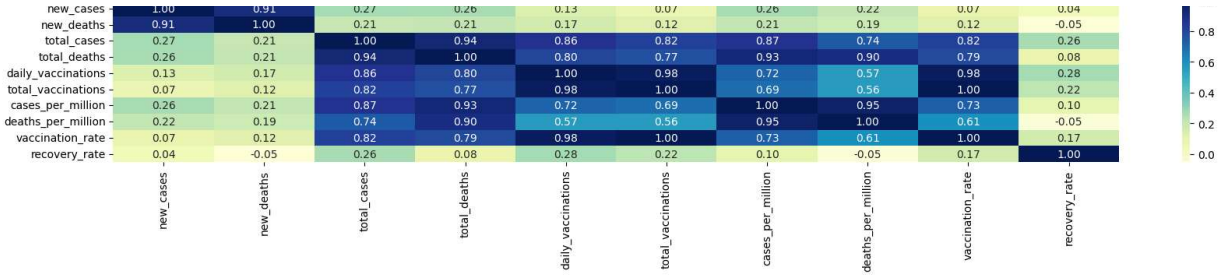
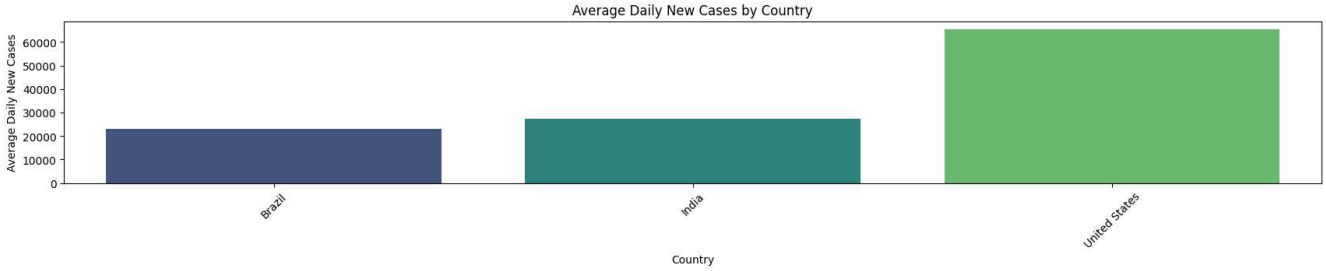
```
import pandas as pd  # Import pandas for data manipulation and analysis
import numpy as np  # Import numpy for numerical operations
import seaborn as sns  # Import seaborn for statistical data visualization
import matplotlib.pyplot as plt  # Import matplotlib for plotting
import plotly.express as px  # Import plotly for interactive visualizations
from sklearn.linear_model import LinearRegression  # Import LinearRegression for predictive analysis

# Load datasets from online sources
url_cases = "https://covid.ourworldindata.org/data/owid-covid-data.csv"
url_vaccinations = "https://covid.ourworldindata.org/data/vaccinations/vaccinations.csv"
url_population = "https://raw.githubusercontent.com/datasets/population/master/data/population.csv"

cases_data = pd.read_csv(url_cases)  # Load COVID-19 case data
vaccinations_data = pd.read_csv(url_vaccinations)  # Load vaccination data
population_data = pd.read_csv(url_population)  # Load population data

# Function to get the latest population of a given country
def get_population(country):
    pop = population_data[population_data['Country Name'] == country]  # Filter population data for the country
    if not pop.empty:
        return pop.iloc[-1]['Value']  # Return the latest population value if found
    return None  # Return None if no data found

# Function to analyze COVID-19 data
def analyze_covid_data(countries, start_date_str, end_date_str, metrics):
    combined_data = pd.DataFrame()  # Initialize an empty DataFrame to store combined data

    # Data collection and merging for each country
    for country in countries:
        # Extract case and vaccination data for the country
        cases_country = cases_data[cases_data['location'] == country][['date', 'new_cases', 'new_deaths', 'total_cases', 'total_deaths']]
        vaccinations_country = vaccinations_data[vaccinations_data['location'] == country][['date', 'daily_vaccinations', 'total_vaccinations

        # Check if data is available for the country
        if cases_country.empty or vaccinations_country.empty:
            print(f"No data found for {country}.")
            continue  # Skip to the next country if no data is found

        # Convert date columns to datetime format
        cases_country['date'] = pd.to_datetime(cases_country['date'])
        vaccinations_country['date'] = pd.to_datetime(vaccinations_country['date'])

        # Merge case and vaccination data on the date
        merged_data = pd.merge(cases_country, vaccinations_country, on='date', how='outer')
        merged_data.set_index('date', inplace=True)  # Set date as the index

        # Filter merged data by the specified date range
        start_date = pd.to_datetime(start_date_str)
        end_date = pd.to_datetime(end_date_str)
        merged_data = merged_data[(merged_data.index >= start_date) & (merged_data.index <= end_date)]

        # Get the population for the country
        population = get_population(country)
        if population:
            # Calculate metrics per million and vaccination rates
            merged_data['cases_per_million'] = (merged_data['total_cases'] / population) * 1_000_000
            merged_data['deaths_per_million'] = (merged_data['total_deaths'] / population) * 1_000_000
            merged_data['vaccination_rate'] = (merged_data['total_vaccinations'] / population) * 100
            merged_data['recovery_rate'] = (merged_data['total_cases'] - merged_data['total_deaths']) / merged_data['total_cases'] * 100

        # Add a column for the country name
        merged_data['country'] = country
        combined_data = pd.concat([combined_data, merged_data])  # Concatenate data for each country

    # Check if combined data is empty
    if combined_data.empty:
        print("No data available for the specified countries and date range.")
        return

    # Descriptive Analysis
    print("\nDescriptive Analysis:")
    print(combined_data.describe())  # Display descriptive statistics

    # Diagnostic Analysis
    print("\nDiagnostic Analysis:")
    numeric_data = combined_data.select_dtypes(include=[np.number])  # Select numeric columns for analysis
```

```
correlation_matrix = numeric_data.corr()  # Calculate correlation matrix
print("Correlation matrix between metrics:")
print(correlation_matrix)

# Visualizations
plt.figure(figsize=(18, 45))  # Set figure size

# Heatmap for Correlation between Metrics
plt.subplot(len(metrics) + 10, 1, 1)  # Create a subplot for the heatmap
sns.heatmap(correlation_matrix, annot=True, cmap="YlGnBu", fmt=".2f")  # Draw the heatmap
plt.title("Correlation Heatmap of Metrics")
plt.tight_layout()

# Bar Chart for Average Daily New Cases
plt.subplot(len(metrics) + 10, 1, 2)  # Create a subplot for bar chart
avg_daily_cases = combined_data.groupby('country')['new_cases'].mean().reset_index()  # Calculate average daily cases
sns.barplot(data=avg_daily_cases, x='country', y='new_cases', palette='viridis')  # Draw the bar chart
plt.title("Average Daily New Cases by Country")
plt.xlabel("Country")
plt.ylabel("Average Daily New Cases")
plt.xticks(rotation=45)  # Rotate x-axis labels

# Pie Chart for Total Cases Distribution
plt.subplot(len(metrics) + 10, 1, 3)  # Create a subplot for pie chart
total_cases_per_country = combined_data.groupby('country')['total_cases'].max().reset_index()  # Get total cases per country
plt.pie(total_cases_per_country['total_cases'], labels=total_cases_per_country['country'], autopct='%1.1f%%', startangle=140)  # Draw the
plt.title("Total Cases Distribution by Country")

# Line Chart for New Cases, New Deaths, and Daily Vaccinations
for i, metric in enumerate(['new_cases', 'new_deaths', 'daily_vaccinations'], 4):
    plt.subplot(len(metrics) + 10, 1, i)  # Create a subplot for each metric
    for country in countries:
        country_data = combined_data[combined_data['country'] == country]  # Filter data for the country
        if not country_data.empty and country_data[metric].notna().any():  # Check for non-empty data
            sns.lineplot(data=country_data, x=country_data.index, y=metric, label=country)  # Draw line plot for the metric

    plt.title(f"{metric.replace('_', ' ').title()} Over Time")  # Set title for the plot
    plt.xlabel("Date")
    plt.ylabel(metric.replace("_", " ").title())  # Set ylabel
    plt.legend()  # Add legend

# Histogram for New Cases Distribution
plt.subplot(len(metrics) + 10, 1, 8)  # Create a subplot for the histogram
sns.histplot(combined_data['new_cases'].dropna(), bins=30, kde=True)  # Draw histogram with KDE
plt.title("Distribution of New Cases")
plt.xlabel("New Cases")
plt.ylabel("Frequency")

# Scatter Plot for Cases per Million vs Deaths per Million
plt.subplot(len(metrics) + 10, 1, 9)  # Create a subplot for the scatter plot
valid_data = combined_data.dropna(subset=['cases_per_million', 'deaths_per_million'])  # Drop rows with NaN values
if not valid_data.empty:
    sns.scatterplot(data=valid_data, x='cases_per_million', y='deaths_per_million', hue='country', palette='deep')  # Draw scatter plot
    plt.title("Cases per Million vs Deaths per Million by Country")
    plt.xlabel("Cases per Million")
    plt.ylabel("Deaths per Million")

plt.tight_layout()  # Adjust layout
plt.show()  # Display plots

# Plotly General Chart for all selected metrics
for country in countries:
    country_data = combined_data[combined_data['country'] == country].reset_index()  # Reset index for plotly
    fig = px.line(country_data, x='date', y=metrics,
                  title=f'COVID-19 Metrics Over Time for {country}',
                  labels={'value': 'Count', 'variable': 'Metrics'},
                  template='plotly_dark')  # Create a plotly line chart
    fig.show()  # Show plotly figure

# Predictive Analysis
print("\nPredictive Analysis:")
for country in countries:
    country_data = combined_data[combined_data['country'] == country]  # Filter data for the country
    if not country_data.empty:
        # Preparing data for linear regression
        country_data = country_data[['new_cases']].reset_index()  # Reset index for linear regression
        country_data['date_ordinal'] = country_data['date'].map(pd.Timestamp.toordinal)  # Convert dates to ordinal format
```

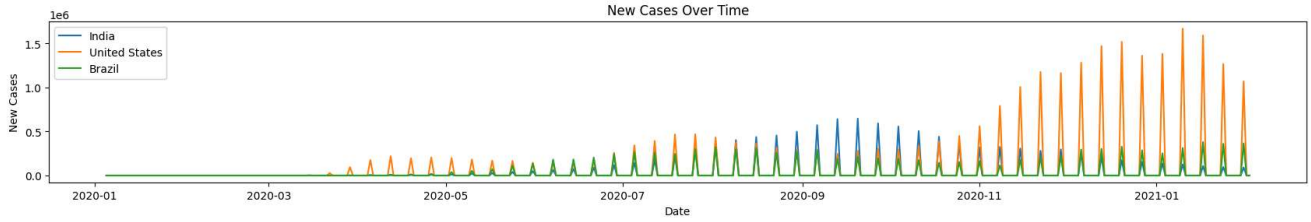
```
            # Fit a linear regression model
            X = country_data[['date_ordinal']]  # Independent variable
            y = country_data['new_cases'].fillna(0)  # Dependent variable, filling NaNs with 0
            model = LinearRegression()  # Create linear regression model
            model.fit(X, y)  # Fit the model

            # Making predictions
            future_dates = pd.date_range(start=country_data['date'].max() + pd.Timedelta(days=1), periods=30)  # Generate future dates
            future_dates_ordinal = future_dates.map(pd.Timestamp.toordinal).values.reshape(-1, 1)  # Convert future dates to ordinal
            predictions = model.predict(future_dates_ordinal)  # Make predictions

            # Visualizing predictions
            plt.figure(figsize=(10, 6))  # Set figure size for predictions
            plt.plot(country_data['date'], country_data['new_cases'], label='Historical New Cases', color='blue')  # Plot historical data
            plt.plot(future_dates, predictions, label='Predicted New Cases', color='orange')  # Plot predictions
            plt.title(f'Predicted New Cases for {country}')  # Set title
            plt.xlabel('Date')
            plt.ylabel('New Cases')
            plt.legend()  # Add legend
            plt.xticks(rotation=45)  # Rotate x-axis labels
            plt.show()  # Display prediction plot

    # Prescriptive Analysis
    print("\nPrescriptive Analysis:")
    # Simple rules or recommendations based on the latest data
    for country in countries:
        country_data = combined_data[combined_data['country'] == country]  # Filter data for the country
        if not country_data.empty:
            latest_data = country_data.iloc[-1]  # Get the latest data for the country
            print(f"Recommendations for {country}:")
            # Check vaccination and recovery rates to provide recommendations
            if latest_data['vaccination_rate'] < 70:
                print("- Increase vaccination campaigns.")
            if latest_data['recovery_rate'] < 90:
                print("- Focus on improving healthcare infrastructure and recovery protocols.")

# User input for analysis
print("COVID-19 Data Analysis")
user_start_date = input("Enter the start date in YYYY-MM-DD format (e.g., '2021-01-01'): ")
user_end_date = input("Enter the end date in YYYY-MM-DD format (e.g., '2021-12-31'): ")

user_countries = input("Enter the country names (comma-separated, e.g., 'India, United States, Brazil'): ")
countries_list = [country.strip() for country in user_countries.split(',')]  # Create a list of countries

# Define available metrics for visualization
available_metrics = ['new_cases', 'new_deaths', 'total_cases', 'total_deaths', 'daily_vaccinations', 'total_vaccinations', 'recovery_rate', '
print("\nAvailable metrics to visualize:", available_metrics)

user_metrics = [metric.strip() for metric in input("Enter metrics to visualize (comma-separated): ").split(',')]  # Get user-defined metrics
user_metrics = [metric for metric in user_metrics if metric in available_metrics]  # Filter metrics based on availability

# Call the analysis function with validated input
analyze_covid_data(countries_list, user_start_date, user_end_date, user_metrics)
```

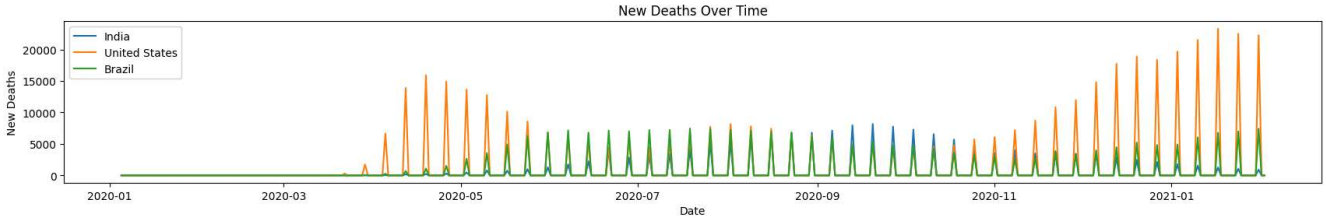
```
COVID-19 Data Analysis
Enter the start date in YYYY-MM-DD format (e.g., '2021-01-01'): 2019-02-02
Enter the end date in YYYY-MM-DD format (e.g., '2021-12-31'): 2021-02-02
Enter the country names (comma-separated, e.g., 'India, United States, Brazil'): India, United States, Brazil

Available metrics to visualize: ['new_cases', 'new_deaths', 'total_cases', 'total_deaths', 'daily_vaccinations', 'total_vaccinations', '
Enter metrics to visualize (comma-separated): new_cases, total_cases

Descriptive Analysis:
          new_cases    new_deaths   total_cases   total_deaths  \
count  1.185000e+03   1185.000000  1.185000e+03    1185.000000
mean   3.858880e+04    699.631224  4.145087e+06   96044.806751
std    1.595090e+05   2533.500104  5.106481e+06   98454.431616
min    0.000000e+00      0.000000  0.000000e+00       0.000000
25%    0.000000e+00      0.000000  2.649600e+04     824.000000
50%    0.000000e+00      0.000000  2.153010e+06   79827.000000
75%    0.000000e+00      0.000000  6.796322e+06  153214.000000
max    1.667151e+06  23312.000000  2.586303e+07  452123.000000

       daily_vaccinations  total_vaccinations  cases_per_million  \
count        8.500000e+01        8.800000e+01        1185.000000
mean         5.098592e+05        8.973659e+06       11360.212604
std          4.568875e+05        1.159965e+07       15836.276891
min          9.970000e+02        0.000000e+00           0.000000
25%          1.822300e+05        1.045193e+06          42.253346
50%          2.968930e+05        2.972606e+06        4819.349614
75%          9.376920e+05        1.338541e+07       18890.756739
max          1.493026e+06        4.119782e+07       77925.641533

       deaths_per_million  vaccination_rate  recovery_rate
count         1185.000000         88.000000    1080.000000
mean           293.418975          2.641500      97.202970
std            347.493128          3.534550       1.640581
min              0.000000          0.000000      93.074818
25%              1.126867          0.165739      96.650020
50%             99.591930          0.881718      97.257887
75%            583.512051          4.033041      98.283198
max           1362.252247         12.412954     100.000000

Diagnostic Analysis:
Correlation matrix between metrics:
                    new_cases  new_deaths  total_cases  total_deaths  \
new_cases            1.000000    0.907235     0.269764      0.260520
new_deaths           0.907235    1.000000     0.207278      0.214541
total_cases          0.269764    0.207278     1.000000      0.936397
total_deaths         0.260520    0.214541     0.936397      1.000000
daily_vaccinations   0.131788    0.169131     0.863561      0.804891
total_vaccinations   0.068279    0.117451     0.816996      0.770008
cases_per_million    0.256876    0.213810     0.867446      0.927979
deaths_per_million   0.217127    0.193110     0.744785      0.901732
vaccination_rate     0.074072    0.123565     0.821496      0.791870
recovery_rate        0.040855   -0.051620     0.257356      0.082083

                    daily_vaccinations  total_vaccinations  cases_per_million  \
new_cases                     0.131788            0.068279           0.256876
new_deaths                    0.169131            0.117451           0.213810
total_cases                   0.863561            0.816996           0.867446
total_deaths                  0.804891            0.770008           0.927979
daily_vaccinations            1.000000            0.979255           0.715656
total_vaccinations            0.979255            1.000000           0.690603
cases_per_million             0.715656            0.690603           1.000000
deaths_per_million            0.568331            0.559017           0.953064
vaccination_rate              0.976248            0.997241           0.726154
recovery_rate                 0.275938            0.222542           0.100733

                    deaths_per_million  vaccination_rate  recovery_rate
new_cases                     0.217127          0.074072       0.040855
new_deaths                    0.193110          0.123565      -0.051620
total_cases                   0.744785          0.821496       0.257356
total_deaths                  0.901732          0.791870       0.082083
daily_vaccinations            0.568331          0.976248       0.275938
total_vaccinations            0.559017          0.997241       0.222542
cases_per_million             0.953064          0.726154       0.100733
deaths_per_million            1.000000          0.605576      -0.047489
vaccination_rate              0.605576          1.000000       0.170209
recovery_rate                -0.047489          0.170209       1.000000
<ipython-input-3-bd08e9fe0737>:93: FutureWarning:


Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend
```

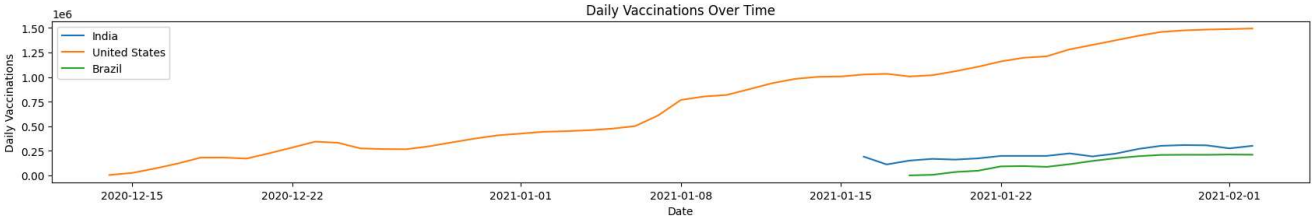

new_cases 1.00 0.91 0.27 0.26 0.13 0.07 0.26 0.22 0.07 0.04
new_deaths 0.91 1.00 0.21 0.21 0.17 0.12 0.21 0.19 0.12 -0.05
total_cases 0.27 0.21 1.00 0.94 0.86 0.82 0.87 0.74 0.82 0.26
total_deaths 0.26 0.21 0.94 1.00 0.80 0.77 0.93 0.90 0.79 0.08
daily_vaccinations 0.13 0.17 0.86 0.80 1.00 0.98 0.72 0.57 0.98 0.28
total_vaccinations 0.07 0.12 0.82 0.77 0.98 1.00 0.69 0.56 1.00 0.22
cases_per_million 0.26 0.21 0.87 0.93 0.72 0.69 1.00 0.95 0.73 0.10
deaths_per_million 0.22 0.19 0.74 0.90 0.57 0.56 0.95 1.00 0.61 -0.05
vaccination_rate 0.07 0.12 0.82 0.79 0.98 1.00 0.73 0.61 1.00 0.17
recovery_rate 0.04 -0.05 0.26 0.08 0.28 0.22 0.10 -0.05 0.17 1.00
new_cases new_deaths total_cases total_deaths daily_vaccinations total_vaccinations cases_per_million deaths_per_million vaccination_rate recovery_rate
0.8 0.6 0.4 0.2 0.0

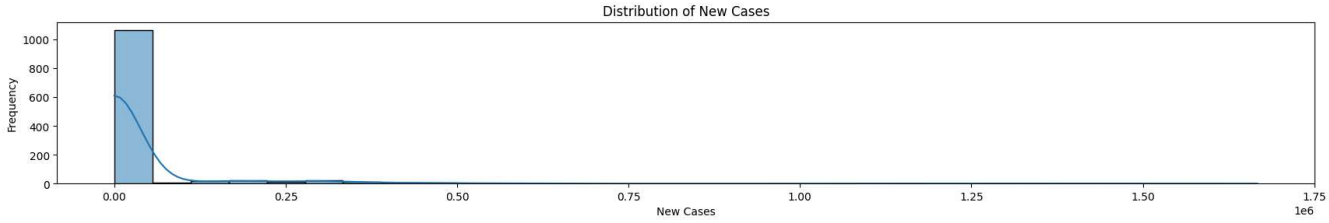

Average Daily New Cases by Country
Average Daily New Cases
60000 50000 40000 30000 20000 10000 0
Brazil
India
United States
Country

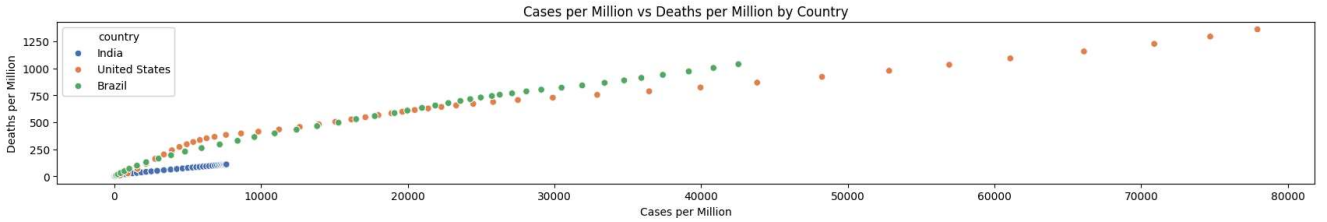

Total Cases Distribution by Country
United States
56.6%
Brazil
19.9%
23.5%
India

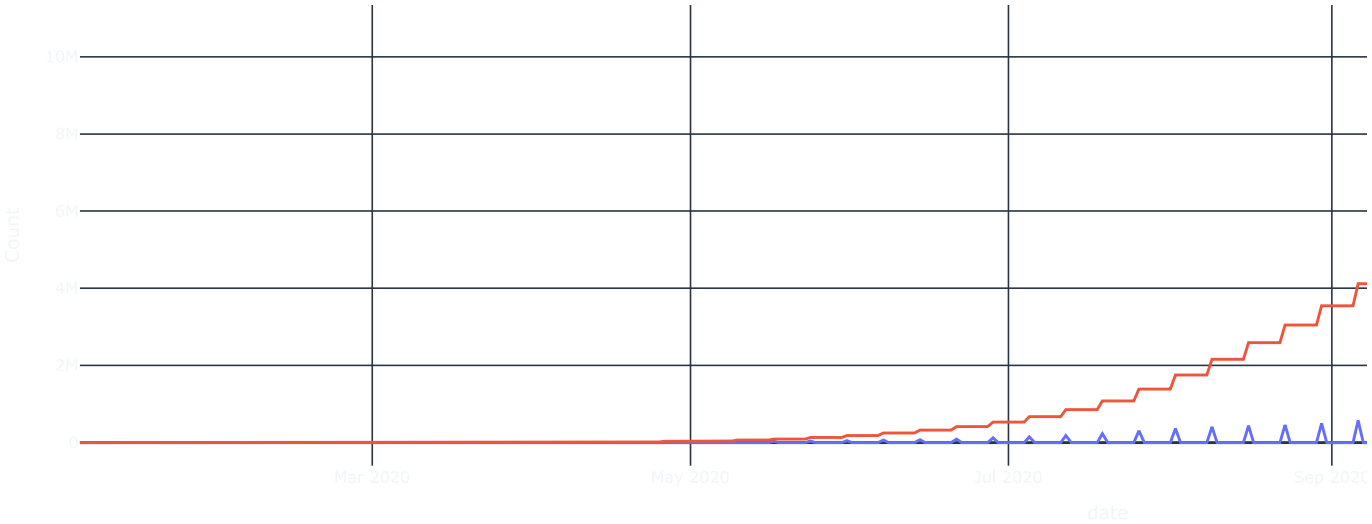

New Cases Over Time
1e6
India
United States
Brazil
New Cases
1.5 1.0 0.5 0.0
2020-01 2020-03 2020-05 2020-07 2020-09 2020-11 2021-01
Date

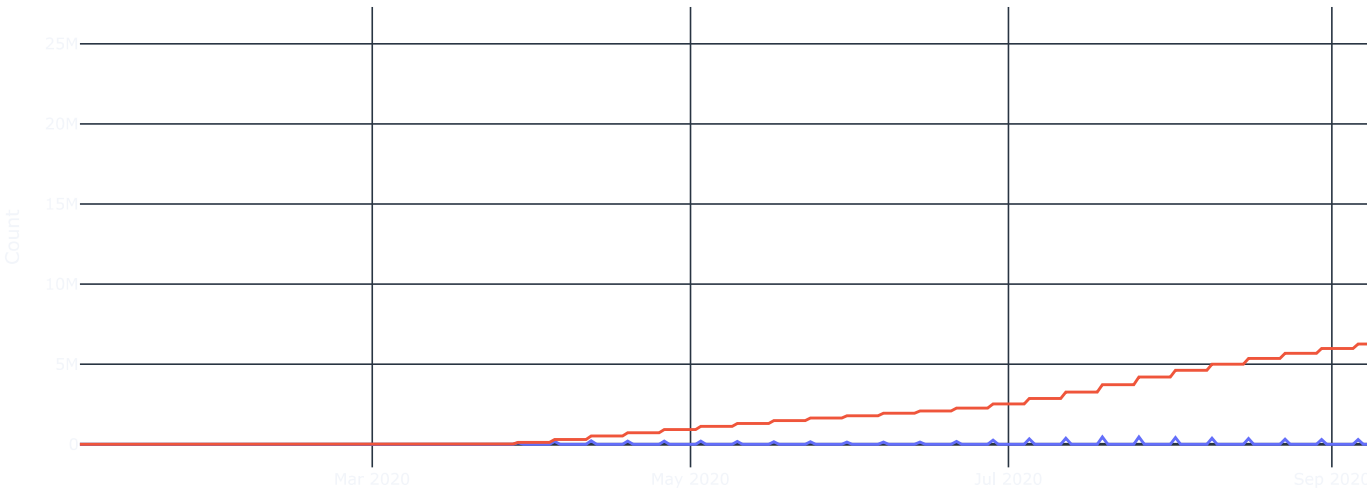

New Deaths Over Time
India
United States
Brazil
New Deaths
20000 15000 10000 5000 0
2020-01 2020-03 2020-05 2020-07 2020-09 2020-11 2021-01
Date

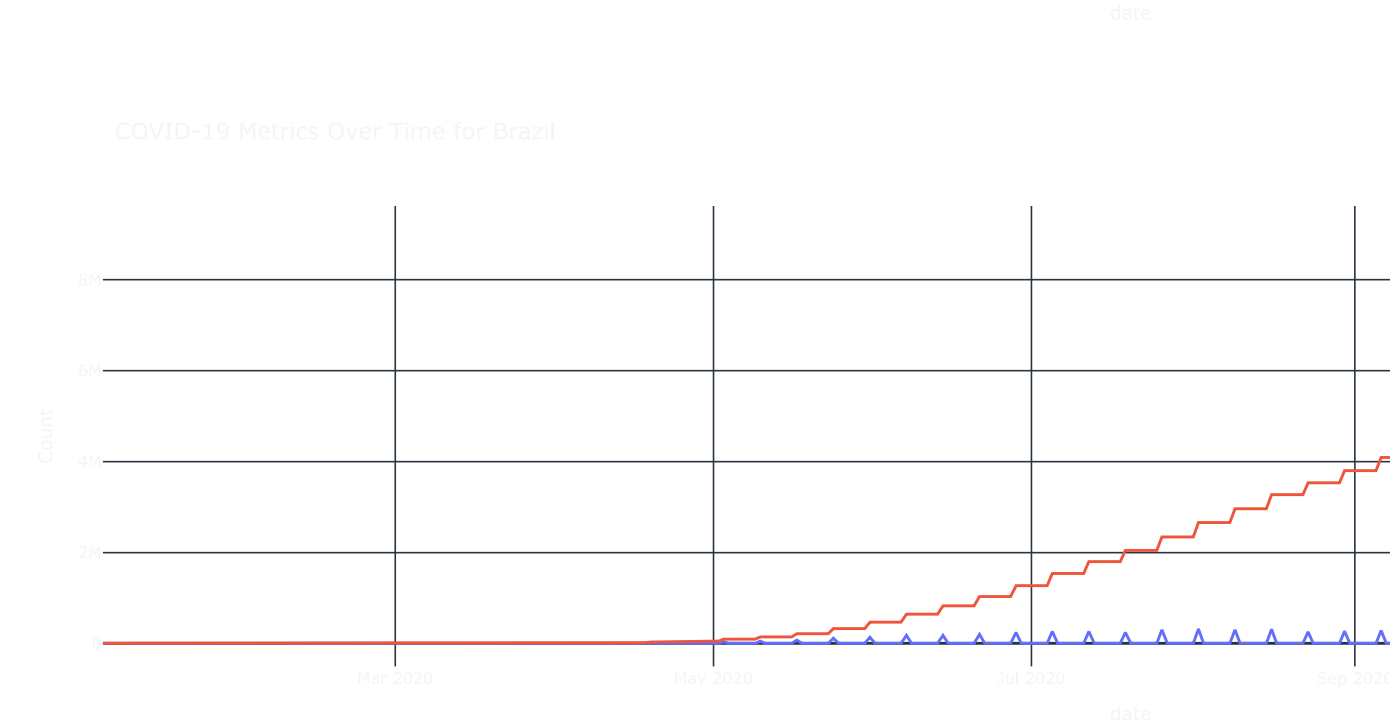

Daily Vaccinations Over Time
1e6
India
United States
Brazil
Daily Vaccinations
1.50 1.25 1.00 0.75 0.50 0.25 0.00
2020-12-15 2020-12-22 2021-01-01 2021-01-08 2021-01-15 2021-01-22 2021-02-01
Date


Distribution of New Cases
Frequency
New Cases
1e6

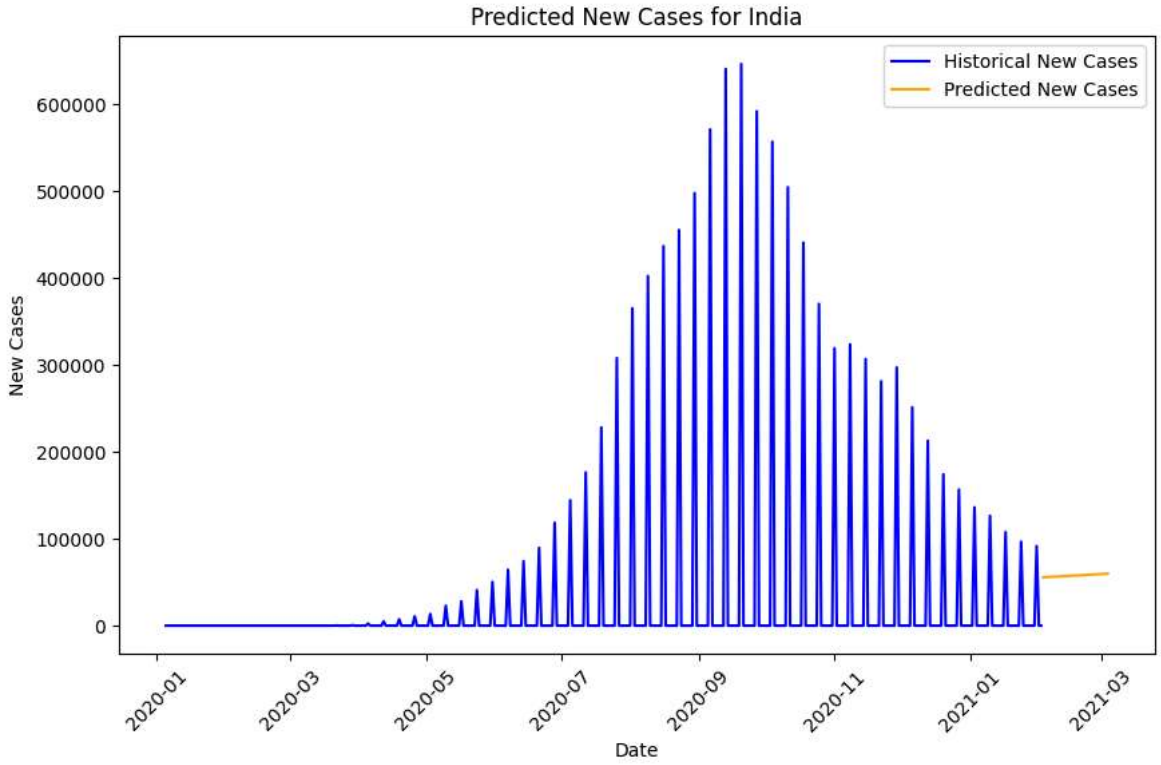

Cases per Million vs Deaths per Million by Country
country
India
United States
Brazil
Deaths per Million
Cases per Million


COVID-19 Metrics Over Time for India
Count
date

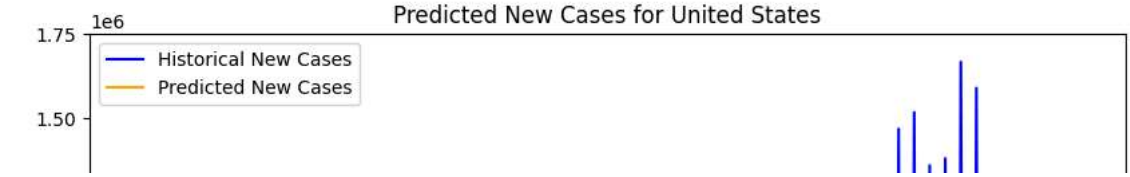

COVID-19 Metrics Over Time for United States
Count

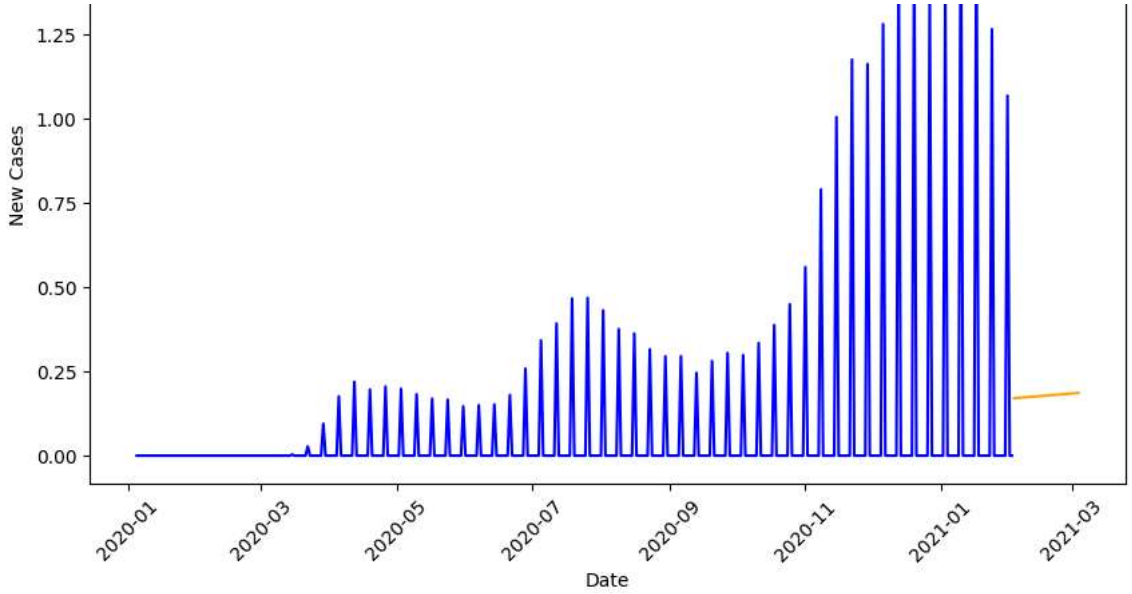



```
Predictive Analysis:
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:493: UserWarning:

X does not have valid feature names, but LinearRegression was fitted with feature names
```

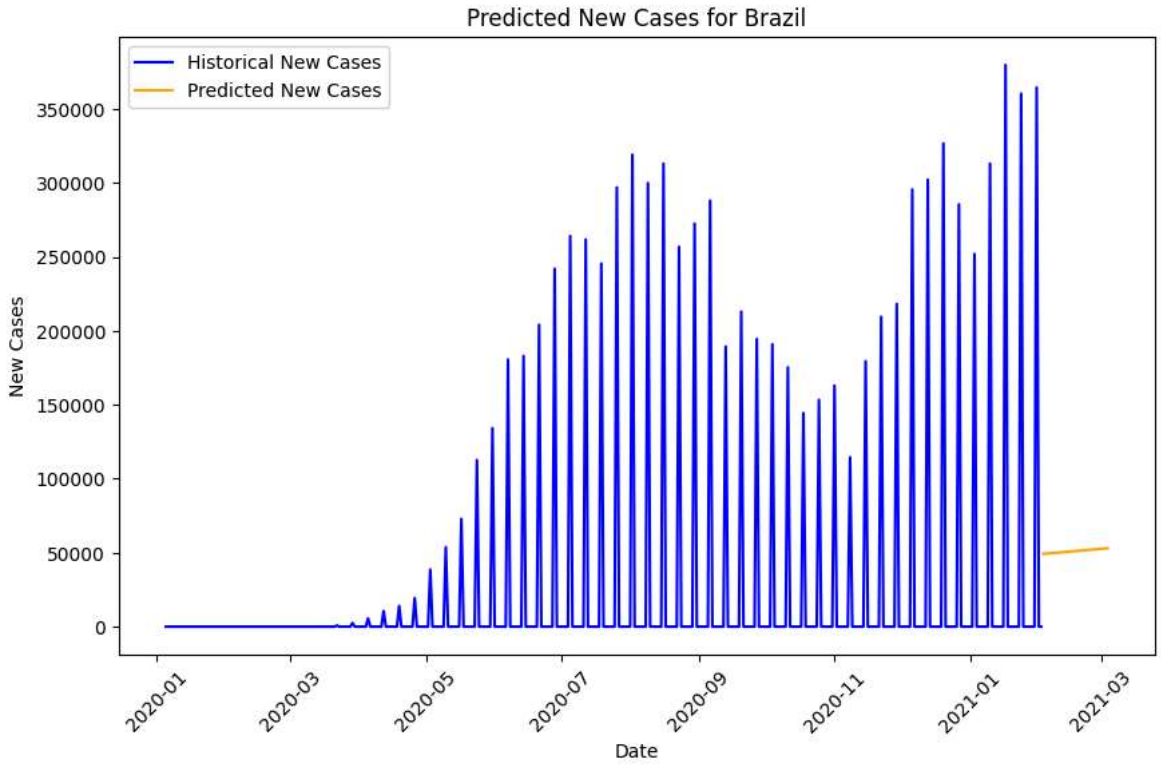



```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:493: UserWarning:

X does not have valid feature names, but LinearRegression was fitted with feature names
```






```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:493: UserWarning:

X does not have valid feature names, but LinearRegression was fitted with feature names
```




```
Prescriptive Analysis:
Recommendations for India:
- Increase vaccination campaigns.
Recommendations for United States:
- Increase vaccination campaigns.
Recommendations for Brazil:
- Increase vaccination campaigns.
```