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ORIGINAL ARTICLE

U.S. adults' reasons for changing their degree of willingness to vaccinate against COVID-19

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Abstract

Introduction COVID-19 vaccines significantly reduce the risk of complications and hospitalizations due to this virus. When COVID-19 vaccines first became commercially available, roughly 30% of U.S. adults reported being hesitant to receive these newly developed vaccines, and 15% said they would not receive the vaccine. However, by May 2021, 19% of adults were vaccine-hesitant, and 13% refused to vaccinate against COVID-19. It is critical to understand why adults' degree of willingness to vaccinate against COVID-19 changed over time to plan for future pandemics and vaccination campaigns.

Methods We conducted two waves of survey research over five months (January and May 2021) with a panel of 890 U.S. adults. One survey question assessed willingness to vaccinate against COVID-19. The response option included a slider scale ranging from 0 (signifying complete unwillingness) to 10 (complete willingness). We asked participants whose willingness score changed by more than one point to report their rationale for their change in perceptions. We conducted a conventional content analysis on all qualitative responses.

Results We analyzed qualitative responses for 289 participants, 54.7% of whom had not been vaccinated against COVID-19 by May 2021. Among those who remained unvaccinated, 36.1% reported increased willingness to vaccinate. The most commonly cited reasons for becoming more willing to receive the vaccine include believing that COVID-19 vaccines are safe and effective, protecting against the pandemic, and desiring to return to pre-pandemic life. Reasons for increased COVID-19 vaccine hesitancy include vaccine safety concerns, the low perceived need for the vaccine, distrust in how COVID-19 vaccines are made and of larger institutions such as the government and pharmaceutical companies, and concerns about vaccine effectiveness.

Conclusion Findings illuminate the rationale behind individuals' changes in their degree of willingness to vaccinate against COVID-19. It is critical to incorporate these considerations in future vaccine rollout initiatives to increase the public's vaccine confidence.

Keywords COVID-19; vaccine hesitancy · Vaccination · Vaccine acceptance

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Introduction

Infection with COVID-19 can lead to secondary infections, acute respiratory distress syndrome, pneumonia, stroke, cardiovascular disorders, lung scarring, and death (COVID-19 Response Team 2020). In 2021, COVID-19 became the third leading cause of death in the U.S. (Amin et al. 2022), representing significant mortality considering the broad public availability of vaccines that are up to 95% effective in preventing new infections and that significantly reduce the risk of hospitalization and infection-associated complications (Polack et al. 2020). However, segments of the U.S. population remain hesitant to receive this life-saving vaccine. Vaccine hesitancy is the refusal or the delayed acceptance of a vaccine even if the vaccine is accessible (MacDonald 2015). This psychosocial barrier differs from structural barriers, systemic factors such as transportation and time that impact individuals' ability and willingness to vaccinate (Fisk 2021). Vaccine hesitancy is influenced by (1) low confidence (lack of trust) in the vaccine and vaccine delivery systems, (2) complacency or low perceived need to vaccinate, (3) psychological constraints such as fear of long-term side effects of the vaccine, (4) complexity finding and understanding information about the vaccine, and (5) collective responsibility, the prosocial behavior of vaccinating to protect others (MacDonald 2015).

Individuals' perceptions of COVID-19 vaccines and their willingness to vaccinate have changed over time, with the highest rates of vaccine hesitancy coinciding with early vaccine dissemination efforts in January 2021. Kaiser Family Foundation reported that in February 2021, 22% of U.S. adults reported wanting to "wait and see" before getting the vaccine, 7% would vaccinate only if required, and 15% reported that they would "definitely not" receive the vaccine (Hamel et al. 2021a). By May 2021, vaccine hesitancy among U.S. adults shifted, with 12% wanting to "wait and see," 7% only willing to vaccinate if required, and 13% refusing the vaccine. At that time, the remaining 68% of U.S. adults had received at least one dose of the vaccine series (Hamel et al. 2021b). It is critical to explore what impacted U.S. adults' willingness to vaccinate against COVID-19 during this short period. This qualitative content analysis explores U.S. adults' reasons for their increased or decreased willingness to vaccinate against COVID-19 between January and May 2021. This information may provide information that can be used in future vaccine rollouts and pandemics.

Materials and methods

Participant recruitment

Upon gaining Institutional Review Board approval (Study 00013200) to conduct this research, we deployed two separate waves of surveys among the same group of participants, one in January 2021 (T1, $n = 1456$ participants), the beginning of the vaccine rollout and another in May 2021 (T2, $n = 890$ participants), when the supply for COVID-19 vaccines surpassed demand (Kates et al. 2021). We utilized an online convenience sample of adults recruited from Amazon Mechanical Turk (MTurk), an online labor market where individuals, also known as MTurk workers, sign up to complete research "tasks" for pay (Mason and Suri 2012). Potential participants met inclusion criteria for the study if they were MTurk workers, over 18, and resided in the United States. We provided an online informed consent document describing how survey participation signified consent. To mitigate threats to data quality, we filtered international respondents from the data by utilizing IP address lookup via IPHub to reveal probably VPN/VPS use (Burleigh et al. 2018). We also required respondents to complete a reCAPTCHA to prevent data contamination by bots. Finally, we embedded a comprehension check ("How often do you eat cement?") within one of our scales to boost data quality (Huang et al. 2015).

We invited MTurk workers who completed the first survey to participate in the second survey and compensated all workers a fee of $0.50 for completing each survey. We offered them an additional $0.56 for responding to additional questions on the survey, including the questions we analyzed for this current research, to describe why their degree of willingness to vaccinate against COVID-19 changed over time. The total compensation was $2.12 for completing both surveys. On average, the survey took eight minutes and thirty seconds to complete, yielding a rate of $7.50 an hour to take this survey.

Survey instrument

We conducted a theoretically-informed survey guided by the Theory of Planned Behavior (TPB, Ajzen 1991), the Health Belief Model (HBM, Rosenstock 1974), and key constructs from the Extended Parallel Processing Model (EPPM, Witte 1992). The survey is described in greater detail elsewhere (Jensen et al. 2022). We measured willingness to vaccinate against COVID-19 with one question, "How willing are you to get the COVID-19 vaccine as soon as it becomes available to you?" Respondents expressed their level of willingness using a slider scale that ranged from 0 (complete unwillingness) to 10 (complete willingness). If participants' self-reported level of willingness changed between T1 and T2, either negatively (less willing to vaccinate) or positively (more willing to vaccinate), the second survey asked participants to describe the rationale that led to the change in their willingness to vaccinate against COVID-19.

Data analysis

We conducted linear regression to assess differences in the sample between those who completed only the first and those who completed both surveys. Table 1 illustrates the differences between these samples (temporarily removed for blinding purposes). Namely, participants who completed both surveys were older and had college degrees.

For our content analysis, we downloaded all qualitative responses ($n = 532$) and excluded data from 77 respondents that did not contain a rationale for their changed scores and from 166 participants whose scores did not change by more than one point in either direction. Our final sample yielded 289 unique qualitative responses. See Fig. 1 for a flow diagram of qualitative response inclusion for this analysis.

We conducted conventional content analysis to examine the qualitative data, allowing up to five themes and subthemes to emerge from participants' responses (Hsieh and Shannon 2005). One author read through the qualitative responses and created an initial coding guide that included potential codes and definitions of the codes. The first and second authors met and, together, coded 15 qualitative responses to test and modify the coding guide and ensure coding similarities. Then, they coded 50 qualitative responses separately, creating new codes and merging similar codes as needed. They met to compare codes and resolve any coding discrepancies. In the second round of intercoder reliability, both authors separately coded an additional 25 qualitative responses and, once again, met to resolve coding discrepancies. After reaching a consensus on any remaining differences, they divided the remaining qualitative responses and independently coded the data.

Results

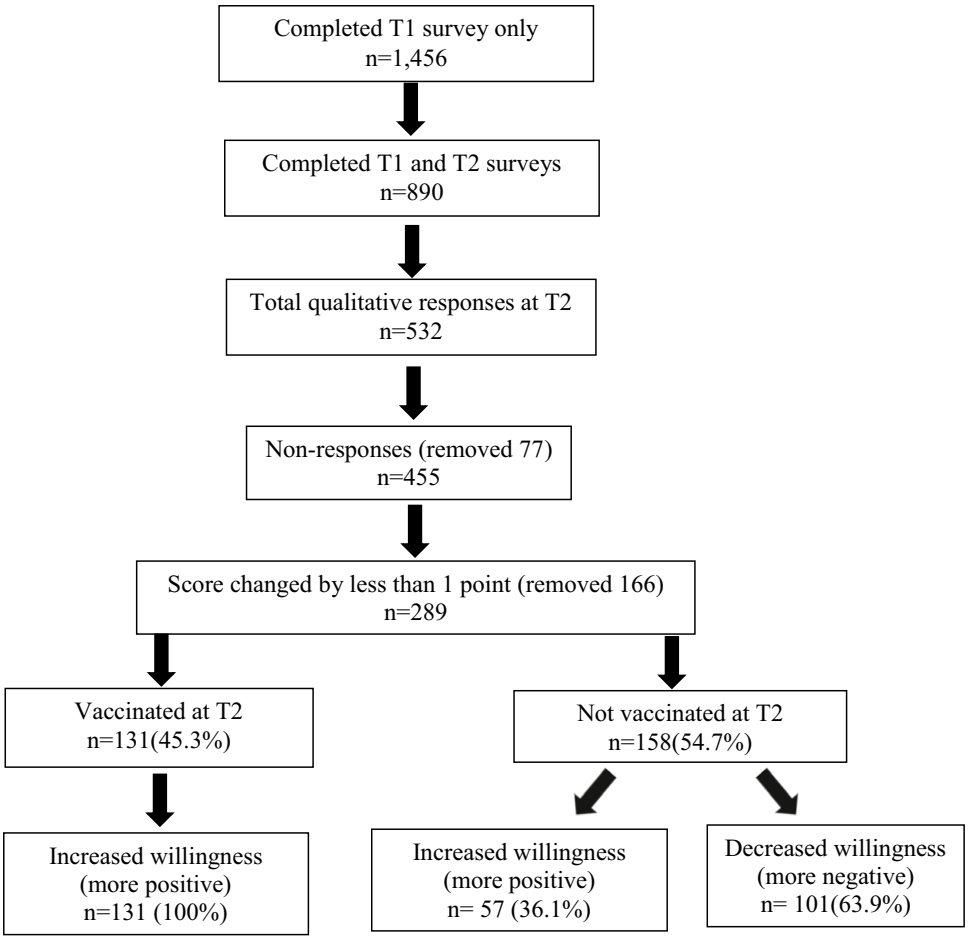
Figure 1 illustrates COVID-19 vaccine uptake by T2 and whether participants reported increased or decreased willingness to vaccinate. At T2, of the 289 participants whose data was included and coded, 45.3% ($n = 131$) had received at least one dose of a COVID-19 vaccine, of whom 75.6% ($n = 99$, 34.3% of the total sample) were fully vaccinated. Although 54.7% ($n = 158$) of participants had not been vaccinated at T2, 36.1% ($n = 57$) of unvaccinated participants' scores illustrated that they had become more willing to receive the vaccine. Tables 2 and 3 show the results of our content analysis, summarizing the most commonly reported reasons for participants' changes in willingness to vaccinate. We first present our findings from participants

Table 1 Demographic differences between participants who completed the survey(s) at T1 and T2

Demographic characteristic	T1	T2
Man (Ref. = Woman)	0.043	0.043
	(1.69)	(1.70)
Age	0.008**	0.008**
	(7.15)	(7.10)
Education (Ref. = High School)		
College	0.075**	0.068*
	(2.68)	(2.41)
Professional Degree	0.08	0.074
	(1.93)	(1.76)
Doctorate	0.016	−0.004
	(0.11)	(−0.03)
White (Ref. = Non-White)	−0.025	−0.029
	(−0.81)	(−0.94)
Ideological Conservatism (Ref. = Liberal)		
Moderate	0.009	0.015
	(0.26)	(0.42)
Conservative	−0.003	0.001
	(−0.10)	(0.05)
Observations	1456	890
R-squared	0.04	0.05
F-test	F(8, 1447) = 7.51***	F(14, 1441) = 4.94***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.00$; T-statistics in parentheses

Fig. 1 Survey Flowchart



whose vaccine willingness scores illustrate an increased willingness to vaccinate against COVID-19 over the survey period (See Table 2), followed by responses among participants whose scores expressed decreased willingness to vaccinate (See Table 3). Direct quotations from study participants further illustrate themes and subthemes identified in our qualitative content analysis, along with the magnitude of change in participants' willingness scores from T1 to T2 (signified by Δ).

Increased willingness to vaccinate

Participants attributed numerous reasons for their increased willingness to vaccinate against COVID-19. The most common reasons included their beliefs that COVID-19 vaccines are safe and effective, that the vaccines offer protection, and the desire to vaccinate to return to pre-pandemic life.

Vaccines are safe and effective

The most frequently reported reason participants became more willing to vaccinate against COVID-19 was their perception that COVID-19 vaccines are safe and effective. One participant described how, over time, his trust grew in the vaccine as it became more available to the broader public.

> *Back when I originally provided feedback, the vaccine was relatively new, and not a large percentage of the population had received the vaccine at that point, as availability was still relatively limited. At that time, I was unsure of not only the effectiveness but the safety of the vaccine, as well. Now I'm at this point comfortable getting the vaccine.* (Δ: +8.68)

Similarly, other participants described their growing trust in the vaccine because other people they knew had been vaccinated. Many reported how knowing that family, friends, and other people who are important to them were vaccinated against COVID-19 influenced their decision to vaccinate. Participants noted that they became more willing to receive the vaccine when they learned that others received the vaccine with minor side effects. Some described weighing the pros and cons of vaccine side effects and becoming ill with COVID-19. To them, the vaccine's side effects were less risky than complications with COVID-19.

Table 2 Reasons for increased willingness to vaccinate against COVID-19

Themes	Subthemes	*N*
Vaccines are safe and effective		Total = 183
	Others have vaccinated	51
	Not worried about side effects	33
	Learned more about vaccine	30
	Growing trust over time	21
	Vaccine is safe	20
	COVID-19 vaccines are effective	9
	Trust data showing COVID-19 vaccines are working	8
	Peace of mind	7
	Healthcare provider recommendation	4
Protection		Total = 88
	Protect family and friends	34
	Civic duty to protect the community	23
	Self-protection	9
	Tendency to get sick	8
	Underlying health condition	7
	Knows other people who were sick with COVID-19	5
	Mentioned variants	2
Return to pre-pandemic life		Total = 85
	Stop wearing a mask	33
	Ready to return to pre-pandemic life	32
	Travel	13
	See family and friends again	7
Other less common themes		Total = 14
	Social pressure to vaccinate	12
	Vaccine endorsement	1
	Reduce vaccine waste	1

While I waited for my turn to be eligible, I watched people in my community, my spouse, and people on television who got the shot and had no adverse effects. I also saw people in my community who were not vaccinated contract COVID and die. So, since I have underlying conditions, I think the safest course of action for me was to get immunized. (Δ: +2.00)

Other participants who had previously been skeptical of the vaccine described how, over time, they came to trust the vaccine. One participant described how time and potential work mandates influenced their vaccination decision.

At first, I was skeptical about receiving the vaccine as I felt it had not been proven. However, I was informed this past week that my office will return to work sometime in July, and most likely, vaccinations will be mandatory. Because of this and as more time has passed, I now feel pretty comfortable being vaccinated. (Δ: +6.14)

Some participants described how they became more willing to vaccinate after learning more about the process of vaccine development and testing.

My knowledge of how the vaccine is currently created rather than how they were created in the past ultimately made me change my view and consideration of accepting a vaccine. Knowing that vaccines are created extremely safer than they were in the past reduced my fears of problematic side effects that could occur. (Δ: +6.11)

Others noted the reduced COVID-19 incidence in the U.S. after the vaccine was introduced and trusted the data showing that the vaccine was reducing hospitalizations. Receiving the vaccine, therefore, increased participants' peace of mind to receive the vaccine.

Protection

Another emergent theme was the desire to protect themselves, their family, and their friends against COVID-19 by

Table 3 Reasons for decreased willingness to vaccinate against COVID-19

Themes	Subthemes	*N*
Safety concerns		Total = 92
	General safety/concern of side effects of new vaccine	54
	Potential negative long-term health effects of the vaccine	25
	Current health status (sick or immunocompromised)	10
	Fear of blood clots	3
Low perceived need		Total =48
	Does not perceive the need to vaccinate	16
	Others have vaccinated (so they do not need to vaccinate)	11
	Does not perceive COVID-19 as dangerous	8
	Recovered from previous COVID-19 infection	4
	Reduced COVID-19 incidence in the community	4
	Minimal to no contact with other people	5
Distrust		Total =32
	Distrust of how COVID-19 vaccines were made (including speed of vaccine development)	17
	Distrust of government	6
	Distrust of pharmaceutical companies	6
	Distrust due to incentivizing vaccination	3
Vaccine effectiveness concerns		Total = 20
	Questions vaccine effectiveness	8
	Length of immunity unknown	5
	Need for a booster dose	4
	Breakthrough infections	3
Structural barriers to vaccination		Total =10
	Inconvenient to obtain the vaccine	5
	Time off work needed to vaccinate	3
	Cost of vaccine	2

vaccinating. Others expressed their civic duty to protect their community from further disease transmission or described vaccinating against COVID-19 as a civic duty to "do their part" to establish herd immunity.

> *I feel that I owe this not only to myself but also to my community to help stop the spread of this virus. I had slight side effects [from receiving the vaccine], but it was nothing compared to getting the virus. Hopefully, the herd immunity method will work, and soon we will not have to wear masks and social distance.* (Δ: +2.23)

Some participants cited a need to protect themselves from infection, especially if they had an underlying health condition that increased their risks of complications with the virus.

> *I have a medical condition that puts me more at risk. I also grew more concerned about unknowingly passing the virus onto someone elderly or with a medical condition that made them more likely to experience complications that could lead to hospitalization or death.* (Δ: +2.36)

Participants described how knowing someone who had experienced severe complications with COVID-19 influenced their decision to seek protection against COVID-19. Meanwhile, others mentioned hearing about new COVID-19 variants. Such news of emerging strains influenced their vaccine-related decisions. One specifically stated,

> *I changed my mind about receiving a vaccine after hearing about the other variants of the virus that are spreading.* (Δ: +6.06)

Return to pre-pandemic life

Many participants described vaccination as a means to return to pre-pandemic life without mask mandates and business closures and the ability to travel freely. For example, one participant's sole description for wanting to vaccinate against COVID-19 was based on the desire to no longer wear a mask.

> *I learned that people who are going to get the vaccine could stop wearing masks. Although I follow all*

the rules, I am not at risk for COVID. So, I wasn't so encouraged to get it to protect me from an illness that is not dangerous for me. But I would like to stop wearing masks, so that is a good reason to get the vaccine. (Δ: +2.24)

Others described missing travel, the requirement of the vaccine to travel, and the drive to see family and friends in person. One participant described both the motivation to travel and to see family and friends.

As a requirement to be able to fly on an airplane until at least the end of 2021, I did not have much choice but to get the vaccination. I wasn't able to see my friends and family in person last year because of the pandemic lockdown, and I deeply miss them. I do not want to miss seeing them for another year. (Δ: +2.00)

Other less common themes

A few less common yet interesting themes emerged from the qualitative data. Such themes included social pressure to vaccinate, endorsement of COVID-19 vaccines, and the drive to reduce vaccine waste. Some participants described how friends and family pressured them to receive COVID-19 vaccines, largely to protect them from complications with the virus.

I was guilted into getting vaccinated. I never thought I would. I do not trust the unknown long-term effects. But if I were to get COVID, I would probably be hospitalized, and chances are I'd be very ill or not survive. My family and friends, my husband, in particular, was not thrilled with that scenario. So, to keep the peace, I got vaccinated. (Δ: +7.49)

In terms of vaccine endorsement, only one participant described how former President Trump's encouragement to vaccinate influenced his decision to seek the vaccine. Specifically, this participant stated,

I changed my mind and became more willing to get vaccinated after I listened to former President Trump encourage individuals to get vaccinated. He made these comments after he was no longer in office. I trust President Trump and the message he shared on the talk show I heard him on. I knew that the vaccine was approved and encouraged under his administration, so I felt safer. (Δ: +3.74)

Additionally, one participant described the drive to increase vaccination and, thereby, reduce vaccine waste as a reason for seeking the vaccine.

Decreased willingness to vaccinate

Themes that emerged among individuals who became less willing to vaccinate include fears of short- and long-term safety after receiving COVID-19 vaccines, the low perceived need to vaccinate, various forms of distrust surrounding vaccine development and dissemination, and concerns about vaccine effectiveness. A less common theme included structural barriers to receiving the vaccine.

Vaccine safety concerns

Participants who reported being less willing to vaccinate against COVID-19 most frequently expressed fears that COVID-19 vaccines are unsafe and could lead to long-term side effects.

I've spoken to people who have taken the vaccine and am surprised by how they felt afterward. The short-term side effects (chills, pain, fatigue) are more than I expected. It makes me think there will be long-term effects we don't know about yet. Instead of getting sick for days from the vaccine, I'll keep risking getting COVID. (Δ= -7.8)

Other participants described health conditions that compromised their immune systems as the reason for their unwillingness to vaccinate. Such pre-existing health complications cited included primary lymphedema, unexplained inflammation, and auto-immune disorders. These individuals talked to their healthcare providers about receiving COVID-19 vaccines and ultimately decided not to vaccinate. Last, a few participants feared the safety of COVID-19 vaccines, explicitly citing the news stories about the risk of developing blood clots after receiving the Johnson & Johnson COVID-19 vaccine.

I am a bit worried about the negative news concerning the vaccine, especially the J&J vaccine causing death in some women. I belong to that age group of women who died of blood clots after the vaccine. (Δ= -1.37)

Low perceived need

Many participants preferred to rely on their body's natural immune defenses against the virus rather than receive COVID-19 vaccines, reasoning that if they were to become infected with COVID-19, they would likely experience only mild symptoms.

I am fairly young and do not feel the need to get a shot every year. If the problem is spreading the virus, I know how not to spread it and will not spread it if I

become infected. If the reason for getting it is to prevent getting sick, I do not believe I will get very sick from it, either. (Δ: −2.25)

Some participants noted that many others had received a COVID-19 vaccine, so they no longer needed to vaccinate. Therefore, it was not important that they vaccinate, given that others' vaccine uptake protected them.

So many Americans have already gotten the vaccine. I do not feel it is as important to get it now. If I have gone this long without being affected by COVID, I believe that with so many people already vaccinated, my chances of being affected by COVID are even less than when no one was vaccinated. (Δ: -5.46)

Others expressed that they were not afraid of contracting COVID-19 because they did not perceive the virus as dangerous to their health.

I have never been infected with COVID so far. Even after going to parties, I was never infected. Neither my close circle of friends nor I have been infected. Honestly, I am not afraid of COVID as much as I was before. I believe we are well immunized naturally against the virus, or we are not in a group at greater risk for falling ill from the virus. (Δ: -2.83)

Others reported a perceived lack of need for vaccination since they recently recovered from COVID-19 and felt sufficiently protected due to naturally-acquired immunity.

I had a severe case of COVID, and I have read various reports that it might be the same as having the vaccine since I have antibodies in my system. (Δ: -4.87)

Some participants described how the reduced COVID-19 incidence and hospitalizations led to their reduced perceived susceptibility to contracting the virus and, therefore, reduced their willingness to vaccinate. Additionally, individuals living in smaller towns and rural regions described how they did not perceive the vaccine as necessary due to living in less populated communities.

I do not think I need it. I live in a small town with a low population, so COVID-19 is not spreading in my town very quickly. I think the vaccine is only important in large population areas with a high spread rate, so I probably will not get the vaccine for the virus. (Δ: −2.92)

Distrust

Participants often described the role of varying types of distrust as impacting their willingness to vaccinate against COVID-19. Many participants described their distrust of the COVID-19 vaccine development process, believing the lack of testing and rapid vaccine development process undermined vaccine safety and effectiveness.

I feel they came about too fast. The scientists did not have enough time to properly test them. We don't know if there will be long-term side effects because they weren't tested long enough. One month with no major side effects in a trial does not mean that there will be none after six months to a year. (Δ: -8.90)

Another participant described doubts about the scientific research behind mRNA vaccine technology and the desire to avoid being experimented upon by receiving what they believe is an unproven vaccine.

I have learned more about the science of the vaccine, or better said, the lack of science on the vaccine. I am not comfortable with mRNA tech just yet. I am just not ready to be part of the experiment that I see this whole vaccination process as being. (Δ: −2.90)

Some individuals described a lack of confidence in COVID-19 vaccines due to the federal government's vaccination promotion campaigns, one describing it as the government "pushing it down our throats." Meanwhile, others described a mistrust of U.S. healthcare and pharmaceutical companies, expressing antipathy toward companies' profit motive for requiring booster doses in the future.

Pharmaceutical companies are already trying to monetize it by requiring boosters and seasonal shots. It's free now, this one time, but it will not continue to be free in the future. Generally, I just have mistrust and disdain for US healthcare. (Δ: −2.05)

A few participants described how the various campaigns incentivizing vaccinating against COVID-19 made them further mistrust these vaccines, calling these initiatives "propaganda" to mislead communities into *vaccinating.*

Vaccine effectiveness concerns

Some respondents questioned vaccine effectiveness as COVID-19 infection rates increased over time. One participant described,

I think that the fact that so many people have taken the vaccine, yet there has not been a significant change in infections, has impacted my belief about the effectiveness of the vaccine. (Δ: −5.45)

Others questioned the vaccine's ability to provide long-lasting protection, given the news that individuals may need booster doses in the future. Additionally, the potential for breakthrough infections even after vaccinating discouraged some participants from vaccinating.

Structural barriers to vaccination

Some participants describe structural barriers such as the inconvenience of obtaining a vaccine, time off work if they experience short-term effects from the shot, and the cost of the vaccine as barriers. One participant described how, due to their disdain for receiving vaccines, they would only receive the vaccine "on the spot" at a doctor's office. Otherwise, they would not put effort into seeking the vaccine. A few participants described how they could take time off work to receive the vaccine or if they experience side effects after receiving it. One participant stated,

> *Some of my friends and family have gotten the vaccine, and they have not reacted well to it. So, I am worried that I might not react well to it, and then I will have to miss out on work, which I cannot afford to do.* (Δ: −5.02)

Two participants, not realizing that COVID-19 vaccines were offered free of charge, noted that the vaccine cost was unaffordable.

Discussion

This paper highlights U.S. adults' rationale for their changes in the degree of willingness to vaccinate against COVID-19 over five months during the initial vaccine distribution efforts. Larger themes that emerged from the data include perceived vaccine safety and effectiveness, perceived protection against COVID-19, a desire to return to pre-pandemic "normal", the role of perceived susceptibility to COVID-19 and complications with this virus in both vaccine hesitancy and acceptance, and trust (in the vaccine, the federal government, and pharmaceutical companies).

The most frequently reported reasons for changes in vaccine hesitancy or acceptance relate to the perceived safety and effectiveness of COVID-19 vaccines. Highly vaccine-hesitant individuals expressed fear that COVID-19 vaccines were unsafe and could lead to long-term negative health outcomes (Kricorian et al. 2022; Peretti-Watel et al. 2020). Few participants specifically cited an increased risk of blood clots as their primary concern about COVID-19 vaccine safety. It is notable that between the deployment of T1 and T2 surveys, the U.S. Food and Drug Administration halted production of the Johnson & Johnson Janssen COVID-19 vaccine for ten days after six vaccine recipients (all women between ages 18–59) developed blood clots post-vaccination (U.S. Food and Drug Administration 2021). U.S. adults' skepticism about vaccine safety is understandable given the proliferation of information about negative side effects and dangers of the vaccine in the news media.

Similar to past research, other vaccine-hesitant participants cited the perceived risk of breakthrough infections and the lack of proven lasting immunity of the initial COVID-19 vaccine doses (illustrating waning protection of the vaccines) as evidence that the vaccine is ineffective (Dzinamarira et al. 2022; Lin et al. 2020). Over time, immunity has waned with the original COVID-19 doses; however, that does not mean that the vaccines are ineffective. Additional COVID-19 vaccine booster doses have become available, and research has estimated a 90–94% effectiveness at reducing both urgent care and emergency department admissions among individuals who received these additional doses (Thompson et al. 2022). Therefore, it is critical to continue promoting the uptake of these CDC-recommended additional COVID-19 doses to continue protecting individuals' health against this virus.

Participants who reported increased willingness to vaccinate described a desire to protect themselves and others from COVID-19 (Cordina and Lauri 2021; Goffe et al. 2021; Kowalski et al. 2022; Shmueli 2021). The desire to protect others by getting vaccinated has also been observed in previous work, particularly in regard to providing additional protection for immunosuppressed or high-risk family and friends, as well as among individuals with children who, at the time, were unable to receive COVID-19 vaccines (Enticott et al. 2022; Evans et al. 2021). Additionally, among those who indicated increased willingness to vaccinate against COVID-19, the theme of pro-social behavior through protecting other community members against the spread of this virus emerged. Other participants described vaccination as a civic duty. In a study of vaccine motivations among hesitant adopters of the COVID-19 vaccine, Moore et al. found that extrinsic motivation factors such as community protection led to increased willingness to vaccinate among healthcare workers (Moore et al. 2021). Another study reported healthcare workers' perception of vaccinating against COVID-19 to protect high-risk individuals as a moral value (Bolsewicz et al. 2021). Other studies found that participants experienced feelings of social obligation to protect their wider communities and do their part to stop the spread of COVID-19, achieve herd immunity, and ultimately eradicate COVID-19 (Evans et al. 2021; Moore et al. 2021). In a large cross-sectional study, investigators found that the sense of social responsibility as a motivating factor for vaccination increased with age among participants, perhaps reflecting generational norms (Kumari et al. 2021). Therefore, emphasizing community protection may serve as a motivating factor to encourage vaccine uptake in future pandemics and vaccine rollout initiatives.

Another motivating factor among more vaccine-receptive individuals was the theme that vaccination would expedite a return to "pre-pandemic" or "normal" life. Similar to past research, participants believed that increased vaccination would decrease the need for social distancing and wearing face masks, preventive behaviors with which many voiced

frustrations (Moore et al. 2021). Additionally, participants reported that a desire to travel without restrictions and visit long-missed family and friends were significant motivators in their willingness to vaccinate. Further, in a study of vaccine-hesitant individuals, Morales et al. reported that resuming their pre-COVID lives was a significant contributing factor to positive inclinations to vaccinate (Morales et al. 2022). The desire to regain some sense of normalcy appears to be a strong influence, particularly among vaccine-hesitant populations. Emphasizing vaccination as a behavior that can lead to a return to societal normalcy may encourage vaccine uptake among some vaccine-hesitant individuals.

Previous research has found that the Health Belief Model constructs of perceived susceptibility and severity of illness act as predictors of vaccine acceptance (Al-Jumaili and Hamzah 2022; Mercadante and Law 2021). Our study supports these findings, as a common theme among participants unwilling to vaccinate against COVID-19 was a low perceived need for the vaccine. Participants frequently made statements indicating the belief that the virus would not result in future negative health outcomes and that COVID-19 was not much more severe than a common viral upper respiratory infection. These beliefs are likely the result of the prevalence of misinformation on social media or other media outlets, promoting skepticism and lack of adherence to official public health recommendations (van der Linden 2022). Participants' low perceived need for vaccination could also highlight the degree to which misinformation surrounding COVID-19 contributes to suboptimal vaccination rates (Loomba et al. 2021).

Participants also frequently cited previous COVID-19 infection and subsequent recovery as a reason for the low perceived need for vaccination. This is consistent with previous research that reported lower willingness to vaccinate following recovery from COVID-19, even for individuals who were hospitalized due to infection (Gerussi et al. 2021). Despite evidence that vaccinating after recovering from COVID-19 reduces the risk of reinfection, individuals who had recently recovered still believed that vaccination was unnecessary (Hammerman et al. 2022). Both natural immunity post-COVID-19 infection and immunity from the initial COVID-19 vaccine doses decline over time; however, hybrid immunity (of natural- and vaccine-induced immunity) has been associated with additional protection from COVID-19 reinfection and hospitalization due to complications with the virus for up to nine months (Nordström et al. 2022), highlighting the additional protection of vaccination after recovering from COVID-19. Therefore, emphasizing this additional protection from vaccination is critical among those who recovered from COVID-19.

Interestingly, rurality was a cited reason among participants for their low perceived need to vaccinate. Many participants in rural areas described the perceived non-necessity due to the relatively low prevalence of COVID-19 in their communities compared to more urban, heavily populated areas. Our analysis suggests that rural populations may have lower vaccination rates due to low perceived susceptibility to infection and not necessarily due to a lack of access to healthcare providers and resources (Murthy et al. 2021). It is important to note that COVID-19 infection rates were lower in rural regions during this study period; however, between August and November 2021, the epidemic epicenter shifted to impact more rural regions of the country (Bass et al. 2021). Further investigation to explore why rural communities have disproportionately lower vaccination rates than urban communities will be crucial to developing strategies to motivate rural communities toward vaccination.

Following previous research, participants reported low levels of trust in COVID-19 vaccination efforts in general (Liu and Chu 2022) and in public health, the federal government, and vaccine manufacturers, in particular, significantly impacting their willingness to vaccinate (Jennings et al. 2021). Among those less willing to vaccinate, many did not trust the process of vaccine development and production, expressing concerns about the insufficient temporal length of clinical trials and of study population numbers inadequate to establish a reliable level of safety and efficacy (Latkin et al. 2021). Some participants reported their lack of trust in pharmaceutical companies as the rationale for their lack of willingness to vaccinate against COVID-19. Past research has identified similarly low levels of confidence in the pharmaceutical industry among participants, with some citing concerns of further pharmaceutical industry malfeasance following the role some companies played in exacerbating the opioid crisis (Latkin et al. 2021). Other forms of distrust that impacted levels of vaccine willingness included distrust in the federal government. Past research has highlighted how the politicization of this disease prevention resource has undermined U.S. adults' COVID-19 vaccine confidence (Bokemper et al. 2021). Future vaccine communication efforts should be encouraged by health professionals rather than political figures. Although past research found that individuals who generally distrust the healthcare system are less likely to vaccinate (Liu and Chu 2022), these findings were not further substantiated within the scope of this qualitative content analysis.

Limitations

Several major considerations limit the interpretation of this study's findings. First, we collected survey data via river sampling from an online survey marketplace, MTurk, a site that is open to global public participation. This data collection method increases the risk of coverage bias and may not adequately represent a random sample of U.S. adults (Lehdonvirta et al. 2021). While MTurk offers access to relatively diverse samples, its community is known to be younger,

white, liberal, and more educated (Boas et al. 2020). Several known threats to MTurk data quality exist, including international respondents masking their geolocation using services like virtual private networks (VPNs), non-human responses (bots), and low attention span. We aimed to control for these threats to data quality by cross-checking individuals' geolocation. We also included a reCAPTCHA to control for bots, as well as an attention check to ensure participants were reading survey questions.

Additionally, our analysis only included responses from individuals whose willingness to vaccinate against COVID-19 changed by more than one point. We believe that this showed a true change in scores instead of a simulated change due to the use of a slider scale in survey response entry, which produced non-discrete data output and could result in inexact data entry on the part of respondents. For example, some respondents with less than a one-point change stated that their willingness to vaccinate did not change, suggesting an error in entry or measurement.

Conclusion

This study summarizes U.S. adults' reported changes in willingness to vaccinate against COVID-19 over the initial vaccine rollout period between January and May 2021. Participants cited vaccine safety and effectiveness as the most compelling reasons for increased or decreased willingness to vaccinate against COVID-19. Individuals who expressed being more vaccine-hesitant also expressed a lower perceived need to vaccinate. In contrast, more vaccine-willing participants described how the desire to protect themselves and others increased their willingness to vaccinate. Study results suggest utilizing various messages promoted by health professionals to increase confidence in COVID-19 vaccines. Messaging strategies can include the continued promotion of COVID-19 vaccines and booster doses to offer additional protection against the virus. Emphasizing vaccination as a pro-social behavior to protect communities may enhance the perceived moral obligation to vaccinate. In future pandemics, articulating that vaccine uptake can lead to a societal return to normalcy may increase individuals' willingness to vaccinate against the pandemic. Furthermore, using such messages in future health communication campaigns may increase individuals' willingness to vaccinate.

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Author contributions **Alexis M. Koskan** created and oversaw the project; co-conducted the qualitative content analysis; wrote a majority of the manuscript, and assisted in editing. **Benjamin S. Teeter** co-conducted the qualitative content analysis and wrote sections of the Discussion. **Casey L. Daniel** contributed to the Discussion and Conclusion. **Iris E. LoCoco** wrote portions of the Results and edited the final paper. **Ulrich T. Jensen**: Was the project administrator for the full experimental study, curated data, and edited the final manuscript. **Stephanie L. Ayers** curated study data and edited the final manuscript.

Data availability Study materials and data are available upon request.

Code availability Not applicable.

Declarations

Ethics approval This research (STUDY00013200) received Institutional Review Board approval.

Consent to participate All study participants completed an online informed consent.

Consent for publication All participants were notified of the researchers' intent to publish study findings in the informed consent.

Conflict of interest Authors have no conflicts of interest to report.

References

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50(2):179–211

Al-Jumaili AA, Hamzah AH (2022) Major drivers for COVID-19 vaccine acceptance: a scoping review. Al-Rafidain. J Med Sci 2:32–39. https://doi.org/10.54133/ajms.v2i.59

Amin K, Ortaliza J, Cox C, et al (2022) COVID-19 preventable mortality. https://www.kff.org/coronavirus-covid-19/issue-brief/covid-19-continues-to-be-a-leading-cause-of-death-in-the-u-s/. Accessed 1 May 2022

Bass SB, Wilson-Genderson M, Garcia DT et al (2021) SARS-CoV-2 vaccine hesitancy in a sample of us adults: role of perceived satisfaction with health, access to healthcare, and attention to COVID-19 news. Front Public Health 9:665724. https://doi.org/10.3389/fpubh.2021.665724

Boas TC, Christenson DP, Glick DM (2020) Recruiting large online samples in the United States and India: Facebook, mechanical Turk, and Qualtrics. Polit Sci Res Methods 8:232–250. https://doi.org/10.1017/psrm.2018.28

Bokemper SE, Huber GA, Gerber AS et al (2021) Timing of COVID-19 vaccine approval and endorsement by public figures. Vaccine 39(5):825–829

Bolsewicz KT, Steffens MS, Bullivant B et al (2021) "To protect myself, my friends, family, workmates and patients… and to play my part": COVID-19 vaccination perceptions among health and aged care workers in New South Wales, Australia. Int J Environ Res Public Health 18(17):8954. https://doi.org/10.3390/ijerph18178954

Burleigh T, Kennedy R, Clifford S (2018) How to screen out VPS and international respondents using Qualtrics: a protocol. SSRN. https://doi.org/10.2139/ssrn.3265459

Cordina M, Lauri MA (2021) Attitudes towards COVID-19 vaccination, vaccine hesitancy and intention to take the vaccine. Pharm Pract 19(1). https://doi.org/10.18549/pharmpract.2021.1.2317

COVID-19 Response Team (2020) Severe outcomes among patients with coronavirus disease 2019 (COVID-19)-United States,

February 12-march 16, 2020. MMWR Morb Mortal Wkly Rep 69(12):343–346. https://doi.org/10.15585/mmwr.mm6912e2
Dzinamarira T, Tungwarara N, Chitungo I et al (2022) Unpacking the implications of SARS-CoV-2 breakthrough infections on COVID-19 vaccination programs. Vaccines 10(2):252. https://doi.org/10.3390/vaccines10020252
Enticott J, Gill JS, Bacon SL et al (2022) Attitudes towards vaccines and intention to vaccinate against COVID-19: a cross-sectional analysis—implications for public health communications in Australia. BMJ Open 12(1):e057127. https://doi.org/10.1136/bmjopen-2021-057127
Evans S, Klas A, Mikocka-Walus A et al (2021) "Poison" or "protection"? A mixed methods exploration of Australian parents' COVID-19 vaccination intentions. J Psychosom Res 150:110626. https://doi.org/10.1016/j.jpsychores.2021.110626
Fisk RJ (2021) Barriers to vaccination for COVID-19 control—experience from the United States. Global Health J:5L51–5L55. https://doi.org/10.1016/j.glohj.2021.02.005
Gerussi V, Peghin M, Palese A et al (2021) Vaccine hesitancy among Italian patients recovered from COVID-19 infection towards influenza and Sars-Cov-2 vaccination. Vaccines 9:172. https://doi.org/10.3390/vaccines9020172
Goffe L, Antonopoulou V, Meyer CJ et al (2021) Factors associated with vaccine intention in adults living in England who either did not want or had not yet decided to be vaccinated against COVID-19. Hum Vaccin Immunother 17:5242–5254. https://doi.org/10.1080/21645515.2021.2002084
Hamel L. Sparks G, Brodie M (2021a) KFF COVID-19 Vaccine Monitor: February 2021. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-february-2021/. Accessed 1 May 2022
Hamel L, Kirzinger A, Lopes L, et al (2021b) KFF COVID-19 vaccine monitor: may 2021. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-may-2021/ Accessed 1 May 2022
Hammerman A, Sergienko R, Friger M et al (2022) Effectiveness of the BNT162b2 vaccine after recovery from Covid-19. N Engl J Med 386:1221–1229. https://doi.org/10.1056/NEJMoa2119497
Hsieh HF, Shannon SE (2005) Three approaches to qualitative content analysis. Qual Health Res 15:1277–1288. https://doi.org/10.1177/1049732305276687
Huang JL, Bolwing NA, Liu M, Li Y (2015) Detecting insufficient effort responding with an infrequency scale: evaluating validity and participant reactions. J Bus Psychol 2015:299–311. https://doi.org/10.1007/s10869-014-9357-6.11
Jennings W, Stoker G, Willis H et al (2021) Lack of trust and social media echo chambers predict COVID-19 vaccine hesitancy. MedRxiv 9:593. https://doi.org/10.3390/vaccines9060593
Jensen UT, Ayers S, Koskan A (2022) Video-based messages to reduce COVID-19 vaccine hesitancy and nudge vaccination intentions. PLOS One 17(4):e0265736. https://doi.org/10.1371/journal.pone.0265736
Kates J, Rouw A, Michaud J (2021) Supply vs demand: Which states are reaching their COVID-19 vaccine tipping points? https://www.kff.org/policy-watch/supply-vs-demand-which-states-are-reaching-their-covid-19-vaccine-tipping-points/. Accessed 4 May, 2021
Kowalski RM, Deas N, Britt N et al (2022) Protection motivation theory and intentions to receive the COVID-19 vaccine. Health Promot Pract. https://doi.org/10.1177/15248399211070807
Kricorian K, Civen R, Equils O (2022) COVID-19 vaccine hesitancy: misinformation and perceptions of vaccine safety. Hum Vaccin Immunother 18:1950504. https://doi.org/10.1080/21645515.2021.1950504
Kumari A, Ranjan P, Chopra S et al (2021) Knowledge, barriers and facilitators regarding COVID-19 vaccine and vaccination programme among the general population: a cross-sectional survey from one thousand two hundred and forty-nine participants. Diabetes Metab Syndr Clin Res Rev 15:987–992. https://doi.org/10.1016/j.dsx.2021.04.015
Latkin CA, Dayton L, Yi G et al (2021) Trust in a COVID-19 vaccine in the US: a social-ecological perspective. Soc Sci Med 270:113684. https://doi.org/10.1016/j.socscimed.2021.113684
Lehdonvirta V, Oksanen A, Räsänen P, Blank G (2021) Social media, web, and panel surveys: using non-probability samples in social and policy research. Policy Internet 13:134–155. https://doi.org/10.1002/poi3.238
Lin C, Tu P, Beitsch LM (2020) Confidence and receptivity for COVID-19 vaccines: a rapid systematic review. Vaccines 9:16. https://doi.org/10.3390/vaccines9010016
Liu S, Chu H (2022) Examining the direct and indirect effects of trust in motivating COVID-19 vaccine uptake. Patient Educ Couns 105:2096–2102. https://doi.org/10.1016/j.pec.2022.02.009
Loomba S, de Figueiredo A, Piatek SJ et al (2021) Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. Nat Hum Behav 5(3):337–348. https://doi.org/10.1038/s41562-021-01056-1
MacDonald NE (2015) Vaccine hesitancy: definition, scope and determinants. Vaccine 33:4161–4164. https://doi.org/10.1016/j.vaccine.2015.04.036
Mason W, Suri S (2012) Conducting behavioral research on Amazon's mechanical Turk. Behav Res Methods 44:1–23. https://doi.org/10.3758/s13428-011-0124-6
Mercadante AR, Law AV (2021) Will they, or Won't they? Examining patients' vaccine intention for flu and COVID-19 using the health belief model. Res Soc Adm Pharm 17(9):1596–1605. https://doi.org/10.1016/j.sapharm.2020.12.012
Moore R, Purvis RS, Hallgren E et al (2021) Motivations to vaccinate among hesitant adopters of the COVID-19 vaccine. J Community Health 47:237–245. https://doi.org/10.1007/s10900-021-01037-5
Morales GI, Lee S, Bradford A et al (2022) Exploring vaccine hesitancy determinants during the COVID-19 pandemic: an in-depth interview study. SSM Qual Res Health 2:100045. https://doi.org/10.1016/j.ssmqr.2022.100045
Murthy BP, Sterrett N, Weller D et al (2021) Disparities in COVID-19 vaccination coverage between urban and rural counties—United States, December 14, 2020–April 10, 2021. MMWR Recomm Rep 70:759–764. https://doi.org/10.15585/mmwr.mm7020e3
Nordström P, Ballin M, Nordström A (2022) Risk of SARS-CoV-2 reinfection and COVID-19 hospitalisation in individuals with natural and hybrid immunity: a retrospective, total population cohort study in Sweden. Lancet Infect Dis 22:781–790. https://doi.org/10.1016/S1473-3099(22)00143-8
Peretti-Watel P, Seror V, Cortaredona S et al (2020) A future vaccination campaign against COVID-19 at risk of vaccine hesitancy and politicisation. Lancet Infect Dis 20:769–770. https://doi.org/10.1016/S1473-3099(20)30426-6
Polack FP, Thomas SJ, Kitchin N et al (2020) Safety and efficacy of the BNT162b2 mRNA COVID-19 vaccine. N Engl J Med 383:2603–2615. https://doi.org/10.1056/NEJMoa2034577
Rosenstock IM (1974) The health belief model and preventive health behavior. Health Educ Monogr 2:354–386. https://doi.org/10.1177/109019817400200405
Shmueli L (2021) Predicting intention to receive COVID-19 vaccine among the general population using the health belief model and the theory of planned behavior model. BMC Public Health 21:1–13. https://doi.org/10.1186/s12889-021-10816-7
Thompson MG, Natarajan K, Irving SA et al (2022) Effectiveness of a third dose of mRNA vaccines against COVID-19–associated emergency department and urgent care encounters and hospitalizations among adults during periods of Delta and omicron variant predominance — VISION network, 10 states, august

2021–January 2022. Morb Mortal Wkly Rep 71(4):139–145. https://doi.org/10.15585/mmwr.mm7104e3

US Food and Drug Administration (2021) FDA and CDC lift recommended pause on Johnson & Johnson (Janssen) COVID-19 vaccine use following thorough safety review [Press release]. https://www.fda.gov/news-events/press-announcements/fda-and-cdc-lift-recommended-pause-johnson-johnson-janssen-covid-19-vaccine-use-following-thorough. Accessed 1 May 2022

van der Linden S (2022) Misinformation: susceptibility, spread, and interventions to immunize the public. Nat Med 28:460–467. https://doi.org/10.1038/s41591-022-01713-6

Witte K (1992) Putting the fear back into fear appeals: the extended parallel process model. Commun Monogr 59:329–349. https://doi.org/10.1080/03637759209376276