A Dangerous Infodemic: An Examination of the Impact Social Media Misinformation has on COVID-19 Vaccination Status

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The concept of misinformation is not new, but the digital age has created a new environment for the rapid spreading of misinformation. The overabundance of information that is available online has made it challenging for individuals to identify trustworthy and reliable sources. Social media in particular provides a global network connecting users, and the information there is created by the users themselves; therefore, it can be inaccurate and subjective. Throughout the COVID-19 pandemic, social media sites have acted as facilitators and multipliers of COVID-19-related misinformation. This misinformation can have a significant impact on global health by impacting individuals' behaviors and has the potential to cause significant harm. In this paper, we explore how COVID-19 misinformation found via social media impacts individuals' decisions to get vaccinated against COVID-19. The results from our study suggest that as one's beliefs in misinformation and conspiracies related to COVID-19 increase, so does their decision to not obtain a vaccine.

CCS Concepts: • **Security and privacy** → **Social aspects of security and privacy**; • **Applied computing** → *Psychology*.

Additional Key Words and Phrases: misinformation, COVID-19, vaccination status, infodemic, social media, information integrity

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1 INTRODUCTION

The Internet has become a popular and readily accessible resource for people around the world to access information. In particular, social media platforms have become an integral part of society today, providing a broad network connecting users globally and serving as an effective web technology for both social interactions and sharing information [22]. These platforms have made it easier than ever for users to connect with each other globally, stay up to date with the latest news stories, and easily access and share information.

While social media has many benefits, it has also become a platform that enables users to access, create, and spread misinformation to a global audience. The information that users create and share via social media has the potential to be unreliable and based on both flawed hypotheses and emotional responses [17]. Information that is posted on social media is immediately available and widely accessible, meaning oftentimes false information will spread rapidly and reach a large audience before anyone has the chance to correct it. Misinformation can have a widespread real-world impact, and due to the vast amount of inaccurate information that is available online, people can quickly become misinformed. This can lead to unwanted and possibly severe consequences [33].

Since the beginning of the outbreak of the novel coronavirus SARS-CoV-2 (COVID-19) in December 2019, social media sites have acted as facilitators and multipliers of COVID-19 misinformation. Information regarding COVID-19 cures and treatments has spread unabated on social media, and these platforms have played a critical role in the perceptions and beliefs that users have and their resulting actions [2, 16]. Health experts and various health organizations have repeatedly warned people about the vast amount of COVID-19 misinformation that is available on social media sites. One COVID-19 related misconception that spread via social media during the beginning of the pandemic was that 5G masts

exacerbate or even cause COVID-19 symptoms. This led to people setting mobile phone masts on fire, endangering both property and lives [29]. Other misconceptions that spread via social media were that the pandemic was a conspiracy or a bioweapon and that vaccine trial participants died after receiving the COVID-19 vaccine [21]. Despite various health experts and organizations having provided specific, science-based health recommendations regarding the pandemic and the best treatments, users still fell prey to false information found via social media.

The spread of misinformation, including COVID-19 misinformation, is a direct attack on the integrity of information and believing COVID-19 misinformation may lead to serious consequences, such as illness and even death. Therefore, it is important to understand the role that COVID-19 misinformation found via social media plays in impacting individuals' vaccination status and the factors that influence their susceptibility to believing false information. Better understanding the characteristics of these individuals will help us to better prevent the impact that the spread of misinformation has on public health.

The overall goal of this study was to determine how COVID-19 misinformation found via social media impacts individuals' decision to get vaccinated against COVID-19. We conducted a survey to gather the data and analyzed it using SPSS. The results from the study suggest that as one's beliefs in misinformation and conspiracies related to COVID-19 increase, so does their decision to not initiate obtaining a vaccine.

2 BACKGROUND

2.1 Misinformation

Misinformation and disinformation involve the spreading of false or misleading information that is disguised as factual. Disinformation is spread by people who are aware that the information is false or misleading and have the intention to harm, while misinformation is spread by people unwittingly and without the intent to harm.

The concept of misinformation is not new. Before the time of social media and the internet, people found their information from a variety of other sources like books, magazines, newspapers, radio, television, advertisements, and people [33]. The digital age has simply produced a new environment for the spread of misinformation, allowing it to be easily created and spread to a large audience [19]. In today's world, there is an overabundance of information that is available online, making it challenging for individuals to identify trustworthy and reliable sources, as opposed to misleading or fake ones. Information that is found on social media sites is created by the users themselves and therefore can be inaccurate and subjective [34].

In 1998, a study was published in The Lancet that claimed that the measles, mumps, rubella (MMR) vaccine causes autism [36]. While this was immediately refuted by the scientific community, this false information had a significant impact on people's beliefs and confidence in the safety of the MMR vaccine. In 2019, there were several public health emergencies declared in the United States due to measles outbreaks and Albania, Czechia, Greece, and the United Kingdom even had their measles eradication status revoked [33]. Another piece of misinformation that has impacted peoples' health is the misconception that eating apricot seeds can cure cancer. While there is no scientific evidence that can support this claim, people still believe it. In fact, it has actually been established that consuming the seeds may cause cyanide poisoning [35]. Even after being debunked, misinformation can continue to influence people's attitudes and beliefs [24].

2.2 COVID-19 Misinformation and Social Media

In December 2019, the first human infection of the novel coronavirus SARS-CoV-2 (COVID-19) was reported in Wuhan, China. Over the next three months, the virus spread throughout the world, becoming a global public health emergency. Since the beginning of the pandemic, there has been a huge amount of widely circulating COVID-19 related misinformation and disinformation. This information ranged from information about the virus and its origins to how it spread and treatments to cure it. During the early stages of the pandemic, misinformation and disinformation began to spread about fake cures, such as drinking or injecting yourself with bleach, ethanol, or methanol [1]. There have also been conspiracy theories about the origin of the virus, such as some suggesting that COVID-19 was bioengineered in a lab in Wuhan, China [3].

One of the most widespread examples of COVID-19 misinformation was the conspiracy film "Plandemic," which first appeared online in May of 2020 and received millions of views [5]. The video promotes dangerous health advice, including suggesting that wearing a face mask actually activates COVID-19, rather than protecting against it [5]. Misinformation oftentimes builds on doubts, anxiety, and fear. Therefore, it can impact individuals' behaviors, which could threaten to limit public acceptance and utilization of COVID-19 vaccines [21, 31].

Despite people looking to social media for directives and while social media has served as a useful tool that governments and health organizations can use to disseminate COVID-19 information to the general public, expert individuals and organizations often lose their legitimacy among the public population [4]. In one analysis of the most highly viewed COVID-19 related YouTube videos, whose views in combination totaled 62 million, it was found that more than 25% of them contained misleading information [29]. One study in the United Kingdom found that 46% of the British population was exposed to COVID-19 misinformation and disinformation and 66% of those exposed reported seeing COVID-19 misinformation daily, while a survey taken in the United States in mid-March 2020 found that 42% of Americans had seen either some or a significant amount of COVID-19 related news which seemed completely made up [23, 29]. Social media platforms in particular have become a popular outlet for people to share their perceptions, attitudes, and opinions regarding COVID-19 and associated public health policies and recommendations [34]. The proliferation of COVID-19 related misinformation and disinformation prompted the World Health Organization to warn people about the ongoing 'infodemic' [29].

The spread of COVID-19 related misinformation, facilitated via social media, has the potential to have severe consequences and can be a serious threat to public health. Becoming misinformed may have a negative impact on individuals' health and make them less likely to believe in scientific facts and trust what scientific experts say [20]. Repeated exposure to misinformation is known to increase the belief that people have in fake news [25]. The abundance of COVID-19 misinformation that can be found via social media has increased peoples' fear and distrust, resulting in greater levels of panic amongst the general public [6]. Thus, misinformation can impact and influence users' responses and behavior.

Based on this discussion, we developed the following hypothesis:

H1: Individuals that more strongly believe in conspiracies related to COVID-19 are less likely to initiate the vaccine for COVID-19.

3 METHODS

3.1 Participants

Since human participants were involved in this study, we sought and obtained Institutional Review Board (IRB) approval prior to collecting any data. We recruited participants from Amazon's Mechanical Turk (MTurk). The survey itself was hosted on the Qualtrics survey platform. Similar to other recruitment methods, MTurk has been shown to be both reliable and efficient for participant recruitment when quality control measures are used, such as attention check questions that were employed in the current study [8, 32].

In this study, we used three automated quality control questions. If a participant failed any of them, the survey would end with a message explaining that they did not answer a quality control question correctly. Furthermore, eligibility to participate in the survey to MTurk workers was limited to those that had an approval rate of 98% or higher and had previously completed 1,000 HITs (human intelligence tasks) or more.

Prior to largescale data collection, we employed a pilot study with 112 participants. This was done to reveal any problems with question wording and survey flow, as well as verify that fair compensation for participants was being provided. We did not detect any significant issues in this pilot study. Compensation for participants was set at $3.51, which was considered fair given the responses provided to a compensation question included at the end of the survey. Overall, 81.6% of participants believed that the compensation provided was either comparable (69.8%) or easier for the money (16.3%) when compared to similar projects they had previously completed on MTurk. A small number (13.9%) believed that more effort was required in comparison. There were 975 participants that began the survey with 15.8% of them failing one or more of the quality control measures. Thus, we obtained 821 valid responses that were used for subsequent analysis.

Over half of the participants (57.2%) identified as male, while the remainder either identified as female (42.4%), non-binary/third gender (0.2%), or preferred not to say (0.1%). Age-wise, over half (60.3%) of the participants were between the ages of 20 and 39 years old, and the remaining either were between the ages of 40 and 59 (32.3%) or were age 60 or older (7.4%). Over three quarters of the participants (79.4%) identified as White/Caucasian. The remaining identified as Black/African American (7.3%), Asian/Pacific Islander (5.8%), Hispanic (4.8%), Other/Multi-Racial (2.2%), or Native American/Alaskan Native/Indigenous (0.5%).

The majority of the participants (71.6%) held some type of college degree. Of these, almost half (49.5%) held a Bachelor's degree, while the remaining held either a Master's degree (11.3%), an Associate's degree (9.6%), a Doctorate degree (0.6%), or a Law degree, M.B.A., or other professional degree (0.6%). The remaining participants (28.4%) did not hold any type of college degree. Almost half of participants (48.4%) listed their annual household income as less than $49,999, over a third (39.3%) listed their annual household income as between $50,000 and 99,999$, and the remaining participants (12.2%) listed their annual household income as over $100,000. Over half (54.1%) of participants identified as a Democrat, while the remaining identified as either an Independent (22.7%), a Republican (21.0%), a Libertarian (1.1%), other (0.6%), or no preference (0.6%).

3.2 Materials

The primary focus of this study was to examine how beliefs about conspiracies related to COVID-19 may be related to one's propensity to initiate COVID-19 vaccination. In order to assess one's beliefs in conspiracies related to COVID-19 we used a previously developed and validated survey instrument [15]. These questions assessed one's beliefs in such

things as the number of deaths related to COVID-19, whether or not the threat from the virus has been exaggerated, the efficacy of ultra-violet light and hydroxychloroquine on preventing or curing COVID-19, etc.

We also adapted previously developed and validated questions related to COVID-19 vaccination status to assess whether the process had been initiated yet or not [7].

4 RESULTS AND ANALYSIS

We tested our hypothesis by conducting an independent samples t-test. Our results support ($t = -8.34$; $p < .001$) the hypothesis that individuals with stronger beliefs related to COVID-19 conspiracies are less likely to initiate the COVID-19 vaccine. While this result may not necessarily be surprising, it does confirm the dangers associated with the spread of misinformation related to COVID-19 given the ability of vaccines to save lives and mitigate the spread of the virus.

Gender identification did not make a difference with respect to our hypothesis with a significance level of $p < .001$ in both cases. We also examined whether educational attainment level, annual household income, and age made a difference in initiating the COVID-19 vaccine. In all three cases, it did. Those with higher levels of education ($t = 6.175$; $p < .001$), higher incomes ($t = 4.048$; $p < .001$), and older in age ($t = 2.707$; $p < .01$) were more likely to seek out a COVID-19 vaccination.

We also examined political party affiliation to better understand the role that might play in conspiracy beliefs related to COVID-19. Republicans (N=172) were much more likely (M=2.6395; SD=1.01) than non-Republicans (N=649) (M=1.77; SD=0.93) to believe in COVID-19 conspiracies. The results is a much lower likelihood of obtaining a vaccine for COVID-19 [30].

Overall, our results support the need for additional measures to combat misinformation related to COVID-19. This may include increased information literacy in both formal and informal educational settings, which could help consumers become more critical of the information that is presented to them. We may also need greater efforts on the part of both traditional and non-traditional media organizations to limit their own spread of misinformation and/or identify when statements on their platform are not supported by the evidence. Some of these solutions may become entangled in ideological leanings, but it does not mean such efforts should not be undertaken given the life and death implications of misinformation related to a significant public health issue.

5 DISCUSSION

The results of this study suggest that as one's beliefs in misinformation and conspiracies related to COVID-19 increase, so does their decision to not obtain a vaccine. The results also show that when looking at differences based on gender identification, the relationship between the two variables remains regardless of gender identification. Those with higher levels of education, higher incomes, and older in age are all more likely to seek the COVID-19 vaccination.

While COVID-19 vaccines are widely available in many countries, including the United States, this is not the case for less developed and lower income countries, or countries in which civil unrest and conflict are ongoing. Yet, despite many of the richer and more developed countries having readily accessible COVID-19 vaccines, there is still hesitancy by some people towards becoming vaccinated.

And although there are indubitably many factors which play a role in why some people are hesitant about becoming vaccinated and/or decide not to become vaccinated, misinformation likely plays a significant role in the decision of some. The participants used a variety of social media platforms with significant variations among them (see Table 1 in Appendix B). As determined in prior research and through our study, COVID-19 related misinformation, including that encountered via social media, can indeed affect people's actions and may aggravate the levels of vaccine hesitancy. The

role that misinformation plays in vaccination hesitancy and the threat that it poses to overburdened health systems and global health, is an ongoing issue that needs to be addressed in order to help save lives and decrease the likelihood of new COVID-19 variants emerging.

5.1 Limitations

It is worth noting several possible limitations of the current study. First, common method bias is a concern given that a single research method was employed—a survey [26]. We employed multiple quality control procedures to help address this concern. Likewise, the participant population is mostly anonymous to the researchers. Therefore, while common method bias remains a concern, multiple approaches were used to help minimize its potential impact on the results obtained and analysis thereof.

Second, participants from the MTurk platform do have an incentive to complete the work as quickly as possible. And while compensation was considered comparable to similar projects or better by most of our participants, the incentive to perform the work in as little time as possible and with perhaps less care than what may be desired remains.

Third, the data collected in the current study is based on a single point in time for the participants. We did not employ a longitudinal study to determine if the opinions and attitudes expressed by them may have changed over time.

Finally, there are many possible reasons why individuals have chosen not to initiate vaccination for COVID-19. We do not discount these other reasons or otherwise suggest that the only reason is related to COVID-19 misinformation. Instead, our focus is on the role misinformation may play on the opinions and attitudes of our participants. The decision to initiate a COVID-19 vaccination can be quite complicated and multi-factorial for many individuals. The current research does not delineate between these other factors and the role misinformation may play with respect to vaccination.

6 CONCLUSION

6.1 Possible Future Directions

Negative emotions are in many ways at the heart of the misinformation problem. It is difficult to know how emotions, whether positive or negative, could be used in an effective and ethical [12] manner to limit the reach of misinformation. However, we do know that psychological factors (e.g., personality, trait affect) do influence the type of behavior individuals engage in on social media [10], including the sharing of inaccurate information [37]. Could there be a way to leverage these psychological factors to change the social and psychological incentives that sharing misinformation in the first place provides?

Additionally, Facebook and other social media organizations have tried to label misinformation when their algorithm detects something (e.g., a political meme) that had previously been checked for accuracy and shown to have incorrect, false, or misleading information contained within it [18]. However, perceptions related to those that make such determinations may limit their effectiveness, such as believing that they are trying to advance on political agenda over another. Perhaps leveraging peer influence/feedback as has been done in other security research [11], may have a potential role in limiting the spread of misinformation. If those within one's own social media network have already rated something as incorrect, false, and/or misleading, it may make it less likely that others will share that same information.

For example, when an individual clicks on the share option within a social media platform, a message could appear that shows how many individuals within their own social network have chosen to share that same information out

of those that would have seen it in their feed. Likewise, it could include information on how many of those same individuals indicated that they thought it was incorrect, false, and/or misleading, as noted earlier. While there would be significant challenges with such a system, such as those within one's social network generally having similar views on political matters, it could provide an interesting avenue to pursue.

6.2 Final Remarks

The problem of misinformation is a difficult one to address. The consequences of misinformation and disinformation can be quite profound, whether in the political arena [14] or as it relates to public health issues as discussed in the current paper. The potential to change the course of history is very real. And while tools are readily available for many cybersecurity threats [9], the attack on the integrity of information poses unique challenges that do not lend themselves to the same approaches or tools. Assuming the use of fear appeals [13, 27], shame [28], and other behavioral modification techniques that use negative emotions in an attempt to improve cybersecurity behavior are effective in some contexts, they are unlikely to be effective in addressing misinformation. In fact, misinformation is often effective because it leverages many of these same negative emotions in an effort to spread the false information in the first place.

Is it possible for us to 'flip the script' on the use of emotions and the benefits it may provide to some in the sharing of misinformation? Or, is there a place for the use of peer influence/feedback to be employed in a positive manner to effectuate the desired change? What we do know is that the status quo is not only insufficient, but it is dangerously inadequate.

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A SURVEY INSTRUMENTS

COVID-19 Conspiracy Beliefs

(Strongly Disagree / Disagree / Neither Agree nor Disagree / Agree / Strongly Agree)

(1) The number of deaths related to the coronavirus has been exaggerated.
(2) The threat of coronavirus has been exaggerated by political groups who want to damage former President Trump.
(3) Coronavirus was purposely created and released by powerful people as part of a conspiracy.
(4) The coronavirus is being used to force a dangerous and unnecessary vaccine on Americans.
(5) Ultra-violet (UV) light can prevent or cure COVID-19.
(6) The coronavirus is being used to install tracking devices inside our bodies.
(7) Hydroxychloroquine can prevent or cure COVID-19.
(8) COVID-19 can't be transmitted in areas with hot and humid climates.
(9) Bill Gates is behind the coronavirus pandemic.
(10) Putting disinfectant into your body can prevent or cure COVID-19.
(11) The dangers of 5G cellphone technology are being covered up.

Vaccination Status

Initiated

(1) I am fully vaccinated
(2) I am fully vaccinated -AND- have received a booster
(3) I am fully vaccinated -AND- previously had a COVID-19 infection
(4) I have received one shot and will be getting the second shot soon
(5) I have received one shot and do NOT plan on getting the second shot
(6) I am scheduled to receive the vaccine

Not Initiated

(1) I plan on scheduling to receive the vaccine soon
(2) I previously had COVID-19 and thus do not feel I need the vaccine
(3) I may get the vaccine sometime later this year
(4) Now that a vaccine has been fully approved by the FDA, I plan on getting it very soon
(5) I will only get the vaccine if it becomes required by my employer
(6) I have no intention of getting the vaccine

Gender Identification

(1) Male
(2) Female
(3) Non-Binary / Third Gender
(4) Prefer not to say

Annual Household Income

(1) Less than $25,000
(2) $25,000 to $34,999
(3) $35,000 to $49,999
(4) $50,000 to $74,999

(5) $75,000 to $99,999
(6) $100,000 to $124,999
(7) $125,000 to $149,999
(8) $150,000 to $199,999
(9) $200,000 or more

Educational Attainment Level

(1) Did NOT graduate high school (12th grade or less)
(2) Graduated high school or equivalent (GED)
(3) Some college, no degree
(4) Associate degree
(5) Bachelor's degree
(6) Master's degree
(7) Law degree, M.B.A., or other professional degree
(8) Doctorate degree

B SOCIAL MEDIA USE AMONG PARTICIPANTS

Table 1. Percent Use of Various Social Media Platforms by Participants (N=821)

	Never	**Rarely**	**Sometimes**	**Often**	**Very Often**	**All the Time**
		once every month or so	*once every week or so*	*once every day or two*	*a few times a day*	*several times a day or more*
Facebook	12.2%	12.5%	12.7%	18.5%	23.3%	20.8%
Instagram	19.0%	13.2%	13.6%	20.2%	17.8%	16.2%
LinkedIn	41.7%	26.1%	15.1%	9.4%	5.4%	2.4%
Pinterest	40.6%	21.3%	18.0%	9.0%	8.5%	2.6%
Reddit	12.1%	11.4%	15.8%	20.0%	21.2%	19.5%
Rumble	77.1%	4.9%	7.3%	4.9%	4.0%	1.8%
Snapchat	58.1%	10.2%	8.6%	9.1%	8.5%	5.4%
Telegram	72.7%	4.1%	5.7%	5.8%	6.8%	4.8%
TikTok	51.8%	10.5%	10.6%	9.1%	10.1%	7.9%
Tumblr	71.6%	10.0%	6.2%	5.4%	5.0%	1.8%
Twitter	16.7%	13.3%	15.0%	18.8%	19.5%	16.8%