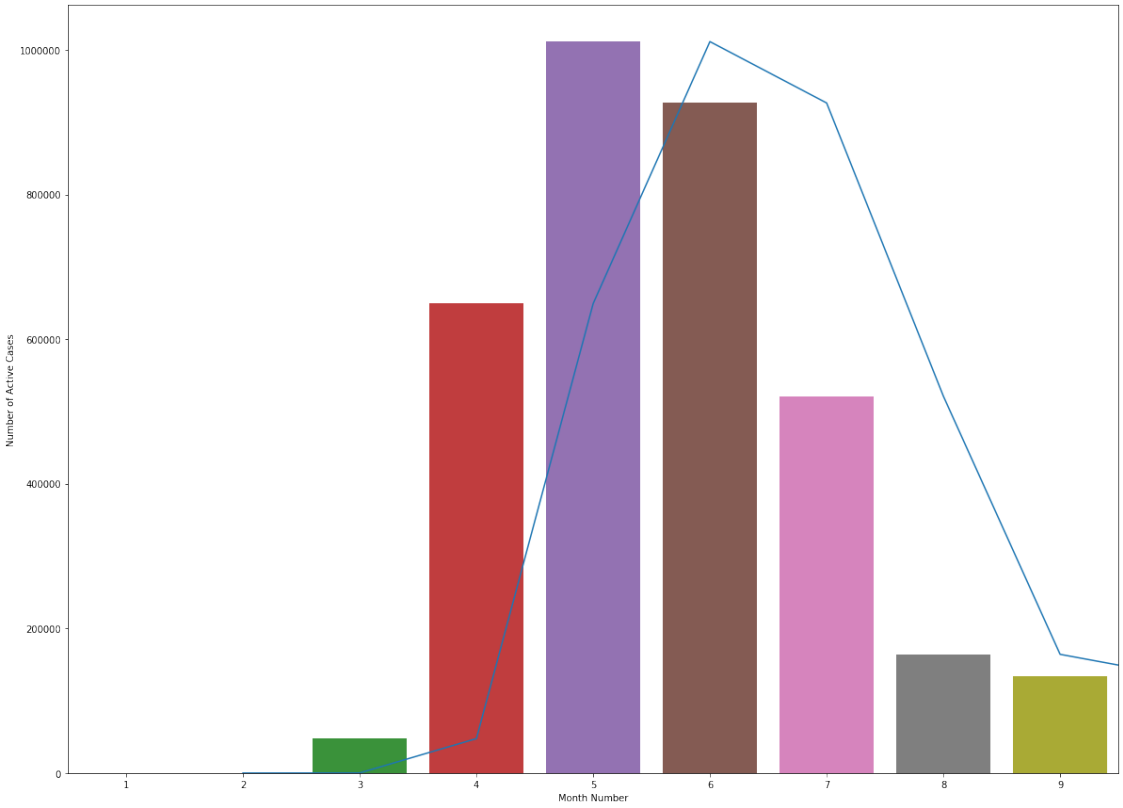
[35]:
```
               pruid  numconf  numprob  numdeaths  numtotal    numtested  \
Month Number
1                 94        4        0        0.0         4          0.0
2                752       85        0        0.0        85          0.0
3              13249    50358     1655      580.0     52013    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]
```

[36]:
```
#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")
```

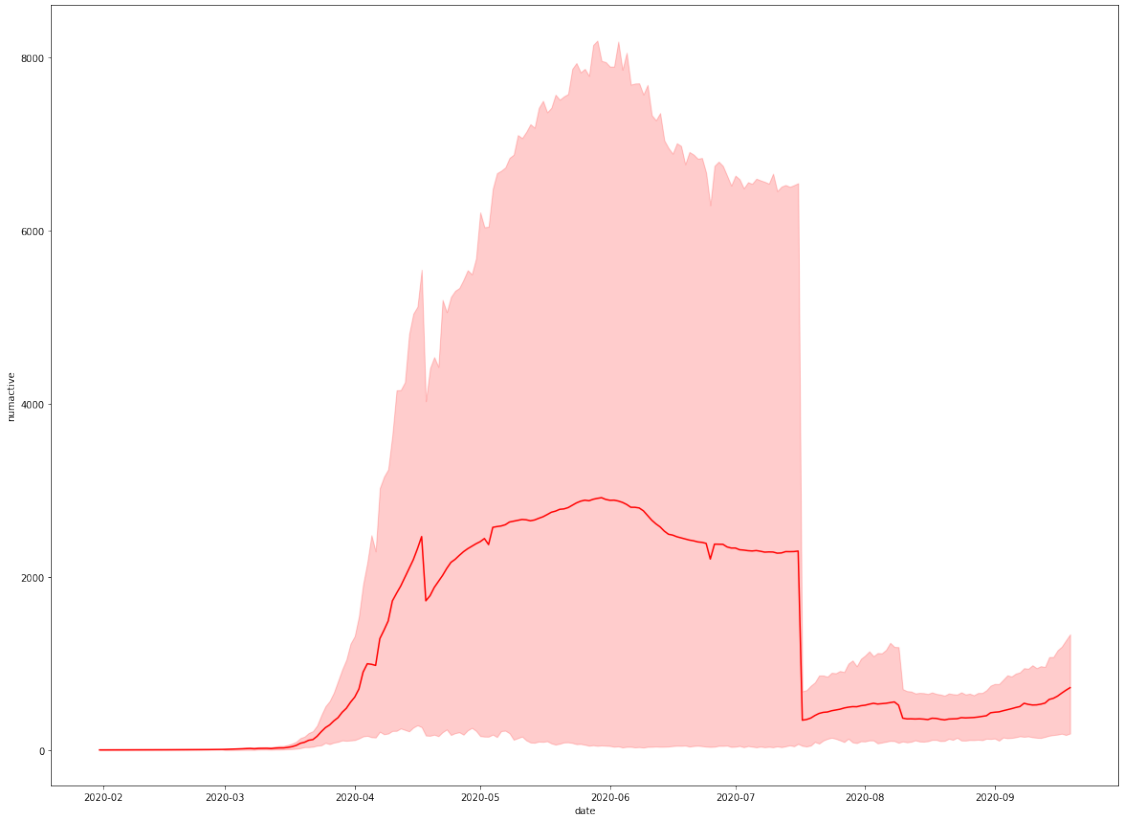
[36]: Text(0, 0.5, 'Number of Active Cases')



- 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.

[37]:
```
# New Cases by Date

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

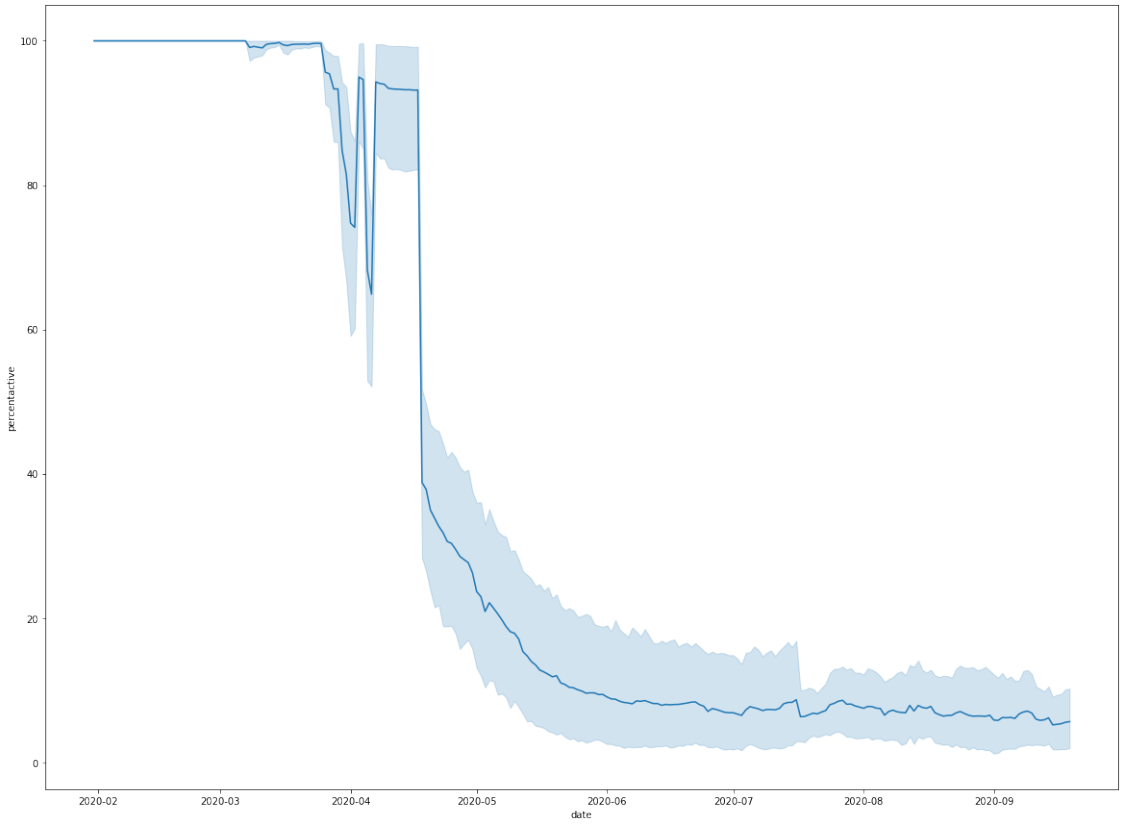
[37]: <matplotlib.axes._subplots.AxesSubplot at 0x2162d96ee08>



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

[38]:
```
# Rate of new cases by previous date

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

[38]: <matplotlib.axes._subplots.AxesSubplot at 0x2162d9c51c8>

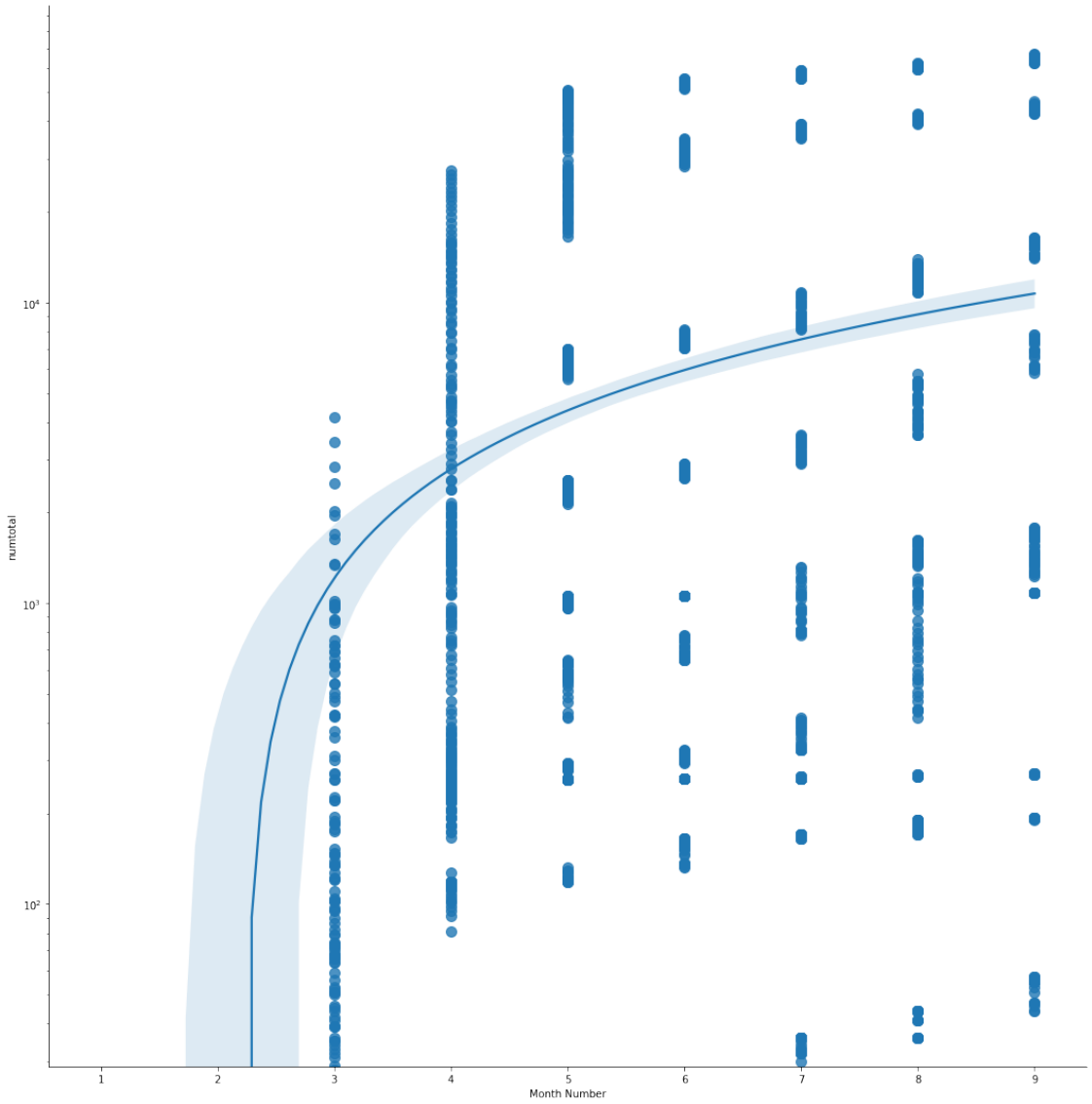


- **% of active cases** dropped significantly after **april**. This can be attributed to nationwide **Shutdown**.
- This graph also shows how **Shutdown** in Global pandemics can help nations contain the spread of the virus.

Total Confirmed cases (log-scale)

[39]:
```
# 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")
```

[39]: <seaborn.axisgrid.FacetGrid at 0x2162de3dc88>



- 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.

[40]:
```
# Load data

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

[40]:

	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/…

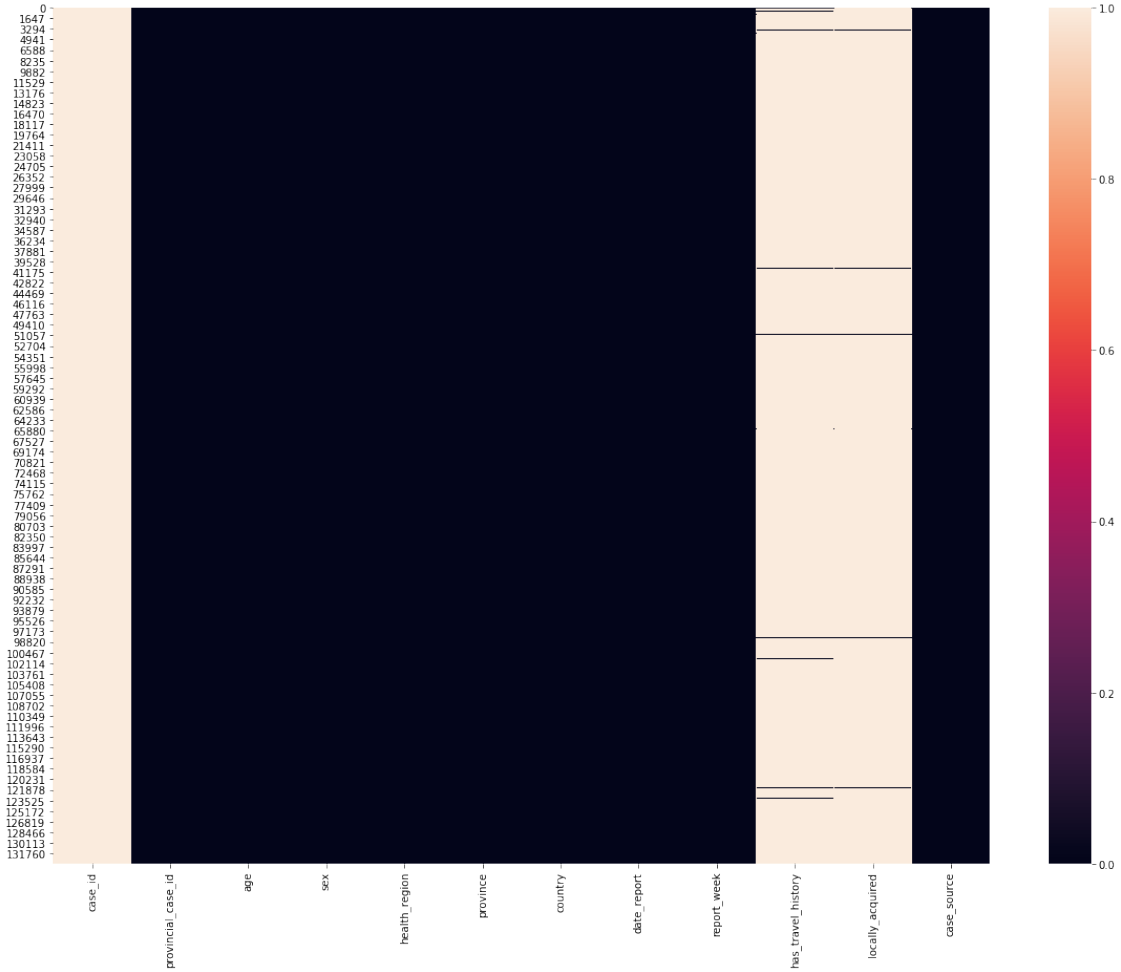
[41]:
```
# Info of the data
```

```
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
```

[42]:
```
# Checking null variables in the dataset

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

[42]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2162dffd488>
```



- 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.

[43]:
```
# Dropping case_id

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

[44]:
```
canada_age_gender_df['has_travel_history']
```

[44]:
```
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
```

[45]:
```
# how many categorical variable in column has_travel_history

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

[45]:
```
array(['t', 'f', nan], dtype=object)
```

[46]:
```
# 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.

[47]:
```
# Categorical variables in locally_acquired column

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

[47]:
```
array([nan, 'Close Contact', 'Community', 'Close contact',
       'close contact', '1'], dtype=object)
```

[48]:
```
canada_age_gender_df[canada_age_gender_df['locally_acquired']=='1']
```

[48]:
```
        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…
```

[49]:
```
canada_age_gender_df[canada_age_gender_df['locally_acquired']=='Community']
```

[49]:
```
        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]
```

[50]:
```
canada_age_gender_df['locally_acquired']
```

[50]:
```
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
```

[51]:
```
# 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)
```

[52]:
```
# 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)
```

[53]:
```
canada_age_gender_df
```

[53]:
```
        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]
```

[54]:
```
# Age categories

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

[54]:
```
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)
```

[55]:
```
# Dropping cases where age was not reported

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

[56]:
```
canada_age_gender_df['age'].unique()
```

[56]:
```
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)
```

[57]:
```
# sex categories

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

[57]:
```
array(['Male', 'Female', 'Not Reported'], dtype=object)
```

[58]:
```
# Dropping sex category where sex was not reported
```

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

[59]:
```
canada_age_gender_df['sex'].unique()
```

[59]:
```
array(['Male', 'Female'], dtype=object)
```

[60]:
```
canada_age_gender_df['date_report'] = pd.
↪to_datetime(canada_age_gender_df['date_report'], infer_datetime_format=True)
```

[61]:
```
canada_age_gender_df.drop('report_week',inplace=True,axis=1)
```

[62]:
```
# Clean Dataset

canada_age_gender_df
```

[62]:

	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]

[63]:
```
# 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'
```

[64]:
```
canada_age_gender_df['age'] = canada_age_gender_df['age'].apply(lambda x :␣
↪convert_agegroup(x))
```

[65]:
```
canada_age_gender_df.head(10)
```

[65]:

	provincial_case_id	age	sex	health_region	province	country	date_report	has_travel_history	locally_acquired
0	1	20 and older	Male	Toronto	Ontario	Canada	2020-01-25	1	0
1	2	20 and older	Female	Toronto	Ontario	Canada	2020-01-27	1	0
2	1	20 and older	Male	Not Reported	BC	Canada	2020-01-28	1	0
3	3	20 and older	Female	Middlesex-London	Ontario	Canada	2020-01-31	1	0
4	2	20 and older	Female	Vancouver Coastal	BC	Canada	2020-02-04	0	1
5	3	20 and older	Male	Not Reported	BC	Canada	2020-02-06	1	0
6	4	20 and older	Female	Not Reported	BC	Canada	2020-02-06	1	0
7	5	20 and older	Female	Interior	BC	Canada	2020-02-14	1	0
8	6	20 and older	Female	Fraser	BC	Canada	2020-02-20	1	0
9	4	20 and older	Female	Toronto	Ontario	Canada	2020-02-23	1	0

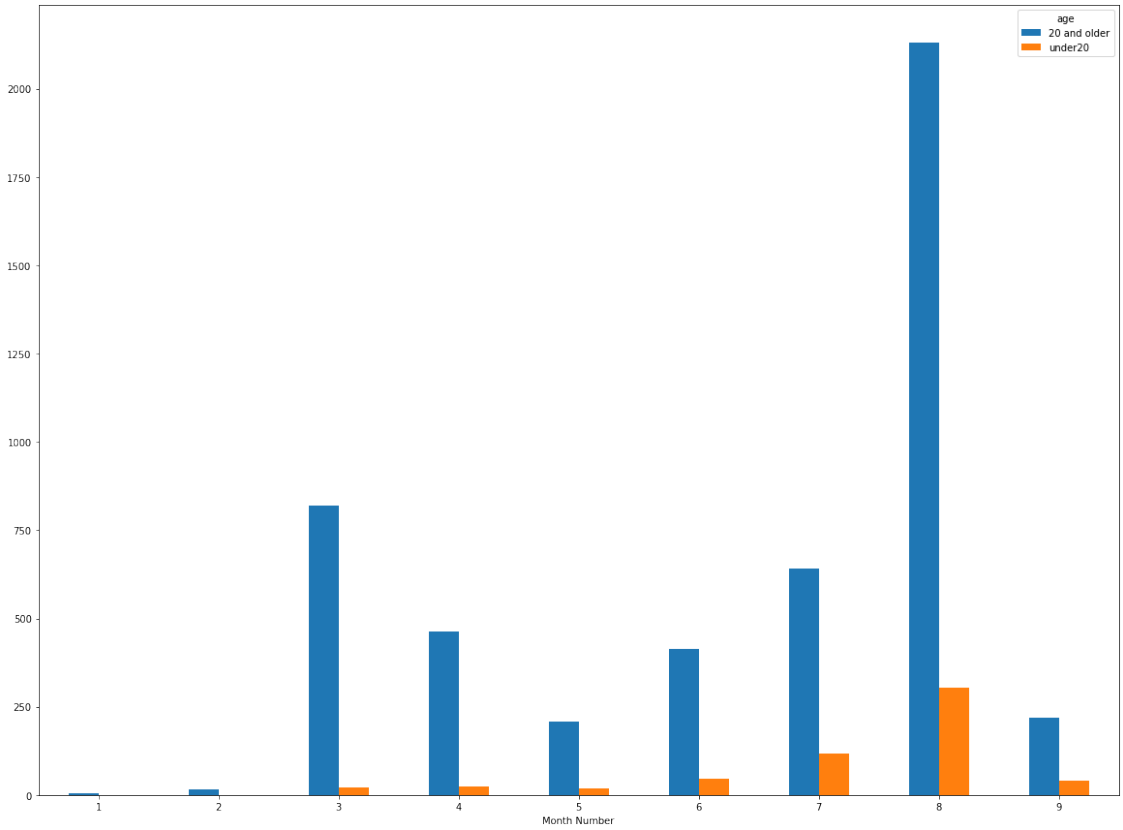
[66]:
```
# Getting Month number and month from the date report

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
```

[67]:
```
# 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
```

[68]:
```
#plotting the data

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

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



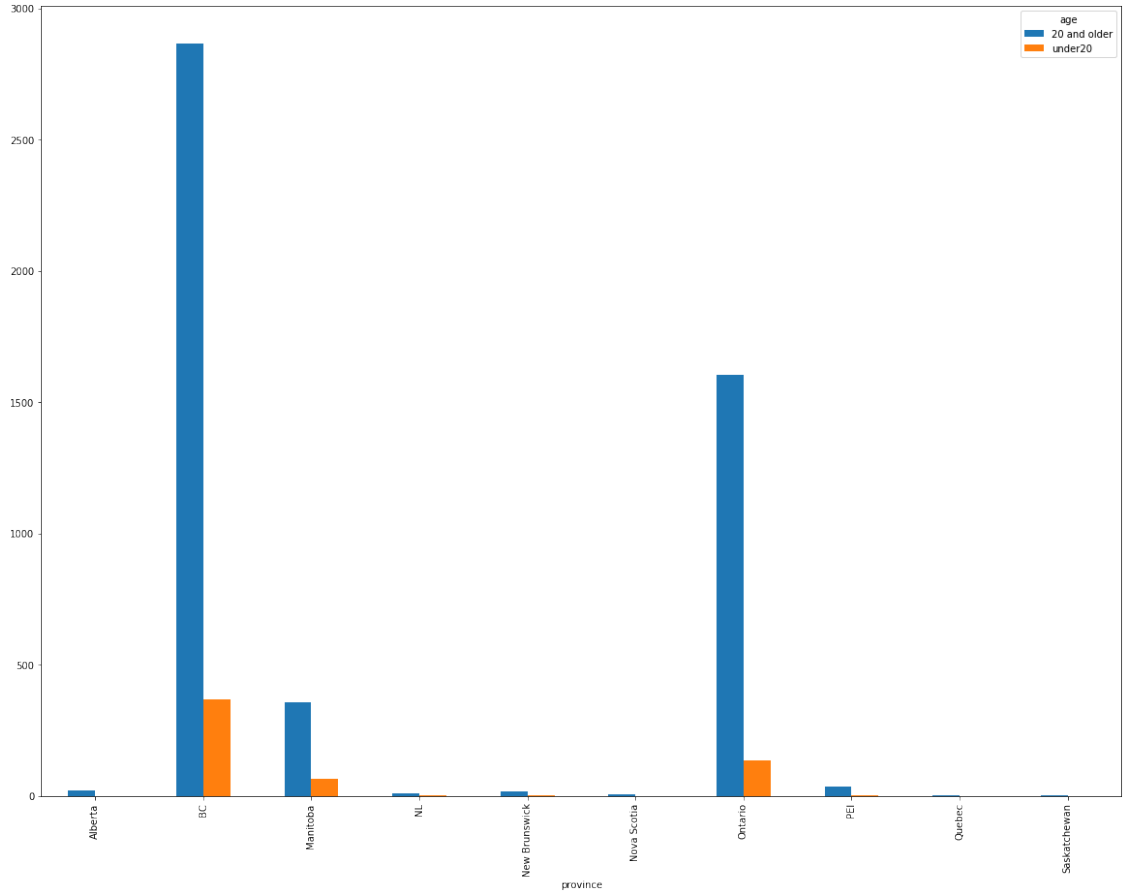
- From this graph we can see that **school closure** has helped Canadian government contain the spread of virus.
- Recent modelling studies of COVID-19 predict that school closures alone would prevent only **2-4%** of deaths only, which is much less than other social distancing interventions. Source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

[69]:
```
# 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

[69]: <matplotlib.axes._subplots.AxesSubplot at 0x2162fdf62c8>

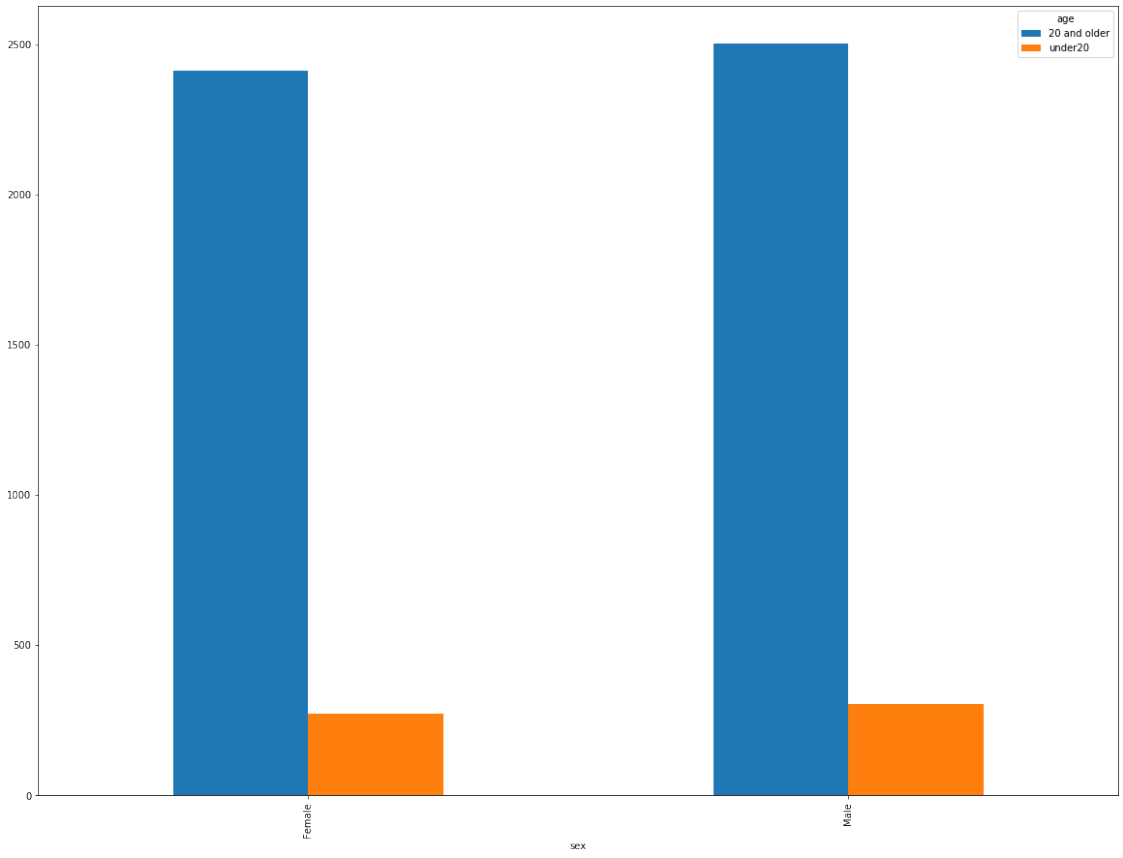


- We can also see how province wise this distribution is. Age group of **Under20** is less affected then age group of **20 and above**.
- We can see this data doesn't give us much of information on provincial level, because there are many good sources for raw tally of cases, deaths and tests across the 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.

[70]:
```
# 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
```

[70]: <matplotlib.axes._subplots.AxesSubplot at 0x21630998788>



- 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.

[71]:
```
# load Data

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

[71]:

	Unnamed: 0_level_0	Unnamed: 1_level_0	Total (incl. age unknown)		0-4 years			5-17 years			18-49 years	
	Week	No. of Labs	Spec Tested	# Pos	% Pos	Spec Tested	# Pos	% Pos	Spec Tested	# Pos	% Pos	Spec Tested	# Pos
0	202010	80	8297	973	11.7	228	10	4.4	586	42	7.2	3179	318
1	202011	86	35674	3484	9.8	975	20	2.1	1966	83	4.2	15549	1371
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									

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
```

[72]:
```
covid_by_age_df.describe()
```

[72]:
```
       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
```

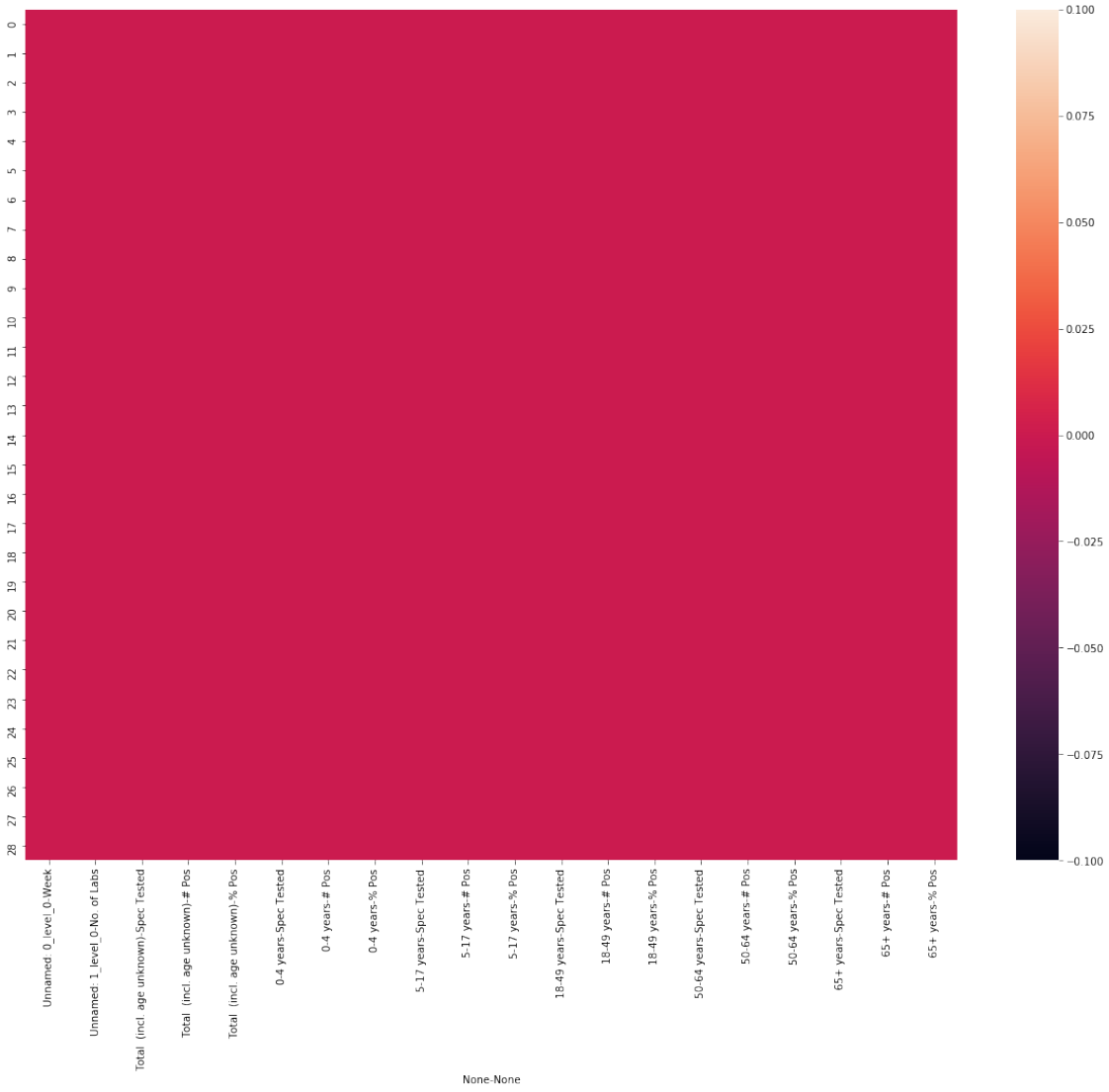
```
                    65+ years
           % Pos   Spec Tested          # Pos      % Pos
count  29.000000  2.900000e+01      29.000000  29.000000
mean    8.675862  9.143069e+04    6930.068966   9.755172
std     4.967081  2.382398e+05   18079.156185   7.213112
min     3.700000  2.153000e+03     331.000000   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
```

[73]:
```
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
```

[74]:
```
# Checking Null values

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

[74]: <matplotlib.axes._subplots.AxesSubplot at 0x216309e8748>



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

[75]:
```
# 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.
```

[75]:

	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

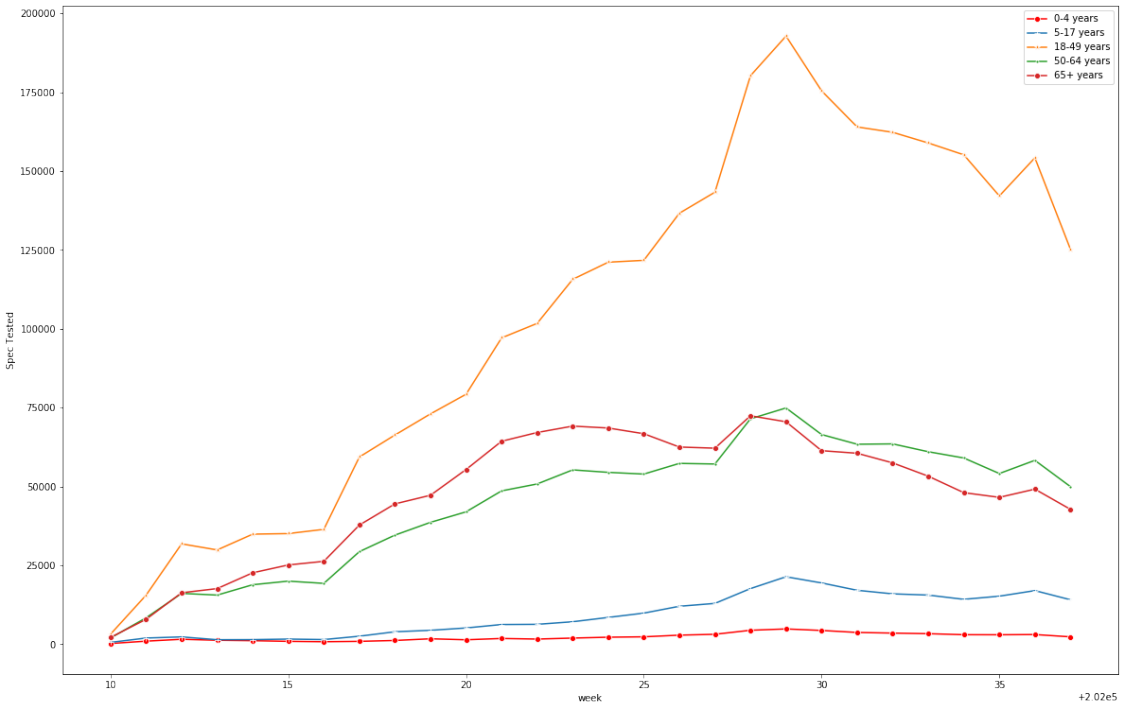
9	526	11.9	73029	7731	10.6	38644	3598	9.3
10	516	10.0	79248	6993	8.8	41972	2999	7.1
11	635	10.2	97119	6754	7.0	48621	2778	5.7
12	637	10.1	101718	5910	5.8	50807	2395	4.7
13	691	9.7	115691	6091	5.3	55274	2136	3.9
14	904	10.6	121119	6772	5.6	54489	2225	4.1
15	1036	10.5	121704	7646	6.3	53945	2367	4.4
16	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
```

[76]:
```
# 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')
```

[76]:
```
Text(0, 0.5, 'Spec Tested')
```



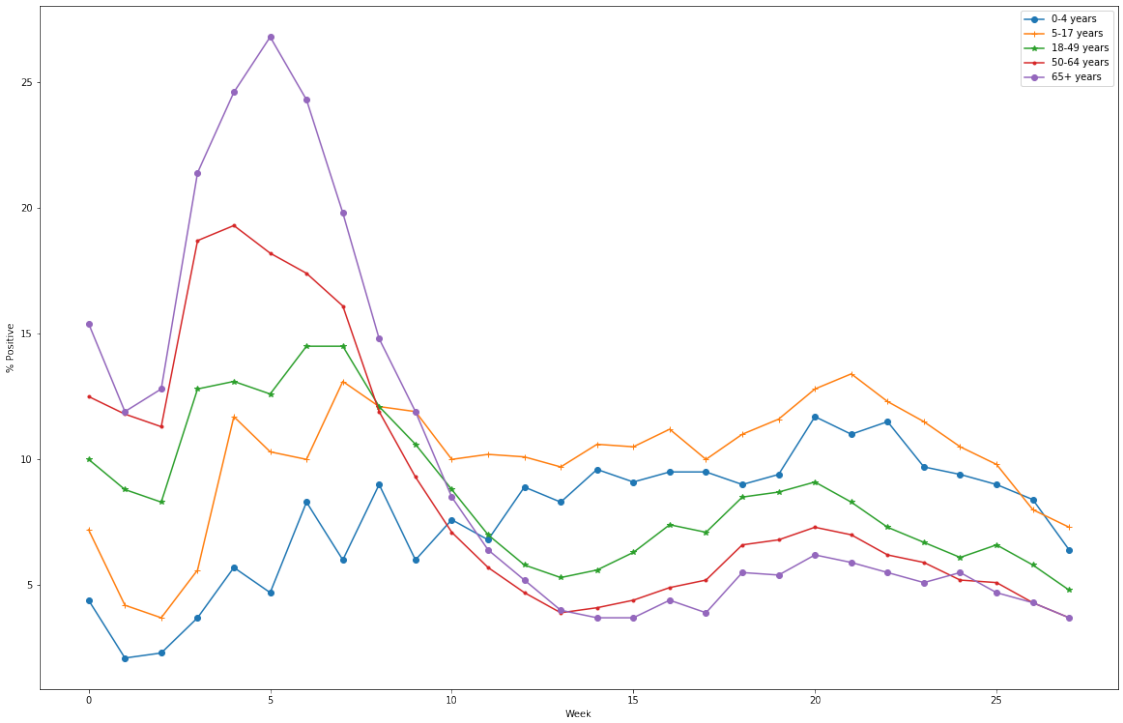
- From this graph we can see that maximum number of persons which got tested for **COVID-19** are from age group **18-49**.
- This age group primarily includes students, and working class. Both of these class were at **high risk** because they were out and exposed to virus more than other age groups.
- 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.

[77]:
```
#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']
```

[78]:
```
# % 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')
```

[78]:
```
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.

[79]:
```
# load data for ratio comparison

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

[79]:

	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

[80]:
```
# 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)
```

[80]:
```
<pandas.io.formats.style.Styler at 0x216311adfc8>
```

- 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)

[81]:
```
# load Alberta specific data

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

[81]:

	Unnamed: 0	Region name	School status	Schools details
0	1	City Of Calgary	Watch	St. Wilfrid Elementary School
1	2	City Of Calgary	Open (Outbreak, 2-4 cases)	Notre Dame High School
2	3	City Of Calgary	Open (Outbreak, 2-4 cases)	Lester B. Pearson High School
3	4	City Of Calgary	Open (Outbreak, 2-4 cases)	Henry Wise Wood High School
4	5	City Of Calgary	Open (Outbreak, 2-4 cases)	Auburn Bay School
..	…	…	…	…
115	116	Vulcan County	Open	No school status to report
116	117	Westlock County	Open	No school status to report
117	118	Wheatland County	Open	No school status to report
118	119	Woodlands County	Open	No school status to report
119	120	Yellowhead County	Open	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.

[82]:
```
school_status_map[school_status_map['School status']=='Watch']
```

[82]:

	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.

[83]:
```
Image('../Images/actiontoreduceCOVID-19.PNG')
```

[83]:

Actions to reduce risk of COVID–19