COVID-19

Knowledge and identity antecedents of COVID-19 vaccine status: a study of South Carolina residents

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Keywords

COVID-19 • Vaccine hesitancy • Vaccine knowledge

Summary

Introduction. *Despite over three years of learning about SARS-CoV-2 and extensive work to develop vaccines, vaccination rates remain suboptimal, thereby preventing our society from reaching herd immunity.*
Purpose. *Extant literature on vaccine hesitancy led us to hypothesize that specific socio/political variables may be contributing to low vaccination rates, particularly in South Carolina.*
Methods. *By use of Qualtrics surveys, we collected data from people across all counties in South Carolina regarding vaccine status, plans to vaccinate, and a host of demographics.*
Results. *Findings revealed that those less likely to be vaccinated against COVID-19 tended to be younger, female, republican. Interestingly, COVID-19 knowledge did not appear to differ between vaccination status groups, although COVID-19 vaccine and general vaccine knowledge did differ.*
Conclusions. *Our results suggest that while understanding of COVID-19 was relatively similar across groups, targeted and tailored interventions aimed at enhancing the public's general and COVID-19-specific vaccine knowledge may aid efforts to reach herd immunity.*

Introduction

Coronavirus Disease 2019 (COVID-19), a respiratory infection caused by the SARS-CoV-2 virus, was declared a worldwide pandemic in March 2020. As of January 2023, there have been more than 1,000,000 deaths in the United States, with risk of severe disease and death increasing with age and comorbidities, including lung disease, heart disease, diabetes, and others [1]. To fight against the spread of the virus, public health and medical experts recommended precautionary measures such as masks and social distancing to prevent the spread of the virus and slow the progression of the pandemic. In December of 2020, the FDA permitted the release of an emergency vaccination release from Pfizer-BioNTech with FDA full approval on August 23, 2021 [2]. The release of the vaccine, however, was met with much criticism and skepticism with only 53.5% of all eligible South Carolinians being fully vaccinated a year after the full approval of vaccine [3]. This statistic is lower than public health experts believe is necessary to acquire herd immunity. Lower vaccination rates may result in overcrowded emergency rooms and physicians having to work longer hours than usual leading to a surge in burnout [4]. Surges of COVID-19 have led to overburdened hospitals which has been shown to cause a significant number of excess deaths. A 2021 study estimated 12,000 and 80,000 excess deaths when intensive care unit beds were at 75% and 100% capacity respectively [5]. The negative outcomes resulting from stressed hospital systems further support the need to reduce the strain on healthcare infrastructure. Improving vaccination rates is one mechanism that can reduce disease rates and therefore hospital burden.

Given the prevalence of vaccine hesitancy, many researchers have tried to identify the reasons why there seems to be a lack of trust in the COVID-19 vaccine. One study from Travis et al. showed COVID-19 knowledge, age, trust in science, and Trump's presidency approval were predictive of vaccine hesitancy, although this study was done prior to an official vaccine release and was based on a hypothetical vaccine becoming available [6]. In regard to age specifically, another study on sociodemographic predictors for vaccine acceptance found that the age group of 5-18 years of age had the lowest vaccine rates as of June 23, 2022 [7]. Another study found that higher levels of trust in health organizations correlated with higher COVID-19 vaccine acceptance while higher levels of trust in social media correlated with lower COVID-19 vaccine acceptance [8]. Further, a study by Carpenter et al. found that only 23% of pharmacists in southern states received COVID-19 vaccine training and that pharmacy type, attitude, and training had a significant effect on the number of vaccines the pharmacy believes they could administer [9].

Similar to Carpenter et al., a study by Leigh et al. that viewed factors associated with health care workers' vaccine hesitancy found that health care workers that made less than the national median income were more likely to be hesitant of the COVID-19 vaccine [10]. Thus, those individuals that live in impoverished areas are more inclined to interact with health care workers that are more hesitant of vaccination, which could facilitate a reciprocal distrust of vaccination between health care workers and

those they serve. In addition, a study in China by Wu et al. found that individuals who had a lower lifestyle score *i.e*., inadequate sleep, smoking, intermittent drinking, etc. were more hesitant of the COVID-19 vaccination [11]. Thus, individuals who tend to lead lower quality lives are more likely to show greater hesitancy.

One growing area of COVID-19 literature has looked at how certain knowledge factors may influence an individual's acceptance, hesitancy, or current vaccine status and/or various prevention behaviors [6]. Although links between COVID-19 knowledge and prevention practice and vaccine intentions have been established, the domain sampling of knowledge has been scattered. For example, a survey of six countries' residents measured COVID-19 knowledge with items that measured symptoms, causes, and prevention methods, but also items assessing knowledge of the number and genesis (in terms of country of origin) of new variants [12]. Despite the high number of correct responses for the symptoms and prevention methods, less than 4% knew all the new variants or the countries of origin for the new variants. Alternatively, a recent study of young Jordanian citizens' vaccine intentions investigated how COVID-19 knowledge and vaccine knowledge (general and specific) predicts vaccine intentions, however, it is unclear exactly what questions were asked to measure participants' vaccine knowledge [13]. The current study proposes to investigate the contribution of each of these three forms of knowledge (COVID-19 knowledge, COVID-19 vaccine knowledge, and general vaccine knowledge) on vaccine hesitancy, and to do so with measures that capture knowledge strictly relevant to the respective construct domains.

Despite the volume and richness of nascent COVID-19 vaccine hesitancy literature, much of the work combines relatively discrete categories into larger categories *(e.g.,* combining vaccinated with "willing" and "delaying" with "anti-vaccine").[11] Other studies combine responses such as "no opinion" or "unsure" with other options that reflect a more direct refusal to receive a vaccine [10].We believe that there could be value in distinguishing these conceptually distinct groups (*e.g.,* "undecided" versus "no, and do not plan to"). One of the primary benefits of the current study is a direct comparison of antecedents between those that are currently vaccinated with those reporting that they are planning to get vaccinated, those that refuse to get vaccinated, and those that are undecided. By maintaining the distinctions in our outcome variables, we are better able to tease apart differences between people's vaccination status and intentions. Thus, the findings of the current study may be more illuminative regarding potential interventions geared towards particular groups (*e.g.,* those that are undecided versus that refuse to get vaccinated).

The purpose of the present study is to identify the determinants of COVID-19 vaccination hesitancy in South Carolina. In particular, the present study compares the determinants of vaccination hesitancy as expressed with various levels of hesitancy, including delay, refusal, and uncertainty. With an understanding of the factors that contribute to vaccine hesitancy against COVID-19, educational and public health campaigns can be created to reach the targeted individuals to encourage COVID-19 vaccination.

Methods

Our data collection protocols and procedures were approved by the University of South Carolina's Institutional Review Board (IRB). All members that participated in the survey were provided consent in a digital form before proceeding further with the survey. To obtain a sample that is regionally proportional to that of South Carolina's population, we used Qualtrics to achieve a sample that captured every county in South Carolina. Qualtrics' proprietary procedures include the use of traditional, double opt-in research panels that source from website intercepts, referrals from members, email lists, customer loyalty portals, and social media. These methods were used to sample all of South Carolina's geographical locations, consisting of email solicitations and online recruitment. If the prospected individuals consenting to be surveyed met criteria, they would be emailed. Our criteria for participants were that they must be 18 years of age and be a South Carolina resident.

Our collection of data started in October 2021 and ran to December 2021. At the end of our data collection represented individuals that were stratified proportionately to the county's population size of South Carolina. A copy of the survey and the items used in the measures section are provided in the supplementary materials.

Measures

COVID-19 Knowledge

Participants were asked to answer a previously used 11-item test that pertained to COVID-19 knowledge: symptoms, transmission, and treatments [6]. Questions were scored with the correct answer given a 1 while incorrect answers a 0. Thus, scores ranged 0-11.

COVID-19 Vaccine Knowledge

We deployed a measure specific to COVID-19 vaccines asking participants to answer 10 questions pertaining to COVID-19 vaccines in a true or false format. The correct answer was assigned a 1 and the incorrect answer was assigned a 0. There was a score range of 0-10.

General Vaccine Knowledge

Participants responded to 7 questions in a true or false format that pertained to general vaccine knowledge, with correct answers assigned a 1 and incorrect answers assigned a 0. Scores ranged 0-7.

Vaccine intentions

Participants were asked to identify their intentions to get vaccinated against COVID-19 as yes, I have gotten the vaccine; no, but I plan to; no and I do not plan to; or no I am undecided.

Political affiliation

Participants were asked to answer a question to identify their political affiliation as Democrat, Republican, and Independent.

Race

Participants were asked to answer a question that pertained to the racial group they most identify: White, Black/African American, Asian/Pacific Islander, Hispanic/Latino, and American Indian/Native American. Answers were recorded as White = 1 and Nonwhite = 0 for analyses.

Education

Participants were asked to answer, "What is your highest level of education" and responded with: Less than Highschool, Highschool diploma, Some college, Associates degree, Bachelor's Degree, or Post-graduate degree.

Results

Descriptive statistics for our sample are shown in Table I. In order to investigate the influence of our various predictors on vaccine acceptance, we conducted multinomial logistic regression in SPSS. Specifically, the four vaccine acceptance categories were regressed on the predictors with "yes" as the reference category. Results showed our omnibus model of antecedents was predictive of vaccine hesitancy ($\chi^2(24) = 444.3$, $p < .001$, Nagelkerke $R^2 = .366$). Although the full results of this analysis are reported in Table II, we will concentrate on detailing themes that were found, particularly between "yes" and "no, and I do not plan to."

Education level and age were statistically significant predictors for all categories. Older and more educated participants were more likely to report being vaccinated than those that chose the remaining three responses ($p < .001$), although the effect sizes for age were quite small (Tab. II). Race was not found to be a statistically significant predictor of vaccine acceptance except when comparing "no, I'm undecided" to "yes." Here, white participants were 35% less likely to report "no, I'm undecided" compared to nonwhite participants (OR = .544, $p < .05$). While sex was not a statistically significant predictor of "no, but I plan to," males were less likely to report "no, and I do not plan to" and "no, I'm undecided" than females (OR = .393 and OR = .498, $p < .05$ respectively).

Political affiliation, like sex, was not a significant predictor of "no, but I plan to," but did share similar patterns of relations with the other two categories. Specifically, participants reporting a Democratic affiliation were less likely to report either "no, and I do not plan to" (OR = .342, $p < .001$) or "no, I'm undecided" (OR = .483, $p < .01$).

COVID vaccine knowledge, general vaccine knowledge, and COVID knowledge scores were not differentiated between vaccinated participants and those that reported "no, but I plan to." Of the three knowledge scores, only COVID vaccine knowledge was a significant predictor of "no, I'm undecided" where those scoring lower on the test were more likely to report indecision compared to those that responded "yes" (OR = .797, $p < .01$). The most pronounced influence of knowledge scores came when comparing participants reporting "no, and I do not plan to" to vaccinated participants. Although COVID knowledge scores did not differ meaningfully between these groups, participants with lower COVID vaccine knowledge and general vaccine knowledge were far less likely to report being vaccinated than "no, and I do not

Tab. I. Means for demographic variables by vaccine status.

	Yes (n = 1063)	No, but I plan to (n = 123)	No, and I do not plan to (n = 407)	No, I'm undecided (n = 172)
Gender (n = 1758)				
Male	347 (70%)	31 (6.3%)	86 (17.3%)	32 (6.5%)
Female	711 (56.3%)	92 (7.3%)	321 (25.4%)	138 (10.9%)
Education (n = 1765)				
Less than high school	28 (33.7%)	10 (12%)	36 (43.4%)	9 (10.8%)
High school diploma	212 (48.1%)	46 (10.4%)	120 (27.2%)	63 (14.3%)
Some college	237 (51.7%)	32 (7%)	131 (28.6%)	58 (12.7%)
Associate degree	178 (66.7%)	15 (5.6%)	58 (21.7%)	16 (6%)
Bachelor's degree	257 (77.4%)	15 (4.5%)	43 (13.0%)	17 (5.1%)
Post graduate degree	151 (82.1%)	5 (2.7%)	19 (10.3%)	9 (4.9%)
Age (n = 1763)	48.91	34.80	38.98	37.95
Race (n = 1732)				
White	812 (61.7%)	73 (5.6%)	316 (24%)	114 (8.7%)
Nonwhite	233 (55.9%)	49 (11.8%)	81 (19.4%)	54 (12.9%)
Political Affiliation (n = 1186)				
Republican	392 (58.2%)	32 (4.7%)	197 (29.2%)	53 (7.9%)
Democrat	365 (71.3)	51 (10%)	56 (10.9%)	40 (7.8%)
COVID Knowledge	9.46	8.90	8.54	9.13
COVID Vaccine Knowledge	8.61	7.96	7.09	7.85
General Vaccine Knowledge	3.20	3.02	2.33	2.83

Tab. II. Odds ratios and confidence intervals from multinomial regression

	No, and I do not plan to	No, but I plan to	No, I'm undecided
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age	.980 (.97, .99)*	.964 (.95, .98)*	.974 (.96, .99)*
Education	.747 (.66, .85)*	.640 (.53, .78)*	.711 (.60, .85)*
COVID Vaccine Knowledge	.651 (.58, .74)*	.908 (.77, 1.08)	.797 (.68, .93)*
General Vaccine Knowledge	.446 (.36, .55)*	.887 (.66, 1.20)	.841 (.63, 1.11)
COVID Knowledge	.992 (.89, 1.11)	.900 (.77, 1.05)	1.052 (.90, 1.23)
Race (White)	1.33 (.79, 2.23)	.618 (.35, 1.11)	.544 (.30, .99)*
Sex (Male)	.393 (.26, .61)*	.885 (.51, 1.54)	.498 (.28, .89)*
Political Affiliation (Democrat)	.342 (.22, .53)*	1.128 (.64, 2.00)	.483 (.28, .84)*

* p < .05. OR = odds ratio, CI = confidence intervals. Reference criterion was "Yes" for vaccine status. Reference categories for predictor variables are shown in parentheses.

plan to" (OR = .651 and OR = .446, p < .001 respectively). Figure 1 shows the averages of the knowledge-based questions for general COVID-19, general vaccine knowledge, and COVID-19 vaccine knowledge. Among all participants that chose "no, and I do not plan to" had the lowest scores for all knowledge-based questions and all participants that chose "yes" had the highest scores for the knowledge-based questions.

Figure 2 shows the reasons chosen that participants decided for choosing to get vaccinated for COVID-19. The top choices for getting vaccinated were for health and safety, with personal health and safety being the highest at ~87%. The second highest choice was for the health and safety of family at ~85%.

Figure 3 displays the most reported reasons that participants decided against getting vaccinated for COVID-19. The top reason against receiving the COVID-19 vaccine was distrust in the vaccine itself at ~53%. The second reason

Fig. 1. Knowledge score differences by vaccine status.

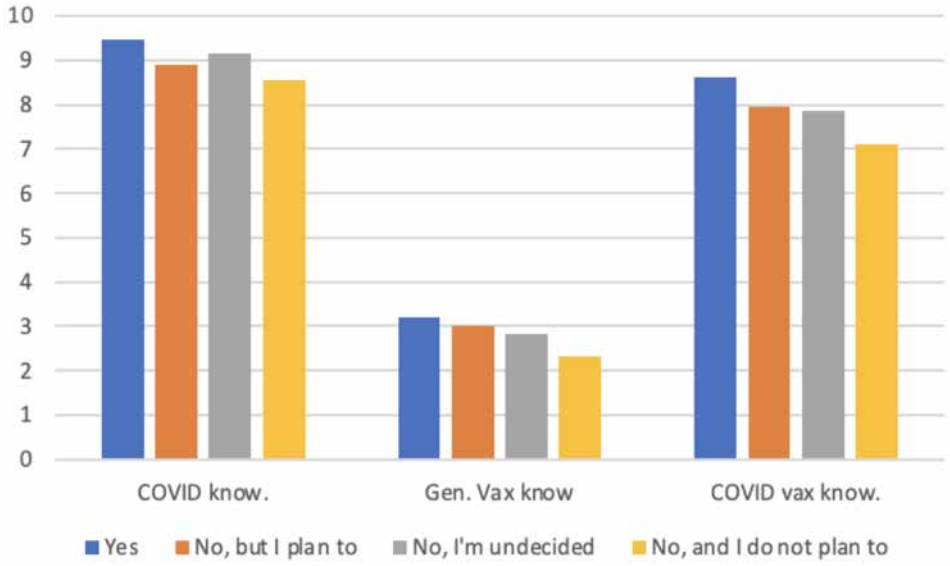


Fig. 2. Top reasons for getting vaccinated.

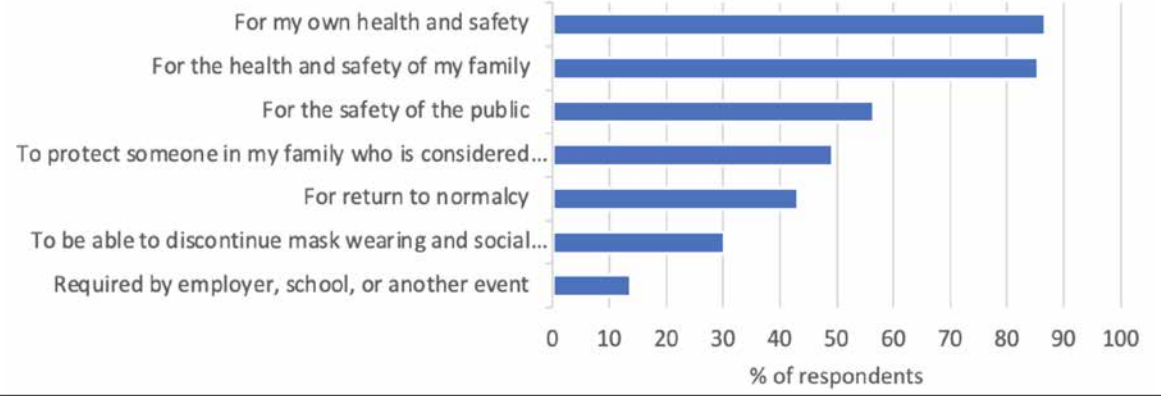
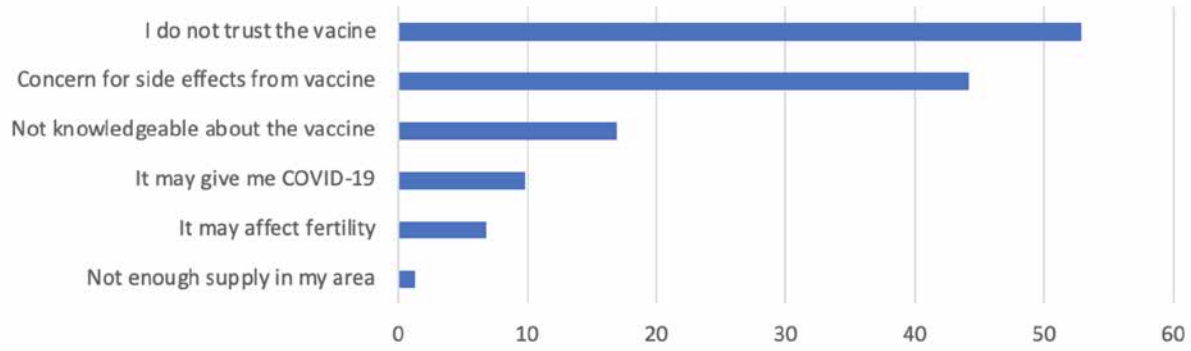


Fig. 3. Top reasons for not getting vaccinated.



against receiving the COVID-19 vaccine is concern about the side effects of the vaccine at ~44%.

Discussion

The purpose of this study was to identify antecedents of vaccine acceptance within the South Carolina community. Administering a survey to residents of every county in South Carolina, we explored demographic, political, and knowledge-related predictors to determine the likelihood of vaccination against COVID-19. Findings revealed several factors that appear to be influential to getting vaccinated: age, sex, political affiliation, COVID-19 vaccine knowledge, and general vaccine knowledge. Our hope for this project is to use these findings to target individuals with COVID-19 vaccination education and encourage vaccination in hopes to eventually reach herd immunity against COVID-19.

According to our results, education level and age were associated with increased COVID-19 vaccine acceptance. Our research suggests that a rise in education tended to have an increase in vaccine acceptance. The relationship between education and vaccine acceptance may be manifested via an understanding of how to decern whether information is credible, an important skill learned in higher education [15]. The finding of the effect of age on vaccine acceptance may be due to older generations having more frequent contact with their doctors and physicians. According to Kini et al., older individuals are more likely to frequent medical offices due to a chronic disease that needs to be treated which allows them to be more informed on immunizations recommendations [16]. In congruence, Kini et al. suggests that younger individuals consider themselves at a lower risk for contracting diseases and are therefore less likely to receive vaccinations against diseases [16].

Our results showed that race was not a significant predictor for vaccine acceptance except for comparing "yes" and "no, I am undecided." According to our results, white participants appear to be more conclusive in their decisions about vaccinations, whereas non-white participants seemed to hold more skepticism. This may be in accordance with the historic mistreatment and abuse towards people of color, especially in the medical and research fields as other research has found much less trust towards modern research and medical treatment when discussing how minority individuals were treated for diseases and ailments decades ago [17]. For example, a study on the impact of the Tuskegee study by Katz et al. found that 81% of African Americans had knowledge of the Tuskegee study and that that knowledge contributed to 46% of African Americans in the study to have mistrust in scientific research [17].

In our study, men were less likely to say "no, I am undecided" than women, while women were less likely to respond with "no, but I plan to." This is consistent with previous studies done that found a gap in acceptance between men and women. According to Zintel et al., women were more skeptical towards the COVID-19 vaccine [18]. According to another study by Conis E., women's skepticism towards vaccination is traced back to the 1970's and 1980's with the surgency of feminism. The women's health movement caused an examination of the scientific immunization rhetoric which led to feelings of mistrust to doctors, scientific expertise, and medical advice that culminated into how women now perceive vaccinations [19].

According to our research, Democrats were far less skeptical of the COVID-19 vaccines than Republicans as Democrats were less likely to choose "no, I am undecided" or "no, and I do not plan to" compared to "yes." This could be an artifact of Republicans tending to rely on their endorsement of misinformation about child vaccinations and more specifically the notion that childhood vaccinations cause autism [20]. Similarly, a study by Joslyn et al. found that educated Republicans were highly conflicted about vaccinations as they showed skepticism towards vaccinations though their education proved otherwise and did not align with their personal beliefs [21].

COVID-19 vaccine knowledge, general vaccine knowledge, and COVID-19 knowledge did not have a significant contribution to "no, but I plan to." This is likely due to the influx of information on general vaccination knowledge and COVID-19 over the past two years and therefore those people that have decided to get the vaccine have already received it. Perhaps most importantly, our research revealed that both COVID-19 vaccine knowledge and general vaccine knowledge were statistically significant predictors of "yes" versus "no, and I do not plan to" whereas COVID-19 knowledge was

not. Research performed in the aftermath of COVID-19's onset but preceding the approval of a vaccine has found that COVID-19 knowledge was a powerful predictor of preventative behavior but not a statistically significant predictor of vaccine intentions when included alongside variables similar to those in the present study (*e.g.,* political identity and education) [6]. As widespread public health campaigns may have enhanced the public's knowledge about the COVID-19 disease, the misinformation of COVID-19 vaccines, and perhaps a broader misunderstanding of vaccines in general, may have persisted despite these efforts. It seems from our research that the most significant contributor to becoming vaccinated against COVID-19 is the COVID-19 vaccine knowledge scores. A study by Sahil et al. found that exposure to misinformation online about the COVID-19 vaccine has determined that the United States has dropped 6.4% in intent to vaccinate [22]. It is our contention that, based on the results of extant literature and the present study, the public would be well-served to receive interventions aimed at raising more general vaccination and immunology education, as the lack of knowledge appears to be a major factor in choosing to vaccinate despite knowing the dangers of a disease like COVID-19.
A few limitations of the current study bear mention. First, the sample used in our analyses was drawn from residents of South Carolina aged 18 and older. While this was our intentional strategy, our findings and conclusions should be contextualized. Indeed, important boundary conditions or contextual features may be identified by comparing our results with those of other regional samples, as well as national and international samples. Another limitation was our selection of antecedents. We chose our model a priori as COVID-19 vaccine-related research had begun to proliferate, and therefore we only included those that we felt most proximal at the time. It is certainly the case that emerging lines of research will prove progressive in offering both nuanced and empirically supported predictors of vaccine status that we did not anticipate.

Conclusions

This study used a large sample of South Carolina residents to investigate various predictors of COVID-19 vaccine acceptance. Our findings showed that many demographic and knowledge variables could meaningfully distinguish between individual's vaccine status. In addition to exploring antecedents of vaccination status, we also made careful distinctions among the groups in which we were seeking to predict – those receiving a vaccine, planning to receive a vaccine, not planning to receive vaccine, and those that were undecided. Such distinctions could be important in constructing more effective interventions to save lives and cut down on medical costs and hospital visits.
We believe that our findings may be instrumental in future studies of vaccine acceptance, particularly COVID-19 vaccines. One prospective area of potential utility is in the use of peripheral route persuasion. In brief, humans process information, and therefore can be influenced, via two routes – a logical route that requires attentional resources (central route) and an automatic route that is quick and reflexive (peripheral route) [23]. Public health interventions have tended to rely on rational, logical appeals (e.g., educating the public on the facts), yet we have observed that despite raising knowledge regarding the subject matter (COVID-19), vaccine uptake is still suboptimal. The use of peripheral route, a more automatic form of information processing, relies on positive and negative cues and their various associations; such as, an authority figure, group identity, and evoked feelings, *etc.* As the central route interventions have frequently come from groups less trusted by those they are seeking to most influence (*e.g.,* the CDC, Democratic politicians, and scientists), it is possible that these evoked negative associations from listeners. Framing messages and embedding them with cues relevant to the targeted group (*e.g.*, delivery by a young female Republican, evoking authority relevant to young female Republicans, etc.) may be a potential persuasion tool towards vaccination for those that are otherwise opposed to vaccination, based on our research. Indeed, recent research[24] has found that the public may be most influenced when both routes are leveraged, suggesting future studies may benefit from exploring which principles of influence may work best, and for which groups and under what conditions.

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Conflict of interest statement

The authors report no conflicts of interest.

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Authors' contributions

B.M. was responsible for study design, data analysis, and writing the manuscript. C.P. contributed to study design, data analysis and manuscript editing. G.W. was responsible for grant funding and study design and contributed in editing the manuscript. J.T. was responsible for data collection and analysis, and contributed in writing and editing the manuscript.

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