Indonesian Scholar Scientific Summit (I3S) | 2021
Rebuilding Post-Pandemic Societies

Forecasting Covid-19 Vaccines

Type of Vaccines

COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)

Last Updated at (M/D/YYYY)
18/06/2021, 10:22

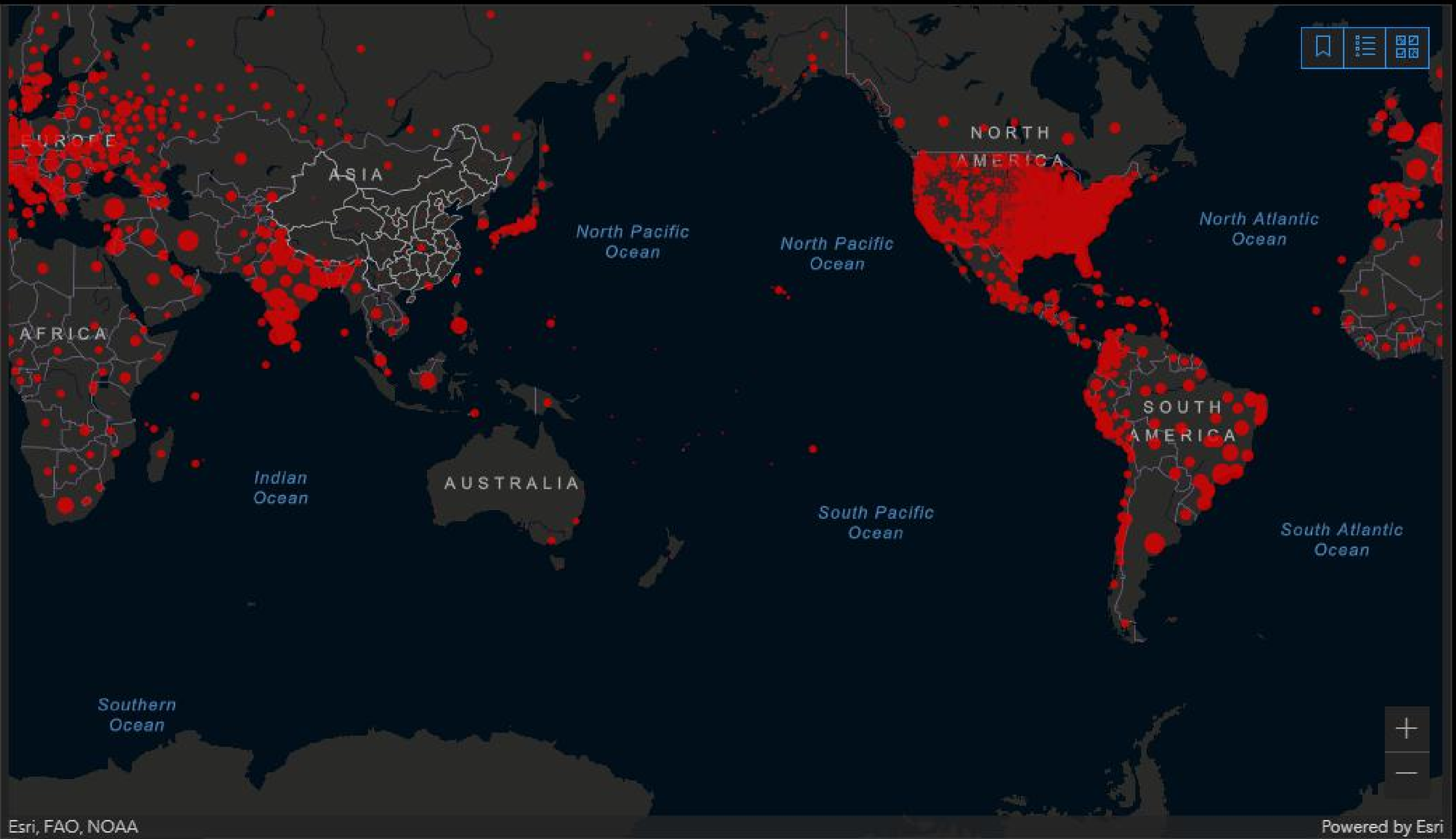
Cases
177,363,051

Deaths
3,840,426

Vaccine Doses Administered
2,485,778,224

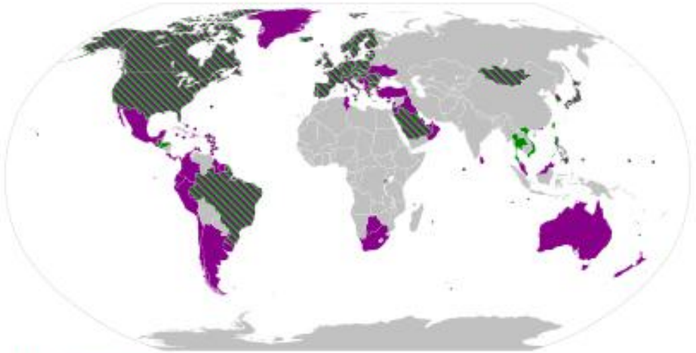
Cases and Deaths by Country/Region/Sovereignty

Cases	Deaths	Country/Region/Sovereignty
33,508,737	600,937	US
29,700,313	381,903	India
17,702,630	496,004	Brazil
5,811,461	110,796	France
5,354,153	49,012	Turkey
5,203,117	125,853	Russia
4,616,628	128,209	United Kingdom
4,249,755	127,190	Italy
4,222,400	87,789	Argentina
3,859,824	98,156	Colombia
3,753,228	80,634	Spain

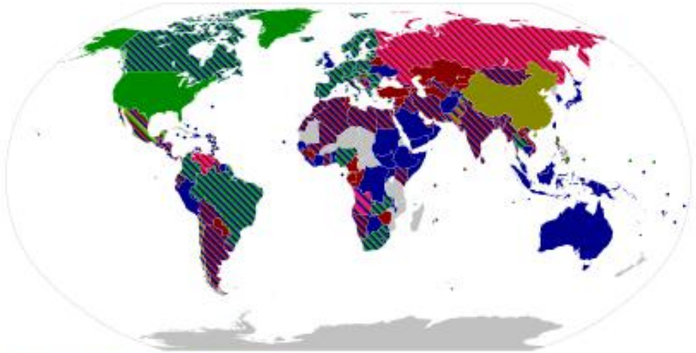


Vaccines for Covid19

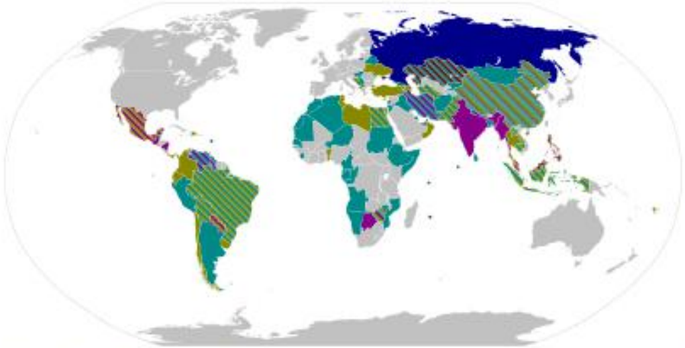
13 different vaccines
(across 4 platforms)
have been administered



RNA vaccines
- Pfizer–BioNTech
- Moderna



Adenovirus vector vaccines
- Oxford–AstraZeneca
- Sputnik V
- Johnson & Johnson
- Convidecia
- Sputnik Light



Inactivated virus vaccines
- Sinopharm (BBIBP)
- CoronaVac
- Covaxin
- Sinopharm (WIBP)
- CoviVac
- QazCovid-in

Protein subunit vaccines
- EpiVacCorona
- RBD-Dimer

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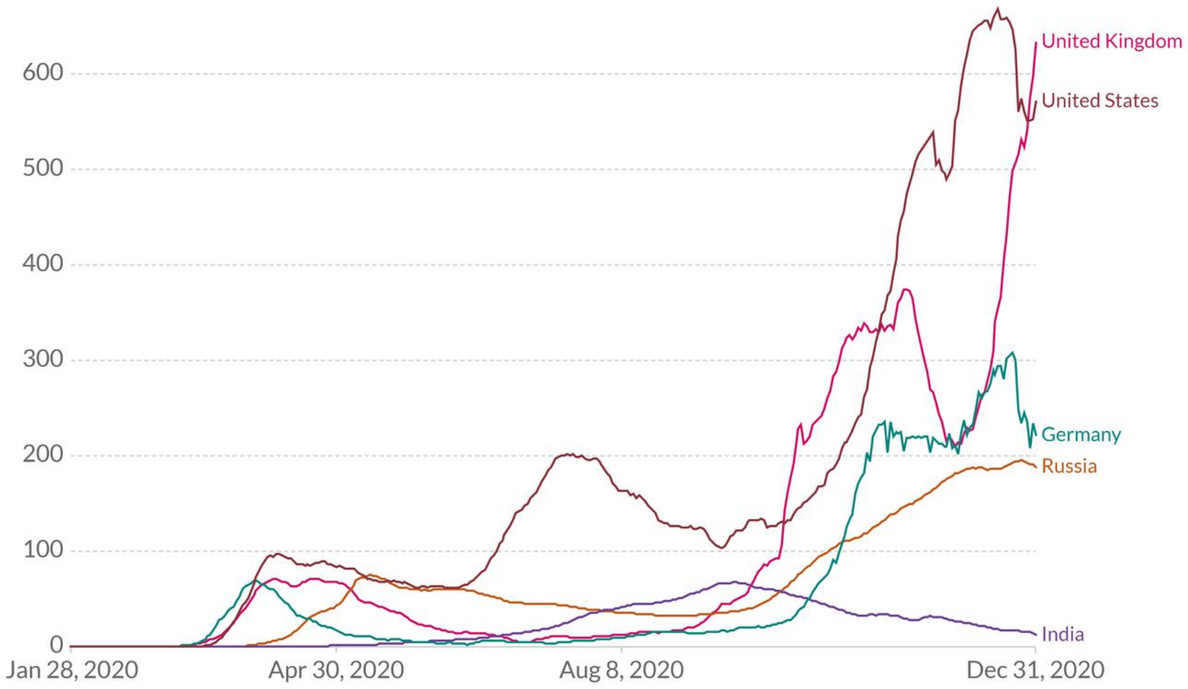
Depend on Type of Vaccine

Covid19 Cases

Before Vaccine

Daily new confirmed COVID-19 cases per million people

Shown is the rolling 7-day average. The number of confirmed cases is lower than the number of actual cases; the main reason for that is limited testing.



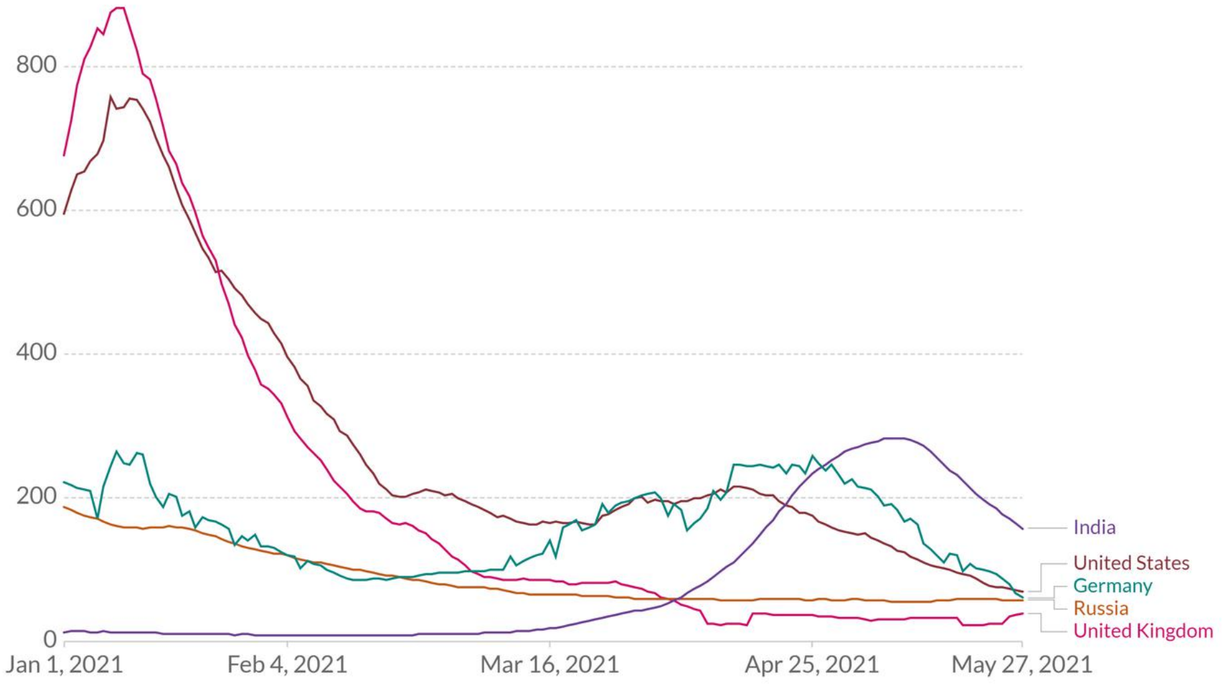
Source: Johns Hopkins University CSSE COVID-19 Data

CC BY

After Vaccine

Daily new confirmed COVID-19 cases per million people

Shown is the rolling 7-day average. The number of confirmed cases is lower than the number of actual cases; the main reason for that is limited testing.



Source: Johns Hopkins University CSSE COVID-19 Data

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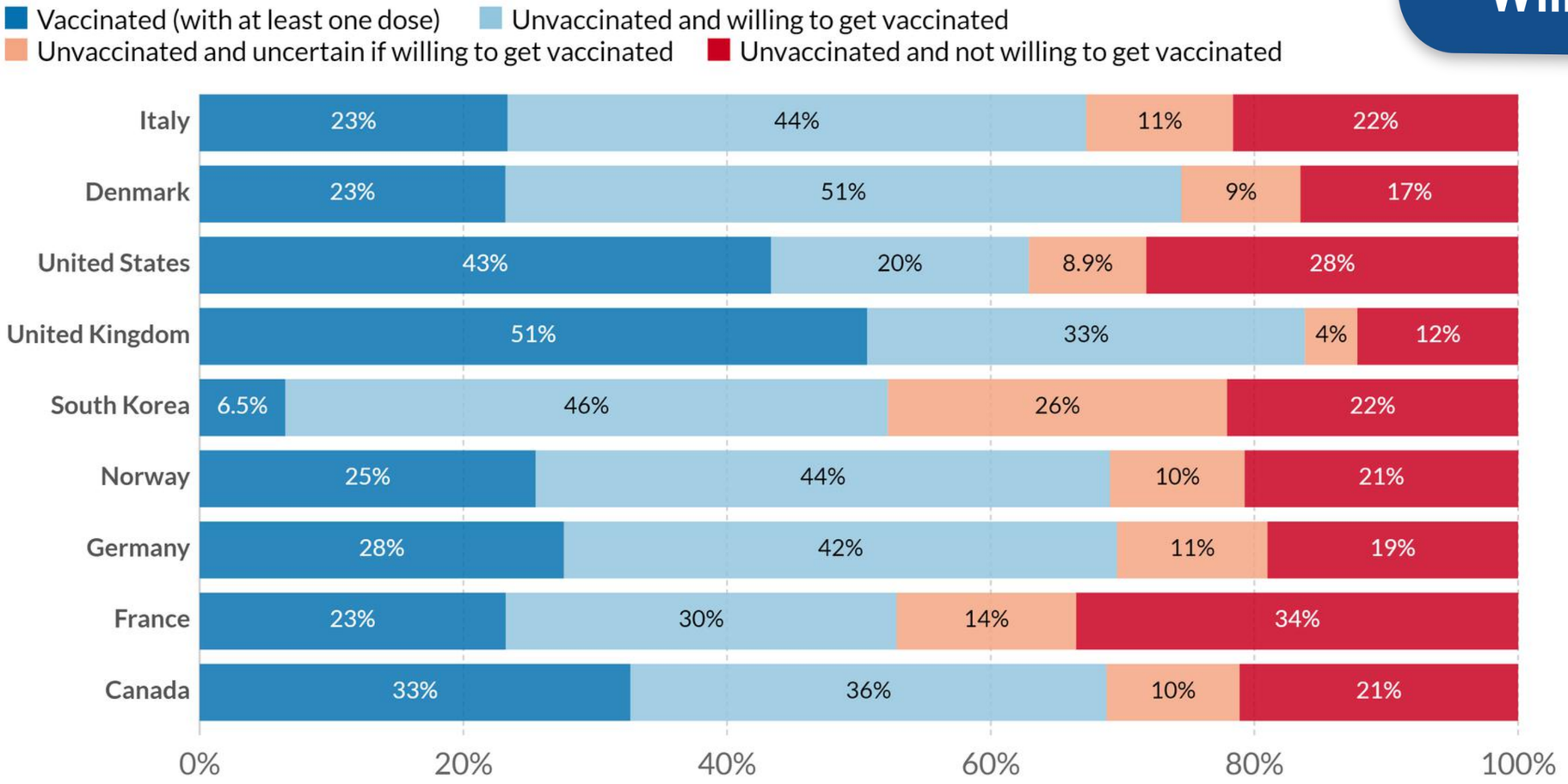
Willingness to get vaccinated against COVID, Apr 30, 2021

Share who have not received a COVID vaccine and who are willing vs. unwilling vs. uncertain if they would get a vaccine this week if it was available to them. Also shown is the share who have already received at least one dose of a COVID vaccine.

Our World in Data

Willingness



Progress Vaccinations on Country who have been got Dozen of Vaccine

Source: Official data collated by Our World in Data – Last updated 11 May, 10:00 (London time) OurWorldInData.org/coronavirus • CC BY
Note: Months containing fewer than 500 survey respondents are excluded. Estimates of willingness to get vaccinated are based on survey responses of people aged 18 years and above.

Vaccine's Prediction

Take **more than a year** to produce enough vaccines to inoculate the World's 50 million medical staff, and that could be **September 2023** before we have enough doses for the whole World.

— **Anthony McDonnell, Robert Van Exan, Steve Lloyd, et.al**

Related Study

De Figueiredo

United Kingdom is the government chose to distribute its vaccine variants, namely AstraZeneca and Pfizer-BioNTech [2]. The government has such confidence that the vaccine's findings are compatible with the physiology of its citizens

Trtica-Majnaric et al.

Describes future forecasting on influenza vaccines using two deep learning comparison methods, namely Linear Regression and Neural Network [3]. forecasting using the NN model is better than the LR model, with an average hit rate of 72%.

Main Contributions

- Trends in the distribution of Covid19 Vaccines
- Comparision of the original and predicted values generated in the Covid19 vaccine trend
- Future forecasting results from Covid19 vaccines data
- Evaluate the accuracy and precision of the tested data

Dataset COVID-19 World Vaccination Progress
https://www.kaggle.com/gpreda/covid-world-vaccination-progress

Dataset COVID-19

Dataset COVID-19 World Vaccination Progress [4]

No	Columns	Non-Null Count	Dtype
1	Country	15666 non-null	Object
2	Iso_code	15666 non-null	Object
3	Date	15666 non-null	Datetime64[ns]
4	Total_vaccinations	15666 non-null	Float64
5	People_vaccinated	15666 non-null	Float64
6	People_fully_vaccinated	15666 non-null	Float64
7	Daily_vaccinations_raw	15666 non-null	Float64
8	Daily_vaccinations	15666 non-null	Float64
9	Total_vaccinations_per_hundred	15666 non-null	Float64
10	People_vaccinated_per_hundred	15666 non-null	Float64
11	People_fully_vaccinated_per_hundred	15666 non-null	Float64
12	Daily_vaccinations_per_million	15666 non-null	Float64
13	Vaccines	15666 non-null	Object
14	Source_name	15666 non-null	Object
15	Source_website	15666 non-null	Object

Methods

Facebook Prophet

$$y(t) = g(t) + s(t) + h(t) + \epsilon_t$$

Our approach uses the Prophet according to trend data based on daily, weekly, and yearly seasonality to present data based on the data obtained where g(t) is trend function, s(t) representative periodic changes data, h(t) represents the holiday condition of the data, and ϵ_t is function customarily distributed data [5].

ARIMA

$$Order\ of\ (p, d, q)$$

The regression value of the ARIMA model characteristics by choosing the order of p, d, and q where p is the order (number of time lags) of the autoregressive model, d is the degree of differencing, and q is the order of the model moving average [6].

Dataset

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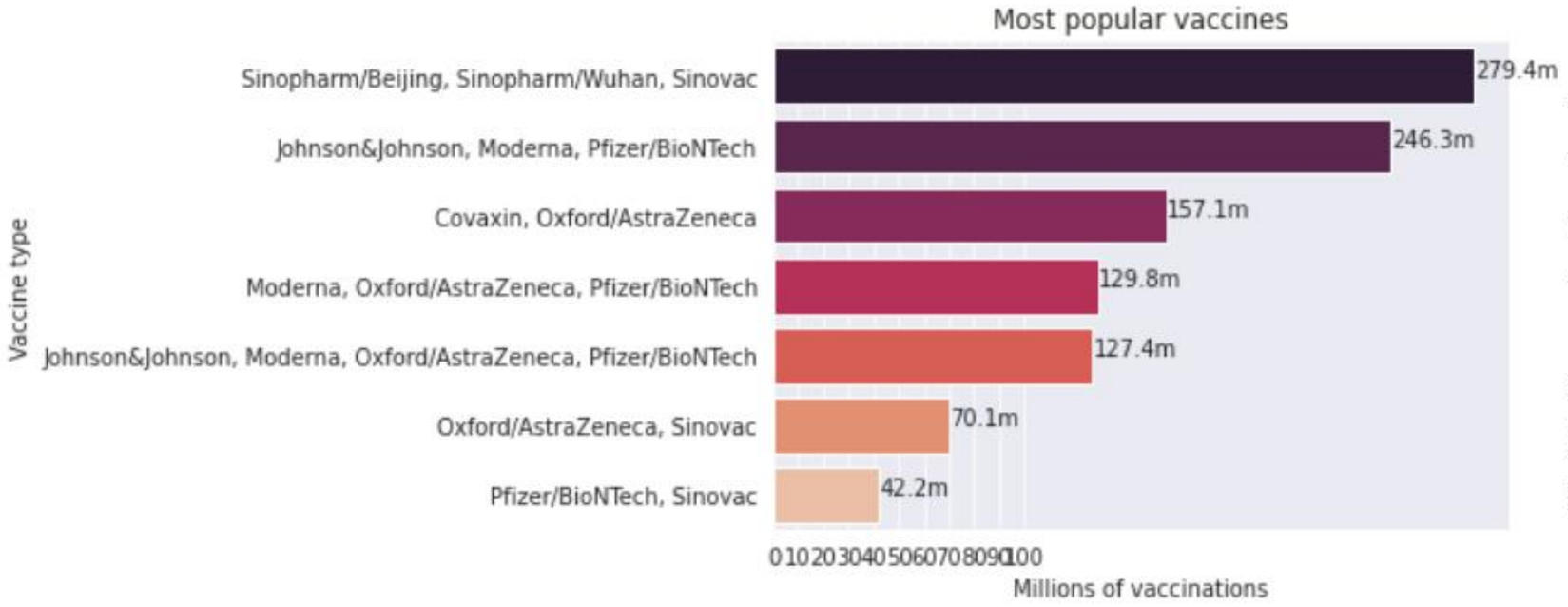
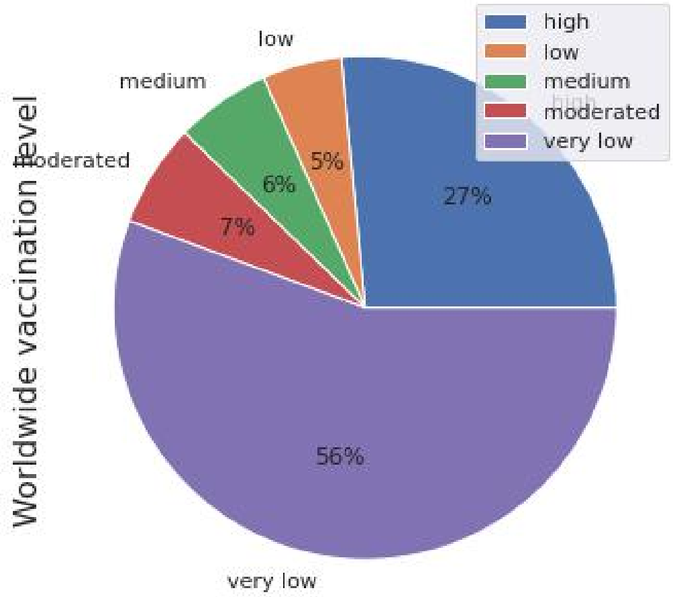
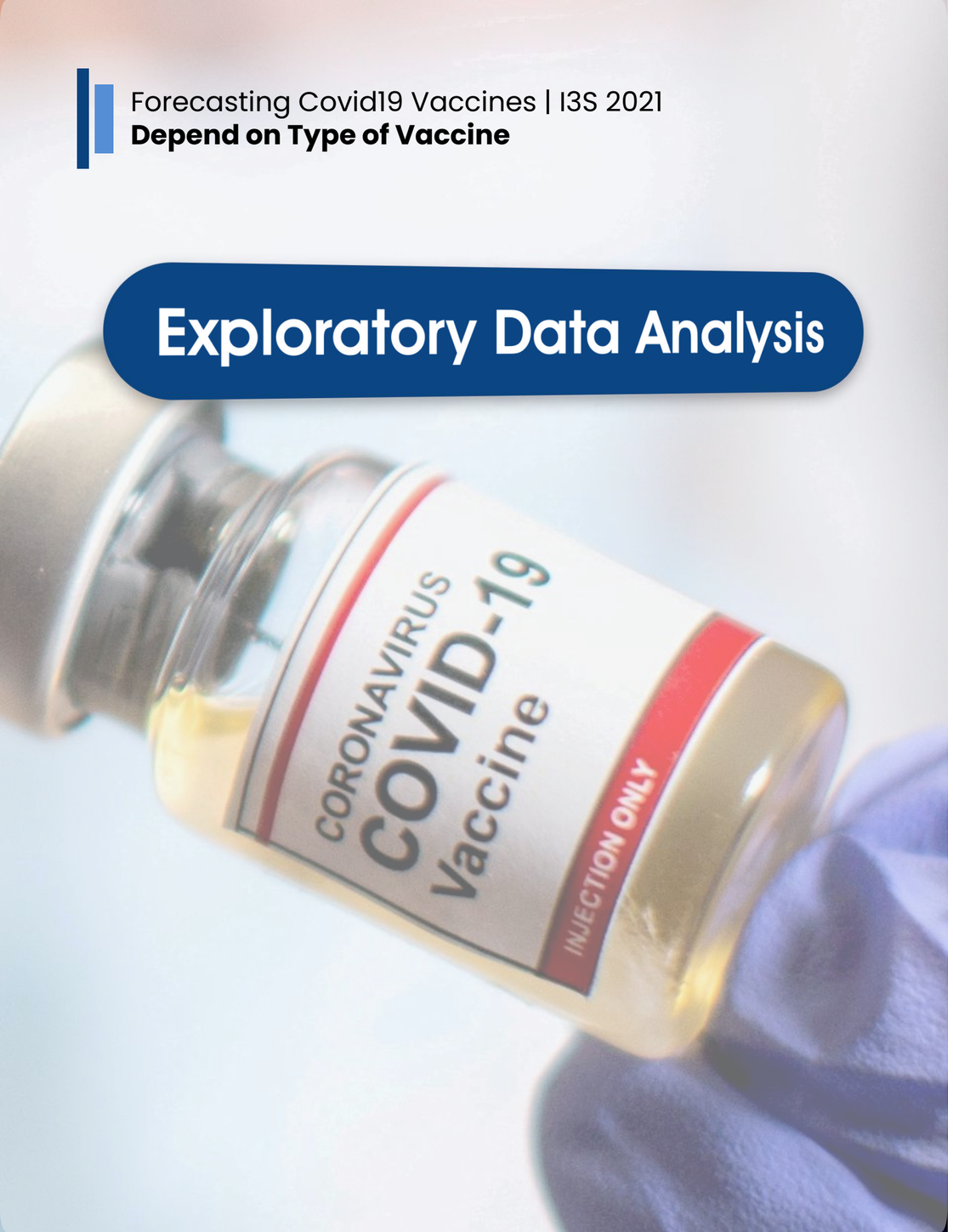
Exploratory Data Analysis

Most Popular Vaccines





Exploratory Data Analysis



Dataset

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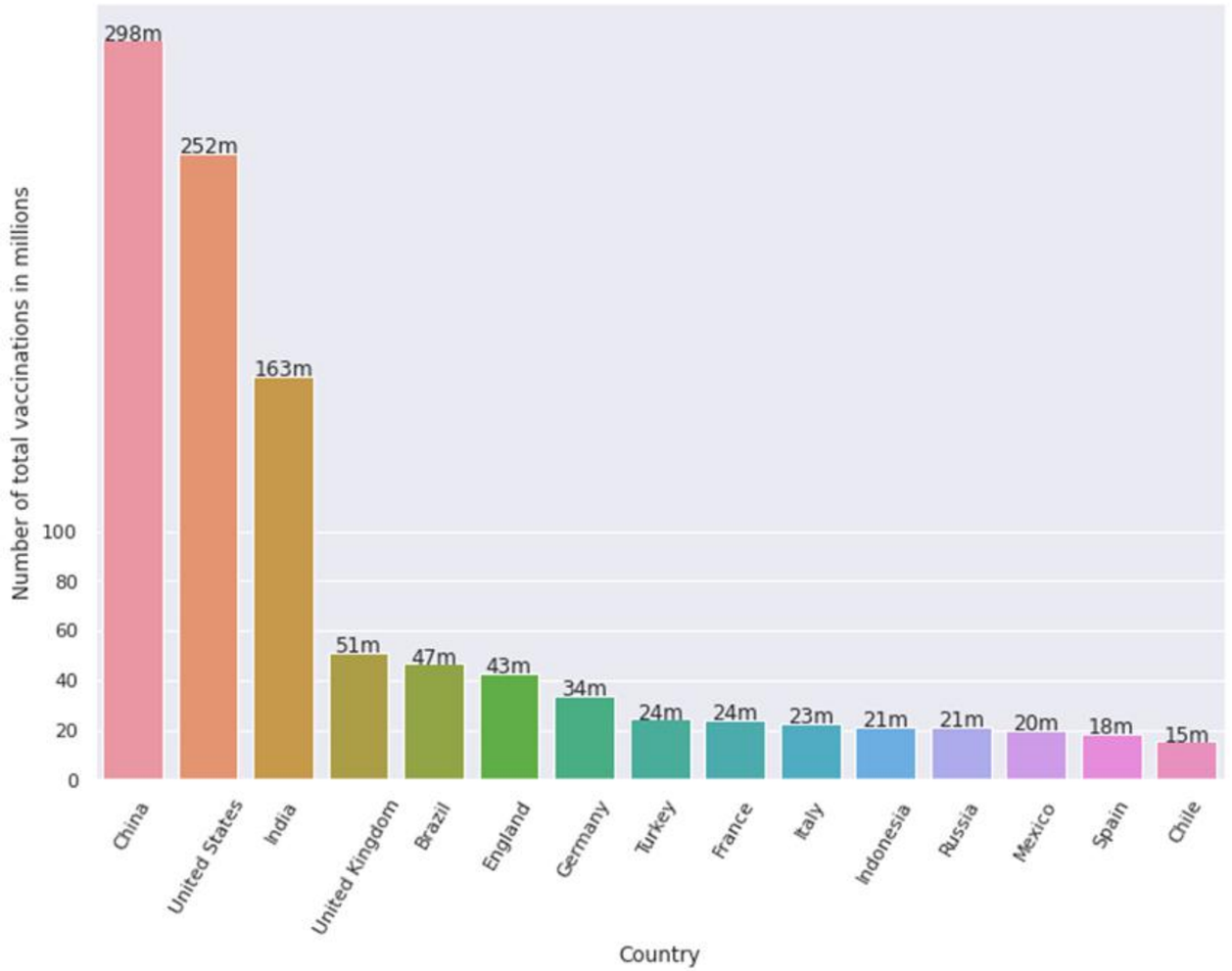
Total Vaccinations by Country



Dataset

Dataset COVID-19 World Vaccination Progress
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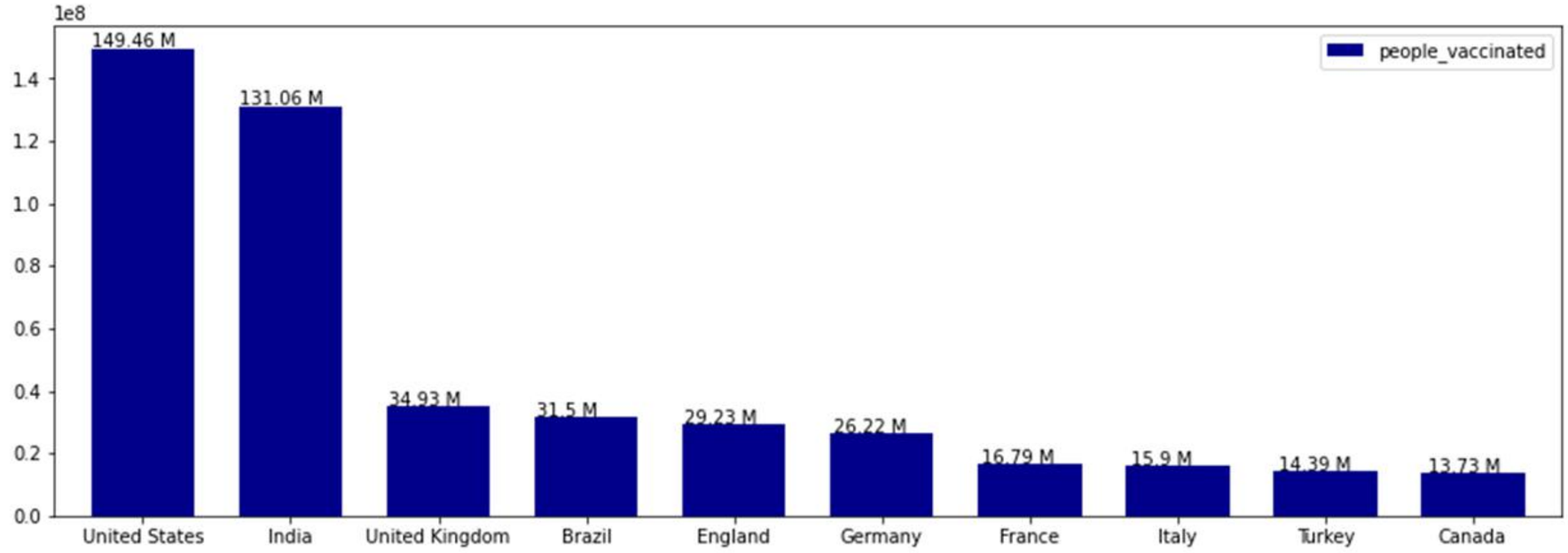
Exploratory Data Analysis

People Vaccinated by Country



Dataset

Dataset COVID-19 World Vaccination Progress
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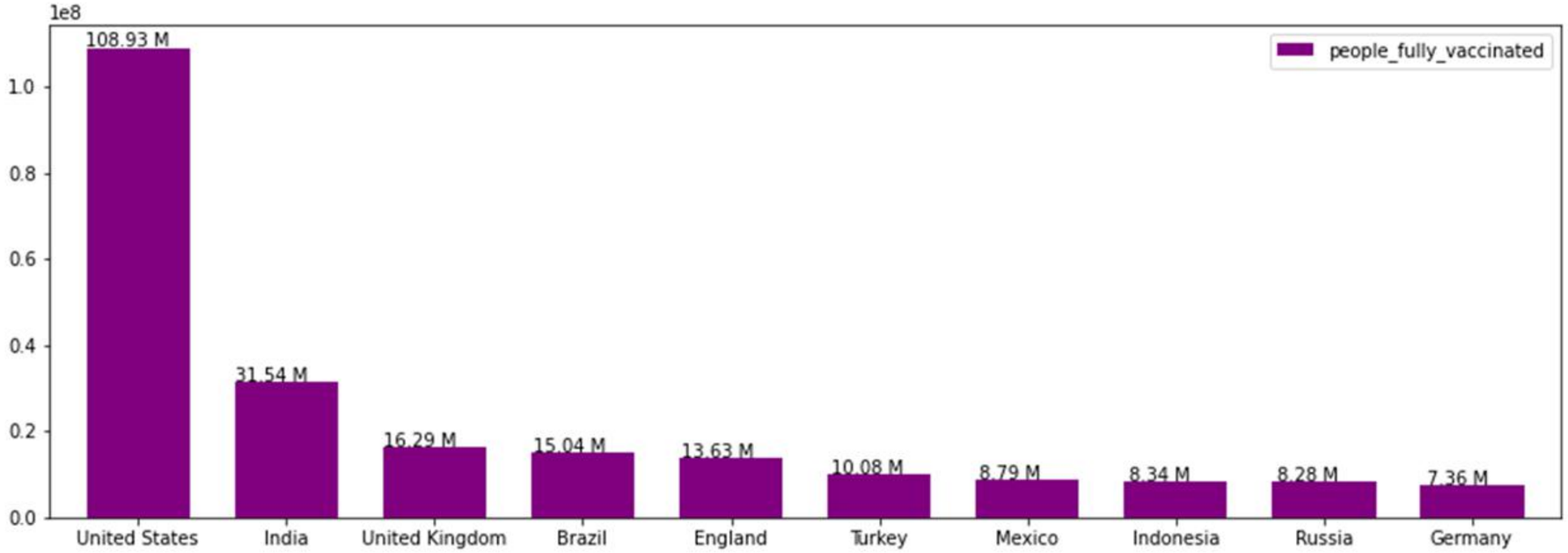
Exploratory Data Analysis

People Fully Vaccinated by Country



Dataset

Dataset COVID-19 World Vaccination Progress
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Exploratory Data Analysis

American Vaccines

Russian Vaccines

Europian Vaccines

Chinese Vaccines

Indian Vaccines

Experiment Step Works

Input Data

- Group by Type Vaccines
- Select by People Vaccinated /hundred

Data Preprocessing

- Stationary Check
- Differencing
- Correlation Check

Fitting Model

- Prophet and ARIMA Model
- Daily Seasonality

Output Data

- **Forecast vs. Actual**
- **Future Prediction**

Dataset COVID-19 World Vaccination Progress
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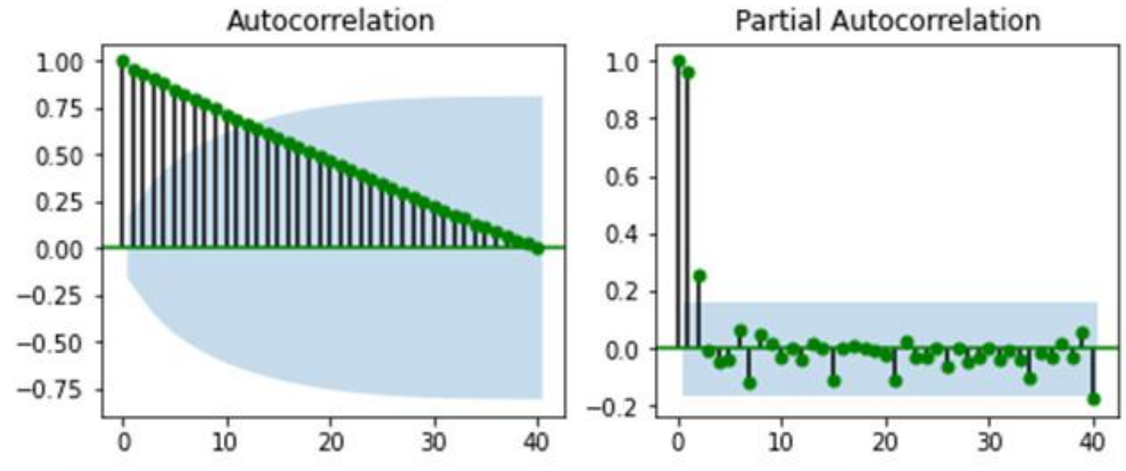
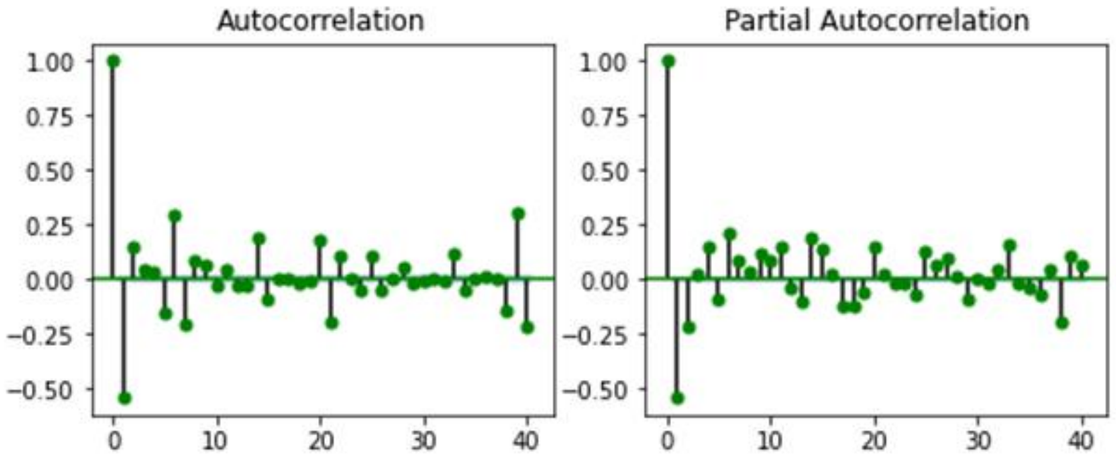
Data Preprocessing



Before Differencing

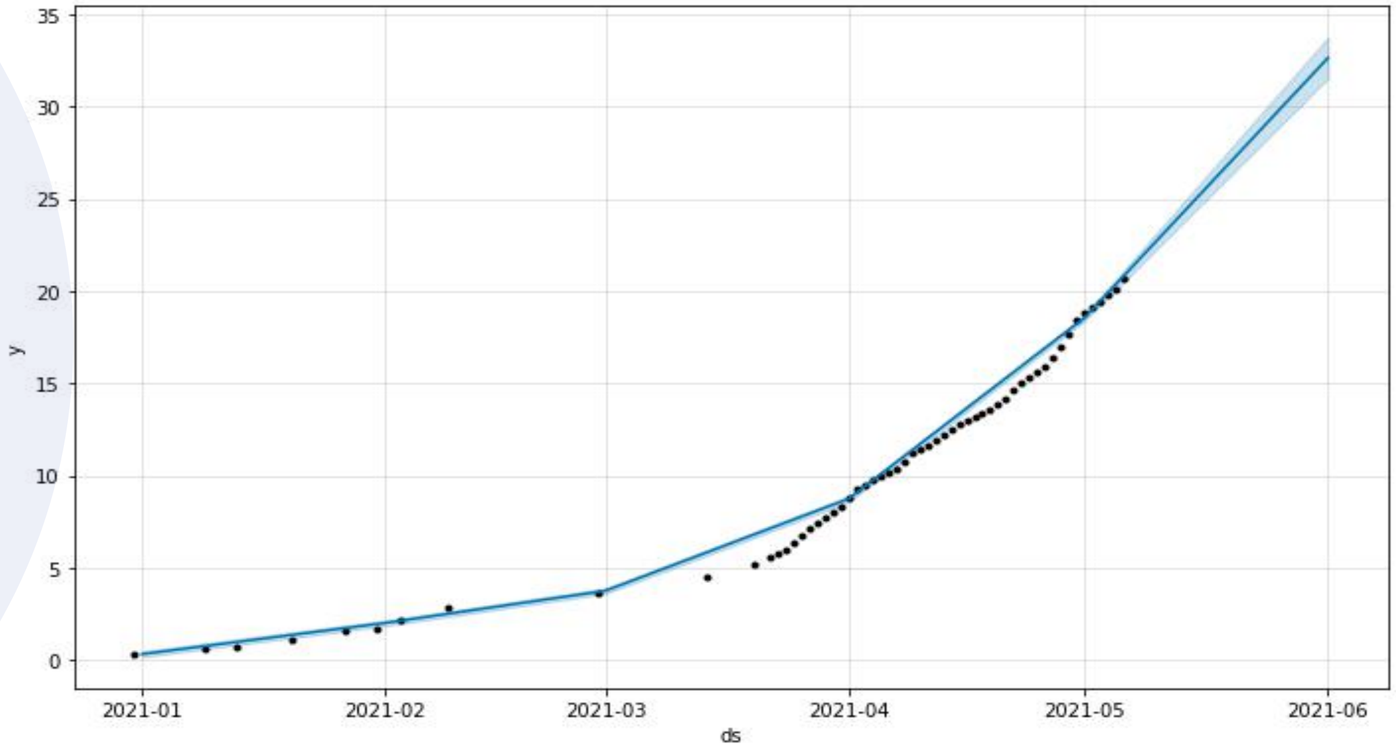


After Differencing

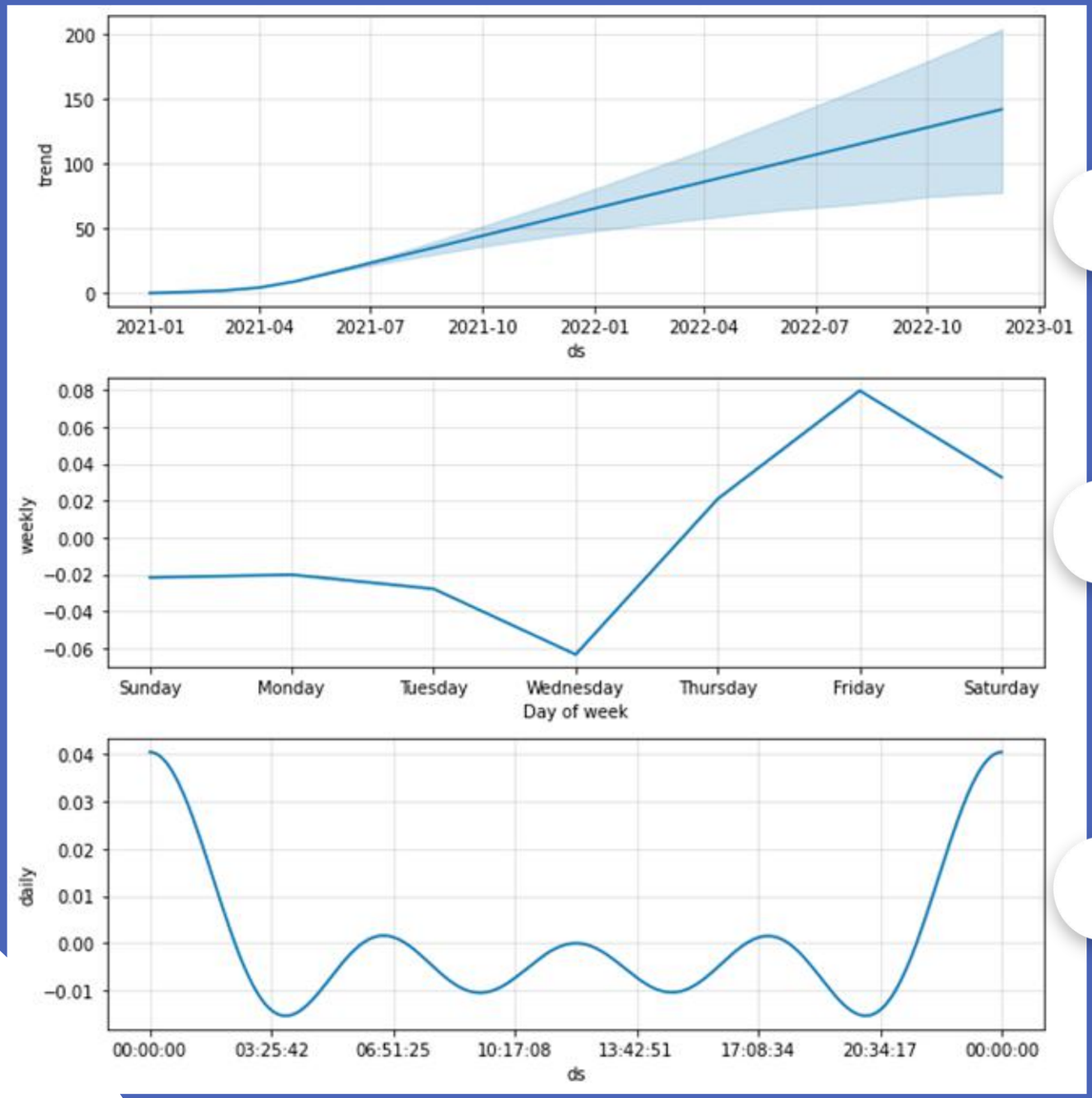
Prophet Deep Learning Implementation

Forecast and Actual ARIMA

- Future Forecast until June 1, 2021
- Daily Seasonality
- Sinopharm and Sinovac
- Total Vaccinations per Hundred



Prophet Deep Learning Implementation



Trend

Weekly

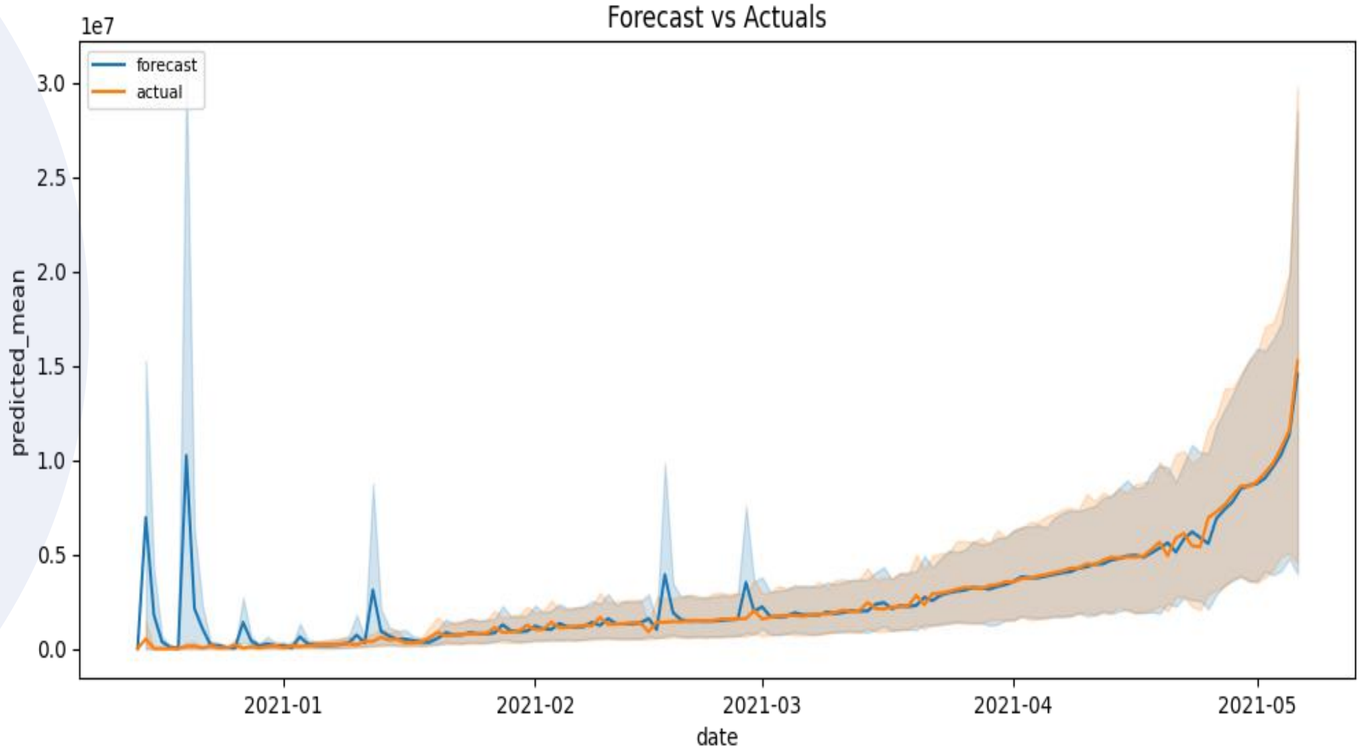
Daily

Seasonality Forecast

ARIMA Deep Learning Implementation

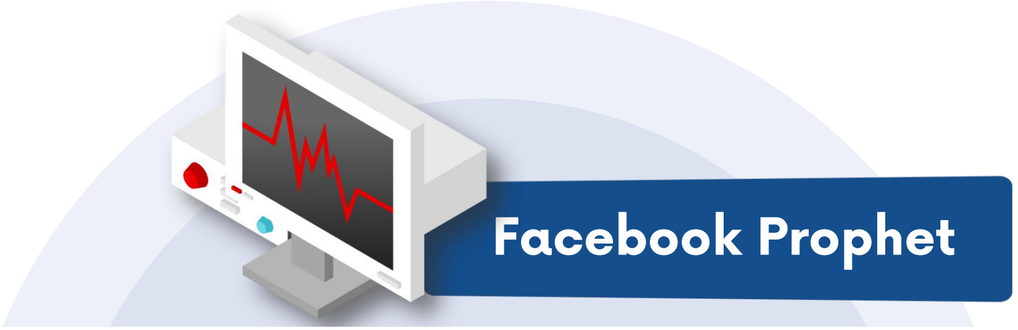
Forecast and Actual ARIMA

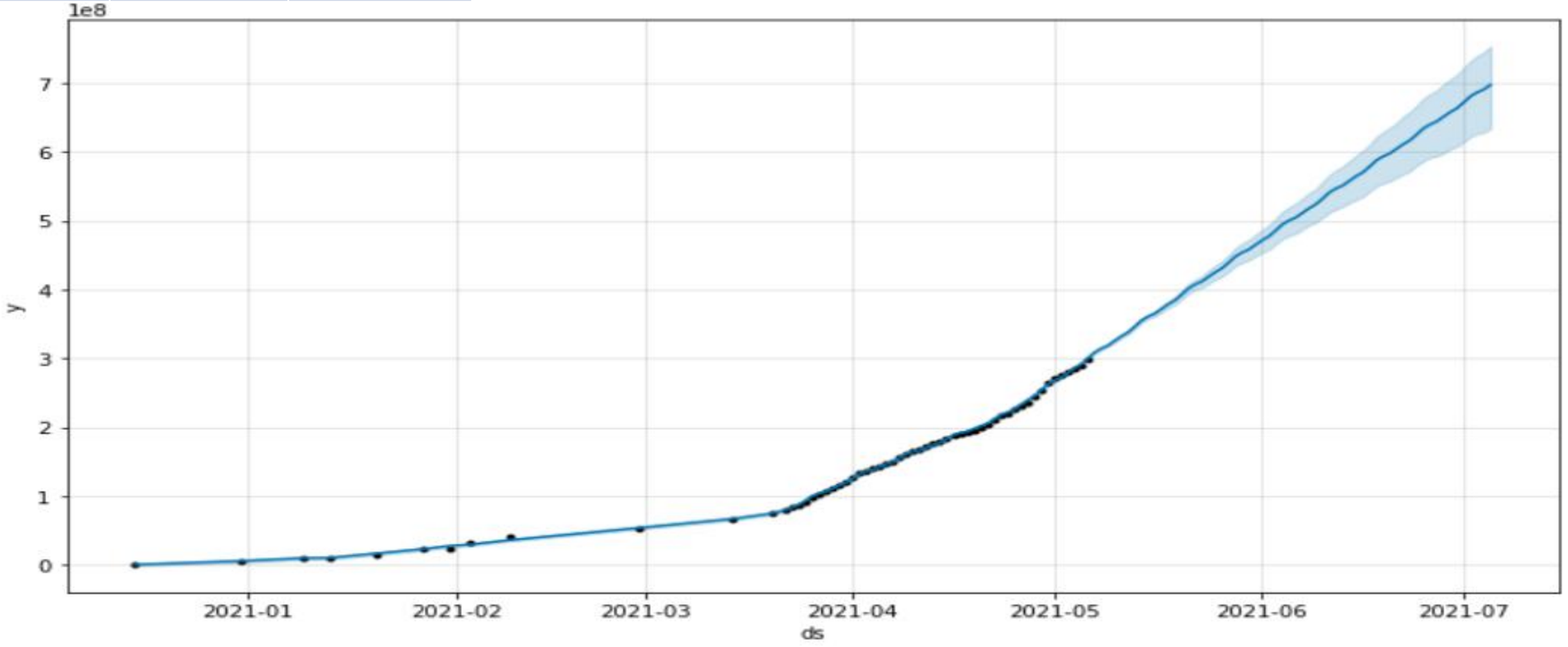
- Future Forecast until June 1, 2021
- Train : Test = 80:20
- Sinopharm and Sinovac
- Total Vaccinations per Hundred



Future Forecasting

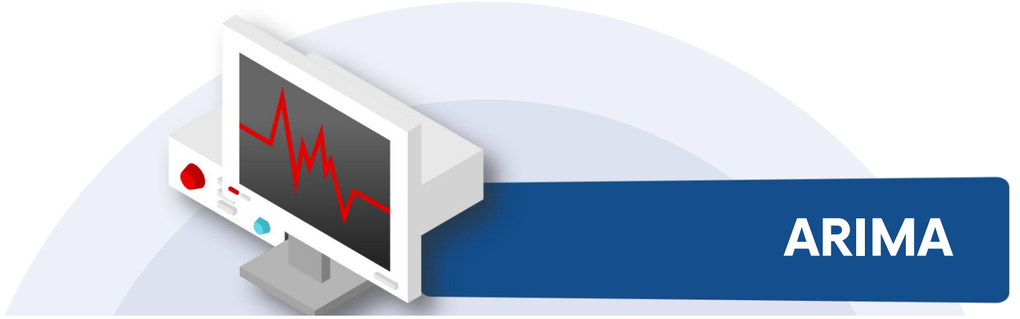
ds	yhat	yhat_lower	yhat_upper
2021-07-01	6.712125e+08	6.141475e+08	7.220045e+08
2021-07-02	6.801729e+08	6.216502e+08	7.318220e+08
2021-07-03	6.860007e+08	6.258757e+08	7.395016e+08
2021-07-04	6.903211e+08	6.280171e+08	7.446853e+08
2021-07-05	6.970889e+08	6.332544e+08	7.535284e+08



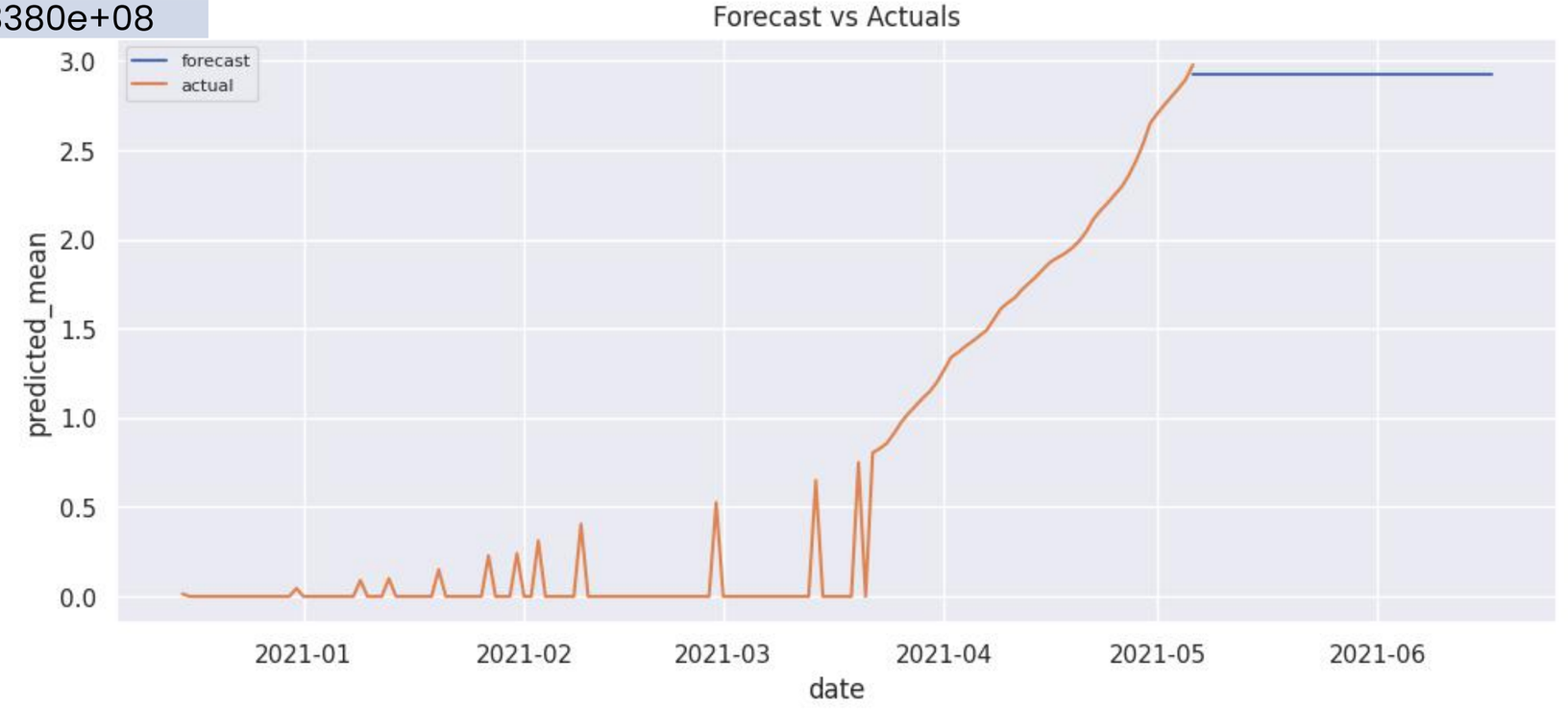


Future Forecasting

ds	pred
2021-06-13	2.923380e+08
2021-06-14	2.923380e+08
2021-06-15	2.923380e+08
2021-06-16	2.923380e+08
2021-06-17	2.923380e+08



ARIMA



Evaluation Metrics

Model	Evaluation Metrics						
	MSE	MAPE	R2	MAE	MedAE	RMSE	MEAN
ARIMA	0.6139603	0.0473144	0.97560	0.58201	0.549417	0.61396	13.153095
Prophet	0.0309044	0.0103888	0.99876	0.15473	0.154735	0.17579	13.64026

Conclusions

Development Future Prediction

Results for COVID-19 vaccines development to useful to encourage the government to make decision to provide vaccines.

Prophet is Best Forecasting Model

Comparison with another model, Prophet getting higher result based evaluation metrics with minimum error.

Considering Another Field

For making a precision decision, another field such as social-economic and important cases will be influence the predictions

References

[1] C. for S. S. E. (CSEE), “COVID-19 Map,” 2021. https://coronavirus.jhu.edu/map.html (accessed May 24, 2021).

[2] A. de Figueiredo, “Forecasting sub-national trends in COVID-19 vaccine uptake in the UK,” medRxiv, pp. 1–17, 2020.

[3] L. Trtica-Majnaric, M. Zekic-Susac, N. Sarlija, and B. Vitale, “Prediction of influenza vaccination outcome by neural networks and logistic regression,” Journal of Biomedical Informatics, vol. 43, no. 5, pp. 774–781, 2010, DOI: 10.1016/j.jbi.2010.04.011.

[4] G.Preda, “COVID-19 World Vaccination Progress,” 2021. https://www.kaggle.com/gpreda/COVID-world-vaccination-progress (accessed May 19, 2021).

[5] E. Žunić, K. Korjenić, K. Hodžić, and D. Đonko, “Application of Facebook’S Prophet Algorithm for Successful Sales Forecasting Based On Real-World Data,” arXiv, vol. 12, no. 2, pp. 23–36, 2020, DOI: 10.5121/ijcsit.2020.12203.

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