Milestone 1: Data Collection, Preprocessing, and Exploratory Data Analysis (EDA)

- **Objective of the project**

The goal of this project is to analyze the global impact of COVID-19 using a data-driven approach. This includes developing an interactive dashboard to visualize patterns in selected datasets, geospatial data, time series forecasts, and key statistics. Enable users to dynamically explore COVID-19 trends through interactive charts, maps, and statistical summaries. Provide real-time insights into the evolution of the outbreak. Understand the spread and trends of COVID-19 across different countries and time periods. Identify key factors influencing the outbreak, such as case growth, recovery rates, and mortality rates. Forecast future COVID-19 trends using time series forecasting techniques.

- **Type of tool**

The project involves:

Data exploration and preprocessing: cleaning, handling missing values, and detecting anomalies.

Statistical analysis: identifying patterns, correlations, and distributions.

Data visualization: creating interactive charts, heat maps, trend analysis, and geographic maps.

Predictive models: implementing machine learning models to predict COVID-19 trends.

Geospatial analysis: mapping the global spread of COVID-19.

Interactive dashboards: providing user-friendly visualization tools for exploring pandemic data in real time. The tool will provide interactive dashboards and statistical insights to visualize and analyze the global impact of the COVID-19 pandemic.

- **tech stack**

Programming languages and libraries: Python, Pandas, NumPy, Matplotlib, Seaborn, Dash, Scipy, Scikit-learn and so on.

Data processing and storage: Jupyter Notebook, SQLite, CSV.

Visualization and reporting: Matplotlib, Seaborn, Plotly, Dash, etc.

Machine learning and forecasting: ARIMA, SARIMA, LSTM (optional), K-Means clustering, Random Forest/XGBoost (optional).

- **Data to be used.**

The following datasets have been utilized for this analysis:

Full Grouped Dataset(full_grouped.csv): Time-series data of confirmed cases, recoveries, deaths, and active cases worldwide.

```
In [124]: print(df_full_grouped.head(), "\n")
```

```
         Date Country/Region  Confirmed  Deaths  Recovered  Active  New cases  \
0  2020-01-22    Afghanistan          0       0          0       0          0
1  2020-01-22        Albania          0       0          0       0          0
2  2020-01-22        Algeria          0       0          0       0          0
3  2020-01-22        Andorra          0       0          0       0          0
4  2020-01-22         Angola          0       0          0       0          0

   New deaths  New recovered            WHO Region
0           0              0  Eastern Mediterranean
1           0              0                Europe
2           0              0                Africa
3           0              0                Europe
4           0              0                Africa
```

```
In [106]: df_full_grouped.describe()
```

Out[106]:

	Confirmed	Deaths	Recovered	Active	New cases	New deaths	New recovered
count	3.515600e+04	35156.000000	3.515600e+04	3.515600e+04	35156.00000	35156.000000	35156.000000
mean	2.356663e+04	1234.068239	1.104813e+04	1.128443e+04	469.36375	18.603339	269.315593
std	1.499818e+05	7437.238354	6.454640e+04	8.997149e+04	3005.86754	115.706351	2068.063852
min	0.000000e+00	0.000000	0.000000e+00	-2.000000e+00	0.00000	-1918.000000	-16298.000000
25%	1.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.00000	0.000000	0.000000
50%	2.500000e+02	4.000000	3.300000e+01	8.500000e+01	2.00000	0.000000	0.000000
75%	3.640250e+03	78.250000	1.286250e+03	1.454000e+03	75.00000	1.000000	20.000000
max	4.290259e+06	148011.000000	1.846641e+06	2.816444e+06	77255.00000	3887.000000	140050.000000

COVID-19 Clean Complete Dataset(covid_19_clean_complete.csv): Comprehensive dataset including country-level statistics with additional geographic information (latitude, longitude).

Worldometer(worldometer_data.csv) Dataset: A snapshot of country-level statistics such as total cases, deaths, recovered cases, active cases, and per capita statistics.

```
print(df_worldometer_data.head(), "\n")
```

```
  Country/Region      Continent    Population  TotalCases  NewCases  \
0            USA  North America  3.311981e+08     5032179       NaN
1         Brazil  South America  2.127107e+08     2917562       NaN
2          India           Asia  1.381345e+09     2025409       NaN
3         Russia         Europe  1.459409e+08      871894       NaN
4   South Africa         Africa  5.938157e+07      538184       NaN

   TotalDeaths  NewDeaths  TotalRecovered  NewRecovered  ActiveCases  \
0     162804.0        NaN       2576668.0           NaN    2292707.0
1      98644.0        NaN       2047660.0           NaN     771258.0
2      41638.0        NaN       1377384.0           NaN     606387.0
3      14606.0        NaN        676357.0           NaN     180931.0
4       9604.0        NaN        387316.0           NaN     141264.0

   Serious,Critical  Tot Cases/1M pop  Deaths/1M pop  TotalTests  \
0           18296.0           15194.0          492.0  63139605.0
1            8318.0           13716.0          464.0  13206188.0
2            8944.0            1466.0           30.0  22149351.0
3            2300.0            5974.0          100.0  29716907.0
4             539.0            9063.0          162.0   3149807.0

   Tests/1M pop      WHO Region
0      190640.0        Americas
1       62085.0        Americas
2       16035.0  South-EastAsia
3      203623.0          Europe
4       53044.0          Africa
```

```
df_worldometer_data.describe()
```

	Population	TotalCases	NewCases	TotalDeaths	NewDeaths	TotalRecovered	NewRecovered	ActiveCases	Serious,Critical	Tot Cases/1M pop	D
count	2.080000e+02	2.090000e+02	4.000000	188.000000	3.000000	2.050000e+02	3.000000	2.050000e+02	122.000000	208.000000	18
mean	3.041549e+07	9.171850e+04	1980.500000	3792.590426	300.000000	5.887898e+04	1706.000000	2.766433e+04	534.393443	3196.024038	9
std	1.047661e+08	4.325867e+05	3129.611424	15487.184877	451.199512	2.566984e+05	2154.779803	1.746327e+05	2047.518613	5191.986457	17
min	8.010000e+02	1.000000e+01	20.000000	1.000000	1.000000	7.000000e+00	42.000000	0.000000e+00	1.000000	3.000000	
25%	9.663140e+05	7.120000e+02	27.500000	22.000000	40.500000	3.340000e+02	489.000000	8.600000e+01	3.250000	282.000000	
50%	7.041972e+06	4.491000e+03	656.000000	113.000000	80.000000	2.178000e+03	936.000000	8.990000e+02	27.500000	1015.000000	2
75%	2.575614e+07	3.689600e+04	2609.000000	786.000000	449.500000	2.055300e+04	2538.000000	7.124000e+03	160.250000	3841.750000	9
max	1.381345e+09	5.032179e+06	6590.000000	162804.000000	819.000000	2.576668e+06	4140.000000	2.292707e+06	18296.000000	39922.000000	12

mean	21.433730	23.528236	1.688490e+04	884.179160	7.915713e+03	8.085012e+03
std	24.950320	70.442740	1.273002e+05	6313.584411	5.480092e+04	7.625890e+04
min	-51.796300	-135.000000	0.000000e+00	0.000000	0.000000e+00	-1.400000e+01
25%	7.873054	-15.310100	4.000000e+00	0.000000	0.000000e+00	0.000000e+00
50%	23.634500	21.745300	1.680000e+02	2.000000	2.900000e+01	2.600000e+01
75%	41.204380	80.771797	1.518250e+03	30.000000	6.660000e+02	6.060000e+02
max	71.706900	178.065000	4.290259e+06	148011.000000	1.846641e+06	2.816444e+06

- ## Project timeline

Project Timeline

Milestone 1: Data Preparation (Due by February 21)

Data Collection

Data Preprocessing

Exploratory Data Analysis (EDA)

Milestone 2: Model Development

Feature Engineering (Due by March 5)

Feature Selection (Due by March 10)

Data Modeling (Due by March 15)

Report Writing (Due by March 17)

Uploading to GitHub (Due by March 20)

Milestone 3: Evaluation & Finalization

Evaluation and Interpretation (Due by March 30)

Tool Development (Due by April 10)

Report Writing (Due by April 13)

Uploading to GitHub (Due by April 15)

4-Minute Presentation (Due by April 20)

- ## Data Preprocessing

The data preprocessing stage involved multiple steps to ensure data integrity, consistency, and usability for analysis. First, we examined the structure of each dataset, identifying missing values and data types. Missing categorical values, such as

Province/State, Continent, and WHO Region, were replaced with "Unknown", while missing numerical values, including Population, TotalTests, and NewCases, were set to 0 to maintain uniformity across all records. A pre- and post-cleaning missing value check was conducted to confirm data completeness.

Handle missing values:

```python
# Define a function to check for missing values
def check_missing_values(df, name):
    print(f"\nChecking Missing Values for {name} dataset:")
    missing_data = df.isnull().sum()
    missing_data = missing_data[missing_data > 0]

    if not missing_data.empty:
        print(missing_data)
    else:
        print("No Missing Values Found.")
    print("\n" + "-" * 50)

# Reload the dataset to ensure integrity before cleaning
df_full_grouped_clean = df_full_grouped.copy()
df_covid_19_clean_clean = df_covid_19_clean.copy()
df_worldometer_data_clean = df_worldometer_data.copy()

# Check for initial missing values
check_missing_values(df_full_grouped_clean, "Full Grouped")
check_missing_values(df_covid_19_clean_clean, "COVID-19 Clean Complete")
check_missing_values(df_worldometer_data_clean, "Worldometer Data")
```

```
Checking Missing Values for Full Grouped dataset:
No Missing Values Found.

--------------------------------------------------

Checking Missing Values for COVID-19 Clean Complete dataset:
Province/State    34404
dtype: int64

--------------------------------------------------

Checking Missing Values for Worldometer Data dataset:
Continent             1
Population            1
NewCases            205
TotalDeaths          21
NewDeaths           206
TotalRecovered        4
NewRecovered        206
ActiveCases           4
Serious,Critical     87
Tot Cases/1M pop      1
Deaths/1M pop        22
TotalTests           18
Tests/1M pop         18
WHO Region           25
dtype: int64

--------------------------------------------------
```

```
# Handling missing values ••in the covid_19_clean_complete dataset
df_covid_19_clean_clean['Province/State'] = df_covid_19_clean_clean['Province/State'].fillna('Unknown')

# Handling missing values ••in the worldometer_data dataset
df_worldometer_data_clean['Continent'] = df_worldometer_data_clean['Continent'].fillna('Unknown')
df_worldometer_data_clean['Population'] = df_worldometer_data_clean['Population'].fillna(0)

# Fill missing numeric columns with 0
df_worldometer_data_clean.fillna({
    'NewCases': 0,
    'TotalDeaths': 0,
    'NewDeaths': 0,
    'TotalRecovered': 0,
    'NewRecovered': 0,
    'ActiveCases': 0,
    'Serious,Critical': 0,
    'Tot Cases/1M pop': 0,
    'Deaths/1M pop': 0,
    'TotalTests': 0,
    'Tests/1M pop': 0
}, inplace=True)

# Fill missing WHO Regions with "Unknown"
df_worldometer_data_clean['WHO Region'] = df_worldometer_data_clean['WHO Region'].fillna('Unknown')

# Recheck the missing values ••after cleaning
print("\nPost-Cleaning Missing Value Check:")
check_missing_values(df_full_grouped_clean, "Full Grouped")
check_missing_values(df_covid_19_clean_clean, "COVID-19 Clean Complete")
check_missing_values(df_worldometer_data_clean, "Worldometer Data")
```

```
Post-Cleaning Missing Value Check:

Checking Missing Values for Full Grouped dataset:
No Missing Values Found.

--------------------------------------------------

Checking Missing Values for COVID-19 Clean Complete dataset:
No Missing Values Found.

--------------------------------------------------

Checking Missing Values for Worldometer Data dataset:
No Missing Values Found.

--------------------------------------------------
```

To handle outliers, different methods were applied based on dataset characteristics. The Interquartile Range (IQR) method was used for Worldometer to remove extreme values from TotalCases, TotalDeaths, TotalRecovered, and related features. Following outlier removal, numerical features were processed using Z-score standardization, ensuring all variables had a mean of 0 and a standard deviation of 1. Additionally, certain features in Worldometer, such as Tot Cases/1M pop, Deaths/1M pop, and Tests/1M pop, were Min-Max normalized to scale values between 0 and 1, making them more interpretable and comparable across different countries. These preprocessing steps ensure the dataset is clean, properly scaled, and ready for further statistical analysis, visualization, and modeling.

Handle outliers:

```
# Use IQR method to handle outliers
def remove_outliers_iqr(df, columns):
    Q1 = df[columns].quantile(0.25)
    Q3 = df[columns].quantile(0.75)
    IQR = Q3 - Q1
    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR
    return df[~((df[columns] < lower_bound) | (df[columns] > upper_bound)).any(axis=1)]

iqr_columns_worldometer = ["TotalCases", "TotalDeaths", "TotalRecovered", "ActiveCases",
                           "Tot Cases/1M pop", "Deaths/1M pop", "TotalTests", "Tests/1M pop"]

# Reload Worldometer data to avoid accidental deletion of data in previous cleanup
df_worldometer_data_clean = df_worldometer_data.copy()

# use IQR method to handle outliers
df_worldometer_data_clean = remove_outliers_iqr(df_worldometer_data_clean, iqr_columns_worldometer)

print(f"Worldometer Data dataset IQR processed size: {df_worldometer_data_clean.shape}")
```

```
Worldometer Data dataset IQR processed size: (140, 16)
```

Normalize or scale features as needed for analysis (e.g., Min-Max scaling, standardization):

```
# Data after handling outliers (Z-score standardization & IQR method)
df_full_grouped_clean = remove_outliers_zscore(df_full_grouped_clean, numerical_cols_full_grouped, threshold=4)
df_covid_19_clean_clean = remove_outliers_zscore(df_covid_19_clean_clean, numerical_cols_covid_19, threshold=4)
df_worldometer_data_clean = remove_outliers_iqr(df_worldometer_data_clean, iqr_columns_worldometer)

# Define the standardization (Z-score) and normalization (Min-Max) scalers
standard_scaler = StandardScaler()
min_max_scaler = MinMaxScaler()

# Columns to be standardized (Z-score)
zscore_columns_full_grouped = ["Confirmed", "Deaths", "Recovered", "Active", "New cases", "New deaths", "New recover
zscore_columns_covid_19 = ["Confirmed", "Deaths", "Recovered", "Active"]
zscore_columns_worldometer = ["TotalCases", "TotalDeaths", "TotalRecovered", "ActiveCases"]

# Columns to be normalized (Min-Max)
minmax_columns_worldometer = ["Tot Cases/1M pop", "Deaths/1M pop", "TotalTests", "Tests/1M pop"]

# Z-score normalization for selected columns
df_full_grouped_clean[zscore_columns_full_grouped] = standard_scaler.fit_transform(df_full_grouped_clean[zscore_colu
df_covid_19_clean_clean[zscore_columns_covid_19] = standard_scaler.fit_transform(df_covid_19_clean_clean[zscore_colu
df_worldometer_data_clean[zscore_columns_worldometer] = standard_scaler.fit_transform(df_worldometer_data_clean[zsco

# Min-Max normalization for selected columns
df_worldometer_data_clean[minmax_columns_worldometer] = min_max_scaler.fit_transform(df_worldometer_data_clean[minma


print("The complete grouped dataset after normalization (first 5 rows): ")
print(df_full_grouped_clean.head(), "\n")

print("Normalized COVID-19 Clean Complete dataset (first 5 rows): ")
print(df_covid_19_clean_clean.head(), "\n")

print("Standardized and normalized Worldometer dataset (first 5 rows): ")
print(df_worldometer_data_clean.head(), "\n")
```

```
The complete grouped dataset after normalization (first 5 rows):
        Date Country/Region  Confirmed    Deaths  Recovered    Active  \
0 2020-01-22    Afghanistan  -0.373005 -0.241166  -0.299827 -0.344399
1 2020-01-22        Albania  -0.373005 -0.241166  -0.299827 -0.344399
2 2020-01-22        Algeria  -0.373005 -0.241166  -0.299827 -0.344399
3 2020-01-22        Andorra  -0.373005 -0.241166  -0.299827 -0.344399
4 2020-01-22         Angola  -0.373005 -0.241166  -0.299827 -0.344399

   New cases  New deaths  New recovered             WHO Region
0  -0.345265   -0.267631      -0.285039  Eastern Mediterranean
1  -0.345265   -0.267631      -0.285039                 Europe
2  -0.345265   -0.267631      -0.285039                 Africa
3  -0.345265   -0.267631      -0.285039                 Europe
4  -0.345265   -0.267631      -0.285039                 Africa

Normalized COVID-19 Clean Complete dataset (first 5 rows):
  Province/State Country/Region       Lat       Long       Date  Confirmed  \
0            NaN    Afghanistan  33.93911  67.709953 2020-01-22  -0.335405
1            NaN        Albania  41.15330  20.168300 2020-01-22  -0.335405
2            NaN        Algeria  28.03390   1.659600 2020-01-22  -0.335405
3            NaN        Andorra  42.50630   1.521800 2020-01-22  -0.335405
4            NaN         Angola -11.20270  17.873900 2020-01-22  -0.335405

     Deaths  Recovered   Active             WHO Region
0 -0.238463  -0.274485 -0.29683  Eastern Mediterranean
1 -0.238463  -0.274485 -0.29683                 Europe
2 -0.238463  -0.274485 -0.29683                 Africa
3 -0.238463  -0.274485 -0.29683                 Europe
4 -0.238463  -0.274485 -0.29683                 Africa

Standardized and normalized Worldometer dataset (first 5 rows):
   Country/Region Continent  Population  TotalCases  NewCases  TotalDeaths  \
71    Ivory Coast    Africa  26437950.0    4.231974       NaN     0.451130
76       Bulgaria    Europe   6942854.0    3.190801       NaN     4.528782
77     Madagascar    Africa  27755708.0    3.042798       NaN     0.831875
80        Senegal    Africa  16783877.0    2.493551       NaN     1.924980
81         Norway    Europe   5425471.0    2.115356       NaN     2.330289

    NewDeaths  TotalRecovered  NewRecovered  ActiveCases  Serious,Critical  \
71        NaN        4.279582           NaN     2.808452               NaN
76        NaN        2.253235           NaN     4.021607              47.0
77        NaN        3.353252           NaN     1.350861              88.0
80        NaN        2.144978           NaN     2.385425              33.0
81        NaN        2.841312           NaN    -0.352970               3.0

    Tot Cases/1M pop  Deaths/1M pop  TotalTests  Tests/1M pop WHO Region
71          0.242460       0.050962    0.165775      0.036948     Africa
76          0.732863       0.817993    0.467377      0.432947     Europe
77          0.175480       0.063963    0.073015      0.013354     Africa
80          0.248727       0.167967    0.181972      0.066667     Africa
81          0.682335       0.609984    0.751872      0.894859     Europe
```

- # Merging dataset

```
]: # Merge `Full Grouped` and `COVID-19 Clean Complete` by `Country/Region` + `Date`
   # Select the appropriate columns to merge
   merge_columns = ["Date", "Country/Region", "Confirmed", "Deaths", "Recovered", "Active"]

   # Ensure that the Date column format is consistent
   df_full_grouped_clean["Date"] = pd.to_datetime(df_full_grouped_clean["Date"])
   df_covid_19_clean_clean["Date"] = pd.to_datetime(df_covid_19_clean_clean["Date"])

   # Merge by `Country/Region` + `Date`, using `outer join` to keep all data
   df_merged = pd.merge(df_full_grouped_clean[merge_columns],
                        df_covid_19_clean_clean[merge_columns],
                        on=["Date", "Country/Region"],
                        how="outer",
                        suffixes=("_full", "_clean"))

   # Handling missing values ••(some countries may only exist in one dataset)
   df_merged.fillna(0, inplace=True)
   df_worldometer_data_clean = df_worldometer_data_clean.drop_duplicates(subset=["Country/Region"])
   df_worldometer_data_clean.drop(columns=["WHO Region"], inplace=True, errors="ignore")
   df_final = pd.merge(df_merged, df_worldometer_data_clean, on="Country/Region", how="left")
   df_final.fillna(0, inplace=True)
   print(f"The size of the combined dataset: {df_final.shape}")
   print(df_final.head())
```

```
The size of the combined dataset: (47436, 24)
        Date Country/Region  Confirmed_full  Deaths_full  Recovered_full  \
0 2020-01-22    Afghanistan       -0.373005    -0.241166       -0.299827
1 2020-01-22        Albania       -0.373005    -0.241166       -0.299827
2 2020-01-22        Algeria       -0.373005    -0.241166       -0.299827
3 2020-01-22        Andorra       -0.373005    -0.241166       -0.299827
4 2020-01-22         Angola       -0.373005    -0.241166       -0.299827

   Active_full  Confirmed_clean  Deaths_clean  Recovered_clean  Active_clean  \
0    -0.344399        -0.335405     -0.238463        -0.274485      -0.29683
1    -0.344399        -0.335405     -0.238463        -0.274485      -0.29683
2    -0.344399        -0.335405     -0.238463        -0.274485      -0.29683
3    -0.344399        -0.335405     -0.238463        -0.274485      -0.29683
4    -0.344399        -0.335405     -0.238463        -0.274485      -0.29683

   ... TotalDeaths  NewDeaths  TotalRecovered  NewRecovered  ActiveCases  \
0  ...     0.000000        0.0        0.000000           0.0     0.000000
1  ...     1.495108        0.0        0.580209           0.0     1.737808
2  ...     0.000000        0.0        0.000000           0.0     0.000000
3  ...     0.000000        0.0        0.000000           0.0     0.000000
4  ...    -0.027871        0.0       -0.464688           0.0     0.137705

   Serious,Critical  Tot Cases/1M pop  Deaths/1M pop  TotalTests  Tests/1M pop
0               0.0          0.000000       0.000000    0.000000      0.000000
1              23.0          0.817861       0.843994    0.061391      0.135911
2               0.0          0.000000       0.000000    0.000000      0.000000
3               0.0          0.000000       0.000000    0.000000      0.000000
4              20.0          0.016451       0.024961    0.102373      0.016417
```

```
: df_merged.describe()
```

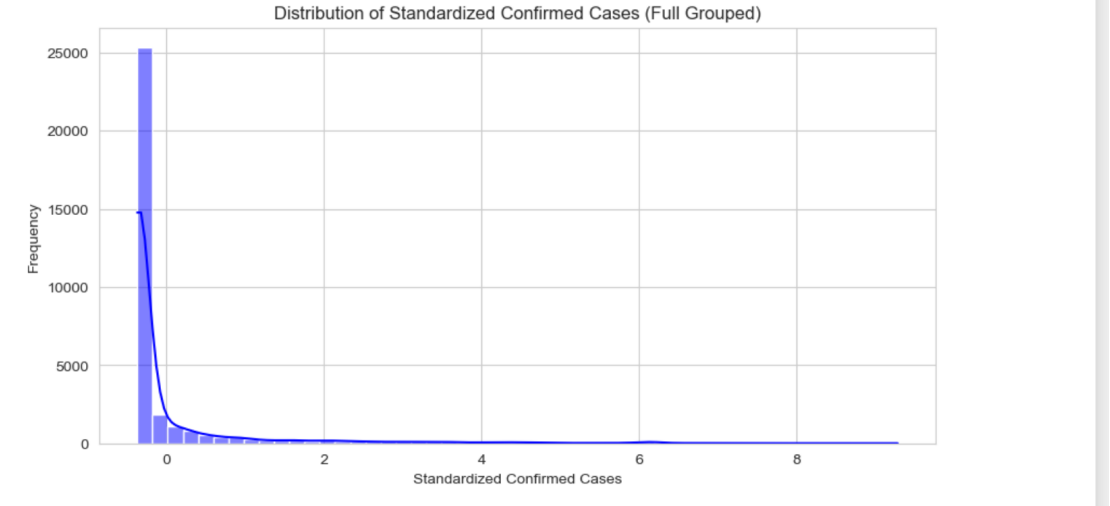
:

	Date	Confirmed_full	Deaths_full	Recovered_full	Active_full	Confirmed_clean	Deaths_clean	Recovered_clean	Active_clean
count	47436	47436.000000	47436.000000	47436.000000	47436.000000	4.743600e+04	4.743600e+04	4.743600e+04	4.743600e+04
mean	2020-04-22 20:23:58.907159040	0.638691	0.543689	0.833929	0.134637	4.793273e-18	9.586545e-17	-3.834618e-17	-1.917309e-17
min	2020-01-22 00:00:00	-0.373005	-0.241166	-0.299827	-0.344725	-3.354046e-01	-2.384631e-01	-2.744853e-01	-2.992062e-01
25%	2020-03-07 00:00:00	-0.372152	-0.241166	-0.299827	-0.343746	-3.351311e-01	-2.384631e-01	-2.744853e-01	-2.968301e-01
50%	2020-04-22 00:00:00	-0.304563	-0.222113	-0.282044	-0.286628	-3.220911e-01	-2.350432e-01	-2.709579e-01	-2.934358e-01
75%	2020-06-08 00:00:00	0.131045	0.000000	0.000000	0.000000	-2.251348e-01	-2.008449e-01	-1.889064e-01	-2.197780e-01
max	2020-07-27 00:00:00	9.285026	12.234827	11.309992	10.035665	9.859118e+00	1.046904e+01	1.104264e+01	9.032246e+00
std	NaN	2.034856	1.835322	2.718387	1.234747	9.984810e-01	9.984810e-01	9.984810e-01	9.984810e-01

- **EDA report with key insights (charts, tables, visualizations, and observations).**

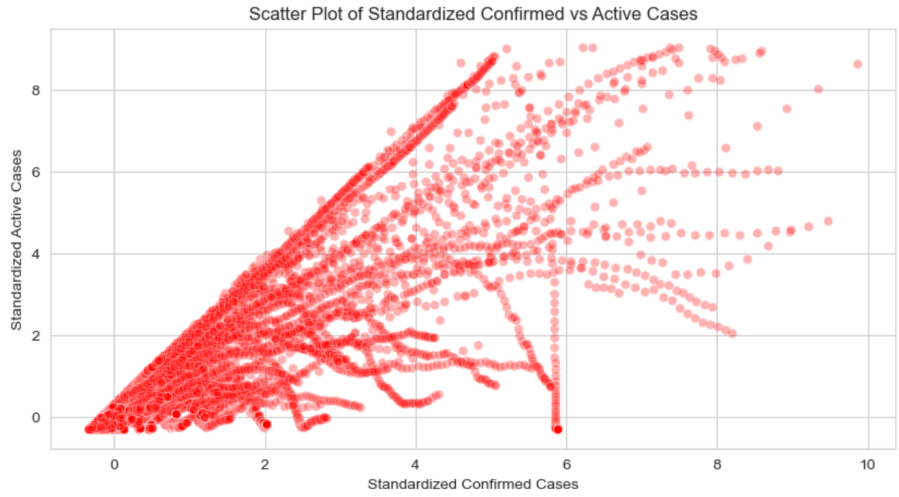
The histogram of standardized confirmed COVID-19 cases shows a highly right-skewed distribution, indicating that most countries have relatively low case counts, while a few have extremely high numbers. This long-tail effect suggests that the pandemic's impact is unevenly distributed globally, with certain countries experiencing significantly higher outbreaks. The Kernel Density Estimation (KDE) curve further highlights this pattern, reinforcing the presence of outliers. Given the severe skewness, applying a log transformation or analyzing high-case and low-case countries separately could provide deeper insights into the spread and trends of COVID-19.

```
import matplotlib.pyplot as plt
import seaborn as sns

# Set drawing style
sns.set_style("whitegrid")

# 1. Histogram: Distribution of confirmed cases (Full Grouped dataset)
plt.figure(figsize=(10, 5))
sns.histplot(df_full_grouped_clean["Confirmed"], bins=50, kde=True, color="blue")
plt.xlabel("Standardized Confirmed Cases")
plt.ylabel("Frequency")
plt.title("Distribution of Standardized Confirmed Cases (Full Grouped)")
plt.show()
```



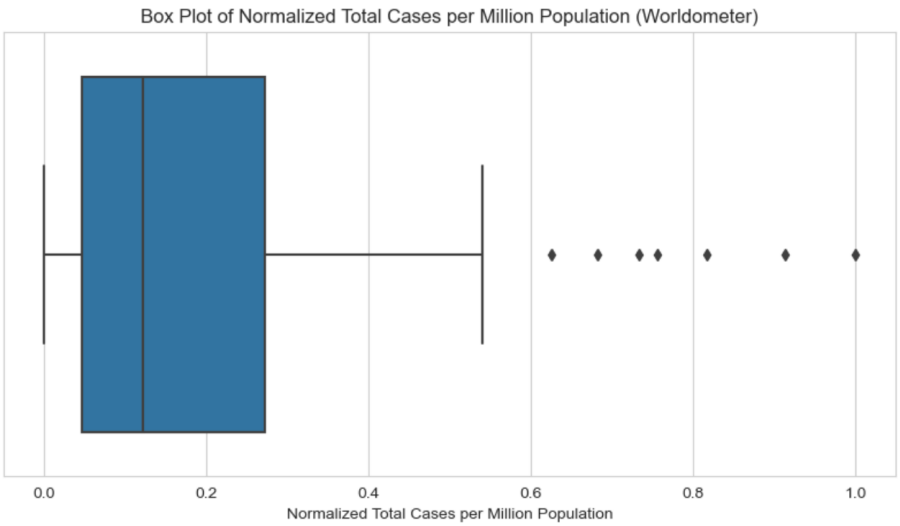
This scatter plot visualizes the relationship between standardized confirmed cases and standardized active cases using the COVID-19 Clean Complete dataset. Each red dot represents a data point corresponding to a specific country and date. The positive correlation observed indicates that as the number of confirmed cases increases, the number of active cases also tends to rise. However, the spread of points suggests variability, where some regions may have a higher proportion of recoveries or deaths, leading to fewer active cases despite high confirmed cases. The fanning-out effect seen in the plot may indicate differences in outbreak severity, government responses, or healthcare system effectiveness across different regions. Further analysis could involve segmentation by country or time-based trends to better understand pandemic dynamics.

```
# 2. Scatter plot: Active cases vs. confirmed cases (COVID-19 Clean Complete dataset)
plt.figure(figsize=(10, 5))
sns.scatterplot(x=df_covid_19_clean_clean["Confirmed"], y=df_covid_19_clean_clean["Active"], alpha=0.3, color="red")
plt.xlabel("Standardized Confirmed Cases")
plt.ylabel("Standardized Active Cases")
plt.title("Scatter Plot of Standardized Confirmed vs Active Cases")
plt.show()
```



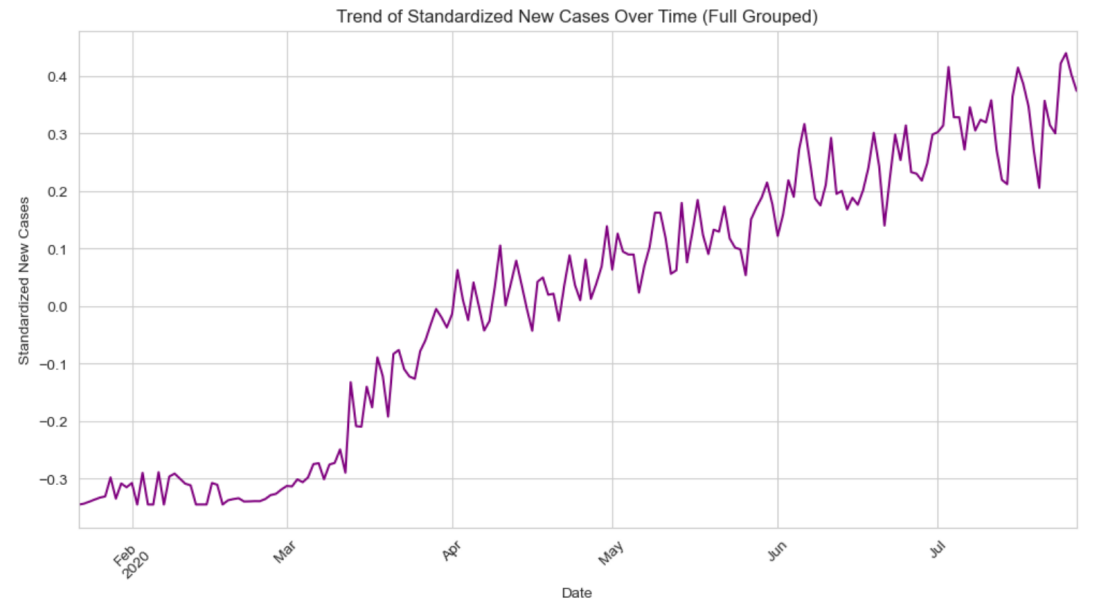
The box plot of normalized total COVID-19 cases per million population reveals a right-skewed distribution, indicating that most countries have relatively low case rates, while a few experience significantly higher infection levels. The presence of multiple outliers suggests that certain countries faced severe outbreaks or had extensive testing policies leading to higher reported cases per million. The wide interquartile range (IQR) reflects substantial variation in case distribution, likely influenced by population density, healthcare infrastructure, and government interventions. Further analysis of outlier countries could provide insights into the factors contributing to these discrepancies.

```
: # 3. Box plot: Distribution of cases per million population in each country (Worldometer dataset)
  plt.figure(figsize=(10, 5))
  sns.boxplot(x=df_worldometer_data_clean["Tot Cases/1M pop"])
  plt.xlabel("Normalized Total Cases per Million Population")
  plt.title("Box Plot of Normalized Total Cases per Million Population (Worldometer)")
  plt.show()
```



The trend chart illustrates the standardized daily new COVID-19 cases over time, based on the Full Grouped dataset. The upward trajectory indicates a consistent increase in reported new cases, suggesting a worsening outbreak over the observed period. The initial rise in March and April 2020 aligns with the global spread of the pandemic, followed by fluctuations but an overall increasing trend until July. The short-term variations suggest periodic surges, potentially due to waves of infections, policy changes, or testing expansions. This trend highlights the need for further investigation into regional variations, intervention measures, and forecasting models to anticipate future outbreaks.

```
# 4. Trend chart: Daily new case trends (Full Grouped dataset)
plt.figure(figsize=(12, 6))
df_full_grouped_clean.groupby("Date")["New cases"].mean().plot(color="purple")
plt.xlabel("Date")
plt.ylabel("Standardized New Cases")
plt.title("Trend of Standardized New Cases Over Time (Full Grouped)")
plt.xticks(rotation=45)
plt.show()
```



When the three datasets are combined, the global COVID-19 trend graph illustrates the cumulative confirmed, death, and recovered cases over time. The confirmed cases (blue) show a continuous upward trajectory, indicating the sustained spread of the virus. Death cases (red) follow a slower but steady rise, while recovered cases (green) increase at a higher rate, suggesting effective recovery efforts. However, data fluctuations in early 2020 and sharp drops in May indicate potential reporting inconsistencies, data corrections, or delayed case adjustments. Further analysis is needed to examine daily new cases, country-specific trends, and data anomalies for a clearer understanding of the pandemic's evolution.

```
]: import matplotlib.pyplot as plt


   # Aggregate data by date
   df_global_trend = df_final.groupby("Date")[["Confirmed_full", "Deaths_full", "Recovered_full"]].sum()

   plt.figure(figsize=(12, 6))
   plt.plot(df_global_trend.index, df_global_trend["Confirmed_full"], label="Confirmed Cases", color="blue")
   plt.plot(df_global_trend.index, df_global_trend["Deaths_full"], label="Deaths", color="red")
   plt.plot(df_global_trend.index, df_global_trend["Recovered_full"], label="Recovered", color="green")

   plt.xlabel("Date")
   plt.ylabel("Number of Cases")
   plt.title("Global Trend of COVID-19 Cases Over Time")
   plt.legend()
   plt.xticks(rotation=45)
   plt.grid(True)

   plt.show()
```