Research on the Effects of Vaccination and Policies on Infection Rate of Covid-19 Taking New York and California as the Examples

Zixuan Liu[a], [*], [†], Yichen Peng[b], [*], [†]

College of Art & Science, New York University, New York, United States

[*]Corresponding author: [a]zl2406@nyu.edu, [b]yp1005@nyu.edu

[†]These authors contributed equally

Keywords: Covid-19; Vaccine; Policy; Trade-off of public health and local economy.

Abstract: Owing to the Covid-19's low fatality rate but extremely high infectiousness and numerous unknown sequels, the government usually has to make a choice in the trade-off between the public health and local economy, embodied by whether they implement strict anti-pandemic policies and regulations. As over 70% of Americans have taken at least one Covid-19 vaccine dose, this pandemic should have been at least almost ended as most people thought before. But as a matter of fact, the pandemic seems to be rampant again starting June 2021. This research attempts to find a better method to deal with Covid-19. This study first presents and compares the latest vaccination situation ranging from the whole of America to specifically New York and California using the geographical data with the basemap. Then it tests the Coivd-19 vaccine's real effect through single-variable and multivariable linear regressions on test positive rate and death rate and finds that the vaccine's real effect is much more significant than that reported from the clinical experiments. After comparing the pandemic situation between New York City and Los Angeles, this research finds that the difference in the anti-pandemic regulations may lead to the difference in controlling the pandemic. Then this study tests the impact of anti-pandemic policies promulgated by the government by statistical comparisons and finds that they have an immense influence on alleviating the pandemic. Finally, by comparing the economy index of New York from different periods, this study finds that New York City government's regulations secured public health without hurting the economy. Therefore, this study suggests other governments could take pattern by it to issue similar regulations and continue to promote vaccination.

1. Introduction

Coronavirus Disease 2019 (COVID-19) causes a tremendous influence on people all over the world. Currently, COVID-19 has spread to almost all countries, infected over 259 million people, and resulted in more than 5.17 million deaths around the world [1]. Compared to the Ebola Virus Disease (EVD) which has such a high fatality rate that the government simply implement full lockdown and strict isolation and Influenza (FLU) which usually has such a low fatality rate that the government just give no response, Covid-19 has an in-between fatality rate and numerous unknown severe sequels like asthma and the loss of smell. Due to this property, in 2020, the government was facing a trade-off between public health and the local economy, and at that time most people regarded the vaccine as the solution to this problem. However, it has been such a long time since the first Covid-19 vaccine was invented and approved to enter the market and until November 12th, more than 194.7 million American has been fully vaccinated [2]. But, as recently the Delta variant attacks and spreads widely in the USA, the Covid-19 become rampant again. So, it seems like the vaccine is not the complete correct answer to stop Covid-19. Maybe another way must be found to co-exist with it.

Previous studies mainly focus on the Covid-19 variants themselves. For example, the research of Effectiveness of Covid-19 Vaccines against the B.1.617.2 (Delta) Variant investigated how efficient it is for Pfizer and AstraZeneca to prevent the infection of Covid 19 delta variant compared with alpha variant, and the result showed that the infection rate of delta variant is slightly higher than alpha variant

after people receiving 2 doses of either kind of vaccine [3]. According to the research of BNT162b2 and mRNA-1273 COVID-19 vaccine effectiveness against the SARS-CoV-2 Delta variant in Qatar, there is the considerable effect of 2 doses of either Moderna or Pfizer on reducing hospitalization and death caused by delta variant among Qatar population. However, for people who took Pfizer, the infection rate is still high [4].

But in conclusion, there is still a research gap on the real effect of the vaccine and decisive solution to the trade-off problem mentioned above. This research will fill this gap by comparing two typical states--New York and California and two cities--New York City and Los Angeles, analyzing their difference and based on the data of these places testing the real effect of the vaccine and anti-pandemic policies to unveil the truth of the trade-off and offer suggestions to the local government.

2. Vaccination in U.S.

2.1 COVID-19 vaccination rates in the USA

The vaccine is a crucial way to control the Covid-19. This study collects the percentage of the people who take at least one dose of vaccine in each state (including all brands of the Covid-19 vaccine like Pfizer-BioNTech, Moderna, Johnson, and so on) the following is the state-wise geographical Covid-19 vaccination rate figure.
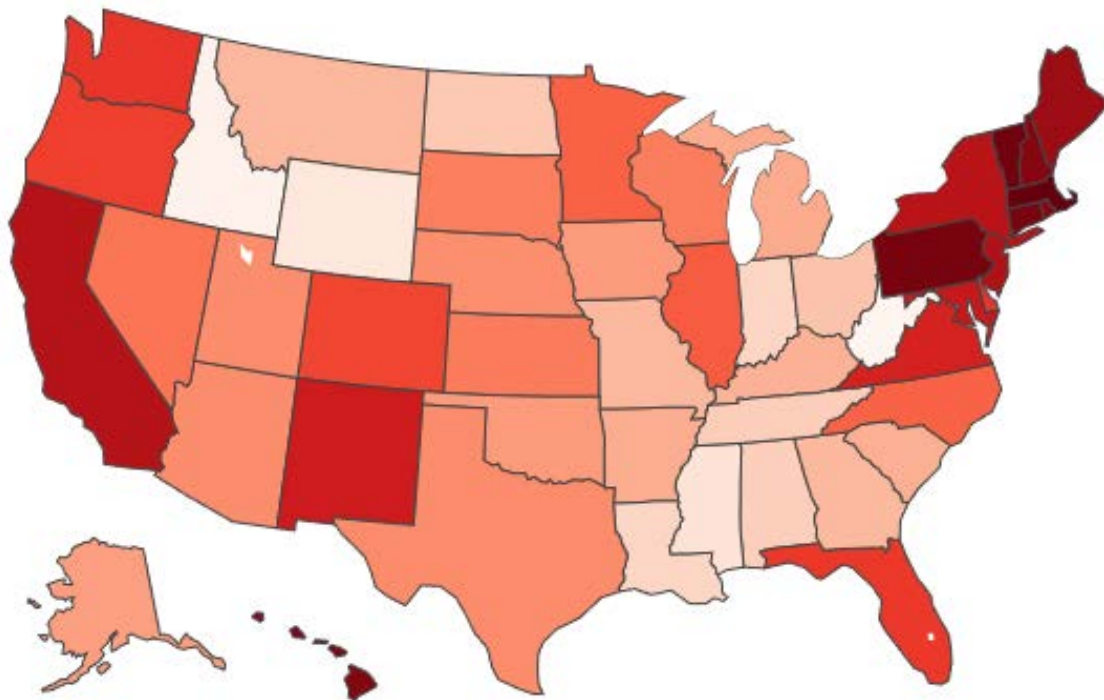

Figure 1. Vaccination percentage among the United States [5].

Figure1 shows the variation of vaccination rate (at least one dose of vaccine) among the states and territories. Tennessee and North Dakota have the highest percentage of taking at least one dose of vaccine population while Maine, Oregon, and Vermont's vaccination rate is relatively lower. However, instead of studying those states which are not so prosperous and typical, this study shifts the focus to New York and California, which are representative of the eastern and western parts of the United States and have a huge population base and a relatively developed economy. From Figure 1, California has the same color as New York State, which means it has a similar percentage of taking at least one dose of vaccine population with New York State.   In terms of full vaccination, actually, according to New York Times website, until November 10th, 2021, New York has a 67.3% fully vaccinated population while California has a 66.4% fully vaccinated population, which means they also have a similar fully vaccinated rate [2]. In a word, both New York State and California do well in

promoting residents to take the vaccine and New York State is a little bit better than California at that. The following figure exhibits the vaccination rate by county in New York State and California.
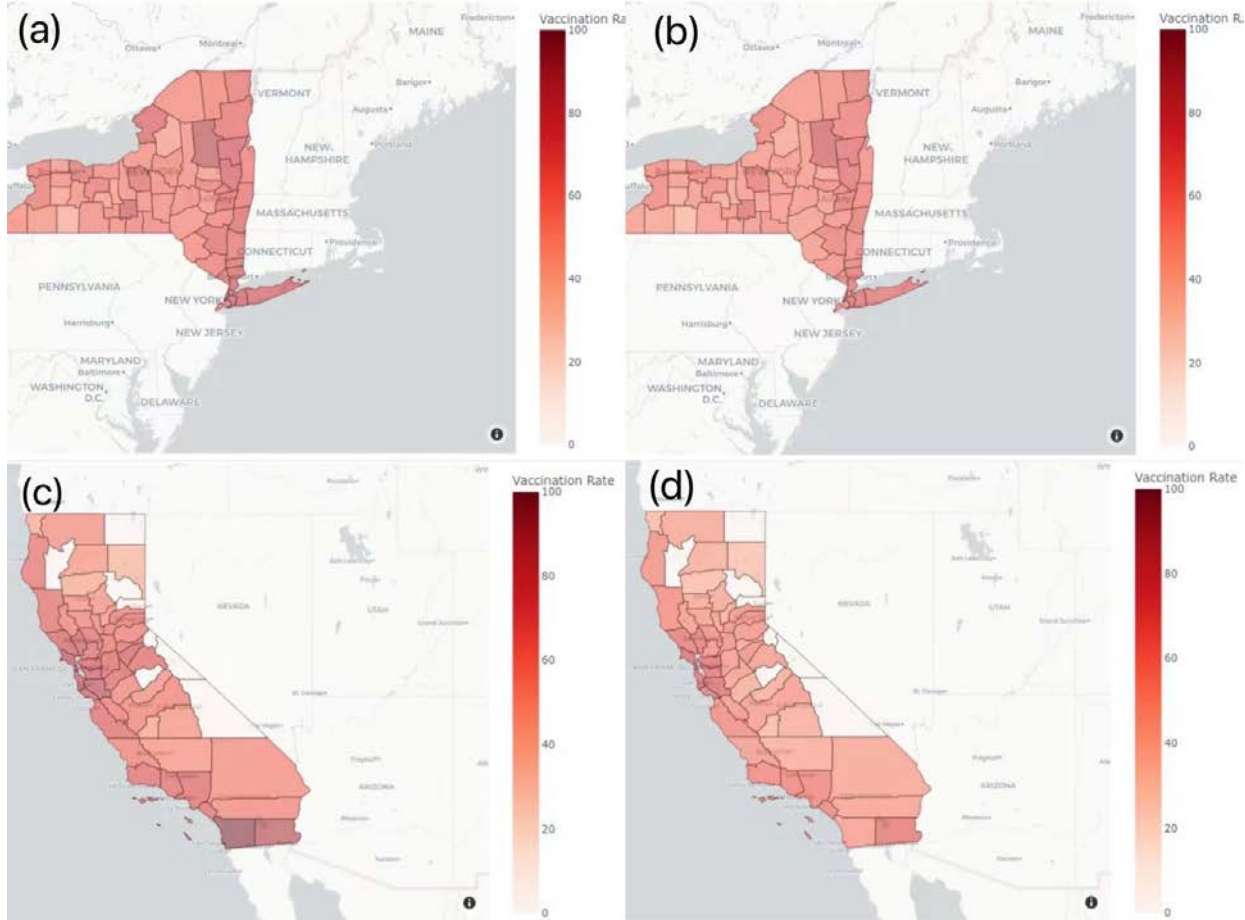

Figure 2. Vaccination Completed percentage in New York and California [6].

oss two states, this research makes this figure containing four sub-figures with the same color scale. From Figure 2 (b), all counties in New York State have over 40% fully vaccinated population and the county with the lightest color, Allegany also has the 45% population with at least one dose while the county with the darkest color, New York City has 86.2% population taking at least one vaccine dose. Compared with New York, the sub-figures of California conspicuously look a little bit lighter, which means its counties overall have a lower percentage of the population with at least one vaccine dose. But some counties are completely white only because of the lack of data. However, it has more than one county that is very light, which means the county has less than 50% population with at least one vaccine dose, for example, Modoc, Lassen, Shasta, and so on.

This specific comparison further shows that New York State does a little bit better than California in the popularization of vaccines. This discrepancy may result from the difference in the public attitude toward the vaccine, the distribution amount of the vaccine, local policies, and so on.

2.2 Vaccine's Real Effect

Instead of studying the theoretical or experimental effect of the vaccine which has been repetitively tested by various pharmaceutical corporations and the U.S. Food and Drug Administration, this study chooses to study the effect from actual data and real situations.

2.2.1 New York's vaccination rate and test positive rate

In order to first take a straightforward look at the Covid-19 vaccine's real effect, this study ingested the test positive rate of each county of New York and made the following figure.
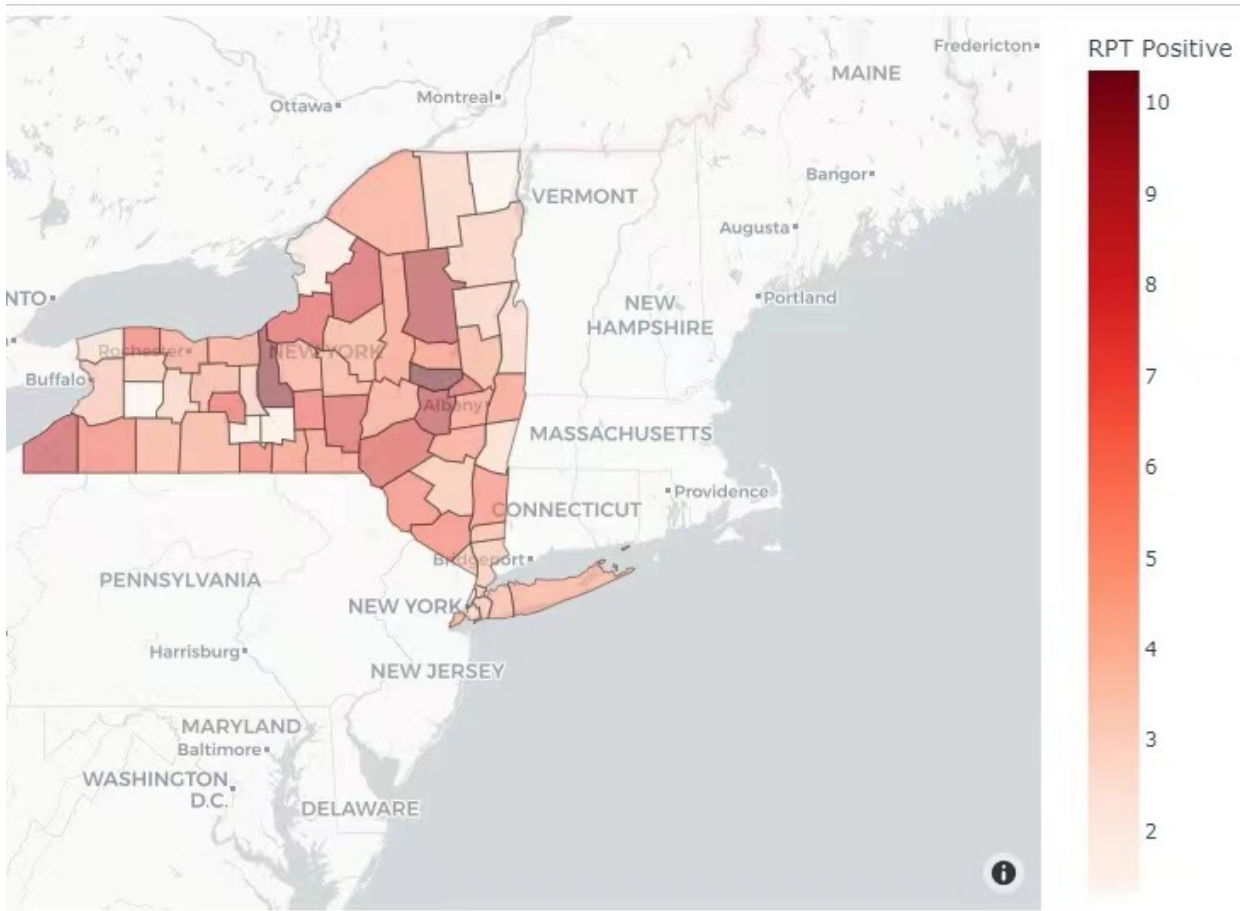
Figure 3. Test positive rate of New York [7].

According to the comparison between Figure 3, Figure 2(a), and Figure 2(b), it reveals that in some cases the lighter a county is in the figure of vaccination rate, the darker it is in the figure of test positive rate, which means the county with lower vaccination rate has much higher test positive rate. For example, Franklin and Essex are relatively dark in Figure 2 A, B and relatively light in Figure 3 which means their high vaccination rate corresponds to the low-test positive rate while Lewis is relatively light in Figure 2(a) and Figure 2(b) and relatively dark in Figure 3 which means its low vaccination rate corresponds to high test positive rate. But several counties do not clearly show this relationship like Hamilton and Cattaraugus.

2.2.2 Regression of Vaccination Completed Rate on Test Positive Rate

For more convincing evidence and knowing how much could vaccine stop Covid-19, the ordinary least square regression model was used to further study the effect of the vaccine on stopping Covid-19. This study chose data of vaccination completed rate and test positive rate from counties in CA and NY and make the following figures with one linear fitting curve to show the relationship between test positive ratio and vaccine completed ratio.

ith a regression equation Test Positive Ratio = -0.2075 * Vaccination Completed Ratio+ 0.1783. That is to say, a 1 percent increase in vaccine completed ratio will decrease the test positive ratio by 0.2075 percent.
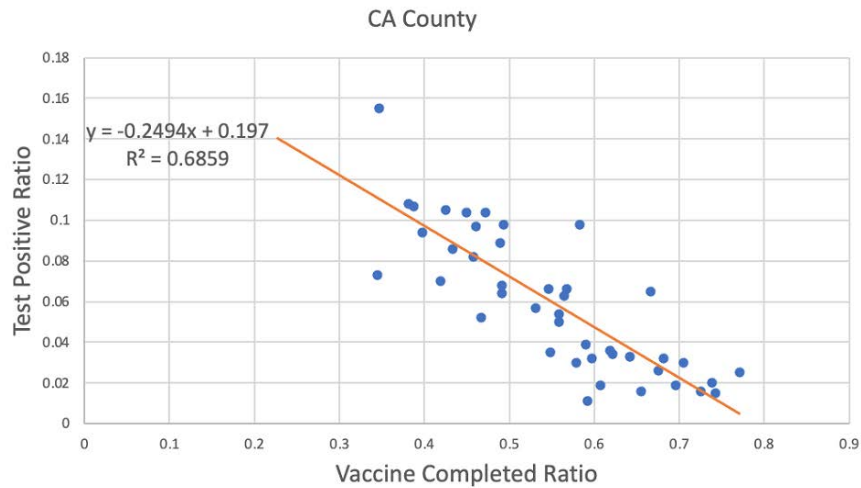
Figure 4 - Relationship of vaccination completed rate and test positive rate for CA [8].

Based on Figure 4, for the counties in California, it indicates that the two variables are negatively correlated with a regression equation Test Positive Ratio = -0.2494 * Vaccination Completed Ratio+ 0.1970. That is to say, a 1 percent increase in vaccine completed ratio will decrease the test positive ratio by 0.2494 percent.

From those two OLS regressions, this paper can draw a preliminary conclusion that the complete vaccination does help stop Covid-19 but the effect is unexpectedly not so significant.

2.2.3 Multi-variable Regression on Death Rate

In order to better test how the Covid-19 vaccine affects the fatality rate, a regression on the fatality rate must be performed. Considering that the ICU capacity is also a crucial factor determining the death rate, this research included ICU Capacity Ratio, Vaccination Initiate Ratio, and Vaccination Completed ratio as the independent variable to make a multi-variable regression on the fatality rate. Specifically, this study ingested the New York and California county-wise data, regressing the death rate on ICU capacity ratio, vaccination completed ratio, and vaccination-initiated ratio. The following is the result.

Table 1. Multi-variable Regression on the Death Rate of New York and California [8].

Item	Death Rate	
State	NY	CA
ICU Capacity Ratio	0.014	-0.016
Vaccination Completed Ratio	-0.261	-0.072
Vaccination Initiate Ratio	0.226	0.067

From Table1, after including more independent variables into the regression model, the absolute number of the regression coefficient between Vaccination Completed Ratio and Death Rate is -0.261 and -0.072 for New York and California respectively. Specifically, it is still negative, which means vaccination does have effects on reducing the fatality rate of Covid-19. But the absolute number of the coefficient, 0.0261 and 0.072, is so small, which indicates that the influence on reducing the death rate of the pandemic is not so significant.

In a word, vaccination is not enough to completely stop Covid-19 in terms of both infection rate and fatality rate. The explosion of Covid-19 since July also supports it.

2.3 Covid-19 comparison between New York City and Los Angeles

For deeper analysis, the New York State and California county-wise covid-19 data were used to make the three-dimensional scatter plots by choosing 3 indexes, specifically the death count, the case count, and the vaccination completed count to do the K-means clustering for each state. By using the

unsupervised machine learning and the elbow method, this study does the clustering and makes those counties divided into three clusters based on their case count, death count and vaccination completed count.
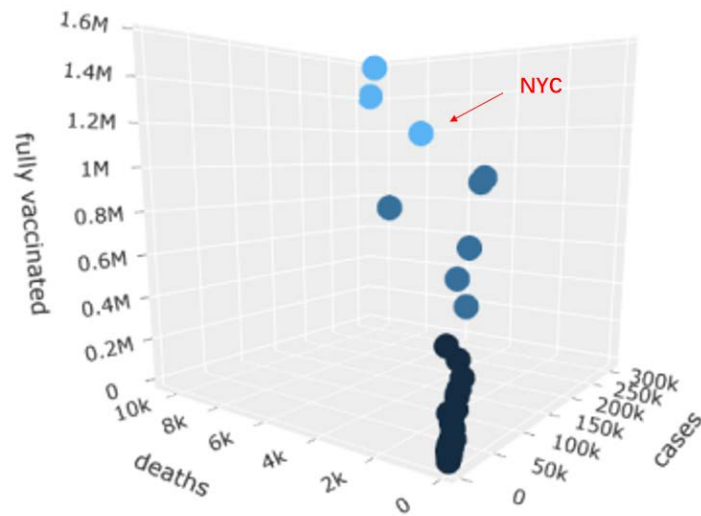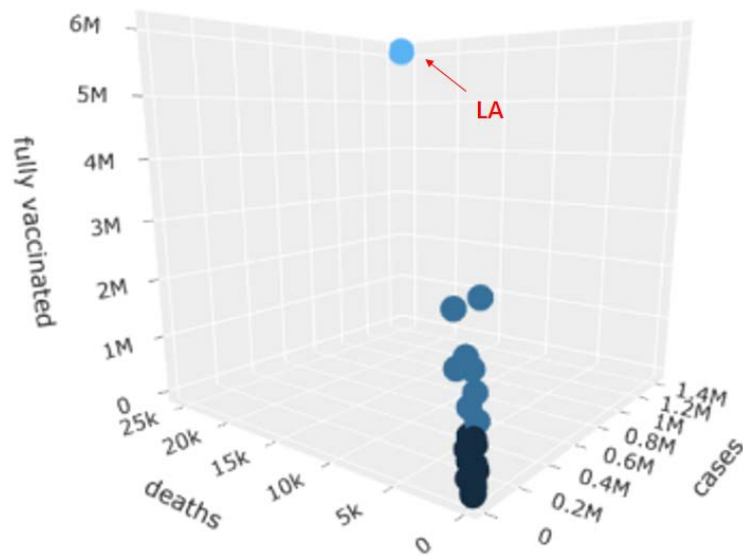

Figure 5. New York counties clustering [8].

Figure 6. California counties clustering [8].

In accord with Figure 5 and Figure 6, the counties for each state are divided into three clusters which are labeled by different colors. In Figure 6, there are three dark blue points, which represent New York City, Kings County, and Queens County. In Figure 6, there is only one dark blue point which is Los Angeles. Actually, they are the most typical city for each state respectively because both of them has high death counts, case counts, and vaccination completion counts. Furthermore, among three counties marked by dark blue in New York State, New York City is the most prosperous and modern county. Los Angles is also the most prosperous and modern county in California. Therefore, this research picks New York City from New York and Los Angeles from California to get a more direct and specific comparison. This study ingested day-wise covid-19 data, specifically case count and death count of these two cities from June 19th, 2021 to September 18th, 2021 when the society became more reopened owing to the great progress on vaccination. For a more conspicuous visualization of the comparison and the tendency, the line charts with two cities into one graph for each variable were made as follows.
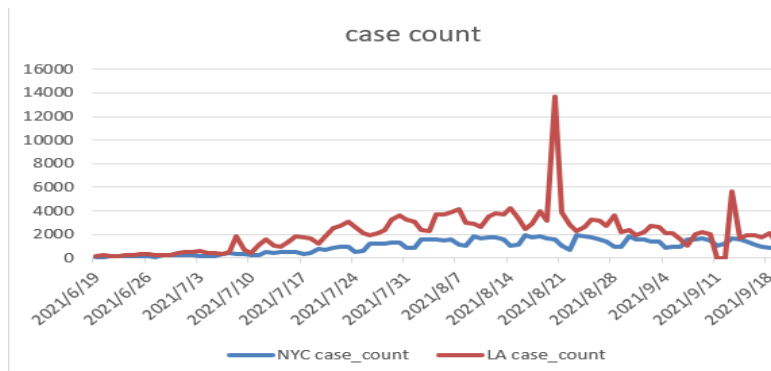
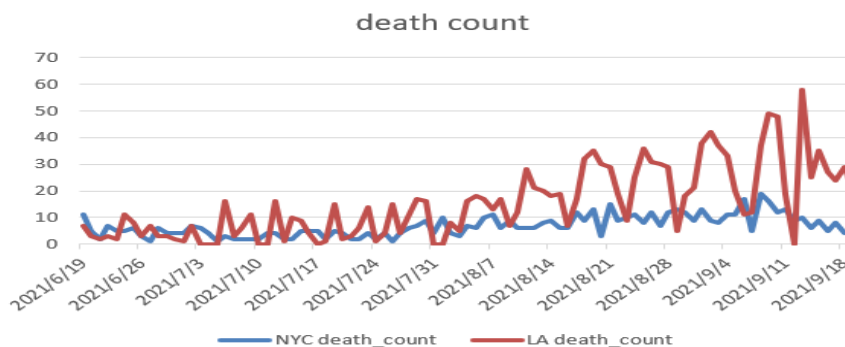Figure 7. Case count comparison between NYC and LA [9].

Figure 8. Death count comparison between NYC and LA [9].

According to Figure 7 and Figure 8, both cities experienced the explosion of Covid from June 19th, 2020 to September 18th. But LA has much more daily case counts, and death counts even though NYC's population in 2020, which is 8,804,190, is twice larger than LA's population in 2020 which is 3,898,747 according to the census [10].

From the above studies, there does exist a difference in the vaccination rate. But this difference is too small to account for such a large difference in Figure 7 and Figure 8. The difference can also be accounted for by the difference in the government policies and their implementation.

2.4 Anti-Covid-19 Policy Comparison between New York City and Los Angeles

New York City has stricter Covid-19 control policies. Specifically, New York City is the first U.S. city to require proof of at least one dose of a coronavirus vaccine for a variety of workers and customers-- indoor dining, gyms, and performances. This program started on August 16th and after a transition period, enforcement began on September 13th when schools were reopened and more workers returned to office in Manhattan [11]. For example, Kyrie Irving, the starting guard of the Brooklyn Nets, has not attended any games this season because he rejects taking the vaccine. Also, New York has a better implementation of mask mandates due to the higher population density.

Compared to New York City, Los Angeles also has a vaccination certificate requirement for indoor activities but this policy is much less strict than New York City. Specifically, Los Angeles County issued a new regulation requiring proof of vaccination at certain indoor places and events which was effective since October 7th. This new regulation is to reduce the spread COVID-19 virus in Los Angeles County. These regulations include: Just like Indoor Mega Events (more than 1,000 participations), vaccine verification or a negative test within 72 hours prior to attending Outdoor Mega Events will be required effective Oct 7th (must be fully vaccinated); Vaccine verification will be required for customers and employees at indoor portions of bars, wineries breweries, nightclubs, & lounges effective Oct 7th (at least one dose by the 7th & fully vaccinated by Nov 4th); Vaccine verification is strongly recommended for customers eating or drinking at indoor portions of restaurants; keep indoor mask mandates [12].

According to the above specific policy description, Los Angeles does not mandate the vaccine verification for indoor dining which is mandated in New York City. Furthermore, Los Angeles mandates the vaccine verification only for indoor Mega Events with more than 1,000 participants while New York City's mandate also applies for small indoor activities. The difference in the requirement of vaccination for indoor dining may be a huge factor for the difference of pandemic situation between New York City and Los Angeles discussed above.

2.5 Anti-Covid-19 Policy Comparison between New York City and Los Angeles

In this section, this paper will discuss several specific policies that can have a huge effect on the Covid-19 situation. In order to have straightforward visualization of the pandemic trendy, Covid-19 daily new cases data was ingested from the start of the pandemic to the present to make the following figure.
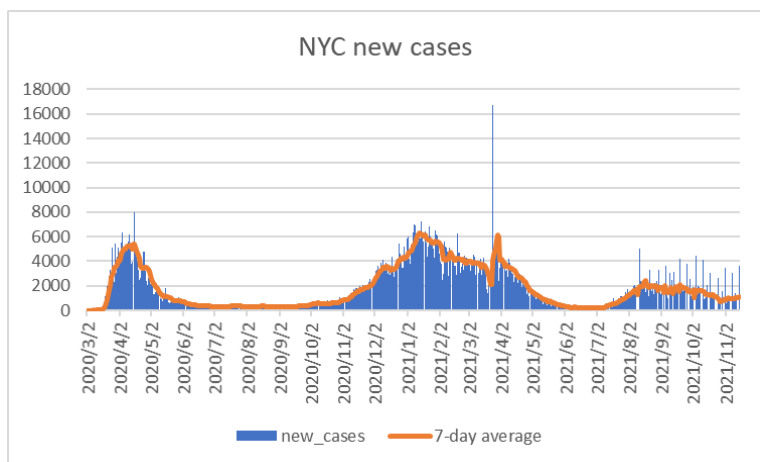

Figure 9. Daily new case count of New York City [13].

Figure 9 directly shows the whole pandemic trend from the start of Covid-19 in New York to the present. It indicates that there are three strikes of Covid-10, starting from March 2020, November 2020, and July 2021. This research will take advantage of the data to analyze how New York City's anti-pandemic policies controlled the pandemic.

2.5.1 Reopening of the Education System

This section will discuss the influence of reopening the education system on aggravating Covid-19.

The New York City government usually promulgated regulations controlling the public elementary, middle, and high school. Therefore, according to Investopedia, this paper organized the education system relevant policies into the following table. However, there is a lag because it takes time for a policy to cause an effect and a policy is always issued when it is urgently needed, the time period for each policy is delayed for a month. The adjusted time period is corresponding to the policy.

Table 2. Education System Policy [14]

Date	Education System Policy	Adjusted Date
2020/3/16	Close all public schools	2020/4/15
2020/9/29	Elementary students returned to public class	2020/10/29
2020/10/1	Middle and high schools begin in-person learning	2020/10/31
2020/11/19	NYC schools switch to all-remote	2020/12/19
2020/12/7	Elementary schools reopen for in-person learning	2021/1/6
2021/2/15	Middle school resume in-person learning	2021/3/17
2021/3/22	High school resume in-person learning	2021/4/21

Based on Table 2, this study can integrate those education system relevant policies to four different statuses: all public schools closed or remote, elementary school resuming in-person learning while middle and high school not, elementary and middle school resuming in-person learning while high school not, and all public schools resuming in-person learning.

This study calculated the average number of daily new cases depending on four different education system policies and made the following figure.
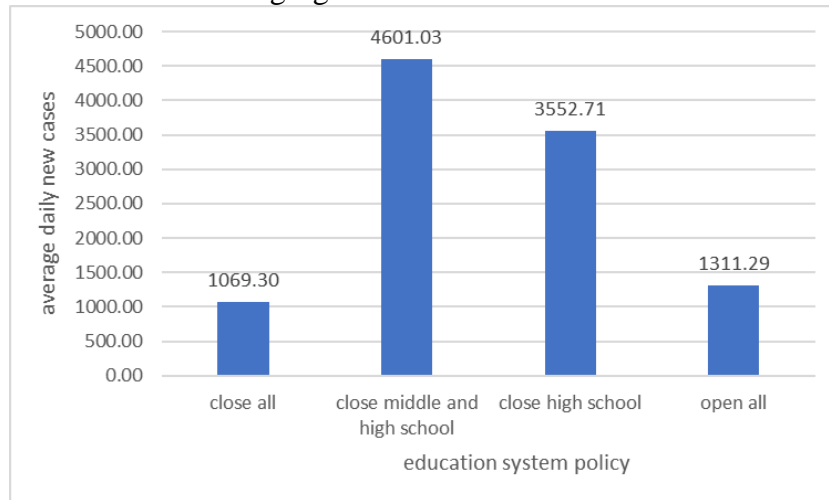

Figure 10. Average daily new case count from different education system policies [13].

Based on the above graph, starting from a month after closing all the public schools, including elementary school, middle school, and high school, the average number of daily new cases is 1069.30, which is smaller than that when only closing middle school and high school, which is 4601.03. Only closing high school lead to an average number of daily new cases 3552.71 which is also far higher than 1069.30. It is smaller than closing middle school and high school because only closing high school happened from February 15th, 2020 to March 21st, 2021 when New York City residents were gradually taking the vaccine. Last but not least, on March 22, 2021, it should focus on a month after opening all the public schools. When New York City vaccination rate was increasing, the average daily number of new cases is still 1311.29. This number is larger than the average daily number of new cases one month after closing all public school. Therefore, the strict control on the public elementary, middle, and high schools can have a huge influence on stopping Covid-19.

As for the universities and colleges in New York City, they usually make their own regulations on whether they take the form of online or in-person learning. But almost all of them switched to online for the 2020 academic year, provided blended mode for 2020 Fall and 2021 Spring, and switched to in-person for 2021 Fall. Considering some students coming from other states or even countries usually return to New York City earlier the formal beginning of the fall semester, this research regards the time period starting from July 16th to September 15th as the time period for reopening of the universities and colleges. Therefore, we will compare the average new daily cases from the time period of 2020 and 2021.
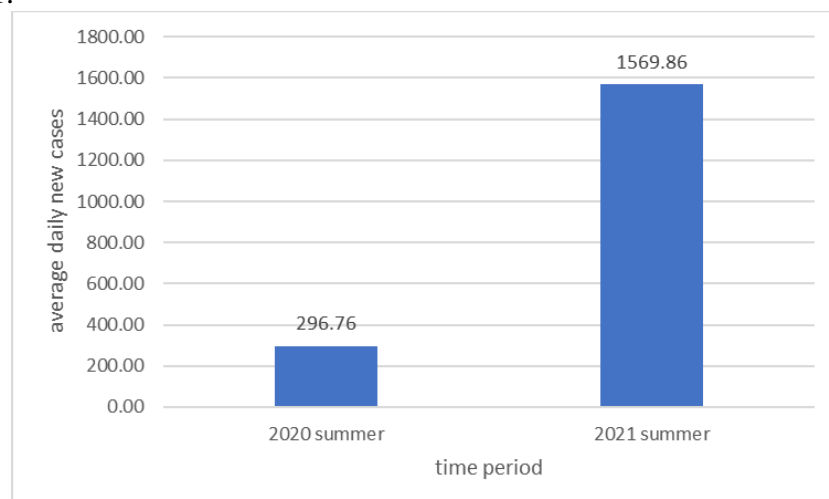

Figure 11. Average daily new case count at the different time periods [13].

Based on the graph above, the average number of daily new cases from July 16th, 2020 to the September 15th, 2020 is 296.76, which is much smaller than that from the same time period in 2021, 1569.86, even though in 2020 vaccine had not been invented while over 70% New York City residents had taken at least one vaccine dose during the time period in 2021. Therefore, the switch from online to in-person learning of the universities and colleges does aggravate the pandemic. It may be because a large number of students come to New York City from all over the world, which increases the population flux and public activities to a large degree.

In summary, the complete reopening of the education system largely aggravates the pandemic.

2.5.2 Reopening of the Indoor Dining

This section will discuss the influence of reopening of the indoor dining on aggravating Covid-19. According to Investopedia, this study integrates the indoor dining relevant policy into the following table. However, there is a lag because it takes time for a policy to cause an effect and a policy is always issued when it is urgently needed, the time period for each policy is delayed for a month. The adjusted time period is corresponding to the policy.

Table 3. Indoor Dining Policy [11, 14].

Date	Indoor Dining Policy	Adjusted Date
2020/3/17	Closed the indoor dining	2020/4/17
2020/9/30	Resumed the indoor dining with a 25% occupancy	2020/10/30
2020/12/13	Suspended the indoor dining	2021/1/12
2021/2/11	Resumed the indoor dining with a 25% occupancy	2021/3/9
2021/6/15	All restrictions lifted including indoor dining occupancy, completely open	2021/7/15
2021/8/16	Proof of at least one dose vaccine required for the indoor dining started	2021/9/16
2021/9/13	Proof of at least one dose vaccine required for the indoor dining became effective	2021/10/13

Based on Table 3, this paper can divide those policies into four kinds: completely closing the indoor dining, resuming the indoor dining with a 25% occupancy, completely opening the indoor dining, and opening the indoor dining but requiring the proof of at least one dose vaccine. This research calculated the average number of daily new cases depending on four different indoor dining policies and made the following graph.
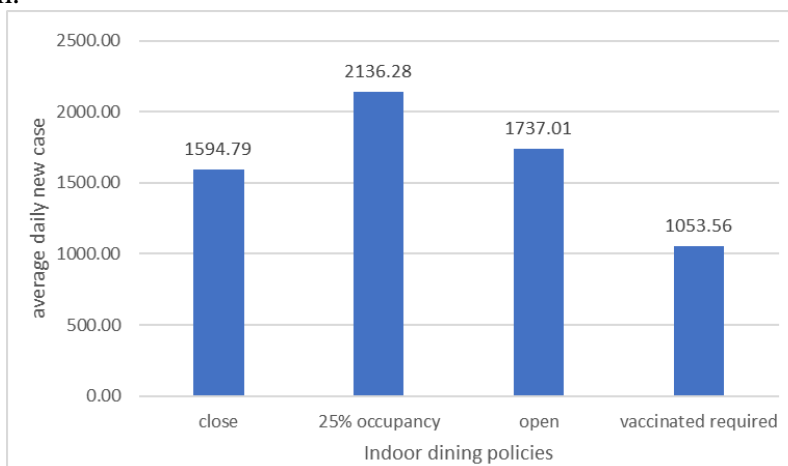

Figure 12. Average daily new case count from different indoor dining policies [13].

According to Figure 12, starting from a month after resuming the indoor dining with 25% occupancy, the average number of daily new cases is 2136.28 which is much larger than that starting

from a month after closing the indoor dining, which is 1594.79, even though the closure of indoor dining happened when vaccine had not been invented. The average number of daily new cases starting from a month after opening the indoor dining is 1737.01, which is still larger even though the New York City government allowed the indoor dining to fully open on the June 15th, 2021 when 70% of New York City residents had taken at least one shot of vaccine. The policy of requiring at least one dose of vaccine for indoor dining lead to the smallest average number of daily new cases, which is 1053.56. Therefore, this paper can preliminarily conclude that the complete reopening of indoor dining largely aggravates the pandemic.

2.6 The relationship between COVID-19 and the local economy

It is widely accepted that the local economy has been negatively affected to a large extent due to the pandemic because it leads to various activities bans from the local government, for example, the travel ban, the shutdown of public activities like music festivals, and the closure of restaurants. In section 2.5, this paper found those policies especially the closure of the education system and the indoor dining can effectively alleviate the pandemic, and based on section 2.4 New York City did have stricter relevant regulations. Now does the above study result means that New York City government chooses public health other than the economy in the trade-off? In order to know this answer, considering the significant economics role New York City and Los Angeles play in their state respectively, this research ingested economic data, specifically the Gross Domestic Product (GDP) and quarterly GDP growth rate for New York State and California, which can straightforwardly represent the local economic situation.
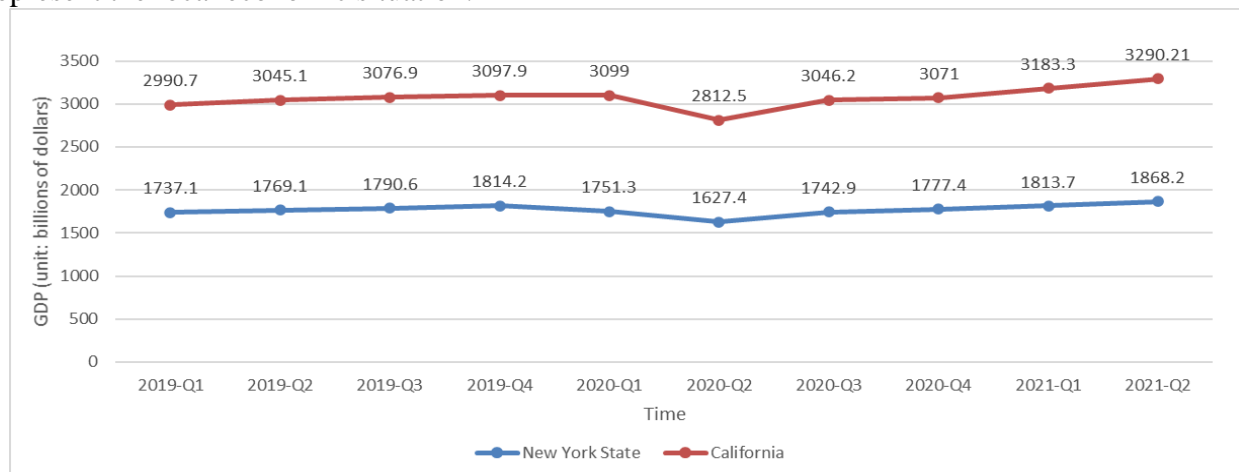

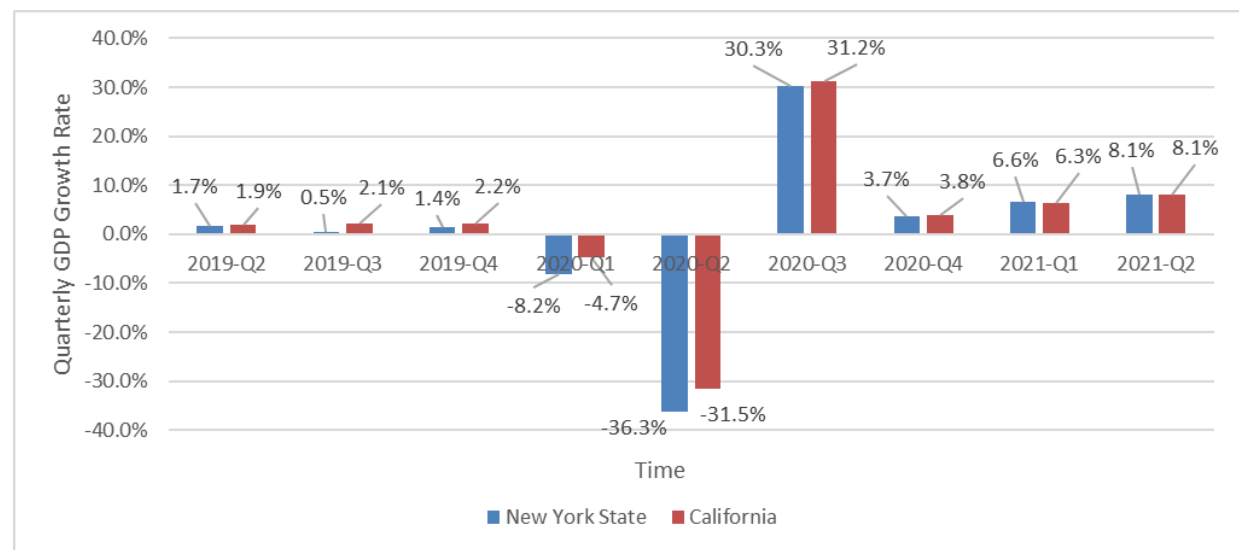Figure 13. GDP comparison between New York and California [15]

Figure 14. GDP growth rate comparison between New York and California [16].

As shown in Figure 13, the GDP of California is always higher than New York possibly because California has a larger population than New York State. Figure 14 indicates that the GDP growth rate of California is larger than that of New York from the second quarter to the fourth quarter in 2019 when Covid-19 had not attacked yet. Then from the first quarter of 2020 to the second quarter of 2020 when the covid-19 broke out, both two states experienced a severe economic shock and New York is affected by the pandemic more seriously than California. During the third quarter of 2020, the GDP growth rate of both states experienced a retaliatory rebound. Then during the first quarter of 2021, the GDP growth rate of these two states returned to normal and California still had a relatively higher GDP growth rate than New York. But the GDP growth rate of New York surpassed that of California during the first quarter of 2021 and was equal to that of California during the second quarter of 2021, which was seldom seen recently. The last time New York beat California in terms of the GDP growth rate can be traced back to the first quarter of 2019.　At that time, the local government of both states gradually reopened the society because residents were used to the existence of Covid-19 and the vaccine was approved to enter the market. However, the local government of New York adopted relatively strict anti-covid-19 policies. Specifically, it strictly implements the mask mandate and New York City requires vaccination certificates for all indoor activities especially indoor dining. With the conservative and strict policies, the New York government can better control the pandemic, which is confirmed by the study in section 2.4, and better reopen the city with a higher GDP growth rate.

3. Result Analysis and Discussion

From the above studies, this paper mainly finds three phenomena and this section will discuss them and possible reasons.

3.1 Vaccine's effect

This study detects that the Covid-19 vaccine cannot completely stop covid-19 or perfectly solve the trade-off problem between public health and the local economy, which can be explained by the following reasons. First, the new variants of Covid-19, especially the Delta variant, have more resistance to the vaccine and have higher infectiousness and fatality. Second, People who are fully vaccinated pay much less attention to the social distancing and mask mandates and attend far more public activities than those who are not. Third, as many places have over 50% fully vaccinated population, the government gradually reopens the society, specifically reopens the education system, and resumes the normal commercial and manufacturing activities, and so on.

3.2 Policy's effect

This research discovers that some anti-pandemic policies and regulations promulgated by the local government like the closure of in-person learning and indoor dining, have an unexpected excellent effect on mitigating the pandemic, which can be accounted for by the following reasons. First, In-person learning for the whole education system immensely increases the close in-person interactions among students and teachers. In-person learning for universities and colleges indirectly increases the population flux. Both results tremendously raise the risk of infection. Second, In-door dining is a public activity where customers usually sit closely and eat. Both behaviors can easily give rise to the infection and spread of the pandemic.

3.3 The secret behind the trade-off

This study finds that relatively strict and conservative anti-pandemic policies and regulations actually secure public health and do not hurt the local economy simultaneously, which may result from the following reasons. First, Conservative policies do not close the society by prohibiting public activities like last year. Manufacturing activities, commercial activities, education system, and so on are all as normal as usual. Second, the Stricter Mask Mandates and vaccination requirement for indoor activities to some degree promotes the popularization of vaccination, which helps secure public health.

Third, Conservative policies better control the covid-19 which leads to less infection and less infection in turn promoting the normal operation of companies and factors.

4. Conclusion and Suggestions

This paper mainly focuses on the two typical and prosperous states--New York and California. First this paper presents and vaccination situation of the whole of America and these two states. Then by analyzing the pandemic data like vaccination rate, test positive rate, death rate, and so on to examine the real effect of the Covid-19 vaccine. Then after comparing the pandemic situation between New York City and Los Angeles, this paper shifts focus from the vaccine to the anti-pandemic policies and makes use of Covid-19 data of New York City to test the policy's effect. Finally, this paper compares the economic data between New York and California to check whether there exists a strict trade-off between public health which usually is secured by strict anti-pandemic regulations and the economy which can be harmed by those regulations. This research mainly finds that the vaccine is effective to a certain point, but in order to completely prevent the spread of Covid-19, the government should play a crucial part by carrying out appropriate regulations such as limitation of indoor activities especially indoor dining, and the switch of the education system from in-person to online. Meanwhile, the research paper shows that the trade-off mentioned above may not exist. New York City, even under the stricter policy control of Covid-19, does not sacrifice the economy and even leads to a better economy for New York than California. Consequently, based on those findings, this paper suggests that in order to minimize the influence of Covid-19 on both the public health and economy, the government ought to keep encouraging people to be fully vaccinated, continue implementing relatively strict anti-pandemic policies and slow down the pace of reopening the whole society depending on its local situation.

References

[1] Wikimedia Foundation. (2021, November 5). Template: COVID-19 pandemic data. Wiki pedia. Retrieved November 26, 2021, from https://en.wikipedia.org/wiki/Template:COVID-19_pandemic_data.

[2] The New York Times. (2020, December 17). See how vaccinations are going in your c ounty and State. The New York Times. Retrieved November 26, 2021, from https://www.ny times.com/interactive/2020/us/covid-19-vaccine-doses.html#by-state.

[3] J. L. Bernal, N. Andrews, C. Gower, et al., Effectiveness of covid-19 vaccines against the B.1.617.2 (delta) variant. N Engl J Med. Retrieved November 21, 2021, from https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/es/covidwho-1319062.

[4] P. Tang, M. R. Hasan, H. Chemaitelly, et al. (2021, November 2). BNT162B2 and mRNA-1273 COVID-19 vaccine effectiveness against the SARS-COV-2 delta variant in Qatar. Nature News. Retrieved November 21, 2021, from https://www.nature.com/articles/s41591-021-01583-4.

[5] Centers for Disease Control and Prevention. (n.d.). Covid-19 vaccinations in the United States, jurisdiction. Centers for Disease Control and Prevention. Retrieved November 27, 2021, from https://data.cdc.gov/Vaccinations/COVID-19-Vaccinations-in-the-United-States-Jurisdi/unsk-b7fc.

[6] Centers for Disease Control and Prevention. (n.d.). Covid-19 vaccinations in the United States, county. Centers for Disease Control and Prevention. Retrieved November 26, 2021, from https://data.cdc.gov/Vaccinations/COVID-19-Vaccinations-in-the-United-States-County/8xkx-amqh.

[7] https://data.cdc.gov/Public-Health-Surveillance/United-States-COVID-19-County-Level-of-Community-T/8396-v7yb

[8] Covid Act Now API: Covid Act Now. Covid Act Now Blog RSS. (n.d.). Retrieved November 23, 2021, from https://apidocs.covidactnow.org/.

[9] Nychealth. (n.d.). Nychealth/coronavirus-data: This repository contains data on coronavirus disease 2019 (COVID-19) in New York City (NYC), from the NYC Department of Health and Mental Hygiene. GitHub. Retrieved November 26, 2021, from https://github.com/nychealth/coronavirus-data

[10] Bureau, U. S. C. (2021, November 26). Census.gov. Retrieved November 29, 2021, from https://www.census.gov

[11] Fitzsimmons, E. G., Otterman, S., & Goldstein, J. (2021, August 3). N.Y.C. will require workers and customers show proof of at least one dose for indoor dining and other activities. The New York Times. Retrieved November 26, 2021, from https://www.nytimes.com/2021/08/03/nyregion/nyc-vaccine-mandate.html.

[12] Consulate general of the Republic of Indonesia in Los Angeles, United States of America. Kementerian Luar Negeri Repulik Indonesia. (n.d.). Retrieved November 26, 2021, from https://kemlu.go.id/losangeles/en/news/16579/los-angeles-county-to-require-vaccination-proof-at-indoor-places-and-large-events.

[13] Nytimes. (n.d.). Nytimes/COVID-19-data: An ongoing repository of data on coronavirus cases and deaths in the U.S. GitHub. Retrieved November 26, 2021, from https://github.com/nytimes/covid-19-data.

[14] A. Kerr, (2021, April 5). Timeline: How covid-19 took over NYC. Investopedia. Retrieved November 26, 2021, from https://www.investopedia.com/historical-timeline-of-covid-19-in-new-york-city-5071986.

[15] Federal Reserve Bank of St. Louis. (n.d.). Federal Reserve Economic Data: Fred: St. Louis fed. FRED. Retrieved November 28, 2021, from https://fred.stlouisfed.org/.

[16] News. News | U.S. Bureau of Economic Analysis (BEA). (n.d.). Retrieved November 26, 2021, from https://www.bea.gov/news.