Assignment 2 Part 2: Covid 19 Cases

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Part 2: Covid-19 Cases

Abstract

This notebook shed's the light on the covid-19 virus' effect on various countries and regions around the world. The Data used in this notebook is a dataset that includes records of countries affected by the COVID-19 pandemic in 2020 and 2021. The notebook includes analysis of such records by obtaining confidence intervals, averages, and graphs for all data analyzed

In this Notebook, the following will be extenisvely analyzed: 1- Complex Analysis of Covid Cases in italy: Confirmed cases and Reported Deaths
2- Comparison between Covid Cases and Deaths in Italy in 2020 and 2021
3- Comparison between Europe and Central Asia and Middle East Regions covid cases in 2020 vs 2021
4- Comparison between upper-middle income countries and lower-middle income countries covid cases in 2020 vs 2021
5- Comparison between Africa and Europe Continents in terms of covid cases in 2020 vs 2021

It was generally concluded that 2021 had struck the world in a more agressive way than 2020 in terms of covid cases and deaths.

Preparing Data for Manipulation

In [2]:
```
import scipy
import numpy as np
!pip install matplotlib
import matplotlib.pyplot as plt
import pandas as pd
import statsmodels.api as sm
from statsmodels.stats.proportion import proportion_confint
import scipy.stats
from scipy.stats import norm,t
!pip3 install livewires
```

```
Requirement already satisfied: matplotlib in c:\users\h\anaconda3\lib\site-packages (3.
4.3)
Requirement already satisfied: numpy>=1.16 in c:\users\h\anaconda3\lib\site-packages (fr
om matplotlib) (1.20.3)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\h\anaconda3\lib\site-packag
es (from matplotlib) (1.3.1)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\h\anaconda3\lib\site-pac
kages (from matplotlib) (2.8.2)
Requirement already satisfied: pillow>=6.2.0 in c:\users\h\anaconda3\lib\site-packages
(from matplotlib) (8.4.0)
Requirement already satisfied: pyparsing>=2.2.1 in c:\users\h\anaconda3\lib\site-package
s (from matplotlib) (3.0.4)
```

```
Requirement already satisfied: cycler>=0.10 in c:\users\h\anaconda3\lib\site-packages (f
rom matplotlib) (0.10.0)
Requirement already satisfied: six in c:\users\h\anaconda3\lib\site-packages (from cycle
r>=0.10->matplotlib) (1.16.0)
Requirement already satisfied: livewires in c:\users\h\anaconda3\lib\site-packages (2.1)
Requirement already satisfied: pygame in c:\users\h\anaconda3\lib\site-packages (from li
vewires) (2.1.2)
```

In [3]:
```
df=pd.read_csv('covid_data.csv',encoding='latin-1')
```

In [4]:
```
df.head()
```

Out[4]:

	date	iso3c	country	income	region	continent	dcases	ddeaths	population	weekdays	mont
0	2020-02-24	AFG	Afghanistan	Low income	South Asia	Asia	5	0	38041754	Mon	Fe
1	2020-02-25	AFG	Afghanistan	Low income	South Asia	Asia	0	0	38041754	Tue	Fe
2	2020-02-26	AFG	Afghanistan	Low income	South Asia	Asia	0	0	38041754	Wed	Fe
3	2020-02-27	AFG	Afghanistan	Low income	South Asia	Asia	0	0	38041754	Thu	Fe
4	2020-02-28	AFG	Afghanistan	Low income	South Asia	Asia	0	0	38041754	Fri	Fe

In [5]:
```
df['country'].unique()
```

Out[5]:
```
array(['Afghanistan', 'Angola', 'Albania', 'Andorra',
       'United Arab Emirates', 'Argentina', 'Armenia',
       'Antigua & Barbuda', 'Australia', 'Austria', 'Azerbaijan',
       'Burundi', 'Belgium', 'Benin', 'Burkina Faso', 'Bangladesh',
       'Bulgaria', 'Bahrain', 'Bahamas', 'Bosnia & Herzegovina',
       'Belarus', 'Belize', 'Bolivia', 'Brazil', 'Barbados', 'Brunei',
       'Bhutan', 'Botswana', 'Central African Republic', 'Canada',
       'Switzerland', 'Chile', 'China', 'Côte d\x92Ivoire', 'Cameroon',
       'Congo - Kinshasa', 'Congo - Brazzaville', 'Colombia', 'Comoros',
       'Cape Verde', 'Costa Rica', 'Cuba', 'Cyprus', 'Czechia', 'Germany',
       'Djibouti', 'Dominica', 'Denmark', 'Dominican Republic', 'Algeria',
       'Ecuador', 'Egypt', 'Spain', 'Estonia', 'Ethiopia', 'Finland',
       'Fiji', 'France', 'Gabon', 'United Kingdom', 'Georgia', 'Ghana',
       'Guinea', 'Gambia', 'Guinea-Bissau', 'Equatorial Guinea', 'Greece',
       'Grenada', 'Guatemala', 'Guyana', 'Honduras', 'Croatia', 'Haiti',
       'Hungary', 'Indonesia', 'India', 'Ireland', 'Iran', 'Iraq',
       'Iceland', 'Israel', 'Italy', 'Jamaica', 'Jordan', 'Japan',
       'Kazakhstan', 'Kenya', 'Kyrgyzstan', 'Cambodia', 'Kiribati',
       'St. Kitts & Nevis', 'South Korea', 'Kuwait', 'Laos', 'Lebanon',
       'Liberia', 'Libya', 'St. Lucia', 'Liechtenstein', 'Sri Lanka',
       'Lesotho', 'Lithuania', 'Luxembourg', 'Latvia', 'Morocco',
       'Monaco', 'Moldova', 'Madagascar', 'Maldives', 'Mexico',
       'Marshall Islands', 'North Macedonia', 'Mali', 'Malta',
       'Myanmar (Burma)', 'Montenegro', 'Mongolia', 'Mozambique',
       'Mauritania', 'Mauritius', 'Malawi', 'Malaysia', 'Namibia',
```

```
       'Niger', 'Nigeria', 'Nicaragua', 'Netherlands', 'Norway', 'Nepal',
       'New Zealand', 'Oman', 'Pakistan', 'Panama', 'Peru', 'Philippines',
       'Palau', 'Papua New Guinea', 'Poland', 'Portugal', 'Paraguay',
       'Palestinian Territories', 'Qatar', 'Romania', 'Russia', 'Rwanda',
       'Saudi Arabia', 'Sudan', 'Senegal', 'Singapore', 'Solomon Islands',
       'Sierra Leone', 'El Salvador', 'San Marino', 'Somalia', 'Serbia',
       'South Sudan', 'São Tomé & Príncipe', 'Suriname', 'Slovakia',
       'Slovenia', 'Sweden', 'Eswatini', 'Seychelles', 'Syria', 'Chad',
       'Togo', 'Thailand', 'Tajikistan', 'Timor-Leste',
       'Trinidad & Tobago', 'Tunisia', 'Turkey', 'Tanzania', 'Uganda',
       'Ukraine', 'Uruguay', 'United States', 'Uzbekistan',
       'St. Vincent & Grenadines', 'Venezuela', 'Vietnam', 'Vanuatu',
       'Samoa', 'Yemen', 'South Africa', 'Zambia', 'Zimbabwe'],
      dtype=object)
```

In [6]:
```
from pandas.api.types import CategoricalDtype
cats=['Fri', 'Sat', 'Sun','Mon','Tue','Wed','Thu']
cat_type = CategoricalDtype(categories=cats, ordered=True)
df['weekdays'] = df['weekdays'].astype(cat_type)
```

In [7]:
```
from pandas.api.types import CategoricalDtype
cats=['Jan', 'Feb', 'Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec']
cat_type = CategoricalDtype(categories=cats, ordered=True)
df['month'] = df['month'].astype(cat_type)
```

Complex analysis of Covid Cases in Italy

In [8]:
```
dfit=df[df['country']=='Italy']
```

Analysis of the daily reported number of cases

In [9]:
```
statsit=dfit.groupby("weekdays").agg({"dcases": [np.mean, np.std, np.size]})
```

In [10]:
```
statsit
```

Out[10]:

	dcases		
	mean	std	size
weekdays			
Fri	10791.336634	17091.397197	101
Sat	9143.490000	10464.409571	100
Sun	7825.990000	8384.702907	100
Mon	5823.940000	6792.823020	100
Tue	7834.880000	10663.598595	100
Wed	9323.480000	12612.832742	100
Thu	10407.280000	15423.978486	100

In [11]:
```
statsit.index
```

Out[11]:
```
CategoricalIndex(['Fri', 'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], categories=['Fri',
'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], ordered=True, dtype='category', name='weekday
s')
```

In [12]:
```
statsit.columns
```

Out[12]:
```
MultiIndex([('dcases', 'mean'),
            ('dcases',  'std'),
            ('dcases', 'size')],
           )
```

In [13]:
```
statsit.index
```

Out[13]:
```
CategoricalIndex(['Fri', 'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], categories=['Fri',
'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], ordered=True, dtype='category', name='weekday
s')
```

In [14]:
```
ci95_hi = []
ci95_lo = []
```

In [15]:
```
for i in statsit.index:
    m, s, n = statsit.loc[i]
    x=scipy.stats.t.interval(.95, n-1, m,s/np.sqrt(n-1))
    ci95_hi.append(x[1])
    ci95_lo.append(x[0])
```

In [16]:
```
ci95_hi
```

Out[16]:
```
[14182.22115859872,
 11230.316233544876,
 9498.078412469755,
 7178.573644847766,
 9961.428769081687,
 11838.74759022996,
 13483.149948787212]
```

In [17]:
```
ci95_lo
```

Out[17]:
```
[7400.452108728011,
 7056.663766455124,
 6153.901587530245,
 4469.306355152233,
 5708.331230918313,
 6808.21240977004,
 7331.41005121279]
```

In [18]:
```
statsit['ci95_hi'] = ci95_hi
statsit['ci95_lo'] = ci95_lo
print(statsit)
```

```
                dcases                          ci95_hi      ci95_lo
```

```
                  mean           std size                                  
weekdays                                                                   
Fri       10791.336634  17091.397197  101  14182.221159  7400.452109
Sat        9143.490000  10464.409571  100  11230.316234  7056.663766
Sun        7825.990000   8384.702907  100   9498.078412  6153.901588
Mon        5823.940000   6792.823020  100   7178.573645  4469.306355
Tue        7834.880000  10663.598595  100   9961.428769  5708.331231
Wed        9323.480000  12612.832742  100  11838.747590  6808.212410
Thu       10407.280000  15423.978486  100  13483.149949  7331.410051
```

In [19]:
```
df_ci= pd.DataFrame(statsit)
```

In [20]:
```
df_ci
```

Out[20]:

	dcases			ci95_hi	ci95_lo
	mean	std	size		
weekdays					
Fri	10791.336634	17091.397197	101	14182.221159	7400.452109
Sat	9143.490000	10464.409571	100	11230.316234	7056.663766
Sun	7825.990000	8384.702907	100	9498.078412	6153.901588
Mon	5823.940000	6792.823020	100	7178.573645	4469.306355
Tue	7834.880000	10663.598595	100	9961.428769	5708.331231
Wed	9323.480000	12612.832742	100	11838.747590	6808.212410
Thu	10407.280000	15423.978486	100	13483.149949	7331.410051

In [21]:
```
df_ci.index
```

Out[21]:
```
CategoricalIndex(['Fri', 'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], categories=['Fri',
'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], ordered=True, dtype='category', name='weekday
s')
```

In [22]:
```
df_ci['weekdays']=df_ci.index
```

In [23]:
```
df_ci
```

Out[23]:

	dcases			ci95_hi	ci95_lo	weekdays
	mean	std	size			
weekdays						
Fri	10791.336634	17091.397197	101	14182.221159	7400.452109	Fri
Sat	9143.490000	10464.409571	100	11230.316234	7056.663766	Sat
Sun	7825.990000	8384.702907	100	9498.078412	6153.901588	Sun
Mon	5823.940000	6792.823020	100	7178.573645	4469.306355	Mon

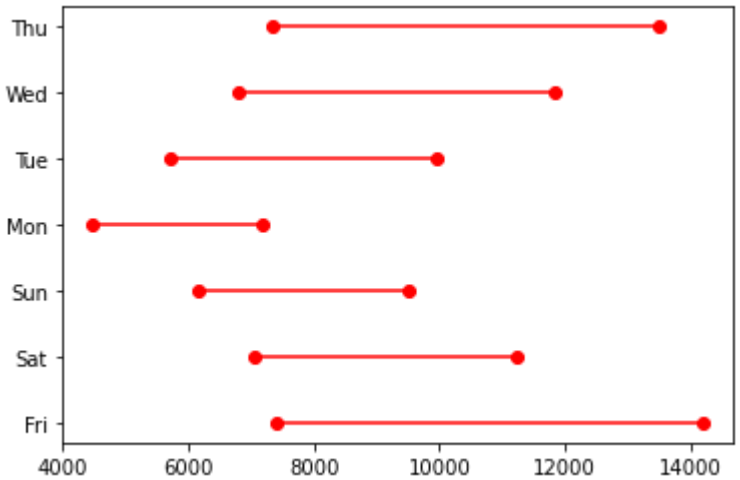
	dcases			ci95_hi	ci95_lo	weekdays
	mean	std	size			
weekdays						
Tue	7834.880000	10663.598595	100	9961.428769	5708.331231	Tue
Wed	9323.480000	12612.832742	100	11838.747590	6808.212410	Wed
Thu	10407.280000	15423.978486	100	13483.149949	7331.410051	Thu

In [24]:
```
df_ci.columns
```

Out[24]:
```
MultiIndex([(  'dcases', 'mean'),
            (  'dcases',  'std'),
            (  'dcases', 'size'),
            ( 'ci95_hi',     ''),
            ( 'ci95_lo',     ''),
            ('weekdays',     '')],
           )
```

In [25]:
```
for lb,ub,y in zip(df_ci['ci95_lo'],df_ci['ci95_hi'],range(len(df_ci))):
    plt.plot((lb,ub),(y,y),'ro-')
plt.yticks(range(len(df_ci)),list(df_ci['weekdays']))
```

Out[25]:
```
([<matplotlib.axis.YTick at 0x1cfbc892fd0>,
  <matplotlib.axis.YTick at 0x1cfbc892850>,
  <matplotlib.axis.YTick at 0x1cfbc87e6a0>,
  <matplotlib.axis.YTick at 0x1cfbce67be0>,
  <matplotlib.axis.YTick at 0x1cfbce77910>,
  <matplotlib.axis.YTick at 0x1cfbce83160>,
  <matplotlib.axis.YTick at 0x1cfbce837f0>],
 [Text(0, 0, 'Fri'),
  Text(0, 1, 'Sat'),
  Text(0, 2, 'Sun'),
  Text(0, 3, 'Mon'),
  Text(0, 4, 'Tue'),
  Text(0, 5, 'Wed'),
  Text(0, 6, 'Thu')])
```



As seen in the graph, Thursday has a very wide conifdence interval, which means that the data collected for covid-19 cases reported on Thursdays is not reliable and has a high probability of

containing erors. On the other hand, Data collected on Wednesdays and Saturdays are the most accurate with the narrowest confidence intervals.

In [26]:
```
statsit
```

Out[26]:

	dcases			ci95_hi	ci95_lo	weekdays
	mean	std	size			
weekdays						
Fri	10791.336634	17091.397197	101	14182.221159	7400.452109	Fri
Sat	9143.490000	10464.409571	100	11230.316234	7056.663766	Sat
Sun	7825.990000	8384.702907	100	9498.078412	6153.901588	Sun
Mon	5823.940000	6792.823020	100	7178.573645	4469.306355	Mon
Tue	7834.880000	10663.598595	100	9961.428769	5708.331231	Tue
Wed	9323.480000	12612.832742	100	11838.747590	6808.212410	Wed
Thu	10407.280000	15423.978486	100	13483.149949	7331.410051	Thu

In [27]:
```
statsit.columns
```

Out[27]:
```
MultiIndex([(  'dcases', 'mean'),
            (  'dcases',  'std'),
            (  'dcases', 'size'),
            ( 'ci95_hi',     ''),
            ( 'ci95_lo',     ''),
            ('weekdays',     '')],
           )
```

In [28]:
```
statsit.index
```

Out[28]:
```
CategoricalIndex(['Fri', 'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], categories=['Fri',
'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], ordered=True, dtype='category', name='weekday
s')
```

In [29]:
```
statsit['weekdays']=statsit.index
```

In [30]:
```
statsit.columns=['mean','std','size','ci95_hi','ci95_lo','weekdays']
```

In [31]:
```
statsit.columns
```

Out[31]:
```
Index(['mean', 'std', 'size', 'ci95_hi', 'ci95_lo', 'weekdays'], dtype='object')
```

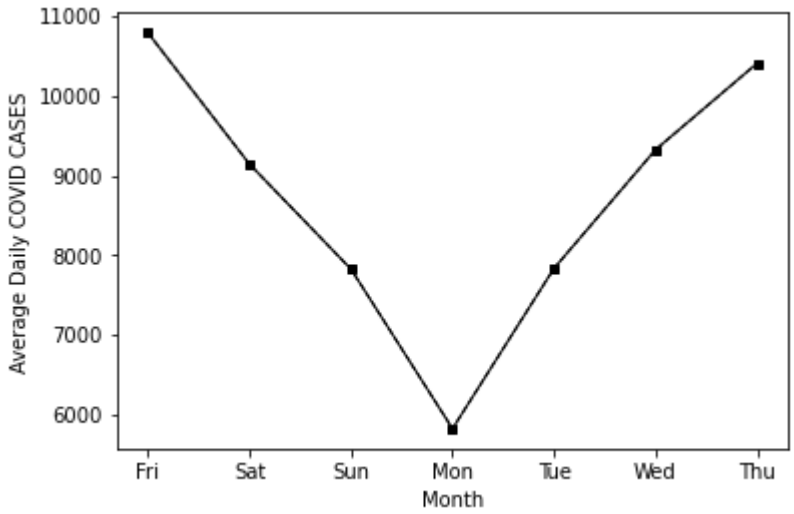
In [32]:
```
statsit
```

Out[32]:

	mean	std	size	ci95_hi	ci95_lo	weekdays

weekdays	mean	std	size	ci95_hi	ci95_lo	weekdays
weekdays						
Fri	10791.336634	17091.397197	101	14182.221159	7400.452109	Fri
Sat	9143.490000	10464.409571	100	11230.316234	7056.663766	Sat
Sun	7825.990000	8384.702907	100	9498.078412	6153.901588	Sun
Mon	5823.940000	6792.823020	100	7178.573645	4469.306355	Mon
Tue	7834.880000	10663.598595	100	9961.428769	5708.331231	Tue
Wed	9323.480000	12612.832742	100	11838.747590	6808.212410	Wed
Thu	10407.280000	15423.978486	100	13483.149949	7331.410051	Thu

In [33]:
```
plt.plot( 'weekdays', 'mean', data=statsit, marker='s', color='black', markersize=4,
plt.plot( 'weekdays', 'mean', data=statsit, marker='o', color='black',  markersize=4, l
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.show()
```



The graph has a V-shaped curve that reflects the average daily covid cases along the 7 days of the week. The highest day that covid cases are reported in is Friday, whereas Monday has the lowest average of reported cases. Monday could be the lowest day of reported cases either due to multiple errors in the data linked to Monday, so close examination of Monday's data is requred. Deeper Analysis about assessing covid-19 based on weekdays will be investigated later in the Discussion Section.

Analysis of the daily number of confirmed death cases in Italy

In [34]:
```
statsit2=dfit.groupby("weekdays").agg({"ddeaths": [np.mean, np.std, np.size]})
```

In [35]:
```
statsit2
```

Out[35]:

	ddeaths

	mean	std	size
weekdays	mean	std	size
weekdays			
Fri	209.564356	241.521693	101
Sat	191.150000	219.482328	100
Sun	147.260000	177.204534	100
Mon	172.330000	195.010596	100
Tue	226.910000	250.471035	100
Wed	211.030000	226.916282	100
Thu	213.990000	240.475938	100

In [36]:
```
statsit2.index
```

Out[36]:
```
CategoricalIndex(['Fri', 'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], categories=['Fri',
'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], ordered=True, dtype='category', name='weekday
s')
```

In [37]:
```
ci95_hi2 = []
ci95_lo2 = []
```

In [38]:
```
for i in statsit2.index:
    m, s, n = statsit2.loc[i]
    x=scipy.stats.t.interval(.95, n-1, m,s/np.sqrt(n-1))
    ci95_hi2.append(x[1])
    ci95_lo2.append(x[0])
```

In [39]:
```
ci95_hi2
```

Out[39]:
```
[257.4815724878798,
 234.91945276643628,
 182.59835977479656,
 211.21926786662394,
 276.85926113169245,
 256.2819415585818,
 261.9460258192309]
```

In [40]:
```
ci95_lo2
```

Out[40]:
```
[161.64714038340728,
 147.38054723356373,
 111.92164022520342,
 133.4407321333761,
 176.96073886830754,
 165.77805844141818,
 166.03397418076912]
```

In [41]:

```
statsit2['ci95_hi2'] = ci95_hi
statsit2['ci95_lo2'] = ci95_lo
print(statsit2)
```

```
            ddeaths                          ci95_hi2     ci95_lo2
               mean         std size
weekdays
Fri        209.564356  241.521693  101  14182.221159  7400.452109
Sat        191.150000  219.482328  100  11230.316234  7056.663766
Sun        147.260000  177.204534  100   9498.078412  6153.901588
Mon        172.330000  195.010596  100   7178.573645  4469.306355
Tue        226.910000  250.471035  100   9961.428769  5708.331231
Wed        211.030000  226.916282  100  11838.747590  6808.212410
Thu        213.990000  240.475938  100  13483.149949  7331.410051
```

In [42]:
```
df_ci2= pd.DataFrame(statsit2)
```

In [43]:
```
df_ci2
```

Out[43]:

	ddeaths			ci95_hi2	ci95_lo2
	mean	std	size		
weekdays					
Fri	209.564356	241.521693	101	14182.221159	7400.452109
Sat	191.150000	219.482328	100	11230.316234	7056.663766
Sun	147.260000	177.204534	100	9498.078412	6153.901588
Mon	172.330000	195.010596	100	7178.573645	4469.306355
Tue	226.910000	250.471035	100	9961.428769	5708.331231
Wed	211.030000	226.916282	100	11838.747590	6808.212410
Thu	213.990000	240.475938	100	13483.149949	7331.410051

In [44]:
```
df_ci2= pd.DataFrame(statsit2)
```

In [45]:
```
df_ci2['weekdays']=df_ci2.index
```

In [46]:
```
df_ci2
```

Out[46]:

	ddeaths			ci95_hi2	ci95_lo2	weekdays
	mean	std	size			
weekdays						
Fri	209.564356	241.521693	101	14182.221159	7400.452109	Fri
Sat	191.150000	219.482328	100	11230.316234	7056.663766	Sat
Sun	147.260000	177.204534	100	9498.078412	6153.901588	Sun

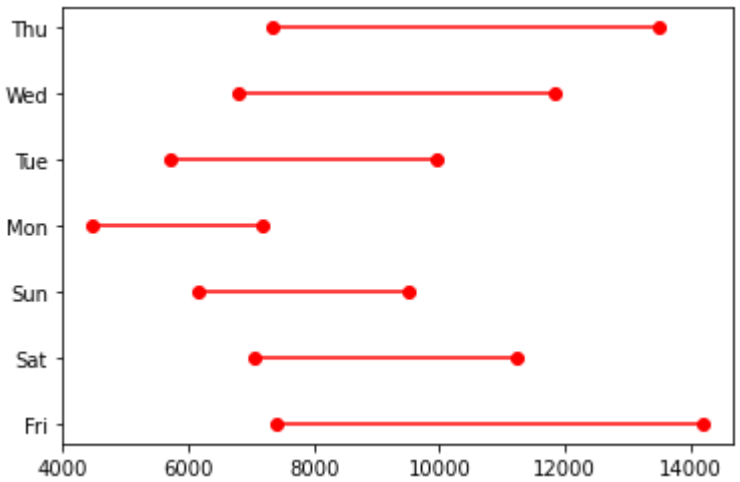
	ddeaths			ci95_hi2	ci95_lo2	weekdays
	mean	std	size			
weekdays						
Mon	172.330000	195.010596	100	7178.573645	4469.306355	Mon
Tue	226.910000	250.471035	100	9961.428769	5708.331231	Tue
Wed	211.030000	226.916282	100	11838.747590	6808.212410	Wed
Thu	213.990000	240.475938	100	13483.149949	7331.410051	Thu

In [47]:
```
df_ci2.columns
```

Out[47]:
```
MultiIndex([( 'ddeaths', 'mean'),
            ( 'ddeaths',  'std'),
            ( 'ddeaths', 'size'),
            ('ci95_hi2',     ''),
            ('ci95_lo2',     ''),
            ('weekdays',     '')],
           )
```

In [48]:
```
for lb,ub,y in zip(df_ci2['ci95_lo2'],df_ci2['ci95_hi2'],range(len(df_ci2))):
    plt.plot((lb,ub),(y,y),'ro-')
plt.yticks(range(len(df_ci2)),list(df_ci2['weekdays']))
```

Out[48]:
```
([<matplotlib.axis.YTick at 0x1cfbd1472b0>,
  <matplotlib.axis.YTick at 0x1cfbd142af0>,
  <matplotlib.axis.YTick at 0x1cfbd13c9a0>,
  <matplotlib.axis.YTick at 0x1cfbd181460>,
  <matplotlib.axis.YTick at 0x1cfbd181bb0>,
  <matplotlib.axis.YTick at 0x1cfbd186340>,
  <matplotlib.axis.YTick at 0x1cfbd186a90>],
 [Text(0, 0, 'Fri'),
  Text(0, 1, 'Sat'),
  Text(0, 2, 'Sun'),
  Text(0, 3, 'Mon'),
  Text(0, 4, 'Tue'),
  Text(0, 5, 'Wed'),
  Text(0, 6, 'Thu')])
```



Similar to what was observed above, Thursday has a widest confidence interval whereas Wednesday has the narrowest. This graph increases the probability that the data of Thursday has several errors which reflected on having a very wide confidence interval.

In [49]:
```
statsit2
```

Out[49]:

	ddeaths			ci95_hi2	ci95_lo2	weekdays
	mean	std	size			
weekdays						
Fri	209.564356	241.521693	101	14182.221159	7400.452109	Fri
Sat	191.150000	219.482328	100	11230.316234	7056.663766	Sat
Sun	147.260000	177.204534	100	9498.078412	6153.901588	Sun
Mon	172.330000	195.010596	100	7178.573645	4469.306355	Mon
Tue	226.910000	250.471035	100	9961.428769	5708.331231	Tue
Wed	211.030000	226.916282	100	11838.747590	6808.212410	Wed
Thu	213.990000	240.475938	100	13483.149949	7331.410051	Thu

In [50]:
```
statsit2.columns
```

Out[50]:
```
MultiIndex([( 'ddeaths', 'mean'),
            ( 'ddeaths',  'std'),
            ( 'ddeaths', 'size'),
            ('ci95_hi2',     ''),
            ('ci95_lo2',     ''),
            ('weekdays',     '')],
           )
```

In [51]:
```
statsit2.index
```

Out[51]:
```
CategoricalIndex(['Fri', 'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], categories=['Fri',
'Sat', 'Sun', 'Mon', 'Tue', 'Wed', 'Thu'], ordered=True, dtype='category', name='weekday
s')
```

In [52]:
```
statsit2.columns=['mean','std','size','ci95_hi2','ci95_lo2','weekdays']
```

In [53]:
```
statsit2['weekdays']=statsit2.index
```

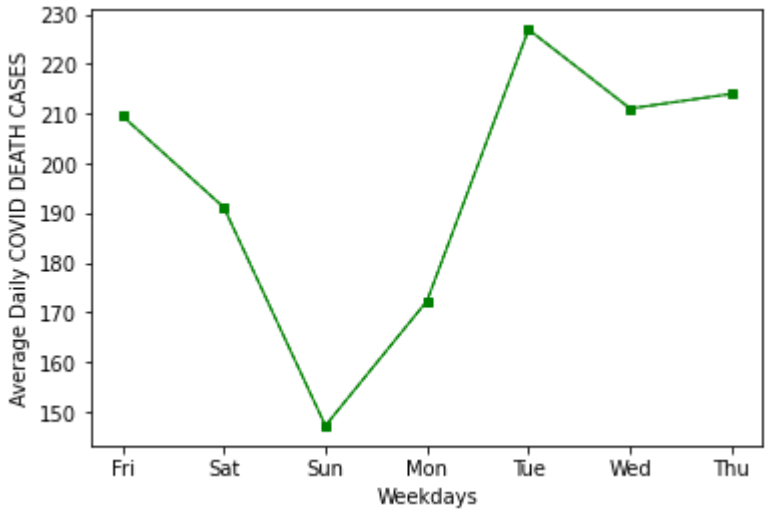
In [54]:
```
statsit2
```

Out[54]:

	mean	std	size	ci95_hi2	ci95_lo2	weekdays
weekdays						
Fri	209.564356	241.521693	101	14182.221159	7400.452109	Fri

weekdays	mean	std	size	ci95_hi2	ci95_lo2	weekdays
Sat	191.150000	219.482328	100	11230.316234	7056.663766	Sat
Sun	147.260000	177.204534	100	9498.078412	6153.901588	Sun
Mon	172.330000	195.010596	100	7178.573645	4469.306355	Mon
Tue	226.910000	250.471035	100	9961.428769	5708.331231	Tue
Wed	211.030000	226.916282	100	11838.747590	6808.212410	Wed
Thu	213.990000	240.475938	100	13483.149949	7331.410051	Thu

In [55]:
```
plt.plot( 'weekdays', 'mean', data=statsit2, marker='s', color='green', markersize=4,
plt.plot( 'weekdays', 'mean', data=statsit2, marker='o', color='green',  markersize=4,
plt.xlabel("Weekdays")
plt.ylabel("Average Daily COVID DEATH CASES")
plt.show()
```



Dissimilar to the confirmed covid cases graph, the average daily death cases graph is not v shaped and is more abstract. Sunday has the lowest average of the 7 days with approx. 147 cases whereas Tuesday has the highest average with 226 death cases. There is a huge difference between Monday's cases and Tuesday's cases which will need further investigation to comprehend. Although Friday had the largest number of confirmed cases, it doesn't have the highest number of deaths

Comparison between Covid Cases and Deaths in Italy in 2020 and 2021

comparison of Number of Cases

In [56]:
```
df['date'][0]
```

Out[56]:
```
'2020-02-24'
```

In [57]:
```
df['date'] = pd.to_datetime(df['date'],format='%Y-%m-%d')
```

```
df['date'][0]
```

Out[57]:
```
Timestamp('2020-02-24 00:00:00')
```

In [58]:
```
df['year'] = pd. DatetimeIndex(df['date']). year
```

In [59]:
```
df['year'][0]
```

Out[59]:
```
2020
```

In [60]:
```
def ci_lb2(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean - margin_of_error
```

In [61]:
```
x=df['dcases']
```

In [62]:
```
ci_lb2(x)
```

Out[62]:
```
2285.1835480837417
```

In [63]:
```
def ci_ub2(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean + margin_of_error
```

In [64]:
```
ci_ub2(x)
```

Out[64]:
```
2422.2624439548763
```

In [65]:
```
statsdcases=df.groupby(['country','year','month']).agg({"dcases": [np.mean, np.std, np.
```

In [66]:
```
statsdcases
```

Out[66]:

			dcases				
			mean	std	size	ci_ub2	ci_lb2
country	year	month					
Afghanistan	2020	Jan	NaN	NaN	NaN	NaN	NaN
		Feb	0.833333	2.041241	6.0	2.975485	-1.308818

			dcases				
			mean	std	size	ci_ub2	ci_lb2
country	year	month					
		Mar	5.258065	10.871883	31.0	9.245904	1.270225
		Apr	55.366667	40.385627	30.0	70.446908	40.286426
		May	430.741935	266.692078	31.0	528.565379	332.918491
...	...	...	...	...	...	...	...
Zimbabwe	2021	Aug	513.322581	386.841948	31.0	655.217353	371.427809
		Sep	201.566667	135.119789	30.0	252.021225	151.112108
		Oct	69.580645	58.035492	31.0	90.868235	48.293055
		Nov	54.933333	82.622087	30.0	85.784928	24.081739
		Dec	2536.548387	2572.199964	31.0	3480.038951	1593.057823

4488 rows × 5 columns

In [67]:
```
statsdcases=statsdcases.reset_index()
```

In [68]:
```
statsdcases
```

Out[68]:

	country	year	month	dcases				
				mean	std	size	ci_ub2	ci_lb2
0	Afghanistan	2020	Jan	NaN	NaN	NaN	NaN	NaN
1	Afghanistan	2020	Feb	0.833333	2.041241	6.0	2.975485	-1.308818
2	Afghanistan	2020	Mar	5.258065	10.871883	31.0	9.245904	1.270225
3	Afghanistan	2020	Apr	55.366667	40.385627	30.0	70.446908	40.286426
4	Afghanistan	2020	May	430.741935	266.692078	31.0	528.565379	332.918491
...	...	...	...	...	...	...	...	...
4483	Zimbabwe	2021	Aug	513.322581	386.841948	31.0	655.217353	371.427809
4484	Zimbabwe	2021	Sep	201.566667	135.119789	30.0	252.021225	151.112108
4485	Zimbabwe	2021	Oct	69.580645	58.035492	31.0	90.868235	48.293055
4486	Zimbabwe	2021	Nov	54.933333	82.622087	30.0	85.784928	24.081739
4487	Zimbabwe	2021	Dec	2536.548387	2572.199964	31.0	3480.038951	1593.057823

4488 rows × 8 columns

In [69]:
```
statsIT=statsdcases[(statsdcases['country']=='Italy') & (statsdcases['year']==2021)]
```

In [70]:
```
statsIT
```

Out[70]:

	country	year	month	dcases				
				mean	std	size	ci_ub2	ci_lb2
1956	Italy	2021	Jan	14382.774194	3339.157825	31.0	15607.587172	13157.961215
1957	Italy	2021	Feb	13294.035714	3389.570392	28.0	14608.373902	11979.697526
1958	Italy	2021	Mar	21278.516129	3899.512806	31.0	22708.868974	19848.163284
1959	Italy	2021	Apr	14591.800000	3747.051148	30.0	15990.971893	13192.628107
1960	Italy	2021	May	6295.741935	2932.354708	31.0	7371.338326	5220.145545
1961	Italy	2021	Jun	1402.933333	714.902884	30.0	1669.882457	1135.984209
1962	Italy	2021	Jul	2907.064516	1958.244110	31.0	3625.354255	2188.774777
1963	Italy	2021	Aug	6127.838710	1273.881499	31.0	6595.102216	5660.575204
1964	Italy	2021	Sep	4412.133333	1295.630608	30.0	4895.929753	3928.336913
1965	Italy	2021	Oct	3213.225806	977.378593	31.0	3571.731169	2854.720444
1966	Italy	2021	Nov	8552.733333	3136.827092	30.0	9724.043819	7381.422847
1967	Italy	2021	Dec	35391.483871	33089.221108	31.0	47528.708162	23254.259580

In [71]:
```
statsIT.columns
```

Out[71]:
```
MultiIndex([('country',       ''),
            (   'year',       ''),
            (  'month',       ''),
            ( 'dcases',   'mean'),
            ( 'dcases',    'std'),
            ( 'dcases',   'size'),
            ( 'dcases', 'ci_ub2'),
            ( 'dcases', 'ci_lb2')],
           )
```

In [72]:
```
statsIT21=statsdcases[(statsdcases['country']=='Italy')
  & (statsdcases['year']==2021)]
statsIT21
```

Out[72]:

	country	year	month	dcases				
				mean	std	size	ci_ub2	ci_lb2
1956	Italy	2021	Jan	14382.774194	3339.157825	31.0	15607.587172	13157.961215
1957	Italy	2021	Feb	13294.035714	3389.570392	28.0	14608.373902	11979.697526
1958	Italy	2021	Mar	21278.516129	3899.512806	31.0	22708.868974	19848.163284
1959	Italy	2021	Apr	14591.800000	3747.051148	30.0	15990.971893	13192.628107
1960	Italy	2021	May	6295.741935	2932.354708	31.0	7371.338326	5220.145545
1961	Italy	2021	Jun	1402.933333	714.902884	30.0	1669.882457	1135.984209

	country	year	month					dcases
				mean	std	size	ci_ub2	ci_lb2
1962	Italy	2021	Jul	2907.064516	1958.244110	31.0	3625.354255	2188.774777
1963	Italy	2021	Aug	6127.838710	1273.881499	31.0	6595.102216	5660.575204
1964	Italy	2021	Sep	4412.133333	1295.630608	30.0	4895.929753	3928.336913
1965	Italy	2021	Oct	3213.225806	977.378593	31.0	3571.731169	2854.720444
1966	Italy	2021	Nov	8552.733333	3136.827092	30.0	9724.043819	7381.422847
1967	Italy	2021	Dec	35391.483871	33089.221108	31.0	47528.708162	23254.259580

In [73]:
```
statsIT20=statsdcases[(statsdcases['country']=='Italy')
  & (statsdcases['year']==2020)]
statsIT20
```

Out[73]:

	country	year	month					dcases
				mean	std	size	ci_ub2	ci_lb2
1944	Italy	2020	Jan	2.000000	NaN	1.0	NaN	NaN
1945	Italy	2020	Feb	38.827586	73.426868	29.0	66.757673	10.897499
1946	Italy	2020	Mar	3376.258065	2050.826207	31.0	4128.507190	2624.008939
1947	Italy	2020	Apr	3322.366667	934.788174	30.0	3671.422307	2973.311026
1948	Italy	2020	May	888.193548	436.496233	31.0	1048.301659	728.085438
1949	Italy	2020	Jun	257.633333	115.008390	30.0	300.578172	214.688495
1950	Italy	2020	Jul	224.483871	62.517662	31.0	247.415535	201.552207
1951	Italy	2020	Aug	699.258065	415.082238	31.0	851.511459	547.004670
1952	Italy	2020	Sep	1521.566667	247.627596	30.0	1614.032331	1429.101003
1953	Italy	2020	Oct	11760.290323	8966.383248	31.0	15049.186250	8471.394395
1954	Italy	2020	Nov	30737.466667	6127.616478	30.0	33025.556263	28449.377070
1955	Italy	2020	Dec	16310.064516	4159.633878	31.0	17835.830541	14784.298492

In [74]:
```
statsIT20.columns=['country','year','month','mean','std','size','ci_lb2','ci_ub2']
```

In [75]:
```
statsIT21.columns=['country','year','month','mean','std','size','ci_lb2','ci_ub2']
```

In [76]:
```
x=statsIT20['month']
x
```

Out[76]:
```
1944    Jan
1945    Feb
1946    Mar
```

```
1947    Apr
1948    May
1949    Jun
1950    Jul
1951    Aug
1952    Sep
1953    Oct
1954    Nov
1955    Dec
Name: month, dtype: category
Categories (12, object): ['Jan' < 'Feb' < 'Mar' < 'Apr' ... 'Sep' < 'Oct' < 'Nov' < 'De
c']
```

In [77]:
```
y1=statsIT20['mean']
y1
```

Out[77]:
```
1944        2.000000
1945       38.827586
1946     3376.258065
1947     3322.366667
1948      888.193548
1949      257.633333
1950      224.483871
1951      699.258065
1952     1521.566667
1953    11760.290323
1954    30737.466667
1955    16310.064516
Name: mean, dtype: float64
```

In [78]:
```
y2=statsIT21['mean']
y2
```

Out[78]:
```
1956    14382.774194
1957    13294.035714
1958    21278.516129
1959    14591.800000
1960     6295.741935
1961     1402.933333
1962     2907.064516
1963     6127.838710
1964     4412.133333
1965     3213.225806
1966     8552.733333
1967    35391.483871
Name: mean, dtype: float64
```

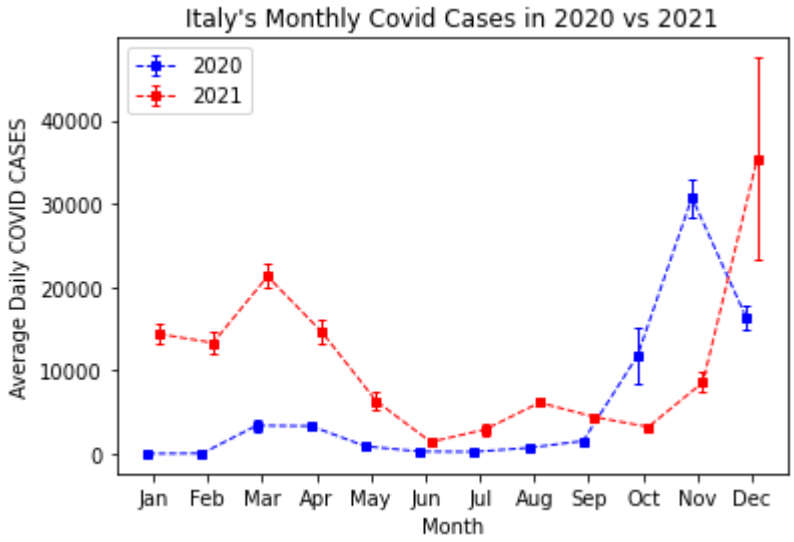
In [79]:
```
ci_lb_ub20=[statsIT20['ci_lb2'],statsIT20['ci_ub2']]
err20 = np.abs(ci_lb_ub20 - statsIT20['mean'].to_numpy())
```

In [80]:
```
ci_lb_ub21=[statsIT21['ci_lb2'],statsIT21['ci_ub2']]
err21 = np.abs(ci_lb_ub21 - statsIT21['mean'].to_numpy())
```

In [81]:
```
from matplotlib.transforms import Affine2D
```

In [82]:
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=err20, data=statsIT20,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=err21, data=statsIT21,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Italy's Monthly Covid Cases in 2020 vs 2021")
plt.show()
```



Analyzing the Time Series graph, generally 2021 has higher averages of Daily covid cases in all the months except in October and November than 2020. It can be concluded that Italy suffered more from covid-19 in 2021 than in 2020. Examining the peaks of every year, Covid cases peaked in November during 2020 and peaked in December in 2021. Both Nov 2020 and Dec 2021 have similar Averages, which can indicate that both covid cases peaks in italy were similar in terms of Average Daily Cases.The error bars in the graph are neglibile due to their minimal value in relation to the cases number,however Dec 2021 has very wide error bars that indicate inaccuracy.

Comparison of Deaths in Italy between 2020 and 2021

In [83]:
```
def ci_lb3(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean - margin_of_error
```

In [84]:
```
x=df['ddeaths']
```

In [85]:
```
ci_lb3(x)
```

Out[85]: 43.18608989544067

In [86]:
```
def ci_ub3(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean + margin_of_error
```

In [87]:
```
ci_ub3(x)
```

Out[87]: 45.399958963672184

In [88]:
```
statsddeaths=df.groupby(['country','year','month']).agg({"ddeaths": [np.mean, np.std, n
```

In [89]:
```
statsddeaths
```

Out[89]:

			ddeaths				
			mean	std	size	ci_ub3	ci_lb3
country	year	month					
Afghanistan	**2020**	**Jan**	NaN	NaN	NaN	NaN	NaN
		Feb	0.000000	0.000000	6.0	0.000000	0.000000
		Mar	0.129032	0.427546	31.0	0.285857	-0.027793
		Apr	1.866667	2.285386	30.0	2.720044	1.013290
		May	6.258065	5.853590	31.0	8.405179	4.110950
...	**...**	**...**	...	...	...	...	...
Zimbabwe	**2021**	**Aug**	28.612903	17.932610	31.0	35.190638	22.035169
		Sep	6.800000	5.803685	30.0	8.967132	4.632868
		Oct	1.774194	1.909794	31.0	2.474712	1.073676
		Nov	0.966667	1.351457	30.0	1.471309	0.462024
		Dec	9.580645	12.443939	31.0	14.145119	5.016172

4488 rows × 5 columns

In [90]:
```
statsddeaths=statsddeaths.reset_index()
```

In [91]:
```
statsIT2=statsddeaths[(statsddeaths['country']=='Italy') & (statsddeaths['year']==2021)
```

In [92]:
```
statsIT2
```

Out[92]:

	country	year	month	ddeaths				
				mean	std	size	ci_ub3	ci_lb3
1956	Italy	2021	Jan	463.129032	95.995396	31.0	498.340428	427.917637
1957	Italy	2021	Feb	327.964286	73.830879	28.0	356.592912	299.335660
1958	Italy	2021	Mar	375.709677	81.696672	31.0	405.676259	345.743096
1959	Italy	2021	Apr	382.033333	107.369322	30.0	422.125697	341.940970
1960	Italy	2021	May	171.645161	66.121377	31.0	195.898678	147.391644
1961	Italy	2021	Jun	47.933333	24.041535	30.0	56.910590	38.956077
1962	Italy	2021	Jul	16.032258	7.040283	31.0	18.614655	13.449861
1963	Italy	2021	Aug	37.354839	17.261804	31.0	43.686520	31.023158
1964	Italy	2021	Sep	56.666667	12.009575	30.0	61.151116	52.182218
1965	Italy	2021	Oct	38.032258	11.004496	31.0	42.068740	33.995776
1966	Italy	2021	Nov	57.600000	18.561361	30.0	64.530926	50.669074
1967	Italy	2021	Dec	115.290323	35.367776	31.0	128.263328	102.317318

In [93]:

```
stats2IT21=statsddeaths[(statsddeaths['country']=='Italy')
  & (statsddeaths['year']==2021)]
stats2IT21
```

Out[93]:

	country	year	month	ddeaths				
				mean	std	size	ci_ub3	ci_lb3
1956	Italy	2021	Jan	463.129032	95.995396	31.0	498.340428	427.917637
1957	Italy	2021	Feb	327.964286	73.830879	28.0	356.592912	299.335660
1958	Italy	2021	Mar	375.709677	81.696672	31.0	405.676259	345.743096
1959	Italy	2021	Apr	382.033333	107.369322	30.0	422.125697	341.940970
1960	Italy	2021	May	171.645161	66.121377	31.0	195.898678	147.391644
1961	Italy	2021	Jun	47.933333	24.041535	30.0	56.910590	38.956077
1962	Italy	2021	Jul	16.032258	7.040283	31.0	18.614655	13.449861
1963	Italy	2021	Aug	37.354839	17.261804	31.0	43.686520	31.023158
1964	Italy	2021	Sep	56.666667	12.009575	30.0	61.151116	52.182218
1965	Italy	2021	Oct	38.032258	11.004496	31.0	42.068740	33.995776
1966	Italy	2021	Nov	57.600000	18.561361	30.0	64.530926	50.669074
1967	Italy	2021	Dec	115.290323	35.367776	31.0	128.263328	102.317318

In [94]:

```
stats2IT20=statsddeaths[(statsddeaths['country']=='Italy')
  & (statsddeaths['year']==2020)]
stats2IT20
```

Out[94]:

	country	year	month	ddeaths				
				mean	std	size	ci_ub3	ci_lb3
1944	Italy	2020	Jan	0.000000	NaN	1.0	NaN	NaN
1945	Italy	2020	Feb	1.000000	1.963961	29.0	1.747051	0.252949
1946	Italy	2020	Mar	399.967742	313.773855	31.0	515.060921	284.874563
1947	Italy	2020	Apr	517.966667	132.823576	30.0	567.563805	468.369528
1948	Italy	2020	May	175.741935	91.021231	31.0	209.128793	142.355078
1949	Italy	2020	Jun	46.100000	24.627361	30.0	55.296008	36.903992
1950	Italy	2020	Jul	12.064516	6.894130	31.0	14.593304	9.535729
1951	Italy	2020	Aug	11.032258	27.449935	31.0	21.100975	0.963541
1952	Italy	2020	Sep	13.700000	5.240097	30.0	15.656685	11.743315
1953	Italy	2020	Oct	87.870968	75.389098	31.0	115.523912	60.218023
1954	Italy	2020	Nov	565.266667	173.229354	30.0	629.951571	500.581763
1955	Italy	2020	Dec	599.451613	167.376390	31.0	660.845768	538.057457

In [95]:
```
stats2IT20.columns=['country','year','month','mean','std','size','ci_lb3','ci_ub3']
```

In [96]:
```
stats2IT21.columns=['country','year','month','mean','std','size','ci_lb3','ci_ub3']
```

In [97]:
```
z=statsIT20['month']
z
```

Out[97]:
```
1944    Jan
1945    Feb
1946    Mar
1947    Apr
1948    May
1949    Jun
1950    Jul
1951    Aug
1952    Sep
1953    Oct
1954    Nov
1955    Dec
Name: month, dtype: category
Categories (12, object): ['Jan' < 'Feb' < 'Mar' < 'Apr' ... 'Sep' < 'Oct' < 'Nov' < 'De
c']
```

In [98]:
```
y3=stats2IT20['mean']
y3
```

Out[98]:
```
1944      0.000000
1945      1.000000
1946    399.967742
```

```
1947    517.966667
1948    175.741935
1949     46.100000
1950     12.064516
1951     11.032258
1952     13.700000
1953     87.870968
1954    565.266667
1955    599.451613
Name: mean, dtype: float64
```

In [99]:
```
y4=stats2IT21['mean']
y4
```

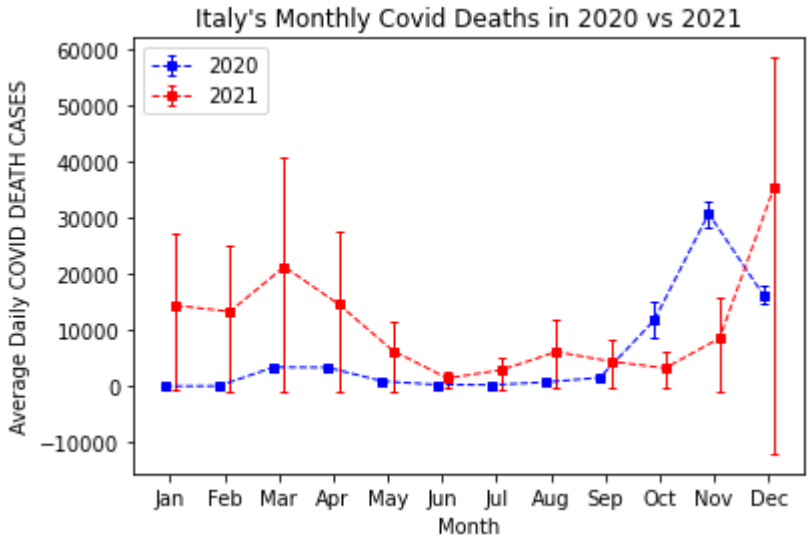
Out[99]:
```
1956    463.129032
1957    327.964286
1958    375.709677
1959    382.033333
1960    171.645161
1961     47.933333
1962     16.032258
1963     37.354839
1964     56.666667
1965     38.032258
1966     57.600000
1967    115.290323
Name: mean, dtype: float64
```

In [100…
```
ci_lb_ub220=[stats2IT20['ci_lb3'],stats2IT20['ci_ub3']]
err220 = np.abs(ci_lb_ub220 - stats2IT20['mean'].to_numpy())
```

In [101…
```
ci_lb_ub221=[statsIT21['ci_lb2'],statsIT21['ci_ub2']]
err21 = np.abs(ci_lb_ub221 - stats2IT21['mean'].to_numpy())
```

In [102…
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=err20, data=statsIT20,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=err21, data=statsIT21,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID DEATH CASES")
plt.title("Italy's Monthly Covid Deaths in 2020 vs 2021")
plt.show()
```



Similarly to the trend observed in the average Covid Cases graph, 2021 had a higher average of death cases than 2020. As Expected, during 2020's peak of covid-19 confirmed cases, the average daily covid deaths peaked too. The same trend appearead in December of 2021. However, the confidence interval of Dec 2021 is extremely wide, and that indicates possible instability and errors in the data collected. 2020's data have minimal to none error bars, which indicate a high accuracy of the data collected.

Computing Italy's Case fatality rate

In [103…
```
df=pd.read_csv('covid_data.csv',encoding='latin-1')
```

In [104…
```
df['totcases'] = df.groupby(['iso3c'])['dcases'].cumsum()
```

In [105…
```
df.loc[df['iso3c']=='ITA'].head(6)
```

Out[105…

	date	iso3c	country	income	region	continent	dcases	ddeaths	population	weekdays	mor
54199	2020-01-31	ITA	Italy	High income	Europe & Central Asia	Europe	2	0	60297396	Fri	.
54200	2020-02-01	ITA	Italy	High income	Europe & Central Asia	Europe	0	0	60297396	Sat	F
54201	2020-02-02	ITA	Italy	High income	Europe & Central Asia	Europe	0	0	60297396	Sun	F
54202	2020-02-03	ITA	Italy	High income	Europe & Central Asia	Europe	0	0	60297396	Mon	F

	date	iso3c	country	income	region	continent	dcases	ddeaths	population	weekdays	mor
54203	2020-02-04	ITA	Italy	High income	Europe & Central Asia	Europe	0	0	60297396	Tue	F
54204	2020-02-05	ITA	Italy	High income	Europe & Central Asia	Europe	0	0	60297396	Wed	F

In [107…
```
df['totdeaths'] = df.groupby(['iso3c'])['ddeaths'].cumsum()
```

In [108…
```
df['totdeaths'].loc[df['iso3c']=='ITA']
```

Out[108…
```
54199         0
54200         0
54201         0
54202         0
54203         0
          ...
54895    136784
54896    136986
54897    137122
54898    137278
54899    137433
Name: totdeaths, Length: 701, dtype: int64
```

In [109…
```
df['cfr']=df['totdeaths']/df['totcases']
```

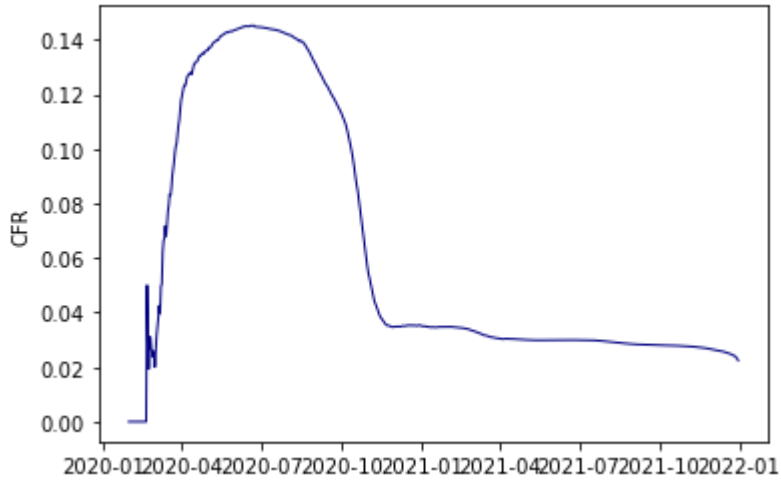
In [113…
```
df_ita=df.loc[df['iso3c']=='ITA']
```

In [114…
```
df_ita['date'] = pd.to_datetime(df_ita['date'],format='%Y-%m-%d')
```

```
C:\Users\h\AppData\Local\Temp/ipykernel_10496/212854159.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  df_ita['date'] = pd.to_datetime(df_ita['date'],format='%Y-%m-%d')
```

In [122…
```
plt.plot( 'date', 'cfr', data=df_ita,  color='navy', markersize=5,     linewidth=1)
plt.xlabel("")
plt.ylabel("CFR")
plt.show()
```



The fatality rate graph has an expected curve in which it peaks then goes down but never reaches 0 again since the virus is still around. It is vivid that the fatality rate was at its peak in 2020 even though 2021 had more cases. However, 0.14 is a fatality rate that concludes that 10% of the people who got covid did die in Italy, and that occured in Italy's peak time.

Comparison of Covid-19 in 2020 and 2021

1. Comparison In terms of region: confirmed COVID 19 cases

Region 1: Europe & Central Asia

In [123…
```
df['date'][0]
```

Out[123…
```
'2020-02-24'
```

In [124…
```
df['date'] = pd.to_datetime(df['date'],format='%Y-%m-%d')
```

In [125…
```
df['date'][0]
```

Out[125…
```
Timestamp('2020-02-24 00:00:00')
```

In [126…
```
df['year'] = pd. DatetimeIndex(df['date']). year
```

In [127…
```
df['year'][0]
```

Out[127…
```
2020
```

In [128…
```
df['region'].unique()
```

Out[128…
```
array(['South Asia', 'Sub-Saharan Africa', 'Europe & Central Asia',
       'Middle East & North Africa', 'Latin America & Caribbean',
       'East Asia & Pacific', 'North America(region)'], dtype=object)
```

In [129…
```
def ci_lb4(x, alpha=0.05):
```

```
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean - margin_of_error
```

In [130…
```
x=df['dcases']
```

In [131…
```
ci_lb4(x)
```

Out[131…
```
2285.1835480837417
```

In [132…
```
def ci_ub4(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean + margin_of_error
```

In [133…
```
ci_ub4(x)
```

Out[133…
```
2422.2624439548763
```

In [134…
```
rdcases=df.groupby(['region','year','month']).agg({"dcases": [np.mean, np.std, np.size,
```

In [135…
```
rdcases
```

Out[135…

			dcases				
			mean	std	size	ci_ub4	ci_lb4
region	year	month					
East Asia & Pacific	2020	Apr	92.700000	177.828711	570	107.329764	78.070236
		Aug	423.417657	1044.901057	589	507.976780	338.858534
		Dec	630.715288	1475.101424	713	739.173912	522.256663
		Feb	250.304795	1155.872616	292	383.435013	117.174576
		Jan	126.679487	436.945076	78	225.195380	28.163595
...	...	...	...	...	...	...	...
Sub-Saharan Africa	2021	Mar	161.274537	393.852860	1457	181.514676	141.034398
		May	128.577213	488.161505	1457	153.663883	103.490544
		Nov	89.737589	588.981229	1410	120.506577	58.968601
		Oct	87.528483	293.259577	1457	102.599123	72.457843
		Sep	247.950355	1021.166824	1410	301.297165	194.603545

166 rows × 5 columns

In [136…
```
rdcases=rdcases.reset_index()
```

In [137…
```
statsR=rdcases[(rdcases['region']=='Europe & Central Asia ') & (rdcases['year']==2020)]
```

In [138…
```
statsR
```

Out[138…

region	year	month	dcases				
			mean	std	size	ci_ub4	ci_lb4

In [139…
```
statsR.columns
```

Out[139…
```
MultiIndex([('region',       ''),
            (  'year',       ''),
            ( 'month',       ''),
            ('dcases',   'mean'),
            ('dcases',    'std'),
            ('dcases',   'size'),
            ('dcases', 'ci_ub4'),
            ('dcases', 'ci_lb4')],
           )
```

In [140…
```
statsR21=rdcases[(rdcases['region']=='Europe & Central Asia')
  & (rdcases['year']==2021)]
statsR21
```

Out[140…

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
36	Europe & Central Asia	2021	Apr	4400.757516	9911.409826	1530	4897.786519	3903.728514
37	Europe & Central Asia	2021	Aug	3180.007590	6844.920329	1581	3517.670508	2842.344672
38	Europe & Central Asia	2021	Dec	9411.908918	22368.523899	1581	10515.358001	8308.459836
39	Europe & Central Asia	2021	Feb	3034.478291	5547.740717	1428	3322.462489	2746.494094
40	Europe & Central Asia	2021	Jan	4423.700822	9236.689814	1581	4879.350777	3968.050868
41	Europe & Central Asia	2021	Jul	2646.413662	7396.965106	1581	3011.309191	2281.518133
42	Europe & Central Asia	2021	Jun	1075.566013	2875.930124	1530	1219.785726	931.346300
43	Europe & Central Asia	2021	Mar	4017.991145	6963.850364	1581	4361.520934	3674.461356
44	Europe & Central Asia	2021	May	1864.763441	3692.159287	1581	2046.899276	1682.627606
45	Europe & Central Asia	2021	Nov	6763.426144	11088.295989	1530	7319.472639	6207.379649
46	Europe & Central Asia	2021	Oct	4243.963947	8383.799608	1581	4657.540454	3830.387440
47	Europe & Central Asia	2021	Sep	3095.722222	6524.122498	1530	3422.888403	2768.556042

In [141…
```
statsR20=rdcases[(rdcases['region']=='Europe & Central Asia')
  & (rdcases['year']==2020)]
statsR20
```

Out[141…

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
24	Europe & Central Asia	2020	Apr	693.848667	1939.781037	1500	792.092653	595.604680
25	Europe & Central Asia	2020	Aug	557.484503	1427.035570	1581	627.880793	487.088214
26	Europe & Central Asia	2020	Dec	5276.588868	21992.213905	1581	6361.474414	4191.703322
27	Europe & Central Asia	2020	Feb	4.819936	24.944837	311	7.603155	2.036716
28	Europe & Central Asia	2020	Jan	0.894737	0.936586	19	1.346157	0.443317
29	Europe & Central Asia	2020	Jul	398.997470	1080.452784	1581	452.296679	345.698261
30	Europe & Central Asia	2020	Jun	351.989542	1137.680770	1530	409.040996	294.938089
31	Europe & Central Asia	2020	Mar	338.220733	1065.272767	1418	393.714208	282.727259
32	Europe & Central Asia	2020	May	424.242884	1403.684633	1581	493.487262	354.998506
33	Europe & Central Asia	2020	Nov	5183.352288	9110.089031	1530	5640.197332	4726.507243
34	Europe & Central Asia	2020	Oct	3193.193548	6395.982837	1581	3508.710184	2877.676913
35	Europe & Central Asia	2020	Sep	1008.238562	2527.394697	1530	1134.980215	881.496909

In [142…
```
statsR20.columns=['region','year','month','mean','std','size','ci_lb4','ci_ub4']
```

In [143…
```
statsR21.columns=['region','year','month','mean','std','size','ci_lb4','ci_ub4']
```

In [144…
```
x=statsR20['region']
x
```

Out[144…
```
24    Europe & Central Asia
25    Europe & Central Asia
26    Europe & Central Asia
27    Europe & Central Asia
28    Europe & Central Asia
29    Europe & Central Asia
30    Europe & Central Asia
31    Europe & Central Asia
32    Europe & Central Asia
33    Europe & Central Asia
34    Europe & Central Asia
35    Europe & Central Asia
Name: region, dtype: object
```

In [145…
```
y1=statsR20['mean']
y1
```

```
24     693.848667
```

Out[145…
```
25     557.484503
26    5276.588868
27       4.819936
28       0.894737
29     398.997470
30     351.989542
31     338.220733
32     424.242884
33    5183.352288
34    3193.193548
35    1008.238562
Name: mean, dtype: float64
```

In [146…
```
y2=statsR21['mean']
y2
```

Out[146…
```
36    4400.757516
37    3180.007590
38    9411.908918
39    3034.478291
40    4423.700822
41    2646.413662
42    1075.566013
43    4017.991145
44    1864.763441
45    6763.426144
46    4243.963947
47    3095.722222
Name: mean, dtype: float64
```

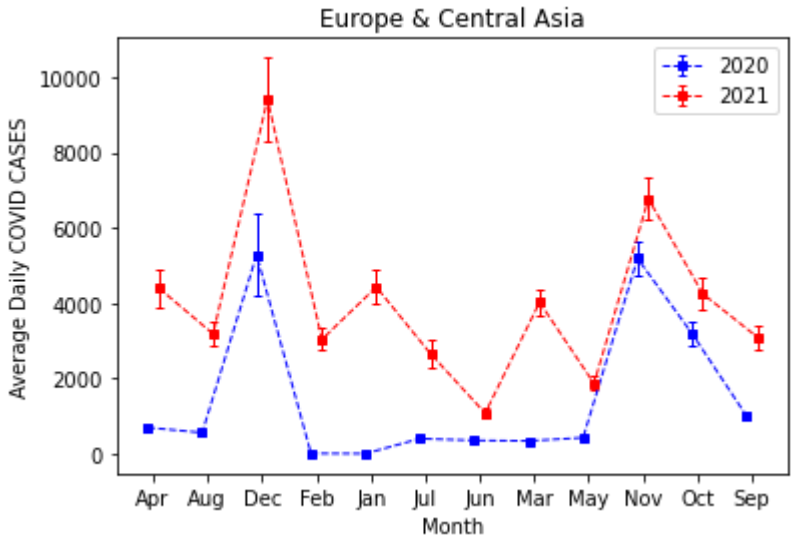
In [147…
```
ci_lb_ubR20=[statsR20['ci_lb4'],statsR20['ci_ub4']]
errR20 = np.abs(ci_lb_ubR20 - statsR20['mean'].to_numpy())
```

In [148…
```
ci_lb_ubR21=[statsR21['ci_lb4'],statsR21['ci_ub4']]
errR21 = np.abs(ci_lb_ubR21 - statsR21['mean'].to_numpy())
```

In [149…
```
from matplotlib.transforms import Affine2D
```

In [150…
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=errR20, data=statsR20,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=errR21, data=statsR21,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Europe & Central Asia")
plt.show()
```



Examining the graph of Avergae daily covid cases in Europe and Central Asia in 2020 vs 2021, it can be seen that both years suffered from an increasing average of covid cases. In 2020, covid cases kept gradually increasing throughout the whole year and a bigger increase was observed in October and onwards. On the other hand, 2021 is more fluctuating since the cases kept increasing and decreasing multiple times during the year. In june 2021, the cases were at their minimum, and after September 2021 the cases started booming and reached its highest in the 2 years in December 2021.

Region 2: Middle East and North Africa

In [151…
```
statsR2=rdcases[(rdcases['region']=='Middle East & North Africa') & (rdcases['year']==2
```

In [152…
```
statsR2
```

Out[152…

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
71	Middle East & North Africa	2020	Apr	209.711755	416.318100	621	242.519488	176.904023
72	Middle East & North Africa	2020	Aug	641.867896	894.732215	651	710.726798	573.008993
73	Middle East & North Africa	2020	Dec	1273.310292	2001.556385	651	1427.350768	1119.269816
74	Middle East & North Africa	2020	Feb	7.000000	26.790811	104	12.210144	1.789856
75	Middle East & North Africa	2020	Jan	1.333333	2.309401	3	7.070204	-4.403537
76	Middle East & North Africa	2020	Jul	699.082949	889.344877	651	767.527241	630.638658
77	Middle East & North Africa	2020	Jun	647.385714	954.622947	630	722.072912	572.698517
78	Middle East & North Africa	2020	Mar	106.802583	387.634558	542	139.509802	74.095364

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
79	Middle East & North Africa	2020	May	404.010753	637.407884	651	453.065885	354.955620
80	Middle East & North Africa	2020	Nov	1582.941270	2690.395225	630	1793.430740	1372.451799
81	Middle East & North Africa	2020	Oct	1124.852535	1487.973491	651	1239.367493	1010.337577
82	Middle East & North Africa	2020	Sep	955.063492	1365.640403	630	1061.907618	848.219366

In [153…
```
statsR2.columns
```

Out[153…
```
MultiIndex([('region',       ''),
            (  'year',       ''),
            ( 'month',       ''),
            ('dcases',   'mean'),
            ('dcases',    'std'),
            ('dcases',   'size'),
            ('dcases', 'ci_ub4'),
            ('dcases', 'ci_lb4')],
           )
```

In [154…
```
statsR221=rdcases[(rdcases['region']=='Middle East & North Africa')
  & (rdcases['year']==2021)]
statsR221
```

Out[154…

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
83	Middle East & North Africa	2021	Apr	2214.015873	4494.082227	630	2565.621087	1862.410659
84	Middle East & North Africa	2021	Aug	3312.694316	7919.025055	651	3922.145242	2703.243391
85	Middle East & North Africa	2021	Dec	672.032258	1064.245135	651	753.936934	590.127582
86	Middle East & North Africa	2021	Feb	1405.054422	1954.685370	588	1563.373290	1246.735554
87	Middle East & North Africa	2021	Jan	1402.342550	2059.496147	651	1560.842090	1243.843009
88	Middle East & North Africa	2021	Jul	2359.718894	5094.053939	651	2751.759059	1967.678729
89	Middle East & North Africa	2021	Jun	1296.085714	2302.221239	630	1476.205470	1115.965959
90	Middle East & North Africa	2021	Mar	1714.384025	2338.872107	651	1894.384436	1534.383613

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
91	Middle East & North Africa	2021	May	1409.675883	2994.057808	651	1640.099615	1179.252152
92	Middle East & North Africa	2021	Nov	690.525397	1576.597451	630	813.874249	567.176545
93	Middle East & North Africa	2021	Oct	964.829493	2616.431979	651	1166.191009	763.467977
94	Middle East & North Africa	2021	Sep	1978.706349	4665.790138	630	2343.745540	1613.667158

In [155…

```
statsR220=rdcases[(rdcases['region']=='Middle East & North Africa')
  & (rdcases['year']==2020)]
statsR220
```

Out[155…

	region	year	month	dcases				
				mean	std	size	ci_ub4	ci_lb4
71	Middle East & North Africa	2020	Apr	209.711755	416.318100	621	242.519488	176.904023
72	Middle East & North Africa	2020	Aug	641.867896	894.732215	651	710.726798	573.008993
73	Middle East & North Africa	2020	Dec	1273.310292	2001.556385	651	1427.350768	1119.269816
74	Middle East & North Africa	2020	Feb	7.000000	26.790811	104	12.210144	1.789856
75	Middle East & North Africa	2020	Jan	1.333333	2.309401	3	7.070204	-4.403537
76	Middle East & North Africa	2020	Jul	699.082949	889.344877	651	767.527241	630.638658
77	Middle East & North Africa	2020	Jun	647.385714	954.622947	630	722.072912	572.698517
78	Middle East & North Africa	2020	Mar	106.802583	387.634558	542	139.509802	74.095364
79	Middle East & North Africa	2020	May	404.010753	637.407884	651	453.065885	354.955620
80	Middle East & North Africa	2020	Nov	1582.941270	2690.395225	630	1793.430740	1372.451799
81	Middle East & North Africa	2020	Oct	1124.852535	1487.973491	651	1239.367493	1010.337577
82	Middle East & North Africa	2020	Sep	955.063492	1365.640403	630	1061.907618	848.219366

In [156…

```
statsR220.columns=['region','year','month','mean','std','size','ci_lb4','ci_ub4']
```

In [157…
```
statsR221.columns=['region','year','month','mean','std','size','ci_lb4','ci_ub4']
```

In [158…
```
x=statsR220['region']
x
```

Out[158…
```
71    Middle East & North Africa
72    Middle East & North Africa
73    Middle East & North Africa
74    Middle East & North Africa
75    Middle East & North Africa
76    Middle East & North Africa
77    Middle East & North Africa
78    Middle East & North Africa
79    Middle East & North Africa
80    Middle East & North Africa
81    Middle East & North Africa
82    Middle East & North Africa
Name: region, dtype: object
```

In [159…
```
y1=statsR220['mean']
y1
```

Out[159…
```
71     209.711755
72     641.867896
73    1273.310292
74       7.000000
75       1.333333
76     699.082949
77     647.385714
78     106.802583
79     404.010753
80    1582.941270
81    1124.852535
82     955.063492
Name: mean, dtype: float64
```

In [160…
```
y2=statsR221['mean']
y2
```

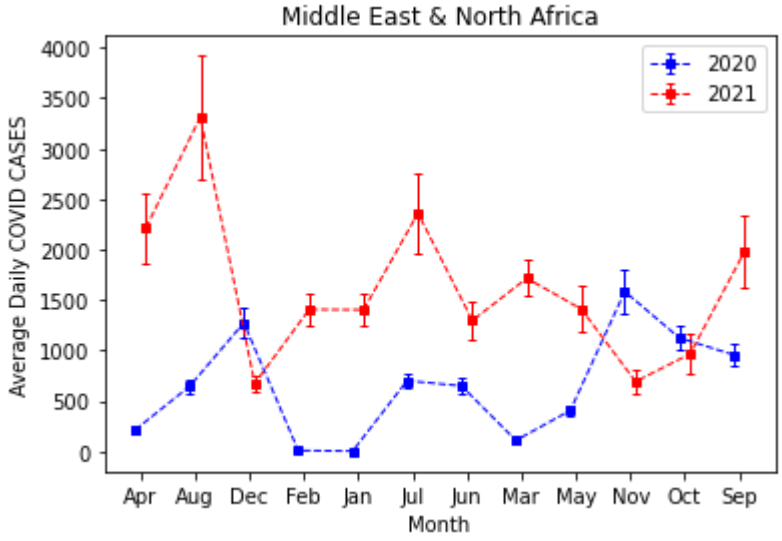
Out[160…
```
83    2214.015873
84    3312.694316
85     672.032258
86    1405.054422
87    1402.342550
88    2359.718894
89    1296.085714
90    1714.384025
91    1409.675883
92     690.525397
93     964.829493
94    1978.706349
Name: mean, dtype: float64
```

In [161…
```
ci_lb_ubR220=[statsR220['ci_lb4'],statsR220['ci_ub4']]
errR220 = np.abs(ci_lb_ubR220 - statsR220['mean'].to_numpy())
```

In [162…
```
ci_lb_ubR221=[statsR221['ci_lb4'],statsR221['ci_ub4']]
errR221 = np.abs(ci_lb_ubR221 - statsR221['mean'].to_numpy())
```

In [163…
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=errR220, data=statsR220,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=errR221, data=statsR221,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Middle East & North Africa")
plt.show()
```



Examining 2020's trend, the cases were gradually increasing throughout the year and peaked in November, then decreased in December. However, 2021 cases were fluctuating and there was no clear trend in the data. The cases peaked in August 2021 then a sharp decrease in cases was observed. August 2021 have significantly wide error bars that indicate the high probability of containing errors.

Comparison in terms of income and confirmed COVID 19 deaths

Lower Middle Income

In [164…
```
df['date'][0]
```

Out[164…
```
Timestamp('2020-02-24 00:00:00')
```

In [165…
```
df['date'] = pd.to_datetime(df['date'],format='%Y-%m-%d')
```

In [166…
```
df['date'][0]
```

Out[166… Timestamp('2020-02-24 00:00:00')

In [167…
```
df['year'] = pd. DatetimeIndex(df['date']). year
```

In [168…
```
df['income'].unique()
```

Out[168…
```
array(['Low income', 'Lower middle income', 'Upper middle income',
       'High income'], dtype=object)
```

In [169…
```
x=df['ddeaths']
```

In [170…
```
def ci_lb5(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean - margin_of_error
```

In [171…
```
ci_lb5(x)
```

Out[171… 43.18608989544067

In [172…
```
def ci_ub5(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean + margin_of_error
```

In [173…
```
ci_ub5(x)
```

Out[173… 45.399958963672184

In [174…
```
incdeaths=df.groupby(['income','year','month']).agg({"ddeaths": [np.mean, np.std, np.si
```

In [175…
```
incdeaths
```

Out[175…

			ddeaths				
			mean	std	size	ci_ub5	ci_lb5
income	year	month					
High income	2020	Apr	98.662573	318.565638	1710	113.772301	83.552845
		Aug	21.320883	132.611288	1767	27.508281	15.133485
		Dec	114.995473	379.800723	1767	132.716274	97.274671

			ddeaths				
			mean	std	size	ci_ub5	ci_lb5
income	year	month					
		Feb	0.108268	0.597571	508	0.160356	0.056179
		Jan	0.000000	0.000000	75	0.000000	0.000000
...	...	...	...	...	...	...	...
Upper middle income	2021	Mar	93.728196	337.437017	1674	109.904429	77.551963
		May	96.706691	295.246678	1674	110.860381	82.553000
		Nov	56.883951	171.705193	1620	65.251510	48.516391
		Oct	61.903226	160.512807	1674	69.597973	54.208478
		Sep	81.536420	176.995456	1620	90.161785	72.911054

96 rows × 5 columns

In [176...
```
incdeaths=incdeaths.reset_index()
```

In [177...
```
incdeaths
```

Out[177...

	income	year	month	ddeaths				
				mean	std	size	ci_ub5	ci_lb5
0	High income	2020	Apr	98.662573	318.565638	1710	113.772301	83.552845
1	High income	2020	Aug	21.320883	132.611288	1767	27.508281	15.133485
2	High income	2020	Dec	114.995473	379.800723	1767	132.716274	97.274671
3	High income	2020	Feb	0.108268	0.597571	508	0.160356	0.056179
4	High income	2020	Jan	0.000000	0.000000	75	0.000000	0.000000
...	...	...	...	...	...	...	...	...
91	Upper middle income	2021	Mar	93.728196	337.437017	1674	109.904429	77.551963
92	Upper middle income	2021	May	96.706691	295.246678	1674	110.860381	82.553000
93	Upper middle income	2021	Nov	56.883951	171.705193	1620	65.251510	48.516391
94	Upper middle income	2021	Oct	61.903226	160.512807	1674	69.597973	54.208478
95	Upper middle income	2021	Sep	81.536420	176.995456	1620	90.161785	72.911054

96 rows × 8 columns

In [178...
```
statsI=incdeaths[(incdeaths['income']==' Lower middle income') & (incdeaths['year']==20
```

In [179...
```
statsI.columns
```

Out[179…

```
MultiIndex([( 'income',       ''),
            (   'year',       ''),
            (  'month',       ''),
            ('ddeaths',   'mean'),
            ('ddeaths',    'std'),
            ('ddeaths',   'size'),
            ('ddeaths', 'ci_ub5'),
            ('ddeaths', 'ci_lb5')],
           )
```

In [180…

```
statsI21=incdeaths[(incdeaths['income']=='Lower middle income')
  & (incdeaths['year']==2021)]
statsI21
```

Out[180…

	income	year	month	ddeaths				
				mean	std	size	ci_ub5	ci_lb5
60	Lower middle income	2021	Apr	61.694815	290.407758	1350	77.200082	46.189548
61	Lower middle income	2021	Aug	68.870266	210.643427	1426	79.812482	57.928051
62	Lower middle income	2021	Dec	27.176718	112.677461	1426	33.029932	21.323504
63	Lower middle income	2021	Feb	18.553968	42.053422	1260	20.878213	16.229723
64	Lower middle income	2021	Jan	23.284588	52.762944	1395	26.055784	20.513392
65	Lower middle income	2021	Jul	64.838710	235.585459	1426	77.076580	52.600839
66	Lower middle income	2021	Jun	68.369565	381.717385	1380	88.526841	48.212290
67	Lower middle income	2021	Mar	19.689606	51.783310	1395	22.409350	16.969862
68	Lower middle income	2021	May	105.464159	569.973755	1409	135.250760	75.677558
69	Lower middle income	2021	Nov	32.799275	113.270292	1380	38.780718	26.817833
70	Lower middle income	2021	Oct	28.604488	86.738223	1426	33.110246	24.098730
71	Lower middle income	2021	Sep	35.465942	87.992029	1380	40.112520	30.819364

In [181…

```
statsI20=incdeaths[(incdeaths['income']=='Lower middle income')
  & (incdeaths['year']==2020)]
statsI20
```

Out[181…

	income	year	month	ddeaths				
				mean	std	size	ci_ub5	ci_lb5
48	Lower middle income	2020	Apr	3.291191	8.492063	1226	3.767014	2.815368
49	Lower middle income	2020	Aug	30.777194	140.381582	1333	38.320087	23.234301
50	Lower middle income	2020	Dec	24.962724	67.862191	1395	28.526957	21.398491
51	Lower middle income	2020	Feb	0.007194	0.084819	139	0.021419	-0.007031
52	Lower middle income	2020	Jan	0.000000	0.000000	18	0.000000	0.000000
53	Lower middle income	2020	Jul	25.108027	98.432430	1333	30.396935	19.819119

	income	year	month	ddeaths				
				mean	std	size	ci_ub5	ci_lb5
54	Lower middle income	2020	Jun	17.723256	77.938291	1290	21.980339	13.466173
55	Lower middle income	2020	Mar	0.532143	1.842141	840	0.656898	0.407388
56	Lower middle income	2020	May	7.261923	23.121114	1321	8.509892	6.013954
57	Lower middle income	2020	Nov	26.042506	83.133271	1341	30.496001	21.589010
58	Lower middle income	2020	Oct	28.715447	117.966352	1353	35.006833	22.424061
59	Lower middle income	2020	Sep	37.388372	174.349485	1290	46.911550	27.865194

In [182…
```
statsI20.columns=['income','year','month','mean','std','size','ci_lb5','ci_ub5']
```

In [183…
```
statsI21.columns=['income','year','month','mean','std','size','ci_lb5','ci_ub5']
```

In [184…
```
x=statsI20['income']
x
```

Out[184…
```
48    Lower middle income
49    Lower middle income
50    Lower middle income
51    Lower middle income
52    Lower middle income
53    Lower middle income
54    Lower middle income
55    Lower middle income
56    Lower middle income
57    Lower middle income
58    Lower middle income
59    Lower middle income
Name: income, dtype: object
```

In [185…
```
y1=statsI20['mean']
y1
```

Out[185…
```
48     3.291191
49    30.777194
50    24.962724
51     0.007194
52     0.000000
53    25.108027
54    17.723256
55     0.532143
56     7.261923
57    26.042506
58    28.715447
59    37.388372
Name: mean, dtype: float64
```

In [186…
```
y2=statsI21['mean']
y2
```

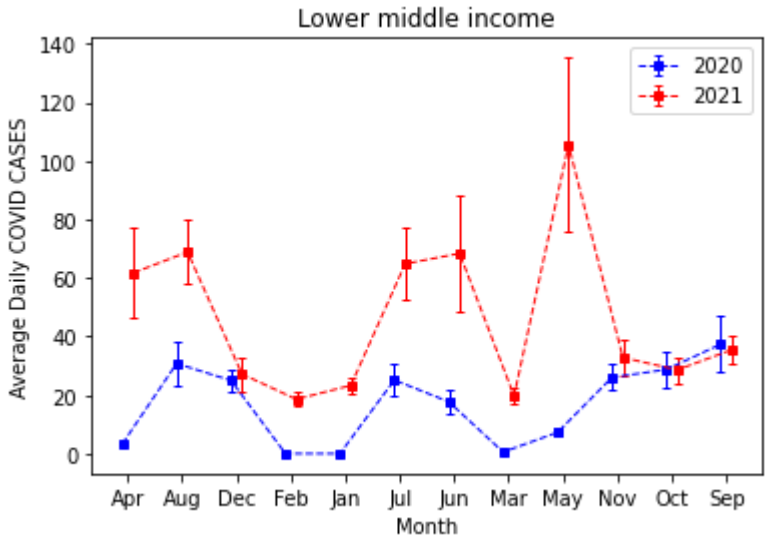
Out[186…
```
60     61.694815
61     68.870266
62     27.176718
63     18.553968
64     23.284588
65     64.838710
66     68.369565
67     19.689606
68    105.464159
69     32.799275
70     28.604488
71     35.465942
Name: mean, dtype: float64
```

In [187…
```
ci_lb_ubI20=[statsI20['ci_lb5'],statsI20['ci_ub5']]
errI20 = np.abs(ci_lb_ubI20 - statsI20['mean'].to_numpy())
```

In [188…
```
ci_lb_ubI21=[statsI21['ci_lb5'],statsI21['ci_ub5']]
errI21 = np.abs(ci_lb_ubI21 - statsI21['mean'].to_numpy())
```

In [189…
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=errI20, data=statsI20,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=errI21, data=statsI21,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Lower middle income")
plt.show()
```



The lower middle income class suffered more in 2021 than in 2020, and that is vivid in the number of average daily cases. 2020's cases were gradually increasing and started to gradually drop from

September and later on. However, 2021 had more fluctuation from high to low averages, and Cases peaked in May 2021.

Upper middle income

In [190…
```
statsI220=incdeaths[(incdeaths['income']=='Upper middle income') & (incdeaths['year']==
```

In [191…
```
statsI221=incdeaths[(incdeaths['income']=='Upper middle income')
  & (incdeaths['year']==2021)]
statsI221
```

Out[191…

	income	year	month	ddeaths				
				mean	std	size	ci_ub5	ci_lb5
84	Upper middle income	2021	Apr	120.103086	411.445821	1620	140.153717	100.052456
85	Upper middle income	2021	Aug	90.756870	197.318167	1674	100.216012	81.297728
86	Upper middle income	2021	Dec	42.937276	148.318079	1674	50.047426	35.827126
87	Upper middle income	2021	Feb	80.735450	238.265359	1512	92.754804	68.716096
88	Upper middle income	2021	Jan	85.315412	230.584674	1674	96.369301	74.261523
89	Upper middle income	2021	Jul	90.015532	307.556616	1674	104.759342	75.271721
90	Upper middle income	2021	Jun	94.161111	307.070283	1620	109.125300	79.196923
91	Upper middle income	2021	Mar	93.728196	337.437017	1674	109.904429	77.551963
92	Upper middle income	2021	May	96.706691	295.246678	1674	110.860381	82.553000
93	Upper middle income	2021	Nov	56.883951	171.705193	1620	65.251510	48.516391
94	Upper middle income	2021	Oct	61.903226	160.512807	1674	69.597973	54.208478
95	Upper middle income	2021	Sep	81.536420	176.995456	1620	90.161785	72.911054

In [192…
```
statsI220.columns=['income','year','month','mean','std','size','ci_lb5','ci_ub5']
```

In [193…
```
statsI221.columns=['income','year','month','mean','std','size','ci_lb5','ci_ub5']
```

In [194…
```
x=statsI220['income']
```

In [195…
```
y1=statsI220['mean']
```

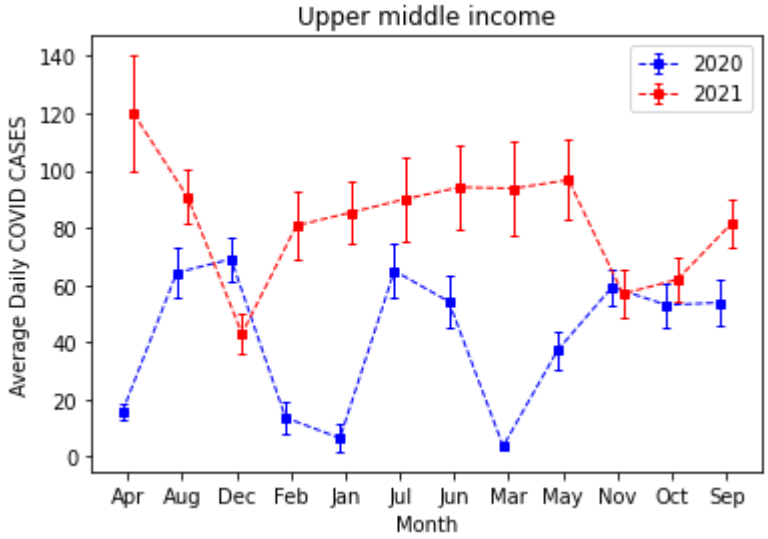
In [196…
```
y2=statsI221['mean']
```

In [197…
```
ci_lb_ubI220=[statsI220['ci_lb5'],statsI220['ci_ub5']]
errI220 = np.abs(ci_lb_ubI220 - statsI220['mean'].to_numpy())
```

In [198…
```
ci_lb_ubI221=[statsI221['ci_lb5'],statsI221['ci_ub5']]
errI221 = np.abs(ci_lb_ubI221 - statsI221['mean'].to_numpy())
```

In [199…
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=errI220, data=statsI220,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=errI221, data=statsI221,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Upper middle income")
plt.show()
```



The upper middle income population had similar averages in both years from July until December. Contrastingly, the start of 2021 was very different than the start of 2020. 2021 decreased before July whereas 2020 was increaing. Both years intersect in November, where they have the same number of Cases.

Comparing Continents in terms of confirmed COVID 19 cases

Continent 1: Africa

In [200…
```
df['continent'].unique()
```

Out[200…
```
array(['Asia', 'Africa', 'Europe', 'South America(continent)',
       'North America(continent)', 'Oceania'], dtype=object)
```

In [201…
```
x=df['dcases']
```

In [202…
```
def ci_lb6(x, alpha=0.05):
```

```
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean - margin_of_error
```

In [203…

```
ci_lb6(x)
```

Out[203…

```
2285.1835480837417
```

In [204…

```
def ci_ub6(x, alpha=0.05):
    sample_s=np.std(x)
    sample_mean=np.mean(x)
    sample_size=len(x)
    margin_of_error = t.ppf(1 - alpha/2,sample_size-1)*sample_s/np.sqrt(sample_size-1)
    return sample_mean + margin_of_error
```

In [205…

```
ci_ub6(x)
```

Out[205…

```
2422.2624439548763
```

In [206…

```
contcases=df.groupby(['continent','year','month']).agg({"dcases": [np.mean, np.std, np.
```

In [207…

```
contcases=contcases.reset_index()
```

In [208…

```
statsC21=contcases[(contcases['continent']=='Africa')
  & (contcases['year']==2021)]
statsC21
```

Out[208…

	continent	year	month	dcases				
				mean	std	size	ci_ub6	ci_lb6
11	Africa	2021	Apr	213.859748	517.379023	1590	239.309836	188.409661
12	Africa	2021	Aug	657.917225	1988.648676	1643	754.146589	561.687860
13	Africa	2021	Dec	650.332928	2476.930717	1643	770.189930	530.475925
14	Africa	2021	Feb	220.328841	415.200449	1484	241.470718	199.186964
15	Africa	2021	Jan	491.986001	1905.282764	1643	584.181346	399.790656
16	Africa	2021	Jul	732.982349	2411.828071	1643	849.689079	616.275620
17	Africa	2021	Jun	416.520126	1607.801075	1590	495.608523	337.431729
18	Africa	2021	Mar	194.475350	399.609813	1643	213.812199	175.138501
19	Africa	2021	May	171.797322	502.644840	1643	196.119966	147.474678
20	Africa	2021	Nov	114.522642	572.546433	1590	142.686436	86.358847
21	Africa	2021	Oct	117.874011	309.180289	1643	132.835036	102.912986

	continent	year	month	dcases				
				mean	std	size	ci_ub6	ci_lb6
22	Africa	2021	Sep	327.310692	1067.995962	1590	379.845853	274.775531

In [209…
```
statsC20=contcases[(contcases['continent']=='Africa')
  & (contcases['year']==2020)]
statsC20
```

Out[209…

	continent	year	month	dcases				
				mean	std	size	ci_ub6	ci_lb6
0	Africa	2020	Apr	21.675871	47.034430	1521	24.041493	19.310249
1	Africa	2020	Aug	197.329884	704.490346	1643	231.419696	163.240073
2	Africa	2020	Dec	356.315277	1350.848871	1643	421.681940	290.948613
3	Africa	2020	Feb	0.130435	0.344350	23	0.279343	-0.018473
4	Africa	2020	Jul	318.388923	1529.184505	1643	392.385127	244.392718
5	Africa	2020	Jun	162.374843	613.492061	1590	192.552770	132.196916
6	Africa	2020	Mar	7.053988	19.438419	815	8.390511	5.717465
7	Africa	2020	May	66.293072	174.256499	1631	74.756235	57.829909
8	Africa	2020	Nov	244.483019	738.751318	1590	280.822500	208.143537
9	Africa	2020	Oct	184.696896	567.755732	1643	212.170212	157.223580
10	Africa	2020	Sep	144.430189	386.168275	1590	163.425965	125.434412

In [210…
```
statsC20.columns=['continent','year','month','mean','std','size','ci_lb6','ci_ub6']
```

In [211…
```
statsC21.columns=['continent','year','month','mean','std','size','ci_lb6','ci_ub6']
```

In [212…
```
x=statsC20['continent']
x
```

Out[212…
```
0     Africa
1     Africa
2     Africa
3     Africa
4     Africa
5     Africa
6     Africa
7     Africa
8     Africa
9     Africa
10    Africa
Name: continent, dtype: object
```

In [213…

```
y1=statsC20['mean']
y1
```

Out[213…
```
0      21.675871
1     197.329884
2     356.315277
3       0.130435
4     318.388923
5     162.374843
6       7.053988
7      66.293072
8     244.483019
9     184.696896
10    144.430189
Name: mean, dtype: float64
```

In [214…
```
y2=statsC21['mean']
y2
```

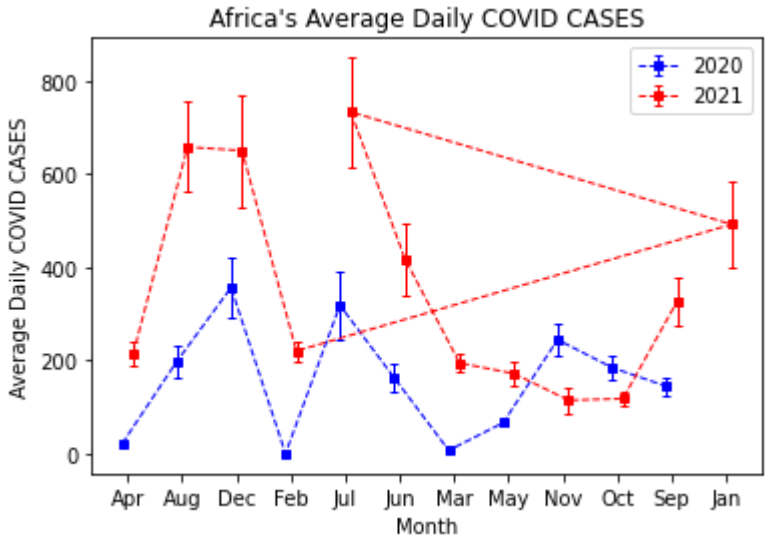
Out[214…
```
11    213.859748
12    657.917225
13    650.332928
14    220.328841
15    491.986001
16    732.982349
17    416.520126
18    194.475350
19    171.797322
20    114.522642
21    117.874011
22    327.310692
Name: mean, dtype: float64
```

In [215…
```
ci_lb_ubC20=[statsC20['ci_lb6'],statsC20['ci_ub6']]
errC20 = np.abs(ci_lb_ubC20 - statsC20['mean'].to_numpy())
```

In [216…
```
ci_lb_ubC21=[statsC21['ci_lb6'],statsC21['ci_ub6']]
errC21 = np.abs(ci_lb_ubC21 - statsC21['mean'].to_numpy())
```

In [217…
```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=errC20, data=statsC20,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=errC21, data=statsC21,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Africa's Average Daily COVID CASES")
plt.show()
```



Africa's average daily cases in 2020 had a different trend than in 2021. In 2020, Africa didn't suffer as much as it did in 2021 in terms of cases. In 2021 the cases reached 600+ whereas the highest number of cases in 2020 was approx 350. This shows that covid struck Africa more violently in 2021 than in 2020. 2021 also had more fluctuation than 2020.

Continent 2: Europe

In [218…

```
statsC221=contcases[(contcases['continent']=='Europe')
  & (contcases['year']==2021)]
statsC221
```

Out[218…

	continent	year	month	dcases				
				mean	std	size	ci_ub6	ci_lb6
59	Europe	2021	Apr	3882.789922	7984.927128	1290	4318.936208	3446.643637
60	Europe	2021	Aug	2896.221305	6796.809360	1333	3261.423109	2531.019501
61	Europe	2021	Dec	10521.554389	23984.334327	1333	11810.265267	9232.843510
62	Europe	2021	Feb	3370.627076	5876.172663	1204	3702.878279	3038.375874
63	Europe	2021	Jan	4974.927982	9883.362427	1333	5505.974477	4443.881487
64	Europe	2021	Jul	2644.664666	7673.031751	1333	3056.947090	2232.382242
65	Europe	2021	Jun	1061.393798	3027.147988	1290	1226.740248	896.047349
66	Europe	2021	Mar	4226.169542	6925.883241	1333	4598.306661	3854.032423
67	Europe	2021	May	1778.587397	3377.861190	1333	1960.084469	1597.090325
68	Europe	2021	Nov	7224.170543	11493.930719	1290	7851.982808	6596.358277
69	Europe	2021	Oct	4167.192798	8245.780023	1333	4610.249765	3724.135831
70	Europe	2021	Sep	2872.321705	6136.287433	1290	3207.493076	2537.150335

In [219…

```
statsC220=contcases[(contcases['continent']=='Europe')
  & (contcases['year']==2020)]
statsC220
```

Out[219…

	continent	year	month	dcases				
				mean	std	size	ci_ub6	ci_lb6
47	Europe	2020	Apr	716.859690	2026.953638	1290	827.574326	606.145054
48	Europe	2020	Aug	574.078770	1526.829653	1333	656.117402	492.040137
49	Europe	2020	Dec	4883.578395	7650.466032	1333	5294.648332	4472.508458
50	Europe	2020	Feb	4.879479	25.101789	307	7.698541	2.060416
51	Europe	2020	Jan	0.894737	0.936586	19	1.346157	0.443317
52	Europe	2020	Jul	342.822206	978.006769	1333	395.371838	290.272573
53	Europe	2020	Jun	350.358915	1227.591513	1290	417.411434	283.306396
54	Europe	2020	Mar	369.486078	1120.091160	1257	431.466215	307.505941
55	Europe	2020	May	451.645911	1513.905248	1333	532.990098	370.301725
56	Europe	2020	Nov	5744.452713	9583.968860	1290	6267.940574	5220.964852
57	Europe	2020	Oct	3655.168792	6861.235403	1333	4023.832295	3286.505289
58	Europe	2020	Sep	1124.893023	2728.262523	1290	1273.913991	975.872056

In [220…
```
statsC220.columns=['continent','year','month','mean','std','size','ci_lb6','ci_ub6']
```

In [221…
```
statsC221.columns=['continent','year','month','mean','std','size','ci_lb6','ci_ub6']
```

In [222…
```
x=statsC220['continent']
x
```

Out[222…
```
47    Europe
48    Europe
49    Europe
50    Europe
51    Europe
52    Europe
53    Europe
54    Europe
55    Europe
56    Europe
57    Europe
58    Europe
Name: continent, dtype: object
```

In [223…
```
y1=statsC220['mean']
y1
```

Out[223…
```
47     716.859690
48     574.078770
49    4883.578395
50       4.879479
51       0.894737
```

```
52     342.822206
53     350.358915
54     369.486078
55     451.645911
56    5744.452713
57    3655.168792
58    1124.893023
Name: mean, dtype: float64
```

In [224…

```
y2=statsC221['mean']
y2
```

Out[224…

```
59     3882.789922
60     2896.221305
61    10521.554389
62     3370.627076
63     4974.927982
64     2644.664666
65     1061.393798
66     4226.169542
67     1778.587397
68     7224.170543
69     4167.192798
70     2872.321705
Name: mean, dtype: float64
```

In [225…

```
ci_lb_ubC220=[statsC220['ci_lb6'],statsC220['ci_ub6']]
errC220 = np.abs(ci_lb_ubC220 - statsC220['mean'].to_numpy())
```

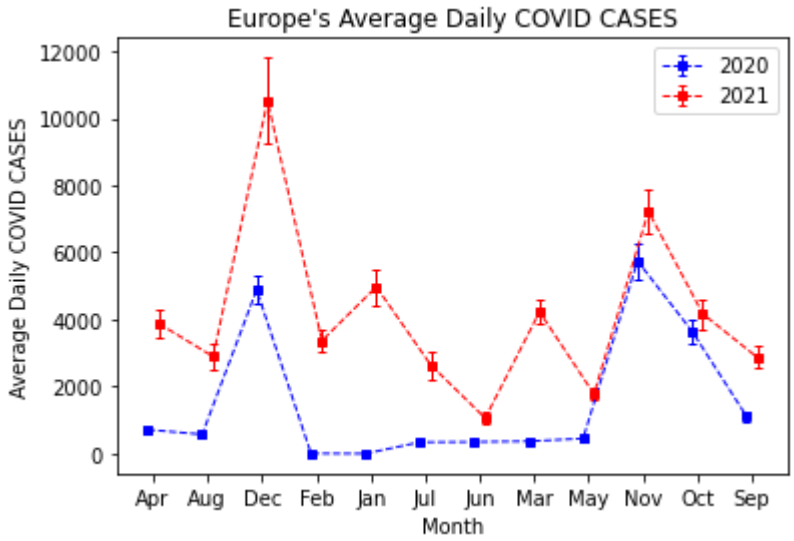
In [226…

```
ci_lb_ubC221=[statsC221['ci_lb6'],statsC221['ci_ub6']]
errC221 = np.abs(ci_lb_ubC221 - statsC221['mean'].to_numpy())
```

In [227…

```
fig, ax = plt.subplots()

trans1 = Affine2D().translate(-0.1, 0.0) + ax.transData
trans2 = Affine2D().translate(+0.1, 0.0) + ax.transData
plt.errorbar('month', 'mean',  yerr=errC220, data=statsC220,marker='s', capsize=2,
             color='blue', markersize=4, linewidth=1, linestyle='--',transform=trans1)
plt.errorbar('month', 'mean',  yerr=errC221, data=statsC221,marker='s', capsize=2,
             color='red', markersize=4, linewidth=1, linestyle='--',transform=trans2)
plt.legend(['2020','2021'])
plt.xlabel("Month")
plt.ylabel("Average Daily COVID CASES")
plt.title("Europe's Average Daily COVID CASES")
plt.show()
```



Europe's Average Daily covid cases had different trends in 2020 and 2021. In 2020, the average was very low in comparison to 2021's numbers until October 2020 where cases started reaching a worrying average. In 2021, the average in January was already higher than the majority of the months' averages. The cases started booming from October 2021 and reached 10,000 daily cases in December.

Discussion and Conclusion

Part 1: Analysis of Covid Cases and reported deaths in Italy based on WEEKDAYS

Closely examining the graphs and numbers obtained, it has been concluded that looking at a virus such as covid-19 in terms of daily cases and identifying the day that has the highest reported cases is not the *optimum* approach. Since covid-19 symptoms take up to more than 10 days to start appearing on a person, maybe someone caught covid on a Monday but showed covid symptoms on a Friday, so his case was reported and reflected on Friday's cases even though he didn't catch covid that day. The graph shows that Monday is the lowest day in terms of reported covid cases, where-as sunday reported the least death cases. It is suggested to examine the cases monthly or daily but not based on weekdays. Weekdays could be a solution for a virus that has symptoms that appear on the same day, but this is not the case for Covid-19.

Part 2: Analysis of Covid cases and reported deaths in Italy in 2020 vs 2021

As seen in the graphs above, Italy suffered in 2021's covid wave more than 2020. Despite that, both years reached the same peak of covid cases per month at approx 30,000 cases. The numbers in the first 2 quarters of 2020 were very low and didn't exceed the 5,000 cases per month, there were even months with 600 cases or fewer. On the other hand, 2021 struck italy more violently and had a fluctuating trend. Approaching summer 2021, the cases sarted to sharply drop to 2020's numbers, however it boomed in December 2021 and reached a very high number of covid cases (30,000). As for Deaths, 2020 also had very minimal deaths in the whole year except for the Peaked month of November. As for 2021, the deaths were greater in quantity, which is expected since the cases were greater than 2020. Surely when the number of cases increase, the deaths will coresspondingly increase.

Part 3: Comparing Europe and Central Asia to Middle East and North Africa covid cases in 2020 vs 2021

Starting with 2020, the middle east generally suffered less than Europe. As for the middle east, the biggest average of cases per month was Approx 1,000 case. However, Europe reached an average of 4,000+ cases per month. Statistically speaking, this is expected since Europe has a more diverse population and people from around the world travel more frequently to Europe than the middle east. As for 2021, the same trend was seen, the middle east had way lower number of cases than Europe. The maximum average of Europe's cases was 8,000 case, and the middle east's max average was 4,000, which is half the number.

Part 4: Comparing income levels with covid-19

Covid 19 struck the poor and the rich countries without discriminating between them. The graphs show no significant differenc between both income levels, which was expected since both income levels are in the "middle" sector. Both income levels' peaks were very close to each other in terms of number of cases, which reassures the conclusion that there is no siginifcant difference in the struggle between income levels. Surely 2021 was worse for both income levels, while 2020 had fewer cases.

Part 5: Comparing between Africa and Europe in terms of Covid Cases in 2020 vs 2021

Generally Speaking, Europe suffered way more than Africa. This is surely the case due to the constant flights that are either returning or departuirng from Europe. Africa has less airplanes hence less travel and contact between different people from different populations. As a result of that, Africa's numbers were between 0-800 cases per month whereas Europe's cases were between 0-12,000 case. The difference is huge and is greatly significant, and expected too. 2021 struck both continents harder than 2020, especially Africa which had fluctuating trend in 2021. As for Europe, the cases peaked in December 2021. On the other hand, Africa peaked in July 2021.

In [ ]: