owid

May 8, 2025

```
[ ]: # Data Loading & Exploration
```

```
[6]: import pandas as pd

     data = pd.read_csv ('owid-covid-data.csv')

     data.columns
```

```
[6]: Index(['iso_code', 'continent', 'location', 'date', 'total_cases', 'new_cases',
            'new_cases_smoothed', 'total_deaths', 'new_deaths',
            'new_deaths_smoothed', 'total_cases_per_million',
            'new_cases_per_million', 'new_cases_smoothed_per_million',
            'total_deaths_per_million', 'new_deaths_per_million',
            'new_deaths_smoothed_per_million', 'reproduction_rate', 'icu_patients',
            'icu_patients_per_million', 'hosp_patients',
            'hosp_patients_per_million', 'weekly_icu_admissions',
            'weekly_icu_admissions_per_million', 'weekly_hosp_admissions',
            'weekly_hosp_admissions_per_million', 'new_tests', 'total_tests',
            'total_tests_per_thousand', 'new_tests_per_thousand',
            'new_tests_smoothed', 'new_tests_smoothed_per_thousand',
            'positive_rate', 'tests_per_case', 'tests_units', 'total_vaccinations',
            'people_vaccinated', 'people_fully_vaccinated', 'total_boosters',
            'new_vaccinations', 'new_vaccinations_smoothed',
            'total_vaccinations_per_hundred', 'people_vaccinated_per_hundred',
            'people_fully_vaccinated_per_hundred', 'total_boosters_per_hundred',
            'new_vaccinations_smoothed_per_million',
            'new_people_vaccinated_smoothed',
            'new_people_vaccinated_smoothed_per_hundred', 'stringency_index',
            'population', 'population_density', 'median_age', 'aged_65_older',
            'aged_70_older', 'gdp_per_capita', 'extreme_poverty',
            'cardiovasc_death_rate', 'diabetes_prevalence', 'female_smokers',
            'male_smokers', 'handwashing_facilities', 'hospital_beds_per_thousand',
            'life_expectancy', 'human_development_index',
            'excess_mortality_cumulative_absolute', 'excess_mortality_cumulative',
            'excess_mortality', 'excess_mortality_cumulative_per_million'],
           dtype='object')
```

[7]:

```
data.head()
```

[7]:

```
  iso_code continent     location        date  total_cases  new_cases  \
0      AFG      Asia  Afghanistan  2020-02-24          5.0        5.0
1      AFG      Asia  Afghanistan  2020-02-25          5.0        0.0
2      AFG      Asia  Afghanistan  2020-02-26          5.0        0.0
3      AFG      Asia  Afghanistan  2020-02-27          5.0        0.0
4      AFG      Asia  Afghanistan  2020-02-28          5.0        0.0

   new_cases_smoothed  total_deaths  new_deaths  new_deaths_smoothed  ...  \
0                 NaN           NaN         NaN                  NaN  ...
1                 NaN           NaN         NaN                  NaN  ...
2                 NaN           NaN         NaN                  NaN  ...
3                 NaN           NaN         NaN                  NaN  ...
4                 NaN           NaN         NaN                  NaN  ...

   female_smokers  male_smokers  handwashing_facilities  \
0             NaN           NaN                  37.746
1             NaN           NaN                  37.746
2             NaN           NaN                  37.746
3             NaN           NaN                  37.746
4             NaN           NaN                  37.746

   hospital_beds_per_thousand  life_expectancy  human_development_index  \
0                         0.5            64.83                    0.511
1                         0.5            64.83                    0.511
2                         0.5            64.83                    0.511
3                         0.5            64.83                    0.511
4                         0.5            64.83                    0.511

   excess_mortality_cumulative_absolute  excess_mortality_cumulative  \
0                                   NaN                          NaN
1                                   NaN                          NaN
2                                   NaN                          NaN
3                                   NaN                          NaN
4                                   NaN                          NaN

   excess_mortality  excess_mortality_cumulative_per_million
0               NaN                                      NaN
1               NaN                                      NaN
2               NaN                                      NaN
3               NaN                                      NaN
4               NaN                                      NaN

[5 rows x 67 columns]
```

[8]:

```
data.isnull().sum().sort_values(ascending=False)
```

[8]:
```
weekly_icu_admissions_per_million          160893
weekly_icu_admissions                      160893
excess_mortality_cumulative_per_million    160630
excess_mortality                           160630
excess_mortality_cumulative                160630
                                            …
total_cases                                  3033
population                                   1075
date                                            0
location                                        0
iso_code                                        0
Length: 67, dtype: int64
```

[9]:
```python
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 166326 entries, 0 to 166325
Data columns (total 67 columns):
 #   Column                                      Non-Null Count   Dtype
---  ------                                      --------------   -----
 0   iso_code                                    166326 non-null  object
 1   continent                                   156370 non-null  object
 2   location                                    166326 non-null  object
 3   date                                        166326 non-null  object
 4   total_cases                                 163293 non-null  float64
 5   new_cases                                   163133 non-null  float64
 6   new_cases_smoothed                          161150 non-null  float64
 7   total_deaths                                145451 non-null  float64
 8   new_deaths                                  145487 non-null  float64
 9   new_deaths_smoothed                         143390 non-null  float64
 10  total_cases_per_million                     162535 non-null  float64
 11  new_cases_per_million                       162375 non-null  float64
 12  new_cases_smoothed_per_million              160398 non-null  float64
 13  total_deaths_per_million                    144706 non-null  float64
 14  new_deaths_per_million                      144742 non-null  float64
 15  new_deaths_smoothed_per_million             142651 non-null  float64
 16  reproduction_rate                           125820 non-null  float64
 17  icu_patients                                23463 non-null   float64
 18  icu_patients_per_million                    23463 non-null   float64
 19  hosp_patients                               24617 non-null   float64
 20  hosp_patients_per_million                   24617 non-null   float64
 21  weekly_icu_admissions                       5433 non-null    float64
 22  weekly_icu_admissions_per_million           5433 non-null    float64
 23  weekly_hosp_admissions                      10923 non-null   float64
 24  weekly_hosp_admissions_per_million          10923 non-null   float64
 25  new_tests                                   67317 non-null   float64
 26  total_tests                                 69255 non-null   float64
 27  total_tests_per_thousand                   69255 non-null   float64
 28  new_tests_per_thousand                     67317 non-null   float64
 29  new_tests_smoothed                         84035 non-null   float64
 30  new_tests_smoothed_per_thousand            84035 non-null   float64
 31  positive_rate                              78655 non-null   float64
 32  tests_per_case                             78084 non-null   float64
 33  tests_units                                86386 non-null   object
 34  total_vaccinations                         45194 non-null   float64
 35  people_vaccinated                          42987 non-null   float64
 36  people_fully_vaccinated                    40241 non-null   float64
 37  total_boosters                             17539 non-null   float64
 38  new_vaccinations                           37447 non-null   float64
 39  new_vaccinations_smoothed                  84398 non-null   float64
 40  total_vaccinations_per_hundred             45194 non-null   float64
 41  people_vaccinated_per_hundred              42987 non-null   float64
 42  people_fully_vaccinated_per_hundred        40241 non-null   float64
 43  total_boosters_per_hundred                 17539 non-null   float64
 44  new_vaccinations_smoothed_per_million      84398 non-null   float64
 45  new_people_vaccinated_smoothed             83088 non-null   float64
 46  new_people_vaccinated_smoothed_per_hundred 83088 non-null   float64
 47  stringency_index                           130072 non-null  float64
 48  population                                 165251 non-null  float64
 49  population_density                         147928 non-null  float64
 50  median_age                                 137831 non-null  float64
 51  aged_65_older                              136337 non-null  float64
 52  aged_70_older                              137092 non-null  float64
 53  gdp_per_capita                             138504 non-null  float64
 54  extreme_poverty                            91215 non-null   float64
 55  cardiovasc_death_rate                      136778 non-null  float64
 56  diabetes_prevalence                        143949 non-null  float64
 57  female_smokers                             106050 non-null  float64
 58  male_smokers                               104595 non-null  float64
 59  handwashing_facilities                     68569 non-null   float64
 60  hospital_beds_per_thousand                 123664 non-null  float64
 61  life_expectancy                            155268 non-null  float64
 62  human_development_index                    136253 non-null  float64
 63  excess_mortality_cumulative_absolute       5696 non-null    float64
 64  excess_mortality_cumulative                5696 non-null    float64
 65  excess_mortality                           5696 non-null    float64
 66  excess_mortality_cumulative_per_million    5696 non-null    float64
dtypes: float64(62), object(5)
memory usage: 85.0+ MB
```

[ ]:

```
# Data Cleaning
```

[12]:

```
countries = ['Kenya', 'Rwanda', 'Uganda', 'South Africa', 'Nigeria', 'United␣
 ↪States', 'India']
```

```
covid_df = data[data['location'].isin(countries)]
```

[13]:

```
columns_to_keep = [
    'iso_code', 'continent', 'location', 'date',
    'total_cases', 'new_cases',
    'total_deaths', 'new_deaths',
    'total_vaccinations', 'people_vaccinated', 'people_fully_vaccinated',
    'population'
]

# Create a new DataFrame with only those
covid_df = data[columns_to_keep]
```

[20]:

```
covid_df.loc[:, 'date'] = pd.to_datetime(covid_df['date'])
```

[16]:

```
covid_df.isnull().sum().sort_values(ascending=False)
```

[16]:

```
people_fully_vaccinated    126085
people_vaccinated          123339
total_vaccinations         121132
total_deaths                20875
new_deaths                  20839
continent                    9956
new_cases                    3193
total_cases                  3033
population                   1075
iso_code                        0
location                        0
date                            0
dtype: int64
```

[18]:

```
# Drop rows with missing key values
covid_df = covid_df.dropna(subset=['date', 'total_cases', 'total_deaths'])

# Sort and forward-fill missing values per country
covid_df = covid_df.sort_values(['location', 'date'])
covid_df = covid_df.fillna(method='ffill')
```

[ ]:

```
# Exploratory Data Analysis (EDA)
```

[19]:

```
covid_df.describe()
```

[19]:

```
                                date   total_cases     new_cases  \
count                         145450  1.454500e+05  1.454500e+05
mean   2021-03-23 02:05:56.510140928  2.847143e+06  1.298287e+04
min              2020-01-22 00:00:00  1.000000e+00  0.000000e+00
25%              2020-09-29 00:00:00  5.342250e+03  6.250000e+00
```

```
50%              2021-03-29 00:00:00  4.647400e+04  1.450000e+02
75%              2021-09-17 00:00:00  3.822640e+05  1.394000e+03
max              2022-03-05 00:00:00  4.451295e+08  4.206334e+06
std                              NaN  1.632664e+07  8.930914e+04

       total_deaths     new_deaths  total_vaccinations  people_vaccinated  \
count  1.454500e+05  145450.000000        1.451140e+05       1.451140e+05
mean   5.766447e+04     171.235923        1.580603e+08       7.631559e+07
min    1.000000e+00       0.000000        0.000000e+00       0.000000e+00
25%    7.900000e+01       0.000000        3.917810e+05       2.575260e+05
50%    7.830000e+02       2.000000        2.613518e+06       1.556134e+06
75%    7.307000e+03      20.000000        1.762255e+07       9.300879e+06
max    5.995245e+06   18020.000000        1.085079e+10       4.976031e+09
std    3.021155e+05     832.370948        8.617947e+08       4.062349e+08

       people_fully_vaccinated    population
count             1.450360e+05  1.454500e+05
mean              6.721368e+07  1.663375e+08
min               1.000000e+00  4.981000e+03
25%               2.268058e+05  2.397240e+06
50%               1.229358e+06  1.016792e+07
75%               8.091251e+06  3.806791e+07
max               4.400787e+09  7.874966e+09
std               3.650945e+08  7.487753e+08
```

[21]:

```
# key column stats
covid_df[['total_cases', 'total_deaths', 'new_cases', 'new_deaths',␣
 ↪'total_vaccinations']].describe()
```

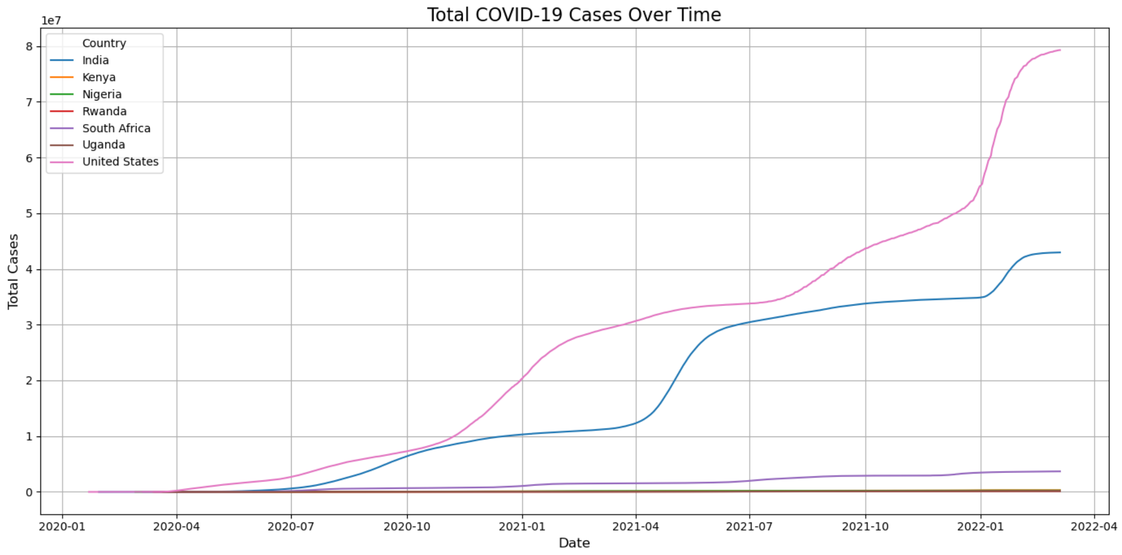
[21]:

```
        total_cases  total_deaths     new_cases     new_deaths  \
count  1.454500e+05  1.454500e+05  1.454500e+05  145450.000000
mean   2.847143e+06  5.766447e+04  1.298287e+04     171.235923
std    1.632664e+07  3.021155e+05  8.930914e+04     832.370948
min    1.000000e+00  1.000000e+00  0.000000e+00       0.000000
25%    5.342250e+03  7.900000e+01  6.250000e+00       0.000000
50%    4.647400e+04  7.830000e+02  1.450000e+02       2.000000
75%    3.822640e+05  7.307000e+03  1.394000e+03      20.000000
max    4.451295e+08  5.995245e+06  4.206334e+06   18020.000000

       total_vaccinations
count        1.451140e+05
mean         1.580603e+08
std          8.617947e+08
min          0.000000e+00
25%          3.917810e+05
50%          2.613518e+06
75%          1.762255e+07
```

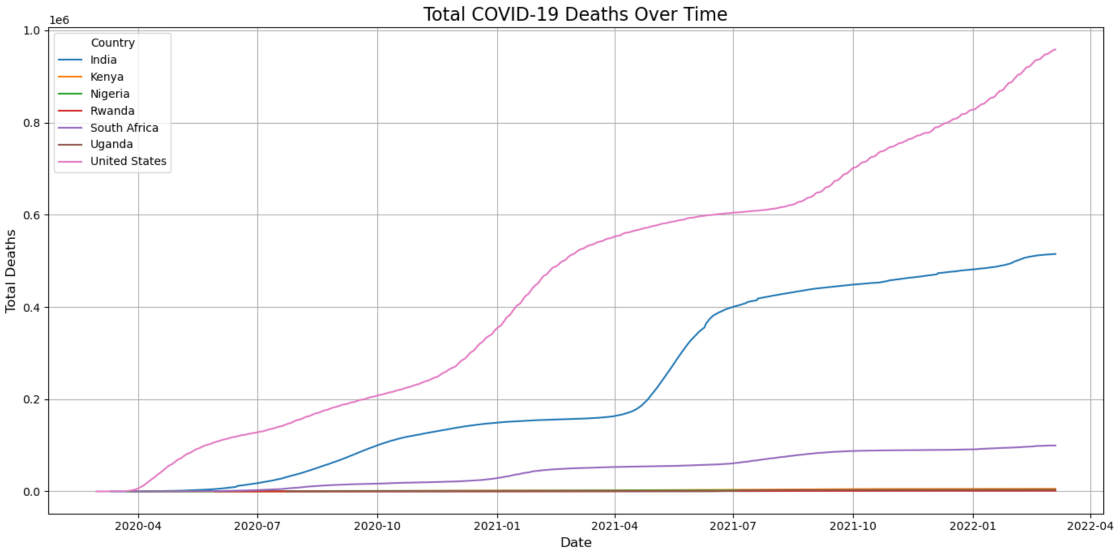
```
max           1.085079e+10
```

[24]:

```
# cases over time

# Step 1: Define countries of interest
countries = ['Kenya', 'Rwanda', 'Uganda', 'South Africa', 'Nigeria', 'United␣
↪States', 'India']

# Step 2: Filter the original data
covid_df = data[data['location'].isin(countries)].copy()  # Use .copy() to␣
↪avoid warnings

# Step 3: Convert date column to datetime
covid_df['date'] = pd.to_datetime(covid_df['date'])


import matplotlib.pyplot as plt

# Set figure size
plt.figure(figsize=(14, 7))

# Plot total cases for each country
for country in covid_df['location'].unique():
    country_data = covid_df[covid_df['location'] == country]
    plt.plot(country_data['date'], country_data['total_cases'], label=country)

# Add titles and labels
plt.title('Total COVID-19 Cases Over Time', fontsize=16)
plt.xlabel('Date', fontsize=12)
plt.ylabel('Total Cases', fontsize=12)
plt.legend(title='Country')
plt.grid(True)
plt.tight_layout()

# Show the plot
plt.show()
```

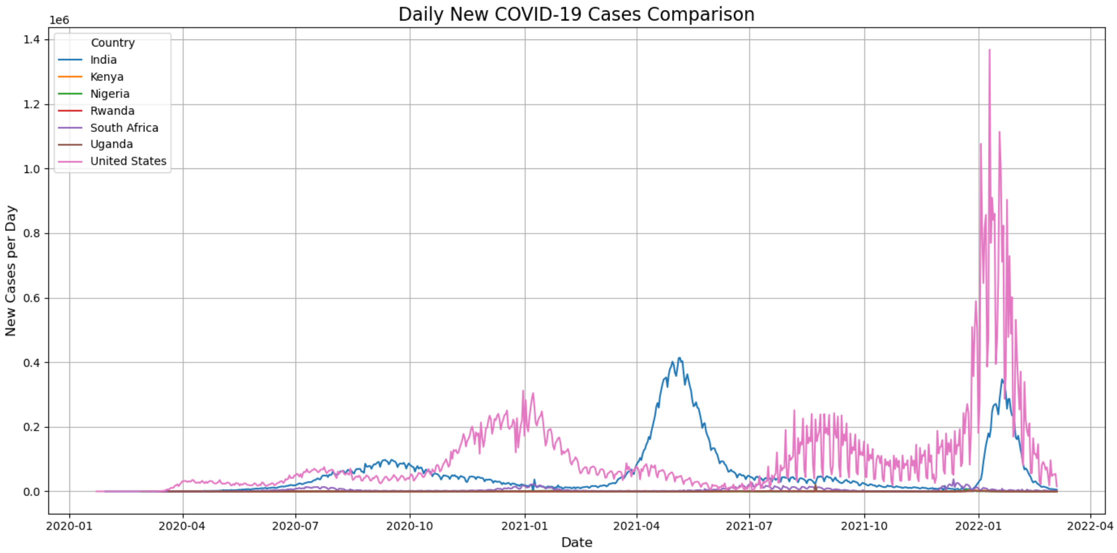


[25]:
```python
# deaths over time

import matplotlib.pyplot as plt

# Set the figure size
plt.figure(figsize=(14, 7))

# Plot total deaths for each selected country
for country in covid_df['location'].unique():
    country_data = covid_df[covid_df['location'] == country]
    plt.plot(country_data['date'], country_data['total_deaths'], label=country)

# Add chart elements
plt.title('Total COVID-19 Deaths Over Time', fontsize=16)
plt.xlabel('Date', fontsize=12)
plt.ylabel('Total Deaths', fontsize=12)
plt.legend(title='Country')
plt.grid(True)
plt.tight_layout()

# Show plot
plt.show()
```



[26]:

```
# Daily new cases between countries

import matplotlib.pyplot as plt

# Set figure size
plt.figure(figsize=(14, 7))

# Plot new daily cases for each country
for country in covid_df['location'].unique():
    country_data = covid_df[covid_df['location'] == country]
    plt.plot(country_data['date'], country_data['new_cases'], label=country)

# Add chart elements
plt.title('Daily New COVID-19 Cases Comparison', fontsize=16)
plt.xlabel('Date', fontsize=12)
plt.ylabel('New Cases per Day', fontsize=12)
plt.legend(title='Country')
plt.grid(True)
plt.tight_layout()

# Show plot
plt.show()
```



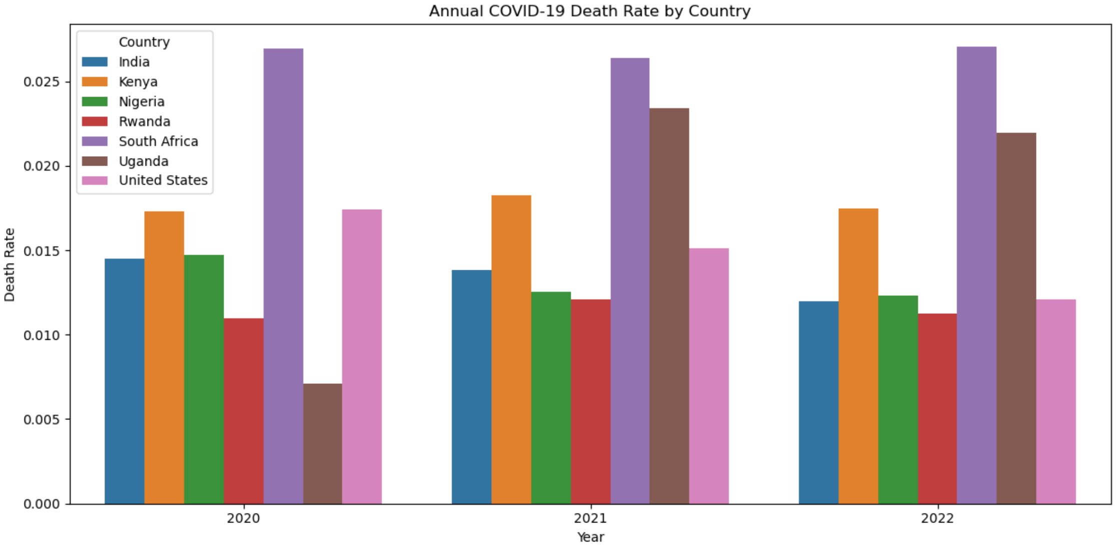
```
[31]: # computed death rate for each year for an overview
covid_df['year'] = covid_df['date'].dt.year
annual_summary = covid_df.groupby(['location', 'year'])[['total_cases',␣
  ↪'total_deaths']].max().reset_index()
annual_summary['death_rate'] = annual_summary['total_deaths'] /␣
  ↪annual_summary['total_cases']
display(annual_summary)
```

```
         location  year  total_cases  total_deaths  death_rate
0           India  2020   10286709.0      148994.0    0.014484
1           India  2021   34861579.0      481486.0    0.013811
2           India  2022   42962953.0      515036.0    0.011988
3           Kenya  2020      96458.0        1670.0    0.017313
4           Kenya  2021     295028.0        5378.0    0.018229
5           Kenya  2022     323071.0        5640.0    0.017457
6         Nigeria  2020      87607.0        1289.0    0.014713
7         Nigeria  2021     241513.0        3030.0    0.012546
8         Nigeria  2022     254637.0        3142.0    0.012339
9          Rwanda  2020       8383.0          92.0    0.010975
10         Rwanda  2021     111786.0        1350.0    0.012077
11         Rwanda  2022     129551.0        1458.0    0.011254
12   South Africa  2020    1057161.0       28469.0    0.026930
13   South Africa  2021    3458286.0       91145.0    0.026356
14   South Africa  2022    3683172.0       99543.0    0.027026
15         Uganda  2020      35216.0         251.0    0.007127
16         Uganda  2021     140737.0        3294.0    0.023405
17         Uganda  2022     163383.0        3590.0    0.021973
18  United States  2020   20193136.0      351754.0    0.017419
19  United States  2021   54810020.0      827893.0    0.015105
```

```
20  United States  2022   79265726.0      958437.0    0.012091
```

[30]:

```python
import seaborn as sns
plt.figure(figsize=(12, 6))
sns.barplot(data=annual_summary, x='year', y='death_rate', hue='location')
plt.title('Annual COVID-19 Death Rate by Country')
plt.ylabel('Death Rate')
plt.xlabel('Year')
plt.legend(title='Country')
plt.tight_layout()
plt.show()
```

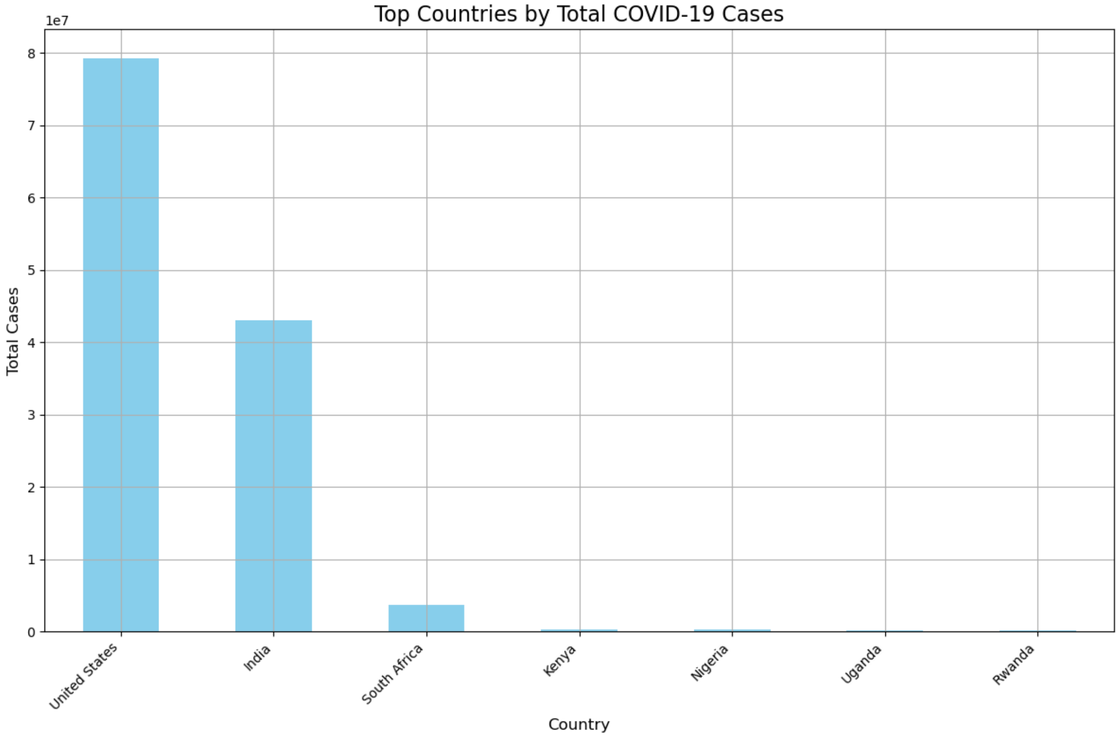


[32]:

```python
# Bar charts (top countries by total cases).
# Group by location (country) and sum total cases
top_countries_cases = covid_df.groupby('location')['total_cases'].max().
 ↪sort_values(ascending=False)

# Display the top countries by total cases
print(top_countries_cases.head(20))


import matplotlib.pyplot as plt

# Set figure size
plt.figure(figsize=(12, 8))

# Plot the bar chart for the top countries
top_countries_cases.head(10).plot(kind='bar', color='skyblue')
```

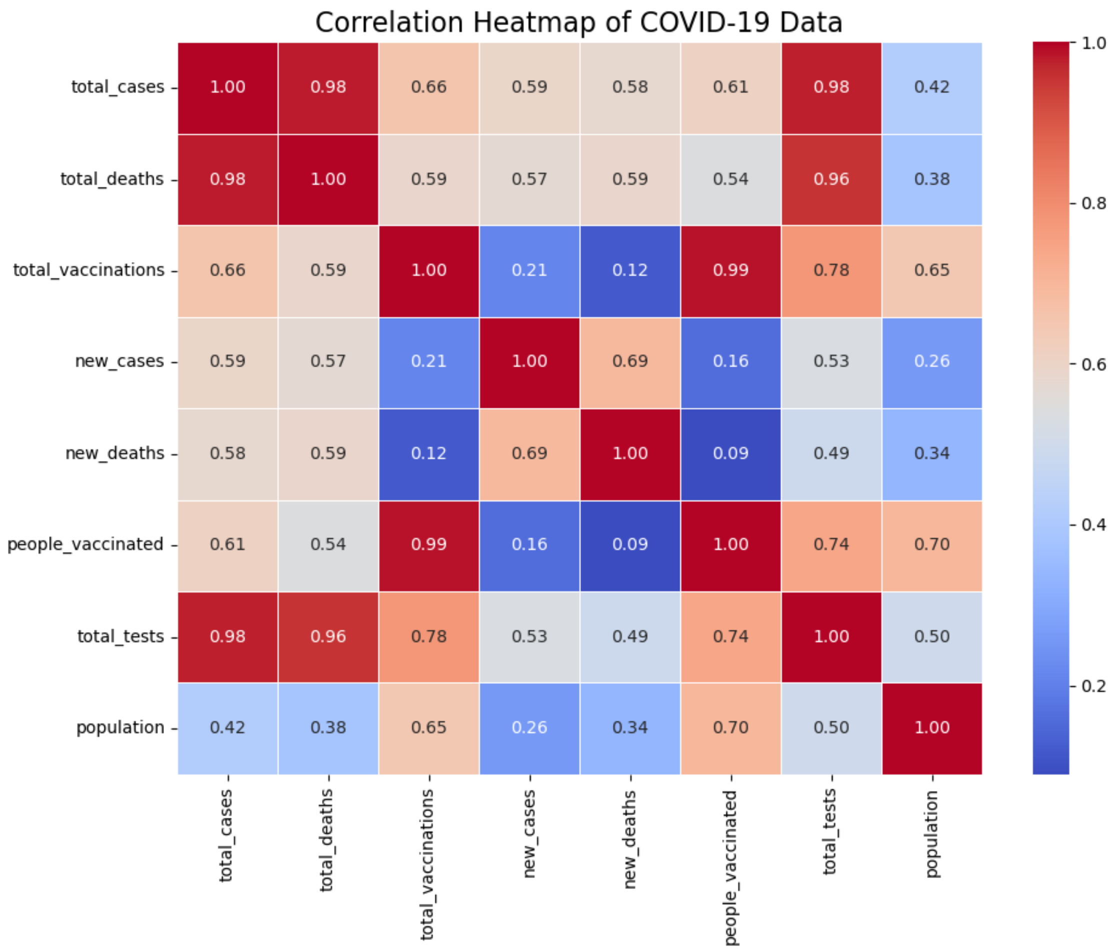
```
# Add chart elements
plt.title('Top Countries by Total COVID-19 Cases', fontsize=16)
plt.xlabel('Country', fontsize=12)
plt.ylabel('Total Cases', fontsize=12)
plt.xticks(rotation=45, ha='right')
plt.grid(True)

# Show plot
plt.tight_layout()
plt.show()
```

```
location
United States    79265726.0
India            42962953.0
South Africa      3683172.0
Kenya              323071.0
Nigeria            254637.0
Uganda             163383.0
Rwanda             129551.0
Name: total_cases, dtype: float64
```



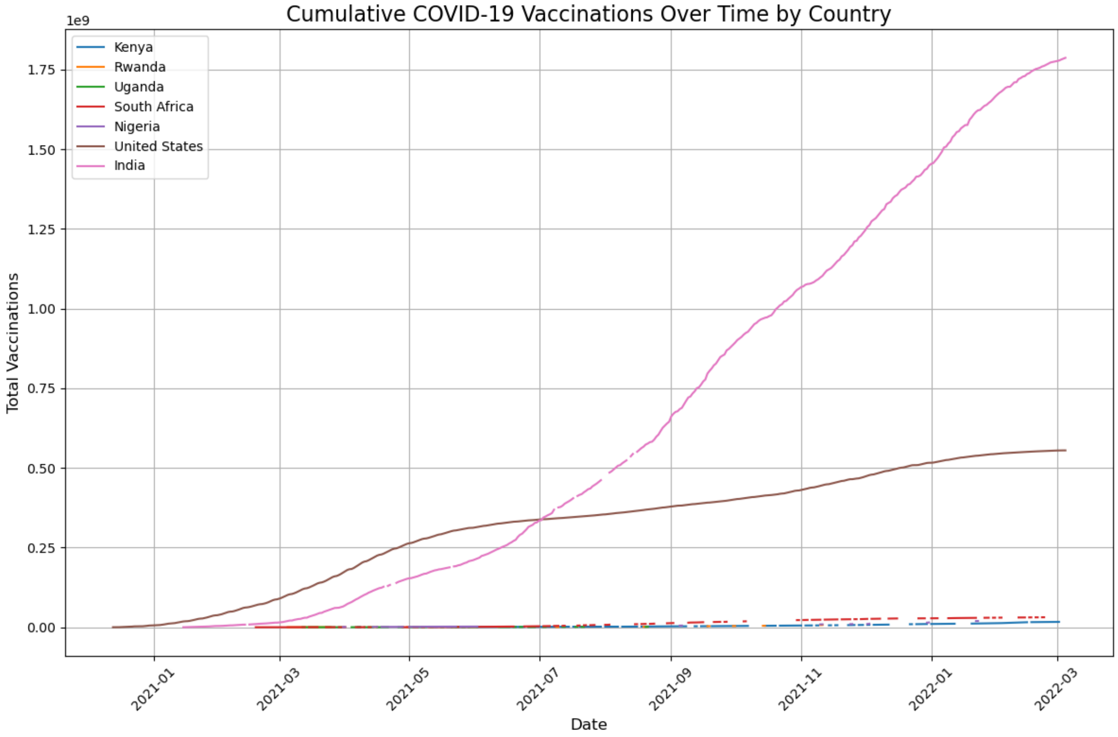
[33]:
```
# Heatmaps (optional for correlation analysis).
# Selecting relevant columns for correlation analysis
```

```python
correlation_columns = ['total_cases', 'total_deaths', 'total_vaccinations', 'new_cases', 'new_deaths', 'people_vaccinated', 'total_tests', 'population']
correlation_df = covid_df[correlation_columns]
# Calculate the correlation matrix
correlation_matrix = correlation_df.corr()

import seaborn as sns
import matplotlib.pyplot as plt

# Set the size of the heatmap
plt.figure(figsize=(10, 8))

# Create the heatmap
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt='.2f', linewidths=0.5)

# Add title and labels
plt.title('Correlation Heatmap of COVID-19 Data', fontsize=16)
plt.tight_layout()

# Show the plot
plt.show()
```



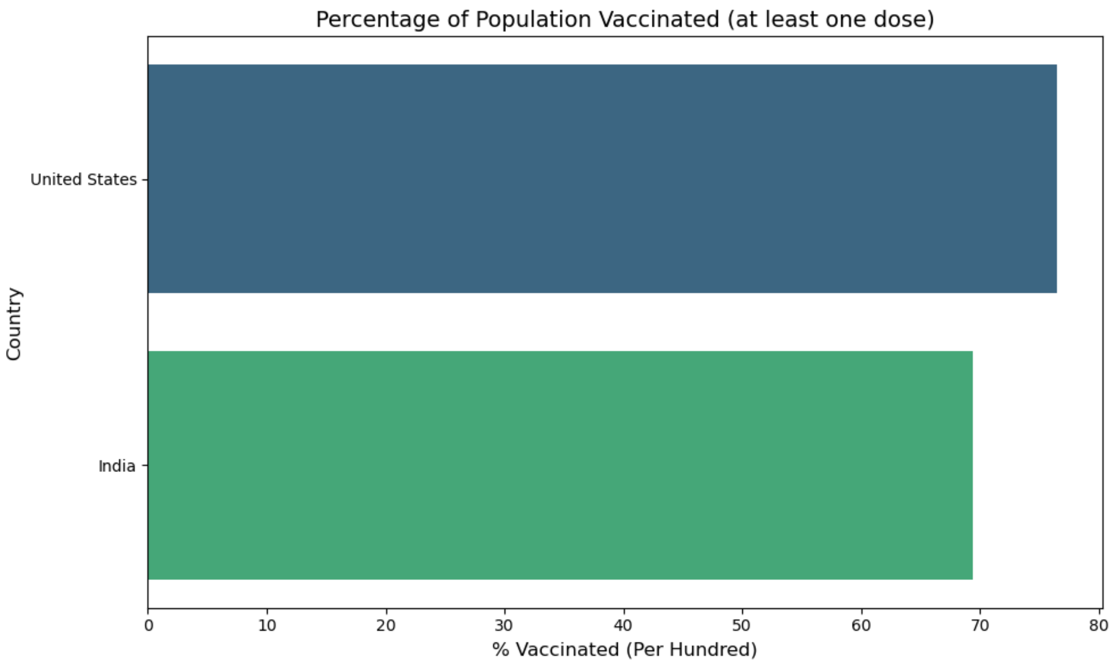
[34]:

```
#vaccination over time

selected_countries = ['Kenya', 'Rwanda', 'Uganda', 'South Africa', 'Nigeria',␣
 ↪'United States', 'India']
covid_df = covid_df[covid_df['location'].isin(selected_countries)]

covid_df['date'] = pd.to_datetime(covid_df['date'])


import matplotlib.pyplot as plt

# Set the figure size for the plot
plt.figure(figsize=(12, 8))

# Plot cumulative vaccinations for each country over time
for country in selected_countries:
    country_data = covid_df[covid_df['location'] == country]
    plt.plot(country_data['date'], country_data['total_vaccinations'],␣
 ↪label=country)

# Add title and labels
plt.title('Cumulative COVID-19 Vaccinations Over Time by Country', fontsize=16)
plt.xlabel('Date', fontsize=12)
plt.ylabel('Total Vaccinations', fontsize=12)

# Rotate x-axis labels for readability
plt.xticks(rotation=45)

# Show legend for country labels
plt.legend()

# Grid for better readability
plt.grid(True)

# Tight layout to adjust spacing
plt.tight_layout()

# Show the plot
plt.show()
```



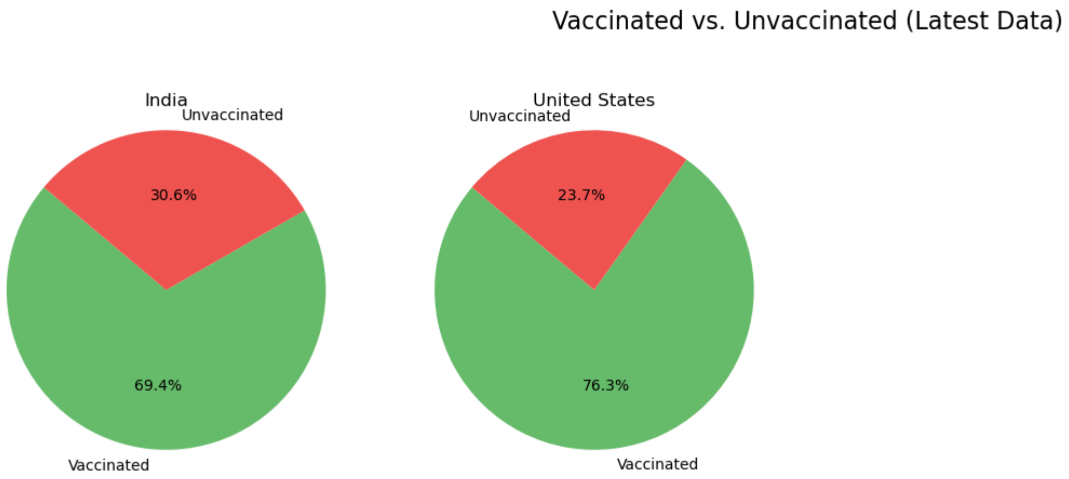
[35]:

```
# compare % vaccinated

# Get the latest date available in the dataset
latest_date = covid_df['date'].max()

# Filter data for the latest date
latest_data = covid_df[covid_df['date'] == latest_date]

# Filter for the selected countries
latest_data = latest_data[latest_data['location'].isin(selected_countries)]

# Select relevant columns
vaccinated_df = latest_data[['location', 'people_vaccinated_per_hundred']].
 ↪dropna()


import seaborn as sns
import matplotlib.pyplot as plt

# Set the figure size
plt.figure(figsize=(10, 6))

# Sort by vaccination percentage for better visuals
vaccinated_df = vaccinated_df.sort_values('people_vaccinated_per_hundred',␣
 ↪ascending=False)

# Create bar plot
sns.barplot(data=vaccinated_df, x='people_vaccinated_per_hundred',␣
 ↪y='location', palette='viridis')

# Add chart labels
plt.title('Percentage of Population Vaccinated (at least one dose)',␣
 ↪fontsize=14)
plt.xlabel('% Vaccinated (Per Hundred)', fontsize=12)
plt.ylabel('Country', fontsize=12)

# Display the chart
plt.tight_layout()
plt.show()
```



[36]:

```
# vaccinated v not-vaccinated

# Get latest date
latest_date = covid_df['date'].max()

# Filter for that date and selected countries
latest_data = covid_df[(covid_df['date'] == latest_date) &␣
 ↪(covid_df['location'].isin(selected_countries))]

# Drop countries with missing vaccination or population data
latest_data = latest_data.dropna(subset=['people_vaccinated', 'population'])
import matplotlib.pyplot as plt

# Set up subplots: one pie per country
fig, axes = plt.subplots(nrows=2, ncols=4, figsize=(16, 8))
axes = axes.flatten()  # flatten to 1D array for easy iteration

for i, country in enumerate(latest_data['location']):
    row = latest_data[latest_data['location'] == country].iloc[0]
    vaccinated = row['people_vaccinated']
    unvaccinated = row['population'] - vaccinated

    # Pie chart data
    sizes = [vaccinated, unvaccinated]
    labels = ['Vaccinated', 'Unvaccinated']
    colors = ['#66bb6a', '#ef5350']

    # Create pie chart
    axes[i].pie(sizes, labels=labels, autopct='%1.1f%%', startangle=140,␣
 ↪colors=colors)
    axes[i].axis('equal')  # Equal aspect ratio ensures circle shape
    axes[i].set_title(country)

# Remove any unused subplots (e.g., if fewer than 8 countries)
for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

# Overall title
plt.suptitle('Vaccinated vs. Unvaccinated (Latest Data)', fontsize=16)
plt.tight_layout(rect=[0, 0, 1, 0.95])
plt.show()
```



[37]:

```
# table on vaccinated/unvaccinated

3no data on vaccinations for other countries

# Prepare table data
vacc_table = latest_data[['location', 'people_vaccinated', 'population']].copy()

# Calculate unvaccinated
vacc_table['unvaccinated'] = vacc_table['population'] -␣
 ↪vacc_table['people_vaccinated']

# Calculate % vaccinated (optional)
```

```
vacc_table['% vaccinated'] = (vacc_table['people_vaccinated'] /␣
 ↪vacc_table['population']) * 100

# Round numbers for clarity
vacc_table[['people_vaccinated', 'unvaccinated', '% vaccinated']] =␣
 ↪vacc_table[['people_vaccinated', 'unvaccinated', '% vaccinated']].round(0)

# Reorder columns
vacc_table = vacc_table[['location', 'people_vaccinated', 'unvaccinated',␣
 ↪'population', '% vaccinated']]

# Display the table
print(vacc_table.to_string(index=False))
```

```
     location  people_vaccinated  unvaccinated   population  % vaccinated
        India        967153861.0   426255172.0 1393409033.0          69.0
United States        254002347.0    78912727.0  332915074.0          76.0
```

[ ]:

0.1 Insights & Reporting

- **USA and India** had the highest number of infections and deaths in absolute terms. However, their **death rates were comparable** to other countries. Notably, **South Africa** and **Uganda** recorded the **highest death rates** in 2021 and 2022.
- **Vaccination data** is primarily available for the USA and India. This may reflect better **access to vaccines**, whereas many African countries had limited or delayed access. Critically, the countries with the highest death rates **should have been prioritized** in global vaccine distribution efforts.
- By **March 2022**, approximately **70% of the population** in India and the USA had received at least one dose of the COVID-19 vaccine. In contrast, the percentage for most African countries was **negligible**. This highlights the need for **Africa to invest in local pharmaceutical manufacturing** to ensure equitable access in future health crises.
- The **death rate for the USA and India peaked in 2020** and **declined steadily** in subsequent years. For other countries, death rates either **remained stable or increased**, suggesting unequal access to vaccines, healthcare quality, or differences in public health strategies. These variations should be **studied in detail** to derive lessons for the management of **future pandemics**.

[ ]: