

The Impact of Social Media on COVID-19 Vaccine Hesitancy and Acceptance: Data Analytic Approach

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ABSTRACT

There is still a great deal of vaccination hesitancy among different populations in the U.S. including health workers, government officials, minorities and marginalized communities. The politicization of the COVID-19 issue made it difficult to contain the infection and led to an increase in the spread of COVID-19 misinformation and conspiracy theories on the internet and social media. Misinformation about COVID-19 and its vaccine hindered efforts to fight the disease and continue to impact measures to contain the pandemic. In this paper, we examine the factors impacting vaccine hesitancy and acceptance in the United States. Data collected from CDC website and Twitter hashtags, #COVIDvaccines was analyzed, and the results have shown that vaccine hesitancy is largely influenced by personal opinion rather than scientific knowledge. Safety and side effect was the major impacting factor followed by misinformation and conspiracy theories.

ALISE RESEARCH TAXONOMY TOPICS

big data; data visualization; information literacy; information use; social media.

AUTHOR KEYWORDS

COVID-19 vaccine; misinformation; conspiracy theory; fake news; vaccine hesitancy.

INTRODUCTION

The United States experienced its first COVID-19 case in New York in February of 2020. China was under strict lockdown and the U.S. was monitoring its rising cases. When the U.S. entered a lockdown, residents began to question the credibility of news outlets and information distributed by the CDC. Misinformation was beginning to spread quickly. As things worsened spatially in New York, people began to realize its magnitude. Individuals compared the rising

COVID-19 pandemic to the 1918 Pandemic, also known as the Spanish Flu. With the SARS situation in the nineties and the ability to contain the virus, politicians, and public health officials speculated that the virus would dissipate within months. Initially, public health officials did not recommend wearing masks. Later, masking policies became politicized and resistance to wearing masks and preventive measures grew (Romer and Jamieson, 2020). Once the government recognized the rise in infections and hospitalizations, they embarked on discovering medical solutions. The government created a task force to spearhead the development of the COVID-19 vaccine and provided funding for several research companies such as Moderna and Johnson and Johnson.

In the early days of COVID-19, residents were highly skeptical about the existence of the virus. Many people labeled it as a “hoax” and undermined the gravity of the disease. Many assumed the effects of COVID-19 were parallel to the seasonal flu and over-the-counter medication would be sufficient (Geldsetzer, 2020; Horton, 2020). However, as the number of hospitalizations and fatalities increased, COVID-19 misinformation and conspiracy theories began to magnify. For example, various conspiracy theories that emerged claimed that COVID-19 may have been a type of bioweapon created in an international laboratory. Another example was the vaccine may have included a microchip where companies, or the government, would be able to track people (Hornsey et al., 2020; Romer and Jamieson, 2020). To understand the impact of misinformation and conspiracy theory on vaccine hesitancy, we carried out a study with the aim of answering the two major questions: What are the factors impacting vaccine hesitancy and vaccine acceptance in the United States? Given the widespread of misinformation and conspiracy theories, what is the general sentiment of social media in particular Twitter users toward vaccinations?

LITERATURE REVIEW

The COVID-19 pandemic has prompted public debate about the degree to which preventive steps are being followed, as well as common conspiracy theories about the virus's origins. Since individuals have various thought styles, cognitive abilities, and critical thinking motivations, conspiracy theories are common. Conspiracy theories are strongly influenced by ideology and religious beliefs. Conspiracy theories and disinformation have an effect on and hinder science-based health policies, as well as attempts to eradicate the virus. Furthermore, previous research has discovered a negative connection between conspiracy theorists' beliefs and health-related measures (Georgiou et al., 2020).

COVID-19 pandemic gave rise to new terminology such as infodemic describing the proliferation of fast spread of misinformation and conspiracy theories on the Internet and social media (Zarocostas, 2020). The term fake news has become prevalent within the COVID-19 pandemic. Most researchers discussed fake news from the perspective of political ideology and partisan identity (Pennycook et al., 2020). Fake news creates doubts in people's minds about the accuracy and reliability of information from the CDC or the World Health Organisation (WHO) (Montagn et al., 2021). The increase in the number of anti-vaccination on social media created a serious problem to vaccination efforts. Pennycook et al (2020) studied the impact of politics and recommended that people should judge and consider the accuracy of the information before sharing the information on social media. As far as vaccine concerns, recent studies have shown people who believe in conspiracy theory may have negative attitudes toward vaccination. Jolley and Douglas (2017) discussed anti-vaccine conspiracy theories associated with a negative impact

on vaccinating children. It contributed to an increase in the number of people reluctant to vaccinate children. Beliefs in conspiracy theory, particularly those related to the medical field have a negative relationship with vaccination intentions. The lack of trust in the government and negative attitudes towards the government increased the number of conspiracy theories and the number of people who believed in these theories.

The spread of misinformation hampers the efforts to get people vaccinated (Geldsetzer, 2020). A study by Loomba, et al. (2020) found that the consumption of misinformation can have different impacts on different socio-demographic groups. The results from the study indicated that those older than 25 years are more hesitant to get the COVID-19 vaccine than younger people. Women have shown higher skepticism about the productivity and benefit of the COVID-19 vaccine than men. Studies also shown that extended exposure to social media and increased participation in social noise can also lead to the spread of COVID-19 misinformation and conspiracy theories (Jolley & Douglas 2017; Jolley & Douglas, 2014; Alasid et al, 2020; Pampapura Madali et al, 2022). Efforts to combat misinformation and conspiracy theories will require a better understanding other factors impacting vaccine hesitancy

METHODOLOGY

This study employed data analytics techniques such as sentiment analysis, clustering, and topic modeling methods to examine factors impacting vaccine hesitancy and acceptance in the United States. Data analytic methods help researchers understand the relationships that exist within a specific corpus and provide insight into complex issues (Hesse-Biber and An , 2017; Neubainuer et al, 2019). The data for this study was collected from Twitter using the hashtags #CovidVaccines from February 2021 to April 2021 and from September 2021 and January 2022 as well as CDC Website. The data sets retrieved from the hashtag #CovidVaccines for the two periods were composed of 30,000 and 116,614 records.

The sentiment analysis technique is used to assess the objectivity and subjectivity of the tweet and determine the level of confidence people have in the vaccine. Sentiment analysis assesses users' positive, negative, or neutral sentiment and whether the text is fact-based or influenced by the writer's personal opinion (Routray et al., 2013). For subjectivity, a score of 0 is categorized as objective or factual based. A text with a subjectivity score of 1 is categorized as subjective reflecting personal opinion and can be emotionally motivated. To assess the factors that impact vaccine hesitancy, we used the factors identified by CDC that included vaccine development and emergency authorization, vaccine safety and side effects, misinformation and conspiracy theory, and vaccine effectiveness. Keywords from these factors are used to analyze data from the Twitter hashtags and see the extent by which these factors influenced users' opinions on Twitter. Weighted topic modeling and clustering techniques are used to analyze the data and calculate the relative importance of these factors.

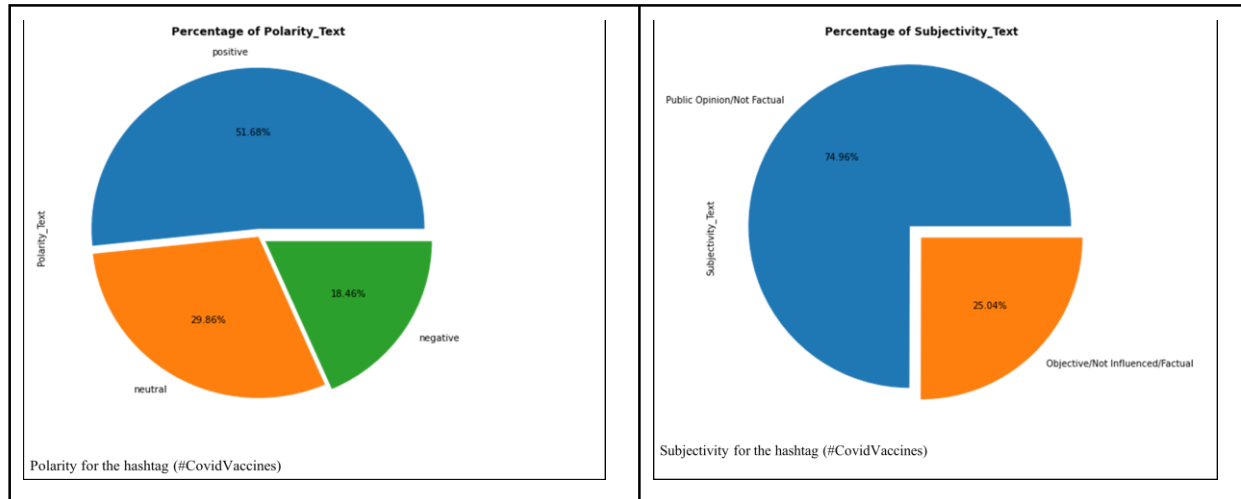
RESULTS AND DISCUSSION

Sentiment analysis is used to assess polarity and subjectivity in terms of users' positive, negative, or neutral sentiment and whether the tweet is fact-based or influenced by the writer's personal opinion. For data set from February 2021 to April 2021, Figure 1 shows the polarity for (#CovidVaccines) at 51.68% of the positive sentiments, 29.86% neutral, and 18.46%. Subjectivity

is shown at 74.96% of the tweets were based on personal opinions, and not based on factual information. At the same time, 25.04 % of the tweets were objectively indicating that tweets were based on factual information.

Figure 1

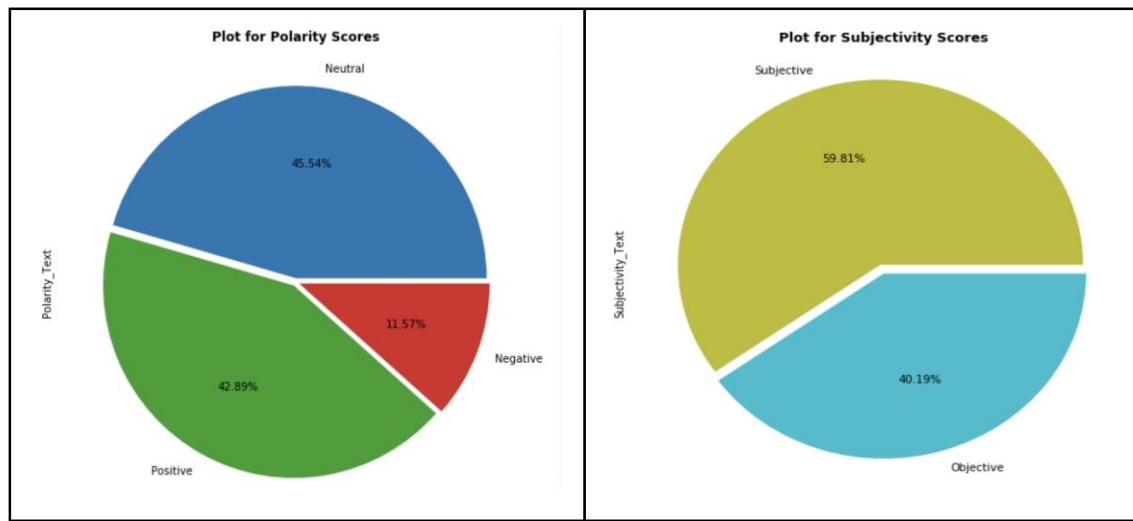
Polarity and Subjectivity of the #Covidvaccines



For the second data set which covers the period from September 2021 and January 2022, Figure 2 shows the polarity for (#CovidVaccines) at 42.89% of the positive sentiments, 45.54% neutral, and 11.57%. Subjectivity is shown at 59.81% of the tweets were based on personal opinions, and not based on factual information. At the same time, 40.19 % of the tweets were objectively indicating that tweets were based on factual information.

Figure 2

Polarity and Subjectivity of the #Covidvaccines



The overall observation from the sentiment analysis results has shown that polarity increased over time and subjectivity decreased implying that people's understanding of COVID199 has improved. To assess the level of vaccination in the United States, we also use data extracted from CDC website for two different dates for comparison purposes. The first data set was extracted from the CDC Website on June 23, 2021, and the second set of data was extracted on March 18, 2022. Figures 3 and 4 show the percentage of people vaccinated by state. The blue line shows the percentage of people who took one shot whereas the red lines show the percentage of people who were fully vaccinated. Despite the widespread misinformation and conspiracy theories, CDC data have shown considerable progress in getting more people vaccinated.

Figure 3

Percentage Of People Vaccinated By State In The U.S. (Source CDC Jun 23, 2021)

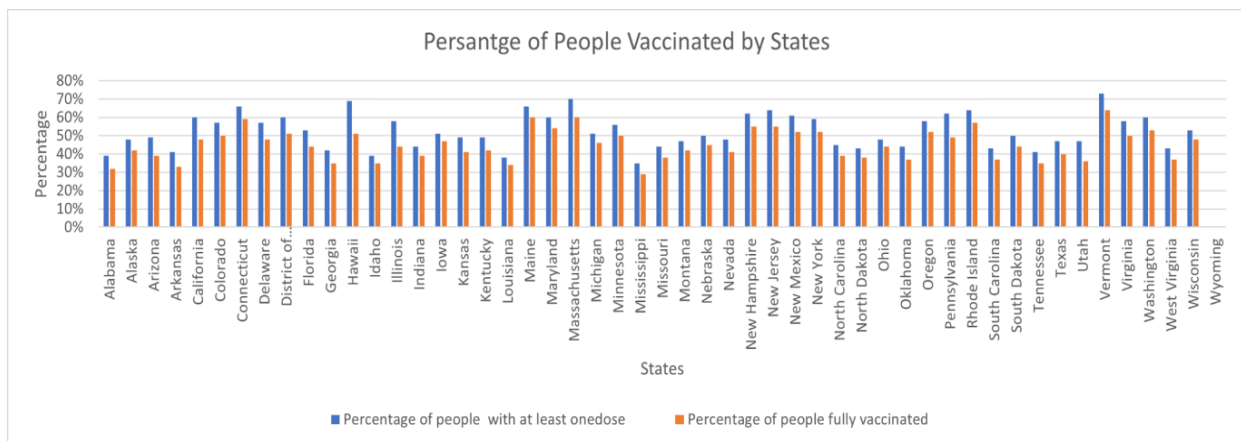
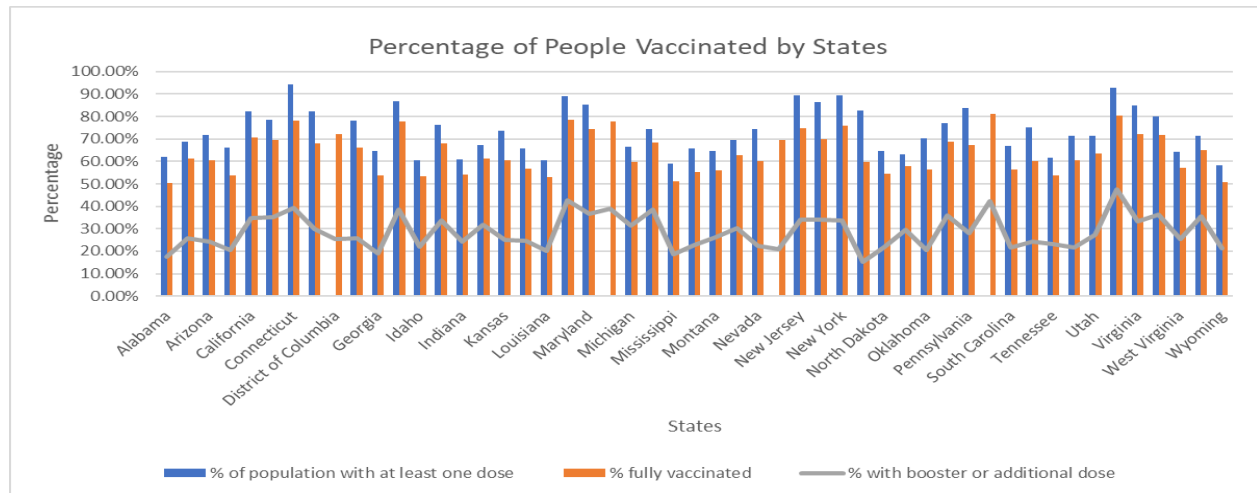


Figure 4

Percentage Of People Vaccinated By State In The U.S. (Source CDC March 18, 2022)



To assess the relative importance of the factors that impacted vaccine hesitancy and acceptance, we used data generated from #CovidVaccineside for the periods from February 2021 to April 2021 and the period from September 2021 and January 2022. The CDC identified several factors that impacted vaccine hesitancy including vaccine development and emergency authorization, vaccine safety and side effects, misinformation and conspiracy theories, and vaccine effectiveness. We used these factors as a basis for the data analytics of Twitter hashtags.

Figure 5 and 6 show the relative importance top factors identified CDC and based on the data analyzed from Twitter. The results show that safety and side effect was the major factor impacted vaccine hesitancy in 2021 and continue to do so in 2022. the second factor is misinformation and conspiracy theory. While concerns about safety and side effects dropped in 2022, misinformation and conspiracy theories seems to have increased indicating continued politicization of the COVID- 19 vaccines issue.

Figure 5

Factors Impacting Vaccination Hesitancy And Acceptance In 2021

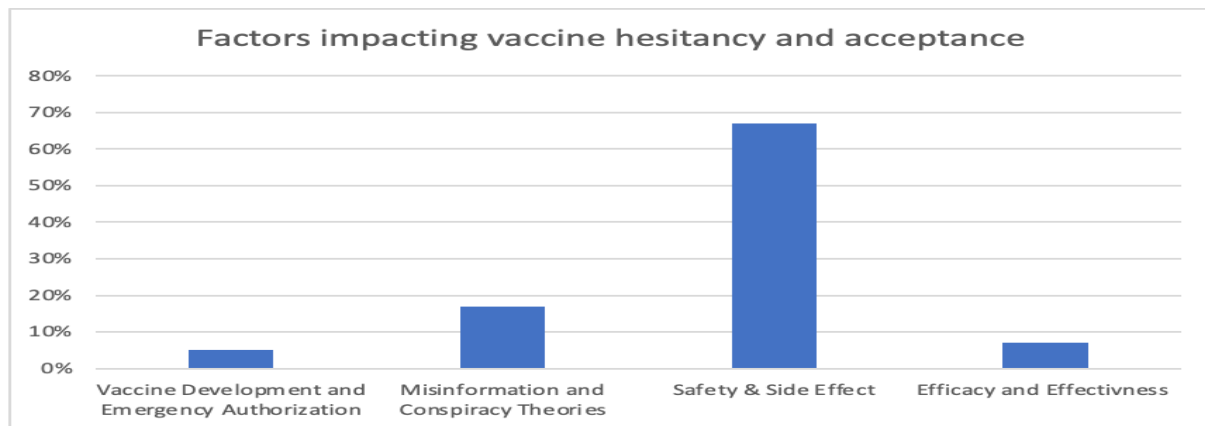
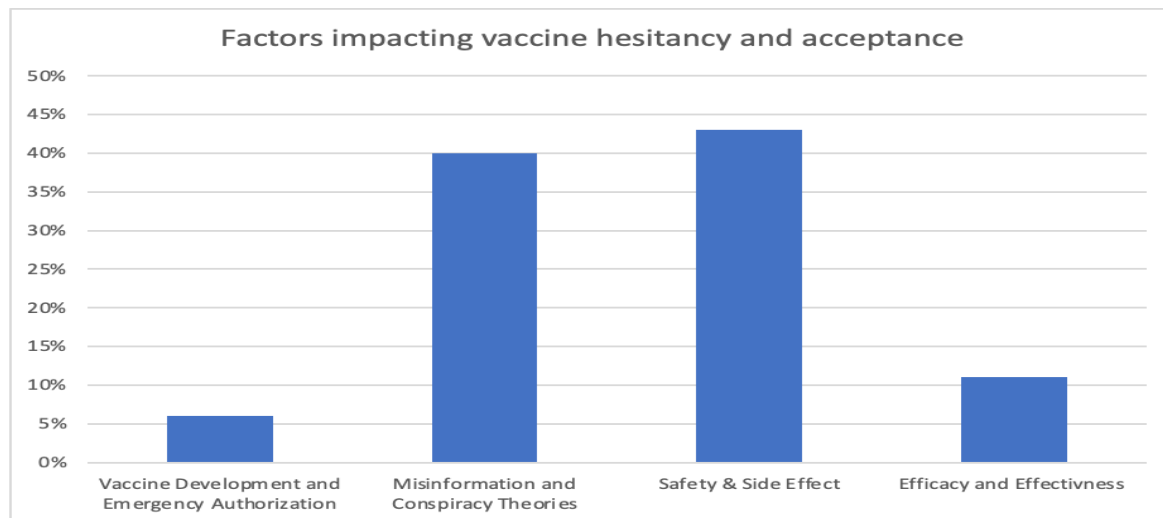


Figure 6

Factors Impacting Vaccination Hesitancy And Acceptance In 2022



Misinformation and conspiracy theories have elevated the level of fear and concerns regarding the safety and effectiveness of COVID-19. Conspiracy theories such as digital tracking, infertility, miscarriage, and magnetic effect spread on social media and are magnified by factors such as politics, culture, and beliefs (Mayo Clinic, 2020; CDC, 2021; Romer and Jamieson, 2020). Despite the widespread misinformation and conspiracy theories on social media, the results from CDC data have shown a significant increase in the number of people fully vaccinated. CDC took a proactive role in combating misinformation and conspiracy theory by posting a list of debunked conspiracy theories on their website.

Studies related to conspiracy theories and misinformation's effect on vaccine hesitancy emphasized the point that one problem with one vaccine affects the hesitancy toward other

vaccines due to the fact that people tend to generalize the issue and label all other vaccines as harmful (Zarocostas, 2020; Pertwee, et al., 2022). Loomba et al. (2021) showed that people who are exposed to misinformation and conspiracy theories are less likely to receive COVID-19 vaccines. Horton (2020) highlighted the political problem and suggested that people from different political parties should trust health science and support the COVID-19 vaccines. CDC publishes daily statistics about the number of people fully vaccinated by the state. Figures 6 and 7 show the percentage of people who received COVID-19 vaccines at least one-dose and fully vaccinated. The data from CDC have shown good progress toward getting more people vaccinated. The overall observation from the sentiment analysis results shows that the increase in polarity and decrease in subjectivity might imply that people over time are developing better understanding of COVID-19 and awareness of the issues related to misinformation.

CONCLUSION

The paper examined Twitter users' sentiment toward COVID-19 vaccine and the factors that impacted vaccine hesitancy and acceptance. The results have shown that despite the widespread of COVID-19 misinformation and conspiracy theory, Twitter users maintain positive sentiment toward the vaccine. The overall observation from the sentiment analysis results shows that polarity increased, and subjectivity decreased implying that people over time are developing a better understanding of COVID-19. Safety and side effect was the number one impacting factor on vaccine hesitancy followed by misinformation and conspiracy in 2021. The decrease in 2020 in the percentages regarding safety and side effect could be due to people having more faith and confident in the vaccine. However, the effect of misinformation and conspiracy theories remained high in 2022.

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