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The role of trust in the likelihood of receiving a COVID-19 vaccine: Results from a national survey

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ABSTRACT

High acceptance of coronavirus disease 2019 (COVID-19) vaccines is instrumental to ending the pandemic. Vaccine acceptance by subgroups of the population depends on their trust in COVID-19 vaccines. We surveyed a probability-based internet panel of 7832 adults from December 23, 2020–January 19, 2021 about their likelihood of getting a COVID-19 vaccine and the following domains of trust: an individual's generalized trust, trust in COVID-19 vaccine's efficacy and safety, trust in the governmental approval process and general vaccine development process for COVID-19 vaccines, trust in their physician about COVID-19, and trust in other sources about COVID-19. We included identified at-risk subgroups: healthcare workers, older adults (65–74-year-olds and ≥ 75-year-olds), frontline essential workers, other essential workers, and individuals with high-risk chronic conditions. Of 5979 respondents, only 57.4% said they were very likely or somewhat likely to get a COVID-19 vaccine. More hesitant respondents ($p < 0.05$) included: women, young adults (18–49 years), Blacks, individuals with lower education, those with lower income, and individuals without high-risk chronic conditions. Lack of trust in the vaccine approval and development processes explained most of the demographic variation in stated vaccination likelihood, while other domains of trust explained less variation. We conclude that hesitancy for COVID-19 vaccines is high overall and among at-risk subgroups, and hesitancy is strongly tied to trust in the vaccine approval and development processes. Building trust is critical to ending the pandemic.

1. Introduction

The United States (US) has experienced devastating consequences of coronavirus disease 2019 (COVID-19). Deaths have disproportionately affected adults over 65 years, racial and ethnic minority populations and those with certain underlying chronic conditions.(Chou et al., 2020; Goldman et al., 2020; Wang et al., 2020) Healthcare workers (Chou et al., 2020) and frontline essential workers (Goldman et al., 2020) are at high risk of infection (Rossen et al., 2020).

The end of the COVID-19 pandemic will depend on widespread uptake of the COVID-19 vaccines recommended by the Federal Drug Administration (FDA) and the Advisory Committee on Immunization Practices (ACIP) (Oliver et al., 2020a,b). Future booster doses or modified vaccines may be needed due to genetic mutations of the coronavirus (Moore and Offit, 2021).

The ACIP initially recommended a phased allocation (Dooling et al., 2020a; Dooling et al., 2020b; Dooling et al., 2021; McClung et al., 2020) of scarce COVID-19 vaccines to at-risk subgroups of the population: Phase 1a – healthcare workers and residents of long-term care facilities; Phase 1b – individuals over 75 years and frontline essential workers; Phase 1c – individuals 65–74 years, other essential workers, and those with chronic conditions that increase risk for severe COVID-19 illness (i.e., high-risk chronic conditions); and Phase 2 – all remaining eligible people (Dooling et al., 2020a; Dooling et al., 2020b). Ending the pandemic depends on these groups accepting the vaccines (Paltiel et al., 2021) (Weintraub et al., 2021). Also, these subgroups are likely at risk from future pandemics.

Published studies using both convenience internet samples (Guidry

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et al., 2021; Head et al., 2020; Kreps et al., 2020; Lazarus et al., 2020; Malik et al., 2020; Pogue et al., 2020; Reiter et al., 2020; Taylor et al., 2020) and probability-based samples (Daly and Robinson, 2020; Fisher et al., 2020; Romer and Jamieson, 2020; Southwell et al., 2020; Szilagyi et al., 2020b) have found that only about one-half to two-thirds of US adults intend to be vaccinated. A national survey performed from November 25–December 8, 2020, found that women, younger adults, Blacks, and individuals with lower educational attainment were more hesitant (Szilagyi et al., 2020b). CDC-sponsored probability-based surveys in September–October and late December 2020 noted high hesitancy among all groups prioritized for early vaccination (Nguyen et al., 2021).

Vaccine hesitancy is a world-wide phenomenon (Edwards and Hackell, 2016). Underlying factors include concerns about vaccine effectiveness or short- or long-term side effects and skepticism about the seriousness of the diseases prevented by vaccines or about the overall benefit of vaccines (Brewer et al., 2017; Kempe et al., 2020; Szilagyi et al., 2020a). A key underlying factor is trust (Kempe et al., 2020; Szilagyi et al., 2020a). In a systematic review, Larson et al. (2018)) noted that vaccine acceptance is contingent on people's trust in the safety and efficacy of vaccines as well as in the health system, health professionals, and the broader vaccine research community. Thus, some interventions addressing hesitancy focus on building trust (Edwards and Hackell, 2016).

Acceptance or hesitancy for COVID-19 vaccines has unique features. While the devastating and immediate consequences of the pandemic might increase desire for vaccination, the vaccines' novelty, their rapid development, evaluation, and approval, and perceptions of political interference in their development and evaluation processes may have reduced the public's trust in the vaccines and their desire to be vaccinated (Bloom et al., 2020).

The objective of this study was to better understand the enduring concept of how trust influences the public's likelihood of getting a COVID-19 vaccine. From December 23, 2020–January 19, 2021, we surveyed a representative, online sample of US adults about their likelihood of getting a COVID-19 vaccine when available (Szilagyi et al., 2020b), and we examined the relationship between different domains of trust and the public's likelihood of getting a COVID-19 vaccine.

2. Methods

The University of Southern California's IRB approved this study; participants provided written, informed consent.

2.1. The Understanding America Study (UAS): online survey and participants

The UAS is a probability-based internet panel of about 9000 adults (≥18 years) representing the non-institutionalized US population (Kapteyn et al., 2020). Panel members are recruited via address-based sampling. A tablet and broadband internet are provided to panel members without prior internet access. Invitations for each new survey are sent by email or postcard; respondents receive about $20 for each half-hour of survey time. Surveys are offered in English or Spanish.

Since April 1, 2020, the UAS has surveyed a subsample of the panel biweekly about the COVID-19 pandemic (Kapteyn et al., 2020; Szilagyi et al., 2020b). The full UAS panel was invited to participate; 89% have consented to participate. Each day, about one-fourteenth of this consenting subsample (about 590 respondents) is invited to complete a survey. On average, about 75% respond in any given two-week period. To balance responses across surveys, a nested stratified design is used to randomly assign each respondent to a start day (the day they are invited to participate in the survey), which repeats every fourteen days. Survey invitations are balanced by age, sex, employment status, and Los Angeles County resident (oversampled in the UAS panel). Each respondent has a 14-day window to respond, after which the next survey becomes available. Thus, the full field cycle for any given survey wave is 28 days, with a 14-day window for the full sample to be invited and another 14-day period for them to respond. To encourage a prompt response, a $1 bonus is awarded to respondents who complete the survey on their assigned start day; on average, 81% of respondents respond on their assigned day. We used the data collected from the December 23, 2020–January 19, 2021 survey wave for this study.

2.2. Survey measures

2.2.1. Outcome measure – likelihood of getting a COVID-19 vaccine

By the time of this survey, 2% of respondents had received their COVID-19 vaccine. Among those who had not, we asked: "How likely are you to get vaccinated for coronavirus once a vaccine is available to the public? (Very Likely, Somewhat Likely, Somewhat Unlikely, Very Unlikely, or Unsure). We classified "Very Likely" or "Somewhat Likely" responses as "likely to vaccinate" (and assigned already vaccinated respondents to this category). We interpreted other responses as indicative of COVID-19 vaccine hesitancy.

2.2.2. Characteristics of individuals

Demographic characteristics were obtained upon recruitment into the UAS panel and are updated quarterly (Kapteyn et al., 2020). These characteristics include age (classified here as 18–49, 50–64, 65–74, and ≥75 years), sex, race and ethnicity (classified here as White, Hispanic, Black, Asian, other), educational attainment, and household income.

We asked a series of questions about employment (National Academies of Sciences et al., 2020) (see Appendix). We classified participants as healthcare workers, other workers working outside of the home (frontline essential workers, other essential workers, non-essential workers), individuals who work from home, and those not currently employed.

We asked participants: "Have you been diagnosed by a doctor or other qualified medical professional with any of the following medical conditions?" We identified individuals with at least one condition from a list of chronic conditions (Razzaghi et al., 2020) that increase the risk of severe COVID-19 illness when infected (high-risk chronic conditions, see Appendix).

2.2.3. Trust

We applied several questions that were embedded in the UAS survey to Larson's model (Larson et al., 2018) of trust in vaccination to identify and assess important domains of trust (Table 1). Belief in Efficacy and Safety of COVID-19 Vaccines: We asked: "On a scale of 0 to 100, what is the percent chance that someone who is vaccinated against the coronavirus could still catch it?" and "On a scale of 0 to 100, what is the percent chance that a coronavirus vaccine will cause serious side effects or long-term health problems for someone who has been vaccinated?" For these questions, we categorized responses into quartiles (0–24%, 25–49%, 50–74%, and 75–100%). Trust in the policy-making/approval and development process for COVID-19 Vaccines: We asked: 1) "How much do you trust the governmental approval process to ensure the COVID-19 vaccine is safe for the public", and 2) "How much do you trust the process in general (not just for COVID-19) to develop safe vaccines for the public?" Trust in Sources of Information: We asked- "How much do you trust the following sources of information about the coronavirus (COVID-19)?" We asked about the respondent's physician, various news sources, public health organizations and leaders, political leaders, and other sources (Table A.1 in the Appendix). For the above categorical questions, response options were: "Fully Trust," "Mostly Trust," "Somewhat Trust," and "Do Not Trust."

2.2.4. Generalized trust/distrust

In core surveys that UAS respondents answer every two years, the following question is asked: "I am someone who is generally trusting," with responses of "Agree Strongly," "Agree a Little," "Neither Agree nor

Table 1
Percent of adults who report they are very or somewhat likely to get a COVID-19 vaccine by level of trust in sources of information about the coronavirus (COVID-19).

Domains of trust	Percent of adults who are very or somewhat likely to get a COVID-19 vaccine by trust level				*p*-Value[a]
Generalized trust	Disagree strongly or a little	Neither agree nor disagree	Agree a little	Agree strongly	
I am someone who is generally trusting	61.9%	53.8%	63.2%	51.8%	<0.0001
Belief in vaccine efficacy and safety	**0%– < 25%**	**25%– < 50%**	**50%– < 75%**	**75%–100%**	
Percent chance that someone who is vaccinated against the coronavirus could still catch it	73.6%	52.0%	35.5%	25.5%	<0.0001
Percent chance that a coronavirus vaccine will cause serious side effects or long-term health problems for someone who has been vaccinated	75.9%	46.2%	28.5%	8.3%	<0.0001
Trust in approval/development process for COVID-19 vaccines	**Fully trust**	**Mostly trust**	**Somewhat trust**	**Do not trust**	
Trust in governmental approval process for COVID-19 vaccine	92.2%	85.8%	51.1%	10.9%	<0.0001
Trust in vaccine development process in general	92.3%	79.7%	45.2%	5.8%	<0.0001
Trust in healthcare provider					
Your physician	76.8%	65.3%	36.3%	23.8%	<0.0001
Trust in sources of information					
The World Health Organization (WHO)	83.0%	78.1%	51.0%	31.6%	<0.0001
Local public health officials (e.g., county health departments	80.1%	77.8%	50.3%	21.3%	<0.0001
The Centers for Disease Control and Prevention (CDC)	79.7%	74.3%	46.7%	19.1%	<0.0001
Your contacts on social media	44.5%	60.1%	58.1%	56.9%	0.43
Friends, family members, coworkers, classmates, or acquaintances	26.2%	61.6%	59.3%	52.7%	0.0015
Public television and radio	84.5%	82.9%	59.9%	35.0%	<0.0001
Fox News	61.8%	71.5%	55.0%	56.7%	<0.0001
CNN & MSNBC	80.6%	85.8%	63.8%	40.9%	<0.0001
NBC News & CBS News & ABC News	80.3%	85.9%	64.7%	37.7%	<0.0001
Your local TV news & local newspaper	62.6%	82.9%	62.7%	37.5%	<0.0001
National newspapers (e.g., NY Times, Washington Post, USA Today)	84.1%	83.9%	60.3%	38.2%	<0.0001
President Trump and VP Pence	38.3%	48.4%	50.0%	64.0%	<0.0001
President-Elect Biden and VP-Elect Harris	83.3%	84.3%	60.3%	38.5%	<0.0001

[a] Significance testing used the Cochran-Armitage test for trend, accounting for survey sampling weights.

Disagree," and "Disagree Strongly or a Little". In our analysis we used the most recent answer for each respondent.

Prior to fielding the COVID-19 vaccine questions, we conducted extensive internal testing and a quality assurance check on the data. We reviewed respondent comments on a small initial sample to identify and address any wording or skip pattern issues.

2.3. Statistical analyses

We performed descriptive analyses to assess the US adult population's stated likelihood of getting vaccinated against COVID-19 and the associations between vaccination likelihood, demographics, and different domains of trust (generalized trust, trust in vaccine safety and efficacy, trust in approval/development processes, trust in physicians, and trust in sources of information). We used Cochran-Armitage tests for trend to evaluate unadjusted associations between individual trust items and vaccination likelihood. We used multivariable Poisson regression models with robust standard errors to evaluate associations of demographic characteristics and phased allocation group membership with individuals' stated likelihood of getting vaccinated. We included the following covariates in our primary model: gender, age group, race/ethnicity, educational level, household income, employment status (Appendix), and having at least one high-risk chronic condition.

To evaluate the explanatory role of trust, we fit several additional models. First, we fit separate models using only predictors from individual trust domains. Second, we fit models combining pairs of trust domains to evaluate the predictive value added by each domain in relation to the other domain. We evaluated the performance of each model using area under the receiver operating characteristic curves (AUC, Table 2) and summarized model results using risk ratios and 95% confidence intervals. We included survey sampling weights in all analyses to account for design effects.

We used a significance level of 0.05 for all analyses and conducted analyses using SAS version 9.4 (SAS Institute Inc., Cary, NC).

Table 2
Area under the receiver operating characteristic curves (AUC) for predicting vaccination likelihood by domains of trust.[a]

	Demographics	Generalized Trust	Trust in Vaccine Efficacy and Safety	Trust in Approval and Development Processes[b]	Trust in Healthcare Provider	Trust in Sources of Information
Demographics	0.70					
Generalized Trust	0.70	0.54				
Trust in Vaccine Efficacy and Safety	0.79	0.76	0.76			
Trust in Approval and Development Processes[b]	0.85	0.85	0.86	0.84		
Trust in Healthcare Provider	0.75	0.70	0.79	0.85	0.68	
Trust in Sources of Information	0.82	0.78	0.83	0.87	0.79	0.78

[a]Each cell reports the AUC of a model combining predictors belonging to the row and column categories. The main diagonal (dark shading) summarizes models containing a single category of predictors.
[b]Model containing both variables: trust in the COVID-19 vaccine approval process variable and trust in the general vaccine development process.

3. Results

The invited sample included all 8002 consenting UAS panelists eligible for inclusion in a weighted survey sample; 6066 responded (76%), of which 5979 (99%) answered the question on being likely to get vaccinated.

Select respondent characteristics (Table 3) included: female (52%), age ≥ 65 years (21%), Black (12%), Hispanic (17%), Asian (5%), bachelor's degree or higher (35%), health care worker (6%), frontline essential worker (10%), other essential worker (4%), and having at least one high-risk chronic condition (31%).

3.1. Likelihood of getting a COVID-19 vaccine: overall and at-risk subgroups

Among all respondents, 57.4% stated they were very likely or somewhat likely to get a COVID-19 vaccine (Fig. 1 and Table 3). Within at-risk subgroups, the stated likelihood of vaccination was significantly higher (adjusted for all other demographic variables) among males, individuals ≥50 years, Asians (versus Whites), individuals with some college or Bachelor's degree, individuals with higher household incomes, and individuals with high-risk chronic conditions. Conversely, Blacks (versus Whites), females, individuals 18–49 years, and those with high school or less education were significantly less likely to get a vaccine. Healthcare workers and other frontline essential workers did not differ significantly from individuals working from home in their stated likelihood of vaccination.

3.2. Bivariate analyses: relationship between trust and stated likelihood of vaccination

Table A.1 (Appendix) displays the percent of respondents who indicated different levels of trust in the following domains: generalized trust, trust in the vaccine, trust in the vaccine development and approval processes, and trust in different sources of information about coronavirus (COVID-19). Table 1 displays the relationship between domains of trust and respondents' likelihood of vaccination.

3.2.1. Generalized trust

There was no linear relationship between levels of generalized trust and stated COVID-19 vaccine likelihood (Table 1).

3.2.2. Trust in the vaccine itself

There was a strong linear relationship between respondents' belief that the *vaccine was effective and safe* and their stated vaccination likelihood ($p < 0.0001$, Table 1).

3.2.3. Trust in the vaccine development and approval process

There was a strong linear relationship between respondents' level of trust in the *governmental approval process* and the *general vaccine development process* and respondents' stated vaccination likelihood (Fig. 2 and Table 1).

3.2.4. Trust in sources of information about the coronavirus (COVID-19)

There was a strong linear relationship between respondents' level of *trust in their physician* about coronavirus and their stated vaccination likelihood ($p < 0.0001$, Table 1). Similarly, there was a linear relationship between respondents' level of trust in the WHO, CDC, local public health, most news organizations, and President Biden and Vice-President Harris and their stated vaccination likelihood ($p < 0.0001$, Table 1).

In contrast, there was no relationship between trust in contacts on social media and respondents' stated vaccination likelihood and only a weak association, with no linear relationship, between respondents' level of trust in friends, family, coworkers, classmates or acquaintances and their stated vaccination likelihood. Levels of trust in former President Trump and Vice-President Pence were inversely related to respondents' stated vaccination likelihood.

Table 3
Multivariate analysis of likelihood of vaccination by demographics, phased allocation subgroups, and trust in the government approval and vaccine development processes.[a]

	Unweighted N	Weighted N	Percent likely to get a vaccine	*Not including* questions on trust	*Including* questions on trust
				Adjusted RR[b] (95% CI)	Adjusted RR[b](95% CI)
Overall	6066	6066	57.4%		
Gender					
Female	3560	3136	51.5%	- REF -	- REF -
Male	2506	2930	63.7%	1.13 (1.06, 1.20)	1.05 (1.00, 1.10)
Age (years)					
18–49	2679	3242	50.0%	- REF -	- REF -
50–64	1850	1539	61.2%	1.25 (1.16, 1.35)	1.07 (1.01, 1.14)
65–74	1094	893	70.3%	1.37 (1.25, 1.50)	1.05 (0.98, 1.13)
75+	442	391	73.3%	1.41 (1.27, 1.58)	0.99 (0.89, 1.09)
Race/ethnicity					
White	4052	3787	59.6%	- REF -	- REF -
Hispanic	896	1007	55.3%	1.03 (0.93, 1.15)	1.04 (0.95, 1.13)
Black	469	726	38.7%	0.78 (0.67, 0.90)	0.97 (0.87, 1.10)
Asian	315	321	77.5%	1.26 (1.13, 1.41)	1.12 (1.02, 1.23)
Other	324	214	59.9%	1.03 (0.89, 1.18)	1.10 (0.98, 1.23)
Education					
High school or less	1264	2282	46.9%	- REF -	- REF -
Some college	2217	1657	51.8%	1.09 (1.00, 1.20)	0.98 (0.91, 1.06)
Bachelor's or more	2583	2122	73.1%	1.42 (1.31, 1.54)	1.08 (1.01, 1.15)
Household income					
$0–29,999	1439	1677	44.6%	- REF -	- REF -
$30,000–59,999	1540	1603	54.0%	1.10 (0.99, 1.22)	1.03 (0.95, 1.12)
$60,000–99,999	1490	1387	61.5%	1.18 (1.06, 1.31)	1.03 (0.95, 1.12)
$100,000 or more	1583	1391	72.2%	1.31 (1.18, 1.45)	1.08 (1.00, 1.18)
Employment[c]					
Working from home	1264	1207	60.4%	- REF -	- REF -
Healthcare provider (HCP)	330	321	64.0%	1.16 (1.02, 1.32)	1.13 (1.02, 1.25)
Non-HCP frontline worker	490	510	55.1%	0.96 (0.85, 1.08)	1.03 (0.95, 1.13)
Non-frontline essential worker	204	221	58.4%	1.01 (0.86, 1.19)	0.95 (0.83, 1.09)
Non-essential worker	562	604	52.0%	0.94 (0.83, 1.06)	1.02 (0.93, 1.12)
Not currently employed	2557	2444	59.5%	1.04 (0.96, 1.14)	1.08 (1.00, 1.15)
High-risk chronic Condition[c]					
None	3610	3657	56.7%	- REF -	- REF -
1+	1811	1661	62.8%	1.11 (1.04, 1.18)	1.05 (1.00, 1.11)
Trust in governmental approval process for COVID-19 vaccine					
Do not trust	1167	1392	10.9%		- REF -
Somewhat trust	1913	1935	51.1%		2.11 (1.64, 2.71)
Mostly trust	2173	1971	85.8%		2.61 (2.03, 3.37)
Fully trust	718	628	92.2%		2.58 (1.99, 3.34)
Trust in vaccine development process in general					
Do not trust	874	1090	5.9%		- REF -
Somewhat trust	1697	1788	45.2%		4.14 (2.76, 6.22)
Mostly trust	2441	2184	79.7%		5.63 (3.74, 8.48)
Fully trust	959	865	92.4%		6.06 (4.02, 9.15)

[a] Percent of adults who indicated (December 23–January 19) that they are likely to get a COVID-19 vaccine (either "very likely" or "somewhat likely").
[b] Adjusted relative risk of vaccination likelihood (not including and then including the two questions on trust in the COVID-19 vaccine approval process and trust in the general vaccine development process). Model area under the curve (AUC) is 0.70 when not including questions on trust and 0.85 when including questions on trust. A model with only the trust variables (not shown) had an AUC of 0.84. Adjusted relative risks are mutually adjusted for all the other factors in the table.
[c] See Appendix for methods used to determine employment and high-risk chronic condition.

3.3. Multivariate analyses: trust and likelihood of getting a COVID-19 vaccine

We investigated the explanatory role of trust in relation to vaccination likelihood by first fitting separate models, each consisting of predictors belonging to a single trust domain, and then fitting models combining pairs of domains. We also assessed the extent to which different trust domains explained demographic variation in stated vaccination likelihood using a similar approach. Table 2 presents the AUCs for each of the resulting models. While each trust domain accounted for some of the variation in vaccination likelihood, we found that trust in the vaccine development and approval processes performed better than any of the other domains (AUC: 0.84 versus 0.54–0.78). We further observed that, while trust in the approval/development processes added substantial predictive value when combined with each of the other trust domains (delta AUC: 0.09–0.29), the predictive value of trust in the approval/development processes itself did not appreciably improve when combined with the other trust domains (delta AUC: 0.01–0.03). This suggests that trust in the approval/development processes explains virtually all of the covariation between the other trust domains and stated vaccination likelihood.

Table 3 presents the results of the demographics-only model, as well as the model combining demographics with trust in the approval and development processes items. The demographics-only model identified the following groups of significantly more hesitant respondents: women, young adults (18–49 years), Blacks, and individuals with lower education, lower income, and without high-risk chronic conditions. After adjusting for the relevant trust items, these differences were substantially attenuated, and, in most cases, no longer significant. Blacks were found to be 22% less likely to vaccinate than whites according to the demographics-only model but were only 3% less likely (and not statistically different) after accounting for trust in the approval and

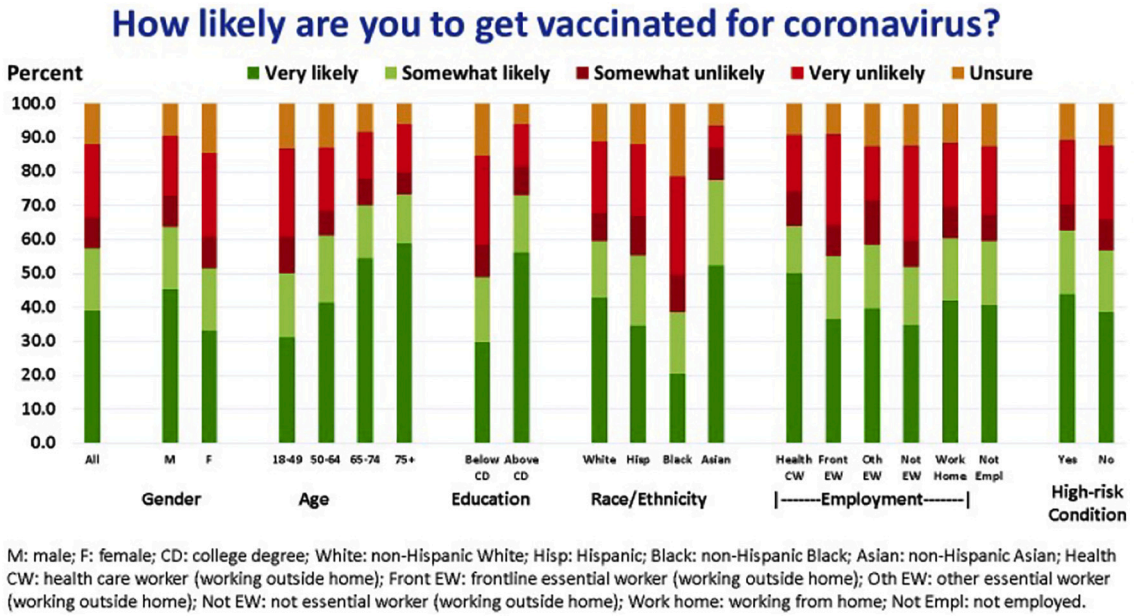

Fig. 1. Likelihood of COVID-19 vaccination among the US adult population (December 23–January 19 Survey): Overall and by gender, age, education, race/ethnicity, healthcare and frontline (or other) essential worker status, and presence of a chronic high-risk condition for severe COVID-19 illness.

development processes. Consistent with what was found for the other trust domains, this suggests that trust in the development and approval processes explains almost all of the demographic variation in stated vaccination likelihood.

4. Discussion

The results of our nationally representative survey performed December 23, 2020–January 19, 2021 show that only 57% of US adults are likely to get a COVID-19 vaccine. Males, adults over 65 years, and individuals with Bachelor's degrees or higher, higher incomes, or with high-risk chronic conditions are more likely to state they will get a vaccine. Females, young adults, Blacks, and individuals with lower educational attainment or household incomes are significantly less likely. Surprisingly, none of the at-risk employment groups, including healthcare workers or other frontline workers, were more likely to state they will get a vaccine than individuals working from home. The central issue driving vaccine hesitancy appears to be trust, particularly trust in the government vaccine approval/development processes.

Our finding that only 57% of US adults plan to get a COVID-19 vaccine is similar to five recent studies (Daly and Robinson, 2020; Funk, 2020; Nguyen et al., 2021; Saad, 2020; Szilagyi et al., 2020b). Our study adds to the literature by demonstrating substantial vaccine hesitancy in January 2021 among at-risk subgroups including healthcare workers and other frontline workers. A particularly concerning finding is that Blacks and individuals with lower educational attainment have substantial hesitancy toward COVID-19 vaccines despite their higher risk of morbidity and mortality from the virus.

The CDC, state and local governments, and health system leaders are developing messaging strategies to address hesitancy. Our findings suggest that these efforts should be culturally tailored and focused upon subgroups with lower levels of trust. For example, messages about COVID-19 vaccines should emphasize the importance of vaccine safety and safety monitoring to underscore the concept of "benevolence" in building trust in the vaccine (Mayer et al., 1995). Communication messages sent by "trusted messengers" (Pornpitakpan, 2004) such as healthcare providers and community leaders might be particularly important in building confidence in the vaccines. Trusted messengers often come from similar backgrounds as the targeted individuals or are otherwise respected by targeted individuals. To help build trust in the vaccines, local and national outreach by trusted messengers for females, young adults (18–49 years), and individuals who are Black will be needed. This is important not only for current COVID-19 vaccinations but will likely bear relevance for future booster vaccinations as well.

A striking finding of our study is that individuals with Bachelor's degree or higher education were substantially more likely to state they will be vaccinated; and although this effect was attenuated, it remained even after accounting for questions on trust. This suggests that messaging also needs to take into consideration health literacy principles.

In addition, transparency in the approval process and effective communication to the public from ACIP (McClung et al., 2020), the National Academy of Sciences (National Academies of Sciences et al., 2020) and other groups regarding ethical vaccine allocation should help build trust in the vaccines. This is particularly important as rare side effects of the vaccines occur and federal agencies continue to review the safety profile of the vaccines (Shay et al., 2021).

Studies on vaccine hesitancy suggest that recommendations by primary care clinicians have a large impact on vaccine receipt (Edwards and Hackell, 2016; Kempe et al., 2020; Szilagyi et al., 2020a). In our study, respondents' trust in their physician was strongly associated with vaccine likelihood. Outreach strategies by primary care and specialty physicians will be critical in building trust in COVID-19 vaccinations. These strategies can include communications sent to patients and allocating time during office visits to discuss COVID-19 vaccination.

Our findings suggest that local public health organizations, news organizations, and political leaders have a major role in boosting trust in COVID-19 vaccines. Public health and vaccine leaders should work with news organizations on effective messaging about the effectiveness and safety of the vaccines.

Recent studies suggest a rise in interest in COVID-19 vaccines among individuals who are black (Johnson and Funk, 2021; Szilagyi et al., 2021). We speculate that this may be due to rising levels of trust in the vaccines and the approval process among Black communities. At the same time, addressing access barriers also remains important in order to optimize COVID-19 vaccination (Binagwaho et al., 2021; Bolcato et al., 2021; Johnson Jr. et al., 2021; Shen et al., 2021) for many communities. Thus, the national effort must simultaneously address trust (Khubchandani and Macias, 2021; Strully et al., 2021) with vaccine accessibility.

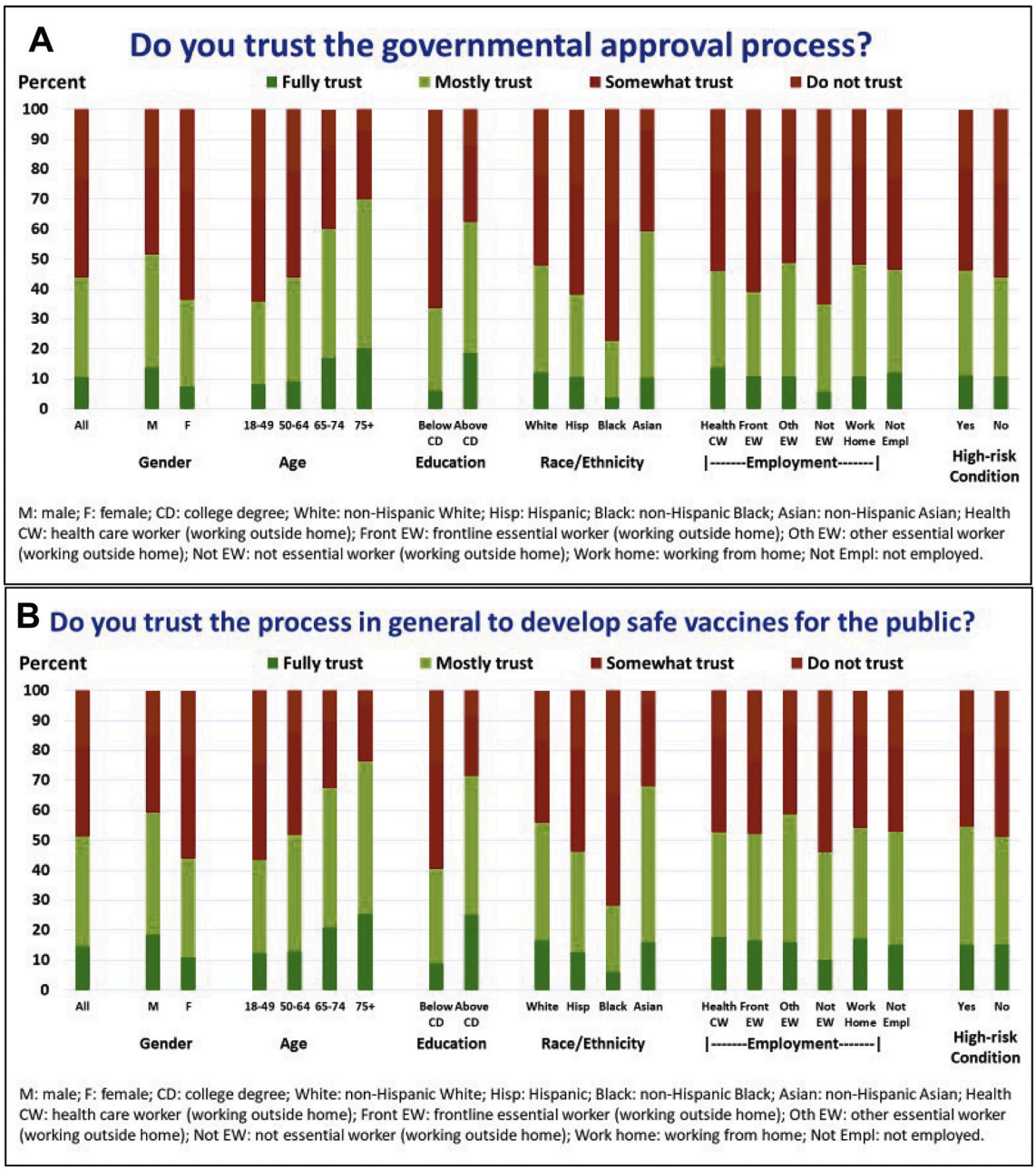

Fig. 2. Level of trust in the **(2a)** governmental approval process specifically for COVID-19 vaccines to ensure the COVID-19 vaccine is safe for the public and **(2b)** the vaccine process in general (December 23–January 19 Survey): Overall and by gender, age, education, race/ethnicity, healthcare and frontline (or other) essential worker status, and presence of a chronic high-risk condition for severe COVID-19 illness.

4.1. Study limitations and strengths

Our study has multiple strengths. We surveyed a large nationally representative sample and delineated key subgroups of the US population to be phased in for COVID-19 vaccines. A high proportion of the online panel responded to the survey, which was performed well after the US presidential election and after the first two COVID-19 vaccines were recommended. One limitation involves generalizability from any sample, although the UAS sampling and recruitment approach mitigated these concerns. Second, for two of the questions ("chance that someone who is vaccinated against the coronavirus could still catch it" and "chance that a coronavirus virus will cause serious side effects…"), we did not specifically ask about trust in vaccine efficacy or safety but rather respondents' "belief" in the vaccine's safety and efficacy. Lastly, we do not know what specific factors about the vaccine approval and development processes drove people's mistrust.

4.2. Conclusions

Our recent nationally representative survey found that a high proportion of US adults are hesitant to get a COVID-19 vaccine, including females, young adults (18–49), Black individuals, essential workers, and even those with high-risk chronic conditions. Trust in the vaccine development and governmental approval processes largely accounts for people's likelihood of getting a COVID-19 vaccine and will likely remain relevant throughout the pandemic, for future COVID-19 vaccine boosters, as well as for other vaccines. Building trust in the vaccine approval/development processes is an essential step toward ending the current pandemic, addressing vaccine hesitancy, and ensuring the future success of any national vaccination program.

Credit author statement

Peter Szilagyi conceptualized the study, obtained funding, led the analysis, wrote the original draft and revision, and approved the final version.

Kyla Thomas helped conceptualize the study, obtain funding, evaluate the analyses, review and edit drafts, and approved the final version.

Megha Shah helped conceptualize the study, obtain funding, evaluate the analyses, review and edit drafts, and approved the final version.

Nathalie Vizueta helped conceptualize the study, obtain funding, evaluate the analyses, review and edit drafts, and approved the final version.

Yan Cui helped conceptualize the study, obtain funding, performed analyses, reviewed and edited drafts, and approved the final version

Sitaram Vangala helped conceptualize the study, obtain funding, performed analyses, reviewed and edited drafts, and approved the final version.

Craig Fox helped conceptualize the study, evaluate findings, review and edit drafts, and approved the final version.

Arie Kapteyn helped conceptualize the study, obtain funding, evaluate the analyses, review and edit drafts, and approved the final version.

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Role of the funder/sponsor

The sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Declaration of Competing Interest

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Appendix A. Method to determine essential worker status and presence of chronic disease.

A.1. Determining essential worker status

First, we asked: "Does your job require you to work outside the home (e.g., healthcare worker, childcare worker, grocery worker etc.?)." Second, among those who worked outside of the home, we asked: "Think about the industry in which you currently work. Which of the following industries is it?"; participants selected from a list of 24 industry categories. Third, for each reported industry category, we asked more specific questions about occupation. Fourth, we used a list of specific industry categories and occupations to classify participants as healthcare workers, other workers who work outside of the home (frontline essential workers, other essential workers, non-essential workers), individuals who work from home, and those not currently employed.

A.2. Determining presence of one or more high-risk chronic condition for COVID-19

We asked each participant: "Have you been diagnosed by a doctor or other qualified medical professional with any of the following medical conditions?" We identified individuals with at least one condition from a list of chronic conditions(Razzaghi et al., 2020) that increase the risk of severe COVID-19 illness when infected. These high-risk chronic conditions include: cancer, chronic kidney disease, chronic obstructive pulmonary disease, serious heart conditions (e.g., heart failure, coronary artery disease, cardiomyopathies), immunocompromised state (weakened immune system) from solid organ transplant, obesity (BMI of 30 or greater), pregnancy, sickle cell disease, smoking, or Type 2 diabetes mellitus.

Table A.1
Percent of respondents by domains of trust-generalized trust, trust in vaccine efficacy/safety, trust in the vaccine approval/development processes, and trust in sources of information about COVID-19.

Generalized trust	Disagree strongly or a little	Neither agree nor disagree	Agree a little	Agree strongly
I am someone who is generally trusting	11.6%	11.4%	37.4%	39.6%
Trust in vaccine efficacy and safety	**0%– < 25%**	**25%– < 50%**	**50%– < 75%**	**75%–100%**
Percent chance that someone who is vaccinated against the coronavirus could still catch it	52.6%	17.0%	22.6%	7.8%
Percent chance that a coronavirus vaccine will cause serious side effects or long-term health problems for someone who has been vaccinated	58.7%	14.5%	19.9%	6.9%
Trust in approval/development processes	**Fully trust**	**Mostly trust**	**Somewhat trust**	**Do not trust**
Trust in governmental approval process for COVID-19 vaccine	10.6%	33.3%	32.6%	23.5%
Trust in vaccine development process in general	14.6%	36.8%	30.2%	18.4%
Trust in healthcare provider				
Your physician	22.0%	44.8%	27.7%	5.4%
Trust in sources of information				
The World Health Organization (WHO)	10.9%	28.8%	35.7%	24.7%
Local public health officials (e.g., county health departments)	8.0%	33.9%	42.7%	15.4%
The Centers for Disease Control and Prevention (CDC)	15.0%	36.1%	34.1%	14.8%
Your contacts on social media	0.6%	5.4%	44.2%	49.8%
Friends, family members, coworkers, classmates, or acquaintances	0.8%	12.2%	60.0%	27.0%
Public television and radio	4.0%	20.0%	44.2%	31.8%
Fox News	1.6%	9.5%	35.5%	53.3%
CNN & MSNBC	2.1%	15.2%	39.4%	43.4%
NBC News & CBS News & ABC News	1.6%	15.8%	42.7%	39.9%
Your local TV news & local newspaper	1.2%	15.3%	50.7%	32.8%
National newspapers (e.g., NY Times, Washington Post, USA Today)	3.3%	19.8%	39.6%	37.3%
President Trump and VP Pence	3.7%	11.1%	27.2%	58.0%
President-Elect Biden and VP-Elect Harris	6.5%	20.4%	30.9%	42.2%

Abbreviations: COVID-19 = coronavirus disease 2019.

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