India's COVID-19 Exploratory analysis

About

This document contains basic exploaratory data analysis of COVID-19 Disease in India. This notebook serves to analyze and visualize the progress of the pandemic from various perspectives.

Introduction

The first signs of **COVID-19 in India** was reported in some towns of Kerala, among three Indian medical students who had returned from Wuhan. After that, the Government of India had announced lockdown on **25 March 2020**. India faced its **first wave** from May 2020 to January 2020 with an Amplitude of around **90,000** new infections a day. As of now India is going under second wave which has proved to be more deadlier than previous one.

1. Cases, Deaths and Recovery

In [1]:
```
import pandas as pd
from matplotlib import pyplot as plt
from matplotlib import dates as mpl_dates
```

In [2]:
```
ind_covid_df = pd.read_csv('https://api.covid19india.org/csv/latest/case_time_series.csv')
```

In [3]:
```
ind_covid_df
```

Out[3]:

	Date	Date_YMD	Daily Confirmed	Total Confirmed	Daily Recovered	Total Recovered	Daily Deceased	Total Deceased
0	30 January 2020	2020-01-30	1	1	0	0	0	0
1	31 January 2020	2020-01-31	0	1	0	0	0	0
2	1 February 2020	2020-02-01	0	1	0	0	0	0
3	2 February 2020	2020-02-02	1	2	0	0	0	0
4	3 February 2020	2020-02-03	1	3	0	0	0	0
...	...	...	...	...	...	...	...	...
499	12 June 2021	2021-06-12	80525	29438859	132664	28035743	3300	369816
500	13 June 2021	2021-06-13	71001	29509860	119574	28155317	3922	373738
501	14 June 2021	2021-06-14	60008	29569868	117376	28272693	2733	376471
502	15 June 2021	2021-06-15	62214	29632082	107767	28380460	2540	379011
503	16 June 2021	2021-06-16	67289	29699371	103900	28484360	2329	381340

504 rows × 8 columns

In [4]:
```
ind_covid_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 504 entries, 0 to 503
Data columns (total 8 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   Date             504 non-null    object
 1   Date_YMD         504 non-null    object
 2   Daily Confirmed  504 non-null    int64
 3   Total Confirmed  504 non-null    int64
 4   Daily Recovered  504 non-null    int64
 5   Total Recovered  504 non-null    int64
 6   Daily Deceased   504 non-null    int64
 7   Total Deceased   504 non-null    int64
dtypes: int64(6), object(2)
memory usage: 31.6+ KB
```

In [5]:
```
ind_covid_df.isnull().sum()
```

Out[5]:
```
Date               0
Date_YMD           0
Daily Confirmed    0
Total Confirmed    0
Daily Recovered    0
Total Recovered    0
Daily Deceased     0
Total Deceased     0
dtype: int64
```

In [6]:
```
ind_covid_df['Date_YMD'] = pd.to_datetime(ind_covid_df['Date_YMD'])
```

In [7]:
```
ind_covid_df.tail(1)
```

Out[7]:

	Date	Date_YMD	Daily Confirmed	Total Confirmed	Daily Recovered	Total Recovered	Daily Deceased	Total Deceased
503	16 June 2021	2021-06-16	67289	29699371	103900	28484360	2329	381340

In [8]:
```
total_cases = ind_covid_df['Total Confirmed']
dates = ind_covid_df['Date_YMD']
```

In [9]:
```
curr_date = dates.max()
curr_total_cases = int(total_cases.tail(1))
```

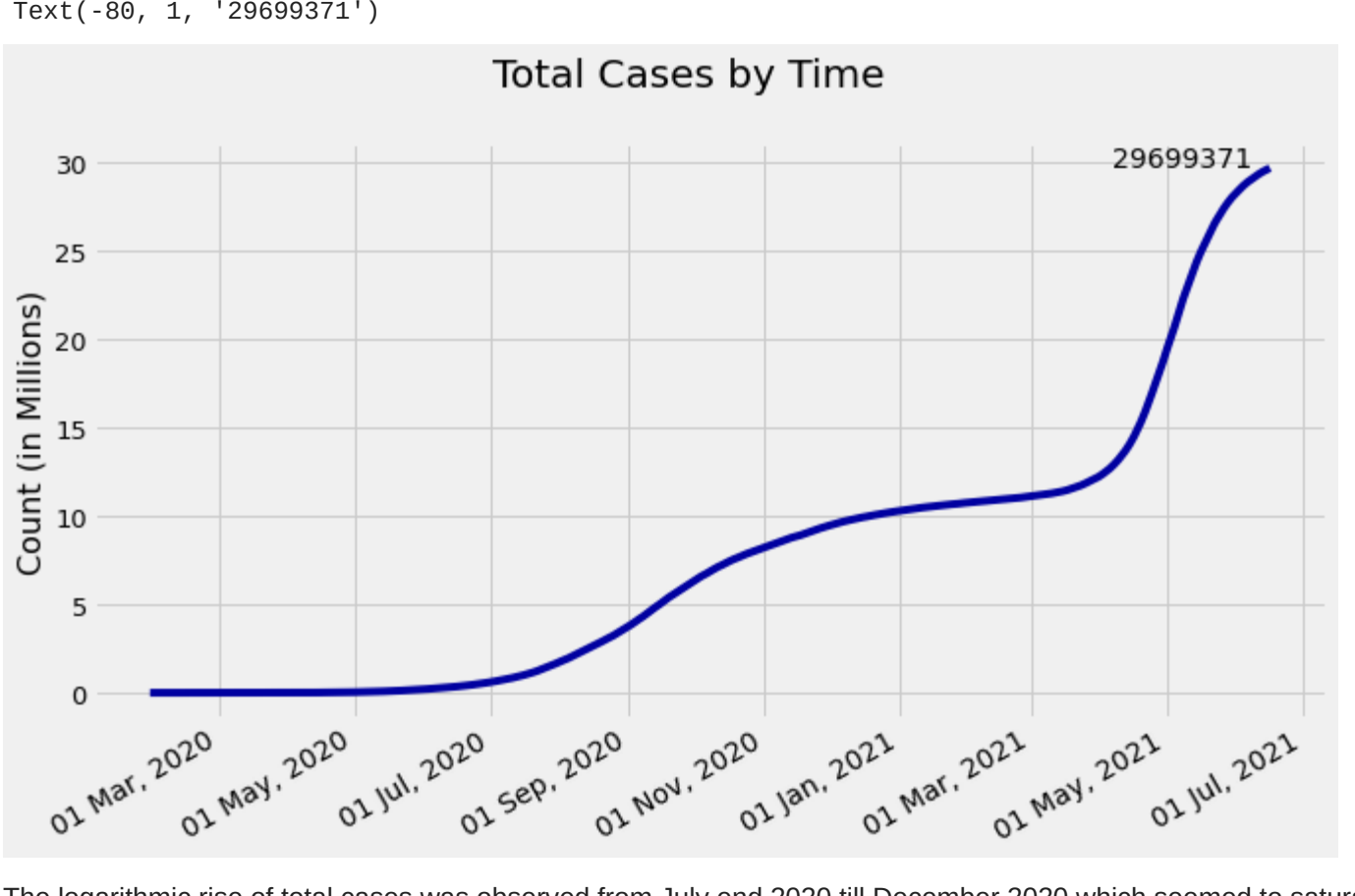
In [10]:
```
dates.max()
```

Out[10]:
```
Timestamp('2021-06-16 00:00:00')
```

In [11]:
```
filt = ind_covid_df.Date_YMD==dates.max()
today_cases = int(ind_covid_df.loc[filt, 'Daily Confirmed'])

today_deaths = int(ind_covid_df.loc[filt, 'Daily Deceased'])

today_recovered = int(ind_covid_df.loc[filt, 'Daily Recovered'])

curr_total_deaths = int(ind_covid_df.loc[filt, 'Total Deceased'])

curr_total_recovered = int(ind_covid_df.loc[filt, 'Total Recovered'])
```

In [12]:
```
plt.style.use('fivethirtyeight')
# total_cases.plot(figsize=(10,6))
plt.figure(figsize=(10,6))
plt.plot(dates, total_cases.values/10**6, color='#0000a0')
# plt.plot(total_deaths.index, total_deaths.values, linewidth=1)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.xlabel('')
plt.ylabel('Count (in Millions)',fontsize=16)
plt.xticks(fontsize=14)
plt.yticks(fontsize=13)
plt.suptitle('Total Cases by Time', fontsize=20)

plt.annotate(text=str(curr_total_cases), xy=(curr_date,curr_total_cases/10**6),
            xycoords='data', xytext=(-80,1), textcoords='offset points', fontsize=14)
```

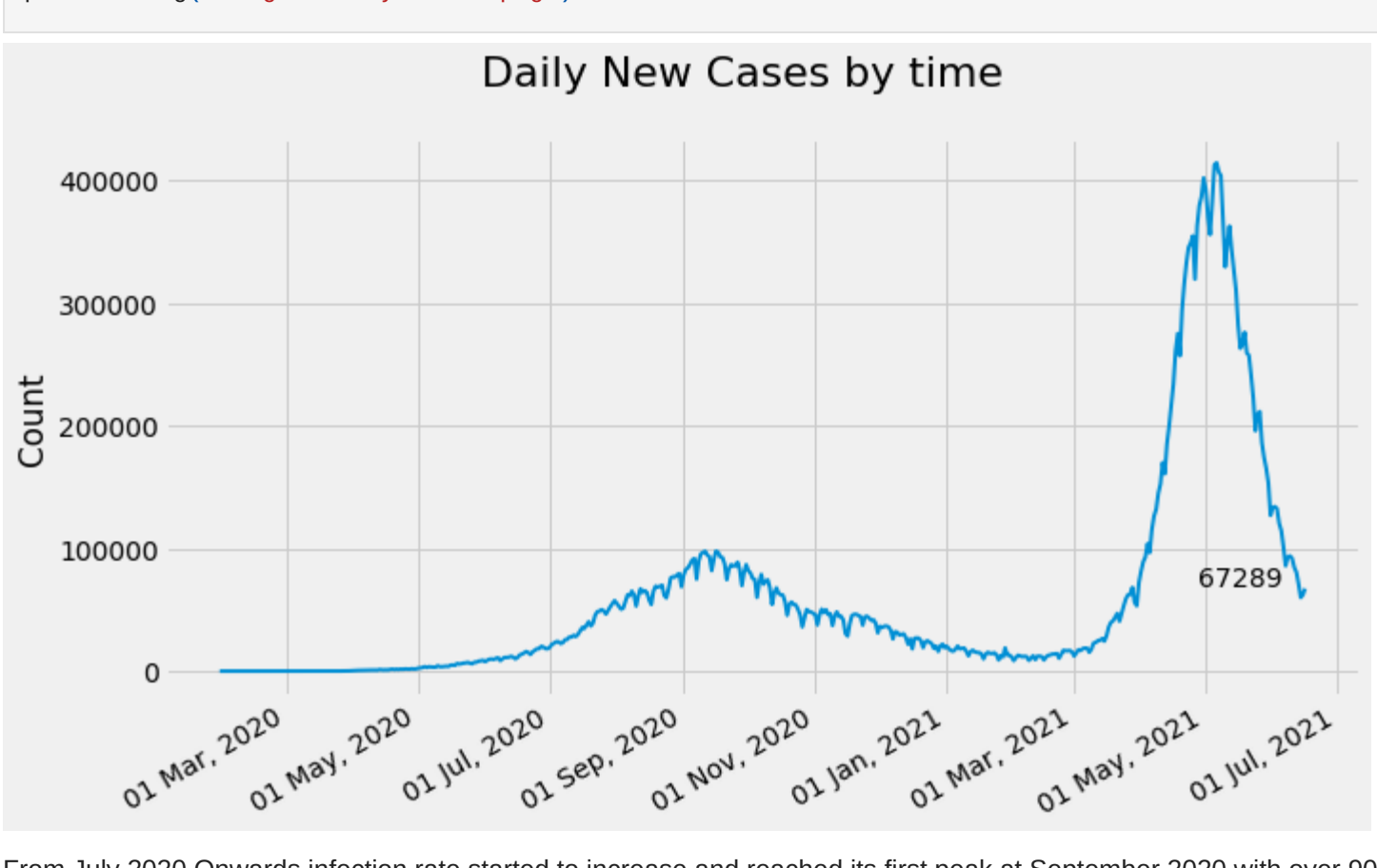
Out[12]:
```
Text(-80, 1, '29699371')
```



The logarithmic rise of total cases was observed from July end 2020 till December 2020 which seemed to saturate in january 2020. But April 2020 onwards, cases started to increase at much higher rate than before

In [13]:
```
daily_cases = ind_covid_df['Daily Confirmed']
```

In [14]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, daily_cases,'-', linewidth=2)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Count')
plt.suptitle('Daily New Cases by time',fontsize=22)

plt.annotate(text=str(today_cases), xy=(curr_date, today_cases),
            xycoords='data', xytext=(-56,1), textcoords='offset points', fontsize=14)

plt.savefig('Images/daily_cases.png')
```



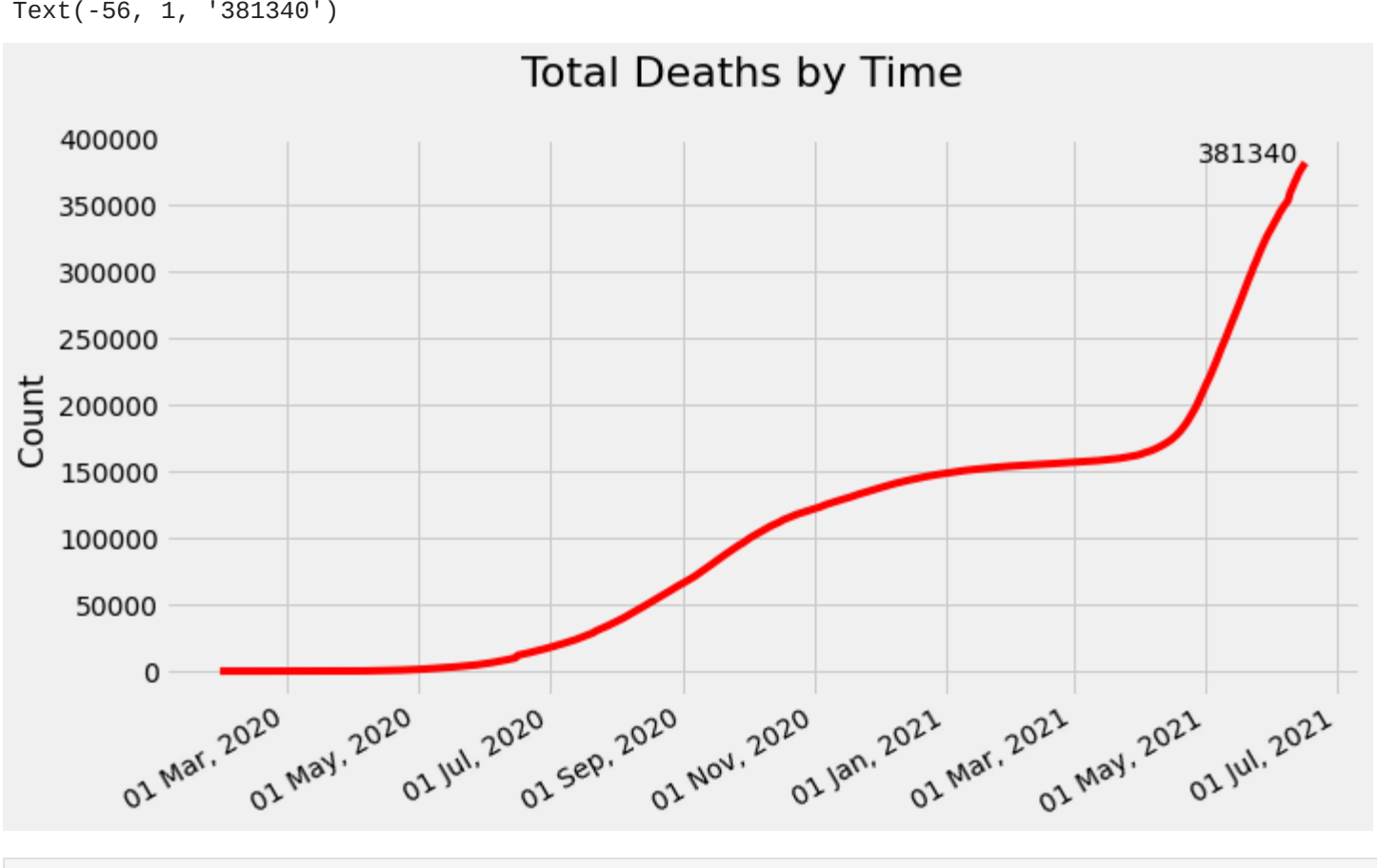
From July 2020 Onwards infection rate started to increase and reached its first peak at September 2020 with over 90,000 cases reported per-day.\ Cases began to decline from October 2020 and were reported below 15,000 in January 2021 which was a good sign.

A second wave beginning in March 2021 was much larger than first, with shortages of vaccines, hospital beds, oxygen cylinders and other medicines such as remdesivir in parts of the country. By April end daily infection count reached over 400,000 which was new record

In [15]:
```
total_deaths = ind_covid_df['Total Deceased']
```

In [16]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, total_deaths, color='red')

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Count')
plt.suptitle('Total Deaths by Time', fontsize=22)

plt.annotate(text=str(curr_total_deaths), xy=(curr_date, curr_total_deaths),
            xycoords='data', xytext=(-56,1), textcoords='offset points', fontsize=14)
```

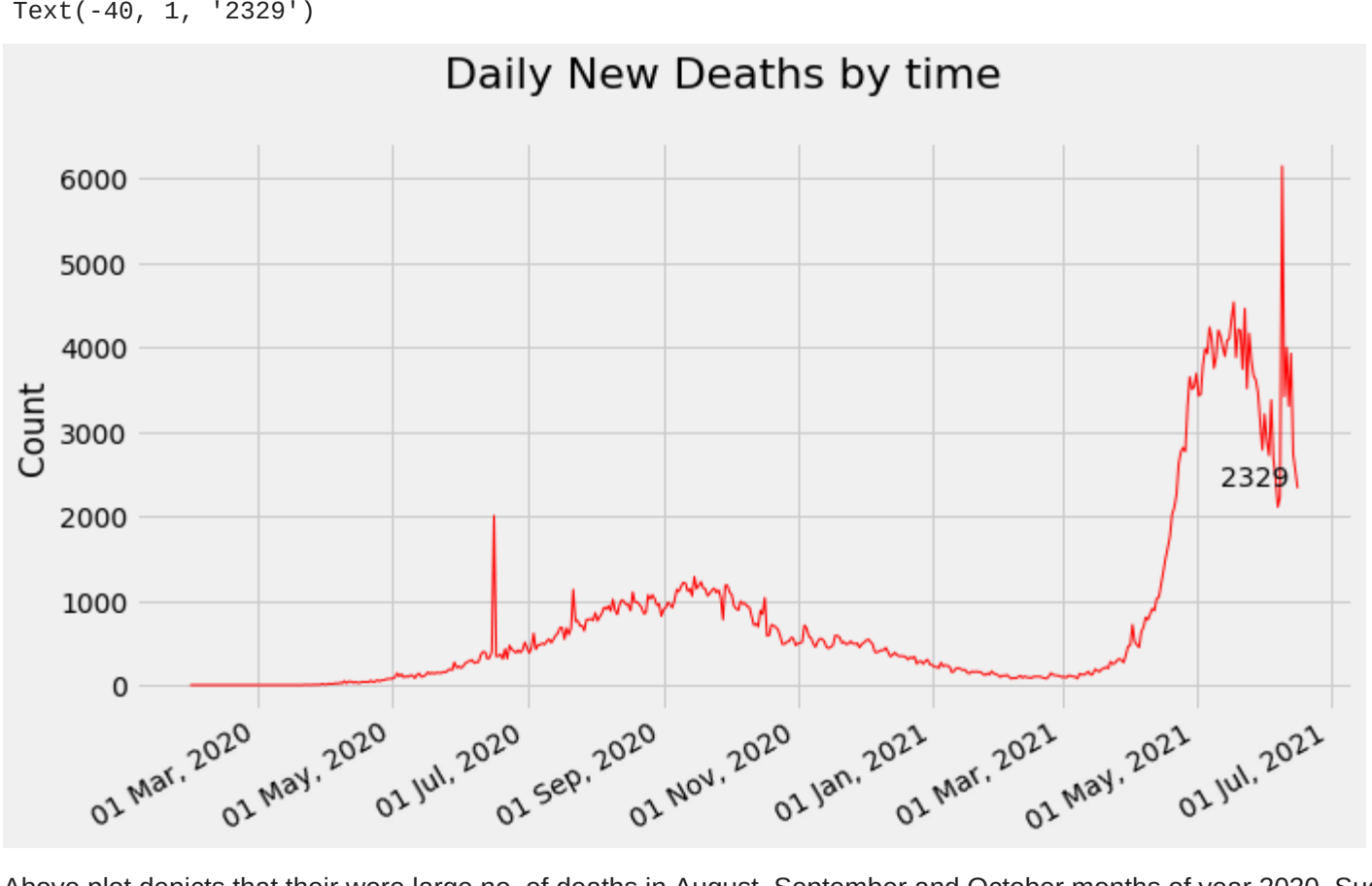
Out[16]:
```
Text(-56, 1, '381340')
```



In [17]:
```
daily_deaths = ind_covid_df['Daily Deceased']
```

In [18]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, daily_deaths,'-r', linewidth=1)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Count')
plt.suptitle('Daily New Deaths by time',fontsize=22)

plt.annotate(text=str(today_deaths), xy=(curr_date, today_deaths),
            xycoords='data', xytext=(-40,1), textcoords='offset points', fontsize=14)
```

Out[18]:
```
Text(-40, 1, '2329')
```

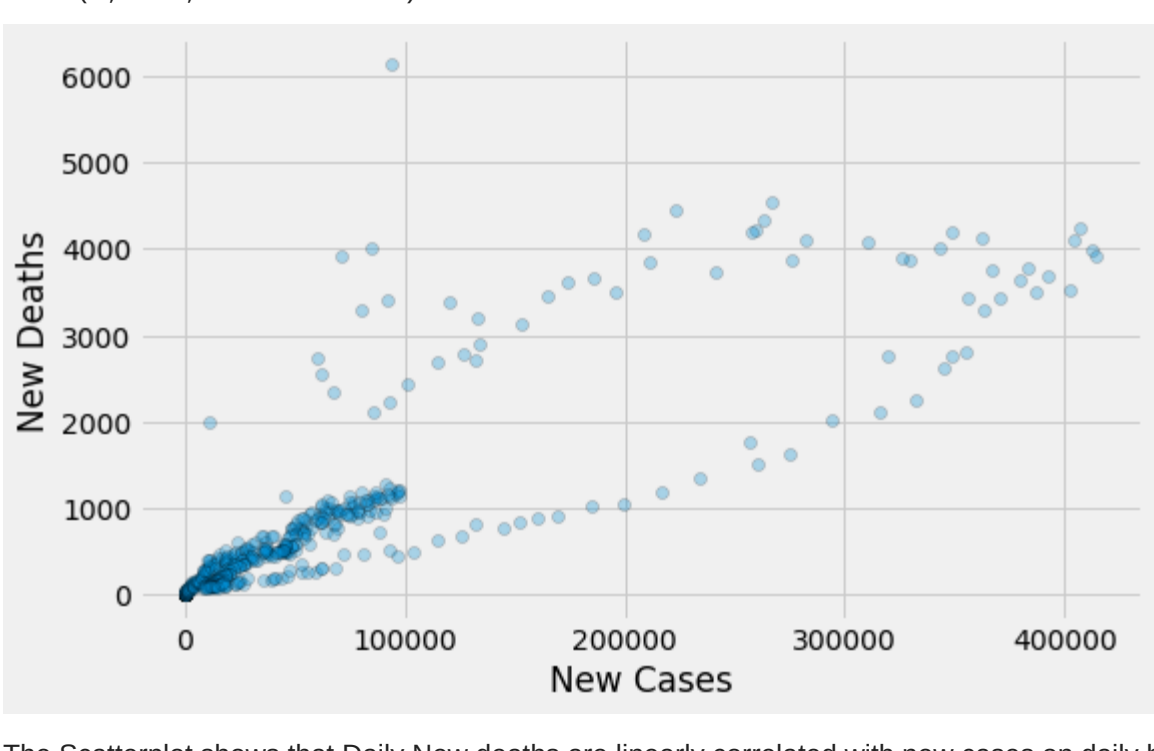


Above plot depicts that their were large no. of deaths in August, September and October months of year 2020. Sudden spike of deaths was seen in mid-June month. In Second wave the deaths are 4 to 5 times more than the previous wave

Let us see if their is any correlation between new cases and new deaths on daily basis

In [19]:
```
plt.figure(figsize=(8,5))
plt.scatter(daily_cases, daily_deaths, edgecolor='black', alpha=.3)
plt.xlabel('New Cases')
plt.ylabel('New Deaths')
```

Out[19]:
```
Text(0, 0.5, 'New Deaths')
```



The Scatterplot shows that Daily New deaths are linearly correlated with new cases on daily basis. Their is positive, strong relation between the two, as more points overlapp to form a line

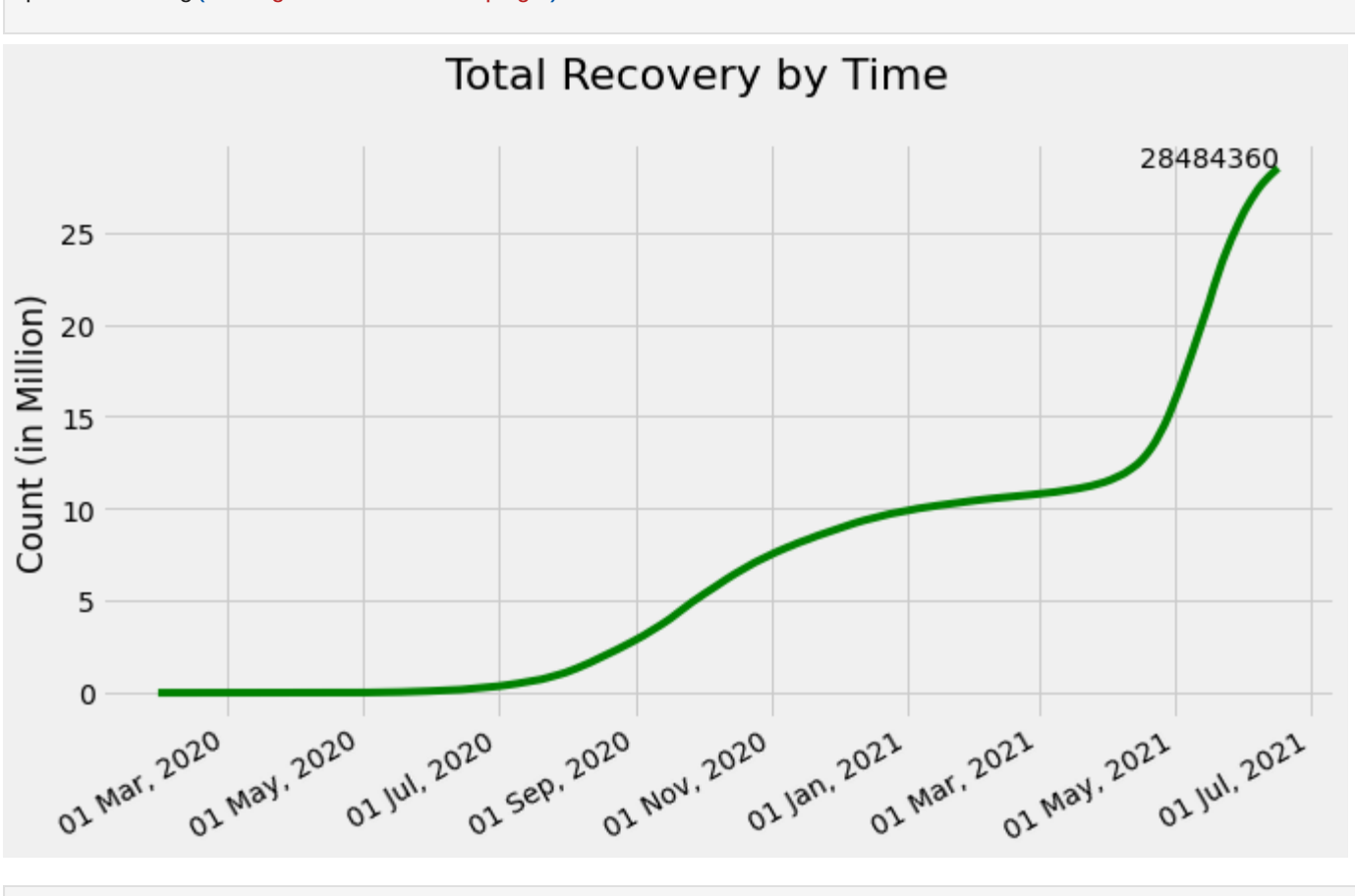
i.e. Deaths occuring each day depends on the fresh Covid cases on that day. More the no. of cases are found more deaths will occur.

From above plots we can conclude, that if we could stop or supress the fresh Covid cases, then their would be less deaths.

`if we could prevent new cases from happening, deaths would reduce`

In [20]:
```
total_recovered = ind_covid_df['Total Recovered']
```

In [21]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, total_recovered/10**6, color='green')

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Count (in Million)')
plt.suptitle('Total Recovery by Time', fontsize=22)

plt.annotate(text=str(curr_total_recovered), xy=(curr_date, curr_total_recovered/10**6),
            xycoords='data', xytext=(-70,1), textcoords='offset points', fontsize=14)

plt.savefig('Images/tot_recov.png')
```



In [22]:
```
daily_recovered = ind_covid_df['Daily Recovered']
```

In [23]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, daily_recovered,'-g', linewidth=1)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Count')
plt.suptitle('Daily Recovered by time',fontsize=22)

plt.annotate(text=str(today_recovered), xy=(curr_date, today_recovered),
            xycoords='data', xytext=(-60,1), textcoords='offset points', fontsize=14)
```

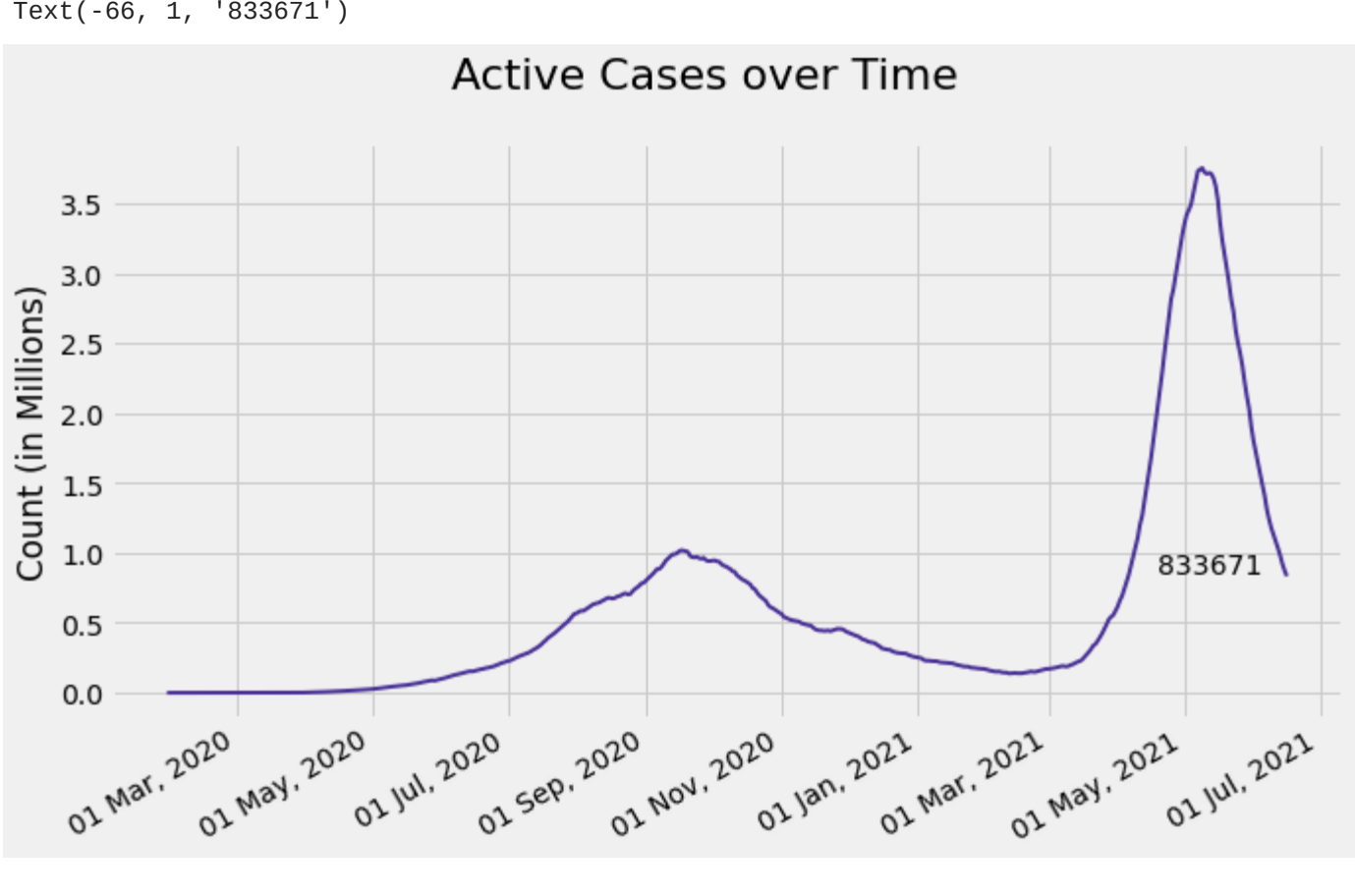
Out[23]:
```
Text(-60, 1, '103900')
```

In [24]:
```
active_cases = total_cases-total_deaths-total_recovered
```

In [25]:
```
curr_active_cases = curr_total_cases - curr_total_deaths - curr_total_recovered
```

In [26]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, active_cases/10**6, color='#483096', linewidth=2)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Count (in Millions)')
plt.suptitle('Active Cases over Time',fontsize=22)

plt.annotate(text=str(curr_active_cases), xy=(curr_date, curr_active_cases/10**6),
            xycoords='data', xytext=(-66,1), textcoords='offset points', fontsize=14)
```

Out[26]:
```
Text(-66, 1, '833671')
```



Summary

1. Case Fatality Ratio (CFR)

Case fatality ratio(CFR) is ratio to measure risk of death when person is infected with a disease. The actual probability of death of person diagonsed with a disease is generally less since everybody is not tested to have a disease or not. Hence their would be a scenario where their are people who have the disease but are not diagonsed. CFR can increase or decrease, or could vary by location and characteristics of the infected person.

CFR gives rough chances of death if person is infected with COVID-19

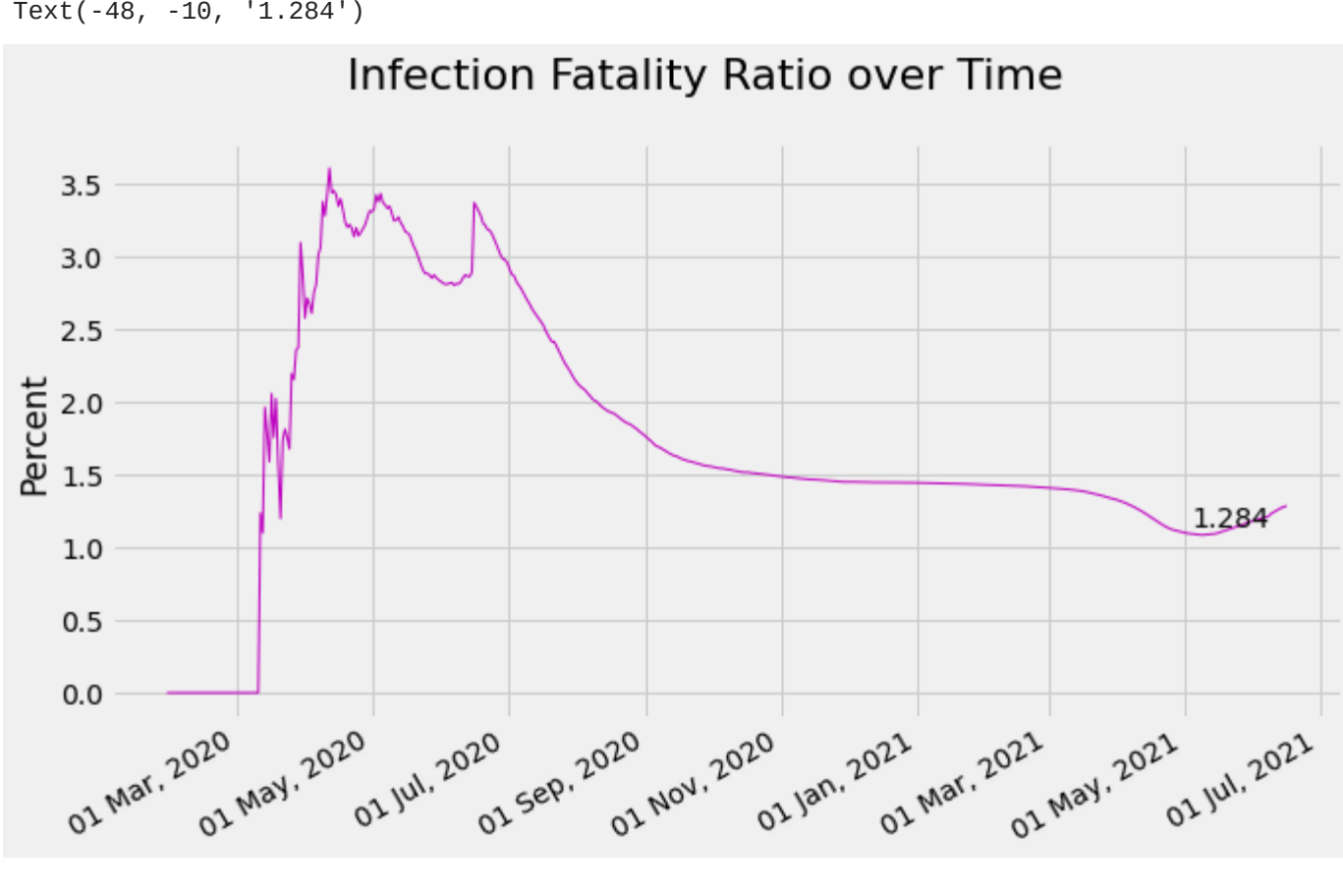
$$CFR = \frac{Number\ of\ deaths\ from\ disease}{Number\ of\ diagonsed\ case\ of\ disease} X\ 100$$

In [27]:
```
inf_fatality_ratio = (total_deaths/total_cases)*100
```

In [28]:
```
curr_fat_ratio = (curr_total_deaths/curr_total_cases)*100
```

In [29]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, inf_fatality_ratio,'-m', linewidth=1)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Percent')
plt.suptitle('Infection Fatality Ratio over Time',fontsize=22)
# plt.title('(Chances of Death)')

plt.annotate(text=str(round(curr_fat_ratio, 3)), xy=(curr_date, curr_fat_ratio),
            xycoords='data', xytext=(-48,-10), textcoords='offset points', fontsize=14)
```

Out[29]:
```
Text(-48, -10, '1.284')
```



2. Rate of Recovery

$$Recovery\ Rate = \frac{Number\ of\ recovries\ from\ disease}{Number\ of\ diagonsed\ case\ of\ disease} X\ 100$$

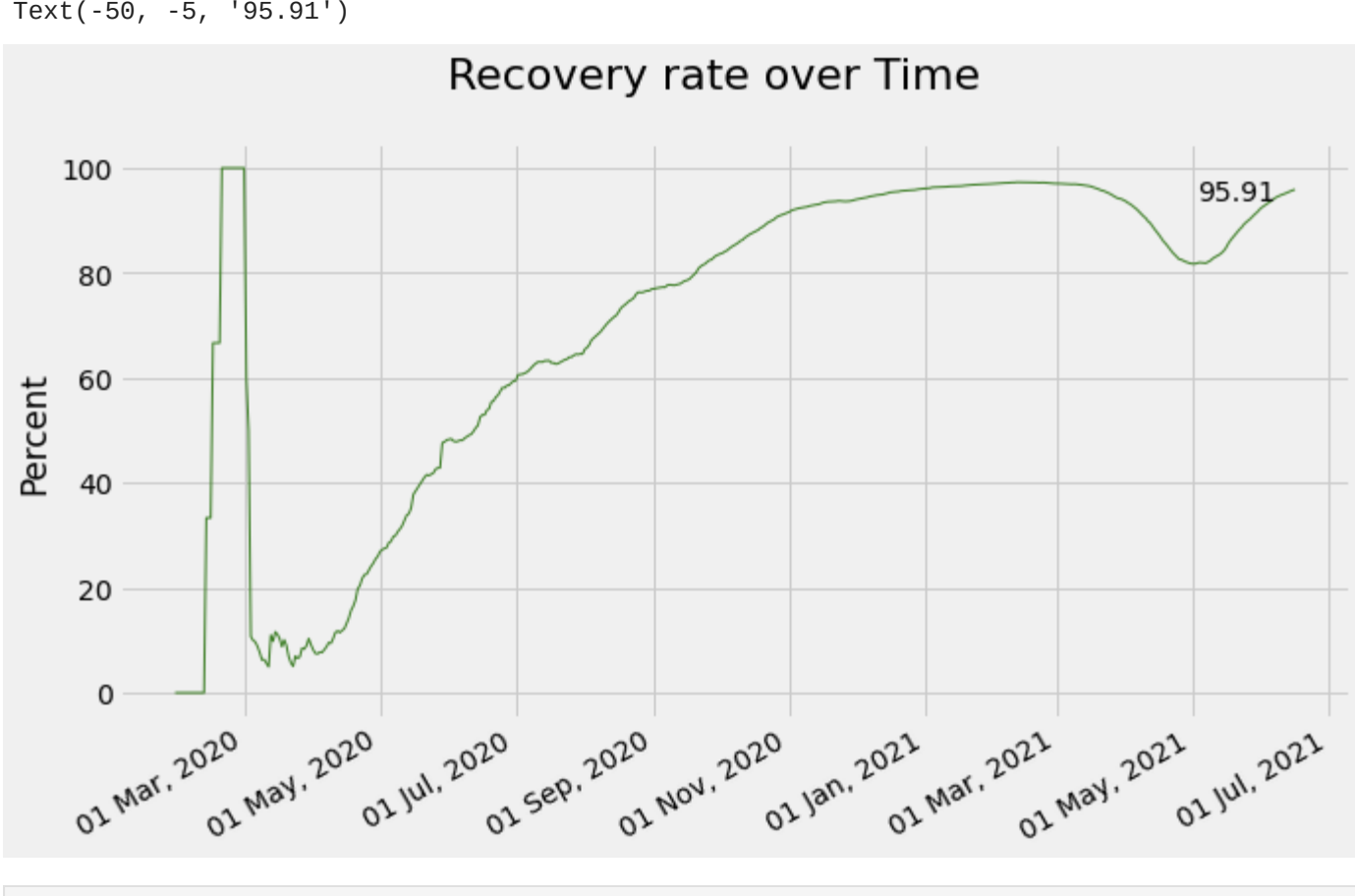
During the rise of second wave, recovery rate started falling from March 2021 and settled at 80% after which has started to grow again

In [30]:
```
recovery_rate = (total_recovered/total_cases)*100
```

In [31]:
```
curr_rec_ratio = (curr_total_recovered/curr_total_cases)*100
```

In [32]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, recovery_rate, color='#3b7d24', linewidth=1)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Percent')
plt.suptitle('Recovery rate over Time',fontsize=22)

plt.annotate(text=str(round(curr_rec_ratio, 2)), xy=(curr_date, curr_rec_ratio),
            xycoords='data', xytext=(-50,-5), textcoords='offset points', fontsize=14)
```

Out[32]:
```
Text(-50, -5, '95.91')
```

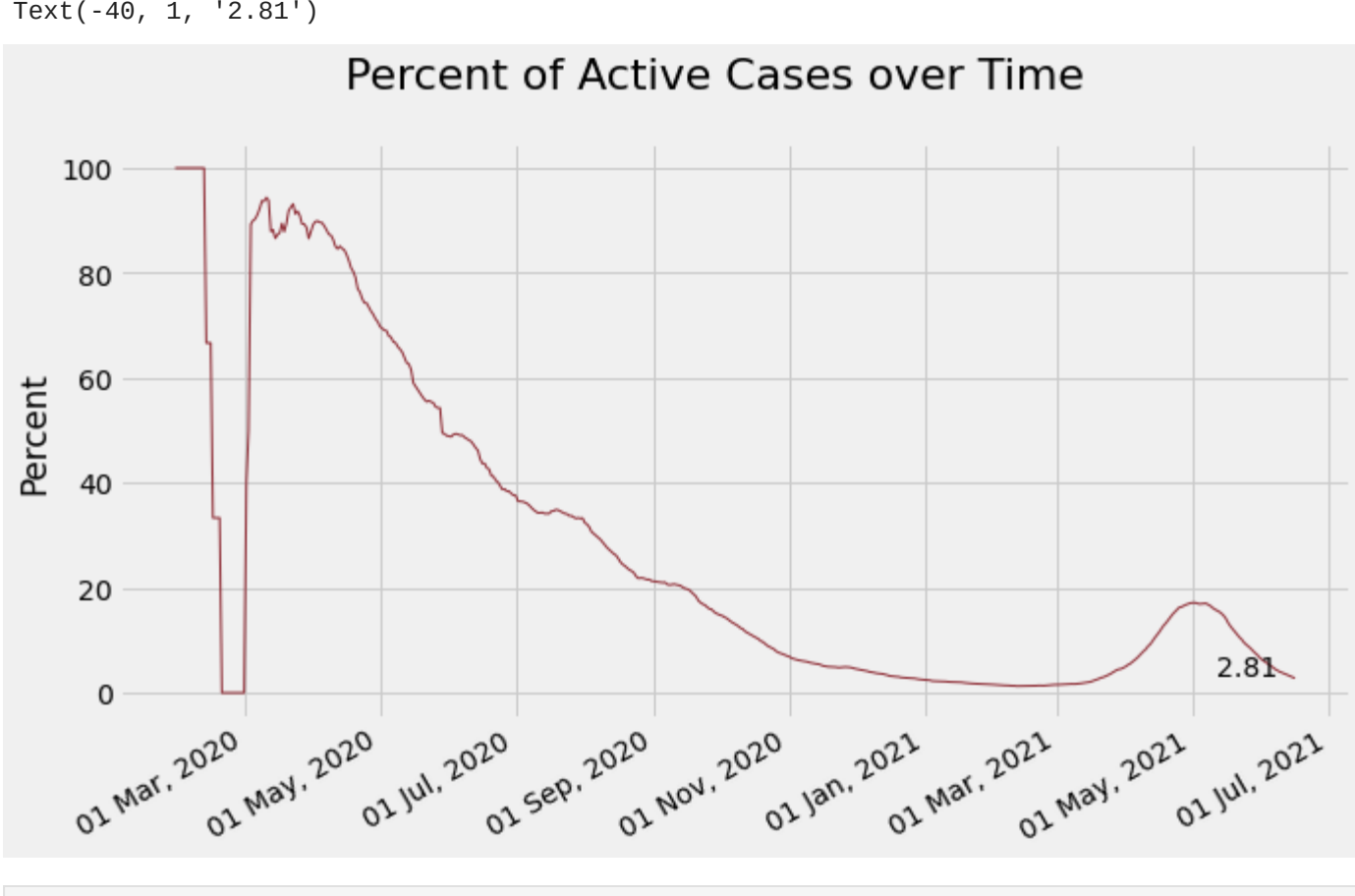


In [33]:
```
per_act_cases = (active_cases/total_cases)*100
```

In [34]:
```
curr_per_act_cases = (curr_active_cases/curr_total_cases)*100
```

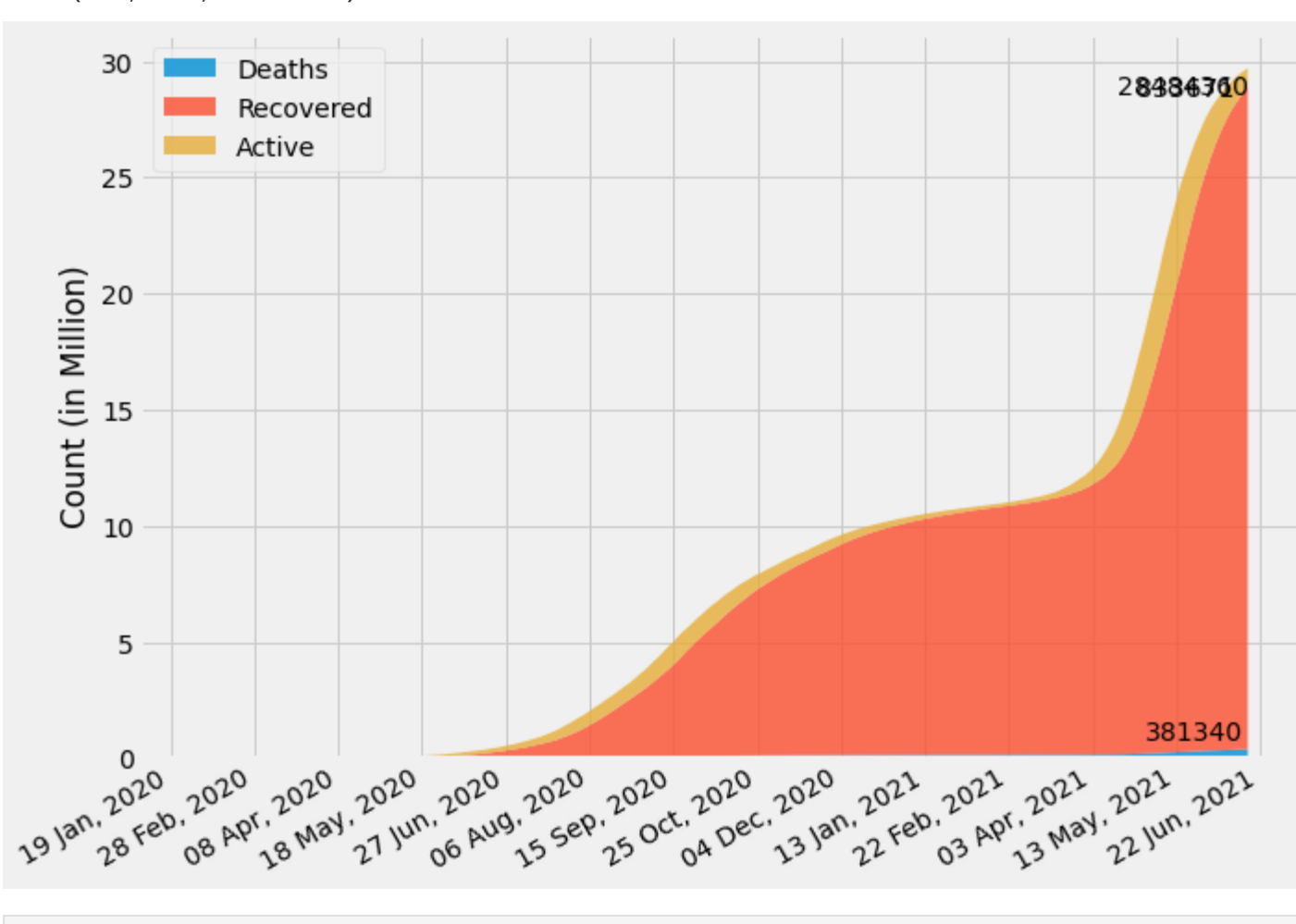
In [35]:
```
plt.figure(figsize=(10,6))
plt.plot(dates, per_act_cases, color='#8c2730', linewidth=1)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

plt.ylabel('Percent')
plt.suptitle('Percent of Active Cases over Time',fontsize=22)

plt.annotate(text=str(round(curr_per_act_cases, 2)), xy=(curr_date, curr_per_act_cases),
            xycoords='data', xytext=(-40,1), textcoords='offset points', fontsize=14)
```

Out[35]:
```
Text(-40, 1, '2.81')
```



In [36]:
```
fig, ax = plt.subplots()
fig.set_figheight(8)
fig.set_figwidth(10)

labels = ['Deaths','Recovered','Active']
ax.stackplot(dates, total_deaths/10**6,total_recovered/10**6,active_cases/10**6, alpha=.8, labels=labels)
ax.set_ylabel('Count (in Million)')
ax.legend(loc='upper left')

fig.autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')

ax.xaxis.set_major_locator(plt.MaxNLocator(18))
ax.xaxis.set_major_formatter(date_format)

plt.annotate(text=str(curr_total_deaths), xy=(curr_date, curr_total_deaths/10**6),
            xycoords='data', xytext=(-55,5), textcoords='offset points', fontsize=14)

plt.annotate(text=str(curr_total_recovered), xy=(curr_date, curr_total_recovered/10**6),
            xycoords='data', xytext=(-70,1), textcoords='offset points', fontsize=14)

plt.annotate(text=str(curr_active_cases), xy=(curr_date, curr_active_cases/10**6 + curr_total_recovered/10**6),
            xycoords='data', xytext=(-60,-10), textcoords='offset points', fontsize=14)
```

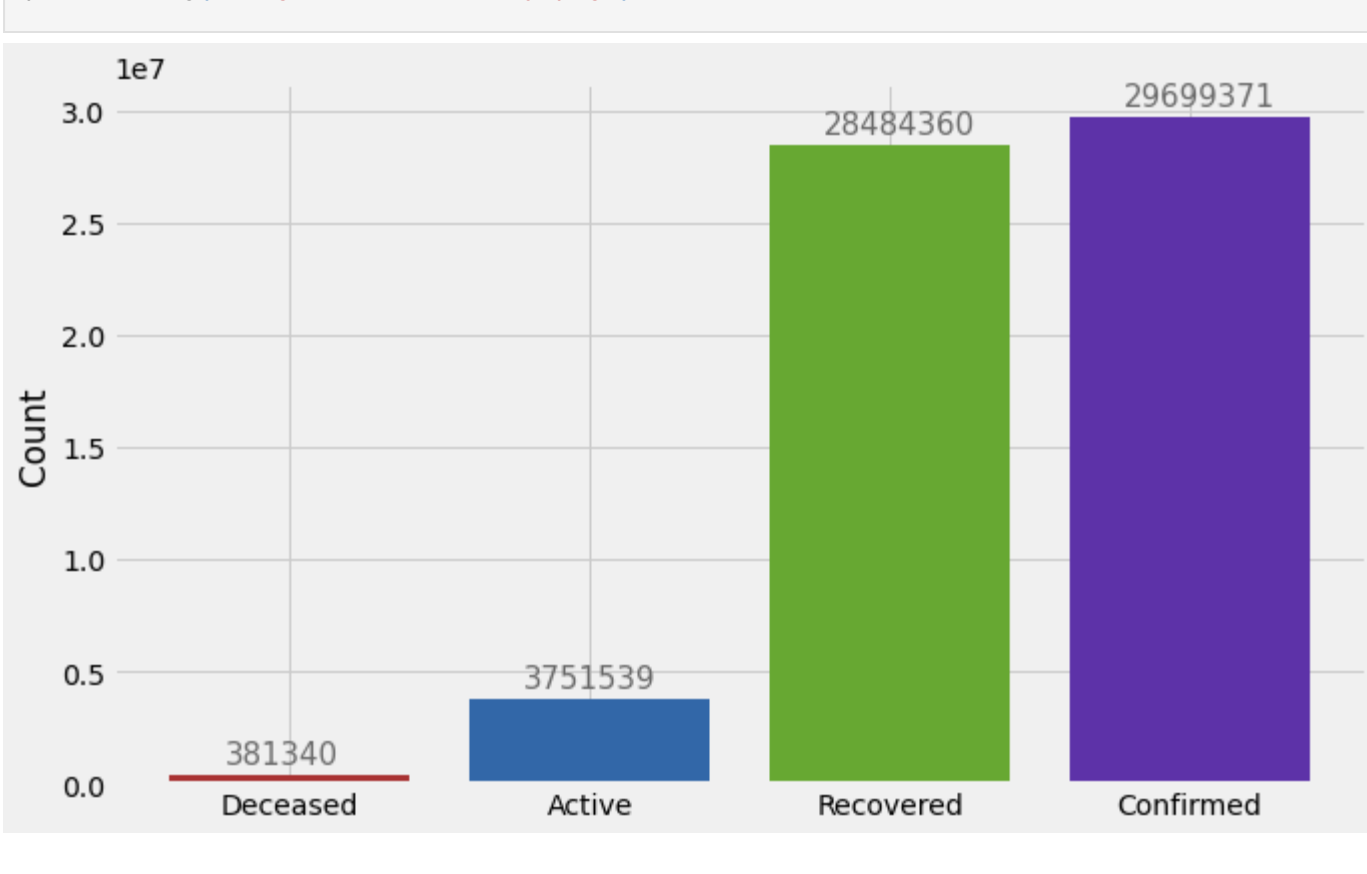
Out[36]:
```
Text(-60, -10, '833671')
```



In [37]:
```
total_deaths.max()
```

Out[37]:
```
381340
```

In [38]:
```
fig, ax = plt.subplots(figsize=(10,6))

labels = ['Deceased', 'Active', 'Recovered', 'Confirmed']
values = [total_deaths.max(), active_cases.max(), total_recovered.max(), total_cases.max()]

ax.bar(labels, values, color=['#a83232','#3267a8','#67a832','#5d32a8'])
ax.set_ylabel('Count')

# create a list to collect the plt.patches data
totals = []

# find the values and append to list
for i in ax.patches:
    totals.append(i.get_height())

# set individual bar lables using above list
for i in ax.patches:
    # get_x pulls left or right; get_height pushes up or down
    ax.text(i.get_x()+.18, i.get_height()+500000, \
            str(round(i.get_height())), fontsize=15,
                color='dimgrey')

plt.savefig('Images/cases_summary.png')
```



2. Vaccination

India began its **vaccination program** on **16 January 2021**. India has approved two vaccines for emergency use, including Oxford-AstraZeneca vaccine also known as **Covisheld** manufactured by the Serum Institue of India, and **Covaxin** developed by Biotech. In April 2021 ,Sputnik V was approved as a third vaccine.

India first started with vaccinating Health care workers being first to receive the vaccine. On **April 1 2021** vaccination of people above **age 45** was started. Followed by vaccination of age **group 18-44** from **1 May** onwards.

In [39]:
```
vac_df = pd.read_csv('http://api.covid19india.org/csv/latest/cowin_vaccine_data_statewise.csv')
pd.set_option('display.max_rows', 10)
```

In [40]:
```
filt = vac_df.State=='India'
ind_vac_df = vac_df.loc[filt].copy()
```

In [41]:
```
ind_vac_df
```

Out[41]:

	Updated On	State	Total Individuals Vaccinated	Total Sessions Conducted	Total Sites	First Dose Administered	Second Dose Administered	Male(Individuals Vaccinated)	Female(Individuals Vaccinated)	Transgender(Indiv Vacc
0	16/01/2021	India	48276.0	3455.0	2957.0	48276.0	0.0	23757.0	24517.0	
1	17/01/2021	India	58604.0	8532.0	4954.0	58604.0	0.0	27348.0	31252.0	
2	18/01/2021	India	99449.0	13611.0	6583.0	99449.0	0.0	41361.0	58083.0	
3	19/01/2021	India	195525.0	17855.0	7951.0	195525.0	0.0	81901.0	113613.0	
4	20/01/2021	India	251280.0	25472.0	10504.0	251280.0	0.0	98111.0	153145.0	
...	...	...	...	...	...	...	...	...	...	
149	14/06/2021	India	207274441.0	14048206.0	46924.0	207274441.0	47378599.0	111868784.0	95369557.0	3
150	15/06/2021	India	209816439.0	11834657.0	41484.0	209816439.0	47789089.0	113266182.0	96513504.0	3
151	16/06/2021	India	212945352.0	14252163.0	44447.0	212945352.0	48173116.0	114978703.0	97929255.0	3
152	17/06/2021	India	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
153	18/06/2021	India	NaN	NaN	NaN	NaN	NaN	NaN	NaN	

154 rows × 18 columns

In [42]:
```
total_population = 1380004385
```

In [43]:
```
ind_vac_df.columns
```

Out[43]:
```
Index(['Updated On', 'State', 'Total Individuals Vaccinated',
       'Total Sessions Conducted', 'Total Sites ', 'First Dose Administered',
       'Second Dose Administered', 'Male(Individuals Vaccinated)',
       'Female(Individuals Vaccinated)', 'Transgender(Individuals Vaccinated)',
       'Total Covaxin Administered', 'Total CoviShield Administered',
       'Total Sputnik V Administered', 'AEFI', '18-45 years (Age)',
       '45-60 years (Age)', '60+ years (Age)', 'Total Doses Administered'],
      dtype='object')
```

In [44]:
```
ind_vac_df.drop(['State','Total Sessions Conducted','Total Sites ','Male(Individuals Vaccinated)','Female(Indiv
```

In [45]:
```
ind_vac_df
```

Out[45]:

	Updated On	Total Individuals Vaccinated	First Dose Administered	Second Dose Administered	Total Covaxin Administered	Total CoviShield Administered	Total Sputnik V Administered	18-45 years (Age)	45-60 years (Age)	60+ years (Age)
0	16/01/2021	48276.0	48276.0	0.0	579.0	47697.0	NaN	NaN	NaN	NaN
1	17/01/2021	58604.0	58604.0	0.0	635.0	57969.0	NaN	NaN	NaN	NaN
2	18/01/2021	99449.0	99449.0	0.0	1299.0	98150.0	NaN	NaN	NaN	NaN
3	19/01/2021	195525.0	195525.0	0.0	3017.0	192508.0	NaN	NaN	NaN	NaN
4	20/01/2021	251280.0	251280.0	0.0	3946.0	247334.0	NaN	NaN	NaN	NaN
...	...	...	...	...	...	...	...	...	...	...
149	14/06/2021	207274441.0	207274441.0	47378599.0	30779165.0	223847280.0	26595.0	60913444.0	82600503.0	63665384.0
150	15/06/2021	209816439.0	209816439.0	47789089.0	31248316.0	226329536.0	27676.0	62448482.0	83290805.0	63979181.0
151	16/06/2021	212945352.0	212945352.0	48173116.0	31695663.0	229393676.0	29129.0	64643068.0	83939373.0	64262201.0
152	17/06/2021	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
153	18/06/2021	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

154 rows × 11 columns

In [46]:
```
ind_vac_df['Total Doses Administered']=ind_vac_df['First Dose Administered']+ind_vac_df['Second Dose Administer
```

In [47]:
```
ind_vac_df.info()
```
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 154 entries, 0 to 153
Data columns (total 11 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   Updated On                    154 non-null    object
 1   Total Individuals Vaccinated  152 non-null    float64
 2   First Dose Administered       152 non-null    float64
 3   Second Dose Administered      152 non-null    float64
 4   Total Covaxin Administered    152 non-null    float64
 5   Total CoviShield Administered 152 non-null    float64
 6   Total Sputnik V Administered  27 non-null     float64
 7   18-45 years (Age)             93 non-null     float64
 8   45-60 years (Age)             93 non-null     float64
 9   60+ years (Age)               93 non-null     float64
 10  Total Doses Administered      152 non-null    float64
dtypes: float64(10), object(1)
memory usage: 14.4+ KB
```

In [48]:
```
ind_vac_df.rename(columns={'Updated On':'Date'}, inplace=True)
```

In [49]:
```
ind_vac_df.dropna(thresh=5,inplace=True)
```

In [50]:
```
ind_vac_df.loc[:,['First Dose Administered','Second Dose Administered',
                 'Total Covaxin Administered','Total CoviShield Administered',
                 'Total Individuals Vaccinated',
                 'Total Doses Administered']]=ind_vac_df.loc[:,['First Dose Administered',
                                                               'Second Dose Administered',
                                                               'Total Covaxin Administered','Total CoviShiel
```

In [51]:
```
ind_vac_df['Date'] = pd.to_datetime(ind_vac_df['Date'],format='%d/%m/%Y')
```

In [52]:
```
ind_vac_df
```

Out[52]:

	Date	Total Individuals Vaccinated	First Dose Administered	Second Dose Administered	Total Covaxin Administered	Total CoviShield Administered	Total Sputnik V Administered	18-45 years (Age)	45-60 years (Age)	60+ years (Age)	Total D Adminis
0	2021-01-16	48276	48276	0	579	47697	NaN	NaN	NaN	NaN	
1	2021-01-17	58604	58604	0	635	57969	NaN	NaN	NaN	NaN	
2	2021-01-18	99449	99449	0	1299	98150	NaN	NaN	NaN	NaN	
3	2021-01-19	195525	195525	0	3017	192508	NaN	NaN	NaN	NaN	1
4	2021-01-20	251280	251280	0	3946	247334	NaN	NaN	NaN	NaN	2
...	...	...	...	...	...	...	...	...	...	...	
147	2021-06-12	202207183	202207183	46825911	29975845	219032482	24767.0	57472406.0	81467278.0	63177391.0	2490
148	2021-06-13	203705131	203705131	46951231	30185294	220445754	25314.0	58561036.0	81756122.0	63296269.0	2506
149	2021-06-14	207274441	207274441	47378599	30779165	223847280	26595.0	60913444.0	82600503.0	63665384.0	2546
150	2021-06-15	209816439	209816439	47789089	31248316	226329536	27676.0	62448482.0	83290805.0	63979181.0	2576
151	2021-06-16	212945352	212945352	48173116	31695663	229393676	29129.0	64643068.0	83939373.0	64262201.0	2611

152 rows × 11 columns

Percentage share of population vaccinated

After the first quarter of the vaccination drive, India has vaccinated **10.13%** of its total population which is about **139 Million** Individuals vaccinated out of which **2.9%** are fully vaccinated. At the end of the quarter one, average Individuals immunized are **0.93 Million**.

In [53]:
```
ind_vac_df.set_index('Date',inplace=True)
```

In [54]:
```
ind_vac_df['Percentage Population Vaccinated'] = (ind_vac_df['Total Individuals Vaccinated']/total_population)*
```

In [55]:
```
ind_vac_df['Percentage Population Completely Vaccinated'] = (ind_vac_df['Second Dose Administered']/total_popul
```

In [56]:
```
ind_vac_df
```

Out[56]:

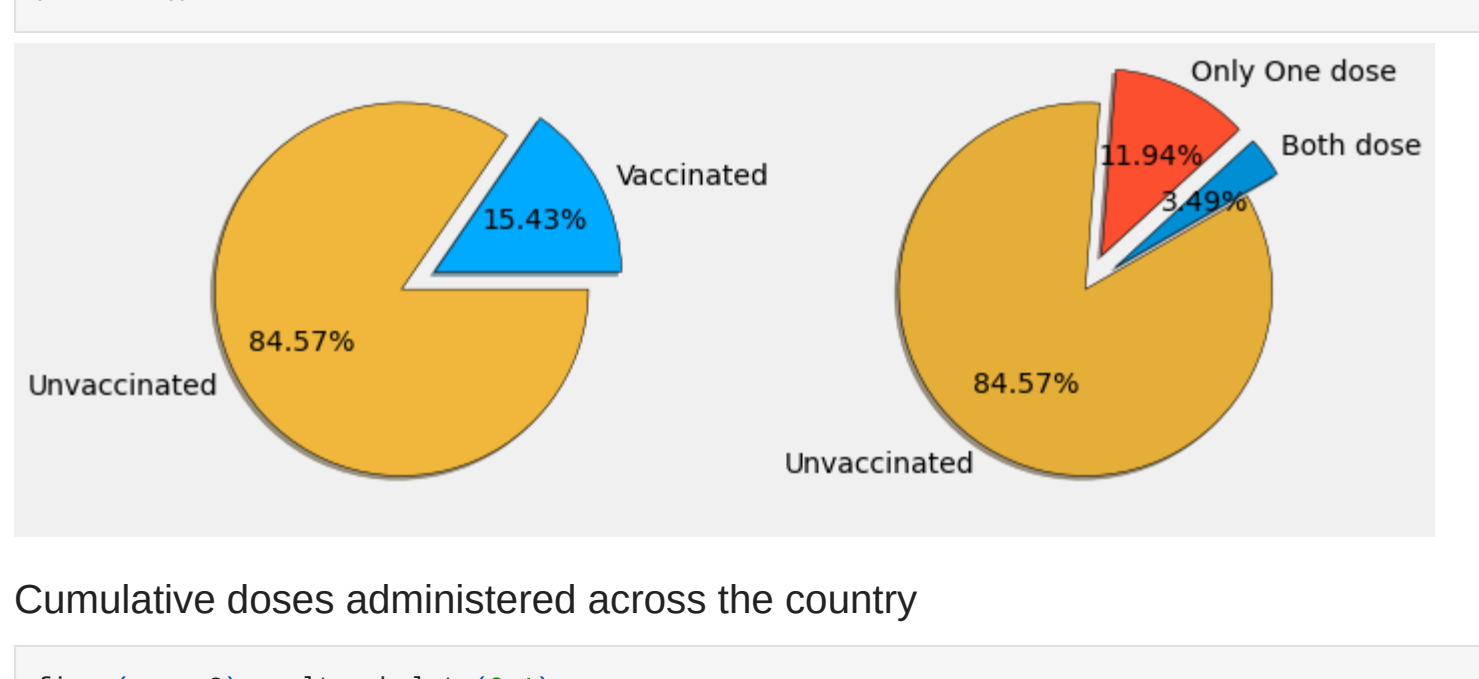
Date	Total Individuals Vaccinated	First Dose Administered	Second Dose Administered	Total Covaxin Administered	Total CoviShield Administered	Total Sputnik V Administered	18-45 years (Age)	45-60 years (Age)	60+ years (Age)	Total Doses Administered
2021-01-16	48276	48276	0	579	47697	NaN	NaN	NaN	NaN	48276
2021-01-17	58604	58604	0	635	57969	NaN	NaN	NaN	NaN	58604
2021-01-18	99449	99449	0	1299	98150	NaN	NaN	NaN	NaN	99449
2021-01-19	195525	195525	0	3017	192508	NaN	NaN	NaN	NaN	195525
2021-01-20	251280	251280	0	3946	247334	NaN	NaN	NaN	NaN	251280
...	...	...	...	...	...	...	...	...	...	...
2021-06-12	202207183	202207183	46825911	29975845	219032482	24767.0	57472406.0	81467278.0	63177391.0	249033094
2021-06-13	203705131	203705131	46951231	30185294	220445754	25314.0	58561036.0	81756122.0	63296269.0	250656362
2021-06-14	207274441	207274441	47378599	30779165	223847280	26595.0	60913444.0	82600503.0	63665384.0	254653040
2021-06-15	209816439	209816439	47789089	31248316	226329536	27676.0	62448482.0	83290805.0	63979181.0	257605528
2021-06-16	212945352	212945352	48173116	31695663	229393676	29129.0	64643068.0	83939373.0	64262201.0	261118468

152 rows × 12 columns

In [57]:
```
curr_date = ind_vac_df.index.max()
curr_fst_dose = ind_vac_df.loc[curr_date, 'First Dose Administered']
curr_snd_dose = ind_vac_df.loc[curr_date, 'Second Dose Administered']
```

In [58]:
```
per_pop_vac = ind_vac_df['Percentage Population Vaccinated'].max()
per_pop_com_vac = ind_vac_df['Percentage Population Completely Vaccinated'].max()
```

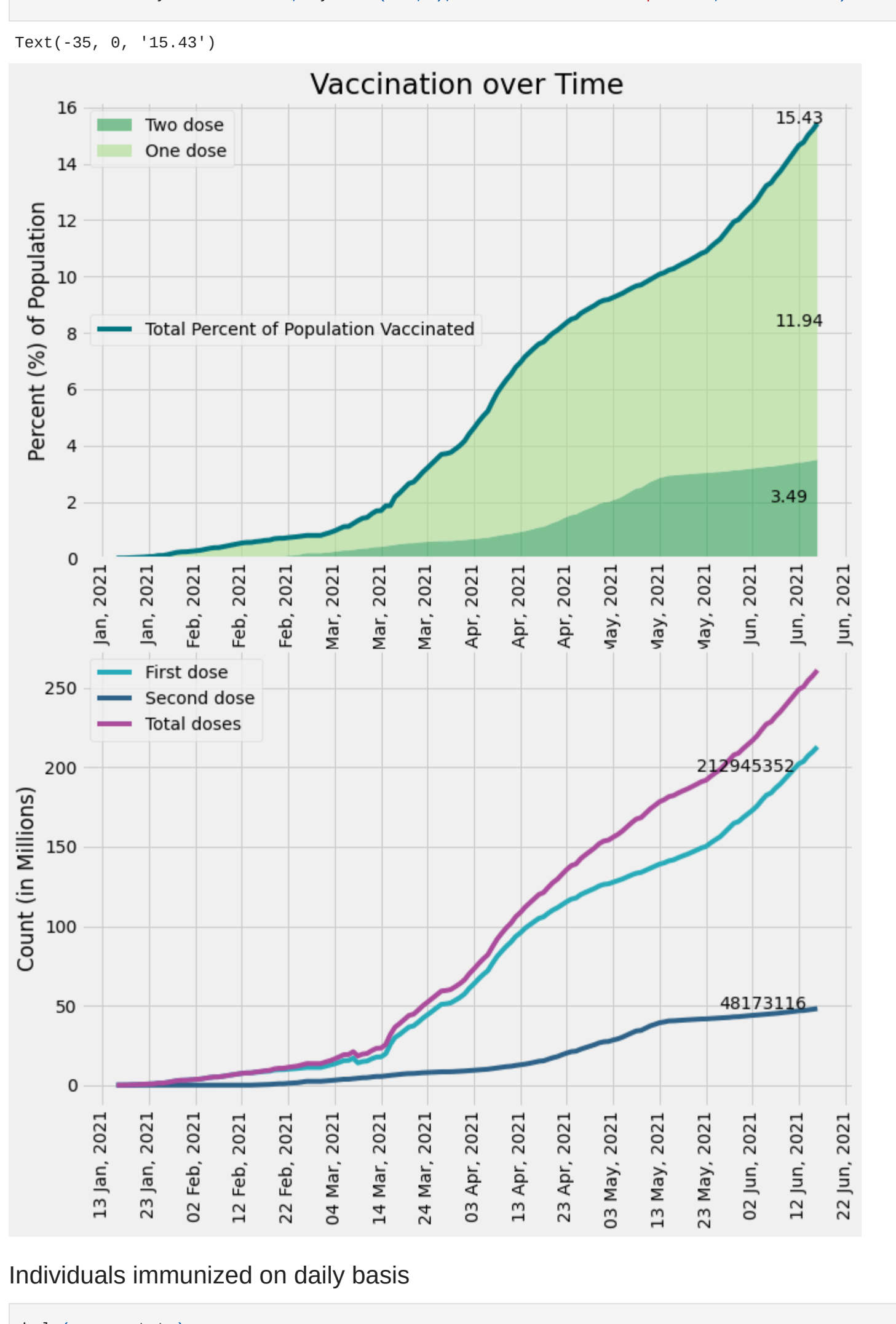
In [59]:
```
fig, (ax1, ax2) = plt.subplots(1,2)
fig.set_figheight(4)
fig.set_figwidth(10)

slices = [per_pop_vac, 100-per_pop_vac]
colors = ['#00aaff', '#f0b73c']
labels = ['Vaccinated','Unvaccinated']
ax1.pie(slices, labels=labels,colors=colors, wedgeprops={'edgecolor':'black'}, shadow=True, explode=(0.2,0),  a

slices = [per_pop_com_vac, per_pop_vac-per_pop_com_vac, 100-per_pop_vac]
labels = ['Both dose','Only One dose','Unvaccinated']
ax2.pie(slices, labels=labels,startangle=30,
       wedgeprops={'edgecolor':'black'}, shadow=True, explode=(0.2,0.2,0),  autopct='%.2f%%')

plt.savefig('Images/vac_percent.png')
plt.show()
```



Cumulative doses administered across the country

In [60]:
```
fig, (ax,ax2) = plt.subplots(2,1)
fig.set_figheight(14)
fig.set_figwidth(10)

ax1 = ax.twiny()
ax.stackplot(ind_vac_df.index, ind_vac_df['Percentage Population Completely Vaccinated'],
            ind_vac_df['Percentage Population Vaccinated']-ind_vac_df['Percentage Population Completely Vaccin
            labels=['Two dose','One dose'],colors=['#31a354','#addd8e'], alpha=.6)
ax.set_ylabel('Percent (%) of Population')
ax.legend(loc='upper left')

ax.set_xticks(ind_vac_df.index)
ax.xaxis.set_major_locator(plt.MaxNLocator(18))
for tick in ax.get_xticklabels():
    tick.set_rotation(90)


date_format = mpl_dates.DateFormatter('%d %b, %Y')
ax.xaxis.set_major_formatter(date_format)

ax1.plot(ind_vac_df.index, ind_vac_df['Percentage Population Vaccinated'],
        label='Total Percent of Population Vaccinated', color='#007580')
ax1.xaxis.set_visible(False)
ax1.yaxis.set_visible(False)
ax1.legend(loc='center left')

ax1.set_title('Vaccination over Time', fontsize=23)


ax2.plot(ind_vac_df.index, ind_vac_df['First Dose Administered']/10**6, color='#28abb9', label='First dose')
ax2.plot(ind_vac_df.index, ind_vac_df['Second Dose Administered']/10**6, color='#2d6187', label='Second dose')
ax2.plot(ind_vac_df.index, ind_vac_df['First Dose Administered']/10**6+ind_vac_df['Second Dose Administered']/1
ax2.legend()
ax2.set_ylabel('Count (in Millions)')
ax2.set_xticks(ind_vac_df.index)
ax2.xaxis.set_major_locator(plt.MaxNLocator(18))
for tick in ax2.get_xticklabels():
    tick.set_rotation(90)
ax2.xaxis.set_major_formatter(date_format)
ax2.annotate(text=str(curr_fst_dose), xy=(curr_date,curr_fst_dose/10**6), xycoords='data',
           xytext=(-98, -20),
           textcoords='offset points')
ax2.annotate(text=str(curr_snd_dose), xy=(curr_date,curr_snd_dose/10**6), xycoords='data',
           xytext=(-80, 0),
           textcoords='offset points')

plt.annotate(text=str(round(per_pop_com_vac,2)), xy=(curr_date, per_pop_com_vac),
            xycoords='data', xytext=(-38,-35), textcoords='offset points', fontsize=14)

plt.annotate(text=str(round(per_pop_vac-per_pop_com_vac, 2)), xy=(curr_date, per_pop_vac-per_pop_com_vac),
            xycoords='data', xytext=(-35,-85), textcoords='offset points', fontsize=14)

plt.annotate(text=str(round(per_pop_vac, 2)), xy=(curr_date, per_pop_vac),
            xycoords='data', xytext=(-35,0), textcoords='offset points', fontsize=14)
```

Out[60]: Text(-35, 0, '15.43')



Individuals immunized on daily basis

In [61]:
```
help(ax.annotate)
```
```
Help on method annotate in module matplotlib.axes._axes:

annotate(text, xy, *args, **kwargs) method of matplotlib.axes._subplots.AxesSubplot instance
    Annotate the point *xy* with text *text*.

    In the simplest form, the text is placed at *xy*.

    Optionally, the text can be displayed in another position *xytext*.
    An arrow pointing from the text to the annotated point *xy* can then
    be added by defining *arrowprops*.

    Parameters
    ----------
    text : str
        The text of the annotation.

    xy : (float, float)
        The point *(x, y)* to annotate. The coordinate system is determined
        by *xycoords*.

    xytext : (float, float), default: *xy*
        The position *(x, y)* to place the text at. The coordinate system
        is determined by *textcoords*.

    xycoords : str or `.Artist` or `.Transform` or callable or (float, float), default: 'data'

        The coordinate system that *xy* is given in. The following types
        of values are supported:

        - One of the following strings:

          ==================== ============================================
          Value                Description
          ==================== ============================================
          'figure points'      Points from the lower left of the figure
          'figure pixels'      Pixels from the lower left of the figure
          'figure fraction'    Fraction of figure from lower left
          'subfigure points'   Points from the lower left of the subfigure
          'subfigure pixels'   Pixels from the lower left of the subfigure
          'subfigure fraction' Fraction of subfigure from lower left
          'axes points'        Points from lower left corner of axes
          'axes pixels'        Pixels from lower left corner of axes
          'axes fraction'      Fraction of axes from lower left
          'data'               Use the coordinate system of the object
                               being annotated (default)
          'polar'              *(theta, r)* if not native 'data'
                               coordinates
          ==================== ============================================

          Note that 'subfigure pixels' and 'figure pixels' are the same
          for the parent figure, so users who want code that is usable in
          a subfigure can use 'subfigure pixels'.

        - An `.Artist`: *xy* is interpreted as a fraction of the artist's
          `~matplotlib.transforms.Bbox`. E.g. *(0, 0)* would be the lower
          left corner of the bounding box and *(0.5, 1)* would be the
          center top of the bounding box.

        - A `.Transform` to transform *xy* to screen coordinates.

        - A function with one of the following signatures::

            def transform(renderer) -> Bbox
            def transform(renderer) -> Transform

          where *renderer* is a `.RendererBase` subclass.

          The result of the function is interpreted like the `.Artist` and
          `.Transform` cases above.

        - A tuple *(xcoords, ycoords)* specifying separate coordinate
          systems for *x* and *y*. *xcoords* and *ycoords* must each be
          of one of the above described types.

        See :ref:`plotting-guide-annotation` for more details.

    textcoords : str or `.Artist` or `.Transform` or callable or (float, float), default: value of *xycoords*
        The coordinate system that *xytext* is given in.

        All *xycoords* values are valid as well as the following
        strings:

        =================   =========================================
        Value               Description
        =================   =========================================
        'offset points'     Offset (in points) from the *xy* value
        'offset pixels'     Offset (in pixels) from the *xy* value
        =================   =========================================

    arrowprops : dict, optional
        The properties used to draw a `.FancyArrowPatch` arrow between the
        positions *xy* and *xytext*. Note that the edge of the arrow
        pointing to *xytext* will be centered on the text itself and may
        not point directly to the coordinates given in *xytext*.

        If *arrowprops* does not contain the key 'arrowstyle' the
        allowed keys are:

        ==========   ======================================================
        Key          Description
        ==========   ======================================================
        width        The width of the arrow in points
        headwidth    The width of the base of the arrow head in points
        headlength   The length of the arrow head in points
        shrink       Fraction of total length to shrink from both ends
        ?            Any key to :class:`matplotlib.patches.FancyArrowPatch`
        ==========   ======================================================

        If *arrowprops* contains the key 'arrowstyle' the
        above keys are forbidden.  The allowed values of
        ``'arrowstyle'`` are:

        ============   =============================================
        Name           Attrs
        ============   =============================================
        ``'-'``        None
        ``'->'``       head_length=0.4,head_width=0.2
        ``'-['``       widthB=1.0,lengthB=0.2,angleB=None
        ``'|-|'``      widthA=1.0,widthB=1.0
        ``'-|>'``      head_length=0.4,head_width=0.2
        ``'<-'``       head_length=0.4,head_width=0.2
        ``'<->'``      head_length=0.4,head_width=0.2
        ``'<|-'``      head_length=0.4,head_width=0.2
        ``'<|-|>'``    head_length=0.4,head_width=0.2
        ``'fancy'``    head_length=0.4,head_width=0.4,tail_width=0.4
        ``'simple'``   head_length=0.5,head_width=0.5,tail_width=0.2
        ``'wedge'``    tail_width=0.3,shrink_factor=0.5
        ============   =============================================

        Valid keys for `~matplotlib.patches.FancyArrowPatch` are:

        ===============  ==================================================
        Key              Description
        ===============  ==================================================
        arrowstyle       the arrow style
        connectionstyle  the connection style
        relpos           default is (0.5, 0.5)
        patchA           default is bounding box of the text
        patchB           default is None
        shrinkA          default is 2 points
        shrinkB          default is 2 points
        mutation_scale   default is text size (in points)
        mutation_aspect  default is 1.
        ?                any key for :class:`matplotlib.patches.PathPatch`
        ===============  ==================================================

        Defaults to None, i.e. no arrow is drawn.

    annotation_clip : bool or None, default: None
        Whether to draw the annotation when the annotation point *xy* is
        outside the axes area.

        - If *True*, the annotation will only be drawn when *xy* is
          within the axes.
        - If *False*, the annotation will always be drawn.
        - If *None*, the annotation will only be drawn when *xy* is
          within the axes and *xycoords* is 'data'.

    **kwargs
        Additional kwargs are passed to `~matplotlib.text.Text`.

    Returns
    -------
    `.Annotation`

    See Also
    --------
    :ref:`plotting-guide-annotation`
```

In [62]:
```
ind_vac_df
```

Out[62]:

Date	Total Individuals Vaccinated	First Dose Administered	Second Dose Administered	Total Covaxin Administered	Total CoviShield Administered	Total Sputnik V Administered	18-45 years (Age)	45-60 years (Age)	60+ years (Age)	Total Doses Administered
2021-01-16	48276	48276	0	579	47697	NaN	NaN	NaN	NaN	48276
2021-01-17	58604	58604	0	635	57969	NaN	NaN	NaN	NaN	58604
2021-01-18	99449	99449	0	1299	98150	NaN	NaN	NaN	NaN	99449
2021-01-19	195525	195525	0	3017	192508	NaN	NaN	NaN	NaN	195525
2021-01-20	251280	251280	0	3946	247334	NaN	NaN	NaN	NaN	251280
...	...	...	...	...	...	...	...	...	...	...
2021-06-12	202207183	202207183	46825911	29975845	219032482	24767.0	57472406.0	81467278.0	63177391.0	249033094
2021-06-13	203705131	203705131	46951231	30185294	220445754	25314.0	58561036.0	81756122.0	63296269.0	250656362
2021-06-14	207274441	207274441	47378599	30779165	223847280	26595.0	60913444.0	82600503.0	63665384.0	254653040
2021-06-15	209816439	209816439	47789089	31248316	226329536	27676.0	62448482.0	83290805.0	63979181.0	257605528
2021-06-16	212945352	212945352	48173116	31695663	229393676	29129.0	64643068.0	83939373.0	64262201.0	261118468

152 rows × 12 columns

In [63]:
```
daily_vac = []

prev_vac=0;
curr_vac=0;

for i in range(ind_vac_df.shape[0]):
    curr_vac=ind_vac_df['Total Individuals Vaccinated'][i]
    daily_vac.append(curr_vac - prev_vac)
    prev_vac=curr_vac

ind_vac_df['Daily Individuals Vaccinated'] = daily_vac
```

In [64]:
```
ind_vac_df
```

Out[64]:

Date	Total Individuals Vaccinated	First Dose Administered	Second Dose Administered	Total Covaxin Administered	Total CoviShield Administered	Total Sputnik V Administered	18-45 years (Age)	45-60 years (Age)	60+ years (Age)	Total Doses Administered
2021-01-16	48276	48276	0	579	47697	NaN	NaN	NaN	NaN	48276
2021-01-17	58604	58604	0	635	57969	NaN	NaN	NaN	NaN	58604
2021-01-18	99449	99449	0	1299	98150	NaN	NaN	NaN	NaN	99449
2021-01-19	195525	195525	0	3017	192508	NaN	NaN	NaN	NaN	195525
2021-01-20	251280	251280	0	3946	247334	NaN	NaN	NaN	NaN	251280
...	...	...	...	...	...	...	...	...	...	...
2021-06-12	202207183	202207183	46825911	29975845	219032482	24767.0	57472406.0	81467278.0	63177391.0	249033094
2021-06-13	203705131	203705131	46951231	30185294	220445754	25314.0	58561036.0	81756122.0	63296269.0	250656362
2021-06-14	207274441	207274441	47378599	30779165	223847280	26595.0	60913444.0	82600503.0	63665384.0	254653040
2021-06-15	209816439	209816439	47789089	31248316	226329536	27676.0	62448482.0	83290805.0	63979181.0	257605528
2021-06-16	212945352	212945352	48173116	31695663	229393676	29129.0	64643068.0	83939373.0	64262201.0	261118468

152 rows × 13 columns

In [65]:
```
daily_vac = ind_vac_df['Daily Individuals Vaccinated']
```

In [66]:
```
daily_vac
```

Out[66]:
```
Date
2021-01-16      48276
2021-01-17      10328
2021-01-18      40845
2021-01-19      96076
2021-01-20      55755
               ...
2021-06-12    3229589
2021-06-13    1497948
2021-06-14    3569310
2021-06-15    2541998
2021-06-16    3128913
Name: Daily Individuals Vaccinated, Length: 152, dtype: int64
```

In [67]:
```
todays_vac = daily_vac.get(curr_date)
```

In [68]:
```
avg_daily_vac = daily_vac.median()
```

In [69]:
```
avg_daily_vac
```

Out[69]: 1269987.0

In [70]:
```
plt.figure(figsize=(10,6))
plt.bar(daily_vac.index, daily_vac.values/10**6,color='#de9d23', alpha=.6)
plt.plot(daily_vac/10**6, color='#6a2c70', linewidth=2)
plt.axhline(y=avg_daily_vac/10**6, linewidth=1, alpha=.9)

plt.gcf().autofmt_xdate()
date_format = mpl_dates.DateFormatter('%d %b, %Y')
plt.gca().xaxis.set_major_formatter(date_format)

# plt.gca().xaxis.set_major_locator(plt.MaxNLocator(len(daily_vac)/15))

plt.ylabel('Count (in Millions)')
plt.suptitle('Daily Individuals Vaccinated over time', fontsize=22)

plt.annotate(text=str(todays_vac), xy=(curr_date, todays_vac/10**6),
            xycoords='data', xytext=(-5,10), textcoords='offset points', fontsize=14)

plt.savefig('Images/daily_vac.png')
```