The Impact of COVID-19 Vaccination on the Daily Death Cases and New Cases in the USA

Rameasa Arna

Introduction

In December 2019, a strange sickness with fever, cough, exhaustion, and gastrointestinal symptoms spread across Wuhan, China and was eventually identified as the new coronavirus sars-cov-2[1]. It became the leading headline all across the world after a few weeks. It spread widely from China to Asia, Europe, and North America[2]. In May 2022, the virus had infected over 80 million people in the United States, with 0.9 million deaths. [3]. Since the beginning of the epidemic, WHO has emphasized the importance of maintaining social distance in order to prevent the virus from spreading [5]. Researchers believe that a vaccination is required to end the pandemic.[4]. Following clinical testing, the WHO approved a few immunizations for sars-cov-2. The vaccination was first restricted to elderly people who were more prone to succumb to the illness. This program gradually drew in middle-aged folks. All of the age groups are now being aggressively vaccinated across the United States. More than 80% of the total population in the United States received at least the first dose of vaccinations, according to COVID data tracker[3].

With the expectation of a solution to the situation, the world is now deciding whether or not the vaccine program is effective. To determine the success of vaccinations, data is

gathered, analyzed, and graphs are made to show the vaccines' effects. To accomplish this, data is being collected and sorted. The purpose of this study is to see how immunizations affect new cases and death cases in the United States.

Literature Review

Researchers have been hunting for a viable strategy to terminate the pandemic since the beginning of the outbreak. Clinical studies were conducted after the discovery of various medications as vaccines to test their efficacy[7]. Before making such vaccinations available to the rest of the world, the CDC and their other partners tested them in real-world scenarios[7].

Ali Roghani[6] showed that vaccination can reduce the number of COVID-19 patients in all age categories, resulting in lower hospitalization and death rates in the elderly. He used publicly available data from the Tennessee Department of Health to demonstrate the effectiveness on covid related hospitalization and death rates in various age groups. Mohammad Reza Davahli, Waldemar Karwowski, Krzysztof Fiok[8] constructed a sequence learning model to forecast the behavior of the COVID-19 outbreak across the United States using two time-series datasets of confirmed cases and effective reproduction numbers from January 22 to November 26 of 2020. Shahid F, Zameer A, Muneeb M[9] developed forecast models that included autoregressive integrated moving average (ARIMA), SVR, LSTM and Bi-LSTM for time series prediction of confirmed cases, deaths, and recoveries in ten major countries affected by COVID-19. They used those techniques to find the comparison among those countries. To assess

the models' performance, the researchers employed the mean absolute error, root mean square error, and r2_score indices. Vinay Kumar Reddy, Chimmula and Lei Zhang(10) used cutting-edge Deep Learning (DL) methods to construct a forecasting model for the COVID-19 epidemic in Canada. They demonstrated an LSTM network that can forecast future covid-19 cases and the end of the epidemic.

Data and Methods

The covid-19 dataset from Kaggle was utilized to evaluate the study, which has 774 observations and 14 variables[14] including people vaccinated, people fully vaccinated, people fully vaccinated per hundred, new deaths per million, new cases per million, new deaths and new cases. Furthermore, the data primarily contained information from all countries across the world; however, because the study's focus is solely on the United States, the data was limited to the United States.

To investigate the relationship between people fully vaccinated per hundred and new deaths per million, as well as people fully vaccinated per hundred and new cases per million, a scatter plot was created. The optimal relationship between those variables was determined by fitting the best fit line. Furthermore, a time series was created showing the 7 days of moving averages of death cases and the 7 days of moving averages of new cases over time. The purpose was to see how death cases and new cases changed once immunization was implemented. Python programming language was used to analyze the data.

Result

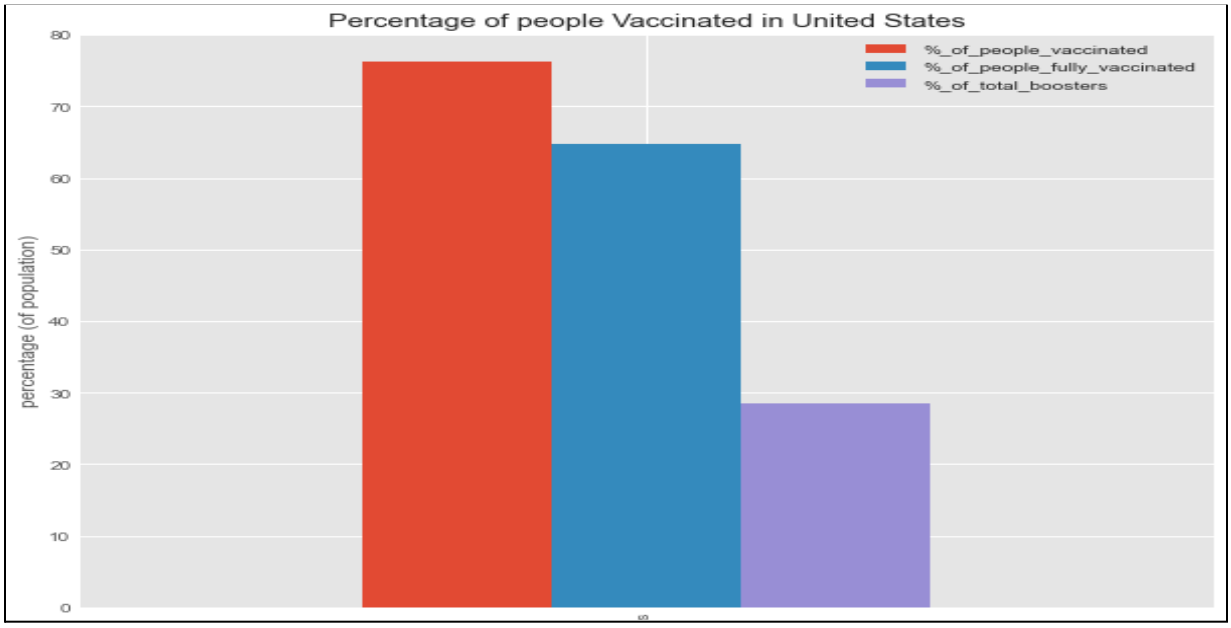

Figure 01: Percentage of people vaccinated in the USA.

In the United States, vaccination started in December 2020 and more than 76% of people have taken vaccination at least once till march 2022 according to Figure-01. Among those 62% have been fully vaccinated. We can find 29% people have taken booster doses till March 2022 from the figure-01.People preferred to obtain less vaccination at first because of lack of trust in vaccination as well as the number of available vaccinations was low in early 2021[15]. Moreover, the CDC didn't prioritize the vaccination of under-16 people earlier. Therefore, total vaccinations haven't reached the full population yet[11]. There was a minimum of 3 to 4 weeks delay between the doses. The delay between doses was increased in some cases to ensure a larger number of people were vaccinated.[12].

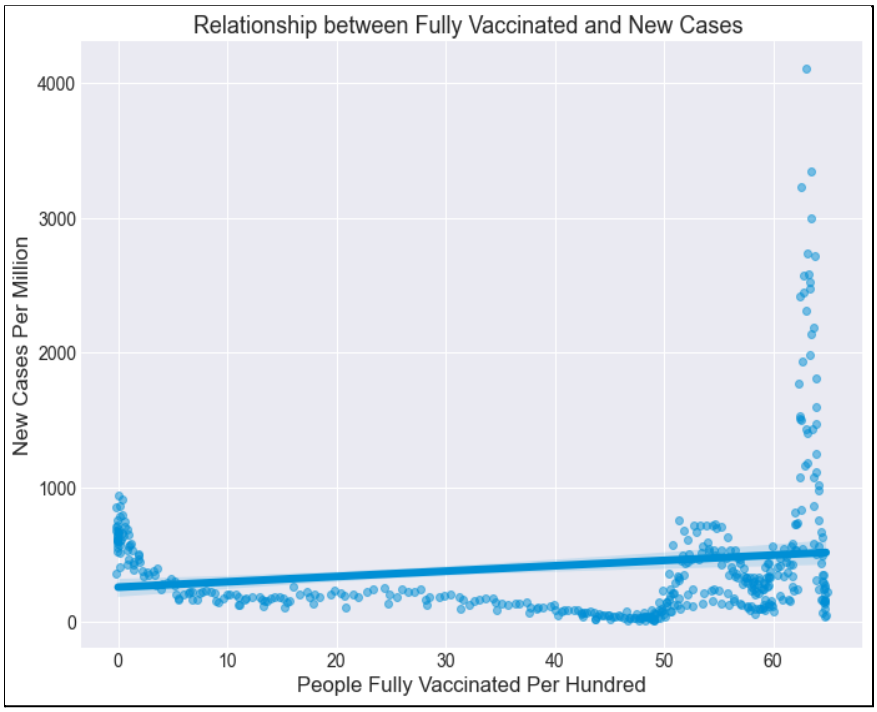

Figure 02: Relationship between Fully Vaccinated and New Cases

Scatter plot diagram was used to estimate the relationship of vaccination and daily new infection cases in Figure 02. The number of fully vaccinated people per hundred is represented on the X-axis, while the number of daily new cases per million is represented on the Y-axis.

The graph shows a nonlinear relationship between new cases per million and people who have been fully vaccinated. The figure shows that the number of new daily cases was first higher when vaccination began, but gradually declined, then began to rise again. The number of new cases was roughly four times higher than at its previous peak, when more than 60% of the population had been vaccinated, because of novel

delta and omicron strains[13]. Therefore, the best fit line is utilized to explain the relationship between the two variables, and the line demonstrates that new cases per million and people fully vaccinated are moderately positively associated.

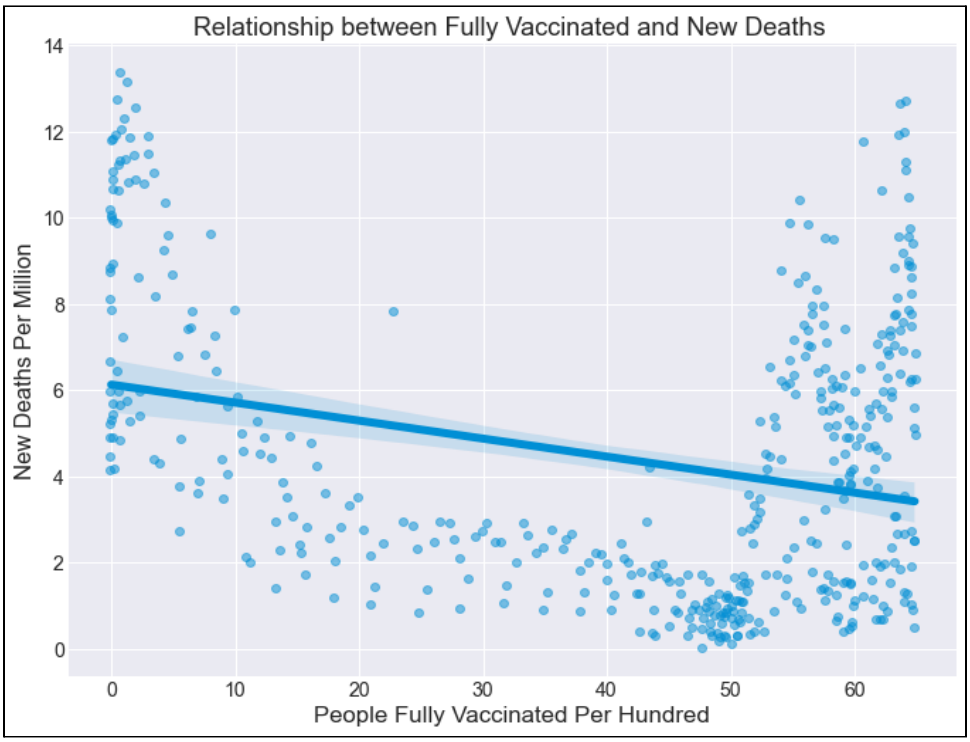

Figure 03: Relationship between people fully vaccinated and death cases

In figure-03 scatter plot was used to identify the impact of vaccination on daily new deaths in the USA. In this graph the X-axis represents fully vaccinated per hundred and the Y-axis represents daily new death cases per million. This graph is U-shaped, nonlinear and the best fit line shows it is weak and negatively correlated.

At the start of the vaccine, the number of new daily death cases was high. By the time the vaccination campaign was fully implemented, the number of daily death cases had dropped significantly. The number of new daily death cases increased during the

start of the delta and omicron variants, however it is lower than the initial peak when vaccination began.

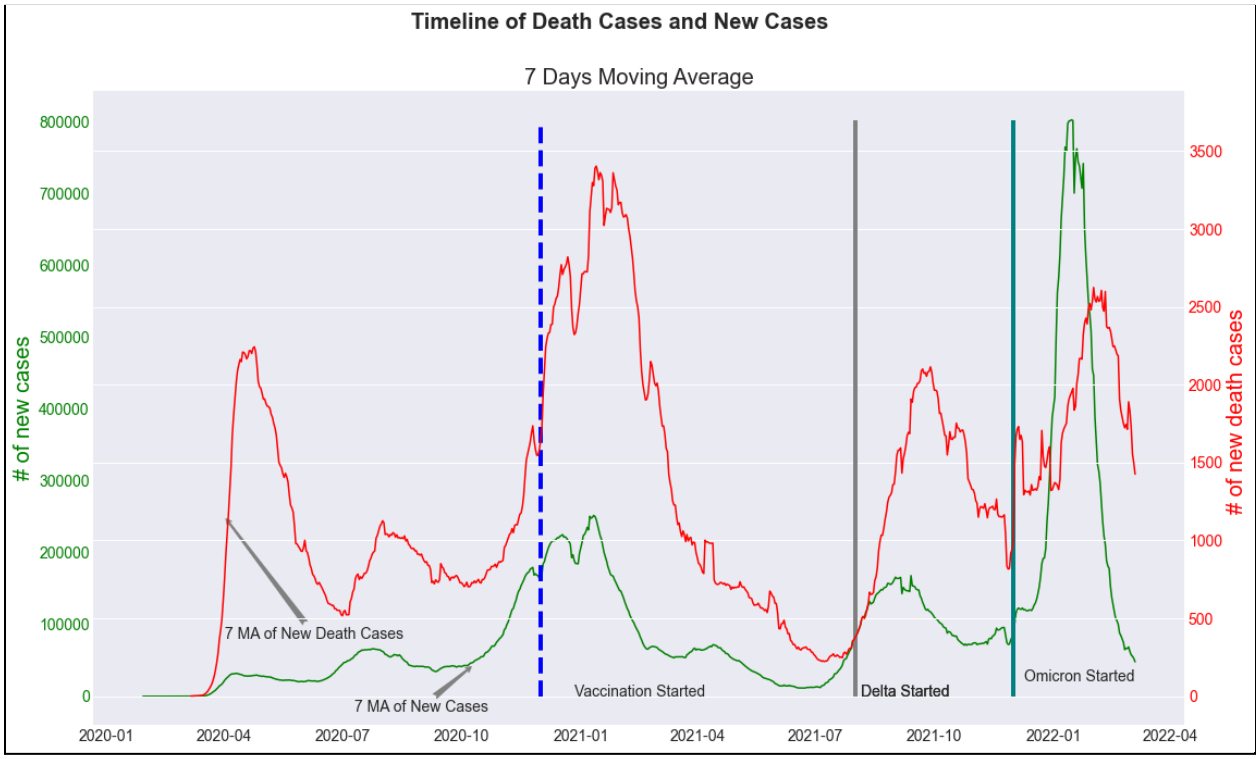

Figure 04: Timeline of death cases and new cases.

To understand how death cases and new cases have changed over time after vaccination began, a time series graph of 7 days moving average of daily new cases and 7 days moving average of daily death cases has been generated in figure-04. The X-axis represents the COVID-19 timeline, which runs from January 2020 to March 2021 while the Y-axis shows two variables in this graph: 7 days moving average of new daily cases (green line) and 7 days moving average of new deaths (red line).

Death cases began to rise in October 2020, reaching their highest point in January

2021. When the vaccination program began in December 2020, death cases were at an all-time high. Despite the fact that the immunization has been available since December 2020, it was only offered to persons aged 65 and up, as well as health-care and essential employees. Covid -19 immunizations were finally made available to everyone in April 2021[20]. After the vaccination program fully started, the number of deaths dropped dramatically after February 2021. Death cases began to rise again after the delta strain arrived in the United States in September 2021. The death cases dropped as the delta variant's influence was minimized. Then Omicron's effect began in January 2022, and the death rate rose slightly. Still, as indicated in the graph, the first peak of new death cases after vaccination began was higher than the later staged peak in the United States.

The number of new infection cases has been dropping since the beginning of immunization until the arrival of the delta and omicron varieties. In the United States, omicron hit harder than other types, with the latest peak of new cases four times higher than the prior peak.

According to those graphs, when the vaccination program started the death cases were higher; however, after vaccination, cases are still similar or somewhat higher but the death cases are comparatively lower. Hence indicating that the vaccination does not protect against the virus but it does help to reduce the severity and harm caused by the virus. To conclude vaccination has some effect on reducing death cases, but the data does not demonstrate that it has the same effect on new daily cases.

Conclusion:

Vaccination in the USA started on 14th of December in 2020[16]. Due to lack of vaccine doses, the program couldn't cover the majority of the USA quickly. The research covered the impact of vaccination on daily death cases and daily new cases. The primary finding shows that vaccination reduced the number of new deaths. On the other hand, vaccination couldn't prevent the rise of daily new cases. This study also indicates the reason behind the rise of daily new cases which are delta and omicron variants.

Discussion:

According to the data, almost 62% of people have been fully vaccinated[14]**.** The research shows that increasing vaccination has reduced the death cases in the USA. Vaccination had decreased the new infection cases however, new cases went up again once the delta and omicron variants hit the USA. The study solely looked at reported new infections and deaths in the United States, implying that the data on original transmission among persons may not be accurate. For example, people without symptoms may not seek testing on their own, yet testing is necessary for determining disease transmission.

Vaccination programs may have a key role to mitigate the impact of delta variants and omicron[17]. Delta variations accounted for more than 50% of circulating variants by the end of June 2021, and 100% by the end of September [3]. On December 1, 2021, omicron arrived in the United States, accounting for 95 percent of all circulating variants by the 2nd of January 2022[3]. Delta variants were found to increase infection and

fatality rates in the United States in several studies[18]. The situation could deteriorate without vaccination.

Several limitations were found in this research. While interpreting the data, clarifications were missing in different variables. For example, data didn't show the age of the patients which is an important factor in death cases. Elderly persons are more likely to die due to Covid-19 than younger people[19]. Moreover, the data didn't show if the infected people were vaccinated or not. Apart from that, the timeline didn't show the full vaccination among people, so people can be infected while having one dose of vaccination or no vaccination at all. The data of fully vaccinated people getting COVID-19 could be useful to identify the real impact of vaccination. Nevertheless, by using different methods in interpreting the data could help find the impact of vaccination.

Reference

1. Cássaro FAM, Pires LF. Can we predict the occurrence of COVID-19 cases? Considerations using a simple model of growth. Sci Total Environ 2020 Aug 01;728:138834

2. Wu, Yi-Chia; Chen, Ching-Sunga; Chan, Yu-Jiuna. The outbreak of COVID-19: An overview.Journal of the Chinese Medical Association: March 2020 - Volume 83 - Issue 3 - p 217-220 Doi:10.1097/JCMA.0000000000000270

3. COVID Data Tracker. Centers for Disease Control and Prevention, 2021. URL:https://covid.cdc.gov/covid-data-tracker/#datatracker-home [accessed on 2022-05-12]

4. Edouard Mathieu, Hannah Ritchie, Esteban Ortiz-Ospina, Max Roser, Joe Hasell, Cameron Appel, Charlie Giattino. A global database of COVID-19 vaccinations. Nature Human Behaviour.doi:https://doi.org/10.1101/2021.03.22.21254100

5. Romer D, Jamieson KH. Conspiracy theories as barriers to controlling the spread of COVID-19 in the U.S. Soc Sci Med 2020 Oct;263:113356

6. Roghani A The Influence of COVID-19 Vaccination on Daily Cases, Hospitalization, and Death Rate in Tennessee, United States: Case Study JMIRx

Med 2021;2(3):e29324 URL: https://xmed.jmir.org/2021/3/e29324 DOI: 10.2196/29324

7. “Vaccine effectiveness research.” URL: https://www.cdc.gov/vaccines/covid-19/effectiveness-research/protocols.html Accessed on 13th May, 2022.

8. Davahli MR, Karwowski W, Fiok K (2021) Optimizing COVID-19 vaccine distribution across the United States using deterministic and stochastic recurrent neural networks. PLoS ONE 16(7): e0253925. doi:10.1371/journal.pone.0253925

9. Shahid F, Zameer A, Muneeb M. Predictions for COVID-19 with deep learning models of LSTM, GRU and Bi-LSTM. Chaos Solitons Fractals. 2020;140:110212. doi: 10.1016/j.chaos.2020.110212. pmid:32839642

10. Vinay Kumar Reddy Chimmula, Lei Zhang,Time series forecasting of COVID-19 transmission in Canada using LSTM networks,Chaos, Solitons & Fractals,Volume 135,2020,109864,ISSN 0960-0779, https://doi.org/10.1016/j.chaos.2020.109864.(tps://www.sciencedirect.com/science/article/pii/S0960077920302642)

11. Islam MR, Oraby T, McCombs A, Chowdhury MM, Al-Mamun M, Tyshenko MG, et al. (2021) Evaluation of the United States COVID-19 vaccine allocation strategy. PLoS ONE 16(11): e0259700. doi:10.1371/journal.pone.0259700

12. Seyed M. Moghadas, Thomas N. Vilches, Kevin Zhang, Shokoofeh Nourbakhsh, Pratha Sah, Meagan C. Fitzpatrick and Alison P. Galvani4. Evaluation of COVID-19 vaccination strategies with a delayed second dose. doi: 10.1101/2021.01.27.21250619

13. Salim S Abdool Karim and Quarraisha Abdool Karim. Omicron SARS-CoV-2 variant: a new chapter in the COVID-19 pandemic. doi: 10.1016/S0140-6736(21)02758-6, PMCID: PMC8640673, PMID: 34871545

14. Saavedra, George. "Covid-19 Dataset." *Kaggle*, 7 Mar. 2022, https://www.kaggle.com/datasets/georgesaavedra/covid19-dataset

15. Khubchandani, J., Sharma, S., Price, J.H. et al. COVID-19 Vaccination Hesitancy in the United States: A Rapid National Assessment. J Community Health 46, 270–277 (2021). https://doi.org/10.1007/s10900-020-00958-x

16. "COVID-19 vaccines I" URL: https://www.hhs.gov/coronavirus/covid-19-vaccines/index.html (Accessed on 18th may,2022)

17. Christie A, Brooks JT, Hicks LA, Sauber-Schatz EK, Yoder JS, Honein MA, CDC COVID-19 Response Team. Guidance for Implementing COVID-19 Prevention Strategies in the Context of Varying Community Transmission Levels and Vaccination Coverage. MMWR Morb Mortal Wkly Rep 2021;70:1044-7. doi:10.15585/mmwr.mm7030e2 pmid:34324480

18. Ong SWX, Chiew CJ, Ang LW, et al. Clinical and virological features of SARS-CoV-2 variants of concern: a retrospective cohort study comparing B.1.1.7 (Alpha), B.1.315 (Beta), and B.1.617.2 (Delta). Clin Infect Dis2021;ciab721. doi:10.1093/cid/ciab721 pmid:34423834

19. Levin AT, Hanage WP, Owusu-Boaitey N, Cochran KB, Walsh SP, Meyerowitz-Katz G. Assessing the age specificity of infection fatality rates for COVID-19: systematic review, meta-analysis, and public policy implications. Eur J Epidemiol2020;35:1123-38. doi:10.1007/s10654-020-00698-1 pmid:33289900

20. Crist, Carolyn. "All U.S. Adults Eligible for COVID-19 Vaccines." *WebMD,* www.webmd.com/vaccines/covid-19-vaccine/news/20210420/all-us-adults-eligible-covid-vaccines. Accessed 19 May 2022.