P4DS (ODL1) Assignment 3

Data Analysis Project

Notebook template design: Brandon Bennett (2020.11.03, revised 2021.03.02)

Analysing the Impact of Covid-19 on European Countries

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Project Plan

The Data (10 marks)

The data used for this project comes from ECDC, the European Agency for Disease Prevention and Control, an official agent of the European Union. There are two datasets that are used as part of this project,the official report of the ECDC daily covid cases/deaths across the EU/EEA area and the vaccination data from the same region. These datasets can be found on the following links: Link 1 Link 2

The dataset for the cases/deaths consists of 13 columns in total excluding the indexes. They are date, day, month, year, country, new cases for that date, new deaths for that date, country code, country geographical code, country population and continent. It is important to note that this dataset contains the data only from the 1st of March 2021 until the 28th of October 2021. Data before March were reported on a weekly basis and are part of a different dataset. By observing the dataset, it becomes apparent that some piece of data do not offer any new information. For example we can identify the day/month/year by looking at the respective columns and as a result the date string is redundant. The same also applies to countries which have 3 different identifiers, while the continent column offers nothing as obviously this dataset concerns european countries only. Later when analysing this data we can trim some of these columns so the dataset becomes smaller and easier to handle with a computer programme.

The dataset for the vaccine data consists of 12 columns in total excluding the indexes. These are the year-week ISO(week of the year identifier), number of first doses administered, number of first doses refused, number of second doses administered, number of unknown doses administered, number of doses supplied to that country, region , country, population, target group, vaccine and denominator. The official and more detailed data dictionary can be found here. At first sight it is clear that the various european countries have a different reporting system. For instance, some countries report by region while some countries don't and just use the country identifier in the region column. It is important to keep that in mind when performing the analysis further down the road.

These datasets are constructed from ECDC using the official reports for covid cases/deaths of member states, so as a result they are the most accurate data available for the EU area. However there are a couple caveats that need to be noted. Firstly, the number of covid cases per country heavily depends on how many covid tests that specific country performs per day. Some countries may not invest heavily in detecting covid so as a result they have lower numbers in new cases. Secondly, since all the data mentioned above describes countries that differ in population significantly, we have to keep in mind that raw numbers offer minimal insight on the covid impact, with percentages and ratios being better descriptors of the situation.

Project Aim and Objectives (5 marks)

The Covid-19 pandemic has had a great impact on everyday life for the past two years. The general aim of this project is to take some very simple daily reported data for each European country, like daily covid cases, deaths and vaccine doses administred, and convert them to more meaningful information that can give a better insight on the situation so far across Europe. In more detail, the following three steps summarise the aim of this project:

1. The fatality rate of the virus is measured for each European country. The fatality rate equals the total number of covid deaths divided by the number of covid cases and is used to described in common terms how deadly the virus is. The fatality rate is a very useful indicator for two reasons. Firstly, the average fatality rate is a good indicator to determine the actual death rate of covid, and secondly it is important to see if the death rate varies significantly between different countries and why.

2. The total cases per 100.000 population are calculated. The official report for each country usually contains the new cases for each day as a simple number. However in order to compare the overall situation between countries and see where covid is more pervalent, it is important to convert those numbers to a ratio per 100.000 population, which allows to compare numbers on equal terms. This ratio is calculated using the following formula:(Events occurance)*100.00/Population. This ratio is afterwards used to classify countries according to covid risk level. Although there is no standard framework to assess risk levels and each authority may use a different model, this project uses a framework developed by the Harvard Global Health Institute and can be found online here.

3. The correlation between vaccine doses administered and deaths from covid is found. A negative correlation is a good indicative that the vaccines do indeed offer strong protection againist death from covid. To calculate the correlation the following mathematical formula is used: $\rho_{X,Y} = \frac{\mathrm{cov}(X,Y)}{\sigma_X \sigma_Y}$, which is the standard method when using the pandas' built-in correlation function.

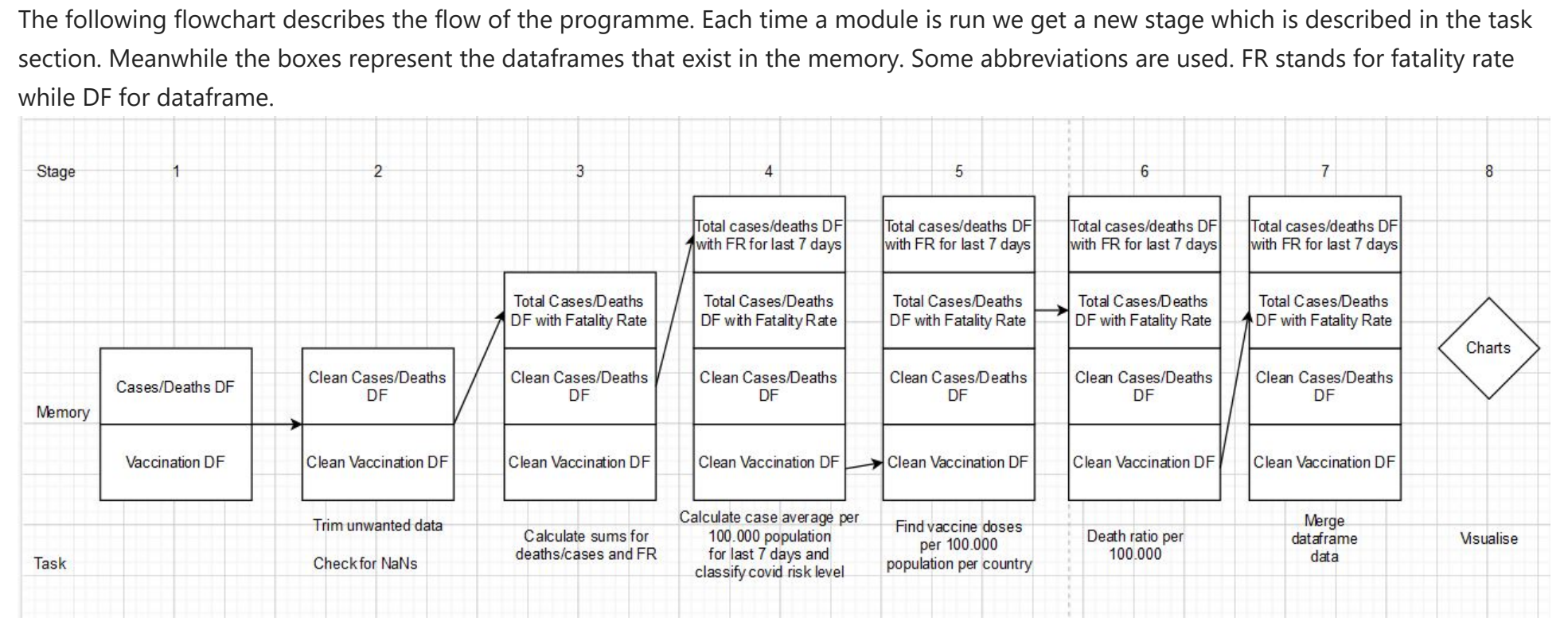
Specific Objective(s)

- **Objective 1:** *Measure the fatality rate of each country.*
- **Objective 2:** *Calculate the case per population ratio and classify countries according to covid risk level.*
- **Objective 3:** *Find the correlation between vaccination and death rates.*

System Design (5 marks)

Architecture

The following flowchart describes the flow of the programme. Each time a module is run we get a new stage which is described in the task section. Meanwhile the boxes represent the dataframes that exist in the memory. Some abbreviations are used. FR stands for fatality rate while DF for dataframe.



Processing Modules and Algorithms

- *Read the data from the online source directly to a pandas dataframe. and trim data parts that are not needed for this project.*
- *Join different datasets based on a common column.*
- *Perform mathematical calculations between data, like fatality rate and cases per 100,000 population.*
- *Visualise data to illustrate the analysis results using graphs and maps.*
- *Run a simple algorithm to classify countries according to covid risk level(check the Harvard Framework linked above).*
- *Find Pearson's Corellation between two columns of a dataframe.*

Program Code (15 marks)

Importing packages and reading the data

In the following code snippet all python packages that are required for this project are imported and the data from the online source is loaded into two pandas' dataframes. The first 5 rows of each dataframe is printed to confirm that the data was successfully read.

In [2]:

```python
import matplotlib.pyplot as plt
import pandas
import numpy as np
import geopandas as gpd

df_cases = pandas.read_csv('https://opendata.ecdc.europa.eu/covid19/nationalcasedeath_eueea_daily_ei/csv', enco
df_vacc = pandas.read_csv('https://opendata.ecdc.europa.eu/covid19/vaccine_tracker/csv/data.csv', encoding='UTF
#Read the csv from the link the ECDC provides into a pandas dataframe.
print(df_cases.head(5))
print(df_vacc.head(5))
#Print the first 5 rows of the dataframe to confirm it was sucessfully read.
```

```
      dateRep  day  month  year  cases  deaths countriesAndTerritories geoId  \
0  29/10/2021   29     10  2021   4232      13                 Austria    AT   
1  28/10/2021   28     10  2021   4407      18                 Austria    AT   
2  27/10/2021   27     10  2021   3388      13                 Austria    AT   
3  26/10/2021   26     10  2021   2765      15                 Austria    AT   
4  25/10/2021   25     10  2021   3655       1                 Austria    AT   

  countryterritoryCode  popData2020 continentExp  
0                  AUT      8901064       Europe  
1                  AUT      8901064       Europe  
2                  AUT      8901064       Europe  
3                  AUT      8901064       Europe  
4                  AUT      8901064       Europe  
  YearWeekISO  FirstDose  FirstDoseRefused  SecondDose  UnknownDose  \
0    2020-W53          0               NaN           0            0   
1    2020-W53          0               NaN           0            0   
2    2020-W53          0               NaN           0            0   
3    2020-W53       5141               NaN           0            0   
4    2020-W53          0               NaN           0            0   

   NumberDosesReceived Region  Population ReportingCountry TargetGroup  \
0                  0.0     AT     8901064               AT         ALL   
1                  0.0     AT     8901064               AT         ALL   
2                  0.0     AT     8901064               AT         ALL   
3              61425.0     AT     8901064               AT         ALL   
4                  0.0     AT     8901064               AT         ALL   

  Vaccine  Denominator  
0     MOD    7358443.0  
1   JANSS    7358443.0  
2     UNK    7358443.0  
3     COM    7358443.0  
4      AZ    7358443.0  
```

Deleting unneccesary information

Since this is not an ongoing project and we know exactly what kind of analysis we want to do beforehand, it is safe to delete some columns that either offer information already given by another column(i.e. country name and country code), or delete columns that give information not needed as part of this project.

In [3]:

```python
del df_cases['continentExp']
del df_cases['dateRep']
#del df_cases['countriesAndTerritories']
del df_cases['countryterritoryCode']
del df_vacc['FirstDoseRefused']
del df_vacc['NumberDosesReceived']
del df_vacc['Region']
del df_vacc['TargetGroup']
del df_vacc['Vaccine']
del df_vacc['Denominator']
del df_vacc['YearWeekISO']
#Delete columns not used at all further down the analysis

print(df_cases.head(5))
print(df_vacc.head(5))
#Check the new format of our dataframes
```

```
   day  month  year  cases  deaths countriesAndTerritories geoId  popData2020
0   29     10  2021   4232      13                 Austria    AT      8901064
1   28     10  2021   4407      18                 Austria    AT      8901064
2   27     10  2021   3388      13                 Austria    AT      8901064
3   26     10  2021   2765      15                 Austria    AT      8901064
4   25     10  2021   3655       1                 Austria    AT      8901064
   FirstDose  SecondDose  UnknownDose  Population ReportingCountry
0          0           0            0     8901064               AT
1          0           0            0     8901064               AT
2          0           0            0     8901064               AT
3       5141           0            0     8901064               AT
4          0           0            0     8901064               AT
```

A note on deleting columns

In general it is not advisable to delete information from our data. Although they may not be needed currently, the scope of the analysis may change in the future. However in this instance, where the project will not be an ongoing system, some columns were deleted to make the debugging part easier and faster, plus make the different outputs of the programme more compact.

Check for NaNs

Now that we have removed unused columns from our dataframes, we should perform one last step before starting the actual analysis, which is to check the entire dataframes for any NaN values.

In [4]:

```python
df_cases.isnull().values.any()
df_vacc.isnull().values.any()
```

Out[4]:

```
False
```

The above function returned false, which means that no NaN values were found. We now know that there are no missing/placeholder data.

Objective 1: Calculate the fatality rate

To get the fatality rate for each country, first the total amount of deaths and cases have to be calculated. Afterwards this info is passed to another dataframe where the fatality rate is calculated as a new column. The new dataframe is going to be much smaller so it is more efficient to calculate the rate at the new dataframe and avoid redundant calculations.

In [5]:

```python
df_cases['sumcases'] = df_cases['cases'].groupby(df_cases['geoId']).transform('sum')
#Find the sum of column named 'cases' by 'geoId' and add it to a new column name 'sumcases'
df_cases['sumdeaths'] = df_cases['deaths'].groupby(df_cases['geoId']).transform('sum')
#Similar with above

df_total=df_cases.drop_duplicates(subset = ["geoId"]).copy()
#Sum is the same for all rows of each country, so drop duplicates

df_total['fatalityrate%'] = (100* df_total['sumdeaths']/df_total['sumcases'])
#Find fatality rate in percentage form
del df_total['day']
del df_total['month']
del df_total['year']
del df_total['cases']
del df_total['deaths']
#Since we dropped duplicates the columns deleted above make no sense in the new dataframe
print(df_total.head(5))
# Print 5 rows to check
```

```
    countriesAndTerritories geoId  popData2020  sumcases  sumdeaths  \
0                   Austria    AT      8901064    810157      11055   
243                 Belgium    BE     11522440   1351818      25976   
486                Bulgaria    BG      6951482    592943      23718   
729                 Croatia    HR      4058165    458090       9142   
972                  Cyprus    CY       888005    124017        571   

     fatalityrate%  
0         1.364550  
243       1.921560  
486       4.000047  
729       1.995678  
972       0.460421  
```

Objective 2a: Calculate cases per 100,000 population

To calculate the cases per 100,000 population, first the seven-day average for new case has to be found according to the latest date. As a result only the rows that contain the final 7 days of the data are kept and the rest are deleted. Afterwards the sum of cases and deaths is calculated like in objective 1, but now accounting only for 7 days of the reported data. The end result of the objective is inserted into the casespercapita column.

In [6]:

```python
df_7day=df_cases.copy()
df_7day=df_7day.loc[(df_7day['day'] >= 22) & (df_7day['month'] == 10)]
#Dataset used is from 28th so last 7 days are 28,27,26,25,24,23,22
df_7day['sumcases'] = df_7day['cases'].groupby(df_7day['geoId']).transform('sum')
#sum of cases for last 7 days
df_7day['sevenavg'] = df_7day['sumcases']/7
#divide by 7 to get average
df_7day=df_7day.drop_duplicates(subset = ["geoId"])
#drop duplicates since all rows contain the same average per geoId
#df_7day.drop(df_7day.columns[[0,1,2,3,4,7,8]], axis = 1, inplace = True)
#delete columns by position that were copied from df_cases and make no sense with no duplicates
df_7day['casespercapita']=df_7day['sevenavg']*100000/df_7day['popData2020']
#calculate case per capita
print(df_7day.head(5))
```

```
     day  month  year  cases  deaths countriesAndTerritories geoId  \
0     29     10  2021   4232      13                 Austria    AT   
243   29     10  2021      0       0                 Belgium    BE   
486   29     10  2021   5178     124                Bulgaria    BG   
729   29     10  2021   4154      26                 Croatia    HR   
972   29     10  2021    109       0                  Cyprus    CY   

     popData2020  sumcases  sumdeaths     sevenavg  casespercapita  
0        8901064     29546      11055  4220.857143       47.419692  
243     11522440     35599      25976  5085.571429       44.136237  
486      6951482     37866      23718  5409.428571       77.816911  
729      4058165     24954       9142  3564.857143       87.844066  
972       888005      1165        571   166.428571       18.741851  
```

Objective 2b: Classify countries according to covid risk level

At this step the dataframe is iterated and each row is assigned a value according to the framework used. This value is stored in the new risklevel column.

In [7]:

```python
df_7day['risklevel']=''
#add new empty column
for i, row in df_7day.iterrows():
    if  df_7day.loc[i,'casespercapita'] >25:
        df_7day.loc[i,'risklevel'] = 'red'
    elif df_7day.loc[i,'casespercapita'] >10:
        df_7day.loc[i,'risklevel'] = 'orange'
    elif df_7day.loc[i,'casespercapita'] >1:
        df_7day.loc[i,'risklevel'] = 'yellow'
    else:
        df_7day.loc[i,'risklevel'] = 'green'
#iterate columns and add colour according to Harvard framework
print(df_7day)
```

```
      day  month  year  cases  deaths countriesAndTerritories geoId  \
0      29     10  2021   4232      13                 Austria    AT   
243    29     10  2021      0       0                 Belgium    BE   
486    29     10  2021   5178     124                Bulgaria    BG   
729    29     10  2021   4154      26                 Croatia    HR   
972    29     10  2021    109       0                  Cyprus    CY   
1215   29     10  2021   4385      16                 Czechia    CZ   
1458   29     10  2021   1847       1                 Denmark    DK   
1701   29     10  2021   1679      11                 Estonia    EE   
1944   29     10  2021    673       4                 Finland    FI   
2187   29     10  2021   6461      33                  France    FR   
2430   29     10  2021  24668     121                 Germany    DE   
2673   29     10  2021   2957      31                  Greece    EL   
2916   29     10  2021   4041      37                 Hungary    HU   
3159   29     10  2021    100       0                 Iceland    IS   
3402   29     10  2021   2598       0                 Ireland    IE   
3645   29     10  2021   4863      50                   Italy    IT   
3888   29     10  2021   2919      64                  Latvia    LV   
4131   29     10  2021      6       0           Liechtenstein    LI   
4374   29     10  2021   3519      34               Lithuania    LT   
4617   29     10  2021    138       0              Luxembourg    LU   
4860   29     10  2021     15       0                   Malta    MT   
5103   29     10  2021   7683      14             Netherlands    NL   
5346   29     10  2021   1193       0                  Norway    NO   
5589   29     10  2021   8382     101                  Poland    PL   
5832   29     10  2021    888       5                Portugal    PT   
6075   29     10  2021  13197     415                 Romania    RO   
6318   29     10  2021      0       0                Slovakia    SK   
6561   29     10  2021   2477       2                Slovenia    SI   
6804   28     10  2021   2212      33                   Spain    ES   
7047   29     10  2021      0       0                  Sweden    SE   

      popData2020  sumcases  sumdeaths      sevenavg  casespercapita risklevel  
0         8901064     29546      11055   4220.857143       47.419692       red  
243      11522440     35599      25976   5085.571429       44.136237       red  
486       6951482     37866      23718   5409.428571       77.816911       red  
729       4058165     24954       9142   3564.857143       87.844066       red  
972        888005      1165        571    166.428571       18.741851    orange  
1215     10693939     33278      30705   4754.000000       44.455088       red  
1458      5822763     11510       2709   1644.285714       28.238926       red  
1701      1328976     12914       1502   1844.857143      138.817943       red  
1944      5525292      4860       1154    694.285714       12.565593    orange  
2187     67320216     44676     117622   6382.285714        9.480489    yellow  
2430     83166711    141412      95606  20201.714286       24.290625    orange  
2673     10718565     26956      15801   3850.857143       35.926984       red  
2916      9769526     22142      30729   3163.142857       32.377649       red  
3159       364134       638         33     91.142857       25.030032       red  
3402      4964440     16890       5436   2412.857143       48.602806       red  
3645     59641488     31344     132004   4477.714286        7.507717    yellow  
3888      1907675     20381       3173   2911.571429      152.624081       red  
4131        38747        44         61      6.285714       16.222454    orange  
4374      2794090     23613       5800   3373.285714      120.729315       red  
4617       626108      1170        843    167.142857       26.695531       red  
4860       514564       104        460     14.857143        2.887327    yellow  
5103     17407585     49090      18371   7012.857143       40.286215       red  
5346      5367580      6243        900    891.857143       16.615628    orange  
5589     37958138     48275      76773   6896.428571       18.168511    orange  
5832     10295909      6277      18149    896.714286        8.709423    yellow  
6075     19328838    112605      46430  16086.428571       83.225016       red  
6318      5457873     31066      12977   4438.000000       81.313728       red  
6561      2095861     17044       5050   2434.857143      116.174553       red  
6804     47332614     13711      87322   1958.714286        4.138192    yellow  
7047     10327589      4424      15018    632.000000        6.119531    yellow  
```

Objective 3a: Find vaccine doses per 100.000 population per country

Similar to previous scenarios, we have to find the sum of the vaccine dosages administered by each country. The only difference here is that we have to sum 3 different columns, for the 1st,2nd and unknown dosages.

In [8]:

```python
target_columns = ['FirstDose', 'SecondDose', 'UnknownDose']
#mark columns to be summed
df_vacc['AllDose']= df_vacc[target_columns].sum(axis=1)
#sum per row for now
df_vacc['SumDoses'] = df_vacc['AllDose'].groupby(df_vacc['ReportingCountry']).transform('sum')
#sum new made column AllDose into SumDoses
df_vacc=df_vacc.drop_duplicates(subset = ["ReportingCountry"])
#drop duplicates
df_vacc['dosepercapita']= df_vacc['SumDoses']*100000/df_vacc['Population']
df_vacc.drop(df_vacc.columns[[0,2,1,5]], axis = 1, inplace = True)
print(df_vacc.head(5))
```

```
      Population ReportingCountry  SumDoses  dosepercapita
0        8901064               AT  22276142  250263.811158
2640    11522440               BE  33618910  291769.017673
4326     6951482               BG   5611540   80724.369278
5932      888005               CY   2383203  268377.205083
7382    10693939               CZ  24952081  233329.187683
```

Objective 3b: Find covid deaths per 100.000 population per country

Similar to previous scenarios, we have to find the sum of the vaccine dosages administered by each country. The only difference here is that we have to sum 3 different columns, for the 1st,2nd and unknown dosages.

In [9]:

```python
df_total['deathspercapita']= df_total['sumdeaths']*100000/df_total['popData2020']
#df_vacc.drop(df_vacc.columns[[0,2,1,4,5,3,9,10,11,6,7,12]], axis = 1, inplace = True)
print(df_total)
```

```
     countriesAndTerritories geoId  popData2020  sumcases  sumdeaths  \
0                    Austria    AT      8901064    810157      11055   
243                  Belgium    BE     11522440   1351818      25976   
486                 Bulgaria    BG      6951482    592943      23718   
729                  Croatia    HR      4058165    458090       9142   
972                   Cyprus    CY       888005    124017        571   
1215                 Czechia    CZ     10693939   1752086      30705   
1458                 Denmark    DK      5822763    382796       2709   
1701                 Estonia    EE      1328976    190201       1502   
1944                 Finland    FI      5525292    156959       1154   
2187                  France    FR     67320216   7146755     117622   
2430                 Germany    DE     83166711   4559120      95606   
2673                  Greece    EL     10718565    731167      15801   
2916                 Hungary    HU      9769526    863419      30729   
3159                 Iceland    IS       364134     13413         33   
3402                 Ireland    IE      4964440    438124       5436   
3645                   Italy    IT     59641488   4757231     132004   
3888                  Latvia    LV      1907675    211702       3173   
4131           Liechtenstein    LI        38747      3557         61   
4374               Lithuania    LT      2794090    403051       5800   
4617              Luxembourg    LU       626108     81501        843   
4860                   Malta    MT       514564     37612        460   
5103             Netherlands    NL     17407585   2108549      18371   
5346                  Norway    NO      5367580    203742        900   
5589                  Poland    PL     37958138   2998891      76773   
5832                Portugal    PT     10295909   1088133      18149   
6075                 Romania    RO     19328838   1616027      46430   
6318                Slovakia    SK      5457873    880635      12977   
6561                Slovenia    SI      2095861    331206       5050   
6804                   Spain    ES     47332614   5008887      87322   
7047                  Sweden    SE     10327589   1170422      15018   

      fatalityrate%  deathspercapita  
0          1.364550       124.198635  
243        1.921560       225.438362  
486        4.000047       341.193432  
729        1.995678       225.274231  
972        0.460421        64.301440  
1215       1.752482       287.125259  
1458       0.707688        46.524305  
1701       0.789691       113.019347  
1944       0.735224        20.885774  
2187       1.645810       174.720176  
2430       2.097027       114.957053  
2673       2.161066       147.417122  
2916       3.558990       314.539313  
3159       0.246030         9.062598  
3402       1.240745       109.498755  
3645       2.774807       221.329153  
3888       1.498805       166.328122  
4131       1.714928       157.431543  
4374       1.439024       207.581001  
4617       1.034343       134.641308  
4860       1.223014        89.396071  
5103       0.871263       105.534455  
5346       0.441735        16.767333  
5589       2.560046       202.257023  
5832       1.667903       176.273897  
6075       2.873096       240.211026  
6318       1.473596       237.766617  
6561       1.524731       240.951094  
6804       1.743341       184.485902  
7047       1.283127       145.416321  
```

Objective 3c: Combining data from different datasets

We have calculated the deaths and doses administered per 100,000 population for each country. Before we calculate the corellation between the two though, it is essential to match each value from one dataset to the other.

In [10]:

```python
df_total['dosepercapita'] = df_total.geoId.map(df_vacc.set_index('ReportingCountry')['dosepercapita'])
#map the dosepercapita from df_vacc to df_total according to geoId=ReportingCountry
print(df_total)
```

```
     countriesAndTerritories geoId  popData2020  sumcases  sumdeaths  \
0                    Austria    AT      8901064    810157      11055   
243                  Belgium    BE     11522440   1351818      25976   
486                 Bulgaria    BG      6951482    592943      23718   
729                  Croatia    HR      4058165    458090       9142   
972                   Cyprus    CY       888005    124017        571   
1215                 Czechia    CZ     10693939   1752086      30705   
1458                 Denmark    DK      5822763    382796       2709   
1701                 Estonia    EE      1328976    190201       1502   
1944                 Finland    FI      5525292    156959       1154   
2187                  France    FR     67320216   7146755     117622   
2430                 Germany    DE     83166711   4559120      95606   
2673                  Greece    EL     10718565    731167      15801   
2916                 Hungary    HU      9769526    863419      30729   
3159                 Iceland    IS       364134     13413         33   
3402                 Ireland    IE      4964440    438124       5436   
3645                   Italy    IT     59641488   4757231     132004   
3888                  Latvia    LV      1907675    211702       3173   
4131           Liechtenstein    LI        38747      3557         61   
4374               Lithuania    LT      2794090    403051       5800   
4617              Luxembourg    LU       626108     81501        843   
4860                   Malta    MT       514564     37612        460   
5103             Netherlands    NL     17407585   2108549      18371   
5346                  Norway    NO      5367580    203742        900   
5589                  Poland    PL     37958138   2998891      76773   
5832                Portugal    PT     10295909   1088133      18149   
6075                 Romania    RO     19328838   1616027      46430   
6318                Slovakia    SK      5457873    880635      12977   
6561                Slovenia    SI      2095861    331206       5050   
6804                   Spain    ES     47332614   5008887      87322   
7047                  Sweden    SE     10327589   1170422      15018   

      fatalityrate%  deathspercapita  dosepercapita  
0          1.364550       124.198635  250263.811158  
243        1.921560       225.438362  291769.017673  
486        4.000047       341.193432   80724.369278  
729        1.995678       225.274231  177911.124856  
972        0.460421        64.301440  268377.205083  
1215       1.752482       287.125259  233329.187683  
1458       0.707688        46.524305  304923.968226  
1701       0.789691       113.019347  218102.132770  
1944       0.735224        20.885774  581989.150981  
2187       1.645810       174.720176  548571.700958  
2430       2.097027       114.957053  131397.543183  
2673       2.161066       147.417122  353843.420271  
2916       3.558990       314.539313  233692.770765  
3159       0.246030         9.062598  285275.200888  
3402       1.240745       109.498755  310421.356689  
3645       2.774807       221.329153  432716.747443  
3888       1.498805       166.328122  194185.277891  
4131       1.714928       157.431543  118798.874752  
4374       1.439024       207.581001  353897.691198  
4617       1.034343       134.641308  250164.348643  
4860       1.223014        89.396071  311723.323046  
5103       0.871263       105.534455  130134.587882  
5346       0.441735        16.767333  299093.353057  
5589       2.560046       202.257023  408513.963462  
5832       1.667903       176.273897  462763.530641  
6075       2.873096       240.211026  176438.568113  
6318       1.473596       237.766617  173164.124559  
6561       1.524731       240.951094  205376.501591  
6804       1.743341       184.485902  310052.601363  
7047       1.283127       145.416321  403665.773299  
```

Objective 3d: Find corellation between vaccine rate and death rate

We have calculated the deaths and doses administered per 100,000 population for each country. Before we calculate the corellation between the two though, it is essential to match each value from one dataset to the other.

In [11]:

```python
g=df_total['deathspercapita'].corr(df_total['dosepercapita'])
print(g)
```

```
-0.2855131011220151
```

Project Outcome (10 + 10 marks)

Overview of Results

By now we have run all code modules and seen the output of each one. A brief observation of the data is enough to see that there is a negative correlation between death and vaccination rates in EU as a whole. Moreover the data from the last 7 days show that currently there is no single country in the EU where the virus is contained(green colour), with them majority of them being in red state, meaning that regardless of death rates covid is rapidly spreading. Finally there seems to be a big variation between the fatality rates for each country. Let's see however each objective set at the beginning of the project separately and provide some visualisations.

Objective 1: Fatality rate of each country

Explanation of Results

The following bar chart gives a representation of the distribution of fatality rates for each European country. Bulgaria, Romania and Hungary seem to lead the "race" in fatality rates whilst Cyprus, Norway and Iceland come last. It is apparent even at a first glance that there is a significant variance among european countries. For instance Bulgaria, has a circa 4% fatality rate which is nearly 8 times greater than that of Cyprus. The code snippet underneath the bar chart calculates the coefficient variation(CV) for the fatality rates percentage. As a general rule of thumb a CV>1 is considered to be high which is also the case here. This variance could be the result of low vaccination rates in some countries or different strategies in treating it that proved less effective.

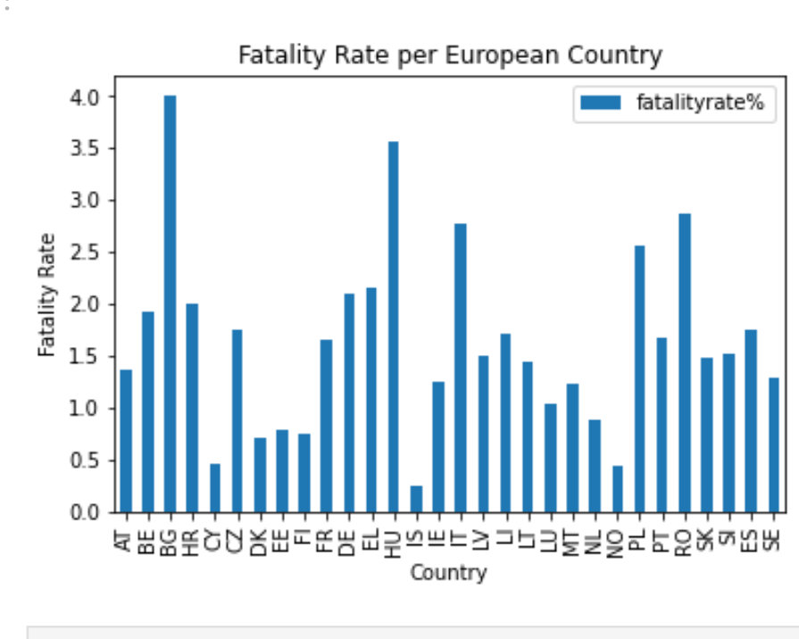
Visualisation

In [12]:

```python
df_total.plot(kind='bar',x='geoId',y='fatalityrate%',xlabel='Country',ylabel='Fatality Rate', title='Fatality
```

Out[12]:

```
<AxesSubplot:title={'center':'Fatality Rate per European Country'}, xlabel='Country', ylabel='Fatality Rate'>
```



In [13]:

```python
cv = lambda x: np.std(x, ddof=1) / np.mean(x) * 100
cv(df_total['fatalityrate%'])
```

Out[13]:

```
54.02157919615409
```

Objective 2: Covid Risk Classification

Explanation of Results

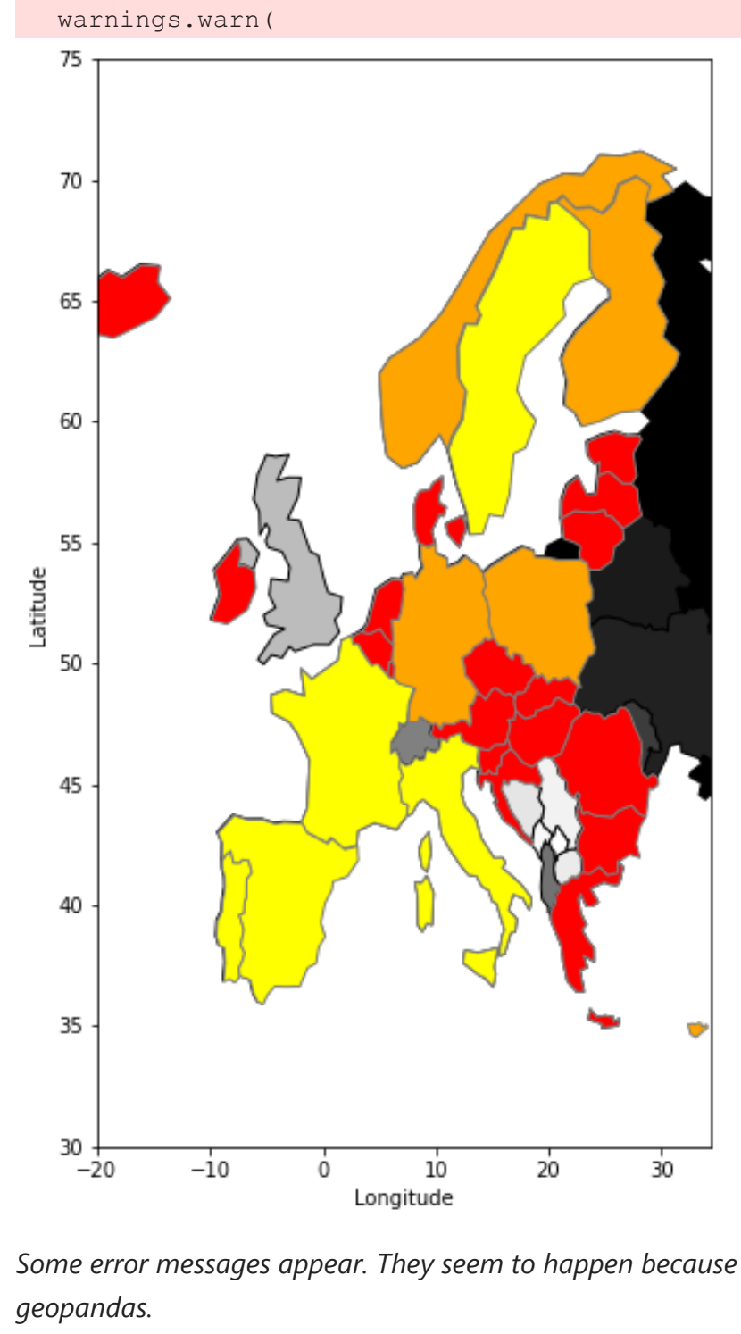
According to the framework used for covid risk classification, a country contains the virus if it is labeled as green, whilst yellow, orange and red mean that the virus is spreading. The output of the objective 2 code snippet showed that zero countries fell in the green area. This is confirmed by the visualisation shown below. A map was of Europe was drawn using geopandas. The countries are coloured according to their risk level. Countries in gray/black are not part of the data. It is clear that all of Europe is in high covid risk currently. This is a sign that despite efforts made and the vaccine programme rollout the pandemic is still not under control and further preventive measures may be required in the future.

Visualisation

In [14]:

```python
world = gpd.read_file(gpd.datasets.get_path('naturalearth_lowres'))

# or plot Africa continent

ax2 = world[world.continent == 'Europe'].plot(figsize=(10,10), edgecolor=u'black', cmap='gray')
t_array = df_7day[['countriesAndTerritories','risklevel']].to_numpy()
ax2.set_ylim([30, 75])
ax2.set_xlim([-20, 34.4])

for row in t_array:
    val1 = row[0]
    val2 = row[1]
    if  val2 =='red':
        world[world.name == val1].plot(edgecolor=u'gray', color='red', ax=ax2)
    elif val2=='orange':
        world[world.name == val1].plot(edgecolor=u'gray', color='orange', ax=ax2)
    elif val2=='yellow':
        world[world.name == val1].plot(edgecolor=u'gray', color='yellow', ax=ax2)
    else:
        world[world.name == val1].plot(edgecolor=u'gray', color='green', ax=ax2)

# the place to plot additional vector data (points, lines)

plt.ylabel('Latitude')
plt.xlabel('Longitude')

plt.show()
```

```
C:\Users\Loukas\anaconda3\envs\my_env\lib\site-packages\geopandas\plotting.py:678: UserWarning: The GeoDataFram
e you attempting to plot is empty. Nothing has been displayed.
  warnings.warn(
C:\Users\Loukas\anaconda3\envs\my_env\lib\site-packages\geopandas\plotting.py:678: UserWarning: The GeoDataFram
e you attempting to plot is empty. Nothing has been displayed.
  warnings.warn(
```



Some error messages appear. They seem to happen because the border/map for countries is downloaded from external source due to geopandas.

Objective 3: Correlation between death and vaccination rates

Explanation of Results

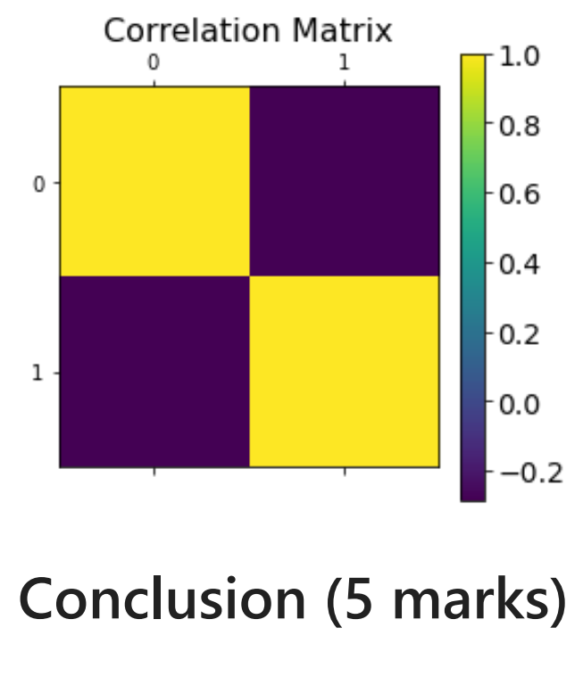
The correlation matrix underneath shows that there is a negative correlation between the values of deathspercapita and dosepercapita. It is expected that vaccines decrease death rate and this is proof that they work. However from this scope we examine the correlation only between vaccine and death rate. In a more realistic scenario it is possible that more variables affect the final outcome.

Visualisation

In [18]:

```python
new = df_total[['deathspercapita', 'dosepercapita']].copy()
f = plt.figure(figsize=(15, 15))
plt.matshow(new.corr(), fignum=3)

cb = plt.colorbar(fraction=0.1)
cb.ax.tick_params(labelsize=14)
plt.title('Correlation Matrix', fontsize=16);
```

```
<Figure size 1080x1080 with 0 Axes>
```



Conclusion (5 marks)

Achievements

As expected, all the signs point towards the vaccines being a very effective solution at preventing death from covid. There is a significant negative corellation between death and vaccine rates from data collected from the ECDC. On the other hand, most european countries as of 28th of October 2021, are on high risk covid levels. Despite the vaccines, people and the authorities must remain alert for what the future comes.

Limitations

This project was done in a limited timeframe and as a result, some less important details were omitted. As can be seen in the vaccine dataset, more than 5 different vaccines are administered. It is expected that not all vaccines are equally effective, but analysing each vaccine individually would be time consuming. Moreover, daily data from before March 2021 are not available. As a result the deaths per 100,000 population ratio is not totally accurate. It is possible that vaccines would prove to be even more effective if death data for a longer time period were to be used.

Future Work

Graphs from this project show that there is some variance among the fatality rates of different european countries. Although the variance among vaccine rates is definitely a big factor for this, it is possible that there are other factors as well. For example, different protocols and strategies followed when preventing or treating covid may prove to be more or less effective. The answer is definitely in the data available and it would be interesting to explore possible links in a future project.