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The Battle Between Expertise and Misinformation to Influence Public Opinion: A Focus on the Anti-Vaccination Movement

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The Battle Between Expertise and Misinformation to Influence Public Opinion:

A Focus on the Anti-Vaccination Movement

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Abstract

How do experts and anti-vaccination advocates effectively influence public opinion? This study examines the role of experts and non-experts in influencing public opinion. It uses the anti-vaccination movement as a case study to observe the antagonism between expert opinion and misinformation and how they are perceived by and influence the public. In particular, I examine the relationships between social media, misinformation, and expert opinion and how these relationships impact individuals to form their opinions. Additionally, I measure individual components such as science education background, ideology, and social media use to determine the effects of personal factors on opinion formation. I expand upon previous research that explored the mechanisms of anti-vaccination advocates to influence public opinion through social media campaigns and misinformation dissemination. Instead of focusing on the mechanisms, I study the effect of the tactics used by anti-vaccination groups in the population as a whole and within different subsets of the population. I conducted two studies consisting of two survey experiments to test my hypotheses. The data suggests expert information is effective to varying degrees at promoting and reinforcing pro-vaccine beliefs when presented both alone and alongside misinformation. The findings also show anti-vaccination methods are effective at inducing negative vaccine beliefs in individuals. The most important results showed that personal factors were the strongest predictors of positive or negative vaccine attitudes. This research is important because misinformation not only poses a risk to intellectual integrity, but anti-vaccination misinformation poses a risk to public health.

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Dedication

This thesis is dedicated to those around the world who have died from COVID-19 as well as all who have died from vaccine preventable diseases.

May they rest in peace.

1. Introduction

On March 28, 2014, Donald Trump tweeted, "Healthy young child goes to doctor, gets pumped with massive shot of many vaccines, doesn't feel good and changes – AUTISM. Many such cases!" (@realDonaldTrump) Although he was not yet president of the United States at the time, Trump's statements hold wider implications for the current state of the country. Not only did the tweet get 53.1 thousand retweets and 29.1 thousand likes, it was viewed by countless others, receiving both praise and criticism (Trump 2014). In 2017, Robert F. Kennedy Jr., a known vaccine skeptic, announced he was to lead President Trump's "vaccine safety and scientific integrity commission," further putting Trump's support of vaccines in question (Weeks 2017, 18). On August 13, 2020, Trump's second wife, Marla Maples, reposted a graphic posted by Robert F. Kennedy Jr. to her Instagram story with over 114,000 followers. The graphic showed a picture of Bill Gates with the words, "The digitalized economy? We get rid of cash and coins. We give you a chip. We put all your money in your chip. If you refuse a vaccine, we turn off the chip and you starve!" The post also included videos with clips of Bill Gates claiming that he wants "control over our identities, control over our transactions, and even control over our bodies (@robertfkennedyjr, August 11, 2020)." Maples added text around the post writing, "Education is key… Ask questions… Dig deeper.." Like her ex-husband, Maples' repost of Kennedy's conspirator propaganda reached far and wide (Klein 2020).

Social media is a tool through which individuals can use to connect with friends and family, share pictures and videos, and reach people far away. However, social media has also become an outlet through which misinformation can spread faster than it can be taken down. While seemingly harmless, misinformation has broader impacts on people beyond the privacy of computer screens. Misinformation and conspiracy theories are especially dangerous with regard to public and individual health (Swire-Thompson and Lazer 2020, 433-451). When public figures like Donald Trump, Robert F. Kennedy Jr., and Marla Maples spread misleading facts or conspiracy theories, they reach many more people than an average American. Trump had an estimated Twitter following of over 88 million followers before Twitter permanently suspended his account in January 2021 (Twitter 2021). Kennedy and Maples combine for a total of 906,000+ followers (@itsmarlamaples and @robertfkennedyjr). Not only this, but public figures like Trump, Kennedy, and Maples receive amplified national attention from the media,

which often report on prominent figures' social media posts, carefully analyzing and critiquing them, thereby giving them a greater spotlight. The rise of social media as a platform for individuals to receive their news has caused a cultural shift that diminishes the credibility of experts and bolsters the credibility of nonprofessional influencers.

In recent years, public figures have become effective "influencers" as media exposure has increased their abilities to persuade individuals in different directions. More people look to these non-experts, including politicians, actors and actresses, entertainers, models, musicians, and more, for their information about pressing issues of the day. Their influence on the public may not always be a national threat. These individuals also post content promoting certain products or tv shows, which isn't a public health hazard. What becomes a hazard, however, is when these celebrities spread false information to thousands and millions of followers who look to them for guidance. Social media has allowed laypeople to feel closer to celebrities more than ever before. We think we know their lives. We trust them, and we believe they are good people without even having met them. Because of this, people tend to follow their favorite celebrities and politicians with blind trust without fact-checking or turning to experts in the field (Nichols 2014).

This thesis examines the roles of experts in public opinion formation and specifically addresses the research question: How effective is the anti-vaccination movement at impacting public opinion about vaccines through social media platforms? Many other questions stem from this. Do certain factors increase an individual's susceptibility to internalizing misinformation? What effect, if any, has the COVID-19 pandemic had on this phenomenon? How can expert advice and public health information effectively "correct" any false medical beliefs after they are formed? Finally, where does public opinion currently stand on the safety and efficacy of vaccines?

Vaccine distrust is growing in the Western world and vaccination rates are falling, causing major outbreaks of serious preventable diseases like measles (Hussain 2018). If this trend continues, it could threaten the health of many vulnerable populations. Engaging the root of these behaviors can help prevent people from mistrusting vaccinations and the professionals that endorse them. This research aims to better understand the effectiveness of social media as a tool for anti-vaccination groups to plant seeds of distrust about vaccinations, a scientifically-proven technology that has saved millions of lives (World Health Organization 2017).

Specifically, this thesis makes three main contributions. First, through the use of survey methods, I measure current public opinion about vaccine safety and efficacy. These survey questions gauge the prevalence of fears about vaccine injuries and side effects, topics used by anti-vaccination groups to cast doubt on vaccine safety. Second, the study examines the anti-vaccination movement and its effect on vaccine opinions during the COVID-19 pandemic, a time in which vaccine development has been at the forefront of scientific research and the media. Through a national survey experiment, I examine the effect, if any, that the COVID-19 pandemic has had on how people react to anti-vaccination propaganda. Finally, this thesis measures how effective the anti-vaccination movement's social media propaganda is at influencing vaccine attitudes. It also measures the effectiveness of expert opinion at "correcting" false beliefs and conspiracy theories. Specifically, it focuses on how corrective information from health professionals and other vaccine experts can eliminate internalized distrust in vaccines.

To examine the relationship between anti-vaccination social media propaganda and public opinion about vaccinations, I conduct two empirical studies. The first study uses a national survey experiment to determine the effect of the COVID-19 pandemic on vaccine attitudes and internalization of anti-vaccine attitudes. The study calculates whether priming certain individuals to reflect on their experiences with the COVID-19 pandemic significantly impacts how they responded to an Instagram post from an anti-vaccination group. This exploratory study also used survey questions to gauge national opinion about four topics surrounding vaccine safety, including a COVID-19 vaccine. The second study also used survey experiments of a nationally representative sample to measure the effectiveness of social media propaganda disseminated by anti-vaccination groups is at altering individuals' opinions. This study also included survey questions measuring various factors that have been found to correlate with inclinations toward a vaccine trust or distrust in previous studies. Finally, the study conducts a survey experiment to determine how these individual factors impact opinion formation, specifically about vaccines.

2. Context

2.1 Historical Context: The History of Vaccines and the Anti-Vaccination Movement

Vaccine development dates back hundreds of years when Edward Jenner developed the first vaccine in 1798 by injecting a 13 year old boy with cowpox, or the vaccinia virus, which created immunity in the boy to smallpox. Though his ideas were unconventional and controversial at the time, scientists built on his innovation, making the practice of vaccination safer over time (Immunisation Advisory Centre 2020). Vaccines work on both the individual and community levels, protecting both the individual and the public. In some cases, vaccines contain an inactivated or dead strain of a bacteria or virus which triggers a person's immune system to respond. There are also other types of vaccines including toxoid vaccines, such as the Dtap vaccine, and mRNA or adenovirus vector vaccines, such as the SARS-CoV-2 vaccines, that use other methods to trigger the immune response. The vaccine induced immune response can cause B cells to produce antibodies or it can also cause T cell activity to produce immunity. Some vaccines cause both responses (B cell and T cell responses) including the MMR vaccine and the SARS-CoV-2 vaccines. When an antigen stimulates the B cell response, B cells replicate and then increase production of antibodies that are reactive to the items in the vaccine. Memory to the pathogens or their products comes at the same time. Immune system memory can be measured in a second response by taking an antibody titer. If the body is ever exposed to the virus again, the immune system is able to act faster than it would without the vaccine. This protects the body without it being exposed to a dangerous pathogen. Vaccines are the safest way to develop immunity to a specific virus without becoming ill (Welsh and Allmann Updyke 2019).

Vaccines also help individuals on a community level. The more people get vaccinated, the less likely a disease outbreak is. When a high percentage of the community is immune to the disease, the likelihood of that disease spreading is slim to none. This is known as herd immunity. This is especially important for the most vulnerable in a population who, for various reasons, may not be able to receive the vaccine themselves. Herd immunity offers them protection because the disease does not have the opportunity to spread throughout the community (APIC 2020). High rates of vaccination can also help eliminate diseases within a population. In the United States, smallpox has successfully been eradicated because of

vaccination (Centers for Disease Control and Prevention 2016). Despite the highly effective nature of vaccines, there is still debate in the United States regarding the safety and viability of vaccines.

The spread of misinformation by public figures plants seeds of doubt and distrust in field experts. This "death of expertise" is especially dangerous when public health is at stake (Nichols 2014). The goal of public health is to keep individuals safe, healthy, and alive. Misconstrued and vague public health information threatens the well-being of communities. The COVID-19 pandemic highlights these issues. Doctors report significantly higher volumes of misinformation related to the coronavirus than any other virus or health condition (Satarino 2020). At least 800 people have died and thousands more have been hospitalized worldwide from ingesting highly concentrated alcohol they thought would kill the virus, a widely spread misconception surrounding COVID-19. Doctors also stated that patient compliance decreased significantly while misinformation spread on social media has increased, a phenomenon they refer to as "Dr. Google." Sadly, hospitals have also reported patients not coming in until it's "too late," because of belief in conspiracies that COVID-19 was planned or a hoax.

Historically and today, vaccines and vaccination requirements have prompted vocal individuals to circulate misinformation and conspiracy theories (History of Vaccines 2018). The anti-vaccination movement dates back to the mid-1800s with opposition to the smallpox vaccine and the rise of anti-vaccination leagues. Anti-vaccination sentiment has continued with skepticism around the safety of the DTap (diphtheria, tetanus, and pertussis) vaccine and the MMR (measles, mumps, rubella) vaccine, up to the most recent resistance to a potential COVID-19 vaccine. The anti-vaccination movement takes many forms, spanning from concerns with vaccine safety to arguments for bodily autonomy and personal liberty from the government. Although the movement has evolved, its purpose remains the same – to plant seeds of distrust in vaccines and discourage those around them from getting vaccinated. The anti-vaccination movement benefits from increased spread of false information and also works to disseminate misinformation as well (Biller-Andorno 2021).

Though the anti-vaccination movement is not a recent development, its popularity has grown through the years. As mentioned previously, research shows correlations between the spread of misinformation and the rise of the anti-vaccination movement (History of Vaccines 2018). However, the rise of pseudoscience and the dissemination of false facts may not be the

only factors bolstering people's opposition to vaccines. Individuals have various reasons and motivations by which they make their decisions. Historically, the opposition to vaccinations came from a wide range of reasons and rationales (Hussain 2018). This is still true today. People's beliefs on various topics are formed by multiple factors throughout their lives. Some of these factors include familial influences, religion, values, political ideology, education. Together they interact to form opinions regarding various issues, including vaccination. These factors may similarly make others more susceptible to the propaganda spread by anti-vax supporters.

The first objections to vaccines came from various rationales including fear, religious beliefs, distrust of science, and political opposition. These arguments were targeted toward the smallpox vaccine, which was the first of its kind to be nationally distributed. This vaccine became the first to globally eradicate a disease that had killed many (Riedel 2005, 21-25). Still, as with modern vaccine skeptics, people objected to this potentially life-saving treatment (History of Vaccines 2018). While arguments of fear and uncertainty, religious skepticism, distrust, and political opposition may seem more viable in the early to mid-1800s, the same attitudes still hold true today. Conspiracies surrounding vaccines use fear and uncertainty to instill distrust of experts who devote their lives to the research and development of safe and effective vaccines.

Despite this criticism, vaccine development is considered a significant accomplishment in the public health community. Specifically, vaccines have allowed for the eradication of smallpox worldwide. Figure 1 shows the number of smallpox deaths per million people in England during different stages of implementation of the smallpox vaccine between the years 1700 and 1898. The graph depicts how, over time, as the smallpox vaccine went optional to compulsory to mandated, the number of deaths from smallpox declined. Additionally, the introduction of the smallpox vaccine correlated with the largest decrease in deaths from smallpox with 3,000 deaths per million inhabitants between the years 1700 and 1797 when no smallpox vaccine was available to 417 deaths per million inhabitants between the years 1838 to 1853 when the vaccine was introduced. This is an 86.1% decrease in deaths from smallpox. The data represented by Figure 1 shows that, without the smallpox vaccine and vaccines like it, lethal diseases would still pose a threat to global public health (O'Neill 2020).

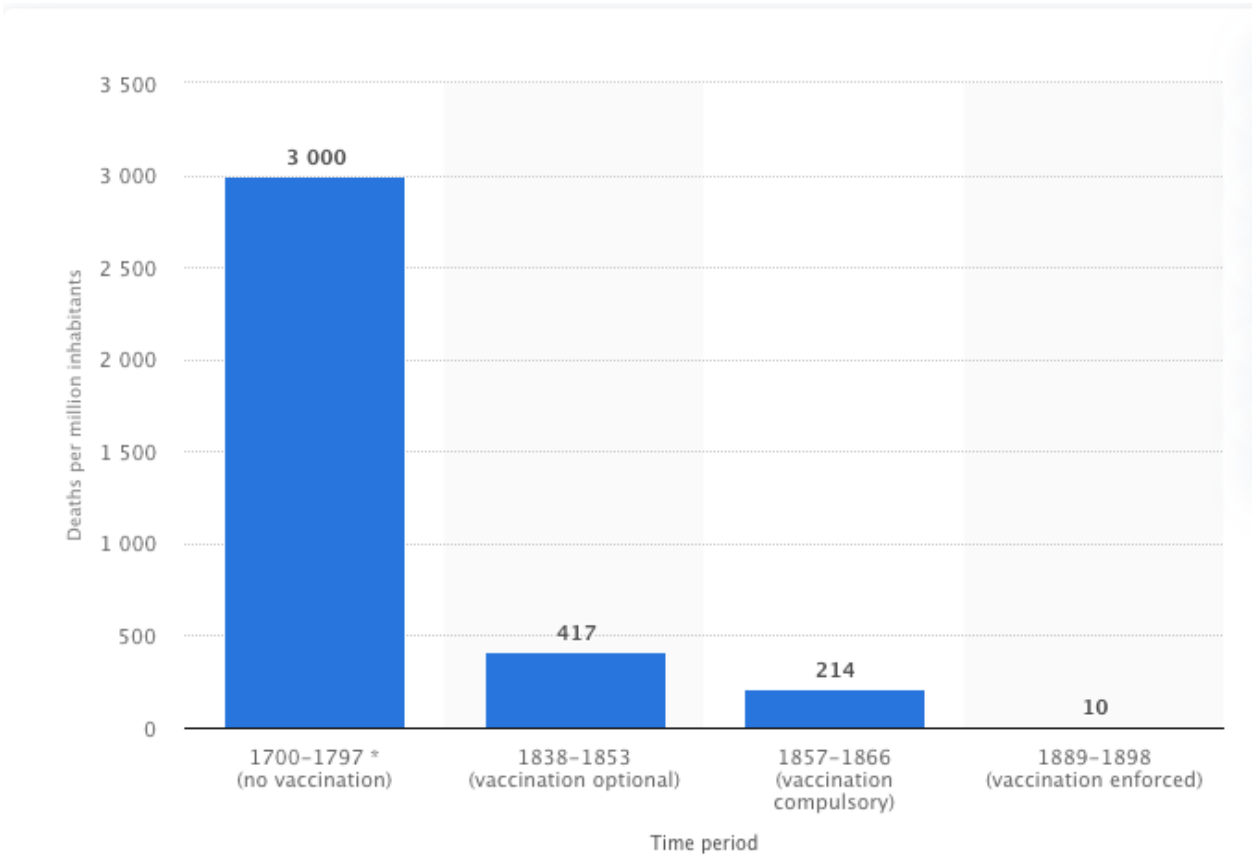


Figure 1: Number of smallpox deaths per million inhabitants in England during the various stages of vaccination implementation between 1700 and 1898

Source: Expert(s) (E.J. Edwardes); https://www.statista.com/statistics/1107661/smallpox-vaccination-impact-england-historical/

2.2 Contemporary Context: The Anti-Vaccination Movement in the Modern World

Vaccine hesitancy, or the refusal or unwillingness to vaccinate, was named a threat to global health by the World Health Organization (WHO) in 2019 because of its danger to progress made in addressing vaccine-preventable diseases. It was listed among deadly diseases and epidemics like Dengue fever, HIV, ebola, and more (Akbar 2019). Scholars concur that vaccine hesitancy correlates to a rise in the popularity and widespread reach of the anti-vaccination movement. As long as vaccines have existed, some people, many misinformed, have resisted them. Research suggests that this population has grown along with an age of distrust, fake news, and misinformation (Krenn 2019).

Social media platforms allow anti-vaccine organizations to spread their message to a wider audience quickly and unfiltered. Experts studying tactics of anti-vaccination groups to bolster their presence and credibility found that these groups primarily operate through social media platforms and independent websites on the internet. One study found that people who relied on social media as their primary information source were more likely to be misinformed than those who relied on traditional media sources (Annenberg Public Policy Center of the University of Pennsylvania 2020). Of the 2,500 U.S. adults surveyed, about 20% were misinformed about vaccines to some extent. Around 15% agreed that vaccines were full of toxins and 18% believed that vaccines caused autism. Individuals who reported getting their information about vaccines from social media, were more likely to be misinformed about vaccines. Researchers found a significant amount of misinformation on social media compared to traditional media sources. Traditional media sources like national news channels reflected a basic consensus about its benefits and safety. Results suggested that internalization of vaccine misinformation was a lasting phenomenon. Over 80% of people who were misinformed in the first survey wave were still misinformed about vaccine efficacy seven months later, even after extensive news coverage of a recent measles outbreak due to low vaccination rates and campaigns by the CDC to educate the public (Annenberg Public Policy Center of the University of Pennsylvania 2020).

Anti-vaccination websites and social media platforms often make unsupported claims, provide misinterpretations of vaccine studies, skew data, and give incorrect information. One study found that of the anti-vaccination websites studied, 88% contained misrepresentations of vaccine studies and claims unsupported by concrete evidence (Kata 2010, 1709-1716). These websites selectively described the data, drew false conclusions and selectively extracted information from sources to distort facts. The websites made unsubstantiated claims and drew correlations and causal relationships between unrelated variables in order to make vaccines seem dispensable. One website even mentioned that smallpox is not contagious but comes from bed bugs and that polio can be caused by eating sugary foods.

Researchers also note tactics anti-vaccine advocates use on social media to silence vaccine supporters including misinformation, harassment, and intimidation (Baughman 2020). Anti-vaxxers target individuals who promote vaccines through a method called doxing. Doxing uses harassment to silence other voices from the conversation and creates an

environment in which an individual will think twice before speaking out in support of vaccines again. Anti-vaxxers on TikTok targeted a Cincinnati pediatrician after she posted a pro-vaccine video. They used tactics like calling her practice to get her fired, writing defamatory reviews online about her and her practice, and threatened to shut down her practice.

Research suggests this is not an isolated incident (Baughman 2020). There are multiple accounts in which anti-vaxxers use doxing to harass and silence pro-vaccine voices from the conversation by finding personal information and sending threats. Anti-vaccination group's large presence on social media makes users believe their movement is larger than it is, creating a false sense of majority versus minority. Experts and academics put out publications supporting vaccine efficacy, but do not have time to interact with fence sitters. Anti-vaxxers use this to their advantage, interacting with these fence sitters and influencing them to join their movement.

Scholars emphasize the threat the anti-vaccination groups pose to public health, specifically increasing numbers of outbreaks of vaccine preventable diseases attributable to declining vaccination rates (Centers for Disease Control and Prevention 2015). Anti-vaccination groups' strong social media presence and well organized websites has led many to join their cause. Researchers note that information provided on these social media accounts and websites are dangerous if taken seriously, especially since these posts do not emphasize the harms of not vaccinating children (Evrony and Caplan 2017, 1475-1476). Children who obtain vaccine exemptions can be up to 35 times more likely to contract harmful diseases like measles than those who are fully vaccinated, a fact that anti-vaccination groups choose to omit (Salmon 1999, 47-53).

Anti-vaccination websites also use scare tactics to dissuade viewers from vaccinating themselves and their children like describing toxic effects of vaccines as inescapable and inevitable without evidence to support their claims. Scholars emphasize that the anti-vaccination message is directly harmful to children and adults who are physically unable to get vaccinated including infants, transplant patients, immunocompromised individuals, and the elderly (Evrony and Caplan 2019, 1475-1479). Falling vaccination rates put these groups at significant risk of infection due to a lack of herd immunity. Because of this, anti-vaccination groups not only harm themselves and their families, but the most vulnerable individuals in the population. These findings emphasize the importance of studying the anti-vaccination movement and how it operates in order to prevent misinformation spread and falling vaccination rates.

While extensive research has covered how the anti-vaccination movement operates there have not been many studies investigating how and if they are effective in their tactics. This thesis seeks to fill this gap in the research. Specifically, it explores how effective anti-vaccination organizations' social media content is in impacting individual vaccine beliefs. It determines the effect of expert opinion on individual vaccine beliefs as well. Finally, it measures the effectiveness of expert information in counteracting misinformation. The anti-vaccination movement is a key example of the battle between misinformation and expertise to influence public opinion and is therefore an excellent case study to investigate public perception of expertise and misinformation as it currently stands.

3. Theoretical Framework

My thesis draws on four main bodies of prior research. First, I examine literature surrounding the shifting role of expertise in public opinion formation and the rise in popularity of conspiracy theories, specifically within the scientific realm. Next, I draw on research surrounding the increase in usage of social media and the internet and its effects on the spread of misinformation. Finally, I consider studies that examine factors that correlate with certain beliefs about scientific issues. Overall, my framework shows that expertise, social media, and misinformation are intricately intertwined. These concepts are interrelated, and their relationships influence how individuals form opinions.

Specifically, expertise is diminished as misinformation and social media usage increase. Misinformation and social media platforms form a symbiotic relationship where both concepts benefit from each other. Finally, the interplay between these elements influences the individual who is also connected to concepts such as political ideology, education, and environmental factors when forming their opinions. This thesis uses this theoretical framework to understand the relationship between the anti-vaccination movement and public opinion formation about vaccines.

3.1 Diminishing Role of Expert Opinion and Rise in Conspiracism

Scholars have highlighted the importance of experts and their knowledge in the formation of policy and decision-making within a democracy. They assert that these individuals play a central role in society as a whole, serving as a bridge between highly educated academia and laypeople. Academics who have devoted years of research to a subject hold a sort of epistemic authority on the issue (Post 2013). In 1987, a study found that expert opinion had a considerable impact on public opinion. These experts were described as nonpartisan individuals with high levels of experience and expertise. They historically influenced public opinion on policy issues such as the Senate vote on SALT II arms limitation treaty. In total, public support dropped about 20% after retired military generals and arms experts spoke out against the treaty (Page, Shapiro, and Dempsey 1987, 23-43). The influence of expert knowledge on public opinion has since changed. Expert knowledge now has less of an influence on public opinion formation, and ultimately, the importance of expert knowledge has diminished in the public eye (Nichols 2014).

It is important to note that, over time, information has been able to spread through many different outlets. This in turn has brought about a "marketplace of ideas" of sorts, where users exchange information fast and easily, and where multitudes of self-proclaimed experts whose opinions culminate in white noise drown out expert knowledge, muddying the ability to distinguish between fact and opinion. This diminishes the epistemological authority experts once held in impacting the viewpoints of the public (Post 2013). However, studies have shown that, while people trust expert opinion less than in previous times, confidence in scientists has increased since 2016, with around 86% of Americans reporting that they have at least a "fair amount" of trust in scientists to act in public interest (Funk, Heffron, Kennedy, and Johnson 2020).

However, confidence and trust in experts changes when broken down by party affiliation. Democrats are more likely to show support and trust in experts than Republicans. In regard to expertise, 66% of Republicans believe that scientific experts were no better or worse at making decisions about scientific issues than other laymen, compared to 46% of Democrats. The same study also found that a majority (54%) of Americans also believe that the public should play an important role in guiding policy decisions on scientific issues. Additionally, more than 80% of survey respondents believed that scientists across all disciplines lacked transparency (Funk, Heffron, Kennedy, and Johnson 2020).

This phenomenon has been dubbed the "death of expertise" (Nichols 2014). In other words, there has been a death to acknowledging that expertise should matter. The diminished value of expert opinion in the public sphere not only rejects knowledge but the way individuals obtain knowledge and the value that that holds. Scholars argue that the internet and social media platforms where individuals can interact and exchange information allow for others to downplay their ignorance as they argue as self-proclaimed experts (Nichols 2014). This is a new globalization, in which the internet is a medium in which anyone in the world can post anything they want while staying completely anonymous.

According to Nichols (2014), this increased exchange of information does not and should not imply that every opinion or every voice has equal weight on certain issues. Yet, in a globalized world, expert opinion has been questioned more than ever. With a decreased reverence for expert opinion, scholars noted a rise and normalization of conspiracism in everyday rhetoric. They also cite a rise in a "new conspiracism" in which conspiracy is not grounded in theory (Rosenblum and Muirhead 2020, 1-20). This new type of conspiracy theory does not adhere to traditional conspiracism, and it is believed to be destructive to democracy. According to scholars, classical conspiracism is grounded in theory, although flawed, and seeks to make sense of the political world. This conspiracism uses obscure theory to thread unrelated phenomena together and creates a new vision of the world. The new, and popular, conspiracism disperses information without explanation or burden of proof. Scholars note that sources of these theories make ambiguous assertions such as, "A lot of people are saying..", followed by unsubstantiated statements.

What academics are most concerned with is how these conspiracy theories could impact individuals' behaviors. This is especially true in medicine. For example, Oliver and Wood (2014) found that a large percentage of Americans had heard medical conspiracy theories, and a concerning amount of them agreed with them, including ideas that the FDA was suppressing natural cures for cancer because of pressure from drug companies. Out of all the survey respondents, 49% agreed with at least one medical conspiracy theory and 18% agreed with three or more. The researchers also found that individuals that believed medical conspiracies also harbored mistrust of traditional medical interventions such as vaccines and therapeutic drugs. This also translated to their health behaviors. Individuals who believed in medical conspiracies were less likely to get annual checkups or flu shots and more likely to use herbal

supplements and alternative medicine. Overall, Oliver and Wood (2014) found that exposure to and beliefs in conspiracy theories about medicine were predictive of decreased trust in and avoidance of traditional medicine.

The previous findings contribute to the overarching framework of this thesis. The diminishing role of experts in public rhetoric and the phenomenon of new conspiracism, especially within the medical community, contribute to the rise in the anti-vaccination movement and increased vaccine hesitancy. The findings concerning changed health behaviors like the rejection of traditional medical interventions including vaccines are especially concerning for public health and the promotion of herd immunity. A greater rejection and distrust of expert opinion brings challenges to the reception of announcements from public health experts. Researchers (Meyers et al. 2020, 909-925) have also studied how to prevent rejection of expert opinion. They conducted 5 studies to understand factors that make it more likely to change their opinions when given expert opinion as opposed to the general public. Specifically, they focused on how individual overestimation of knowledge plays a role in the rejection of expert opinion about economic issues. Their studies found that overall people will adjust their beliefs in response to a consensus beliefs but do not adjust to expert opinion more than lay opinion. However, when Meyers et al. (2020) created an "illusion of explanatory depth" to cast doubt in the participant and create a general feeling of ignorance, the participants were more likely to change their normative beliefs to align more closely with expert opinion. The same phenomenon emerged when researchers induced doubt in the participants about a specific topic related to their normative belief. Inducing doubt in the participants about a topic unrelated to their normative belief also produced the same result. Although related to economics, these findings suggest tactics in which public health information could effectively "debunk" conspiracy theorists' beliefs and allow for an effective reception of expert opinion.

These studies concerning the changing roles of experts contribute to the theoretical foundation of this thesis. Expert opinion's role in belief formation, although once highly esteemed, diminished over the years, opening the door for other voices with limited knowledge to enter the dialogue, and sometimes dominate even it. The rise of a new conspiracism not rooted in reasoning or any concrete phenomena threatens the public, especially concerning health information. Public opinion and informed choices are threatened when popularity and virality is substituted for expertise, especially when physical and mental well-being are at stake. The

subsequent research explores how social media allows for wide dissemination of false rhetoric and misinformation, especially surrounding medical facts. This phenomena also contributes to the diminishing effect plaguing experts in their respective fields.

3.2 Internet, Media, and an Era of Misinformation

Researchers agree that the increased internet usage and innovation have led to a rise in social media usage and reliance on the media for information (O'Connor and Weatherall 2019, 147-186). Today, almost 80% of American adults use the internet. Of these users, about 70% rely on Facebook as a social media platform. Additionally, Twitter users account for almost 30% of the US adult population. These statistics show that information posted on these sites, and many others, has the ability to spread far and wide. This has huge implications. "Fake news" or misinformation is not a new phenomenon in the United States. Before the age of the Internet and social media, individuals would post false articles and stories through print media sources (O'Connor and Weatherall 2019, 147-186). Now, fake news has the ability to spread like never before. Not only can it spread farther and wider, but also faster, making it more difficult to stop, and thereby, more dangerous. Increased social media use provides more opportunities for users to gather information from a variety of sources and voices, many of them nonexperts.

Almost everyone has been exposed to fake news on the internet. Ipsos Public Affairs conducted a survey that revealed shocking results about the pervasiveness of fake news. Participants were shown six headlines, three of which contained false information. One-third of respondents said they had seen at least one of the false headlines. The participants that remembered these fake headlines concluded the story to be "very" or "somewhat" accurate about 75% of the time (Silverman and Singer-Vine 2016). Another survey of US adults found that 23% disclosed that they had shared fake news. Of those that shared the false news headline, 73% said they did not know the news was fake, only to discover later that it was false information, and the other 27% said they knew it was fake news, but shared it anyway (Barthel, Mitchell, and Holcomb 2016). Researchers have also found that false information diffused faster and more broadly than true information on Twitter (Vosoughi, Roy, and Aral 2018, 1146-1151). These findings are troubling. In an age where information is shared fast and far, it is imperative that information and news is accurate.

Scholars define misinformation and disinformation as, "information contrary to the epistemic consensus of the scientific community" (Swire-Thompson and Lazar 2020, 433-451). When this information spreads, it can alter public opinion, especially if widely endorsed. This is a special concern for health information. Studies have already shown that publications of falsified data and misleading facts can change health behaviors. Mass movements of parents in certain school districts boycotted school mandated immunizations, resulting in outbreaks of vaccine-preventable diseases. This infamous example followed a publication of a misleading article from *Lancet*, a highly regarded medical journal, whose lead author later lost his medical license (Green, Brownson, and Fielding 2020, v-vii). The journal also retracted the publication of the piece after multiple studies found his conclusions to be unsupported and invalid (Eggertson 2010, 199-200). The internet has quickly become a resource to find information about various facets of life from a myriad of sources. Studies show increasing amounts of individuals get their health information from online sources. A study in 2013 found that 72% of adults looked for health information on the Internet (Fox and Duggan 2013). This trend makes it especially important to ensure quality of health information accessible online. Two meta-analysis studies revealed that this is not the case. In terms of accuracy, completeness, and comprehensiveness, both studies showed a lack of quality in the health information available online (Eysenbach, Powell, Kuss, and Sa 2002, 2691-2700; Zhang, Sun, and Xie 2015, 2071-2084).

Researchers studying this phenomenon have also made suggestions on how to tackle health misinformation (Grinberg et al. 2019, 374-378; Guess, Nagler, and Tucker 2019; Swire-Thompson and Lazar 2020, 433-451). Specifically, improving eHealth literacy throughout the population through improved public health campaigns, specifically targeting older adults who have been found to spread most of the online misinformation (Grinberg et al. 2019, 374-378; Guess, Nagler, and Tucker 2019). Additionally, researchers have suggested that physicians work collaboratively with online health sources to ensure accuracy of information as well as frequently correcting misinformation and increasing fact-checking signals (Swire-Thompson and Lazar 2020, 433-451). Health misinformation is harmful to individuals and public health overall as it undermines the knowledge of experts in the medical field.

The internet provides a great vehicle for fast and wide misinformation spread. Some researchers propose an inadvertent algorithmic amplification of false information sources, news,

and articles (Baughman 2020). There are such things as data voids in which a specific search term or keyword has little to no results. Individuals that want to spread false information can fill that void with misinformation. Because platforms are not liable for the information they hold, they do not have an obligation to moderate. This is a huge problem unless the platform has an internal motivation to provide quality and factual information.

As one of the biggest sources of misinformation, Facebook has taken steps to stop the spread. In 2020, it banned anti-vaccination ads that discouraged people from getting vaccines by portraying them as unsafe or ineffective (Graham and Rodriguez 2020). Facebook also has a policy to remove, reduce, and inform users that the information they shared is false. However, users are still able to create content that contains conspiratorial narratives and bad health information. By using clickbait inducing headlines like "The things your doctor doesn't want you to know," scholars propose that social media platforms could have a vested interest in allowing users to create bad viral content that increases their viewership and usage (Baughman 2020).

Researchers have found that social media usage translates to changed beliefs and behaviors surrounding health issues as well. A study conducted in the United Kingdom found that individuals who obtained their news online and through social media rather than through radio or television were more likely to believe in conspiracy theories and not follow public health guidelines (Duffy and Allington 2020). An alarming number of individuals believed public health conspiracies surrounding the COVID-19 pandemic. Of the survey respondents, 30% believed COVID-19 was created in a lab and 1 in 7 believed that the death toll was being deliberately exaggerated. Additionally, 1 in 8 participants believed the pandemic was part of a global effort to force everyone to be vaccinated and 5% believed there was no hard evidence that COVID-19 even existed at all. Individuals who believed conspiracy theories about the COVID-19 pandemic were more likely to have gotten their information from social media platforms. These people were also more likely to have broken important lockdown rules. These findings further reiterate the importance of understanding how and why health misinformation spreads unfiltered through social media platforms. Widespread dissemination of fake news and false information results in dangerous behaviors contrary to medical facts.

3.3 Factors Affecting Beliefs about Science and Vaccination

Many studies have concluded correlational relationships between various individual factors and beliefs about science. Tyson and Kennedy (2020) found that partisanship drastically altered the way individuals answered questions regarding climate change, with Democrats more confident in the overwhelming scientific consensus that human activity is changing the climate and Republicans more skeptical. Correlations between partisanship and vaccination attitudes follow similar trends. Researchers have concluded that partisanship has a direct impact on vaccine attitudes (Baumgaertner, Carlisle, and Justwan 2018; Krupenkin 2020, 451-472). One study found that conservative respondents were much less likely to express pro-vaccination beliefs than other individuals. Intent to vaccinate also differed among liberals and conservatives, with fewer conservatives expressing they intended to vaccinate. Individuals with lower levels of trust in the government medical experts were more likely to be conservative and less likely to express intent to vaccinate. Political ideology was also predictive of who the individuals trusted and thus indicative of their trust or distrust in vaccines (Baumgaertner, Carlisle, Justwan 2018).

In-party versus out-party partisanship also impacts beliefs and trust in vaccines. One study found that presidential co-partisans, or individuals that share the president's ideology, were more 4-10% more likely to believe in the safety of vaccines and more likely to vaccinate themselves and their children than presidential out-partisans (Krupenkin 2020, 451-472). This is likely a result of differing levels of trust in government depending on affiliation with the in-group or out-group party in the White House as well as increased party polarization. Partisanship also affects the receptivity to vaccination. That is, when someone from an individual's in-group promotes the benefits of vaccines, that individual is much more likely to be receptive to that message. Vaccination rates among the different partisan groups also change after a shift in the party of the presidency, likely due to distrust in the out-partisan group.

Knowledge and education also play an important role in beliefs about vaccine safety and efficacy. Studies show that individuals with high science knowledge are more likely to support vaccines and see their benefits (Villa 2020). A large percentage of individuals with high science knowledge (91%) believe vaccines provide high preventive health benefits compared to a far lower percentage (55%) of individuals with low science knowledge. Individuals with low science knowledge and education also considered the risk of side effects much higher than those with high science education, with 47% of those with low science knowledge believing the risk of

side effects to be medium or high compared to 19% of those with high science knowledge. Education about vaccines and the science behind them is crucial to ensuring the population understands their importance to public and global health.

3.4 Theoretical Model

The literature on expert opinion, social media and the spread of misinformation, and factors affecting individual beliefs about science suggests a model of mass response to elite opinion that explains public receptivity to public health measures, including vaccines.

Three main concepts emerge as anchors for the model - expert opinion, social media, and misinformation. Expert opinion is the beliefs, judgements, and assertions of an individual with extensive authoritative knowledge and research on a certain area of study. Social media is any platform on the internet that allows users to post, share, and disseminate information with other users through an online social network. Misinformation is any information that is false, inaccurate, or misleading, often meant to persuade individuals to think a certain way through deception. Sometimes individuals spread misinformation without knowing it's false.

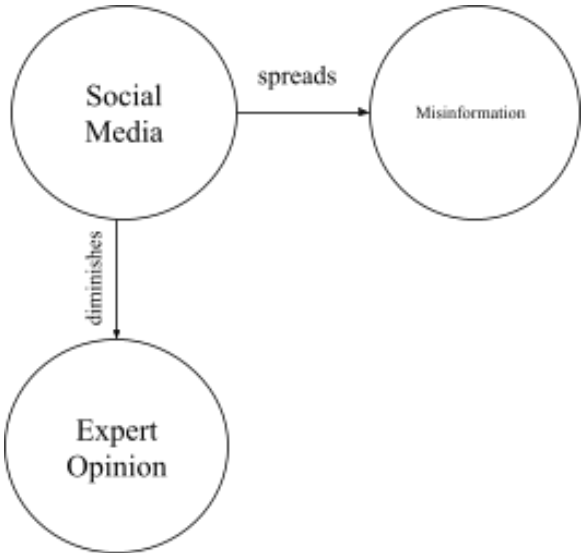


Figure 2.1 - Effect of Social Media on Misinformation and Expert Opinion

These concepts are related to each other in different ways. Figure 2.1 proposes a pathway to illustrate the influence social media has on misinformation and expert opinion. Social media has wide-reaching effects, and it especially affects misinformation and expert opinion (Barthel, Mitchell, Holcomb 2016). Because of the nature of social media (its accessibility,

convenience, and open forum), it has the ability to spread misinformation. Though social media platforms themselves do not spread misinformation, they are the vessels that users utilize to spread misinformation (Swire-Thompson and Lazar 2020, 433-451). Additionally, social media allows for many users to have a voice, with equal opportunities given to every user to post and share opinions. This diminishes the clout of experts, thereby diminishing expert opinion.

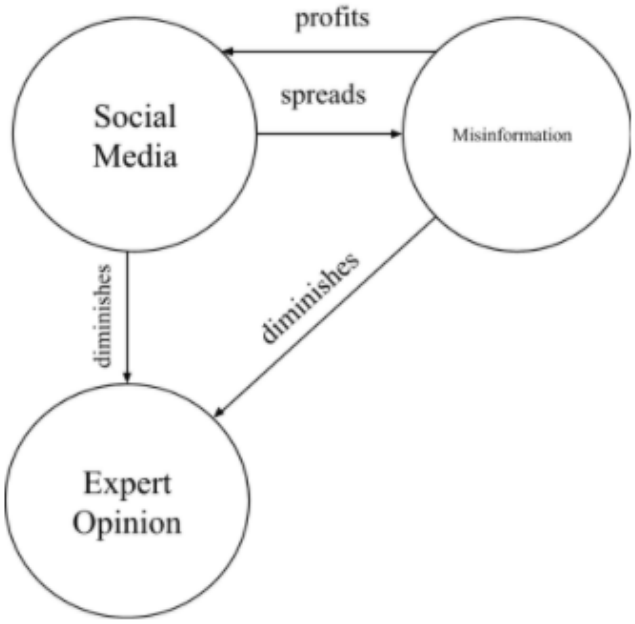


Figure 2.2 - Effect of Misinformation on Social Media and Expertise

Misinformation has the potential to impact both social media and expert opinion. Figure 2.2 shows this relationship. Misinformation diminishes the gravity of expert opinion (Post 2013). It contributes to the noise that drowns out expertise, especially in open forums on social media platforms. More individuals have turned to social media for information (Fox and Duggan 2013). Misinformation diffuses faster on social media platforms than factual information (Vosoughi, Roy, and Aral 2018, 1146-1151). Increased misinformation, especially when it goes "viral" benefits social media platforms (Baughman 2020). Social media forums profit from increased engagement with their platforms. Misinformation often spreads at a viral rate, and when it does, it increases traffic and involvement on their platforms that benefits them financially and developmentally.

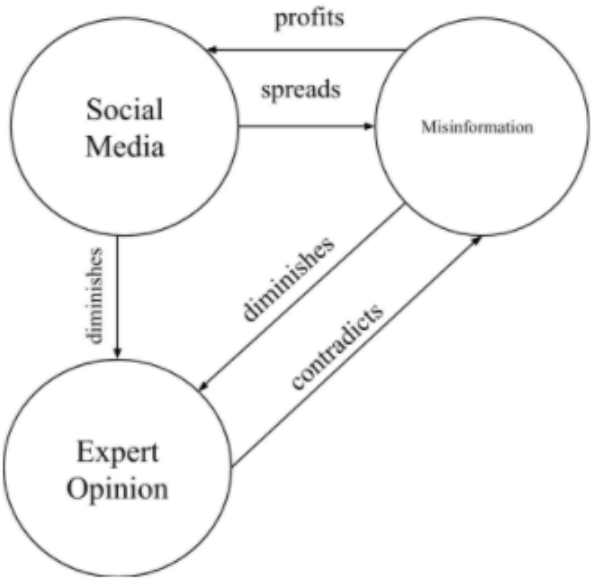


Figure 2.3 - Expert Opinion Contradicts Misinformation

Expert opinion directly contradicts misinformation (Swire-Thompson and Lazar 2020, 433-451). Public awareness campaigns headed by experts in the respective fields seek to drown out misinformation with factual information backed by research. How effective these campaigns are is ambiguous and vague as more research is needed to understand how to improve their efficacy. Research suggests that effective contradiction and "debunking" requires casting doubt in normative false beliefs rooted in misinformation (Meyers et al. 2020, 909-925).

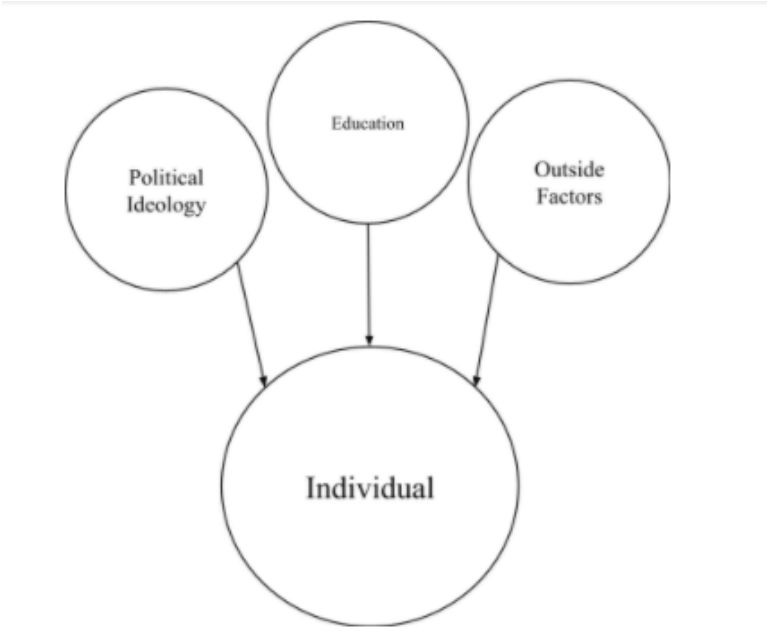


Figure 2.4 - The Individual is Impacted by Political Ideology, Education, and Outside Factors

The theoretical framework for this thesis also focuses on the individual. The individual represents any person who has some interaction with social media and the internet, which accounts for about 80% of the population (O'Connor and Weatherall 2019, 147-186). This individual is also impacted by various factors, three of which are highlighted in the framework. Figure 2.4 shows this phenomena. First, political ideology is the set of beliefs, ideals, and values an individual holds about politics, ranging from conservative to liberal. Education refers to the level of schooling and knowledge individuals attain in their lifetime as well as the type and quality of education. Finally, outside factors are defined as mitigating factors in the individual's environment, which would include major events such as the COVID-19 pandemic. These factors collectively influence the individual and have roles in belief formation (Baumgaertner, Carlisle, Justwan 2018; Krupenkin 2020, 451-472; Villa 2020; Duffy and Allington 2020).

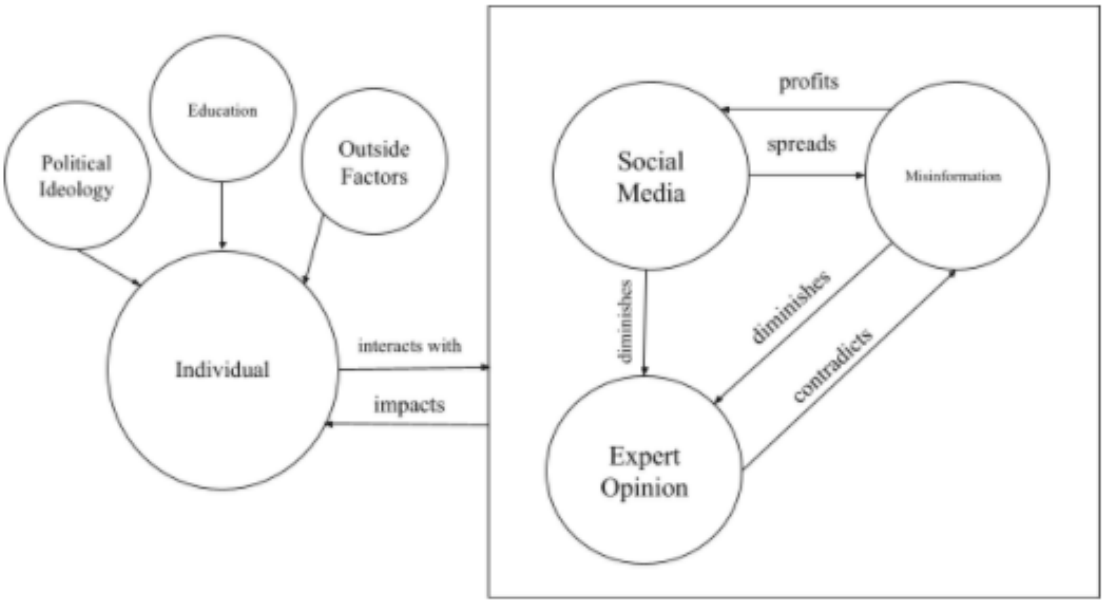


Figure 2.5 - The Individual Interacts Social Media, Misinformation, and Expertise

The theoretical framework for this thesis assumes that the individual has access to the internet and is therefore involved in the connections between social media outlets and different types of information. Figure 2.5 shows how the relationships between expert opinion, social media, and misinformation may influence the individual. The individual often interacts with these connections through social media and internet use. Much expertise and misinformation, flood social media sites, and individuals must assess its reliability to inform their decisions. This has the ability to influence their opinions. Therefore, not only do factors such as political ideology, education, and current events have the potential to impact the individual, but so do the relationships between social media, misinformation, and expert opinion.

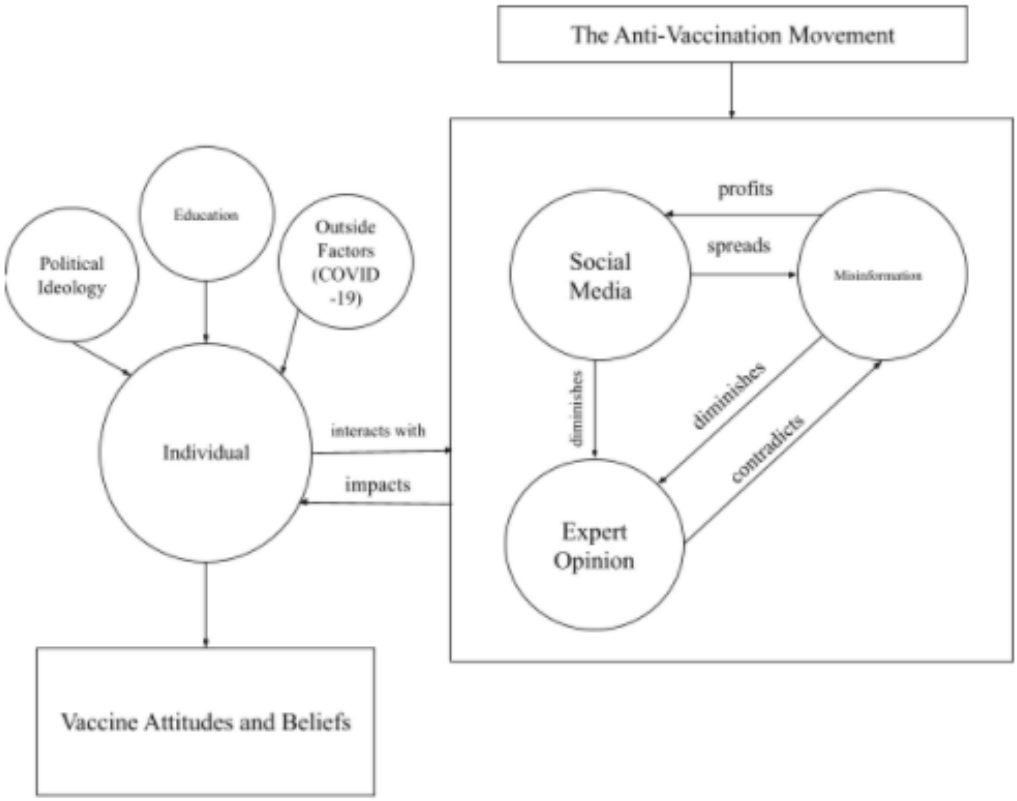


Figure 2.6 - The Final Theoretical Model: How the Anti-Vaccination Movement Impacts Vaccine Beliefs

Figure 2.6 shows the overall theoretical approach to this study. The anti-vaccination movement contributes to the spread of misinformation via social media and other internet platforms. Experts attempt to push back. Individuals on social media bring their own perspectives as they interact with the push and pull on various platforms. These theorized relationships generate a set of hypotheses that this thesis examines to assess how effective the anti-vaccination groups' tactics are at altering and influencing individual vaccine attitudes. The COVID-19 pandemic provides context for these tests.

4. Hypotheses

The relationships that Figure 2.6 summarizes suggest five sets of predictions about how the individual interacts with and is impacted by the interactions between social media, misinformation, and expert opinion. Two different survey experiments examine these hypotheses. The first survey experiment tested a single hypothesis about the relationship between

COVID-19 and opinion formation. Since the pandemic upended the world, vaccine development has been at the forefront of scientific research and the media. This has likely had an impact on individuals' trust in and beliefs and attitudes about vaccine efficacy, which the hypothesis describes.

> *COVID-19 Hypothesis: Individuals primed to think about the current COVID-19 pandemic will produce different answers to questions regarding vaccine trust and efficacy than those that are not primed to think about COVID-19.*

The second survey experiment further probed vaccine attitudes and their relationship to misinformation, expert opinion, and individual characteristics. The experiment tested four specific hypotheses. The first expectation focuses on the general diminishment of expert opinion as a byproduct of an easily accessible market of misinformation.

> *Hypothesis 1. Misinformation and Expertise: Misinformation spreads via social media and thus:*
>
> a. *Diminishes individual trust in experts and expert opinion*
> b. *Diminishes trust in health experts when they speak about vaccine information*

The next expectation focuses on vaccines and considers how the anti-vaccination movement utilizes the relationships between expert opinion, social media, and misinformation to spread false information and promote its cause.

> *Hypothesis 2. Anti-vaccination Advocates:*
>
> a. *Use social media to spread misinformation contrary to expert opinion about vaccines*
> b. *Effectively impact individual vaccine attitudes and beliefs through their social media strategies*

The next two expectations describe how individuals may respond differently to the anti-vaccination movement's utilization of social media to spread misinformation and the propaganda

of anti-vaccination groups specifically. These responses depend on an individual's characteristics.

Hypothesis 3. Education: Individuals with higher educational backgrounds in science are:

a. *Less likely to be influenced by anti-vaccination misinformation*
b. *More likely to have high trust in vaccine efficacy*

Hypothesis 4. Ideology: Individuals who self-identify as having extreme political ideologies (i.e. extremely conservative or extremely liberal) are:

a. *More likely to hold negative vaccine attitudes at a baseline measurement*
b. *More likely to disagree with government vaccine mandates*
c. *More likely to trust or agree with anti-vaccination misinformation*

The two surveys that test these hypotheses included a questionnaire component as well as a survey experiment component. Both included questions about vaccine attitudes and survey experiments, which the next two sections describe. The two surveys differed both in their purpose and design, as well as their target population. The first survey was conducted nationally around the 2020 presidential election in November 2020. The second survey was also conducted nationally but in April 2021.

5. Survey 1 Design and Results: National Survey Questionnaire and Experiment Testing the COVID-19 Factor

Survey 1 was distributed through Lucid, an independent survey sampling service to a nationally representative sample of adults in the U.S. The study was conducted around the time of the 2020 presidential election in November 2020. The survey included a random sample of adults nationwide ages 18 and older. There were a total of 1622 respondents in all. The survey was an exploratory pilot study to develop a basic understanding of vaccine attitudes on a national level and to measure whether COVID-19 was a significant factor in opinion formation.

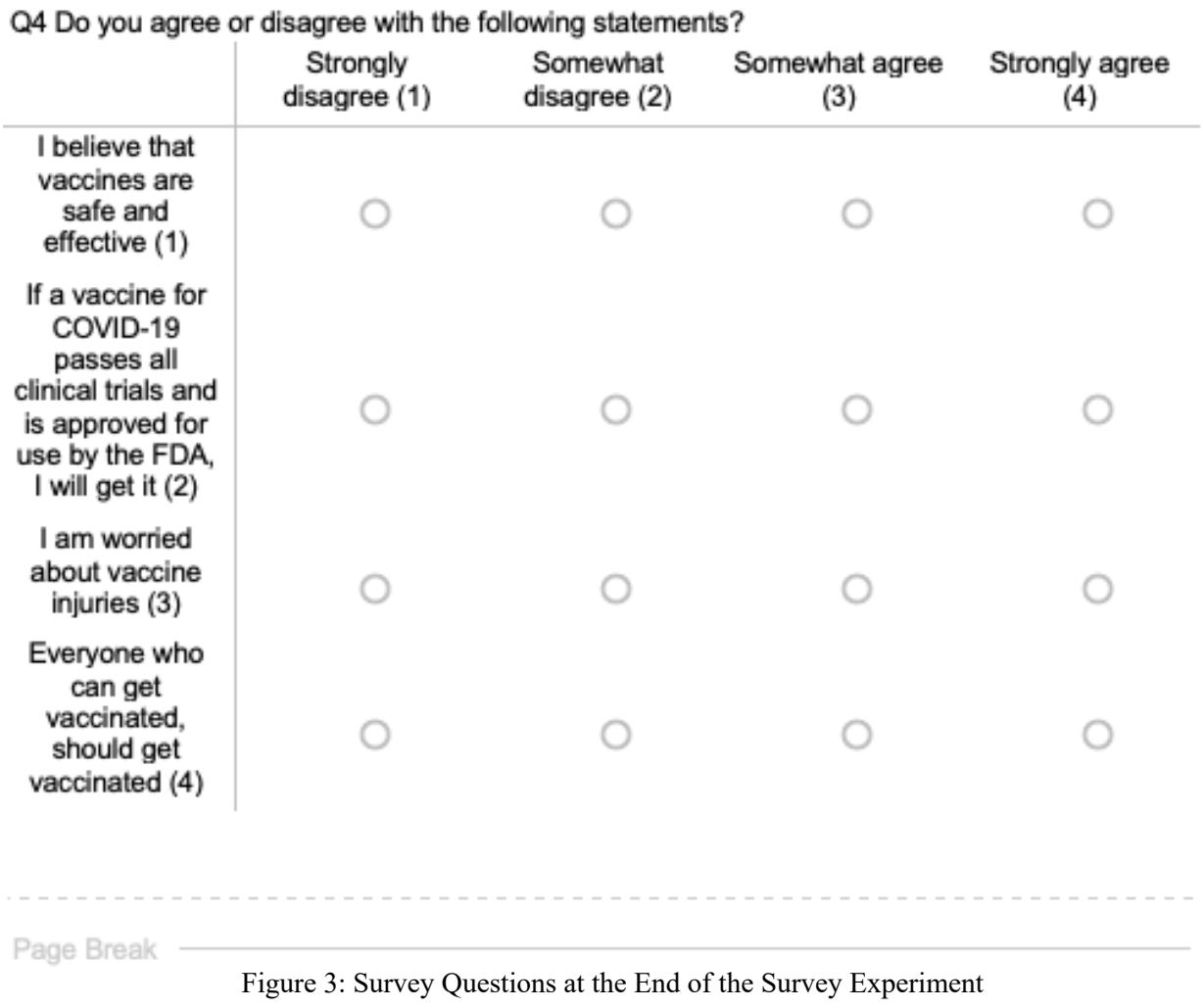


Figure 3: Survey Questions at the End of the Survey Experiment

Figure 3 shows the key battery of survey questions regarding vaccine attitudes. To gauge public opinion about vaccine safety and efficacy, all participants were asked a series of questions in four main categories - (1) the safety and efficacy of vaccines, (2) perception of the COVID-19 vaccine, (3) vaccine injuries concerns, and (4) vaccine mandates. These four categories were structured as statements, specifically: "I believe that vaccines are safe and effective," "If a vaccine for COVID-19 passes all clinical trials and is approved for use by the FDA, I will get it," "I am worried about vaccine injuries," and "Everyone who can get vaccinated, should get vaccinated." Participants had the option to either strongly disagree, somewhat disagree, somewhat agree, or strongly agree to the statements.

Figure 4: Anti-vaccination propaganda from LearntheRisk.org
Source: Instagram @learntherisks

The questions in Figure 3 appeared for all participants immediately after they viewed the anti-vaccination social media post from LearntheRisk.org, which Figure 4 presents. The graphic came from LearntheRisk.org's Instagram account, @learntherisks, which was shown to all participants before completing the survey questions. The post includes false allegations about vaccine components and misleads viewers about the incidence of Sudden Infant Death Syndrome (SIDs) after vaccines. It also suggests an unsubstantiated causal relationship between high childhood vaccination rates in the United States and the US having the "sickest children," another unsupported assertion. This figure is representative of the social media posts of many anti-vaccination organizations.

Survey 1 also contained a survey experiment that randomized participants into a control group or an experimental group. The control group was not primed to reflect on their experiences with COVID-19. This group was only shown the anti-vaccination social media post before receiving the survey questions in Figure 3. The experimental group received the same prompts as the control group with the addition of the COVID-19 prime, appearing below in Figure 5. That prime prompted them to reflect on their experiences with COVID-19 and how the pandemic impacted their lives. The purpose of the COVID-19 prime was to determine whether individual experiences with COVID-19 might have influenced the way individuals form their vaccine opinions.

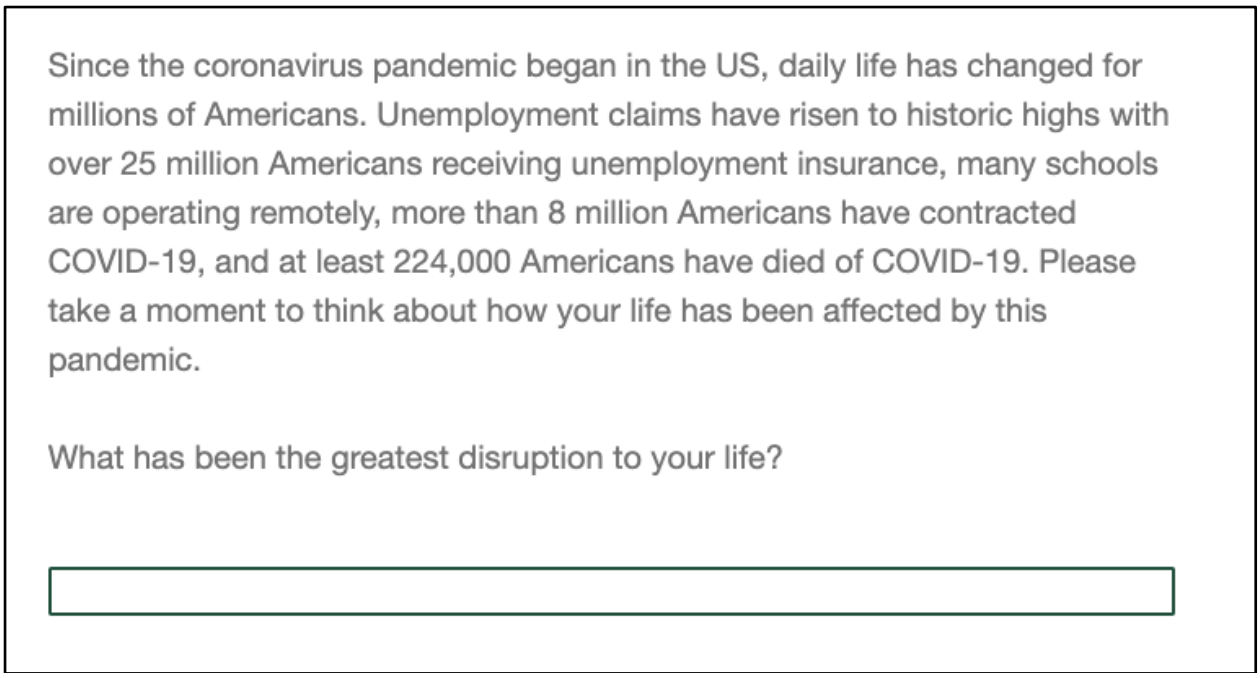


Figure 5: COVID-19 Prime Included in National Survey Experiment

The purpose of the open-ended question at the end of the prompt was to prevent participants from knowing they were being primed. This study tested the COVID-19 Hypothesis that states, "Individuals primed to think about the current COVID-19 pandemic will produce different answers to questions regarding vaccine trust and efficacy than those that are not primed to think about COVID-19." Therefore, the goal of the prime was to test this hypothesis and determine if COVID-19 significantly changed the way individuals formed their opinions.

When all research participants had taken the survey, I received the raw data from the Lucid program. Then, using R studio I cleaned and recoded the variables from the survey experiment. To measure the effectiveness of the COVID-19 prime, I ran t-tests comparing the control group's answers and the experimental group's answers to the four different statements. I also ran t-tests within different subsets of the population to determine if the treatment produced significant differences in the responses of individuals with certain identities including different genders and political party affiliations. These analyses served as ways to measure correlations between the viewpoints about vaccines and individual identity differences on a national level.

After data analysis, results did not support the proposed hypothesis, meaning the COVID-19 prime was not shown to be significantly effective in altering participants' answers to the survey questions. This also held true when comparing individuals by gender and political party affiliation. Several t-tests analyses for each of the survey statements found no significant causal

relationship between the COVID-19 prime and survey responses. The p-values in each of the tests were always greater than 0.05, signaling a lack of a significant difference between the experimental group's answers and the control group's answers. In order to best explain the results, I divide the results by question.

Survey Question 1: Do you agree that vaccines are safe and effective?

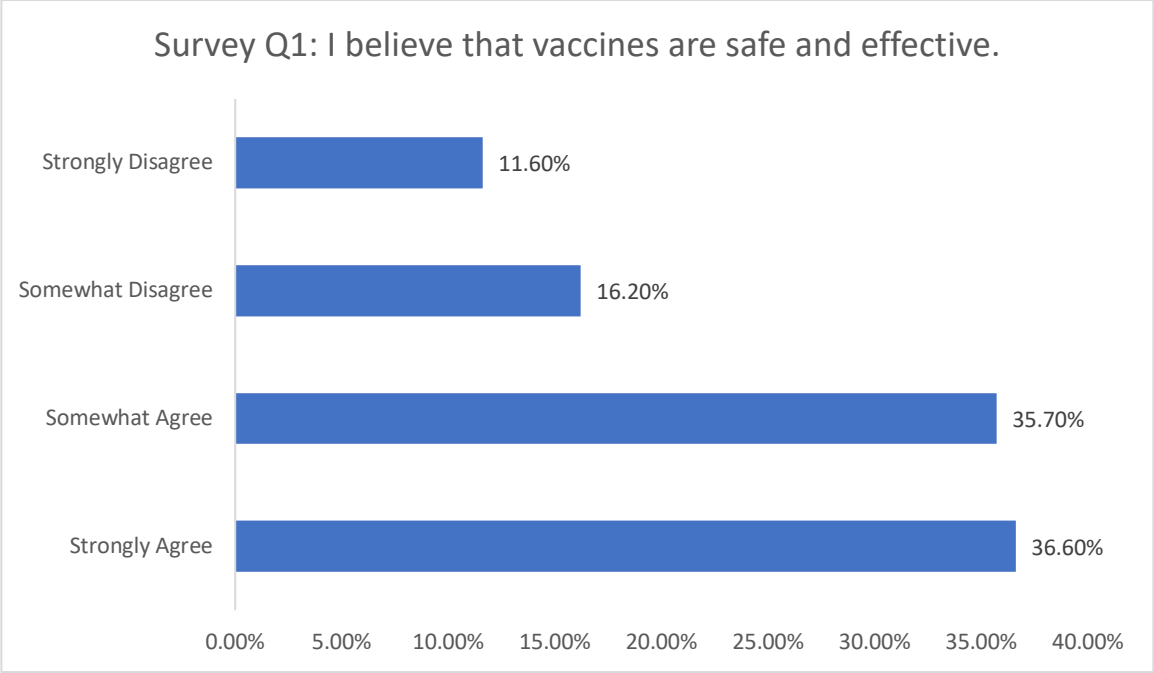


Figure 6-1: Breakdown of Responses for Survey Question 1 by Percentage

Figure 6-1 shows the breakdown of responses as percentages for the participants who answered this survey question. Overall, I found strong support for beliefs in vaccine safety and efficacy, with 36.6% of participants strongly agreeing that vaccines are safe and effective and 35.7% of participants somewhat agreeing with the statement. In other words, at least 72.3% of participants agreed to some degree that vaccines were safe and effective. However, this also meant that about 28.7% did not agree with that statement, with even 11.6% with strong disagreement to the statement. Using a rejection criterion of $p < 0.05$, the t-test analysis comparing the control group to the experimental group's responses to this statement did not find a significant difference in the responses between these groups ($p=0.20$), meaning that the COVID-19 prime did not cause a significant change in how participants responded to this statement.

Survey Question 2: If a vaccine for COVID-19 passes all clinical trials and is approved for use by the FDA, will you get it?

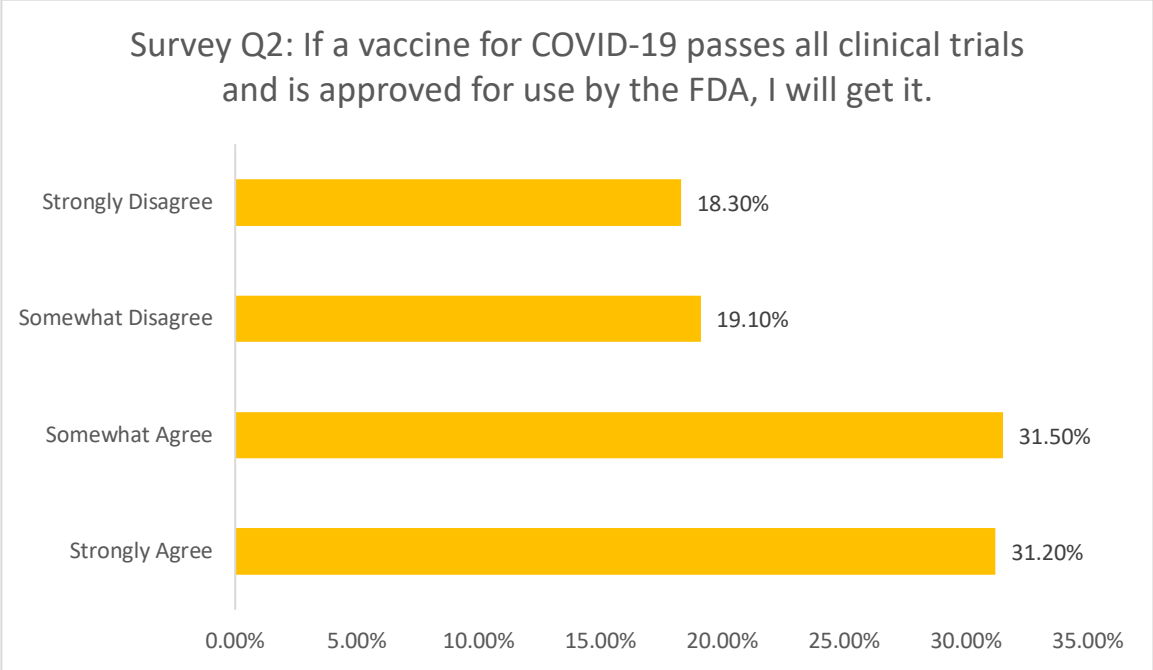


Figure 6-2: Breakdown of Responses for Survey Question 2 by Percentage

Figure 6-2 summarizes responses to the statement, "If a vaccine for COVID-19 passes all clinical trials and is approved for use by the FDA, I will get it." Overall, a majority of participants said they would either strongly agree or somewhat agree to receive the COVID-19 vaccine with 31.2% strongly agreeing and 31.5% somewhat agreeing. Together, at least 62.7% of respondents agreed to some degree that they would opt to get the vaccine. On the other hand, 38.3% of respondents either somewhat or strongly disagreed with getting a COVID-19 vaccine. Using a rejection criterion of $p < 0.05$, the t-test analysis comparing the control group to the experimental group's responses to this statement did not find a significant difference in the responses between these groups ($p=0.1398$), meaning that the COVID-19 prime did not cause a significant change in how participants responded to this statement.

Survey Question 3: Are you worried about vaccine injuries?

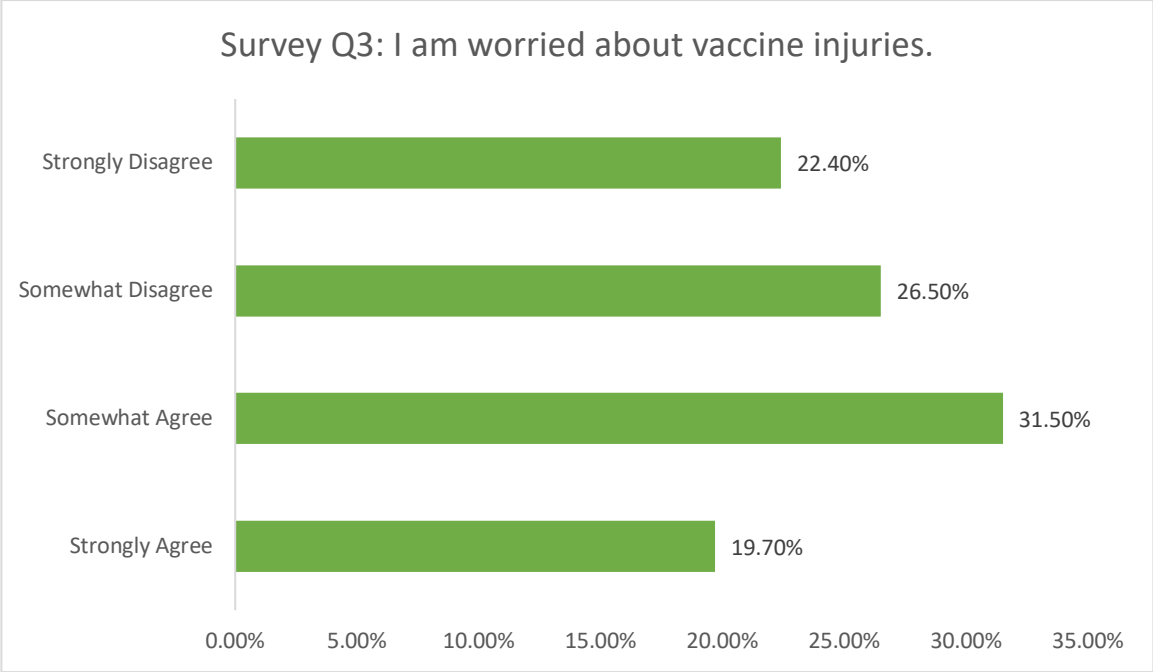


Figure 6-3: Breakdown of Responses for Survey Question 3 by Percentage

Figure 6-3 shows the breakdown of the survey responses to the third survey question about vaccine injuries. Overall, there was a largely even split between the four possible responses. Slightly more respondents at least somewhat agreed with the statement, with 51.2% of respondents responding with either somewhat agree or strongly agree. This result showed validity in a substantial prevalence of fears of vaccine injuries. On the other hand, about 48.8% of respondents at least somewhat disagreed with the statement. Using a rejection criterion of $p < 0.05$, the t-test analysis comparing the control group to the experimental group's responses to this statement did not find a significant difference in the responses between these groups ($p=0.3009$), meaning that the COVID-19 prime did not cause a significant change in how participants responded to this statement.

Survey Question 4: Should everyone that can receive vaccines get vaccinated?

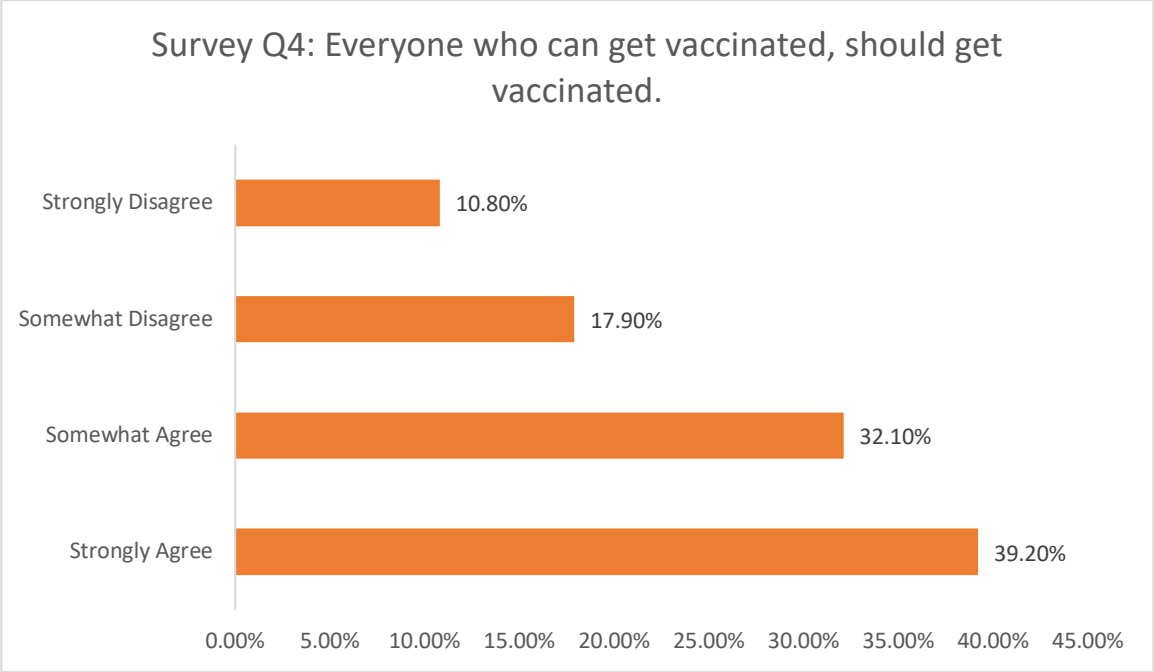


Figure 6-4: Breakdown of Responses for Survey Question 4 by Percentage

Figure 6-4 shows survey answers to the fourth question about whether people should get vaccinated. Overall, the results showed strong support for the statement, "Everyone who can get vaccinated, should get vaccinated," as 71.4% of respondents either somewhat or strongly agreed. Conversely, 28.7% of respondents said they would at least somewhat disagree with the statement. A t-test analysis to compare the control and experimental groups' responses to the fourth question did not find a significant difference between the two groups ($p=0.84$), indicating that the COVID-19 prime given to the experimental group did not cause a significant difference in responses regarding the relative importance of vaccines on both a personal and community level for respondents.

6. Survey 2 Design and Results: Survey Experiment Measuring Anti-Vaccination Impact on Opinion Formation

Survey 2 was distributed through Lucid, the same service that distributed Survey 1, to a nationally representative sample of adults in the U.S. The study was approved by the William & Mary IRB and distributed in April 2021. It included a random sample of 980 U.S. adults ages 18 and older. Expanding on the previous exploratory study, this survey measured vaccine attitudes and their relationship to misinformation, expert opinion, and individual characteristics. The survey tested four hypotheses, focusing on vaccine opinions and the factors related to them. These factors included educational background, political ideology, and social media usage. It also assessed levels of trust in experts versus levels of trust in social media.

The survey included a questionnaire component and a survey experiment. The survey began with background questions to gather demographic information. Participants were asked to provide their age, gender identity, and cultural and ethnic identities. Following these initial demographic questions, the survey proceeded with questions meant to measure factors related to vaccine opinions. These questions probed factors such as educational background, including their level of education, primary educational focus, and their level of knowledge and confidence in life sciences or natural sciences. Next, participants were asked to report their political ideology, indicating whether they identified as conservative or liberal and strength of that identification (i.e. extremely conservative vs moderately conservative). The final background questions measured individual social media usage, specifically how long participants spent on social media sites when obtaining information or news. These questions were used to understand the social media patterns of the participants as a whole.

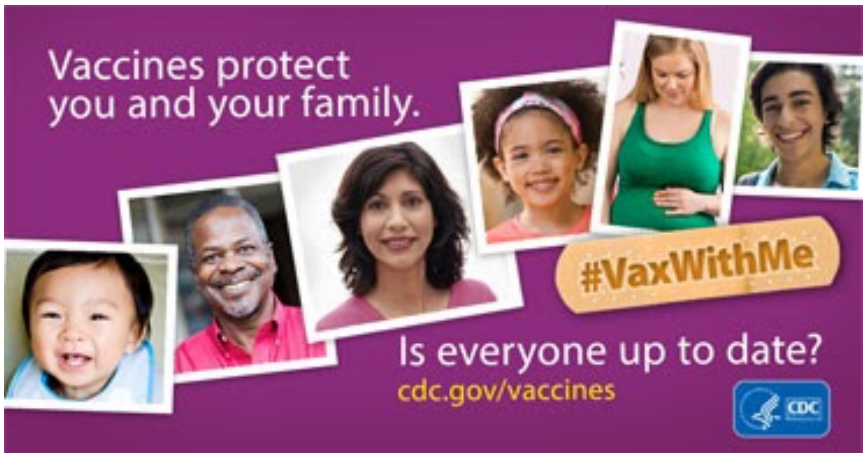
Group	Prime	Action
Control Group	No prime	Prompted to next portion of the survey
Experiment Group A	Post from “LearntheRisk.Org”, an anti-vaccination organization	Prompted to answer questions about the validity and reliability of the post and the source
Experiment Group B	Post from the Centers for Disease Control and Prevention (CDC), a reputable government agency specializing in infectious and chronic diseases	Prompted to answer questions about the validity and reliability of the post and the source
Experiment Group C	Both the post from “LearntheRisk.Org” (Post 1) and the post from the Center for Disease Control and Prevention (CDC)	Prompted to answer questions about the validity and reliability of each of the posts and their sources

Table 7.2 - Control Group and Experimental Groups for Survey 2

After answering the initial background questions, participants were randomly selected into one of four different groups - the control group, Experiment Group A, Experiment Group B, or Experiment Group C. Table 7.2 shows the breakdown of the differences between these groups. The control group did not receive any prime. Experiment Group A received a social media post from LearntheRisk.org, a prominent anti-vaccination group and asked to answer questions pertaining to the validity and reliability of the information from the post and the account that posted it. Experiment Group B saw information about vaccines from the Centers for Disease Control and Prevention (CDC), a government agency consisting of experts on disease control and prevention. This group also received questions about the validity and reliability of the information and its source. Experiment Group C saw both the post from “LearntheRisk.Org” and the information from the CDC. This experiment group was asked to answer questions pertaining to the validity and reliability of both posts and both sources of information.

Figure 7.3 - Post from "LearntheRisk.Org", a well-known anti-vaccination organization.

Figure 7.3 displays the social post from "LearntheRisk.Org", a well-known anti-vaccination group, shown to Experiment Group A and Experiment Group C. The source of this post clearly holds negative vaccine beliefs, specifically regarding the safety of vaccines overall. The post itself contains misinformation about the contents of vaccines, labeling them as "toxic." It links vaccines to serious unrelated medical conditions without any scientific backing to these claims. These scare tactics are characteristic of the strategies of many anti-vaccination groups to instill distrust in vaccines and their safety.



Why your child should get vaccinated

Vaccines can prevent infectious diseases that once killed or harmed many infants, children, and adults. Without vaccines, your child is at risk for getting seriously ill and suffering pain, disability, and even death from diseases like measles and whooping cough.

MEASLES: The United States had **more than 1,200** cases of measles **in 2019**. This was the greatest number of cases reported in the U.S. since 1992 and since measles was declared eliminated in 2000.

It is always better to prevent a disease than to treat it after it occurs.

- Vaccination is a highly effective, safe and easy way to help keep your family healthy.
- On-time vaccination throughout childhood is essential because it helps provide immunity before children are exposed to potentially life-threatening diseases.
- Vaccines are tested to ensure that they are safe and effective for children to receive at the recommended ages.

Figure 7.4 - Post from the Centers for Disease Control and Prevention (CDC), a reputable government agency specializing in disease control and prevention

Figure 7.4 shows the information from the Centers for Disease Control and Prevention (CDC), a respected government agency specializing in disease control and prevention, that was shown to Experiment Group B and Experiment Group C. The CDC has experts in medicine, including vaccine safety and development. This source has very positive vaccine attitudes, emphasizing the importance of vaccinating children. Unlike the post from "LearntheRisk.Org", the CDC's post emphasizes that vaccines are safe and effective ways to keep children and families healthy. It also outlines the purpose behind vaccines as protection against deadly diseases.

When the survey experiment concluded, all participants were prompted to respond to two statements regarding overall trust in experts and social media. The two statements included: "I

trust medical experts to give me accurate health information and advice." and "I trust social media platforms to give me accurate health information and advice." Participants had the option to either strongly disagree, somewhat disagree, somewhat agree, or strongly agree to the statements.

The final survey questions presented to the participants were a set of five statements to which participants could either strongly disagree, somewhat disagree, somewhat agree, or strongly agree with. Some of these statements were taken from the previous survey conducted in November 2020 in order to draw comparisons between the two samples. The statements from the previous survey were expanded upon in order to gain deeper insight into vaccine attitudes. The five statements were:

- I believe that vaccines are safe and effective.
- The COVID-19 vaccines people are receiving are safe and effective.
- I am worried about vaccine injuries.
- Everyone who can get vaccinated should get vaccinated.
- Government vaccine mandates are legitimate and important ways to limit the spread of deadly diseases.

After the survey concluded, participants in Experiment Group A and Experiment Group C were given a debriefing outlining that the post from LearntheRisk.org was not factual nor endorsed by the creators of the survey. The William & Mary IRB approved this debriefing strategy.

When all respondents finished the survey, I collected the raw data from Lucid. Using R Studio software, I cleaned the data by coding variables from the survey experiment into numerical values. After this, I ran tests through R Studio to measure differences in responses to questions after the experiment between the control groups and the experimental groups. I used t-tests to compare the experimental and control groups' vaccine attitudes. The t-tests revealed whether differences in the answers among the groups were statistically significant. I also ran t-tests within subsets of the sample to determine whether participants with the same individual factors (i.e. science education background and political extremism) recorded significantly different responses than the rest of the population. To further analyze the data, I used functions within R Studio to determine the overall breakdown of responses to questions across the entire sample. These statistics revealed the overall opinion of the participants in the survey.

After data analysis, results showed mixed support for the proposed hypotheses. Several t-test analyses showed significant differences in responses between various identity groups within the survey, with multiple p-values less than 0.05. Additional tests revealed vaccine attitudes among the overall sample and within groups. In order to organize the results, I break them down by question and then by group.

Survey Question 28-1: I trust medical experts to give me accurate health information and advice.

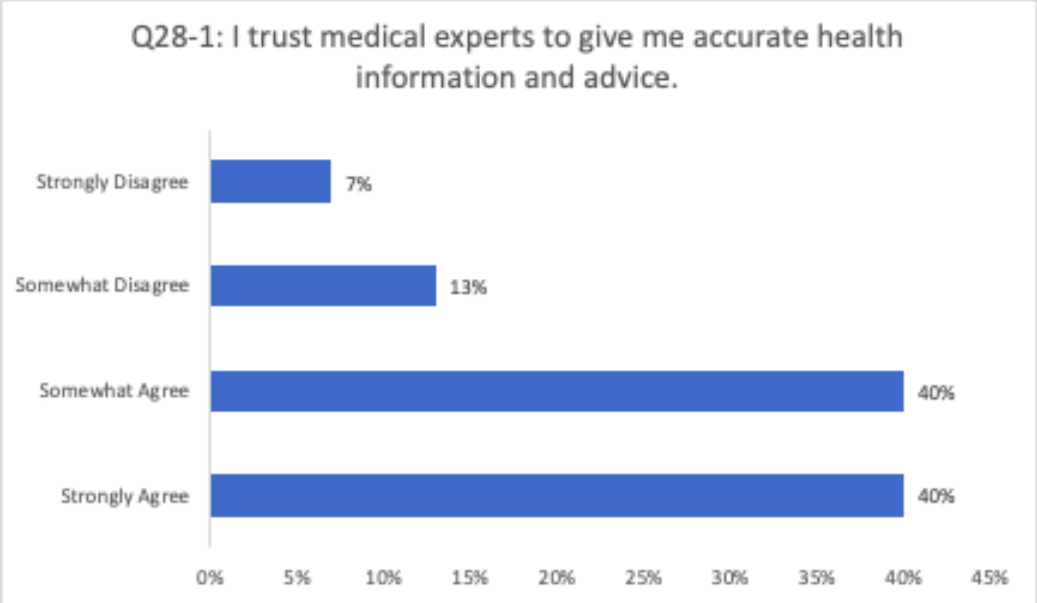


Figure 8.1 - Question 28-1 Sample Breakdown of Overall Responses

Figure 8.1 displays the breakdown of responses by percentage of the population, with 80% of the participants indicating they would at least somewhat agree with the statement. As shown in the figure, the breakdown of percentages of responses for strongly agree, somewhat agree, somewhat disagree, and strongly disagree are 40%, 40%, 13%, and 7% respectively. The overall sample population had a mean score of 2.128, suggesting overall trust in medical experts as sources of medical information. When dividing the sample into subsets based on individual factors (i.e. experimental groups, ideologies, etc.), there are some important differences. T-tests showed significant differences in responses to this question between liberals and conservatives, social media users and non-social media users, participants with high levels of education in the natural or life sciences and those without education in natural or life sciences, and those with high levels vs. low levels of confidence in their knowledge of the natural or life sciences.

Identity Groups	**P Value = (p < 0.05 for significance)**
Liberals vs. Conservatives	1.783e-10
Social Media Users vs. Non-Social Media Users	0.03044
No Science Education vs. High Science Education	0.02848
Low Confidence in Science Knowledge vs. High Confidence in Science Knowledge	0.03428

Table 8.2 - Question 28-1 Identity Group T-Test Comparison Results

Table 8.2 shows the p-values from the t-tests run for Question 28-1 between the identity groups. As the table states, in order for the differences in responses to be significant, the p-value must be less than 0.05. For these four sets of groups, the p-values showed a strong difference in responses. The most significant difference was between liberals and conservatives, with a p-value of 1.783e-10 (1.783 x 10^-10). These t-tests results were investigated further to determine where the responses fell a scale of 0 to 3, with responses averages closer to 3 showing greater trust of medical experts.

Identity Group	**Average Response Score (Max = 3)**
Liberals	2.391
Conservatives	1.925
Social Media Users	2.152
Non Social Media Users	1.967
No Science Education	2.03
High Science Education	2.215
Low Confidence in Science Knowledge	2.088
High Confidence in Science Knowledge	2.227

Table 8.3 - Question 28-1 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the more groups trust in medical experts.)

Table 8.3 shows the average response scores of the various identity groups whose t-tests indicated significant differences in responses. Comparing liberals and conservatives, liberals were found to be more trusting of medical experts, as liberals and conservatives had average scores of 2.391 and 1.925, respectively. Social media users were also shown to be more trusting of medical experts, with a score of 2.152, compared to non-social media users who had a score of 1.967. Individuals with high levels of education in natural or life sciences were more likely to trust medical experts and had a score of 2.215, compared to those without an educational background in life or natural sciences who had a score of 2.03. Finally, those with higher confidence in science knowledge had more trust in medical experts than those with low confidence with these groups scoring 2.227 and 2.088 respectively.

Survey Question 28-2: I trust social media platforms to give me accurate health information and advice.

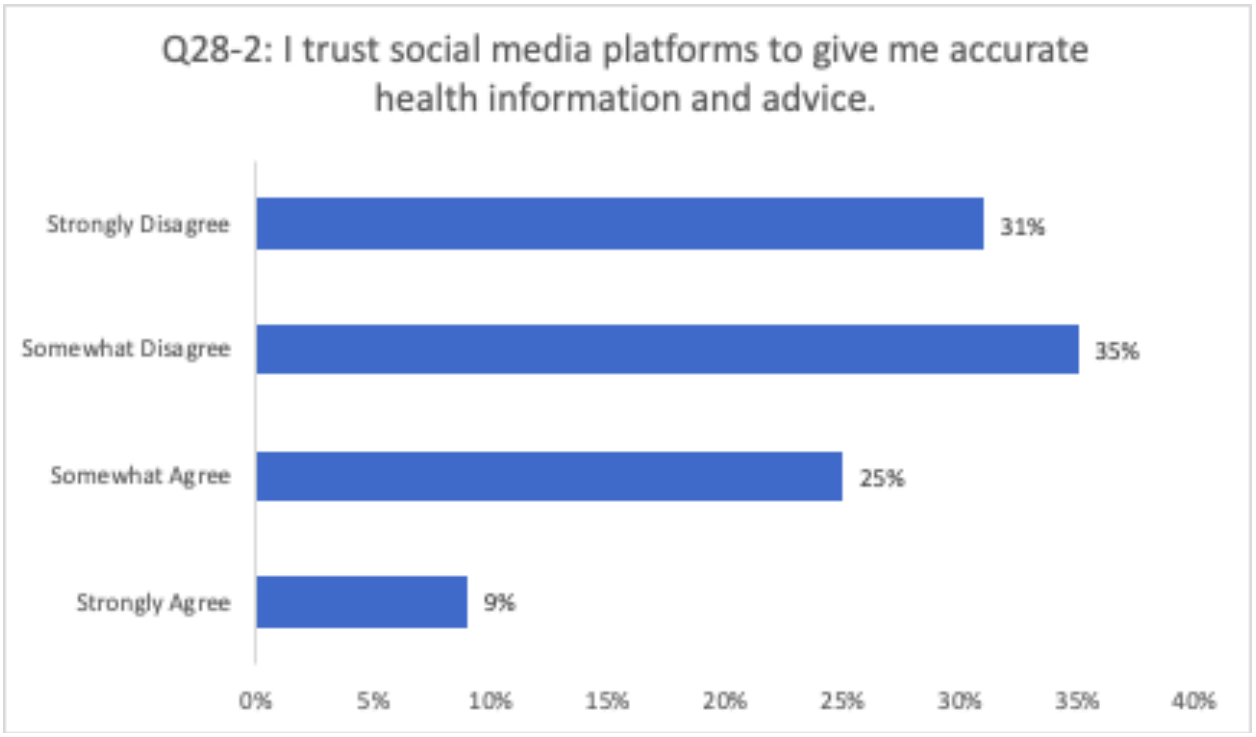


Figure 8.4 - Question 28-2 Sample Breakdown of Overall Responses

Figure 8.4 shows the breakdown of responses from the sample for Question 28-2. Overall, it shows that 66% of participants at least somewhat distrusted social media as a source of health information and advice. The breakdown of responses for strongly agree, somewhat

agree, somewhat disagree, and strongly disagree were 9%, 25%, 35%, and 31% respectively. The sample had an average score of 1.124 for this question, showing overall low trust in social media. T-tests revealed significant differences between moderates and ideological extremists (both extremely conservative and extremely liberal), social media users and non-social media users, participants with high science education backgrounds and those without science education backgrounds, and participants with high levels vs. low levels of confidence in their science knowledge.

Identity Groups	**P Value = ($p < 0.05$ for significance)**
Moderates vs. Ideological Extremists	0.003015
Social Media Users vs. Non-Social Media Users	4.886e-8
No Science Education vs. High Science Education	0.03886
Low Confidence in Science Knowledge vs. High Confidence in Science Knowledge	9.569e-14

Table 8.5 - Question 28-2 Identity Group T-Test Comparison Results

Table 8.5 lists the significant p-values for the t-tests run for Question 28-2. The most significant difference, indicated by the lowest p-value, was between those with low confidence in their science knowledge and those with high confidence in their science knowledge, with a p-value of 9.569e-14 (9.569 x 10^-14). Another significantly low p-value of 4.886e-8 (4.886 x 10^-8) was found between social media users and non-social media users. These results were investigated further to determine where these groups fell on the scale of 0 to 3, with response averages closer to 3 showing greater trust of social media platforms.

Identity Group	**Average Response Score (Max = 3)**
Moderates	1.076
Ideological Extremists (Very Conservative or Very Liberal)	1.318
Social Media Users	1.191
Non Social Media Users	0.7213
No Science Education	0.9924
High Science Education	1.188
Low Confidence in Science Knowledge	0.9557
High Confidence in Science Knowledge	1.52

Table 8.6 - Question 28-2 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the more groups trust in social media.)

Table 8.6 shows the average response scores of the identity groups whose t-test revealed significant p-values. Comparing moderates and ideological extremists (either very conservative or very liberal individuals), ideological extremists were found to be more trusting of social media platforms as outlets for information, with an average score of 1.318, compared to moderates whose average was 1.076. Social media users were also found to be more trusting of social media platforms when compared to those who don't use social media, with average responses of 1.191 and 0.7213 respectively. Those with high levels of science education were also found to be more trusting of social media platforms than participants without science education, with averages of 1.188 and 0.9924 respectively. Finally, respondents with high confidence in their science knowledge showed significantly more trust in social media when compared to those with low confidence in their science knowledge. Those with high confidence had an average score of 1.52, and those with low confidence had an average score of 0.9557.

Survey Question 30-1: I believe that vaccines are safe and effective.

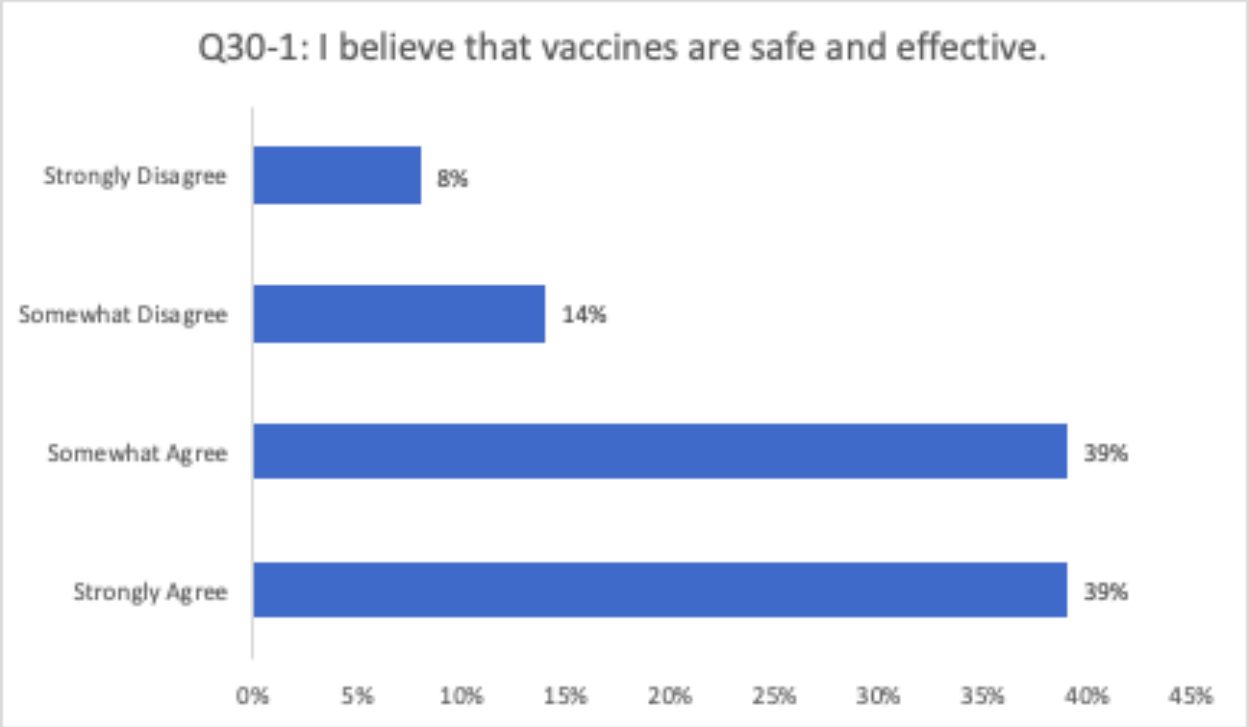


Figure 8.7 - Question 30-1 Sample Breakdown of Overall Responses

Figure 8.7 displays a chart of the percentage of participants that chose each answer to Question 30-1. Overall, 78% of participants at least somewhat agreed with the statement, indicating a majority of the sample believes in vaccine safety. The breakdown of responses for strongly agree, somewhat agree, somewhat disagree, and strongly disagree was 39%, 39%, 14%, and 8% respectively. The sample population had a mean score of 2.089, again suggesting substantial support for vaccine efficacy among the sample. T-test analysis established significant differences between liberals and conservatives, those with high levels of science education and those without science education backgrounds, and those with high levels of confidence in their science knowledge and those with low levels of confidence in science knowledge.

Identity Groups	**P Value = ($p < 0.05$ for significance)**
Liberals vs. Conservatives	2.886e-10
No Science Education vs. High Science Education	0.0008448
Low Confidence in Science Knowledge vs. High Confidence in Science Knowledge	0.002778

Table 8.8 - Question 30-1 Identity Group T-Test Comparison Results

Table 8.8 shows the significant p-values for the t-tests run between the respective groups in Question 30-1. As shown in the table, the most significant difference, indicated by the lowest p-value, was found between liberals and conservatives with a p-value of 2.886e-10 (2.886 x 10^-10). These results were analyzed further to determine how the different groups responded when compared with one another on a scale of 0 to 3, with averages closer to 3 conveying stronger beliefs in the safety and efficacy of vaccines.

Identity Group	**Average Response Score (Max = 3)**
Liberals	2.37
Conservatives	1.882
No Science Education	1.932
High Science Education	2.232
Low Confidence in Science Knowledge	2.028
High Confidence in Science Knowledge	2.227

Table 8.9 - Question 30-1 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the more groups believe vaccines are safe and effective.)

Table 8.9 shows the average response scores of the identity groups whose t-test revealed significant p-values. Compared to conservatives, liberals showed a stronger belief in vaccine safety and efficacy with an average of 2.37 compared to conservatives' average of 1.882. Those with high levels of science education were also more likely to have stronger beliefs in vaccine safety than those without previous science education, with average scores of 2.232 and 1.932 respectively. Finally, those with high levels of confidence in their science knowledge were more likely to believe in vaccine safety than those with low confidence. Those with high confidence had an average of 2.227 and those with low confidence had an average of 2.028.

Survey Question 30-2: The COVID-19 vaccines people are receiving are safe and effective.

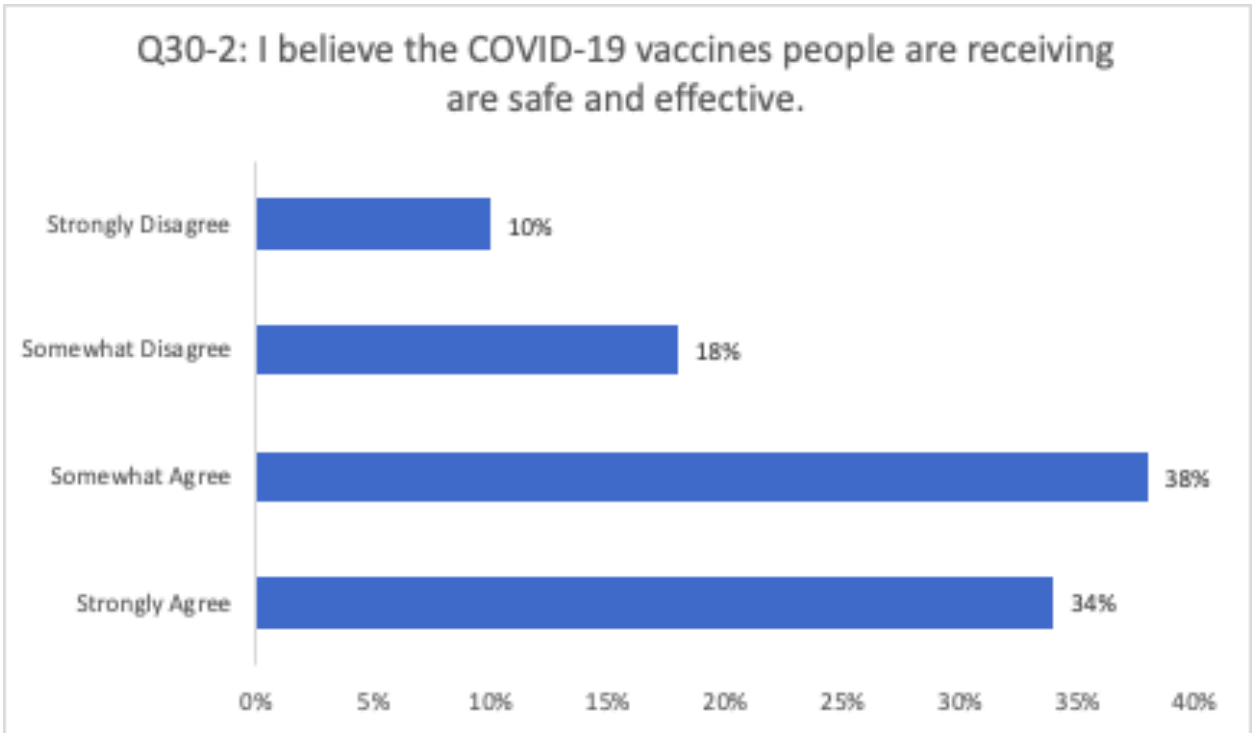


Figure 8.10 - Question 30-2 Sample Breakdown of Overall Responses

Figure 8.10 displays the distribution of responses by percentage for Question 30-2. As shown in the pie chart, about 72% of participants at least somewhat agreed that COVID-19 vaccines were safe and effective. In the previous question, however, 78% of participants indicated that they would at least somewhat agree vaccines were safe and effective. This is a 6% difference. Still, a majority of participants agreed that COVID-19 vaccines were safe and effective. The percentages of responses for strongly agree, somewhat agree, somewhat disagree, and strongly disagree were 34%, 38%, 18%, and 10% respectively. The sample population had a mean score of 1.965, which is 0.124 points less than Question 30-1 concerning overall vaccine safety. This result still shows substantial support for COVID-19 vaccine efficacy. T-test analysis revealed significant differences in responses between liberals and conservatives, those with high levels of science education and those without previous science education, and those with high levels vs. low levels of confidence in their science knowledge.

Identity Groups	**P Value = ($p < 0.05$ for significance)**
Liberals vs. Conservatives	2.323e-11
No Science Education vs. High Science Education	0.003887
Low Confidence in Science Knowledge vs. High Confidence in Science Knowledge	0.006766

Table 8.11 - Question 30-2 Identity Group T-Test Comparison Results

Table 8.11 displays the significant p-values found by running t-test comparisons of the groups for Question 30-2. The most significant difference, indicated by the lowest p-value, was found between liberals and conservatives, with a p-value of 2.323e-11 (2.323 x 10^-11). These groups were studied further to determine how they responded to the question on average on a scale of 0 to 3. Averages closer to 3 indicated a stronger belief in the safety and efficacy of the COVID-19 vaccines.

Identity Group	**Average Response Score (Max = 3)**
Liberals	2.274
Conservatives	1.748
No Science Education	1.777
High Science Education	2.051
Low Confidence in Science Knowledge	1.907
High Confidence in Science Knowledge	2.095

Table 8.12 - Question 30-2 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the more groups believe the COVID-19 vaccines are safe and effective.)

Table 8.12 shows the average response scores of the identity groups with significant p-values. As indicated in the table, liberals showed a stronger belief in the safety and efficacy of the COVID-19 vaccines than conservatives. Liberals had an average score of 2.274 while conservatives had an average score of 1.748. Similarly, participants with high levels of science education also had stronger beliefs in the safety of the COVID-19 vaccines than those without science education backgrounds, with scores of 2.051 and 1.777 respectively. Finally, those with

high levels of confidence in science knowledge also were more likely to agree with the statement than those with low confidence in science knowledge. Those with high confidence had an average score of 2.095, and those with low confidence had an average score of 1.907.

Survey Question 30-3: I am worried about vaccine injuries.

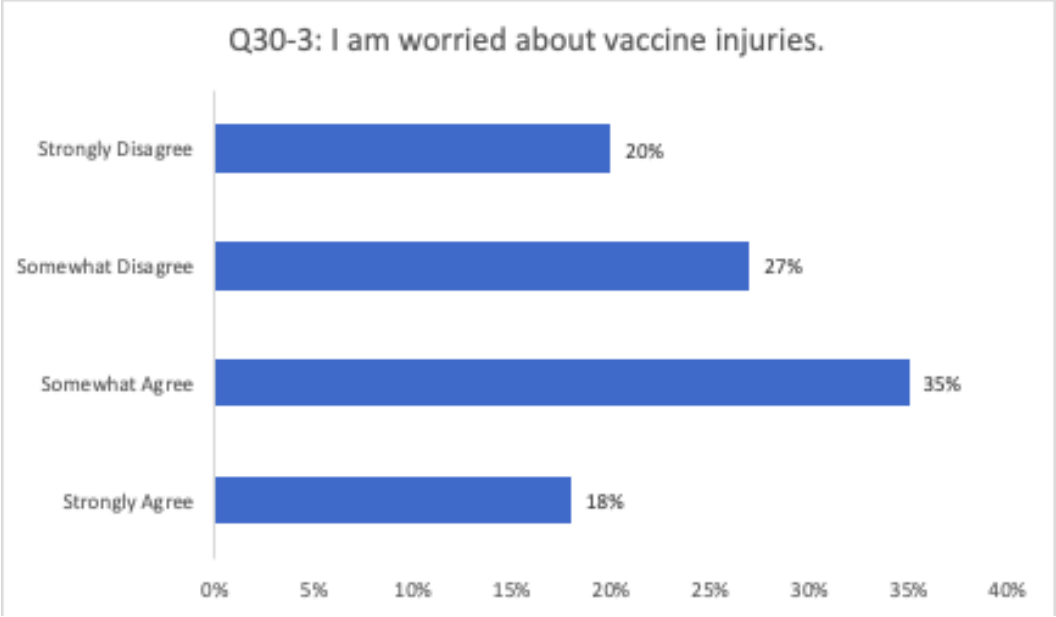


Figure 8.13 - Question 30-3 Sample Breakdown of Overall Responses

Figure 8.13 illustrates the breakdown by percentage of each response to Question 30-3. About 47% of participants at least somewhat disagreed with the statement, and 53% of participants at least somewhat agreed with the statement. A majority of participants were worried about vaccine injuries, which is indicative of vaccine distrust. As shown in the figure, the distribution of percentages for strongly agree, somewhat agree, somewhat disagree, and strongly disagree are 18%, 35%, 27%, and 20% respectively. These results show a majority fear of vaccine injuries. The sample had a mean score of 1.481 in which averages closer to 3 indicate less fear of vaccine injuries. This mean score is closer to 0 than 3, indicating more fear of vaccine injuries. T-tests revealed inter-group differences in responses for Experiment Group A and Experiment Group C, moderates and ideological extremists, liberals and conservatives, social media users and non-social media users, and participants with high confidence in science knowledge vs. those with low confidence in science knowledge.

Identity Groups	**P Value = (p < 0.05 for significance)**
Experiment Group A vs. Experiment Group C	0.04254
Moderates vs. Ideological Extremists	0.03903
Liberals vs. Conservatives	3.123e-6
Social Media Users vs. Non Social Media Users	0.001229
Low Confidence in Science Knowledge vs. High Confidence in Science Knowledge	5.578e-6

Table 8.14 - Question 30-3 Identity Group T-Test Comparison Results

Table 8.14 shows the statistically significant p-values found in the t-test run comparing the various identity groups. The most significant difference, specified by the lowest p-value, was between liberals and conservatives with a p-value of 3.123e-6 (3.123 x 10^-6), followed by high confidence in science knowledge vs. low confidence in science knowledge with a p-value of 5.578e-6 (5.578 x 10^-6). The data from these groups was examined further to determine how the groups responded to the question in comparison to one another on a scale of 0 to 3. Averages closer to 0 indicated more worry about vaccine injuries.

Identity Group	**Average Response Score (Max = 3)**
Control Group	1.498
Experiment Group A (Anti-Vax Prime)	1.357
Experiment Group C (Anti-Vax Prime and CDC Prime)	1.547
Moderates	1.551
Ideological Extremists (Very Conservative or Very Liberal)	1.373
Liberals	1.692
Conservatives	1.287
Social Media Users	1.439
Non Social Media Users	1.752
Low Confidence in Science Knowledge	1.582
High Confidence in Science Knowledge	1.239

Table 8.15 - Question 30-3 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the less groups fear vaccine injuries.)

Table 8.15 presents the average response scores of the groups with significant p-values. As shown in the table, the maximum score for the question is 3. Response averages closer to 0 indicate greater fear of vaccine injuries. Experiment Group A, the experimental group shown the anti-vaccine social media post from LearntheRisk.Org, was found to have more fear of vaccine injuries than Experiment Group C, the experimental group who was shown both the anti-vaccine social media post and the post from the Centers for Disease Control and Prevention (CDC). Experiment Groups A and C had scores of 1.357 and 1.547 respectively. Ideological extremists on both ends of the spectrum were also found to have more fear of vaccine injuries when compared to moderates, with scores of 1.373 and 1.551 respectively. Conservatives overall indicated more fear of vaccine injuries than liberals. Conservatives had an average score of 1.287, and liberals had an average of 1.692. Social media users also indicated more fear of

vaccine injuries than those who did not use social media with scores of 1.439 and 1.752 respectively. Finally, individuals with high confidence in science knowledge indicated more worry of vaccine injuries than those with low confidence in science knowledge. Those with high confidence had an average score of 1.239, and those with low confidence had an average score of 1.582.

Survey Question 30-4: Everyone who can get vaccinated should get vaccinated.

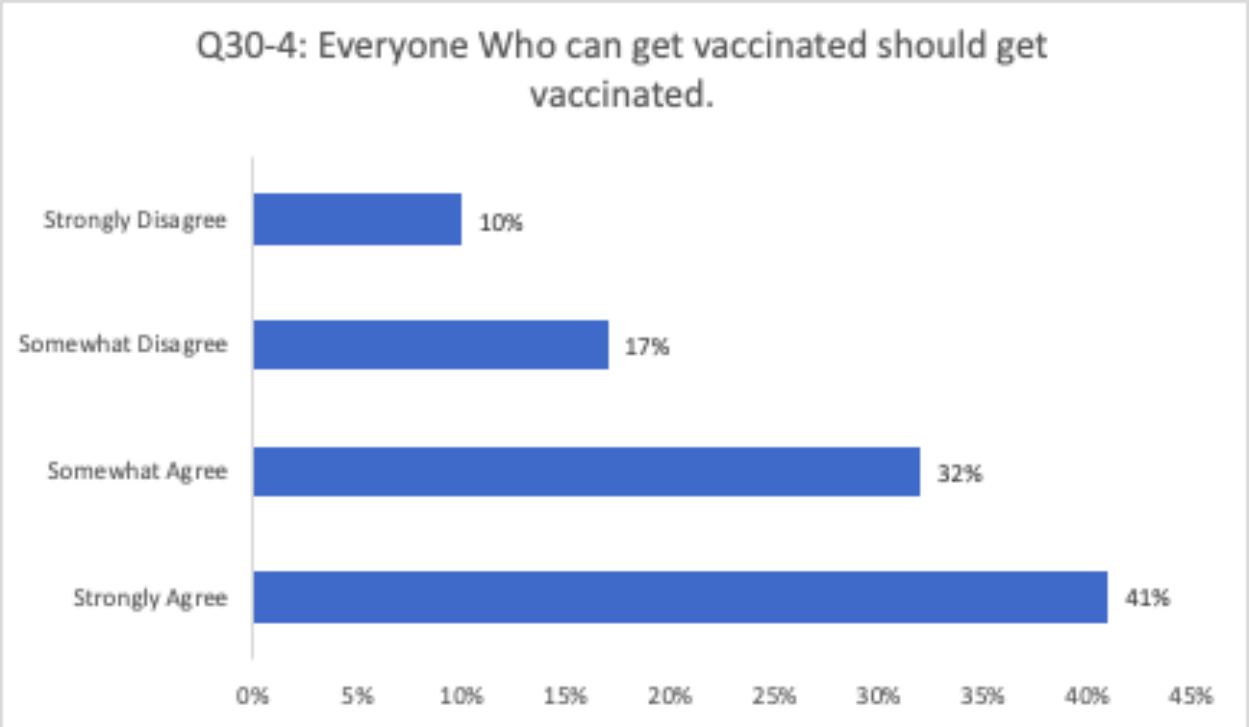


Figure 8.16 - Question 30-4 Sample Breakdown of Overall Responses

Figure 8.16 shows the breakdown of responses by percentage in the sample population to Question 30-4. Overall, 73% of respondents at least somewhat agreed with the statement, indicating support within the sample for the importance of vaccination. The breakdown of responses for the responses strongly agree, somewhat agree, somewhat disagree, and strongly disagree were 41%, 32%, 17%, and 10% respectively. The sample population had an overall mean score of 2.046, indicating substantial agreement with the statement T-tests indicated significant differences between the responses of Experiment Group A and Experiment Group B, liberals and conservatives, and those with high levels of science education vs those without a science education background.

Identity Groups	**P Value = (p < 0.05 for significance)**
Experiment Group A vs. Experiment Group B	0.04688
Liberals vs. Conservatives	4.454e-13
No Science Education vs. High Science Education	0.005697

Table 8.17 - Question 30-4 Identity Group T-Test Comparison Results

Table 8.17 shows the significant p-values from the t-test analyses run in Question 30-4. The most significant difference, specified by the lowest p-value, was between liberals and conservatives with a p-value of 4.454e-13 (4.454 x 10^-13). The data was examined further to determine how the groups responded to this question compared to one another on a scale of 0 to 3. Averages closer to 3 indicated more support for the importance of vaccination.

Identity Group	**Average Response Score (Max = 3)**
Control Group	1.991
Experiment Group A (Anti-Vax Prime)	1.965
Experiment Group B (CDC Prime)	2.148
Liberals	2.371
Conservatives	1.78
No Science Education	1.867
High Science Education	2.136

Table 7.18 - Question 30-4 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the more support for the importance of community level vaccination.)

Table 8.18 presents the average response scores of the groups with significantly different responses indicated by p-values < 0.05. As shown in the table, the maximum score for the question is 3, and the closer the response score is to this number, the greater the perceived importance of community wide vaccination within the group. Experiment Group B, who was shown the post from the Centers for Disease Control and Prevention (CDC), had significantly more agreement with the statement than Experiment Group A, who was shown the anti-vaccination post from LearntheRisk.org. Experiment Group B had an average score of 2.148,

and Experiment Group A had an average score of 1.965. Liberals were also more likely to agree with the statement than conservatives. Liberals had a score of 2.371, while conservatives had a score of 1.78. Finally, those with high levels of science education were more likely to agree with the statement compared to those without a science education background, with average scores of 2.136 and 1.867 respectively.

Survey Question 30-5: Government vaccine mandates are legitimate and important ways to limit the spread of deadly diseases.

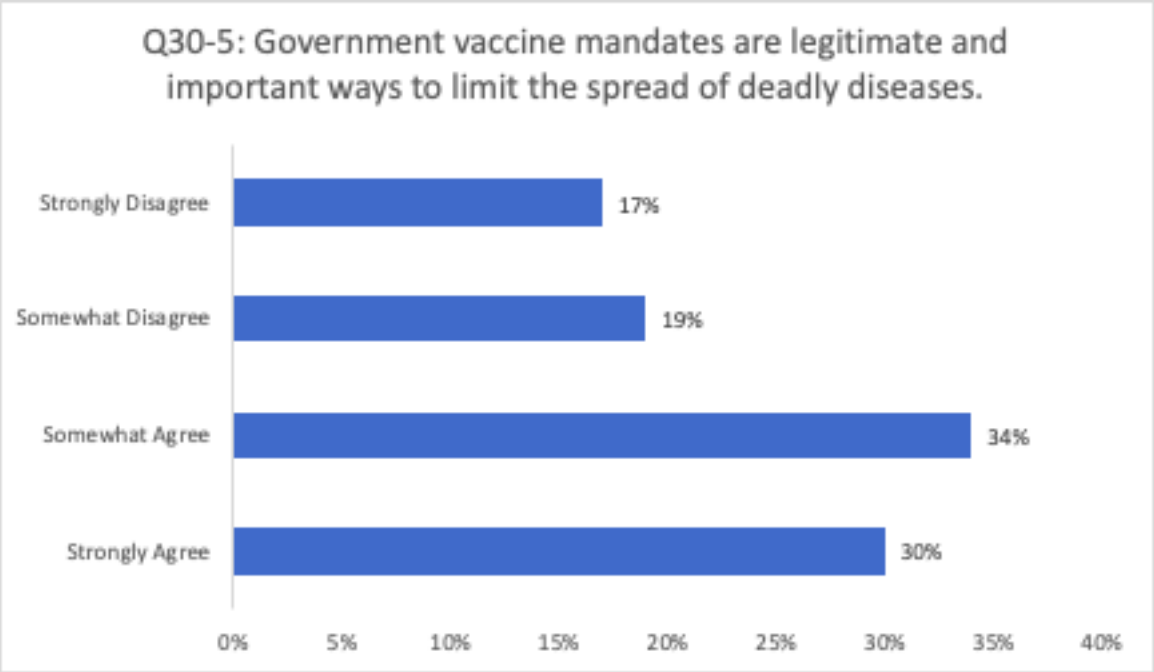


Figure 8.19 - Question 30-5 Sample Breakdown of Overall Responses

Figure 8.19 presents the response breakdown from the sample population as percentages. As shown in the figure, about 64% of participants indicated that they at least somewhat agreed with the statement, and about 36% at least somewhat disagreed with the statement. The breakdown of responses for strongly agree, somewhat agree, somewhat disagree, and strongly disagree were 30%, 34%, 19%, and 17% respectively. The sample population had an average response score of 1.787, which indicates that a slight majority of respondents agreed with the statement. This majority, however, is not as significant as in previous questions, which showed strong majority support for the statements overall.

T-tests found that liberals and conservatives as well as those with high confidence in their knowledge of science vs. those with low confidence in their knowledge of science had significantly different responses indicated by p-values less than 0.05.

Identity Groups	**P Value = ($p < 0.05$ for significance)**
Liberals vs. Conservatives	< 2.2e-16
Low Confidence in Science Knowledge vs. High Confidence in Science Knowledge	0.00622

Table 8.20 - Question 30-5 Identity Group T-Test Comparison Results

Table 8.20 shows the two sets of groups found to have significantly different responses to Question 30-5. The most significant difference, indicated by the lowest p-value, was between liberals and conservatives, with a p-value of less than 2.2e-16 (2.2 x 10^-16). This is also the lowest p-value among all the t-tests run during the data analysis process. The data from these groups was examined further to determine how the groups responded to the question in comparison to one another on a scale of 0 to 3. Averages closer to 3 indicated more support for government vaccine mandates.

Identity Group	**Average Response Score (Max = 3)**
Liberals	2.206
Conservatives	1.473
Low Confidence in Science Knowledge	1.726
High Confidence in Science Knowledge	1.935

Table 8.21 - Question 30-5 - Identity Groups Average Response Score out of 3. (The closer the response is to 3, the more support for government vaccine mandates.)

Table 8.21 shows the average response scores of the two sets of groups found to have significantly different responses. As shown in the table, liberals were substantially more likely to support government vaccine mandates than conservatives. Liberals had an average score of 2.206 and conservatives had an average score of 1.473. Similarly, individuals with high confidence in science knowledge indicated higher levels of support for government vaccine

mandates than those with low confidence in their science knowledge, with scores of 1.935 and 1.726 respectively.

The final tests run in the data analysis were conducted to determine the overall vaccine attitudes of various groups by combining average response scores across Questions 30-1, 30-2, 30-3, 30-4, and 30-5. This test was similar to the ones conducted in each survey question, in which responses were measured by a score out of 3. Combining the five questions with maximum scores of 3 for each question, the maximum value for vaccination attitudes overall was 15. The closer the average vaccination attitudes score was to 15, the more pro-vaccine the group's beliefs were. Once these values were calculated for each group, the scores were compared to one another by running more t-test analyses to determine whether differences in scores were significant, as indicated by a p-value of less than 0.05. The overall sample population was found to have a vaccination attitudes score of 9.364 out of a possible 15. The remaining findings are reported below and separated by group.

The ideological groups measured in this analysis were ideological extremists, moderates, liberals, conservatives, extreme liberals, and extreme conservatives.

Ideological extremists, which included individuals that indicated they were either very liberal or very conservative, had a vaccination attitudes score of 9.646. Moderates, which were composed of individuals that stated they were moderate, had an average score of 9.595. When these scores were compared against each other, t-tests did not find significant difference.

Liberals, which was made up of individuals who said they were either somewhat liberal or very liberal, had an average score of 10.93 out of 15. Conservatives, which included individuals who indicated they were either somewhat conservative or very conservative, had an average score of 8.161. T-tests indicated a statistically significant difference in these scores, with a p-value of less than 2.2e-16 (2.2 x 10^-16)

Extreme liberals, which included individuals that indicated that they were very liberal, had an average score of 11.06. Extreme conservatives, which consisted of individuals that said that they were very conservative, had an average score of 8.497. T-test analysis revealed a statistically significant difference between these scores, with a p-value of 4.946e-8 (4.946 x 10^-8).

Social media users' and non-social media users' scores were also compared against one another. Social media users had a score of 9.348, and non-social media users had a score of 9.471. T-test analysis did not find a statistically significant difference between these values.

The groups measured in this analysis included no science education, low science education, and high science education. No science education included individuals who indicated that they had never taken a life or natural science course at the college level. This group had an average score of 8.688. Low science education was made up of individuals who had taken at least 1 but no more than 2 life or natural science courses at the college level. This group had an average score of 9.548. High science education consisted of participants who had taken at least 5 courses or more in life or natural sciences at the college level. This group had an average score of 9.829. When comparing the no science education group to the high science education group, t-test analysis showed a statistically significant difference between the vaccination attitudes with a p-value of 0.002332.

The groups measured in the analysis of science confidence levels included low confidence in science knowledge and high confidence in science knowledge. The low confidence in science knowledge group included individuals who indicated that they were either not at all or somewhat confident in their knowledge of life or natural sciences. This group had an average vaccination attitudes score of 9.266. The high confidence in science knowledge group consisted of individuals who indicated that they were either very or extremely confident in their knowledge of life or natural sciences. The high confidence group had an average score of 9.585. T-test analysis did not show a statistically significant difference between the two groups' overall vaccine attitudes.

The experiment groups in this analysis were the control group, Experiment Group A, Experiment Group B, and Experiment Group C. The control group did not receive any prime and had an average vaccine attitudes score of 9.266. Experiment Group A, the group that viewed the anti-vaccination social media post from LearntheRisk.org, had an average score of 8.987. Experiment Group B, the group that received the pro-vaccine post from the Centers for Disease Control and Prevention (CDC), had an average score of 9.644. Experiment Group C, the group that received both the anti-vaccination social media post and the post from the CDC, had an average score of 9.57. Several t-test analyses did not reveal statistically significant differences in overall vaccination attitudes between these groups.

7. Discussion

Overall, the results from the two surveys produced mixed support for my hypotheses. The first study focused on testing the COVID-19 hypothesis, and the second study tested four hypotheses related to the relationships between expert opinion, misinformation, and vaccine attitudes. The data from both surveys produced some unanticipated results. Despite this, the results provided support for many of the expectations and hypotheses.

The results from the initial survey did not support the COVID-19 hypothesis, "Individuals primed to think about the current coronavirus pandemic will produce different answers to questions regarding vaccine trust and efficacy than those that are not primed to think about COVID-19." The control group's responses and the experimental group's responses to the four survey statements did not differ on a statistically significant level. This held true even when dividing the population into subsets with shared factors and running comparative t-test analyses (i.e. men vs. women, conservatives vs. liberals). This shows that the COVID-19 prime was not effective in altering vaccine attitudes. Overall this finding suggests that COVID-19, while it has impacted many facets of life, may not affect the way individuals form their opinions about vaccines. While COVID-19 was not found to be significant on a statistical level in a survey experiment, that does not mean it isn't significant at all. The COVID-19 pandemic's effects cannot be quantified in a survey nor can they be understood fully through statistical analysis. At the time the survey was distributed, COVID-19 vaccines were still in the final stages of their clinical trials. Vaccine development was a fast-moving area and new information was coming out every day. If the survey were distributed well into the national rollout of the vaccines, the findings might have been different. Although the survey experiment results did not support the hypothesis, more research can be done to unveil the possible effects of COVID-19 on individual opinions.

Despite unsupportive results for the effectiveness of the COVID-19 prime, the questions from the first survey still provided notable preliminary insights into public opinion about vaccines as it currently stands. Three of the questions in particular had noteworthy results. Each of these questions was framed in the form of a statement in which the participants either strongly disagreed, somewhat disagreed, somewhat agreed, or strongly agreed.

The first question of interest was Survey Question 2: "If a vaccine for COVID-19 passes all clinical trials and is approved for use by the FDA, I will get it." About 38.3% of respondents

at least somewhat disagreed with this statement, suggesting that they would not get the COVID-19 vaccine even if it had been approved by the FDA. This is a notable result, as this is over a third of the participants. As mentioned previously, in order for a vaccine to provide protection on a community level, vaccination rates must be high enough to achieve herd immunity which protects the most vulnerable in the population. In general, to achieve herd immunity, over 80% of the population must be vaccinated. The participants indicated that about 60% would get the COVID-19 vaccine, not nearly enough to achieve herd immunity.

Compared to the first survey question which read, "I believe that vaccines are safe and effective," 10% fewer participants agreed with this question. This means that, while over 72% of participants agree that vaccines overall are safe and effective, only 62% believe the COVID-19 vaccine is safe enough to receive. Considering the events during the time of the survey, specifically the inconsistent rhetoric surrounding the pandemic, this finding is significant. Tom Nichols (2021) describes that this inconsistency produced, "a certain amount of hysteria," in his article about expert opinion and the COVID-19 pandemic. As more information came out, it was hard for individuals to know what to believe and even who was a trustworthy voice. This could explain the doubts about the safety of the COVID-19 vaccine.

The second question of interest for the first survey was Survey Question 3 which states, "I am worried about vaccine injuries." About 51.2% of respondents stated that they at least somewhat agreed with this statement, and 48.8% said that they at least somewhat disagreed with this statement. Therefore, a slight majority of individuals were fearful of vaccine injuries to varying extents. This is an interesting finding, especially when compared to the distribution of answers in the first survey question. The first survey question found strong support for vaccine safety and efficacy, with 72.3% of respondents indicating they at least somewhat agreed that vaccines were safe and effective. The distribution of responses to Survey Question 3 shows that, despite strong support for vaccine efficacy, there is a substantial level of fear and hesitancy surrounding vaccine injuries.

This question was replicated in the second as Survey Question 30-3. The second survey showed similar results, providing more support that there is legitimate fear of vaccine injuries on a national level. The findings of the second survey showed that 53% of the sample at least somewhat had fears of vaccine injuries. These two national surveys were conducted at different times. The first survey was distributed in November 2020 and the second survey was distributed

April 2021. The consistency of results between the two surveys suggests these trends are sustainable despite differences in time of distribution. Because a majority of the population indicated fear of vaccine injuries to some extent in both surveys, it is important for both policy-makers and medical experts to inform the public about the rarity of vaccine injuries in a clear and concise way in order to ensure public fear of vaccine injuries does not promote vaccine hesitancy.

The final question of interest from the first survey was Survey Question 4 which read, "Everyone who can get vaccinated, should get vaccinated." The data found that 71.3% of participants at least somewhat agreed with the statement and 28.7% at least somewhat disagreed with the statement. This question was also replicated in the second survey as Question 30-4. The second survey found that 73% of respondents at least somewhat agreed with the statement and 27% of the respondents at least somewhat disagreed with the statement. These are similar results and suggest that a strong majority of the population believes in the importance of community wide vaccination. Despite these findings of support, however, the results show hesitancy among the population with receiving a COVID-19 vaccine and a general fear of vaccine injuries.

The findings from the second survey overall showed support for the four hypotheses it tested. The Hypothesis 1 on misinformation and expertise states, "Misinformation spreads via social media and thus: (1) diminishes individual trust in experts and expert opinion (2) diminishes trust in health experts when they speak about health information." The survey results offered indeterminate answers for this hypothesis. Question 28-1 measured individual trust of medical experts as sources of viable health information by asking participants to either strongly agree, somewhat agree, somewhat disagree, or strongly disagree to the statement, "I trust medical experts to give me accurate health information and advice." Experiment Group A, who viewed the anti-vaccination social media post from LearntheRisk.Org, was the experimental group of interest for this question. The maximum score for this question was 3, and the closer to value was to three, the more likely the group was to strongly agree with the statement. The sample overall had an average of 2.128 for this question, while Experiment Group A had an average of 2.065. After t-test analysis, the difference between these two groups was not significant, with a p-value of 0.34. While this difference may not be statistically significant, it is still notable that there was at least some difference between the responses of the group receiving

the anti-vaccination prime and the rest of the population. Specifically, the experimental group receiving the anti-vax social media post was less trusting of medical experts when compared to the rest of the population. It is unclear whether the data supports or rejects the first hypothesis.

The Hypothesis 2 focusing on anti-vaccination advocates and experts states that, "Anti-vaccination advocates: (1) Use social media to spread misinformation contrary to expert opinion about vaccines (2) Effectively impact individual vaccine attitudes and beliefs through their social media strategies." The findings from previous research support the first part of the hypothesis, stating that anti-vaccination advocacy groups primarily use social media outlets to spread false information about vaccines (Annenberg Public Policy Center of the University of Pennsylvania 2020; Baughman 2020; Biller-Andorno 2021; Evrony and Caplan 2017). The data from the second survey tested the second part of the hypothesis, observing the idea that these social media posts effectively impact vaccine attitudes and beliefs. When looking at overall vaccination attitudes as a score out of 15, with values closer to 15 being more pro-vaccine, Experiment Group A, who received the anti-vaccination social media post, had more negative vaccine attitudes than Experiment Group B, who received the post from the Centers for Disease Control and Prevention (CDC). They also had more negative vaccine attitudes when compared to the entire population.

This data suggests that anti-vaccination propaganda does impact individuals to be more distrustful of vaccines. This specifically was found to be statistically significant when looking at two questions: Question 30-3 and Question 30-4. Question 30-3 states, "I am worried about vaccine injuries." There was a statistically significant difference ($p = 0.04254$) in responses between Experiment Group A and Experiment Group C, who received both the anti-vaccine post and the CDC post. Experiment Group A reported more fear of vaccine injuries than Experiment Group C. This is important considering Experiment Group C also received the anti-vaccination message, but still had more pro-vaccine attitudes compared to Experiment Group A. Unlike Experiment Group A, however, Experiment Group C also viewed the CDC post, which could have counteracted the effects of the anti-vaccine post. This could suggest a positive effect of the CDC post in promoting beliefs in vaccine safety. Question 30-4 states, "Everyone that can get vaccinated, should get vaccinated." The t-test analyses showed a significant difference in responses to this question between Experiment Group A and Experiment Group B who received opposite vaccine messages. Specifically, Experiment Group A again had more anti-vaccine

attitudes and were more likely to disagree with this statement than those in Experiment Group B. This suggests that anti-vaccine messages produce more negative responses to vaccines when compared to individuals viewing messages from experts like the CDC. These results support the second hypothesis that anti-vaccination social media posts influence vaccine attitudes.

The Hypothesis 3 regarding education states that, "Individuals with higher educational backgrounds in science are: (1) less likely to be influenced by anti-vaccination misinformation and (2) more likely to have high trust in vaccine efficacy." The findings showed strong support for these hypotheses.

Focusing on the first sub-hypothesis, the data supported that participants with higher educational backgrounds in science were less likely to be influenced by anti-vaccination misinformation. In order to test this hypothesis, I focused on two groups - the control group and Experiment Group A. As previously noted, Experiment Group A was exposed to the anti-vaccination post from LearntheRisk.org and the control group did not receive a prime. To test this hypothesis, I divided the data into four subsets - participants with high science educational backgrounds in the control group, those with high science educational backgrounds in Experiment Group A, those with no science background in the control group, and those with no science background in Experiment Group A. The goal was to determine whether respondents with high science educational backgrounds had a smaller difference in overall vaccine attitudes between the control group and Experiment Group A compared to those with no science educational background. The difference between the overall vaccine attitudes scores of individuals with high science education backgrounds in the control group and in Experiment Group A was 0.154. The difference between the vaccine attitudes scores of individuals with no science education in the control group and in Experiment Group A was 0.429. Therefore, participants with high levels of science education had a smaller difference in vaccine attitudes between the control group and the experimental group than those with no science education. In sum, respondents with no science educational background were more influenced by anti-vaccine messages compared to individuals with high science educational backgrounds. These findings support the first sub-hypothesis of Hypothesis 3 regarding education.

I tested the second sub-hypothesis by measuring the overall vaccine attitudes of participants with no science background and those with a high science educational background and comparing them. On a scale of 0 to 15, with scores closer to 15 being more pro-vaccine,

respondents with no science background had an average score of 8.688. Individuals with a high science background who had a score of 9.829. Therefore, individuals with high science education backgrounds were found to hold more pro-vaccine attitudes than those with no science education. T-test analysis also found this difference to be statistically significant. Focusing specifically on vaccine safety and efficacy measured by Question 30-1, the participants with high levels of science education were more likely to agree that vaccines were safe and effective than those with no science education. T-test analysis found this to be a statistically significant difference. These results support that those with high levels of science knowledge are more likely to have a more trust in vaccine efficacy.

The Hypothesis 4 addresses ideology and states, "Individuals who self-identify as having extreme political ideologies (i.e. extremely conservative or extremely liberal) are: (1) more likely to hold negative vaccine attitudes at a baseline measurement (2) more likely to disagree with government vaccine mandates (3) more likely to trust or agree with anti-vaccination misinformation." The data did not support all of these sub-hypotheses, but brought new insight into the effects of ideological beliefs.

The findings from the second survey did not support the first sub-hypothesis that ideological extremists are more likely to hold negative vaccine attitudes. The sample as a whole had a vaccine attitudes score of 9.364, with scores closer to 15 being more pro-vaccine. Participants with extreme ideological beliefs, either extremely conservative or extremely liberal, had a score of 9.646. This average is more pro-vaccine than the sample population as a whole. This data did not support that ideological extremists were more anti-vaccine. However, when observing the data, another trend emerged, showing significant differences in vaccine attitudes between liberals and conservatives. The data shows that conservatives are overall more likely to have negative vaccine attitudes than liberals. This was also true for every question measuring vaccine attitudes. Conservatives had an average vaccination attitudes score of 8.161, and liberals had a score of 10.93. T-test analysis found this difference to be statistically significant with a p-value of less than 2.2e-16. Across the board, conservatives hold significantly more anti-vaccination beliefs than liberals. This finding is consistent with the emerging identity of the anti-vaccination movement as a whole. Though typically they are depicted as tree-hugging hippies, more anti-vaccination advocates are concerned with protecting individual freedoms and following conspiracy theories, which are

traits found among many far-right conservatives (Jarry 2020). Therefore, while unanticipated by the hypotheses, given the trends of the anti-vaccination movement as it currently stands, these results are unsurprising.

The results from the second survey also did not support the second sub-hypothesis that extremists were more likely to disagree with government vaccine mandates. Question 30-5 measured participants' agreement or disagreement with government vaccine mandates as legitimate and important ways to stop the spread of deadly diseases. Ideological extremists were not more likely to disagree with this question when compared to moderates and the sample population overall. Similar to the first sub hypothesis, however, the data showed significant differences in liberals and conservatives in regard to vaccine mandates. Conservatives were more likely to disagree with vaccine mandates than liberals. T-test analysis also found this difference to be statistically significant, with a p-value less than 2.2e-16. This conclusion is also not surprising considering the conservative ideals of less government intervention. The conservative value of limited government likely is the reason why conservatives were more likely to disagree with government vaccine mandates (Jarry 2020). The trends found in the data show a greater association between negative vaccine beliefs and conservatism rather than ideological extremism.

The data from the second survey supported the third sub-hypothesis. This sub-hypothesis focused on the likelihood of ideological extremists to trust or agree with anti-vaccination information. To evaluate this, I looked at responses from extremists and moderates that viewed the anti-vaccine post from LearntheRisk.org. These participants were asked questions about the accuracy and trustworthiness of the post. Ideological extremists were found to be more trusting of the anti-vaccination post and were also more likely to view the post as more accurate compared to moderates. This finding is interesting as it does not follow the trend found in the previous two hypotheses. Ideological extremists were more likely to trust anti-vaccine social media posts, but they were not found to be more likely to hold negative vaccine beliefs overall. One possible explanation for this is the difference between trust and perception of a certain piece of information and its ability to influence opinions. Thus, while extremists on either side could have perceived the anti-vaccination post as more trustworthy and accurate, some extremists may not have allowed it to alter their preformed beliefs.

Beyond the hypotheses, the survey data revealed noteworthy trends. As mentioned previously, liberals were more pro-vaccine than conservatives overall. Liberals were also more likely to trust medical experts than conservatives. The differences in responses between liberals and conservatives was the most significant among any of the compared groups, with extremely significant p-values. Individuals with high levels of science educational backgrounds also held more pro-vaccine beliefs than those who had no science educational background. These participants were also more trusting of medical experts than those without science education backgrounds. Additionally, participants with high science education backgrounds were more likely to believe in vaccine safety and efficacy in general and in regard to the COVID-19 vaccine. This is likely because individuals with a greater knowledge of science understand the mechanisms behind vaccines more than those without a background in science education.

The results showed that participants who reported high confidence in their knowledge of science held more pro-vaccine attitudes. These participants were also more likely to trust medical experts. They also had strong beliefs in the safety and efficacy of the COVID-19 vaccines and vaccines in general. Additionally, participants with high confidence in their knowledge of science were more likely to agree with government vaccine mandates. These results, like the ones found in individuals with high levels of education in science, are likely a product of a greater understanding of the science behind vaccines.

Significant differences between social media users and non-social media users appeared in three different areas. Social media users were more likely to trust medical experts than non-social media users. They were also more likely to trust social media platforms as sources of health information and advice than non-social media users. This is likely because of their knowledge and familiarity with social media platforms. These social media users, however, reported more fear of vaccine injuries than non-social media users. Anti-vaccination groups use social media to spread misinformation about vaccines through fear mongering strategies, specifically to increase fear of injuries from vaccines. Exposure to these tactics through the use of social media could account for the elevated fear of vaccine injuries in social media users.

Differences between the experimental and control groups were not as significant as previously anticipated. Only two notable differences emerged, specifically in Questions 30-3 and 30-4. Question 30-3 found that Experiment Group A, that received the anti-vaccination post, was more likely to report fear of vaccine injuries than Experiment Group C, that received both

the anti-vaccination post and the post from the CDC. Question 30-4 found Experiment Group A, who received the anti-vaccination post, was also more likely to disagree with the importance of vaccination on a community level than Experiment Group B, who received the CDC post. While these were the only differences found to be statistically significant, it is important to note their implications. The introduction of the pro-vaccine CDC post to counteract the anti-vaccination post for participants in Experiment Group C proved effective in promoting pro-vaccine attitudes in regard to fear of vaccine injuries. Viewing the post from the CDC instead of the anti-vaccination post also produced positive vaccine attitudes regarding the importance of vaccination on a community level. These findings support the importance of expertise in curbing the effects of misinformation. Similarly, they show that expert information impacts opinion formation positively, especially about vaccines. These results were not produced across all questions, however, so more research must be done to reveal how expert information can most effectively shape public opinion.

7.2 Limitations and Strengths

As with any research, the studies conducted for this thesis had both limitations and strengths. One of the major limiting factors was the structure of both studies as self-report surveys. In each of the studies, participants responded to questions about themselves and their opinions. With this self-report format, participants are subject to social desirability bias, in which they may choose answers they think are socially acceptable rather than what they truly believe. Similarly, respondents are sometimes more likely to choose neutral answers rather than answers that force them to take a stance on an issue that may not be socially desirable. Because the survey experiments were conducted virtually, participants were not able to ask clarifying questions as they were completing the survey. Therefore, their answers were based on their interpretations of the survey questions. The wording of some of the questions could have been confusing to some participants and could have altered the way they responded to the questions.

One of the major strengths of the studies were their large sample sizes. Each survey was conducted on a national level and had around 1,000 respondents. These large sample sizes allowed conclusions to be more generalizable to the national population. The samples were not only nationally representative, but questions repeated in both surveys produced similar answers, suggesting validity of the questions and their results. Finally, the survey answer options did not

have a neutral choice, which forced participants to take a stance rather than remain impartial. This effort was meant to eliminate social desirability bias as much as possible. Many of the questions included in the survey involved topics in which neutrality seems socially desirable. Few, if any, people can be completely neutral on these topics, however. By eliminating the neutral option, the results gave a more accurate picture of vaccine beliefs nationally.

7.3 Opportunities for Future Research

The findings of this thesis suggest multiple opportunities for future research. Specifically, more research should be conducted to explore the strength of association between liberals and conservatives and pro-vaccine vs. anti-vaccine beliefs. The results of this study showed strong indications that liberals held more pro-vaccine beliefs than conservatives. Since this study did not establish a causal relationship necessarily, more research should be done to explore these findings more in depth to determine the nature of the relationship. The survey results also revealed that a majority of the population is fearful of vaccine injuries and that social media users in particular have more fear of vaccine injuries. Research should be directed to explore how social media use correlates with exposure to anti-vaccination messages that amplify fear of vaccine injuries and side effects. The second study found significant differences between the vaccine beliefs of Experiment Group A, who viewed the anti-vaccine post, and Experiment Group B, who received the CDC post. Additionally, the study found significant differences between Experiment Group A and Experiment Group C, who received both the anti-vaccine post and the CDC post. The results suggest positive effects of expert information to induce and reinforce positive vaccine attitudes. These initial results are promising, but more research should be directed toward determining the effectiveness of expert information in counteracting misinformation. Future research could explore the effectiveness of fact-checking and other methods in debunking misinformation. Finally, the data indicated that COVID-19 was not a significant factor altering vaccine beliefs and attitudes. Future research could further investigate whether this is a valid conclusion or a flaw in the research design by retesting the hypothesis. It would be best for these studies to be conducted after the COVID-19 pandemic rather than in the midst of it to best understand its lasting effects.

8. Conclusion

The purpose of this thesis was to explore the struggle between expertise and misinformation to influence public opinion by focusing on the anti-vaccination movement. The anti-vaccination movement is known to defy expert information and spread conspiracy and falsehoods to further its cause and therefore was an appropriate topic for this case study. The two studies included in this thesis tested five hypotheses and yielded results that both supported and rejected the hypotheses. Overall, expert opinion was found to be somewhat effective in influencing public opinion, specifically in promoting and reinforcing pro-vaccine beliefs. The results also showed that anti-vaccination misinformation also impacts public opinion. Most importantly, the findings revealed that individual factors such as social media usage, science education, and ideological beliefs are most influential in determining how individuals formed their opinions. When assessing how individuals form their opinions, it is important to consider that their personal factors are perhaps the most powerful determinants of their attitudes and beliefs. These individual characteristics inform people about who and what to trust, which news source to listen to, what information is factual and what is not, and, most importantly, what they believe to be true. As the findings of this thesis suggest, when it comes to the battle between expertise and misinformation, it is not so much about the external information as it is the internal personal factors that influence public opinion.

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