

PG DOORSTEP

Final Report – Analysis of COVID-19 (Delta Variant)

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Abstract

The delta variant of COVID-19 virus, is a dominant strain in many countries, driving up cases in particular where vaccination rates are lower. Also known as B.1.617.2, the variant was discovered in India in late 2020. According to many studies, Delta spreads 50% faster than Alpha, which was 50% more contagious than the original strain of SARS-CoV-2. In this report, we have closely analyzed the impact of delta variant on India, United Kingdom Russia and Germany. Furthermore, we found that delta variant has increased the transmissibility of coronavirus, which also led to increased number of deaths in these countries. We have analyzed the reasons which ushered the delta variant to spread in India, United Kingdom and Russia. This report also assesses the current scenario of the COVID-19 pandemic using our data analysis and prediction approaches with the emphasis on the impact of delta variant and forecast the number of COVID-19 cases and deaths in Germany. The outcomes from our findings would aid the German government to decide and develop on response measures, provide improvement in the prevention and containment strategies and also identify factors that mostly influencing the spread of COVID-19 due to Delta Variant.

Keywords: - Delta variant, Covid-19, lockdown, vaccination, Daily coronavirus cases, daily deaths, German Government, SEIR model, data analysis, response measures.

1. Introduction

SARS-CoV-2 Delta variant, also known as lineage B.1.617.2, is a variant of lineage B.1.617 of SARS-CoV-2, the virus that causes COVID-19. It was first detected in India on October 5, 2020, and later World Health Organization (WHO) names it as Delta variant. It has several mutations in its gene which encodes the SARS-CoV-2 spike protein, giving rise to substitutions T478K, P681R and L452R. Data indicates that delta is 40-60 percent more than other highly transmissible variant like Alpha and almost twice as transmissible as the original Wuhan strain of SARS-CoV-2. [1]

According to surveys conducted in U.K, where Delta accounts for almost 90% of current COVID-19 cases, symptoms of Delta tend to be a little different than other strains. Fever, headache, sore throat and runny nose are common, while cough and loss of smell are not. Other reports link Delta to more serious symptoms, including hearing impairment, severe gastrointestinal issues and blood clots leading to tissue death and gangrene. Public health officials in Britain there have said that Delta could be 40 to 60% more contagious than Alpha, although estimates of its infectiousness vary. The problem statement of this report is to predict the number of COVID-19 cases and deaths in Germany until the end of September and provide suggestions to the german government to manage the COVID-19 outbreak.

The contribution of this report is summarized as follows,

- We analyze the impact of delta variants for countries like India, United Kingdom and Russia.
- We will also find the reasons associated with the surge of delta variant cases in India, United Kingdom and Russia.
- We illustrate the possible solution approach by performing exploratory data analysis and building intelligent prediction models using different machine learning algorithms for short-term forecasting to extract useful information from various data sources. We also apply the SEIR model to estimate and accurately predict the COVID-19 spread due to Delta variant for a longer time period.
- Leveraging the key insights obtained from the prediction models can be utilized by the German government to enable them to make decisions on the infection control measures by taking necessary 3 pillar response strategy to combat COVID-19 spread due to Delta Variant by protection (vaccination), containment (non-pharmaceutical interventions), mitigation (testing and contact tracing).

2. Impact of Delta Variant on the World

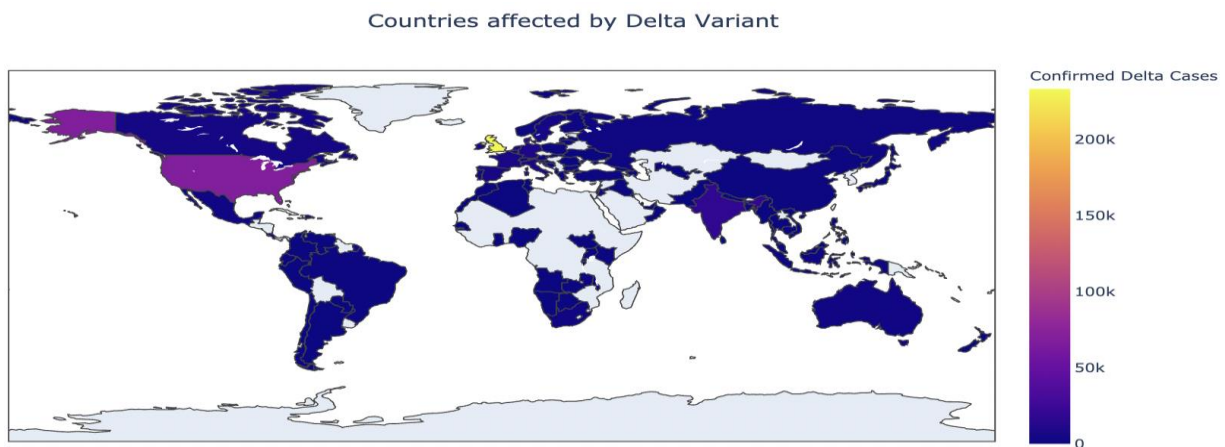


Fig 1: Countries with confirmed delta variant cases

As evident from the figure, Delta variant has reached most parts of the World. There are 433k confirmed delta variant cases that have been reported around the world, with the confirmed cases coming from 120 countries. United Kingdom accounts for 60 percent of all the delta cases around the world, with an astonishing number of 233k confirmed delta variant cases. [6] It can also be observed from the figure that most of the countries in Europe have been experiencing surge of delta variant cases.

3. Analysis of Delta Variant in India, United Kingdom and Russia

3.1 Proportion of different corona variants in India, United Kingdom and Russia

Proportion of Sequences of Different Variants Found in UK, India and Russia till April 30, 2021 Proportion of Sequences of Different Variants Found in UK, India and Russia till July 15, 2021

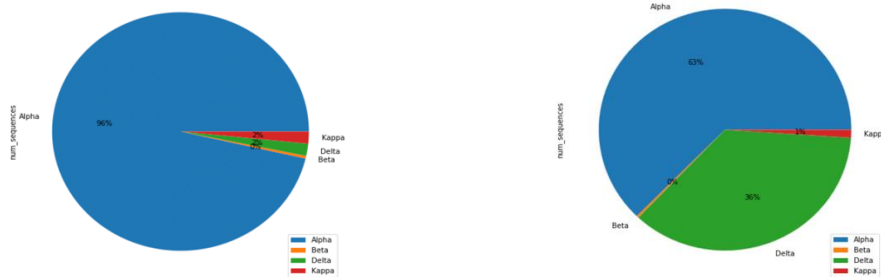


Fig 2: Difference in Proportion of Delta sequences found till April 30, 2021 and July 15, 2021

We can observe from the pie chart on left that alpha variant was largely dominant in India, United Kingdom and Russia till April 30, 2021, with a huge share of 96 percent. But within a span of two months, delta variant share increased significantly. Delta variant, which was consisting only two percent of all the variants till end of April 2021, now shares 36 percent share of all the variants in India, Russia and United Kingdom.

3.2 India



Fig 3: Percentage delta sequences in India

Delta variant was first identified in India on 5th October 2020 and caused a havoc during the second coronavirus wave of India. As seen in the figure, an upward trend in delta sequences started from April 2021 and keeps on increasing during subsequent months.

3.2.1 Situation in India due to Delta Variant

When the second wave of the COVID-19 pandemic hit India this spring with the full force of the delta variant, it flung a myriad of problems out into the open as the country's healthcare infrastructure crumbled, hospitals running on full capacity and people dying due to lack of oxygen. The second wave of covid was four times stronger than its first coronavirus wave. At its peak, India reported over 400,000 cases in one day, breaking the global records. [2] The second in India driven by delta variant was so critical that 7000 people died in one day. Following steps were taken to mitigate the spread of delta variant in India.

3.2.1.1 Lockdown implementation

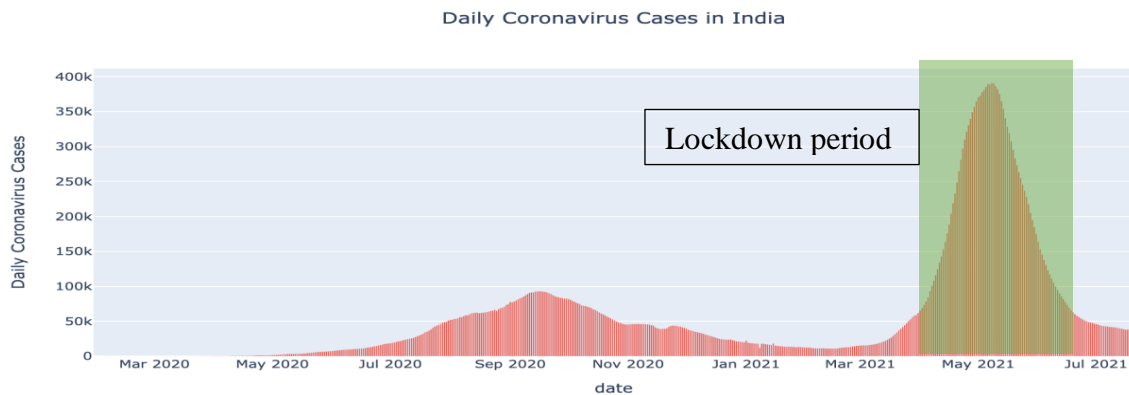


Fig 3: Daily Coronavirus cases in India and lockdown period

As the daily number of cases started increasing during the month of April 2021, most of the Indian states started putting lockdowns in their respective areas. The restrictions include closure of all educational institutions, public events and curfew during the night.

3.2.2 Reasons for Delta Surge in India

There were several reasons which contributed to the rise of delta variant in India. India is a country of billion people and has one of the highest population densities in the world. People specially in urban areas live in very dense areas which provides a favorable condition for the viruses to spread. Furthermore, there were other reasons which are discussed in the below sections also provide the favorable conditions for the growth of delta variant.

3.2.2.1 No Lockdown till April 2021

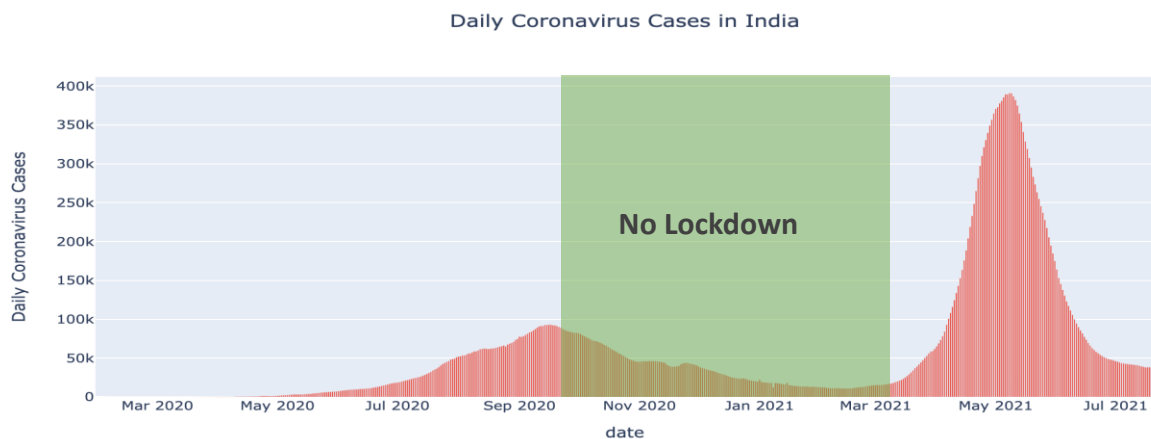


Fig 4: No lockdown period and daily coronavirus cases in India

By the end of September 2021, India opened most of its states since coronavirus cases started falling. The second wave of coronavirus cases, driven by delta variant started to emerge from the month of February 2021. But the Indian government did not put any nationwide lockdown and gave the power to states on lockdown decisions. This led to the delay in lockdown implementation and provides the sufficient time for delta variant to surge.

3.2.2.2 Slow Vaccination

India started giving vaccines to its people from the month of January 2021. But the vaccination drive was very slow.

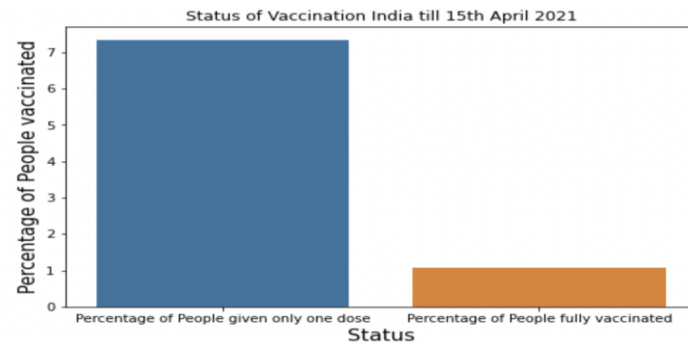


Fig 5: Status of vaccination in India till 15th April 2021.

As a consequence of slow vaccination in India, only 7 percent of India's population was given one dose whereas the percentage of fully vaccinated was even worse, with only 1 percent of people were given two doses of vaccines.

3.2.2.3 High Population density

India is the world's second most populous country with a population of more than 1.3 billion people. There are some metropolitan cities like Delhi, Mumbai, Kolkata and Chennai where population is more than 15 million. The high population density of India where people usually live in compact spaces, makes it easy for the delta variant to spread.

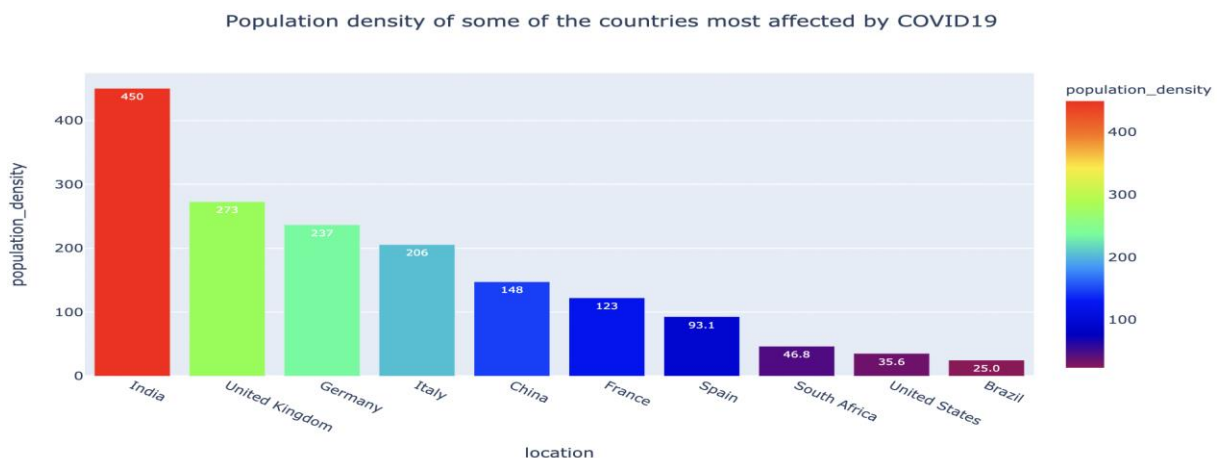


Fig 6: Population density of the countries affected by COVID-19

As we can see from the figure, India is having the highest population density when it is compared to the other countries affected by COVID-19.

3.2.2.4 Kumbh Festival

During the 1st week of April, religious congregation happened in the holy city of Haridwar. 9 million gathered for the festival without any social distancing measures, making it a super spreader event. The union government refused to cut short the event, but Health Ministry issued a list of Standard Operating Procedures to prevent the spread of COVID during the event, including a mandatory negative RT-PCR test report for the attendees. However, many attendees refused to follow the guidelines, refusing to wear masks or practice social distancing. By April 14, 1701, attendees tested positive for COVID. Most of the attendees came from states like Uttarakhand, Uttar Pradesh, Bihar and Maharashtra. Below graph depicts the rise of coronavirus in those states after the Kumbh festival.

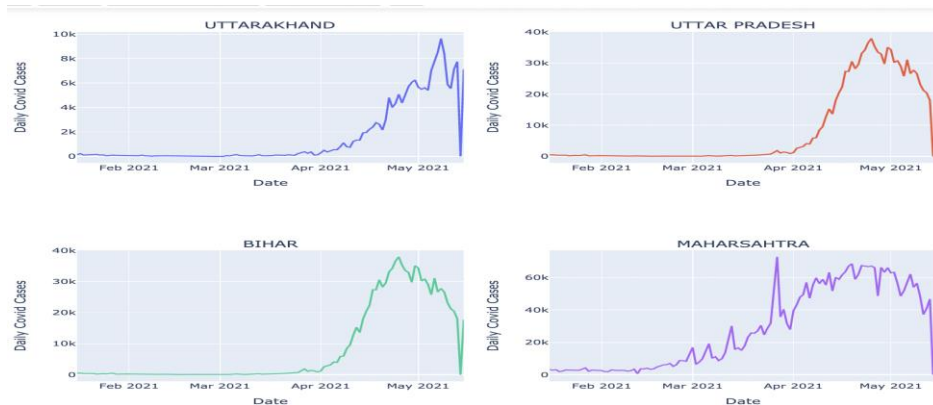


Fig 7: Rise of Covid cases in different states of India after Kumbh Festival

3.3 United Kingdom

United Kingdom has total of 233k confirmed delta variant cases. It has recorded 68.8k confirmed delta variant in the last one month. [6]

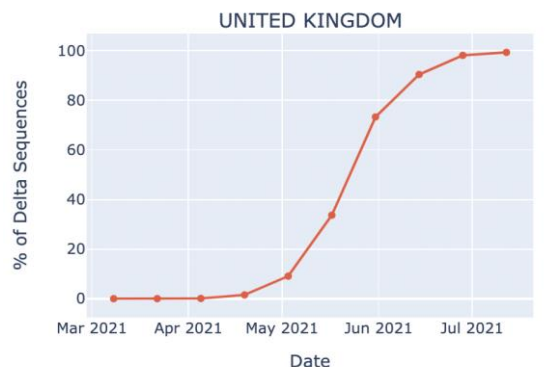


Fig 7: Percentage delta sequences in United Kingdom

As we can observe from the above figure, there was an upward trend in the delta sequences from the month of May 2021 in United Kingdom. In recent times, most of the covid cases in UK come out to be delta variant.

3.3.1 Situation in United Kingdom due to Delta Variant

The U.K. has had a relatively successful rollout of vaccinations for COVID-19. In fact, over 74% of adults have now received both doses. However, despite the high number of vaccinations, the number of people testing positive for SARS-CoV-2 has significantly increased during the recent times. [4] The surge in delta led to an increase in the number of people requiring hospitalization and people getting admitted in Intensive Care Unit (ICU).

3.3.1.2 Increase in average daily deaths

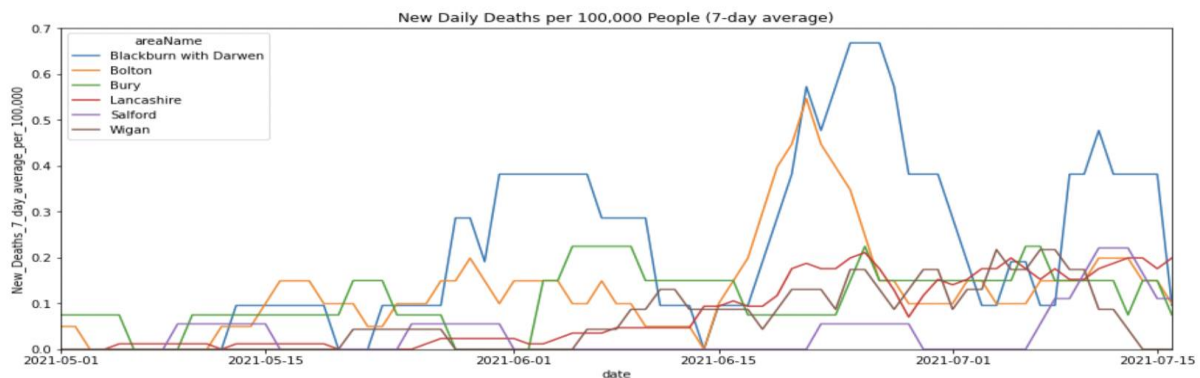


Fig 8: New daily deaths per 100,00 people in 7 days rolling average

The figure shows that majority of the United Kingdom regions were recording high average deaths from the month of May 2021. Regions like Bolton (Greater Manchester), Blackburn and Darwen (Lancashire) have been experiencing huge jumps in average daily deaths. The increase in average daily deaths started to become more vibrant during the recent times. [7]

3.3.2 Reason for Delta Surge in United Kingdom

United Kingdom opened its borders for many countries, once the third wave of coronavirus started getting stabilized in early 2021. Many people from different parts of the world travelled to United Kingdom. Following section provides an overview as how travelling to United Kingdom became the prominent reason for the exponential growth of Delta variant in United Kingdom.

3.3.2.1 Travel to United Kingdom

According to the fact check by BBC news [5], the delta variant was through genetic sequencing as being in the UK in the week beginning March 8th 2021. India was not put on the red list of countries who were not allowed to travel United Kingdom. UK put India put on the red list by 23rd April 2021. By that time, there were already 42,406 people who had travelled between United Kingdom and India according to the Civil Aviation Authority of UK. This led to many people from India, who might have contacted delta variant were allowed to travel United Kingdom and potentially became reason for spread of delta variant in UK.

3.4 Russia

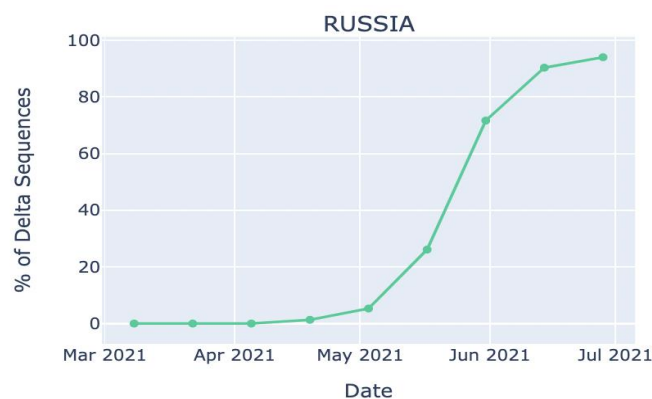


Fig 9: Increase in percentage delta sequences

Russia has recorded a total of 1600 delta variant cases and 160 COVID-19 cases were sequenced to delta variant in recent times. [6]. From the above graph, we can observe that there is constant increase in the percentage sequences of delta variant from the month of May 2021.

3.4.1 Situation in Russia due to Delta Variant

Russia recorded a death tally of 185,000 people in the month of June 2021, a figure which was not never achieved during the whole coronavirus pandemic in Russia. The hospitals in Russia are overrun and the health care system is on the verge of collapse. [8]

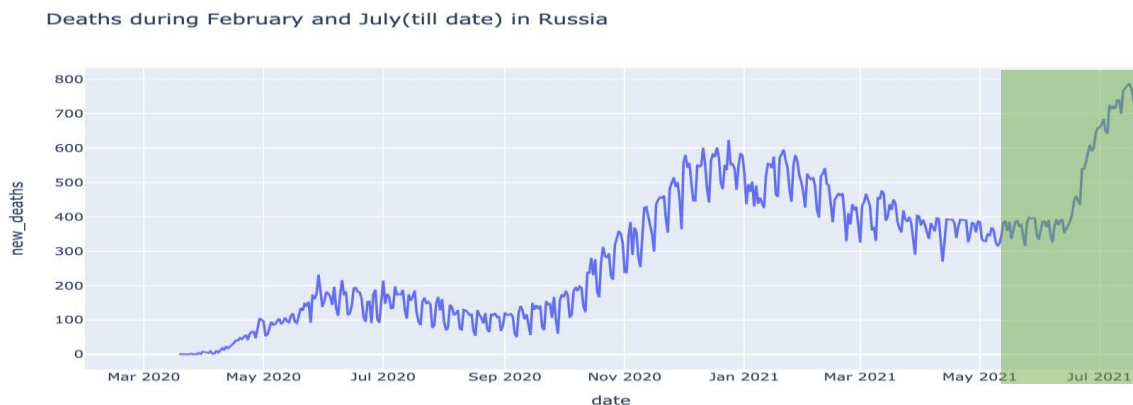


Fig 10: Daily deaths in Russia due to COVID-19

The highlighted area in the above figure clearly outlines the impact of delta various on daily deaths in Russia. The rapid surge of the Delta variant, rise in hospitalizations and deaths in June made the regional authorities across the country to reintroduce some restrictions and roll out mandatory vaccination rules in a bid to kickstart Russia's sluggish jab drive.

3.4.2 Reason for delta surge in Russia

Russia approved its own homegrown vaccine called Sputnik during the end of year 2020. Initially, Russia's vaccination drive was quite fast, and it has vaccinated a record number of 4 million people in one day as it can be seen from the figure below. [8]



Fig 11: Daily Vaccinations in Russia

But Russia's vaccination declined considerably from the month of April, leaving a huge portion of its people unvaccinated and without any protection against the delta variant.

4. Forecasting Covid-19 spread in Germany due to delta variant

4.1 Exploratory Data Analysis:

It can be observed for the exploratory data analysis that the B.1.617.2 (Delta Variant) has emerged as the dominant variant circulating in Germany over an 10-week period. Initially, The B.1.1.7 (Alpha Variant) was risen gradually from Dec 2020 was significant till June 2021. However, The Delta variant quickly overtakes the Alpha variant with its high reproduction number and increased severity which makes it more transmissible and dangerous than the Alpha variant. The below visualizations depicts this key insight.[12]

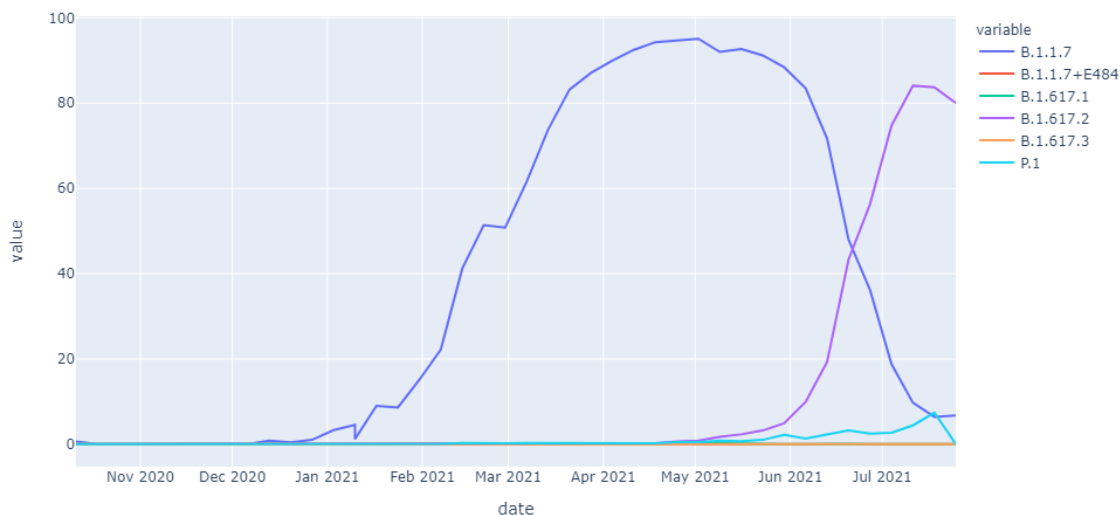


Fig 12: Trend of VOC(Variants of Concern) Distribution(%) in Germany (Nov 2020-Jul 2021)

Week-18 COVID-19 variants Percentage Distribution Week-28 COVID-19 variants Percentage Distribution

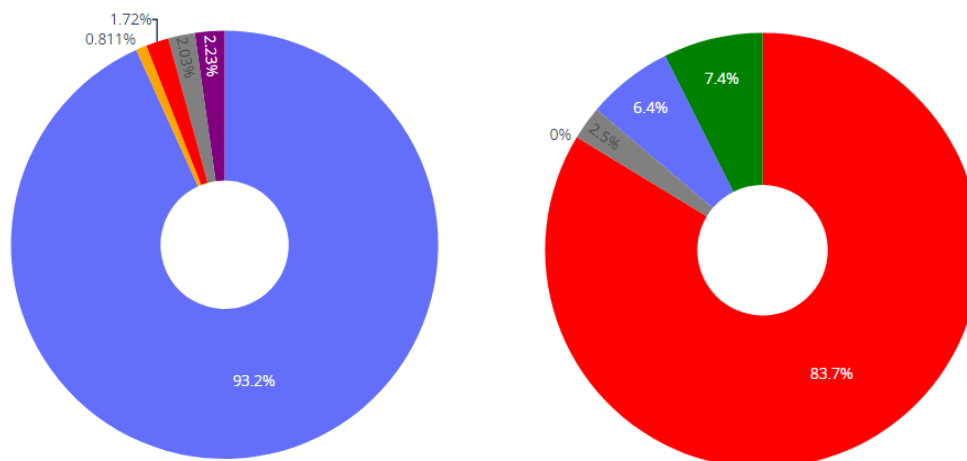


Fig 13: Pie chart Visualization: COVID-19 Variant Analysis from Week-18 to Week-28 2021

From the above pie chart visualization, it is clear that the it has a very high potential on trasmissibility with justifies the estimation that it is in fact 55% higher than the Alpha variant in reproduction number and 40-60% more transmissible than Alpha. Thus, Delta variant spreads rapidly, despite relatively high vaccination coverage.[12]

4.2 Approach Overview:

This section describes the approach that is used for the analysis and prediction of COVID-19 cases and deaths and thereby obtain key insights to better handle the disease spread.

1. Raw Data Collection, Data Preparation and Data Pre-processing to perform Initial Exploratory Data Analysis – Daily and Cumulative COVID-19 cases and deaths.

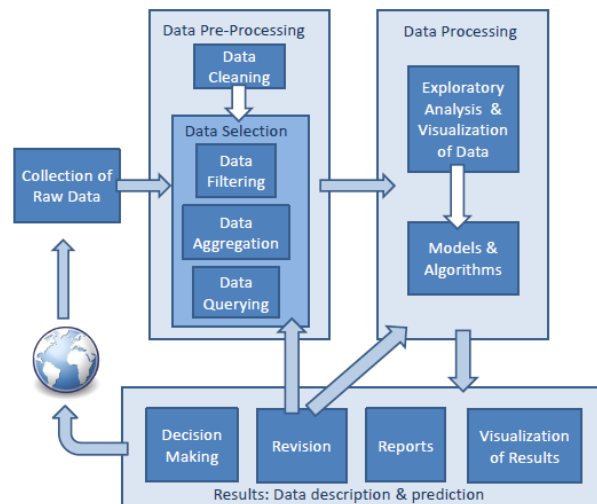


Fig 14: Approach for Data analysis and Data Visualization[14]

4.3 Data Sources:

Description of Data Sources:

The Data regarding different variants used for exploratory data analysis were obtained from GISAID from the ECDC website from the beginning of Nov 2020.

The COVID-19 dataset maintained by Our World in Data was used for modelling SEIR. Since, the accurate data was updated daily throughout the duration of the COVID-19 pandemic.

Daily COVID-19 prevalence data were retrieved from the GitHub repository of the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University and the cumulative infectious and fatality records have been taken for COVID-19 cases from 5 June to 11 August 2021 as representative case analyses.

4.4 Methodology:

Regression Models:

To estimate the number of infectious cases, different machine learning models were implemented namely Linear Regression (LR), Polynomial Regression (PR), Support Vector Regression (SVR). These models were already used to forecast numerous epidemic diseases and hence, it is reasonable to also be used to only short-term forecast COVID-19 pandemic.[9]

SIER Model:

The SIER Model can be used to represent main characteristics of the Delta Variant of the SARS-CoV-2 virus as it is already used to model one of the best COVID-19 forecasting model to date is a [modified SEIR model](#). The below diagram illustrates the COVID-19 dynamics of the SIER model.[10]

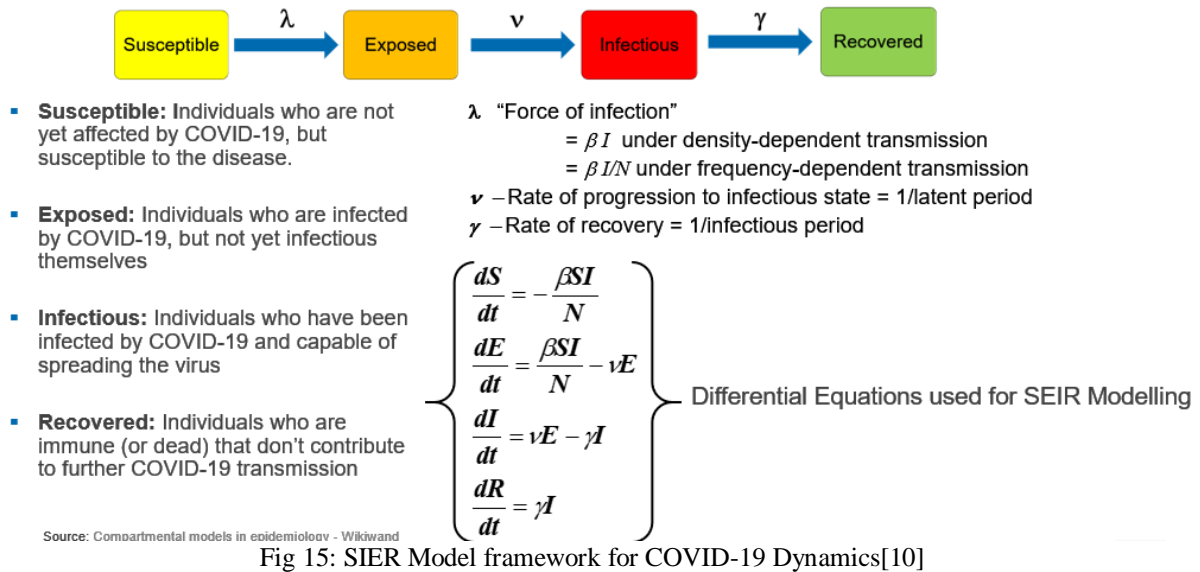


Fig 15: SIER Model framework for COVID-19 Dynamics[10]

There is a closed population and an initial number of infected people. During each day, every infected person infects someone from the Susceptible group with some probability. Someone from the Infected group recovers when the period of illness passes and moves to the Recovered group. The algorithm goes like this for many days ahead. The SIER model also accounts for the incubation/ latency period by introducing the Exposed group which can better characterize COVID-19.

4.5 Empirical Evaluation:

Short-term Prediction using Regression Models [9]:

- Linear Regression Model:** The linear regression model showed considerable results due to cumulative cases did not change much initially and it has notable error rates.

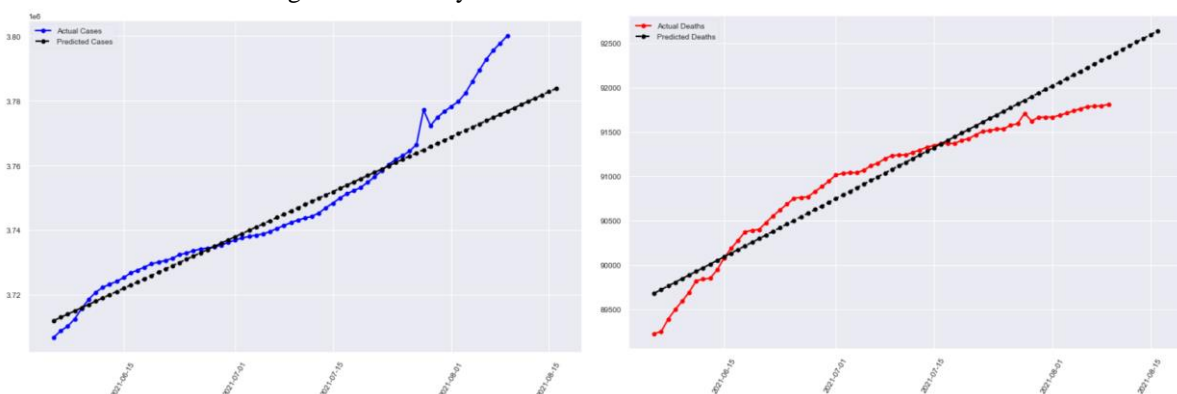


Fig 16: Linear Regression Model[9]

- Support Vector Regression Model: The Support Vector Regression performs well for the short-term prediction of the COVID-19 cases with low error rates but it fails to forecast the COVID-19 deaths correctly and has notable error rates with hyperparameter tuning of degree=5.

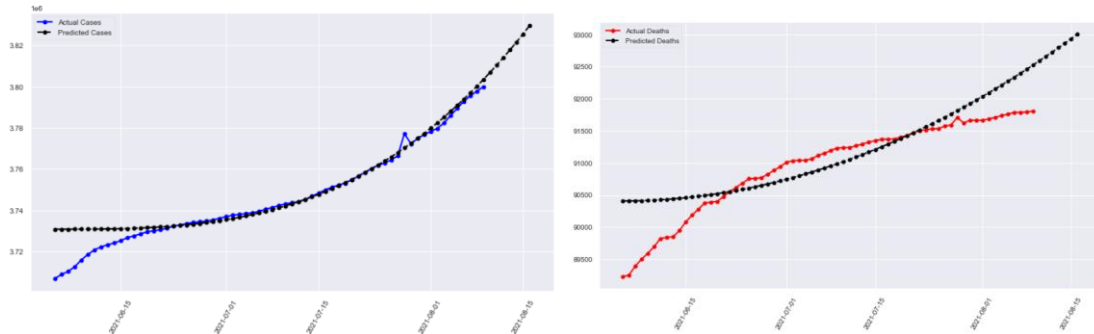


Fig 17: Support Vector Regression Model[9]

- Polynomial Regression Model: The Polynomial Regression Model presents promising results with low error rates compared to linear regression model but requires hyperparameter tuning with degree=4.

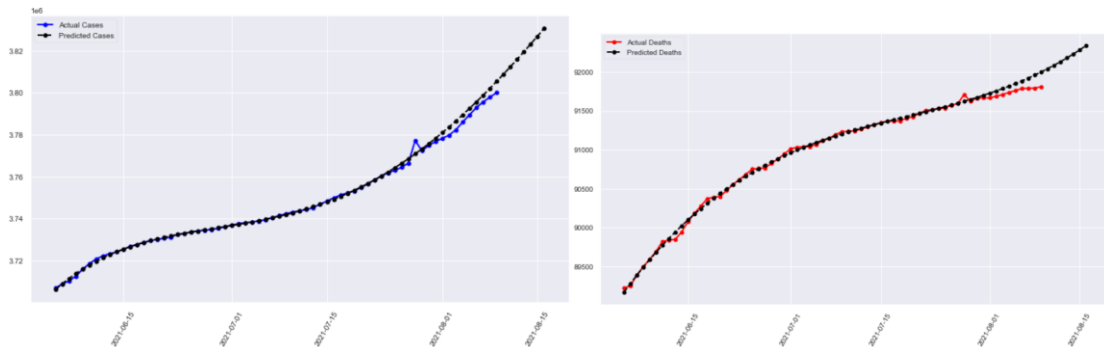


Fig 18: Polynomial Regression Model[9]

SEIR Model for Forecasting of COVID-19: This predicts the rise in number of cases in Germany over 100 days. However, considering the fact that value of R_0 can fall to lower value due to enforcements like social distancing etc. This model should consider $R_t(t)$ as a time varying variable. After Hyperparameter tuning to mimic the fall in the reproduction number ($R_t(t)$) over time the model introduces the Hill delay function to predict the COVID-19 cases more accurately in Germany. [11]

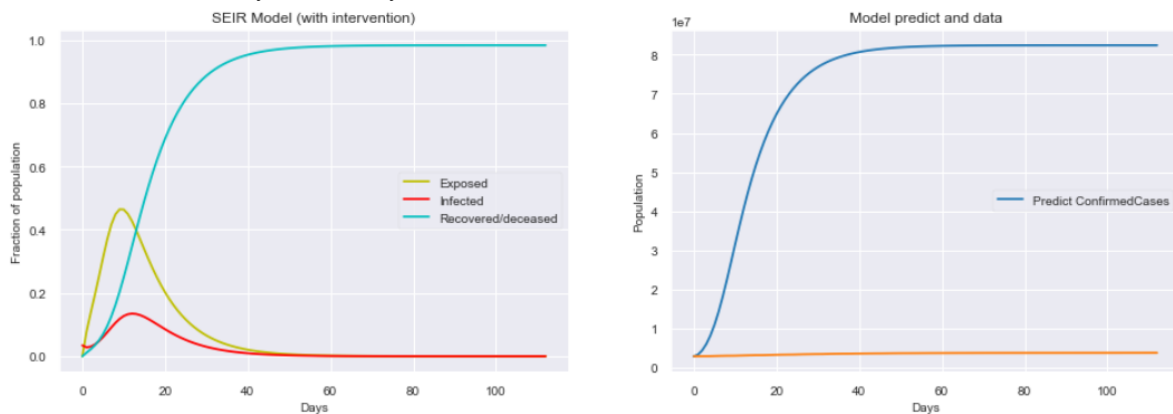


Fig 19: Simple SIER Model to predict COVID-19 cases with 'intervention'[11]

Estimate Confirmed Case ,Germany Total population =83783942

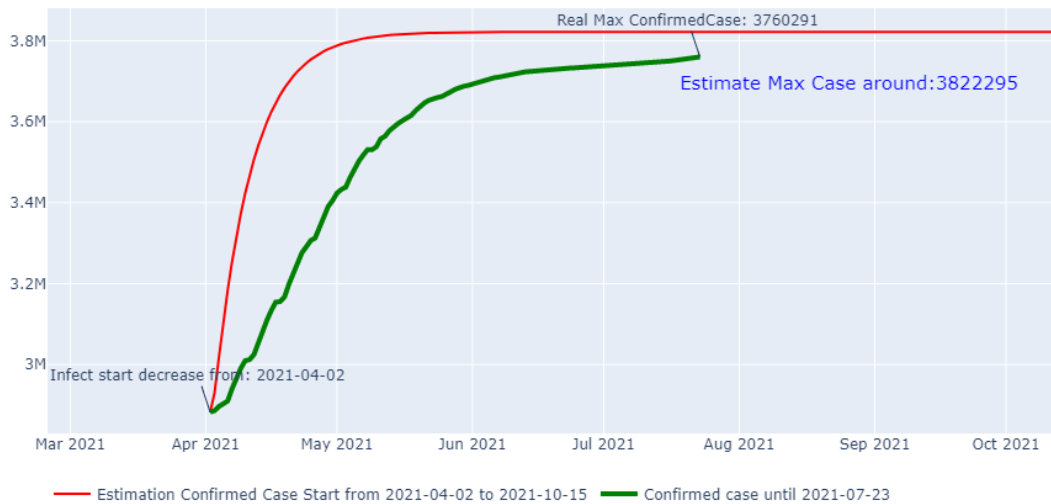


Fig 20: Estimation of the COVID-19 cases from 2nd April 2021 to 15th Oct 2021 using SIER Model

5 Response Strategy:

The Response strategy for the COVID-19 consists of three-pillars processes or steps that is used to combat COVID-19 which are (1) **Protection** of vulnerable groups through vaccination (2) **Containment** of the spread of the disease that includes Non-pharmaceutical (3) **Mitigation** of the consequences through Contact Tracing and Testing.

5.1 Protection-Vaccination Rollout: Acceleration of vaccine rollout in the shortest time possible to ensure all eligible individuals receive a full course vaccination to protect against the COVID-19 by immunization. Since, the Delta Variant is potentially more transmissible with increased severity it can greatly increase the risk of infection.[12]

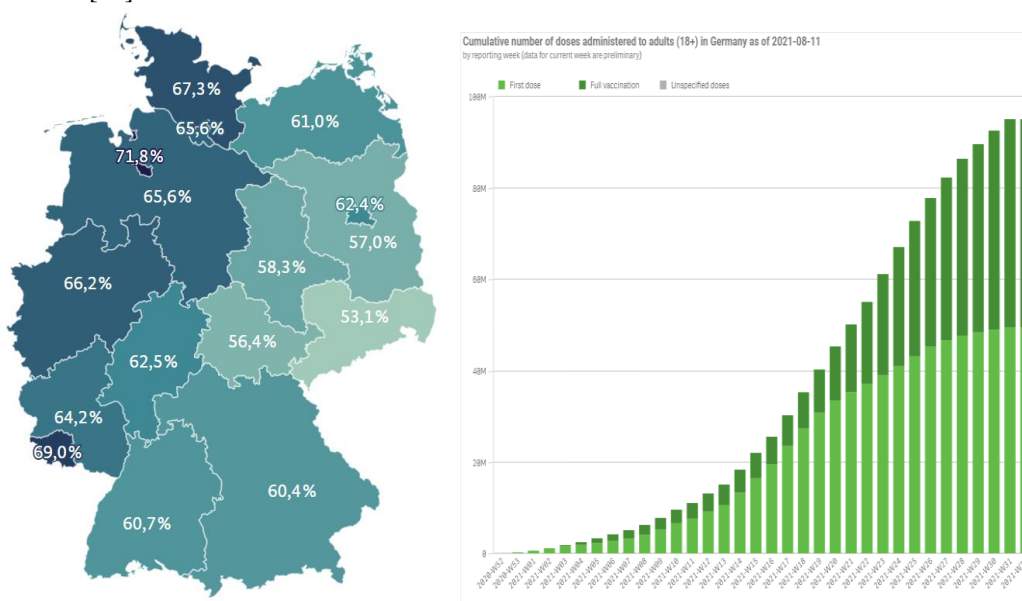


Fig 21: Vaccination Progress by State[15] and Cumulative number of doses administered to adults in Germany

5.2 Containment via Non-pharmaceutical Interventions: Enforcement of Non-pharmaceutical interventions should be maintained by taking into account of the analysis trend of the Delta variant. Restriction of International Travel measures plays an essential role in containment the spread of Delta variant infection from countries like United Kingdom, India and so on.[12]

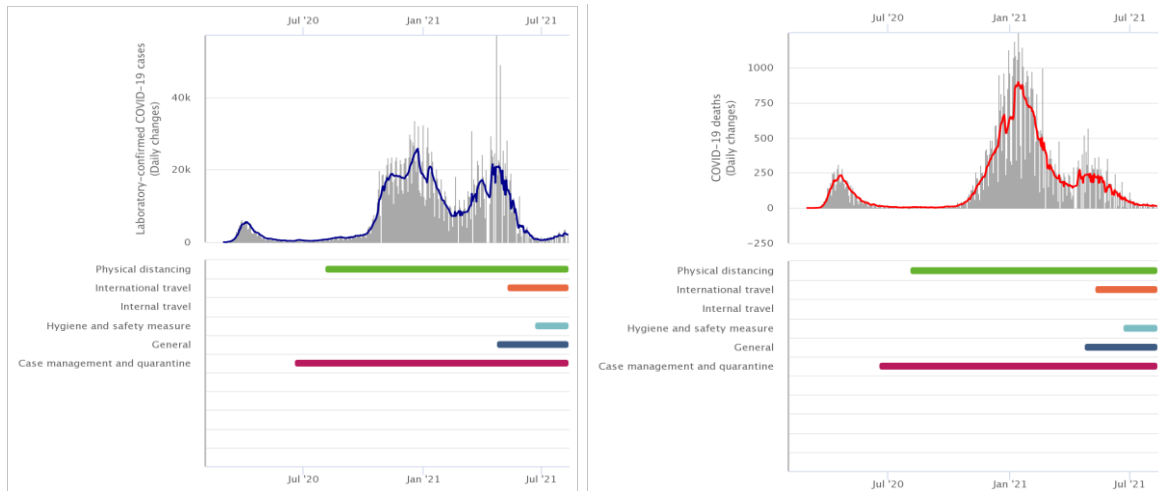


Fig 22: Public Measure of Non-pharmaceutical Interventions impact on COVID-19 cases and deaths[17]

5.3 Mitigation: Testing and Contact Tracing: Improved weekly testing strategies and Sequencing is of high importance for early detection and monitoring for targeted COVID-19 variant (Delta). Contact Tracing remains a key mitigation tool to break transmission chains. It helps in effective outbreak management during current phase of COVID-19 spread.[12]

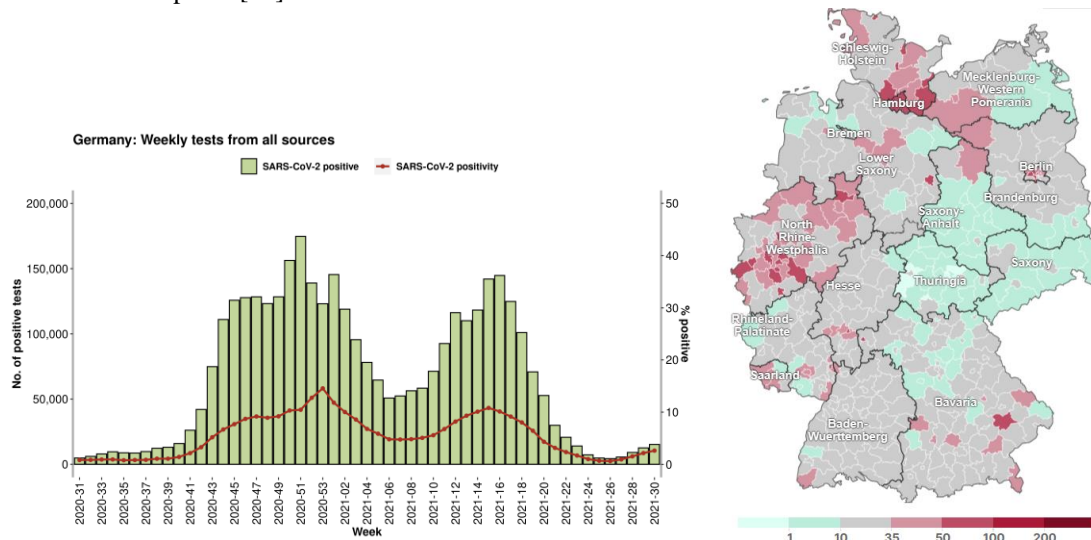


Fig 23: Weekly tests from all sources[18] and last 7-day COVID-19 infections[19]

6 Conclusion:

To summarize the report, The exploratory data analysis allowed us to identify the Delta variant is the cause for concern and through short-term prediction models such as the Linear regression model cannot forecast significant variations in the number of COVID-19 cases and deaths. And similarly, The Support Vector regression model partially does the short-term prediction of COVID-19 cases and deaths due to Delta Variant.

Ultimately, The polynomial regression model is suitable for short-term prediction of COVID-19 cases and deaths due to Delta Variant. And finally, it is observed that From figure regarding the SEIR model for COVID-19 estimation can predict COVID-19 with good accuracy over long-term (90-100 days) considering the characteristics of the delta variant's rapid transmission and infection rates with the initial reproduction rate ~ 7.95 , average incubation period as 8.5 and average infection period as 2.7.

Summary on the response strategy, The overall risk related to Delta Variant is expected to increase for the general population since, Delta variant is 40-60% more transmissible than the Alpha variant. Individuals with only one dose are less protected against Delta variant. Full vaccination provides better immunity and protection against the Delta variant. Non-pharmaceutical interventions should be maintained at a level sufficient to contain community transmission of the Delta VOC until greater shares of the population are fully vaccinated, in order to avoid a resurgence of cases. Targeted surveillance through contact tracing of the Delta variant which is currently circulating is of significance for early detection and monitoring of emerging Delta variants.

7 References:

1. https://en.wikipedia.org/wiki/SARS-CoV-2_Delta_variant
2. <https://badgerherald.com/features/2021/08/11/its-not-over-yet-how-indias-dealings-with-the-delta-variant-led-to-catastrophe-for-the-country-those-watching-from-afar/>
3. <https://indianexpress.com/article/explained/the-delta-variant-what-scientists-know-7371864/>
4. <https://coronavirus.data.gov.uk/>
5. <https://www.bbc.com/news/57500637>
6. <https://www.gisaid.org/hcov19-variants/>
7. <https://www.kaggle.com/vascodegama/covid-19-uk-delta-variant-surge/execution>
8. <https://www.themoscowtimes.com/2021/08/06/russias-excess-death-toll-passes-530k-as-delta-variant-hits-hard-a74721>
9. Satu, Md, et al. "Short-term prediction of COVID-19 cases using machine learning models." Applied Sciences 11.9 (2021): 4266
10. https://www.wikiwand.com/en/Compartmental_models_in_epidemiology#/The_SEIR_model
11. <https://www.kaggle.com/anjum48/seir-hcd-model?scriptVersionId=31459842>
12. European Centre for Disease Prevention and Control. Implications for the EU/EEA on the spread of the SARSCoV-2 Delta (B.1.617.2) variant of concern - 23 June 2021. ECDC: Stockholm; 2021.
13. European Centre for Disease Prevention and Control. Emergence of SARS-CoV-2 B.1.617 variants in India and situation in the EU/EEA– 11 May 2021. ECDC: Stockholm; 2021
14. Molina-Solana, Miguel & Ros, María & Ruiz, M. & Gómez-Romero, Juan & Martin-Bautista, Maria. (2017). Data science for building energy management: A review. Renewable and Sustainable Energy Reviews. 70. 598-609. 10.1016/j.rser.2016.11.132.
15. <https://impfdashboard.de/>
16. <https://worldhealthorg.shinyapps.io/euro-covid19/>
17. <https://covid-statistics.jrc.ec.europa.eu/RMeasures>
18. ECDC-WHO/Europe COVID-19 Surveillance Explorer (shinyapps.io)
19. Berliner Morgenpost