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REVIEW ARTICLE

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How has the Vaccine Changed COVID-19?

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ABSTRACT

Almost two years since the first case of Coronavirus 2019. Vaccine development in many countries have been accelerated due to the suffering of COVID-19 pandemic. We analyzed the daily data related to new cases, new deaths, and vaccinations in United States of America, European Union, and Japan. Each country or area representing one continent in order to evaluate the impact of COVID-19 vaccination. We conclude that the vaccination did help decrease the daily new cases in all those three countries or area at the beginning. However, due to the group of population who refused to take vaccination, the impact of the vaccination in controlling the virus decreased as time goes by, situation that happened in all those three countries or area. We would highly suggest the government in each country to take all possible action to encourage people to be fully vaccinated as soon as possible and maintain other practices of COVID-19 infection control.

ARTICLE HISTORY

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Introduction of COVID-19

The World Health Organization (WHO) declared a worldwide pandemic on March 11, 2020[1]. This was determined to be a novel coronavirus that was initially named 2019nCov (SARS-CoV-2 or Covid-19). More than a year have passed since the COVID-19 global pandemic started, and since then, scientists, and researchers have discovered very crucial and important information regarding the COVID-19 disease which is caused by a virus of the family Coronaviridae called SARS-CoV-2, which possess a single strand, positive-sense RNA genome [9]. The virus has been noted to be similar to SARS-COV-1 (80%) and MERS-COV (50%). Similar to SARS-COV-1, COVID-19 also infects human cells by spike glycoprotein binding to a cellular receptor, angiotensin-converting enzyme Z [10,11]. The main transmission route for SARS-CoV-2 is human-to human transmission via respiratory droplets and skin contact, with incubation times of 2–14 days. The SARS-CoV-2 is an enveloped RNA surrounded by spike glycoproteins that let it enter cells through membrane fusion, immune responses shape the clinical course of COVID-19; 7–10 days after the onset of symptoms there may be an increase of respiratory failure, and organ support, and on approximately the tenth day of infection, COVID-19 may provoke respiratory failure due to high-flow oxygen [14]. The appearance of the symptoms is not consistent in the infected patients. The variation of symptoms or lack of made tracking the virus very difficult. It was needed to make an effective control plan for the virus. Some infected patients had zero to mild symptoms, while others had a more severe reaction to COVID-19. Patients with pre-existing conditions are more likely to experience severe acute respiratory disorder and multi-organ failure [12]. The appearance of the symptoms will mostly depend on the age and the state of the patient's immune systems. What is known is that this virus affects those over the age of 60 or have pre-existing conditions more severely than those who are younger. Patients over the age of 70 were more likely to develop symptoms later than those who were younger [13]. Multiple studies found that the most common symptoms of COVID-19 are fever (77.4-98.6%), cough (59.4-81.8%), muscle pain (3.2-55.0%), and shortness of breath (11.1-34.8%). In contrast, the least common tended to be gastrointestinal symptoms (39.6%) [13,11,9].

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-COV-2) was declared as an infectious disease and no available vaccine was able to fight the virus. Because of no vaccine, SARS-COV-2 created a pandemic in March 2020 due to high levels of infection and spreading followed by increasing levels of inaction. As the Severe Acute Respiratory Syndrome Coronavirus 2, or SARS-COV-2 for shorter terms, swiftly took the world by surprise.

Vaccine in COVID-19

Unfortunately, due to the quick development of the vaccine, one problem lies in the willingness of taking the vaccine. The public is hesitant due to the lack of knowledge of the vaccine's internal components. This created what experts are calling "Vaccine Hesitancy" and is affecting the rate of immunization against COVID-19 [2-5]. Vaccines are first developed in laboratories and are essential to controlling infectious diseases outbreaks. The more common viruses, Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) are all related to the virus that caused COVID-19 [3]. The knowledge that was previously gained by studying the other related viruses helped accelerate the development of recent COVID-19 vaccines.

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Most vaccines and medicines are developed within 10-15 years with the special exception of the COVID-19 vaccine. The coronavirus vaccine was created within a year since the start of the pandemic [6]. There are three general categories for concerns against the COVID-19 vaccine. First is the necessity of vaccines. Secondly is vaccine safety. Lastly is the freedom of choice.

India has the world's second largest population and is a fraction of the world's population. Getting India vaccinated will help in controlling the spread of the disease [8]. Through the use of vaccination plans, India's healthcare workers were completely vaccinated and were able to fight most suspicions of COVID-19 vaccine hesitancy [4]. Former president Trump's plan "Operation Warp Speed" and President Biden's plan of "One Million Vaccinations per Day" were both used in the simulations. However, one unforeseen consequence in this study was that a significant reduction in non-pharmaceutical interventions resulted in a situation that a higher vaccine compliance then leads to an increase in infections. With this study, it was concluded that vaccines alone cannot end the pandemic solely from the vaccine strategy [7]. Non-pharmaceutical interventions need to be enforced so the rate of immunity can outweigh the rapid spreading of infections. Moghadas et al. [15] pointed out that vaccination can have a substantial impact on mitigating COVID-19 outbreaks, even with limited protection against infection, however, continued compliance with non-pharmaceutical interventions is essential to achieve this impact.

Objectives

- Describe the population behavior of the number of COVID-19 cases in different continents of the world.
- Describe the population behavior of the number of COVID-19 deaths in different continents of the world
- Describe the population behavior of number of COVID-19 vaccinations in different continents of the world.
- Discuss the relationship between COVID-19 number of cases and number of vaccinations in different continents of the world

Methodology

The COVID-19 data used for this research was obtained from Our World Data, Coronavirus Source Data. It is an open access source of COVID data under the Creative Commons By license. World Data is a project of the Global Change Data Lab a registered charity in England and Wales Charity Number 1186433 [16].

The variables studied were the following.

- New Cases. New cases are defined as the total new cases of COVID-19 confirmed per day.
- New deaths: New deaths are defined as the total number of deaths attributed to COVID-19 per day.
- New deaths per million. New deaths per million are defined as the total number of deaths per million attributed to COVID-19 per day.
- New vaccinations. New COVOD 19 vaccinations are defined as the total number of vaccinations per day.

The data from a selected country located in each continent was used for this research. America: United States of America, Europe: European Union, Asia: Japan.

Graphs were constructed for each of the countries and variables using IBM SPSS 26. To compare simultaneously the number of cases and number of vaccinations, the variables were standardized using z-scores (www.theanalysisfactor.com).

Results

Results in the United States of America. Figure 1 shows that starting in January 2020, the number of new cases per day increased from 1 new case on January 24, 2020 to a maximum of 295,257 new cases on January 8, 2021. The number of new cases decreased from 295,257 new cases on January 8, 2021 to a minimum of 3,892 new cases on June 20, 2021. After that date, the number of cases started to increase again up to 194,608 cases per day on July 30, 2021. Figure 2 shows that the first deaths occurred on February 29, 2020 was 0.003 deaths per million. The graph has three modes. One occurred on May 4, 2020 with 5,362 deaths per million, the second occurred on August 2020 with 4,099 deaths per million, and the highest mode occurred on January 12, 2021 with 13,474 deaths per million. After the last date, the number of deaths decreased to a minimum on July 17, 2021 with 0.211 deaths per million. In Figure 3, the first vaccinations occurred on December 21, 2020 with 57,909 new vaccinations per day. The maximum number of new vaccinations occurred on April 10, 2021 with 4,629,928 new vaccinations per day. From this date on, the number of vaccinations has decreased to a minimum on July 26, 2021 with 393,083 new vaccinations per day. In Figure 4, we can see from December 2020 to March 2021, the number of cases decreased as the number of vaccinations increased.

From April 16, 2021 to June 5, 2021, the number of vaccinations decreased and the number of cases decreased at the same time. However, starting in late June 2021, the number of cases increased again. As of July 30, 2021, 56.96 % of the population has been vaccinated.

Results in The European Union. Figure 5 shows starting in January 2020, the number of cases per day increased from 2 new cases on January 24, 2020 to a maximum of 274,748 new cases on November 2, 2021. The number of new cases decreased from 237,721 new cases on April 8, 2021 to a minimum of 6,190 new cases on June 27, 2021. After that date, the number of cases started to increase again up to 90,693 new cases per day on July 28, 2021. The curve has four modes in April 2020, November 2020, January 2021, and April 2021. Figure 6 shows that the first deaths occurred on February 14, 2020 with 0.002 deaths per million. The graph has three modes, which occurred on April 15, 2020 with 8,995 deaths per million, on January 19, 2021 with 11,274 deaths, which is the highest mode, and on March 14, 2021 with 6,932 deaths per million. After April 17, 2021, the number of deaths decreased to a minimum on July 7, 2021, of 0.13 deaths per million. In Figure 7, the first vaccination occurred on December 17, 2020 with 1 new vaccination. The maximum number of new vaccinations occurred on June, 2021 with 4,935,785 new vaccinations per day. From this date on, the number of vaccinations has decreased to a minimum on July 30, 2021 with 1,711,297 new vaccinations per day. Figure 8 tells us that from April 8 to June 27, 2021, the number of

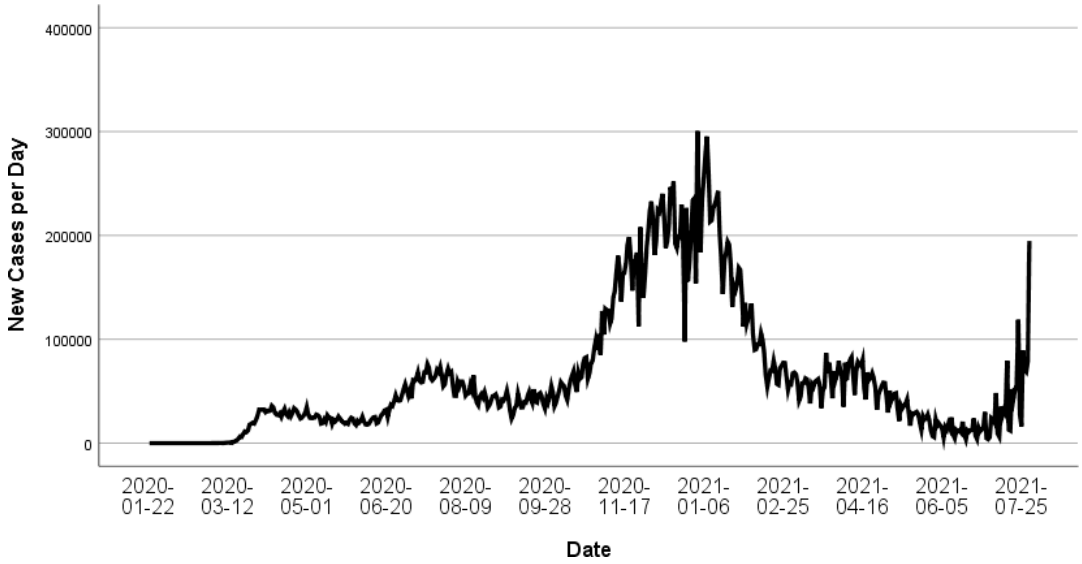

Figure 1: Describes COVID-19 new cases per day in United States of America from January 2020to July, 2021.

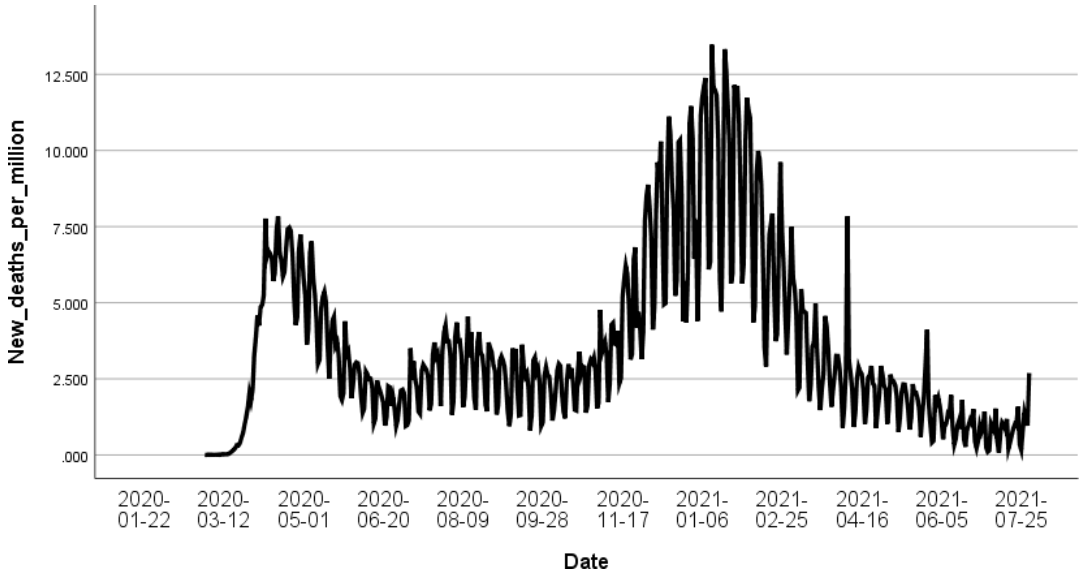

Figure 2: Describes the number of COVID-19 new deaths per million in Unites States of America.

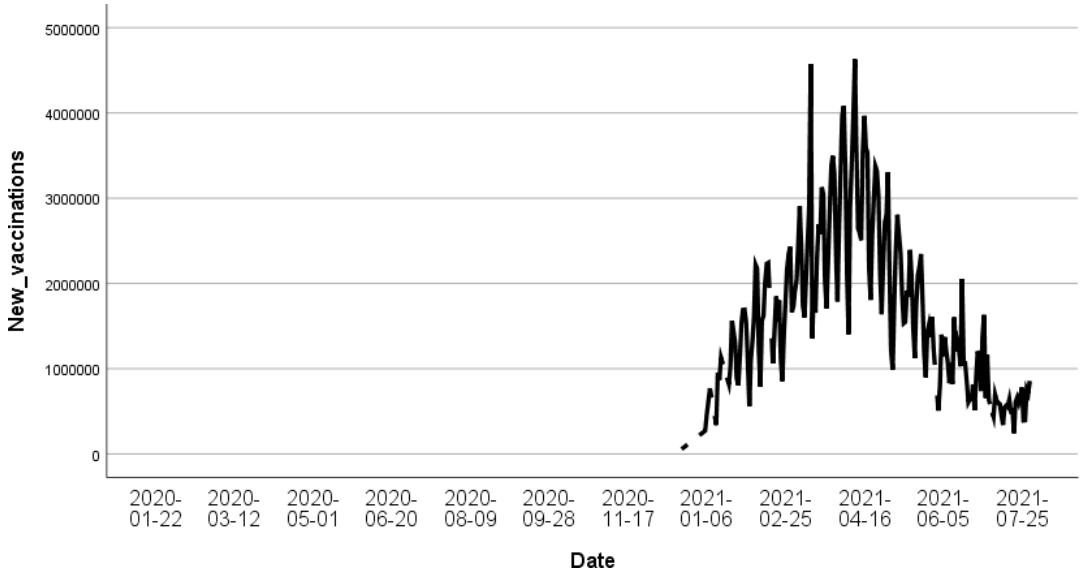

Figure 3: Describes the number of new vaccinations per day from January 2020 to July 2021 in United States of America.

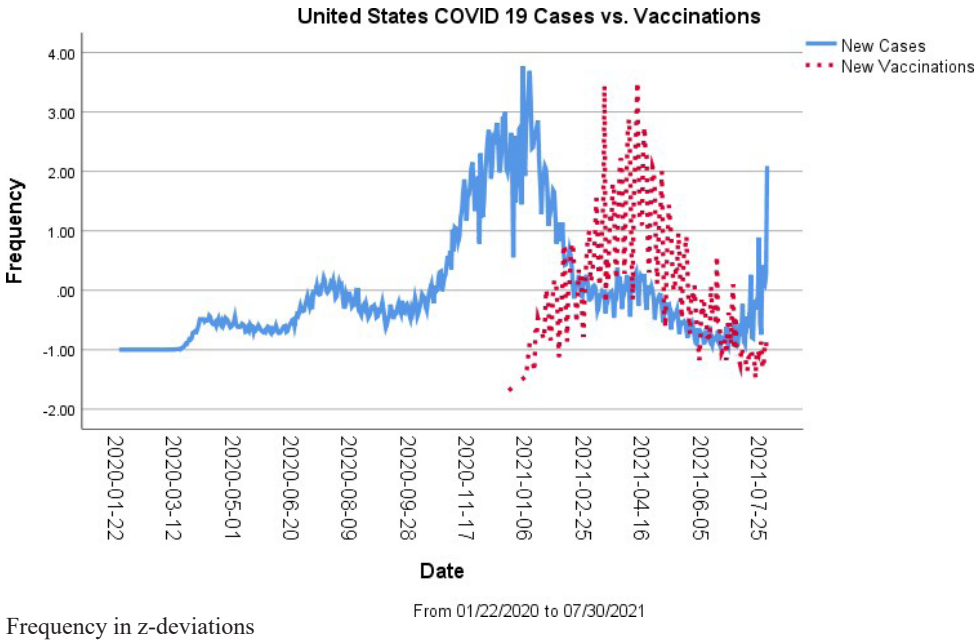

Figure 4: Compares the number of new cases (z-deviations) and the number of vaccinations from January 2020 to July 2021 (z-deviations) in United States of America.

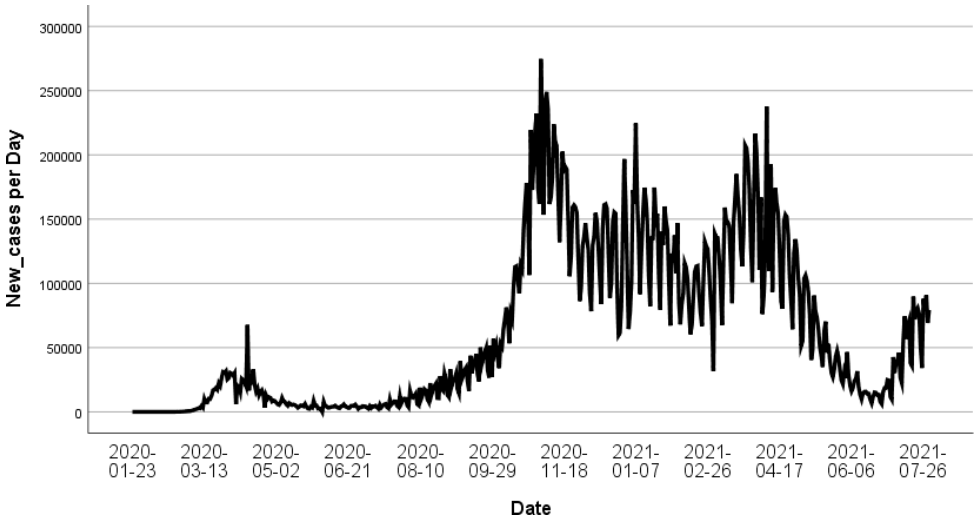

Figure 5: COVID-19 new cases per day in the European Union from January 2020 to July, 2021.

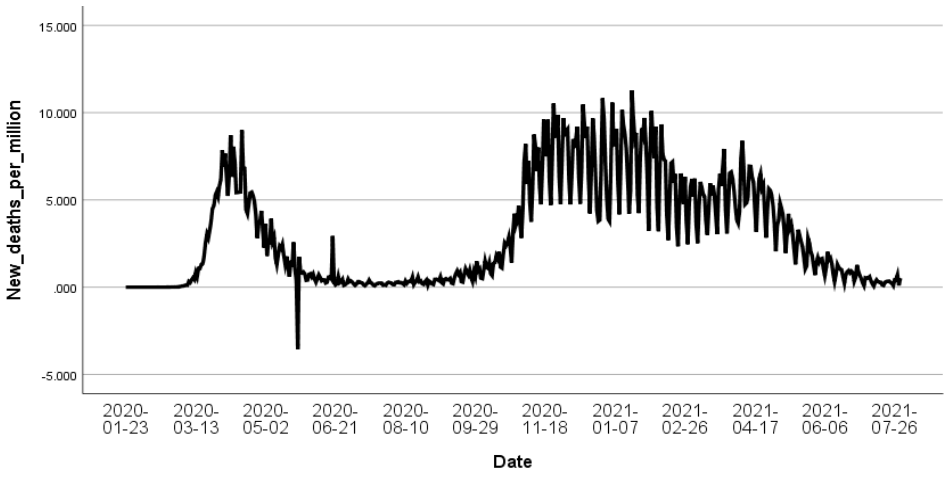

Figure 6: European Union number of COVID-19 deaths from January 2020 to July 2021.

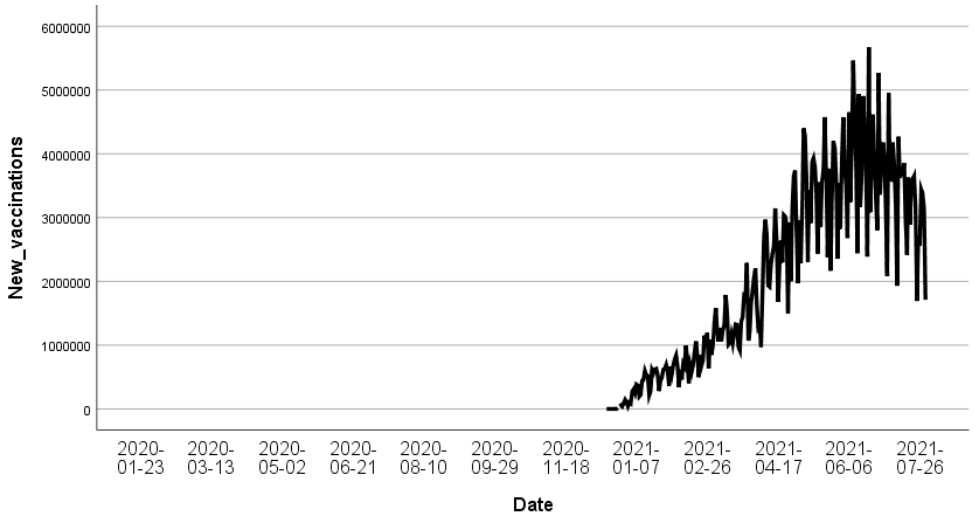

Figure 7: European Union number of vaccinations per day from January 2020 to July 2021.

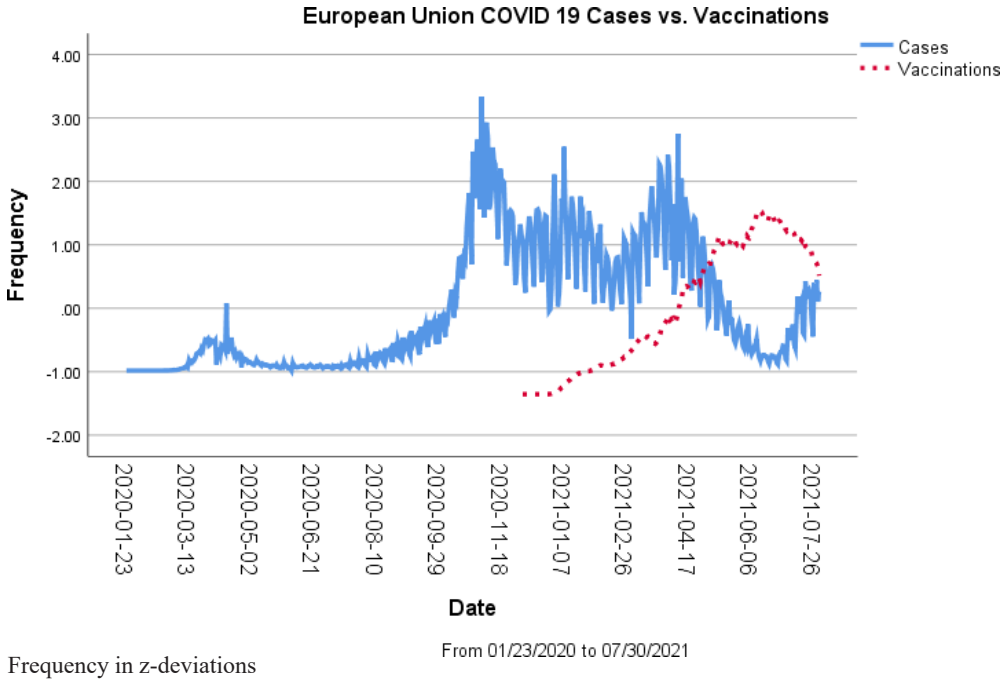

Figure 8: European Union number of cases vs. number of vaccinations from January 2020 to July 2021.

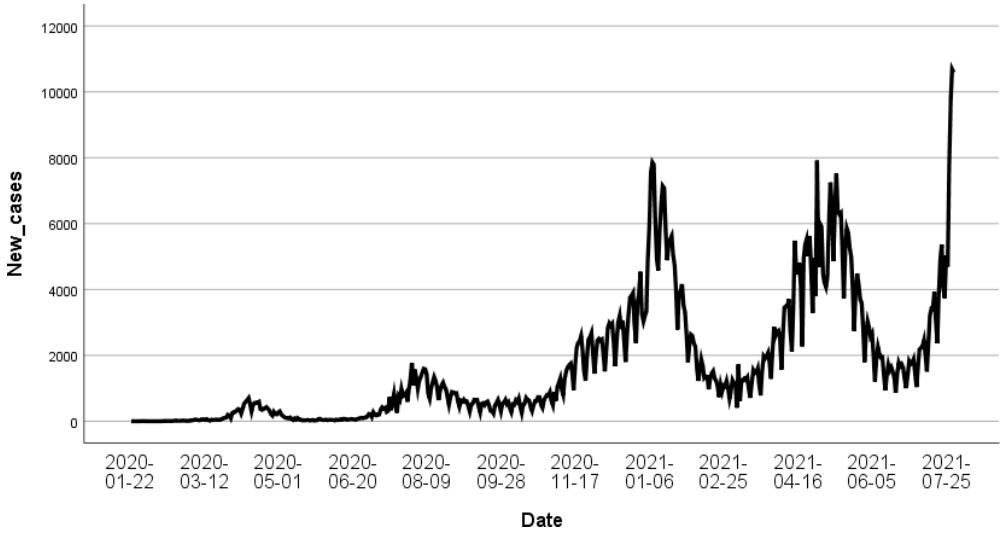

Figure 9: Describes COVID-19 new cases per day in Japan from January 2020 to July, 2021.

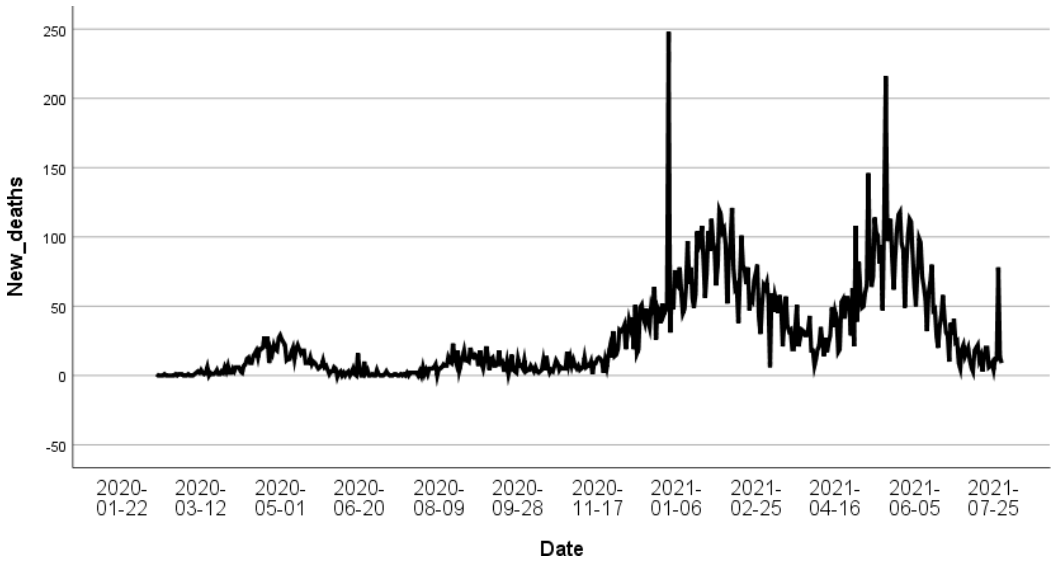

Figure 10: Japan number of COVID-19 deaths from January 2020 to July 2021.

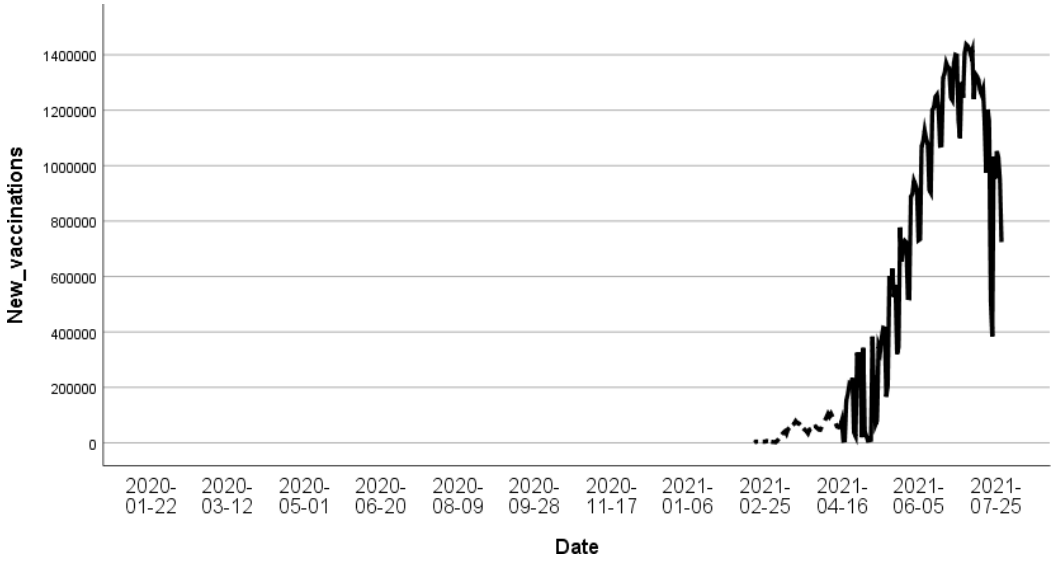

Figure 11: Japan number of vaccinations per day from January 2020 to July 2021.

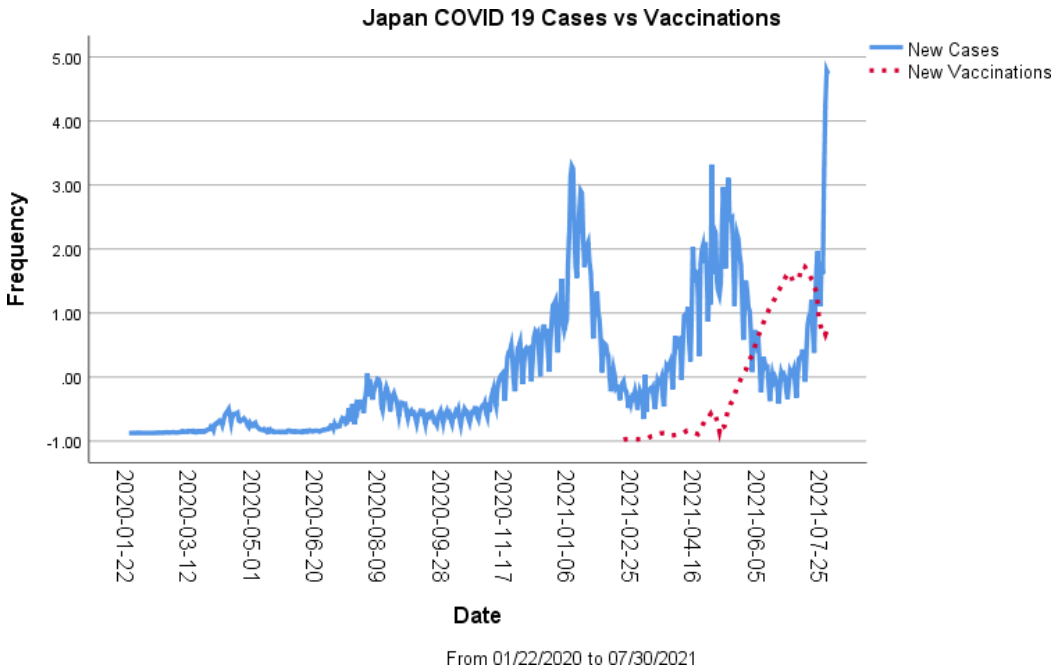

Figure 12: Compares the number of new cases (z-deviations) and the number of vaccinations from January 2020 to July 2021 (z-deviations) in Japan.

cases decreased as the number of vaccinations increased. From that date on, the number of vaccinations decreased and the number of cases decreased at the same time. However, starting on June 27, 2021, the number of cases increase again. As of July 30, 2021 59.11 % of the population has been vaccinated.

Results in Japan. Figure 9 shows that starting in January 2020 the number of new cases per day increased from 2 new cases on January 26, 2020 to a maximum of 10,684 new cases on July 29, 2021. The graph has four modes and a high point. The modes are as follows 701 new cases on April 11, 2020, 1,347 new cases on August 14, 2020, 7,863 new cases on January 8, 2021, 7249 new cases on May 8, 2021, and a high point 10, 684 new cases on July 29, 2021. In Figure 10, the first deaths occurred on February 13, 2020, with 1 death. The graph has four modes. One on May 1, 2020 with 29 deaths, the second mode on September 8, 2020 with 21 deaths, the third mode on February 2, 2021 with 119 deaths, and the last mode on May 27, 2021 with 118 deaths. After May 27, 2021, the number of deaths decreased to a minimum of 3 deaths on July 18, 2021. Figure 11 shows that the first vaccinations occurred on February 18, 2021 with 486 new vaccination. The maximum number of new vaccinations occurred on July 8, 2021 with 1,420,481 new vaccinations per day. From this date on, the number of vaccinations has decreased to a minimum on July 30, 2021 with 724,316 new vaccinations per day. From Figure 12, we can see that from May 03, 2021 to July 05, 2021, the number of vaccinations increased and the number of new cases decreased. After that point, even that the number of vaccinations kept increasing until July 10, 2021, the number of new cases increased. 27.79 % of the population has been vaccinated by July 30, 2021.

Discussion

The data shows that the number of cases and deaths decreased as the vaccinations increased. However, it is paradoxical that after the vaccination increased, there was an increase in number of cases. Deepa Caturvedi et al. [17] concluded that vaccination is not the only solution to reduce the cases of COVID-19. They proposed that the percentage of the population vaccinated, social distance, hygienic practices, restrictions in educational institutions, and travel need to be continued to reduce the number of cases. They propose that these actions should be continued for at lest one more year, Clare C. Brown et al. [18] found that more vulnerable areas related to minority status, language, housing type, transportation, household composition, and disabilities, and health care systems affect the number of individuals vaccinated and then make some populations vulnerable to COVID-19. Andrea L. Benin MD et al. [19] compared COVID- 19 incidence rates among nursing homes residents living in facilities with vaccination clinics with those living in facilities with no vaccination clinics. They found that vaccination of residents contributed to the decline in COVID-19 incidence. However, other factors contributed also. A multi faced approach to prevention contributed to the reduction of cases not only vaccination. Katarzina et al. (20 found that the efficacy of vaccination was lower in real-life vaccination when compared with what is expected from clinical trials. Moreover, they confirmed that a reduction of mobility among countries help reduce mortality also. Costar A. Varotsos et al. [21] concluded that the complete eradication of COVID-19 is possible only through successful vaccination of the entire population. Based on the discussion above we can argue that the increase of number of cases after vaccinations was due to an increase in cases among a non- vaccinated individuals and a decrease of the application of other measures of prevention.

Conclusion

Combining all the results from three different areas, we can see that COVID-19 vaccine did help to decrease the number of new COVID-19 cases. Especially, when the vaccine was originally applied widely, the new lowest of new cases since the vaccination happened in U.S. and European in February 2021, and Japan in July 2021. However, the impact of vaccinations was reduced later on, which happened in all three areas. Even though the number of vaccine continue increasing, the number of new cases increased as well. This trend happened in April 2021 in U.S. and European, and in late July 2021 in Japan. This trend might be because there were certain number of people in every area, who did not trust the vaccine, thus refused to take the vaccine. This group of population may be the source of new cases that contributed to the increase of new cases. Therefore, the impact of vaccine in each country shows a trend similar to the law of diminishing marginal utility: all else equal, as consumption, which here similar to the vaccination, increases, the marginal utility derived from each additional unit declines, which here means the impact of vaccination in controlling the virus. As the decreasing of the vaccine number, we can see the number of new cases arrived a new peak value in July 2021 in all three areas. The decreasing of impact of the vaccination might also be because the percentage of vaccinated population is still not big enough with regard to the total population in each country. Moreover, other methods of reduction of possibility of COVID-19 infection with should be applied like social distancing, hygienic practices, institutional control, and reduction of international mobility.

As a suggestion we would give to the government is that they should try everything to encourage people to be fully vaccinated as soon as possible.

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