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Explaining demographic differences in COVID-19 vaccination stage in the United States – April-May 2021

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ABSTRACT

COVID-19 vaccine coverage in the US has marked demographic and geographical disparities, but few explanations exist for them. Our paper aimed to identify behavioral and social drivers that explain these vaccination disparities. Participants were a national probability sample of 3562 American adults, recruited from the Ipsos KnowledgePanel. Participants completed an online survey in spring 2021, when COVID-19 vaccination was available for higher-risk groups but not yet available to all US adults. The survey assessed COVID-19 vaccination stage (intentions and vaccine uptake), constructs from the Increasing Vaccination Model (IVM) domains (thinking and feeling, social processes, and direct behavior change), self-reported exposure to COVID-19 vaccine information, and demographic characteristics. Analyses used multiple imputation to address item nonresponse and linear regressions to conduct mediation analyses. Higher COVID-19 vaccination stage was strongly associated with older age, liberal political ideology, and higher income in adjusted analyses (all \( p < .001 \)). Vaccination stage was more modestly associated with urbanicity, white race, and Hispanic ethnicity (all \( p < .05 \)). Some key mediators that explained more than one-third of demographic differences in vaccination stage were perceived vaccine effectiveness, social norms, and recommendations from family and friends across most demographic characteristics (all \( p < .05 \)). Other mediators included safety concerns, trust, altruism, provider recommendation, and information seeking. Access to vaccination, barriers to vaccination, and self-efficacy explained few demographic differences. One of the most reliable explanations for demographic differences in COVID-19 vaccination stage is social processes, including social norms, recommendations, and altruism. Interventions to promote COVID-19 vaccination should address social processes and other domains in the IVM.

The COVID-19 pandemic has had a profound effect on public health, including more than one million deaths in the US (US Centers for Disease Control and Prevention, 2022). The pandemic's burden has fallen disproportionately on certain populations (Couch et al., 2020). Black and Indigenous people have experienced greater mortality and economic loss than their white counterparts (Hooper et al., 2020; US Centers for Disease Control and Prevention, 2022). People living in rural areas have faced more economic and psychological impacts of the pandemic compared to those living in suburban and urban areas (Mueller et al., 2021; Ranscombe, 2020).

Demographic differences in COVID-19 vaccination uptake and intentions are well-documented, including higher uptake among adults who are white, older, politically liberal, and from urban areas (Kaiser Family Foundation, 2022; Wang and Liu, 2022). However, few studies have examined reasons for these demographic differences or relied on a theoretical model (e.g., Berg and Lin, 2021; Torre et al., 2022; Zampetakis and Melas, 2021). Identifying these drivers accounting for the demographic differences in COVID-19 vaccination intentions and uptake could help inform tailored public health interventions to improve COVID-19 vaccination uptake nationally.

We employed the Increasing Vaccination Model (IVM) (Brewer, 2021; Brewer et al., 2017a) to identify potential mediators of
demographic differences in COVID-19 vaccination. The IVM proposes that constructs from three domains can influence vaccine uptake: thinking and feeling, social processes, and direct behavior change. The thinking and feeling domain includes risk appraisals, vaccine confidence, and motivation. The social processes domain includes social norms, social preferences, and receiving recommendations from health care providers, friends, and family members. The direct behavior change domain includes practical facilitators and barriers (e.g., reminders or on-site vaccination clinics) that could increase vaccination uptake without changing an individual’s thinking, feeling, or social experiences regarding vaccination. The model has been adapted by the US Centers for Disease Control and Prevention and the World Health Organization in designing vaccine-related research and campaign programs (National Academies of Sciences and Medicine et al., 2020; World Health Organization, 2018). In addition to constructs from the IVM, self-reported exposure to negative information and misinformation regarding COVID-19 vaccination could affect vaccination intentions and uptake (Davis et al., 2021).

Misinformation about COVID-19 vaccination and preventive behaviors has been a feature of the pandemic (Muric et al., 2021). Topics prone to misinformation have included the extent to which preventive measures, such as wearing masks and maintaining social distancing, could prevent the virus from further spreading (Bok et al., 2021) and the efficacy and safety of vaccines (Loomba et al., 2021; Skafle et al., 2022). Previous efforts to foster mistrust of government leaders and medical experts (Jaiswal et al., 2020; Pierre, 2020) have likely made the public more receptive to misinformation. Thus, the present survey examined constructs from both IVM and self-reported exposure to COVID-19 information.

1. Methods

1.1. Participants

Study participants came from a national sample of non-institutionalized US adults ages 18 years and older. We drew a random sample of 5768 members from the Ipsos KnowledgePanel (Ipsos, 2021), a probability-based web panel that is similar to US adults on key demographic characteristics, including age, gender, race and ethnicity, education, income, home ownership status, metropolitan area, and Census region. We oversampled Non-Hispanic Black persons and American Indian or Alaskan Native (AI/AN) persons to ensure adequate representation from these groups that are usually underrepresented in social science research. A total of 3621 adults completed the survey, yielding a completion rate of 63%. We excluded 59 participants whose information was inconsistent with their stored profile information or whose responses were of low quality, resulting in an analytic sample of 3562.

1.2. Procedures

From March 18 to April 2, 2021, eligible panel members received a notification email with a link to the survey and additional email reminders if they did not respond within three days. At the time this survey was in the field, three COVID-19 vaccines had emergency use approval in the US, and CDC had prioritized their availability to high-risk groups. (The vaccines became available to all US adults on April 19, 2021.) Participants completed the survey online. The survey was available in English and Spanish; 4% completed the survey in Spanish. Participants received incentives as part of their ongoing membership in the panel and for completing the survey; near the end of the recruitment period, participants from some groups with low response rates received a cash-equivalent incentive of $2 to $5. This activity was reviewed by CDC and determined to be IRB-exempt, and was conducted consistent with applicable federal law and CDC policy (45C.F.R. part 46.102(D)(2), 21C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq).

1.3. Measures

The survey assessed the self-reported number of COVID-19 vaccine doses survey participants had received and vaccination intentions for those who were unvaccinated. The intentions item had a 5-point response scale that ranged from “definitely will not” (coded as 1) to “definitely will” (5) get a COVID-19 vaccine. We combined these vaccine uptake and intention measures to create a 6-level vaccination stage variable: “definitely will not” get vaccinated (coded as 1), “probably will not” get vaccinated (2), “not sure” about getting vaccinated (3), “probably will” get vaccinated (4), “definitely will” get vaccinated (5), and had received at least one dose of the vaccine (6). Vaccination stage refers to the phase of adoption of the behavior, as suggested in various stage models of health behavior (e.g., the Trans-Theoretical Model, Prochaska and DiClemente, 1983; the Precaution Adoption Process Model, Weinstein, 1988).

The survey assessed constructs in the three domains of the IVM. In the thinking and feeling domain, the survey assessed COVID-19 vaccine appraisal (4 items, scale α = 0.70), COVID-19 vaccine confidence (10 items, scale α = 0.94; which included subscales for perceived effectiveness, 3 items, subscale α = 0.91; perceived safety, 5 items, subscale α = 0.88; and trust, 2 items, subscale r = 0.86), ending protective activities (2 items, r = 0.83), and restarting routine activities (2 items, r = 0.73). In the social processes domain, the survey assessed social norms (Fishbein and Ajzen, 2011) for COVID-19 vaccination (3 items, scale α = 0.79) on descriptive norms and injunctive norms, recommendation for COVID-19 vaccines from family, friends, employer, their own health care provider, and other health care provider (5 items, scale λ6 = 0.69), and self-reported exposure to negative COVID-19 vaccine information (2 items, r = 0.71). In the direct behavior change domain, the survey assessed access to COVID-19 vaccination (5 items, scale α = 0.83), barriers to vaccination (14 items, scale λ6 = 0.66), and self-efficacy (1 item). The survey also assessed four aspects of COVID-19 vaccination information, including information-seeking behavior (1 item), COVID-19 vaccination information adequacy (1 item), questioning accuracy on COVID-19 vaccination (1 item), and knowing where to get accurate information on COVID-19 vaccination (1 item). Further details on survey items and coding are in Appendix A.

For demographic characteristics, the study assessed age, gender, race, Hispanic ethnicity, income, being a frontline or essential worker, health insurance status, having a physical or mental disability, having a risk factor for severe COVID-19 disease, political leaning, and urbanicity.

1.4. Statistical analysis

Missingness ranged from less than 1% to 7%, with the highest missingness for political leaning and disability. Analysis of item nonresponse using Little’s MCAR test (SPSS version 27) indicated that data were not missing completely at random (χ²(5144) = 10,446, p < .001) (Little, 1988). We then used multiple imputation (Appendix B) to address item nonresponse using the R (version 4.1.1) mice package (version 3.13.0)(van Buuren, 2021) with the 181 variables, generating 15 final imputation datasets which were analyzed separately with results combined using Rubin’s rules (van Buuren, 2018). We report the integrated, unweighted findings from pooled results of the 15 imputations (Mansolf et al., 2020).

We first examined the association of demographics with vaccination stage using unweighted multivariable linear regression, entering all demographics simultaneously and reporting standardized regression coefficients (β). Sensitivity analyses of overall demographic differences with and without the survey weights yielded a similar pattern of findings. Analyses used two-tailed tests and a critical alpha of 0.05.

Next, we examined whether the IVM and other variables mediated the relationships between each demographic characteristic and vaccination stage, as shown in Fig. 1. Mediation is where a potential mediator...
variable fully or partially explains an association. In full mediation, all the shared variance between predictor and outcome is explained by the mediator. In partial mediation, the shared variance between predictor and outcome is partially, but not completely, reduced by adding the mediator into the model.

The mediation analyses followed the approach of MacKinnon and colleagues (MacKinnon et al., 2007; MacKinnon et al., 2000), controlling for statistically significant demographic characteristics. Specifically, the mediation analyses examined: 1) the \(a\) pathway of a demographic characteristic predicting the mediator; 2) the \(b\) pathway of the mediator predicting vaccination stage; and 3) the product of pathways \(a\) and \(b\), which was the mediation effect (and which we compare to pathway \(c\), the overall association of a demographic characteristic with vaccination stage). We conducted mediation analyses using the semTools package (version 0.5–5) (Jorgensen, 2021) in R, which used Rubin (1987) rules to pool point and standard error estimates across the 15 imputed data sets. We report standardized regression coefficients with confidence intervals of 95% for linear regressions and standardized values for mediations in Tables 2–7.

2. Results

The mean age of participants was 52 years (Table 1). Political ideology was split fairly evenly across conservative (36%), moderate (36%), and liberal (29%). Nearly one-third of participants had an annual household income below $50,000 US. About 18% lived in rural areas. Overall, 63% were non-Hispanic white, 14% non-Hispanic Black, and 12% Hispanic. With respect to COVID-19 vaccination stage, most said they would probably (10%) or definitely would get vaccinated (20%) or had already received at least one dose (44%). A minority of respondents said they definitely or probably would not get vaccinated or were unsure (10%, 8%, and 8%).

2.1. Demographic correlates of vaccination stage

Older age, liberal political leaning, and a higher income were associated with higher vaccination stage (\(\beta_s = 0.32, 0.29, \) and 0.15, all \(p < .001\); Table 1). Vaccination stage was higher for people who lived in non-rural areas, were white, and Hispanic (\(\beta_s = 0.05, 0.05, \) and 0.03; all \(p < .05\)), though these associations were smaller. Having a risk factor for severe COVID-19 disease, health insurance, and not having a physical or mental disability were also associated with higher vaccination stage (\(\beta_s = 0.11, 0.09, \) and –0.05; all \(p < .05\)). Gender and being a frontline or essential worker did not differentiate vaccination stage (all \(p > .05\)).

2.2. Mediation analyses

Mediation analyses examined the three largest differences in vaccination stage: age, political leaning, and income. They also examined urbanicity, race, and ethnicity, given ongoing policy concerns regarding these topics. The mediation analyses also controlled for the remaining statistically significant correlates (i.e., health insurance status, physical or mental disability, and having a risk factor for severe COVID-19 disease).

![Fig. 1. Mediation approach. C' pathway adjusts for the potential mediator.](continued on next page)
motivation, self-efficacy, information-seeking behavior, questioned accuracy of COVID-19 information, adequacy of information, and knowing where to get accurate information (all \( p < .05 \)).

\[ \beta_{c} \approx 0.27 \]

\[ \beta_{c}' \approx 0.27 \]

\[ \beta' \approx 0.27 \]

where to get accurate information (all \( p < .05 \); Table 4). Self-reported exposure to negative COVID-19 vaccine information suppressed the relationship between higher income and COVID-19 vaccination stage (\( p < .05 \)).

\[ \beta_{c} \approx 0.27 \]

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\[ \beta' \approx 0.27 \]

where to get accurate information (all \( p < .05 \); Table 4). Self-reported exposure to negative COVID-19 vaccine information suppressed the relationship between higher income and COVID-19 vaccination stage (\( p < .05 \)).
2.2.4. Urbanicity, race, and ethnicity

Perceived effectiveness and safety of COVID-19 vaccines, trust, social norms, recommendations from family, friends, employers, and health care provider, and altruistic motivation fully mediated the relationship between urbanicity and vaccination stage (all p < .05, Table 5). Full mediators of the relationship with white race were the vaccine confidence scale and perceived safety and trust, social norms, and recommendations from family and friends (all p < .05, Table 6). Ending protective activities suppressed the relationship between race and vaccination stage. Full mediators of the relationship with Hispanic
Table 5
Mediators of the association of urbanicity with vaccination stage (n = 3562).

| Potential mediator                              | Association of urbanicity with mediator (a pathway) | Association of urbanicity with vaccination stage (b pathway) | Mediation effect (a*b pathway) | Direct association of urbanicity with vaccination stage (c’ pathway) |
|------------------------------------------------|---------------------------------------------------|------------------------------------------------------------|-----------------------------|-----------------------------------------------------------------|
| What people think and feel                      |                                                   |                                                            |                             |                                                                                 |
| Disease risk appraisal                           | 0.04*                                             | 0.39**                                                     | 0.02*                       | 0.04*                                                                          |
| Risk appraisal scale                             |                                                   |                                                            |                             |                                                                                 |
| Vaccine confidence                               | 0.07**                                            | 0.79**                                                     | 0.05**                      | -0.001                                                                         |
| Vaccine confidence scale                         |                                                   |                                                            |                             |                                                                                 |
| Perceived effectiveness subscale                 | 0.07**                                            | 0.78**                                                     | 0.05**                      | -0.001                                                                         |
| Perceived safety subscale                        | 0.06**                                            | 0.66**                                                     | 0.04**                      | 0.01                                                                           |
| Trust subscale                                   | 0.05*                                             | 0.63**                                                     | 0.03*                       | 0.02                                                                           |
| Restoring routine activities scale               | -0.03                                             | -0.12**                                                    | 0.001                       | 0.05**                                                                         |
| Social processes                                 |                                                   |                                                            |                             |                                                                                 |
| Social norms scale                               | 0.08**                                            | 0.62**                                                     | 0.04**                      | 0.01                                                                           |
| Recommendation                                    | 0.08**                                            | 0.40**                                                     | 0.03**                      | 0.02                                                                           |
| Provider rec subscale                            | 0.06**                                            | 0.27**                                                     | 0.02**                      | 0.04*                                                                           |
| Family/friend rec subscale                       | 0.06**                                            | 0.39**                                                     | 0.02**                      | 0.03                                                                           |
| Social preferences                               | 0.06**                                            | 0.69**                                                     | 0.04**                      | 0.01                                                                           |
| Altruistic motivation                            | -0.001                                            | -0.17**                                                    | 0.001                       | 0.05**                                                                         |
| Self-reported negative information exposure scale |                                                   |                                                            |                             |                                                                                 |
| Direct behavior change                           |                                                   |                                                            |                             |                                                                                 |
| Access scale                                     | -0.03                                             | 0.22**                                                     | -0.01                       | 0.06**                                                                         |
| Barriers to vaccination                          | 0.06**                                            | -0.04                                                     | -0.001                      | 0.05**                                                                         |
| Self-efficacy                                    | -0.04                                             | -0.07**                                                    | 0.002                       | 0.05**                                                                         |
| COVID-19 vaccine information                    | 0.05*                                             | 0.34**                                                     | 0.02**                      | 0.04*                                                                           |
| Information seeking                              | 0.001                                             | -0.19**                                                    | -0.001                      | 0.05**                                                                         |
| Questioned information accuracy                  | 0.02                                              | 0.13**                                                     | 0.001                       | 0.05**                                                                         |
| Adequacy of information                          | 0.02                                              | 0.12**                                                     | 0.001                       | 0.05**                                                                         |
| Know where to get accurate info                  | 0.04*                                             | 0.39**                                                     | 0.02*                       | 0.04*                                                                           |

Note. Each row was a separate mediation model controlling for age, race, Hispanic ethnicity, political ideology, income, physical or mental disability, health insurance, and COVID-19 risk. $\beta$ = standardized regression coefficient. Total effect of urbanicity on COVID-19 vaccination stage (pathway c) = 0.05.

Each row was a separate mediation model controlling for age, race, Hispanic ethnicity, political ideology, income, physical or mental disability, health insurance, and COVID-19 risk. $\beta$ = standardized regression coefficient. Total effect of urbanicity on COVID-19 vaccination stage (pathway c) = 0.05.

Table 6
Mediators of the association of white race with vaccination stage (n = 3562).

| Potential mediator                              | Association of white race with mediator (a pathway) | Association of white race with vaccination stage (b pathway) | Mediation effect (a*b pathway) | Direct association of white race with vaccination stage (c’ pathway) |
|------------------------------------------------|---------------------------------------------------|-------------------------------------------------------------|--------------------------------|------------------------------------------------------------------|
| What people think and feel                      |                                                   |                                                            |                               |                                                                                 |
| Disease risk appraisal                           | -0.01                                            | 0.39**                                                      | -0.001                        | 0.05**                                                                          |
| Risk appraisal scale                             |                                                   |                                                            |                               |                                                                                 |
| Vaccine confidence                               | 0.08**                                            | 0.79**                                                      | 0.07**                         | -0.02                                                                           |
| Vaccine confidence scale                         |                                                   |                                                            |                               |                                                                                 |
| Perceived effectiveness subscale                 | 0.03*                                             | 0.78**                                                      | 0.02*                          | 0.02*                                                                            |
| Perceived safety subscale                        | 0.10**                                            | 0.66**                                                      | 0.06**                         | -0.02                                                                           |
| Trust subscale                                   | 0.10**                                            | 0.63**                                                      | 0.06**                         | -0.01                                                                           |
| Restoring routine activities scale               | 0.07**                                            | -0.12**                                                     | -0.01**                        | 0.06**                                                                          |
| Social processes                                 |                                                   |                                                            |                               |                                                                                 |
| Social norms scale                               | 0.08**                                            | 0.62**                                                      | 0.05**                         | 0.01                                                                           |
| Recommendation scale                             | 0.04*                                             | 0.40**                                                      | 0.02**                         | 0.03**                                                                          |
| Provider rec subscale                            | 0.01                                              | 0.27**                                                      | 0.001                          | 0.05**                                                                          |
| Family/friend rec subscale                       | 0.07**                                            | 0.39**                                                      | 0.03**                         | 0.02                                                                            |
| Social preferences                               | 0.01                                              | 0.69**                                                      | 0.01                           | 0.04**                                                                          |
| Altruistic motivation                            | 0.01                                              | -0.17**                                                     | -0.001                         | 0.05**                                                                          |
| Self-reported negative information exposure scale |                                                   |                                                            |                               |                                                                                 |
| Direct behavior change                           |                                                   |                                                            |                               |                                                                                 |
| Access scale                                     | -0.02                                             | 0.22**                                                      | -0.001                         | 0.05**                                                                          |
| Barriers to vaccination                          | 0.06**                                            | -0.04                                                      | -0.001                         | 0.05**                                                                          |
| Self-efficacy                                    | 0.02                                              | -0.07**                                                     | 0.002                          | 0.05**                                                                          |
| COVID-19 vaccine information                    | 0.01                                              | 0.34**                                                      | 0.001                          | 0.05**                                                                          |
| Information seeking                              | -0.06*                                            | -0.19**                                                     | -0.01                          | 0.04**                                                                          |
| Questioned information accuracy                  | 0.02                                              | 0.13**                                                      | 0.001                          | 0.04**                                                                          |
| Adequacy of information                          | 0.05*                                             | 0.13**                                                      | 0.01                           | 0.04                                                                            |
| Know where to get accurate info                  | 0.01                                              | 0.12**                                                      | 0.001                          | 0.05                                                                            |

Note. Each row was a separate mediation model controlling for age, Hispanic ethnicity, political ideology, income, urbanicity, physical or mental disability, health insurance, and COVID-19 risk. $\beta$ = standardized regression coefficient. Total effect of white race on COVID-19 vaccination stage (pathway c) = 0.05. $p < .05$, **$p < .001$.

associations appear in Tables 5-7. A summary of mediation findings is in Table 8 (see Appendix C).

3. Discussion

In a large national survey, COVID-19 vaccination stage differed by
demographics and vaccination stage were risk appraisal; vaccine confidence; social norms; and recommendations from family, friends, and providers. These are novel findings that offer important insights to guide future vaccination programs and interventions that could influence vaccination behavior.

Looking at our findings by the main demographic characteristics, age differences were partially explained by any of the mediators except restarting routine activities. Urbanicity, race, and ethnicity had smaller associations with vaccination stage. Racial and urbanicity differences were partially or fully explained by higher vaccine confidence, more supportive social norms, and more recommendations from family, friends, and health care providers. Urbanicity differences were also partially explained by higher risk perception. The findings of this study also echoed the rural-urban divide in belief in health authorities and risk perceptions (Mauller et al., 2021; Sun and Monnat, 2021). This multifactorial divide involves geographic, financial, and infrastructural components, resulting in mistrust in public health authorities to which they have minimal connection (Owsley et al., 2020). Thus, a didactic, top-down manner of promoting health information and vaccination might be less effective than a community-oriented approach.

The only demographic difference that vaccine confidence did not explain was for Hispanic ethnicity. Otherwise, ethnic differences were fully explained by higher risk appraisals, more supportive social norms, and more recommendations from family, friends, health care providers, and employers.

3.1. Thinking and feeling

Looking at our findings by mediators, risk appraisal explained some demographic differences in COVID-19 vaccination stage, consistent with some previous findings (McLaughlin et al., 2021). The urban-rural differences in risk appraisal of COVID-19 are understandable. People living in rural areas, compared to those living in urban or suburban areas, are less likely to use public transportation or visit populous places, and thus may feel less concerned about COVID-19 (Chauhan et al., 2021).

Across most demographic correlates, vaccine confidence was a consistent mediator. This finding underscores the urgency of supporting high vaccine confidence, especially related to effectiveness and safety, through timely and clear communication from health care providers and public health authorities (Danchin et al., 2020).

3.2. Social processes

Another prominent mediator was social norms, accounting for some or all of the demographic differences in COVID-19 vaccination stage that we examined. The pandemic has been a very public event with strongly voiced social norms that vary considerably across demographic characteristics. Extant research has supported the vital and independent role played by social norms in informing vaccination behaviors (Latkin et al., 2021). Conformity with social norms can facilitate vaccine uptake, with or without being catalyzed by other factors (Quinn et al., 2017; Xiao and Borah, 2020). For example, a campaign using clips of the former president endorsing vaccination led to somewhat higher vaccine uptake (Larsen et al., 2022). Our findings offer an important insight that normalizing vaccination behaviors through interventions, campaigns, and messages could be a promising way to support communities with low vaccine uptake and limited access to health care (Sun and Monnat, 2021).

As a cue to action, recommendations from family and friends and health care providers are among the most effective approaches to nudge vaccine uptake, mediating some or all of the demographic differences. Receiving recommendations mediated income differences in vaccination stage, suggesting one way that income disparities may generate variations in health care utilization. Future efforts may consider encouraging recommendations to improve vaccination, especially by health care providers, given that these have been highly influential for

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### Table 7

Mediators of the association of Hispanic ethnicity with vaccination stage (n = 3562).

| Potential mediator | Association of Hispanic ethnicity with mediator (a path pathway) | Association of mediator with vaccination stage (b path pathway) | Mediation effect (a*b path pathway) | Direct association of Hispanic ethnicity with vaccination stage (c' path pathway) |
|-------------------|---------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------|---------------------------------------------------------------------|
|                   | β_a                                                          | β_b                                                          | β_ab                             | β_c                                                                |
| Disease risk appraisal | Risk appraisal scale                                          | Vote consent scale                                             | 0.11**                            | 0.39**                  | 0.04**              | −0.01 |
|                   | Vaccine confidence                                           | Perceived effectiveness subscale                               | 0.006**                           | 0.79**                  | 0.01               | 0.02** |
|                   | Perceived safety subscale                                    | Trust subscale                                                 | −0.04*                           | 0.63**                  | 0.01               | 0.03** |
|                   | Ending protective activities scale                            | Restarting routine activities scale                            | 0.03                             | 0.25**                  | 0.01               | 0.03   |
| Social processes  | Social norms scale                                           | Self-reported negative information exposure scale              | 0.06**                           | 0.62**                  | 0.04**              | 0.01   |
|                   | Recommendations scale                                         | Provider rec subscale                                          | 0.08**                           | 0.40**                  | 0.03**              | 0.001  |
|                   | Provider rec subscale                                         | Family/friend rec subscale                                     | 0.06**                           | 0.27**                  | 0.02**              | 0.02   |
|                   | Social preferences                                           | Social norms scale                                             | 0.09**                           | 0.39**                  | 0.03**              | 0.001  |
|                   | Altruistic motivation                                         | Acces                                                          | 0.08**                           | 0.69**                  | 0.06**              | −0.02  |
|                   | Self-reported negative information exposure scale            | Access                                                         | −0.02                            | −0.17**                 | 0.002              | 0.04** |
|                   | COVID-19 vaccine information                                 | Information seeking                                            | 0.04**                           | 0.22**                  | 0.01**              | 0.03   |
|                   | Questioned information accuracy                               | Questioned information accuracy                                 | 0.03                             | 0.34**                  | 0.03**              | 0.01   |
|                   | adequacy of information                                      | Adequacy of information                                        | −0.01                            | 0.13**                  | −0.001             | 0.04** |
|                   | Know where to get accurate info                              | Know where to get accurate info                                 | −0.02                            | 0.12**                  | −0.001             | 0.04** |

Note. Each row was a separate mediation model controlling for age, race, political ideology, income, urbanicity, physical or mental disability, health insurance, and COVID-19 risk. β = standardized regression coefficient. Total effect of Hispanic ethnicity on COVID-19 vaccination stage (pathway c) = 0.03. p < .05. **p < .001.
other vaccines (Oh et al., 2021). Provider communication training is effective in increasing adolescent vaccine uptake and may be promising as an intervention to increase COVID-19 vaccination uptake (Brewer et al., 2017b).

### 3.3. Direct behavior change

Constructs from the direct behavior change domain played a minimal role as mediators. Age differences were mediated by access to COVID-19 vaccination, which may reflect varying resources held by older and younger people. In general, younger people in the US have more constraints – childcare responsibility, fixed work shifts, and financial inadequacy – that make it harder for them to perform many health behaviors (DePew and Gonzales, 2020). That said, it is also possible that the perceived sufficiency of access is specific to COVID-19 vaccination and pandemic-related disruptions. Some previous studies have found access and barriers were associated with vaccination intentions and uptake (Korn et al., 2018; Williams et al., 2021), but there is not a strong pattern across the literature. One possible explanation is that barriers serve to widen the intention-behavior gap (Sheeran and Webb, 2016), as suggested in the IVM (Brewer, 2021; Brewer et al., 2017a), which is an important question to explore in future studies.

### 3.4. Information exposure and seeking

Aspects of information about COVID-19 partially mediated the three strongest disparities (age, political leaning, and income) in vaccination stage. These included information seeking, questioning the accuracy of the information, perceived information adequacy, knowing where to get accurate information, and self-reported exposure to negative information or misinformation. Self-reported exposure to misinformation about COVID-19 vaccines or other vaccines (e.g., HPV and seasonal influenza) is more associated with risk appraisals and vaccine confidence than vaccination behaviors (Davis et al., 2021). In addition, monitoring trends, volumes, types of misinformation, and information gaps regarding COVID-19 vaccination on social media platforms can inform the design and use of messages that promote vaccination and debunk misinformation about vaccination (i.e., refutational messages) (Okuno et al., 2022). Closing the information gaps in COVID-19 information across age and income groups is urgent as they likely widen the inequity in information, access, and health outcomes. Moreover, because political leaning has shaped most dimensions of COVID-19 risk appraisals and vaccination uptake from early in the pandemic (McLaughlin et al., 2021), addressing partisan influences may require more innovative and sophisticated approaches.

Programs and campaigns that focus on debunking misinformation and addressing health inequity may, at least indirectly, help lessen the impact of COVID-19 by bolstering confidence in public health and vaccination. Greater belief in misinformation has been associated with more consumption of partisan media (Choi and Fox, 2022; Motta et al., 2020) and political conspiracy theories on social media (Islam et al., 2021). Moreover, misinformation in one's social network has considerable influence on people's risk perceptions and attitudes about vaccination (Mheidly and Fares, 2020; Pilch-Loebid et al., 2021). This also echoes our findings in the evident relationship between social norms and vaccination stage. Nevertheless, the impacts of misinformation are moderated by other social and psychological determinants as opposed to acting alone in influencing attitudes and behaviors (Simione et al., 2021). Therefore, targeting misinformation on COVID-19 may need to operate in conjunction with addressing these issues, including partisan

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**Table 8**

**Summary of mediation findings (n = 3562).**

| Potential mediator                                                                 | Age | Liberal political leaning | Income | Urbanicity | White race | Hispanic ethnicity |
|----------------------------------------------------------------------------------|-----|---------------------------|--------|------------|------------|-------------------|
| **What people think and feel**                                                   |     |                           |        |            |            |                   |
| Disease risk appraisal                                                           | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Vaccine confidence                                                               |     |                           |        |            |            |                   |
| Vaccine confidence scale                                                         | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Perceived effectiveness subscale                                                | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Perceived safety subscale                                                        | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Trust subscale                                                                  | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Ending protective activities scale                                               | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Restarter Protective Activities scale                                            | ○   | ●                         | ○      | ●          | ○          | ●                 |
| **Social processes**                                                             |     |                           |        |            |            |                   |
| Social norms                                                                     | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Social norms scale                                                               | ○   | ●                         | ○      | ●          | ○          | ●                 |
| **Recommendation**                                                               |     |                           |        |            |            |                   |
| Recommendation scale                                                             | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Provider rec subscale                                                            | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Family/friend rec subscale                                                       | ○   | ●                         | ○      | ●          | ○          | ●                 |
| **Social preferences**                                                           |     |                           |        |            |            |                   |
| Autologic motivation                                                             | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Self-reported negative information exposure scale                                | ○   | ●                         | ○      | ●          | ○          | ●                 |
| **Direct behavior change**                                                       |     |                           |        |            |            |                   |
| Access                                                                          | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Barriers to vaccination                                                          | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Self-efficacy                                                                   | ○   | ●                         | ○      | ●          | ○          | ●                 |
| **COVID-19 vaccine information**                                                 |     |                           |        |            |            |                   |
| Information seeking                                                             | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Adequacy of information                                                          | ○   | ●                         | ○      | ●          | ○          | ●                 |
| Know where to get accurate information                                           | ○   | ●                         | ○      | ●          | ○          | ●                 |

Note. ● = Complete mediation (the variable explains all of the association). ○ = Mediation (the variable explains part of the association). □ = Partial suppression (the association would be even stronger without the influence of this variable).
The purpose of the current paper was to explain key demographic differences in COVID-19 vaccination stage in the US in the context of the approval of the first dose of COVID-19 vaccines. The priority of public health authorities was on promoting the vaccines broadly to buffer the impacts of the pandemic. Hence the findings reported in this paper drew upon psychological and social circumstances during the spring of 2021. Nevertheless, with COVID-19 and the public’s perception of it continuing to evolve and living with COVID-19 as the new normal, campaigns that promote multifaceted preventive measures may be promising. More studies are needed to understand factors that could facilitate vaccination as new boosters come out and COVID-19 vaccination adopts a more regular cadence.

4. Limitations

Study limitations include that the findings on mediations are based on cross-sectional studies; thus, no causal relationships between mediators and the outcome can be inferred. Second, given the multicollinearity between mediators such as risk appraisal and vaccine confidence, we did not enter all mediators into one model. A disadvantage of this approach is that we could not compare magnitudes and directions of variances explained by each mediator in an association of a demographic with vaccination stage. Third, the data collection happened in early 2021, before the US recommended COVID-19 vaccination for the general adult population. Because the situation related to the pandemic has constantly been evolving, the generalizability of the findings to the current context remains to be established. Fourth, we did not measure the effects of workplace mandates and incentives on COVID-19 vaccination in this survey. Given that some empirical studies have found they may increase COVID-19 vaccine uptake (Albarracin et al., 2021; Campos-Mercade et al., 2021), future studies should examine the effects of mandates and incentives in increasing vaccination to integrate them into useful programs and interventions. Fifth, we used a single item to measure self-efficacy, which may partially explain the little demographic differences accounted for by self-efficacy. Better measures for self-efficacy are needed to precisely gauge the relationships between self-efficacy and vaccination stage. Nevertheless, despite the limitations, the findings of the present study may help triangulate how to promote COVID-19 vaccines and disseminate accurate information about COVID-19 and vaccines in the future.

5. Conclusion

Our national survey documented reliable demographic differences in COVID-19 vaccination stage that are consistent with previous findings (Hooper et al., 2020; Kelly et al., 2021; Lin et al., 2022). Older age, liberal political leaning, and a higher income had stronger associations with a higher COVID-19 vaccination stage; whereas, urbanicity, white race, and Hispanic ethnicity had modest associations. The study has also identified various behavioral and social drivers of these differences. Greater vaccine confidence from the thinking and feeling domain and more conformity with social norms and recommendations from family, friends, and providers from the social processes domain explained most variations in vaccination stage across demographics. On the other hand, access and barriers from the direct behavior domain did not explain much variation in vaccination stage. These discrepancies with literature and past research deserve further exploration. To summarize, the findings provide valuable insights to implementations and strategies for promoting COVID-19 vaccine uptake even after the pandemic. More efforts involving social processes – social norms and recommendations from people’s social networks – are promising areas for future COVID-19 vaccination programs and interventions.

CRediT authorship contribution statement

Qian Huang: Formal analysis, Writing - original draft, Writing - review & editing, Visualization.
Neetu Abad: Conceptualization, Methodology, Funding acquisition, Writing - original draft, Writing - review & editing.
Kimberly E. Bonner: Writing - Original draft, Writing - review & editing.
Brittney Baack: Writing - original draft.
Robert Petrin: Data curation, Formal analysis, Validation, Writing - original draft.
Megan A. Hendrich: Data curation, Project administration, Validation, Writing - original draft, Writing - review & editing.
Zachary Lewis: Data curation.
Noel T. Brewer: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision.

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Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention.

Declaration of Competing Interest

Noel Brewer has served as a paid advisor for Merck, Novartis, US Centers for Disease Control and Prevention, and the World Health Organization. The remaining authors declared no conflicts of interest.

Data availability

The authors do not have permission to share data.

Appendix A. Survey items and scales

| Risk appraisal scale (α = 0.70) | Zero-order correlations | Raw coding | Recoding |
|--------------------------------|-------------------------|------------|----------|
| Scale = average all four items | Mean (SD)               | 1          | 2        | 3        | 4        |          |
| 1. How concerned are you about getting COVID-19? Not at all concerned, A little concerned, moderately concerned, very concerned |
| 2. (displayed to unvaccinated respondents) if you don’t get vaccinated, how likely do you think you would be to get infected with COVID-19 within the next year? (displayed to vaccinated respondents) how likely do you think you are to get infected with COVID-19 within the next year? Not at all likely, somewhat likely, very likely, extremely likely | |
| 2.59 (1.17) | 1.00 | 1.4 | N/A | |
| 1.70 (0.75) | 0.31 | 1.00 | 1.4 | N/A | |

(continued on next page)
### Risk appraisal scale ($\alpha = 0.70$)

Scale = average all four items

| Zero-order correlations | Raw coding | Recoding |
|-------------------------|------------|----------|
| Mean (SD)               | 1 2 3 4    |          |

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|----------------|---------------------------------------|
| 3. How afraid are you of getting COVID-19? | 2.30 (1.14) 0.79 0.29 1.00 1-4 N/A |
| Not at all afraid, A little afraid, moderately afraid, very afraid | |
| 4. (displayed to unvaccinated respondents) if I do not get a COVID-19 vaccine when it is available, I will regret it. (displayed to vaccinated respondents) if I had not gotten a COVID-19 vaccine when it was available, I would have regretted it. | 2.38 (1.33) 0.37 0.13 0.35 1.00 1-4 N/A |
| Do not agree, somewhat agree, strongly agree, very strongly agree | |

### Vaccine confidence scale

Vaccine confidence main scale = average all items after recoding ($\alpha = 0.94$)

Vaccine confidence subscale: Effectiveness = average items 1, 2, and 6 ($\alpha = 0.91$)

Vaccine confidence subscale: Safety = average items 3, 4, 6, 7, and 8 ($\alpha = 0.88$)

Vaccine confidence subscale: Trust = average items 9 and 10 ($r = 0.76$)

| Zero-order correlations (after recoding/rescaling) | Raw coding | Recoding |
|---------------------------------------------------|------------|----------|
| Mean (SD)                                         | 1 2 3 4 5 6 7 8 9 10 |          |

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|----------------|---------------------------------------|
| 1. How important do you think getting a COVID-19 vaccine is to protect yourself against COVID-19? | 3.23 (1.05) 1.00 1-4 N/A |
| Not at all important, A little important, moderately important, very important | |
| 2. How important do you think getting a COVID-19 vaccine for yourself is to protect other people in your community against COVID-19? | 3.25 (1.04) 0.88 1.00 1-4 N/A |
| Not at all important, A little important, moderately important, very important | |
| 3. How safe do you think a COVID-19 vaccine is for you? | 2.89 (1.16) 0.77 0.73 1.00 1-4 N/A |
| Not safe, somewhat safe, fairly safe, very safe | |
| 4. (displayed to unvaccinated respondents) how concerned are you that a COVID-19 vaccine could cause you to have a serious reaction? (‘serious’ means you would not be able to perform your normal daily activities for a few days). (displayed to unvaccinated respondents) before you got vaccinated, how concerned were you that a COVID-19? Not at all concerned, A little concerned, moderately concerned, very concerned | 2.72 (1.11) 0.34 0.33 0.50 1.00 1-4 Reverse coded |
| 5. How much do you agree with each of the following statements? (displayed to unvaccinated respondents) the COVID-19 vaccine side effects are likely to be bad. (displayed to vaccinated respondents) the COVID-19 vaccine side effects were bad. Do not agree, somewhat agree, strongly agree, very strongly agree | 3.29 (0.92) 0.54 0.51 0.60 0.54 1.00 1-4 Reverse coded |
| 6. How much do you agree with each of the following statements? (displayed to unvaccinated respondents) I will feel relieved when I’m fully vaccinated against COVID-19. (displayed to vaccinated respondents) I feel relieved now that I’m vaccinated against COVID-19. Do not agree, somewhat agree, strongly agree, very strongly agree | 2.65 (1.29) 0.74 0.70 0.73 0.37 0.47 1.00 1-4 N/A |
| 7. How much do you agree with each of the following statements? the approval of COVID-19 vaccines was too rushed. Do not agree, somewhat agree, strongly agree, very strongly agree | 3.06 (1.12) 0.58 0.55 0.66 0.48 0.61 0.54 1.00 1-4 Reverse coded |
| 8. How much do you agree with each of the following statements? I’m worried about long-term side effects from a COVID-19 vaccine. Do not agree, somewhat agree, strongly agree, very strongly agree | 3.01 (1.14) 0.58 0.54 0.69 0.59 0.68 0.55 0.71 1.0 reverse coded |
| 9. (displayed to unvaccinated respondents) how much do you trust the health care providers who would give you a COVID-19 vaccine? (displayed to vaccinated respondents) how much do you trust the health care providers who gave you a COVID-19 vaccine? Do not trust, somewhat trust, mostly trust, Fully trust | 3.01 (1.03) 0.64 0.61 0.71 0.41 0.53 0.62 0.55 0.57 1.00 0.76 1-4 N/A |

(continued on next page)
### Vaccine confidence scale
Vaccine confidence main scale = average all items after recoding (α = 0.94)
Vaccine confidence subscale: Effectiveness = average items 1, 2, and 6 (α = 0.91)
Vaccine confidence subscale: Safety = average items 3, 4, 6, 7, and 8 (α = 0.88)
Vaccine confidence subscale: Trust = average items 9 and 10 (r = 0.76)

10. How much do you trust the public health agencies that recommend COVID-19 vaccines? Do not trust, somewhat trust, mostly trust, Fully trust

### Zero-order correlations (after recoding/rescaling)
| Mean (SD) | Recoding |
|-----------|-----------|
| 2.67 (1.12) | 1-4 N/A |

### Vaccine confidence subscale: Effectiveness
= average items 1, 2, and 6 (α = 0.91)

### Vaccine confidence subscale: Safety
= average items 3, 4, 6, 7, and 8 (α = 0.88)

### Vaccine confidence subscale: Trust
= average items 9 and 10 (r = 0.76)

### Social norms scale (α = 0.71)
Social norms scale = average three items after rescaling

1. If you had to guess, about how many of the people at your work or school have really wanted to get a COVID-19 vaccine? None, A few, some, many, almost all, I do not currently work or go to school
2. If you had to guess, about how many of your family and friends have really wanted to get a COVID-19 vaccine? None, A few, some, many, almost all
3. (displayed to unvaccinated respondents) do you think most of your close family and friends would want you to get a COVID-19 vaccine? None, A few, some, many, almost all

### Zero-order correlations (after rescaling)
| Mean (SD) | Raw coding | Recoding |
|-----------|-----------|-----------|
| 2.52 (0.68) | 1.00 | 1-5 |

### Recommendation main scale = sum of all checked recommendations (λ6 = 0.69)
Recommendation from family and friends subscale = sum of recommendations received from family and friends (2 items; r = 0.67)
Recommendation from health care providers subscale = sum of recommendations received from their health care provider and other health care provider (2 items; r = 0.58)

### Recommendation
Recommendation from family and friends subscale = sum of recommendations received from family and friends (2 items; r = 0.67)
Recommendation from health care providers subscale = sum of recommendations received from their health care provider and other health care provider (2 items; r = 0.58)

### Recommendation Question: Since December 2020, has anyone below recommended that you get a COVID-19 vaccine?
Yes, no, not sure

### Recommendation from family and friends
1. Your personal doctor or healthcare provider
2. Another healthcare provider you know personally
3. Your employer
4. Your friends
5. Your close family members

### Recommendation from health care providers

### Self-reported exposure to negative information scale (r = 0.71)
Scale = sum up scores of two items

| Mean (SD) | Raw coding | Recoding |
|-----------|-----------|-----------|
| 1.25 (0.93) | Y/N/not sure | (continued on next page) |
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Self-reported exposure to negative information scale ($r = 0.71$)

Scale = sum up scores of two items

| Question                                                                 | Mean (SD) | Raw coding | Recoding |
|-------------------------------------------------------------------------|-----------|------------|----------|
| 1. In the last month, have you seen or heard any negative information about the safety or effectiveness of COVID-19 vaccines? | 3.28 (0.90) | 1.00       | 1-4      |
| No, not sure, yes                                                       |           |            | Reverse coded |
| 2. In the last month, have you seen or heard any other negative information about COVID-19 vaccines? | 2.80 (1.15) | 0.33 1.00  | 1-4      |
| No, not sure, yes                                                       |           |            | "I have not looked for this information" mean |

Access scale ($\alpha = 0.83$)

Scale = average all items after the recoding and rescaling

| Zero-order correlations (after reverse coding) | Raw coding | Recoding |
|-----------------------------------------------|------------|----------|
| Mean (SD) 1                                  | 3.28       | 1.00     |
| 2.                                            | 2.80       | 0.33 1.00 |
| 3.                                            | 2.78       | 0.39 0.60 1.00 |
| 4.                                            | 2.75       | 0.50 0.56 0.63 |
| 5.                                            | 2.34       | 0.36 0.44 0.44 0.23 1.00 |

Barrier scale ($\lambda_4 = 0.66$)

Scale = sum of checked barriers

| Question                                                                 | Raw coding | Recoding |
|-------------------------------------------------------------------------|------------|----------|
| 1. I can't go on my own (I have a physical limitation),/I couldn't go on my own (I have a physical limitation). | Yes/skip  | Yes → 1 |
| 2. I would have to travel too far.,/I had to travel too far.            |            | Skip → 0 |
| 3. I don't know where to go to get vaccinated.,/I didn't know where to go to get vaccinated. |           |          |
| 4. I don't have transportation.,/I didn't have transportation.         |            |          |
| 5. I am not in a group prioritized to receive a COVID-19 vaccine right now.,/I wasn't eligible to get a COVID-19 vaccine. |           |          |
| 6. I have a medical reason that makes me ineligible to get vaccinated (such as I have had a severe allergy to vaccines in the past). |           |          |
| 7. The hours of operation are inconvenient./the hours of operation were inconvenient. |           |          |
| 8. The waiting time is too long./the waiting time was too long.         |            |          |
| 9. It is difficult to make an appointment online./it was difficult to make an appointment online. |           |          |
| 10. Convenient appointment times are hard to find./convenient appointment times were hard to find. |           |          |
| 11. I am too busy to get vaccinated./I was too busy to get vaccinated.   |            |          |
| 12. It is difficult to arrange for childcare./it was difficult to arrange for childcare. |           |          |
| 13. I don't have time off work.,/I didn't have time off work.           |            |          |
| 14. I am concerned side effects will interfere with my daily activities./I was concerned side effects would interfere with my daily activities. |           |          |

Self-efficacy

| Mean (SD) | Raw coding | Recoding |
|-----------|------------|----------|
|           |            |          |
### Self-efficacy

| Statement | Mean (SD) | Raw coding | Recoding |
|-----------|-----------|------------|----------|
| How much do you agree with each of the following statements? | | |
| I can get a COVID-19 vaccine if I want to. | 2.35 (0.99) | 1-4 | Skipped if vaccinated → mean for people who definitely will get vaccinated. |

### Vaccine information

Each item was treated as an independent predictor of vaccination stage

| Question | Mean (SD) | Raw coding | Recoding |
|----------|-----------|------------|----------|
| 1. In the past month, how often have you tried to find information about COVID-19 vaccines? | 2.56 (1.39) | 1-5 | N/A |
| 2. In the past month, have you gotten information about COVID-19 vaccines that made you question its accuracy? | – | Binary (Y/N) | N/A |
| 3. How do you feel about the amount of information on COVID-19 vaccines that you are getting? | 1.76 (0.53) | 1-3 | N/A |
| 4. Do you know where to get accurate, timely information about COVID-19 vaccines? | 1.41 (0.79) | Y/N/not sure | No → 0 |

### Appendix B. Multiple imputation

Imputation is a statistical procedure used to address item nonresponse by filling in missing values in data sets using values from a distribution of plausible values, as determined via one or more algorithms (van Buuren, 2018). Best practice requires creating multiple imputed values for each individual missing value and then analyzing the resulting complete-data data sets separately before pooling results so that resulting inferences represent analysts' uncertainty in the imputed values (Schafer and Graham, 2002).

We used multiple imputation procedures to generate 15 datasets. The multiple imputation procedures used the entire data set, a 7-level vaccine status and intent variable that separated partially and fully vaccinated, and an additional 180 variables, using random forest imputation (Stekhoven and Bühlmann, 2012). To generate regression estimates, their standard errors, and mediation estimates, we combined estimates from the 15 imputed datasets using Rubin's rules (Rubin, 1987; van Buuren, 2018).

### Appendix C. Proportion of association between demographic variable and vaccination stage explained by potential mediators (n = 3562)

| Potential mediator | Age | Politics | Income | Urbanicity | Race | Hispanic |
|--------------------|-----|----------|--------|------------|------|----------|
| Disease risk appraisal | | | | | | |
| Risk appraisal scale | 13% | 45% | 40% | | 100% |
| Vaccine confidence | | | | | | |
| Vaccine confidence scale | 63% | 100% | 93% | 100% | 100% |
| Perceived effectiveness subscale | 53% | 100% | 60% | 100% | 50% |
| Perceived safety subscale | 47% | 66% | 87% | 80% | 100% |
| Trust subscale | 47% | 79% | 60% | 60% | 100% |
| Ending protective activities scale | 6% | 10% | | | -18% |
| Restarting routine activities scale | -65% | 7% | 13% | 20% | 23% |
| Social processes | | | | | | |
| Social norms scale | | | | | 100% |
| Recommendation | 13% | 28% | 40% | 60% | 55% |
| Provider rec subscale | 13% | 10% | 13% | 40% | 67% |
| Family/friend rec subscale | 19% | 31% | 32% | 40% | 52% |
| Social preferences | | | | | 100% |
| Altruistic motivation | 41% | 86% | 47% | 80% | 100% |
| Self-reported negative information exposure scale | 65% | 3% | .7% | | |
| Direct behavior change | | | | | | |
| Access | | | | | | |
| Access scale | 13% | 7% | | | 33% |
| Barriers to vaccination | 3% | | | | |
| Self-efficacy | 1% | 1% | 3% | | |
| Covid-19 vaccine information | | | | | | |
| Information seeking | 9% | 28% | 20% | 40% | 100% |
| Ever questioned accuracy of information | 3% | 14% | 13% | | 13% |
| Adequacy of information | 6% | 3% | 7% | | 2% |
| Know where to get accurate information | 3% | 3% | 7% | | |
Torre, L., Barattucci, M., Pagliaro, S., Ballone, C., Teresi, M., Consoli, C., Garofalo, A., De Giorgio, A., Ramaci, T., 2022. Trust in Science as a Possible Mediator between Different Antecedents and COVID-19 Booster Vaccination Intention: An Integration of Health Belief Model (HBM) and Theory of Planned Behavior (TPB). https://doi.org/10.3390/vaccines10071099.

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