DATA ANALYSIS

COVID-19 VACCINATION RATE

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Figure 1: Courtesy of Google images.

BACKGROUND RESEARCH

Introduction

SARS-CoV-2 (also known as COVID-19), a China originated disease, formed a global pandemic that led to the widespread implementation of preventative measures such as social distancing and usage of masks in the United States (Abedi, V. and Olulana, O., 2020). According to CDC and their COVID-19 Timeline, the first reported case in the US was on January 20, 2020 (David J. Sencer CDC Museum, 2022) and less than three months later, on April 14, 2020, there were approximately 1.9 million confirmed cases across the world with roughly 601,000 confirmed cases and 24,100 deaths in the United States alone (JHU, 2020).

Within a year, the COVID-19 pandemic spread worldwide infecting millions and causing hundreds of thousands of deaths. Under the Federal Operation Warp Speed program, administered by the U.S. Department of Health and Human Services (DHHS), billions of dollars were invested into several vaccines (Savoia, E. and Piltch-Loeb, R., 2021). However, Pfizer-BioNTech and Moderna reported their highly anticipated vaccines demonstrated greater than 90% effectiveness in protecting individuals from the novelty disease leading them to being amongst the two most trusted COVID-19 vaccines by government and health officials (Savoia, E. and Piltch-Loeb, R., 2021).

With the high prevalence of COVID-19 and infectiousness, administering vaccination is an essential tool for mitigating the pandemic aside from preventative measures (i.e., social distancing and masks). Although, Pfizer and Moderna's vaccines showed 90% effectiveness towards protecting individuals from the disease, vaccination rates among minority groups, especially African American and Hispanic populations, were lower than those among other racial and ethnic groups making them more susceptible to the disease and its devastating effects (Ndugga, N. and Pham, O., 2021).

Logical Order of Review

While reviewing the literature, it became apparent there are countless factors that could and currently still affect individuals of rural regions, younger age populations, and African American communities' will to get the COVID-19 vaccination. When trying to understand individuals in the United States willingness and hesitancy with getting vaccinated, it is important to also think about personal beliefs, cognitiveness to receive and understand information, trust towards immunization, political affiliation, amongst additional other factors. In this literature review, we will discuss how age, region, and race affects those individuals' willingness to receive the COVID-19 vaccine by reviewing scientific and statistical evidence.

How has Race, Age, and Region played a factor into COVID-19 Vaccination?

Despite the devastating toll COVID-19 caused on Americans, many remain unwilling to receive the vaccine. A study conducted by Kricorian concluded from their US national survey, that people who didn't believe the COVID-19 vaccine was the safest were less likely to and willing to get the vaccine. This study also concluded that those same individuals showed that they knew less about the vaccine and were more likely to believe COVID-19 vaccine myths (Kricorian, K., 2021). Kricorian further concluded that those individuals who believed the vaccine was unsafe, common myths, and knew less about it; were also on average less educated, lower income recipients, and people of rural populations, than those who believed the vaccine is safe (Kricorian, K., 2021).

When identifying the willingness of aging individuals to receive the vaccine, it is important to take into account who is more prone to getting the disease and how the effects of contracting the disease will affect them. A study conducted by Basta and Sohel of American Journal of Epidemiology, concluded that among adults aged 50-96 years old, 84% were very or somewhat willing to receive the

COVID-19 vaccine and 16% were uncertain or unwilling (Basta, N. and Sohel, N., 2022). Basta and Sohel analyzed using logistic regression, those individuals who were of younger age, lower education and income, were non-White, and more than likely lived in a rural areas (Basta, N. and Sohel, N., 2022), supporting the previously reviewed article and study conducted by Kricorian. As mentioned, the high willingness of older individuals is largely due to them being at a significantly higher risk of developing severe illnesses if they contract the COVID-19 because of potential underlying health conditions.

Across the United States, African American communities have been disproportionately affected by COVID-19, with higher case rates, deaths, and more severe economic effects compared to other racial and ethnic communities (Padamsee, T. and Bond, R., 2022). A study conducted by Padamsee and Bond suggests that vaccine hesitancy increased throughout US populations between the spring of 2020 when the global pandemic first began and vaccines were only hypothetical, and December of 2020 when the first COVID-19 vaccine was made available. In December 2020, only 36% - 49% of African American individuals, compared to 44%-59% of White individuals, had intentions of receiving the vaccine (Padamsee, T. and Bond, R., 2022). One of the early on and leading reasons for African Americans' hesitancy towards the vaccine was due to historical and institutional racism. A well-known historical trauma was the Tuskegee syphilis study, referring to the unethical and non consensual cancer cells from Henrietta Lacks (National Foundation for Infectious Diseases, 2021). Those in the African American community have recognized that they or others in their communities have experienced neglect or inadequate treatment in healthcare settings which has ultimately caused distrust.

Conclusion

In conclusion, the authors argue and provide empirical evidence to support that despite COVID-19's devastating toll on individuals and populations across the world, many Americans remain unwilling to receive immunization towards to COVID-19. Race, age, and geographical location of the individuals

played a huge factor into whether or not they'd be willing to get the vaccine. As discussed, those in the African American community are often experiencing hesitancy or unwillingness due to past historical trauma and distrust of government immunization. Those of older age are more willing to get vaccinated because they have a significantly higher risk of contracting COVID-19 and severe illnesses as an outcome due to potential underlying health conditions, compared to younger aged individuals. Lastly, those of younger age and rural area populations are less likely to receive the COVID-19 vaccine because of early on during the pandemic when information was being shared and changed almost everyday resulting in them not trusting the information or feeling it wasn't accurate.

(ADD ADDITIONAL LIT SOURCES USED TO BIB, JORDYN)**

PROBLEM STATEMENT

The purpose of this analysis is to use business analytics to gain a better understanding of the disparities of COVID vaccination rates among different races, regions, and age groups in the United States. Specifically, we will evaluate the dataset using different analytical methods and try to find trends in vaccination rates based on these variables. The findings of this analysis as well as the literature research will then help us to draw possible conclusions to explain important factors that create a general tendency toward vaccination acceptance and vaccination hesitancy among people.

Based on this issue, we came up with three key insights that are important to explore with the help of our data. A key hypothesis that we will discuss by analyzing the data is that African Americans have a lower vaccination rate in the United States than Hispanics, Whites, and Asians. Another hypothesis that we will discuss is that the Northeast region of the United States has a higher vaccination rate than the West, South, and Midwest region. This analysis will also discuss the hypothesis that the population of people in the United States above the age of 65 have a higher vaccination rate than the population of people above the age of 18.

4

What motivated us to explore these hypotheses is that the COVID-19 pandemic caused the whole world to long for a solution to get control of this global health crisis including administering vaccines. However, an issue that arises with administering vaccines is that the vaccine acceptance varies greatly among the population and is influenced by sociodemographic variables such as age, sex, ethnic background, level of education, religious affiliation, as well as income level. Therefore, we decided to use business analytics to gain a better understanding of some of the factors that influence vaccination acceptance and hesitancy among the population.

DATA AND METHODS

About our Data

Our data is a collection of different covid figures divided by age and race for each state of the US. Our dataset includes the number of doses administered and the number of people vaccinated in each state. This means that our dataset clearly differentiates which state is consistent with second doses/boosters and which states are not consistent with covid shots. We have also divided the states by region to understand the regional differences. Our hypothesis, however, mainly focuses on the disparity of Covid vaccines between different races, age groups, and regions. Although our dataset has multiple information we can draw from, we will be focusing on the three mentioned earlier.

Variables

Our data focuses on the Covid vaccination rate for four different races, dose administrations, dose distributions, and dose administration by age, each is described for the 50 states plus District of Columbia. Predominantly, it describes the vaccination rate of 4 races, White, Black, Asian, and Hispanic. The rate is kept as the total population of each race, so for example, if 60 out of 100 Black people and 70 out of 100 White people are vaccinated, the data shows 60% and 70%, respectively. In order to display

our findings, we have decided to take the average of each state based either on race or region. We have also used the descriptive statistics function excel provides to show a broader sense of the data.

Methods

Our hypothesis required different datasets integrated into one. For example, we had the total numbers of doses distributed and administered in each state and the doses administered by age. However, we realized that race-based vaccination statistics would be more exciting and informative than age-based. Therefore we added a different dataset that showed the percentage of vaccination rate for Blacks, Whites, Asians, and Hispanics. We had to do further research to complete this data as some states missed the percentage needed to fulfill the data. Data that were missing were difficult to find. For example, states like Arkansas had almost no race-related vaccination data, while states in the Northeast were relatively easy to find. At first glance, it was clear that Asians were the most vaccinated, and more came to light with more research. When integrating our data, researching was the most integral part; besides that, we used Excel's Vlookup function to match the states with the percentage vaccinated. Vlookup was also another method we used for matching each state to its region.

When making comparisons between races, age, or region, we mainly used the average function used on Excel. Our dataset was more research-focused as we needed to have the information for all states, and some states lacked such data. Finally, we used the descriptive statistics tool to find information about each race, such as the min and max vaccination rate and the overall average in the country.

RESULTS AND INTERPRETATION

Based on our data analysis, we found the following results. Figure 2 gives an overview of the data providing a breakdown of the average vaccination rate by race. Using descriptive statistics with a confidence level of 95%, we calculated the mean of the percent of African American, White, Asians, and

6

Hispanics/Latino vaccinated in the United States. The results show that the vaccination rate of the White population is 63%, the African American population is 57%, the Hispanic/Latino population is 58%, and the Asian population is 76%. These results clearly indicate that Asians have the highest vaccination rate and Whites have the second highest rate. The results also indicate that while African Americans and Hispanics/Latinos have the lowest vaccination rate, we can see that African Americans represent the population with the lowest rate. Therefore, our analysis supports the hypothesis that African Americans have a lower vaccination rate in the United States, than Hispanics/Latino, White, and Asians.

In an attempt to explain this disparity, there are two factors that we feel are important to consider when interpreting these results. A reason for this disparity may be the educational and cultural differences among the African American and Hispanic/Latino population compared to White and Asians. Although these two groups have similar factors that contribute to the tendency of vaccination hesitancy, the biggest indicator for the differences in Hispanics/Latinos is because of the big number of unauthorized and undocumented immigrants, who are hesitant to get vaccinated. According to the article "Equity Series Part III: Understanding the Fear of Undocumented Immigrants in Accessing Health Care", the increase in this hesitancy can be explained by the fear of being deported. (Hud Exchange)

	White	Black	Hispanic/Latino	Asians
Average Vaccination Rate	63%	57%	58%	76%

Figure 2: CDC Vaccination Dataset. Excel File.

Our analysis shows that only an average of 57% of African Americans are vaccinated with at least one dose of the Covid-19 vaccine. According to "A Theory-Based Analysis of COVID-19 Vaccine Hesitancy among African Americans in the United States: A Recent Evidence", the African American population only represents 13.5% of the USA population. Another factor to take into consideration is that the method that was used to analyze vaccination rates within the population was through a survey. The survey was hard-to-reach, implicating email reading and app downloading, being the sampling not strictly loyal to the reality. (Sharma, M., Batra, K., Batra, R., 2021)

It was surprising to notice that the African Americans in the Northeast represented a lower vaccination rate since the Northeast region has high vaccination rates. Still, one reasonable explanation for this data is that most African Americans in the Northeast are foreign-born, particularly from the Caribbean, indicating cultural differences for the more significant disparity presented in African Americans' behaviors in the Northeast region. The study also shows a necessity to have marketing specifically targeted to African Americans. (Sharma, M., Batra, K., Batra, R., 2021) The study observes that there is more hesitancy among the Republican party voter population and indicates that the African American republicans need more examples of republican leaders within their group that are pro-vaccine. (Sharma, M., Batra, K., Batra, R., 2021).

Religion was also a factor in the hesitancy. The predominant other religion within the African American community is Islam, and the majority of these Muslim African Americans also live in the Northeast. The study indicates that this factor could also lead us to an explanation of the resistance of this population related to vaccination. (Sharma, M., Batra, K., Batra, R., 2021)

Figure 3 gives an overview of the data providing a breakdown of the average vaccination rate by region. By filtering the data by regions, we calculated the average rate per race and created a separate table to summarize the results in a clear manner using color scales. The results show that the average rate per region is 58.07% in the Midwest, 65.77% in the South, 62.77% in the West, and 74.10% in the Northeast. These results clearly indicate that the Northeast region has the highest vaccination rate and

the South region has the second highest rate. The results also indicate that the West region and Midwest region have the lowest vaccination rates. Therefore, we can conclude that the North-east region of the United States has a higher vaccination rate than the West, South, and Mid-west region.

Moreover, this analysis supports our previous hypothesis that African Americans have a lower vaccination rate in the United States than Hispanics/Latino, White, and Asians. The analysis indicates that in the Midwest, South, and Northeast region, African Americans have the lowest average vaccination rate. As mentioned in the article above, the general tendency towards vaccination hesitancy among African Americans can be explained by various factors including cultural differences, a lack of race-specific marketing, as well as religious differences. (Sharma, M., Batra, K., Batra, R., 2021)

Regions	White	Black	Hispanic/Latino	Asians	Average per region
Mid-west	60.00%	49.88%	54.63%	67.75%	58.07%
South	57.00%	56.54%	64.33%	85.22%	65.77%
West	65.00%	61.18%	54.50%	70.20%	62.72%
Northeast	74.00%	67.11%	71.29%	84.00%	74.10%
Total Average	64.00%	58.68%	61.19%	76.79%	65.16%

Figure 3: CDC Vaccination Dataset. Excel File.

According to the study "A Theory-Based Analysis of COVID-19 Vaccine Hesitancy among African Americans in the United States: A Recent Evidence", although the vaccine rates in the Northeastern region are the highest in the country, the study also displays that there is more hesitancy within the African American population in the same area, contributing to the disparity, and also explains that by the time the research was done, the Northeast region had not reached its peak of vaccination rates, indicating that the result may change.

Figure 4 gives an overview of the data providing a breakdown of the average vaccination rate by age. We first filtered the data by regions and then we calculated the average rate per age group and created a separate table to summarize the results in a clear manner using color scales. The results show

that the total average of people 18+ who are vaccinated with at least one dose represents 85.50% of the population in 50 states that were analyzed from the data provided by the CDC and other sources. The results also show that a total average of people 65+ who are vaccinated with at least one dose represent 94.66% of the population in the states that were analyzed. Therefore, we can conclude that the population of people in the United States above the age of 65 have a higher vaccination rate than the population of people above the age of 18.

Moreover, this analysis supports our previous hypothesis that the North-east region of the United States has a higher vaccination rate than the West, South, and Mid-west region. Our analysis shows that while the Northeast and West region have the highest vaccine acceptance among the older and younger age group, the South and Midwest region have the lowest vaccine acceptance among both age groups. In an attempt to explain this disparity, we feel like it would be interesting to find a study that discusses the progression of vaccination rates based on various factors in different regions in the United States. When interpreting these results, it is also important to keep in mind that these rates may change in the future based on changes in the perception of the safety and effectiveness of vaccines.

Regions	AVG of 65+ Vaccination Rate	AVG of 65+ Pop Vaccination Rate	AVG of 18+ Pop Vaccination Rate	AVG of 18+ Pop Vaccination Rate
Mid-west	868,290	94.63%	3,262,350	80.33%
South	1,382,484	94.20%	5,420,731	81.48%
West	1,020,772	94.83%	4,545,963	86.30%
Northeast	1,024,379	95.00%	4,195,722	93.90%
Total Average		94.66%		85.50%

Figure 4: CDC Vaccination Dataset. Excel File.

The figure below supports our hypothesis insofar as it shows an analysis combining the results of the study "The US COVID-19 Trends and Impact Survey: Continuous real-time measurement of COVID-19 symptoms, risks, protective behaviors, testing, and vaccination.", made by Proceedings of the National Academy of Sciences (PNAS), by age highlighting the high levels of acceptance among older

respondents in all categories, but lower and more variable results at younger ages. (Salomon, J.,
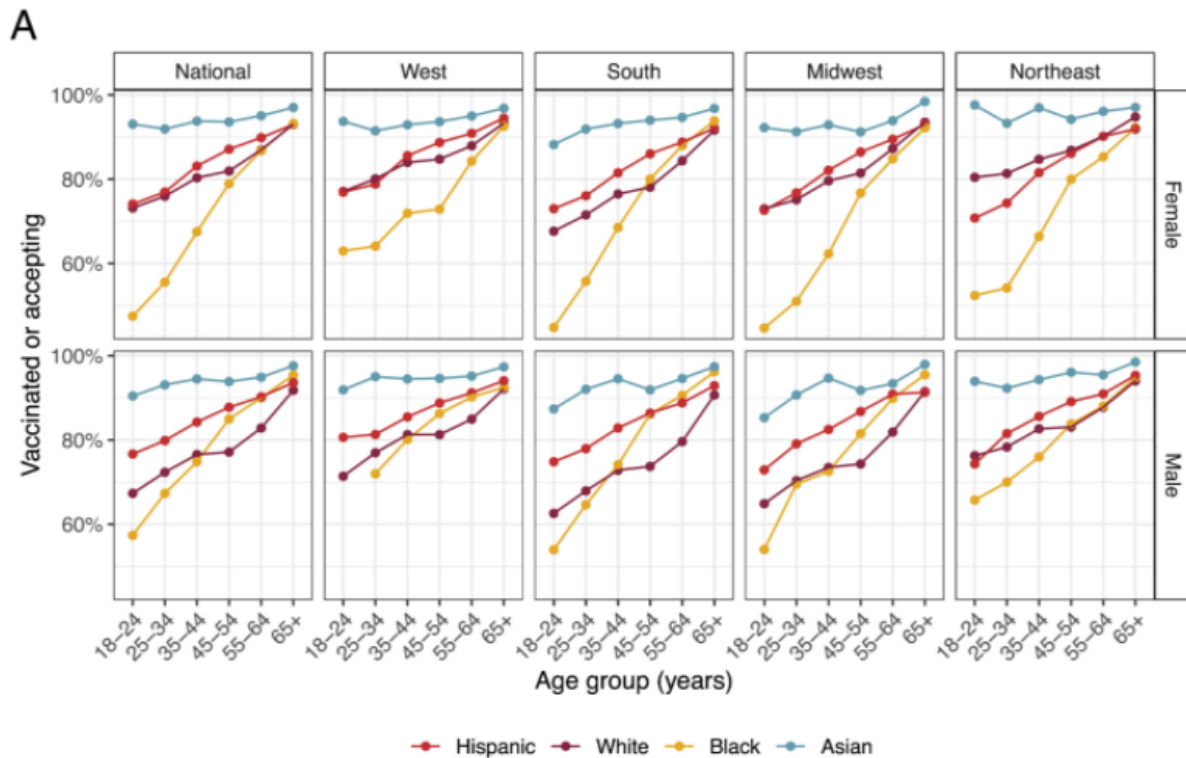
Reinhart, A., Bilinski, A., Tibshirani, R., 2021).

Figure 5: Vaccinated or accepting table versus age group (years). Retrieved from:

https://www.pnas.org/doi/10.1073/pnas.2111454118

DISCUSSION AND CONCLUSION

So far, we have come to find that African Americans and Hispanics have the lowest vaccination

rate of the country. Based on the analysis we made, it is in fact true that African Americans, along with

Hispanics, have the lowest vaccination rate of the country. Previous studies that have been done have

been put into written works that show the vaccination disparity between African Americans and other

races. One of the reasons for the disparity is hesitancy among the AA and Hispanic community for Covid-

19 vaccines. 13 studies were made on a population of 107,841. Here, it was found that 41.6% of African Americans and 30.2% of Hispanics were hesitant to take the Covid vaccine. In the AA study, the sample size had a range from 67 to 2,179 people and a total of 6,253 participants, and in the Hispanic study the sample had a range from 68 to 3,235 people with a total of 8,748 Hispanics participating in the study. (Khubchandani & Macias, 2021)

We also hypothesized that the Northeastern region would have a higher vaccination rate, which turned out to be correct based on our analysis. NE had a 74.10% vaccination rate which is almost 10% higher than the next region, the South. Similarly, a study found that the northeastern region has a better acceptance of wearing masks, but were also more likely to use a packed public transportation. The hesitancy rate in the Northeastern region is much lower than the other regions, as it's shown in the figure below.
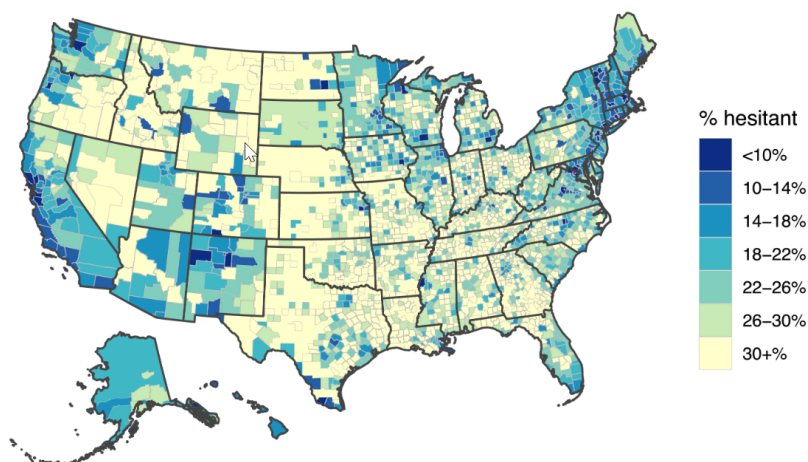

Figure 6: Vaccine acceptance and hesitancy mapped. Retrieved from:

https://www.pnas.org/doi/10.1073/pnas.2111454118

The blue regions show less hesitancy, while the yellow regions show more hesitancy. We can see darker blues in the Northeast, especially from Vermon to the south up to Delaware and DC. These smaller

states created the vaccine acceptance and vaccination rate of the region to go up. (Salomon, Reinhart, Bilinski, & Tibshirani, 2021).

Finally, we hypothesized that the older age group had a much higher vaccination rate compared to the younger age group. This turned out to be correct based on the analysis we made. According to CDC data, the age group of 65+ has a 95% vaccination rate, while the next closest number is the 18+ age group with a vaccination rate of 89%. The 65+ population that are fully vaccinated are at 90.2% while the remaining age group is all under 80% for full vaccination. (COVID Data Tracker, 2022).

Contribution

Background Research/Literature Review - Jordyn

Problem Statement/Hypothesis - Magdalena and Viviane

Data and Methods - Brook

Results and Interpretation - Magdalena and Viviane

Discussion/Conclusion - Brook

Presentation - Magdalena, Jordyn, Viviane and Brook

Infographics - Viviane and Magdalena

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