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Inside the ‘black box’ of COVID-19 vaccination beliefs: Revealing the relative importance of public confidence and news consumption habits[☆]

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ABSTRACT

Rationale: President Biden’s goal for 70% of U.S. adults to have received at least one vaccine by July 4, 2021 was not achieved.

Objective: The aim of this research was to assess the ‘black box’ of positive COVID-19 vaccination beliefs to determine the relative importance of each factor and thus inform well-targeted and tailored health promotion efforts.

Methods: A cross-sectional survey was conducted in a sample of U.S. adults ($N = 1656$), assessing the influence of demographic characteristics, cognitive effects, public confidence, and news source variety and evaluation on positive COVID-19 vaccination beliefs.

Results: Overall, the strongest predictor of positive beliefs was high confidence in public health officials and political institutions to handle the COVID-19 pandemic effectively, yet negative sentiments toward COVID-19 research and science and COVID-19 vaccine ambivalence reduced the likelihood that beliefs were positive. Cognitive effects and public confidence were identified as key predictors of positive COVID-19 vaccination beliefs over and above party identification. Importantly, high levels of confidence in science and government were mostly driven by positive evaluations of liberal news sources. High levels of COVID-19 science backlash were mostly driven by positive evaluations of conservative news sources.

Conclusions: To motivate COVID-19 vaccination among hesitant or resistant groups in the population, health promotion efforts should seek to reinforce positive COVID-19 vaccination beliefs by increasing public confidence and by reducing COVID-19 science backlash, largely by choosing specific news media and social media platforms (e.g., Breitbart, Fox News, and Facebook) as channels for health promotion and health information dissemination.

1. Introduction

Effective COVID-19 vaccines have been developed and administered to the public to stop the spread of SARS-CoV-2 and reduce its disease burden in the United States (U.S.). Unfortunately, after about half of the U.S. population had been vaccinated against COVID-19 in early 2021, vaccination rates began to stall and President Biden’s goal for 70% of U.S. adults to have received at least one vaccine dose by July 4, 2021 was not achieved (Keith and Montanaro, 2021). Thus, for a considerable proportion of the U.S. population, there continues to be a risk for community spread and severe illness from COVID-19 and its novel variants (Stein, 2021). Vaccine hesitancy, defined as the decision to

delay or refuse vaccination despite available opportunities, has become increasingly common in the U.S. (Callaghan et al., 2019). The emerging literature on COVID-19 vaccination adds new knowledge to an existing body of research on vaccine hesitancy, which often points to concerns about vaccine safety (Dubé et al., 2013). Previous research, however, has mostly examined vaccine hesitancy for vaccines with long-term safety records. Such data are not yet available for novel COVID-19 vaccines, which likely exasperates existing fears about vaccine safety and thus reduces vaccine uptake in the population.

Effective health communication efforts are needed to increase positive COVID-19 vaccination attitudes and to improve COVID-19 vaccine uptake in segments of the population that are hesitant to vaccinate

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against COVID-19 (Callaghan et al., 2021; Fisher et al., 2020; Lueck and Spiers, 2020). Common approaches in health communication seek to influence behavior indirectly by first targeting beliefs, which can then shape attitudes and behavior. In order to inform theory-based health promotion efforts, Lueck and Spiers (2020) utilized a behavioral theory, the reasoned action framework, to assess COVID-19 vaccination beliefs (Fishbein and Ajzen, 2010). To accurately identify key beliefs predictive of COVID-19 vaccination behavior, the authors first conducted an open-ended belief elicitation in a sample of U.S. adults by asking participants about the positive and negative things that come to mind when they think about getting vaccinated against COVID-19. In a second study, the authors regressed those beliefs on attitudes and intention to vaccinate in a sample of U.S. adults to identify key beliefs that should be targeted with health promotion strategies to encourage COVID-19 vaccination. The study's findings revealed that intentions to vaccinate against COVID-19 were largely determined by positive COVID-19 vaccination attitudes and beliefs, such as the belief that COVID-19 vaccination will lead to "peace of mind" (Lueck and Spiers, 2020). The current study expands on these previous findings by identifying the determinants of such positive beliefs.

In order to effectively influence beliefs, it must first be established *who* should be targeted with health communication efforts (Larson et al., 2015). To do so, researchers have focused on identifying unique demographic characteristics of individuals who are less likely to receive a COVID-19 vaccine. For example, previous research has usefully identified several demographic factors that are associated with COVID-19 vaccine hesitancy in the U.S. population, such as sex, race, political ideology, and party identification, among other factors (Callaghan et al., 2021; Fridman et al., 2021; Khubchandani et al., 2021; Ruiz and Bell, 2021). Yet, it remains unclear whether demographic characteristics also influence the determinants of vaccination – the underlying belief structure of attitudes about COVID-19 vaccination.

1.1. Research question 1 (RQ1): Which demographic characteristics most strongly determine positive beliefs about COVID-19 vaccination in the U.S. Population?

While demographic characteristics may be strong influencing factors, they may not fully explain variation in COVID-19 vaccination beliefs in the population. Particularly during health crises such as the COVID-19 pandemic, the news media fulfill important societal functions. High levels of stress, uncertainty, and fear motivate people to turn to the news media for timely and accurate information – a phenomenon that can strengthen the influence of news media reporting on individual-level perception and beliefs (Weitzer and Kubrin, 2004; Vasterman et al., 2005). Unfortunately, engagement with the news media can be a double-edged sword, particularly in the context of vaccine hesitancy (Mason and Donnelly, 2000; Smith et al., 2007). During the pandemic, the media has provided critical information about preventive health behaviors like mask-wearing and vaccination, yet the news media environment has also been rife with conflicting and confusing COVID-19 guidelines, misinformation, and conspiracy theories that have negatively influenced health decision-making in the U.S. population (Gollust et al., 2020). U.S. Surgeon General Jerome Adams, for example, expressed regret over the dissemination of confusing COVID-19 guidelines to the American public through the media, which likely created higher levels of mistrust in public health messaging in the population at a time when compliance with health directives was critically important to public health (Mastrangelo, 2021).

Especially in the early stages of the pandemic, public health messaging was not sufficiently clear and consistent to counterbalance significant levels of stress, uncertainty, and fear in the U.S. population. As a result, various negative cognitive effects have been documented, such as information backlash (negative sentiments toward COVID-19 information), science backlash (negative sentiments toward COVID-19 research and science), and ambivalence about health directives

(ambivalence toward receiving a COVID-19 vaccine). Furthermore, low public confidence in the effectiveness and safety of vaccines, the manufacturers and health systems that deliver them, the competence of health officials, and the motivations of policymakers, has also been reported (Kim et al., 2020; Latkin et al., 2021; MacDonald, 2015; Mohammed et al., 2021).

It is thus plausible that the news media have led to negative cognitive effects in the population, as well as low public confidence in public health officials and political institutions to handle the COVID-19 pandemic effectively – sentiments that may increase vaccine hesitancy. The association between these negative sentiments and vaccine hesitancy has been documented for other vaccines, such as the HPV vaccine and beliefs surrounding vaccines causing autism (Nan and Daily, 2015; Dixon and Clarke, 2012). However, it remains unclear whether such negative cognitive effects and low public confidence play a more important role in shaping beliefs and attitudes about COVID-19 vaccination than demographic characteristics alone, which a majority of early and emerging research on COVID-19 vaccine hesitancy has focused on. This knowledge has important implications for health promotion because targeting certain demographic groups may not suffice in influencing vaccination beliefs and behavior unless they also seek to influence negative cognitive effects and low public confidence, as well.

1.2. Research question 2 (RQ2): What is the relative importance of cognitive effects and public confidence in determining positive COVID-19 vaccination beliefs over and above demographic characteristics?

People who are more influenced by the news media during times of crisis may also be more likely to interpret COVID-19 health information and directives through the lens of political news media framing (Gollust et al., 2020). Even prior to the pandemic, researchers have emphasized that debates about politicized health issues in the media are particularly "sticky" and thus strongly influence public perceptions and behavior (Fowler and Gollust, 2015), yet it remains unclear whether and how news consumption during the COVID-19 pandemic influences negative cognitive effects such as information backlash (negative sentiments toward COVID-19 information), science backlash (negative sentiments toward COVID-19 research and science), and ambivalence about health directives (ambivalence toward receiving a COVID-19 vaccine). The focus of this current investigation was the evaluation of specific news sources in addition to the variety of news sources people consumed during the COVID-19 pandemic.

1.3. Research question 3 (RQ3): What is the relative importance of news source variety and evaluation of news sources in determining cognitive effects and public confidence over and above demographic characteristics?

Determining the relative importance of cognitive effects and public confidence over and above demographic characteristics, as well as news source variety and evaluation of news sources over and above demographic characteristics, could help inform evidence-based and well-tailored approaches to promote COVID-19 vaccination in the population (Fishbein and Ajzen, 2010; Goldstein et al., 2015; Jarrett et al., 2015). Thus, the primary aim of the current research was to extend previous work by elucidating which segments of the population hold certain COVID-19 vaccination beliefs and why. Findings can be used to inform *who* should be targeted with effective health promotion efforts (i.e., which segments of the population), and *how* (i.e., targeting cognitive effects and public confidence) to increase COVID-19 vaccination rates in the U.S. population. Without such information, there is no evidence upon which to base effective health communication efforts to promote COVID-19 vaccination in the U.S.

2. Methods

2.1. Study design

Upon receiving IRB approval (Texas A&M University IRB: IRB2020-1066M), an online survey was conducted with a national sample of U.S. adults weighted to population benchmarks (N = 1656). This sample was obtained from the Lucid marketplace survey platform. Lucid recruits participants through a double opt-in procedure for becoming a panel member and to participate in specific surveys. Researchers pay Lucid a cost per completed interview (CPI) and Lucid pays suppliers who then provide a portion of those earnings to participants in the form of cash, gift cards, or loyalty reward points. Prior research has shown that Lucid samples closely match population benchmarks and outperform convenience samples, leading to growing use of the platform in the social sciences and the study of vaccine hesitancy in particular (Coppock and McClellan, 2019; Callaghan et al., 2021). Lucid relies on quota sampling to ensure that sampling distributions for key demographic characteristics closely match population benchmarks. To account for any remaining deviations between this sample and the U.S. population, post-stratification weights to Census benchmarks for gender, education, race, age, and income were calculated and applied to all models. Additional information about the sample and how raw and weighted demographic characteristics compare to population benchmarks are provided in Table 1.

2.2. Measures

All survey respondents were asked a series of questions about their beliefs, cognitive effects, public confidence in individuals and institutions, and news consumption habits during the COVID-19 pandemic. The primary dependent variable in this research was 'positive COVID-19 vaccination beliefs.'

COVID-19 vaccine beliefs. Positive and negative beliefs about COVID-19 vaccination were previously elicited, analyzed, and tested according to the reasoned action framework (Fishbein and Ajzen, 2010) in a sample of U.S. adults (N = 1656) (please see the published paper reporting on these findings, Lueck and Spiers, 2020). Each previously elicited belief was assessed separately by asking participants, "how likely is it that the following would happen if you get vaccinated against COVID-19 once a vaccine becomes available?" (1 = very unlikely; 7 = very likely; 7-pt Likert Scale). This prior research suggested that positive beliefs were a strong predictor of vaccine attitudes, whereas negative beliefs were not (Lueck and Spiers, 2020). Thus, the five most important positive beliefs that emerged from this previous research (e.g., vaccination would lead to "peace of mind," "return to normal life," "knowing that you did the right thing for society") were selected for further examination in this current study. The five positive beliefs yielded good internal consistency (α = 0.90) and were averaged to form a single measure for positive vaccination beliefs. Each positive belief was explored separately in the analyses to allow for an examination of

possible subdimensions of the composite measure.

In addition to the dependent variable, the survey also included a number of independent variables. These explanatory measures were selected based on prior research on vaccine hesitancy, as well as the specific context surrounding COVID-19 vaccination.

Demographic characteristics. Sex was assessed by asking participants whether they identified as 'male,' 'female,' or 'other.' None of the participants in this study chose 'other,' thus, sex was coded as 1 for female and 0 for male. Participants indicated their age by entering a numeric value (interval). Dichotomous indicators were used for race and ethnicity (1 for 'White/Caucasian' and 0 for 'other'). Education was assessed with an ordinal scale with seven response options and household income within the past 12 months was assessed with an ordinal scale with 12 response options. To assess party identification, a standard 7-pt measure ranging from 'strong Democrat' to 'strong Republican' was used.

Cognitive effects. To assess COVID-19 information backlash, participants were asked to indicate their level of agreement ('strongly disagree' – 'strongly agree'; 5-pt Likert Scale) with 12 statements (e.g., "I feel overwhelmed by the amount of COVID-19 information that I am supposed to follow;" "There is not enough time to do all of the things recommended to prevent COVID-19"). The average of the 12 items was used to capture COVID-19 information backlash, α = 0.92. To assess COVID-19 science backlash, participants were asked about their level of agreement ('strongly disagree' – 'strongly agree'; 5-pt Likert Scale) with three statements (e.g., "scientific research provides good guidance about how to prevent COVID-19," "the evidence about how to prevent COVID-19 is growing;" "I pay attention to new research on COVID-19" (reverse coded)). The average of the three items was used to capture COVID-19 science backlash, α = 0.80. To assess COVID-19 vaccine ambivalence, participants were asked to indicate their level of agreement ('strongly disagree' – 'strongly agree'; 5-pt Likert Scale) with one statement ("I have mixed feelings about getting vaccinated against COVID-19"). These measures were adapted from previous research which examined the cognitive effects of conflicting messages on health attitudes and behavior to match the context of COVID-19 (Han et al., 2014; Nagler et al., 2019).

Public confidence. A public confidence measure was developed by asking participants to rate how much faith they have (1 = 'none at all,' 5 = 'a great deal;' 5-pt Likert Scale) in various individuals and institutions ("Joe Biden," "the CDC," "the WHO," "scientists," "academic/research institutions," "Dr. Fauci," "pharmaceutical companies," and "the governor of the state you [they] live in") to effectively handle public health emergencies like the COVID-19 pandemic. The eight items yielded good internal consistency and were averaged to form a measure for public confidence in individuals and institutions to handle COVID-19 effectively, α = 0.90.

News consumption habits. A 15-item battery was developed to assess news source variety in any given week (Monday through Sunday) based on the variety of news sources participants consume (e.g., "print version of a local newspaper," "a website of an international news organization") (1 = 'never,' 5 = 'all or almost all of the time;' 5-pt Likert

Table 1
Comparison of raw and weighted lucid data to national benchmarks.

Variable	Data (Raw)	Data (Weighted)	Benchmark	Benchmark Source
Female	56.84%	53.83%	51%	CPS 2018
College Degree	41.90%	32.48%	31%	CPS 2018
Hispanic	11.76%	15.73%	18%	CPS 2018
Black (Non-Hispanic)	11.08%	13.20%	13%	CPS 2018
White (Non-Hispanic)	71.18%	63.32%	62%	CPS 2018
Median Age in Years	41	47	47	ANES 2016
Median Income	\$35,000–49,999	\$50,000–74,999	\$55,000–59,999	ANES 2016

Note: Table 1 presents a comparison of our raw and weighted data to known population benchmarks. The CPS is the Current Population Survey from the US Census. The ANES is the American National Election Study. We rely on the CPS wherever possible but supplement with ANES data whenever it is not possible to use the CPS. Post-stratification weights in our survey adjust for gender, age, education, race, and income. Data for Whites and Blacks are based on estimates without the inclusion of Hispanics.

Scale). The 15 items yielded good internal consistency, $\alpha = 0.93$ and were thus averaged to form a measure for news source variety. Higher scores indicate a higher variety of news sources consumed in any given week.

A 16-item battery assessing *evaluation of news sources* was also developed by asking participants, “specifically, how would you rate each of the following news sources?” (1 = ‘very unfavorably,’ 5 = ‘very favorably,’ 5-pt Likert Scale). News sources included a variety of liberal-leaning (e.g., “CNN”) and conservative-leaning (e.g., “Fox News”) news sources, as well as international news sources (e.g., “Al-Jazeera,” “BBC”), sources containing news commentary (e.g., “The Young Turks;” “Breitbart”), and social media (e.g., “Twitter;” “Facebook”). A principal component analysis (varimax orthogonal rotation with Kaiser normalization; variance explained: 68.5%, KMO = 0.97; Bartlett’s test, $p < .001$) suggested that items loaded onto two factors. The 13 items that emerged from a factor analysis included liberal-leaning news sources (e.g., “CNN,” “Al-Jazeera,” “The Young Turks,” “Twitter”) and yielded good internal consistency, $\alpha = 0.96$ and were thus averaged to create a measure for *evaluation of liberal-leaning news sources*. The three items that emerged from the same factor analysis included conservative-leaning news sources and social media (“Breitbart,” “Fox News,” “Facebook”) and yielded acceptable internal consistency, $\alpha = 0.75$ and were thus averaged to create a measure for *evaluation of conservative-leaning news sources*.

2.3. Missingness

Across all variables included in the analyses, missing data levels never exceed 4.68% (observed for *age*). Further, missingness on the primary outcome variables, COVID-19 vaccination attitudes and beliefs, were below 3.82%. Consequently, imputation strategies to adjust for missing data were not used.

3. Results

3.1. Main analyses

In prior research (Lueck and Spiers, 2020), positive and negative COVID-19 vaccination beliefs explained 52% of the variance in COVID-19 vaccination attitudes, $R^2_{Adj.} = 0.52$, $F(2, 1515) = 830.50$, $p < .01$. Positive beliefs were a strong determinant of vaccination attitudes, whereas negative beliefs were not. A second linear regression analysis including all positive beliefs determined that “achieving peace of mind” and “protecting yourself against COVID-19 infection” were most strongly associated with attitudes, followed by “knowing that you did the right thing for society and those who are vulnerable in your community,” “life returning to normal,” and “protecting close others,” $R^2_{Adj.} = 0.53$, $F(5, 1491) = 335.31$, $p < .01$. Presented findings in this manuscript supplement and extend findings reported elsewhere (Lueck and Spiers, 2020). Novel findings regarding positive COVID-19 vaccination beliefs (DV) are presented below.

First, a linear regression model for the dependent variable of interest, *positive beliefs about COVID-19 vaccination* (DV), was created including all of the independent variables (demographic characteristics, cognitive effects, *public confidence*, *news source variety*, and *evaluation of news sources*) for a direct comparison of effects on positive beliefs. The model explained 38% of the variance in *positive beliefs about COVID-19 vaccination*, $R^2_{Adj.} = 0.38$, $F(13, 1279) = 61.97$, $p < .01$. The strongest predictors were *public confidence in individuals and institutions* (positive predictor) and *science backlash* and *COVID-19 vaccine ambivalence* (negative predictors) (see Table 2).

Next, research questions were examined in a stepwise approach because independent variables theoretically reside at different levels of the media effects process. Furthermore, the goal was to test whether adding certain independent variables to each statistical model would significantly improve the model’s ability to predict the variable of

Table 2

Entire regression model for positive beliefs about COVID-19 vaccination (DV) with all independent variables.

Positive COVID-19 Vaccination Beliefs			
Variable	<i>i</i>	SE B	β
<i>Demographic Characteristics</i>			
Sex (female)	-.09	.07	-.03
Race (White vs other)	.39	.08	.11**
Age	-.00	.00	-.01
Education	.01	.05	.00
Party Identification	.03	.02	.05
Income	.05	.05	.02
<i>Cognitive Effects</i>			
Information backlash	.15	.04	.10**
Science backlash	-.37	.05	-.34**
Vaccine ambivalence	-.20	.03	-.20**
<i>Public Confidence</i>			
Public confidence	.58	.05	.38**
<i>News Consumption</i>			
Variety	.04	.05	.03
Eval. liberal sources	.05	.05	.03
Eval. cons. sources	.07	.04	.06*
R^2_{Adj}	.38		
F for change in R^2	61.97**		

Note. Sex: female = 1, male = 0; race: White = 1, other = 0; age (interval); education (interval), party identification: 7-pt measure, 1 = strong Democrat, 7 = strong Republican; income (interval); information backlash: 5-pt scale; 1 = strongly disagree, 5 = strongly agree (higher values represent higher levels of information backlash); science backlash: 5-pt scale; 1 = strongly disagree, 5 = strongly agree (higher values represent higher levels of science backlash); vaccine ambivalence: 5 pt scale, 1 = strongly disagree, 5 = strongly agree (higher values represent higher levels of vaccine ambivalence); public confidence: 5-pt scale; 1 = none at all, 5 = a great deal (higher values represent higher levels of public confidence); news source variety: 5-pt scale, 1 = never, 5 = all or most of the time (higher values represent higher news source variety), evaluation of liberal news sources: 5-pt scale, 1 = very unfavorably, 5 = very favorably (higher values represent more positive evaluation of liberal news sources); evaluation of conservative news sources: 5-pt scale, 1 = very unfavorably, 5 = very favorably (higher values represent more positive evaluation of conservative news sources). * $p < .05$, ** $p < .01$.

interest, holding constant the influence of demographic characteristics.

RQ1. Which demographic characteristics most strongly determine positive beliefs about COVID-19 vaccination in the U.S. population? A linear regression analysis was conducted to test the influence of demographic characteristics, such as *sex*, *race*, *age*, *income*, *education*, and *party identification* on *positive beliefs* (the strongest predictor of attitudes). The model explained 6% of the variance in *positive beliefs about COVID-19 vaccination*, $R^2_{Adj.} = 0.06$, $F(6, 1339) = 15.15$, $p < .01$. The strongest positive predictor was *race* (identifying as ‘White’), followed by a higher level of *education*, and *party identification* (identifying as ‘Democrat’). Separate linear regression analyses determined that the strongest predictor for the *positive beliefs* such as “achieving peace of mind,” “protecting yourself,” “knowing that you did the right thing for society,” and “life returning to normal,” was *race* (identifying as ‘White’). *Party identification* (identifying as ‘Republican’) was a negative predictor for the *positive belief* “protecting others from infection,” $R^2_{Adj.} = 0.04$, $F(6, 1335) = 10.38$, $p < .01$.

RQ2. What is the relative importance of cognitive effects and public confidence in determining positive COVID-19 vaccination beliefs over and above demographic characteristics? A linear hierarchical regression analysis was conducted to assess the influence of *cognitive effects* and *public confidence* on *positive beliefs* (the strongest predictors of attitudes) (DV). The demographic characteristics (*sex*, *race*, *age*, *income*, *education*, and *party identification*) were entered at step 1. The cognitive effects measures (*COVID-19 information backlash*, *COVID-19 science backlash*, and *COVID-19 vaccine ambivalence*) and *public confidence* were entered at step 2. Cognitive effects and *public confidence*

explained a substantive additional amount of variance (32%) in the model, $R^2_{\text{Change}} = 0.32$, $F(4, 1325) = 175.52$, $p < .01$. The final model explained 38% of the variance in *positive beliefs* about COVID-19 vaccination, $R^2_{\text{Adj.}} = 0.38$, $F(10, 1325) = 84.00$, $p < .01$. *Public confidence* at step 2 was the strongest predictor of *positive beliefs* and a much stronger predictor than *party identification* at step 1. *COVID-19 science backlash* and *COVID-19 vaccine ambivalence* were negatively associated with *beliefs* (see Table 3). The same patterns of results were found for each belief separately.

RQ3. What is the relative importance of news source variety and evaluation of news sources in determining cognitive effects and public confidence over and above demographic characteristics? Four hierarchical regression analyses were conducted to determine whether news consumption and evaluation of news sources influence *COVID-19 information backlash*, *COVID-19 science backlash*, *COVID-19 vaccine ambivalence*, and *public confidence* (the strongest predictors of positive beliefs about COVID-19 vaccination). The demographic characteristics (*sex*, *race*, *age*, *income*, *education*, and *party identification*) were entered at step 1. *News source variety* and *evaluation of conservative and liberal news sources* were entered at step 2. For *public confidence* (DV), *news source variety* and *evaluation of news sources* explained a substantive additional amount of variance (30%) in the model, $R^2_{\text{Change}} = 0.30$, $F(3, 1291) = 226.85$, $p < .01$. The final model explained 42% of the variance in *public confidence*, $R^2_{\text{Adj.}} = 0.42$, $F(9, 1291) = 106.38$, $p < .01$. *Evaluation of liberal news sources* and *news source variety* were strong positive predictors of *public confidence*, whereas *evaluation of conservative news sources* emerged as a weak, but negative predictor of *public confidence* (see Table 4).

For *COVID-19 information backlash* (DV), *news source variety* and *evaluation of news sources* explained 7% of the variance in the model, $R^2_{\text{Change}} = 0.07$, $F(3, 1291) = 40.30$, $p < .01$. The final model explained 24% of the variance in *COVID-19 information backlash*, $R^2_{\text{Adj.}} = 0.24$, $F(9, 1291) = 47.60$, $p < .01$. *Evaluation of conservative news sources* and *news source variety* emerged as positive predictors, whereas *evaluation of liberal news sources* emerged as negative predictor. For *COVID-19 science backlash* (DV), *news source variety* and *evaluation of news sources*

Table 3

The influence of cognitive effects and public confidence on positive COVID-19 vaccination beliefs.

Variable	Model 1			Model 2		
	B	SE B	β	B	SE B	β
Sex (female vs male)	-.17	.08	-.06*	-.09	.07	-.03
Race (White vs other)	.55	.10	.16**	.36	.08	.10**
Age	.00	.00	.03	-.00	.00	-.04
Education	.25	.06	.12**	.02	.05	.01
Party Identification	.06	0.2	-.10**	.04	.02	.05*
Income	.16	.06	.07*	.06	.05	.03
Public confidence				.65	.04	.42**
Information backlash				.19	.04	.13**
Science backlash				-.39	.04	-.24**
Vaccine ambivalence				-.21	.03	-.20**
Adjusted R^2	.06			.38		
F for change in R^2	15.08**			175.52**		

Note. Sex: female = 1, male = 0; race: White = 1, other = 0; age (interval); education (interval), party identification: 7-pt measure, 1 = strong Democrat, 7 = strong Republican; income (interval); public confidence: 5-pt scale; 1 = none at all, 5 = a great deal (higher values represent higher levels of public confidence); information backlash: 5-pt scale; 1 = strongly disagree, 5 = strongly agree (higher values represent higher levels of information backlash); science backlash: 5-pt scale; 1 = strongly disagree, 5 = strongly agree (higher values represent higher levels of science backlash); vaccine ambivalence: 5 pt scale, 1 = strongly disagree, 5 = strongly agree (higher values represent higher levels of vaccine ambivalence). * $p < .05$, ** $p < .01$.

Table 4

Effects of news source variety and evaluation of news sources on public confidence.

Variable	Public Confidence					
	Model 1			Model 2		
	B	SE B	β	B	SE B	β
Sex (female vs male)	-.02	.05	-.01	.03	.04	.01
Race (White vs other)	.11	.06	.05	.08	.05	.04
Age	.00	.00	.08**	.01	.00	.24**
Education	.24	.04	.18**	.05	.03	.04
Party Identification	-.11	.01	-.28**	-.05	.01	-.12**
Income (interval)	.11	.04	.08**	.07	.03	.05*
Variety				.22	.03	.21**
Eval. liberal sources				.48	.03	.52**
Eval. cons. sources				-.08	.02	-.09**
Adjusted R^2	.12			.42		
F for change in R^2	30.29**			226.85**		

Note. Sex: female = 1, male = 0; race: White = 1, other = 0; age (interval); education (interval), party identification: 7-pt measure, 1 = strong Democrat, 7 = strong Republican; income (interval); news source variety: 5-pt scale, 1 = never, 5 = all or most of the time (higher values represent higher news source variety), evaluation of liberal news sources: 5-pt scale, 1 = very unfavorably, 5 = very favorably (higher values represent more positive evaluation of liberal news sources); evaluation of conservative news sources: 5-pt scale, 1 = very unfavorably, 5 = very favorably (higher values represent more positive evaluation of conservative news sources). * $p < .05$, ** $p < .01$.

explained an additional 16% of the variance in the model, $R^2_{\text{Change}} = 0.16$, $F(3, 1290) = 94.60$, $p < .01$. The final model explained 26% of the variance in *COVID-19 science backlash*, $R^2_{\text{Adj.}} = 0.26$, $F(9, 1290) = 52.07$, $p < .01$. *Evaluation of conservative news sources* emerged as positive predictor. *Evaluation of liberal news sources* and *news source variety* were negative predictors. For *COVID-19 vaccine ambivalence* (DV), *news source variety* and *evaluation of news sources* did not explain a meaningful additional amount of variance in the model (3%), $R^2_{\text{Change}} = 0.03$, $F(3, 1285) = 13.57$, $p < .01$. The final model explained 6% of the variance in *COVID-19 vaccine ambivalence*, $R^2_{\text{Adj.}} = 0.06$, $F(9, 1285) = 9.38$, $p < .01$.

4. Discussion

This research aimed to open the ‘black box’ of COVID-19 vaccination attitudes by examining the underlying belief structure and relative importance of demographic characteristics, cognitive effects, public confidence, and news source variety and evaluation of news sources in order to reveal the most important determinants of positive COVID-19 vaccination beliefs in the U.S. population. Supplementing previous findings reported elsewhere (Lueck and Spiers, 2020), this study revealed that the strongest predictor of positive beliefs about COVID-19 vaccination was confidence in public health officials and political institutions to handle the COVID-19 pandemic effectively. Negative sentiments about COVID-19 research and science, as well as COVID-19 vaccine ambivalence, reduced the likelihood that beliefs would be positive (see Table 2).

Among demographic characteristics, results suggested that positive COVID-19 beliefs are particularly prevalent among Whites, those who are highly educated, and those who identify as Democrats. Those who identified as Republicans were significantly less likely to hold positive COVID-19 vaccination beliefs such as believing in the value of vaccination to protect close others (e.g., family, friends, those who are vulnerable due to age, pre-existing conditions, and other factors). This finding is in line with previous research that has identified party identification as a strong driver of COVID-19 prevention behavior (Adolph et al., 2021; Bruine de Bruin, Saw and Goldman, 2020; Collins et al., 2021), but adds that party identification also influences the determinants of behavior, such as attitude structures as well as underlying beliefs. Given the importance of positive

COVID-19 vaccination beliefs in determining attitudes and behavior, these findings are also consistent with previous research that has called for pro-vaccine messaging to promote vaccination, rather than messaging attempting to dispel vaccine myths (Nyhan et al., 2014) (see Table 3).

Cognitive effects and public confidence were important determinants of positive COVID-19 vaccination beliefs, with public confidence emerging as a particularly strong predictor over and above party identification. This finding supports previous research pointing to the important role of public confidence in determining vaccination behavior, yet also highlights that public confidence is often low in certain segments of the population (Larson et al., 2011). For all positive beliefs, public confidence was the strongest positive predictor, whereas COVID-19 science backlash and COVID-19 vaccine ambivalence were negative predictors. Interestingly, higher levels of COVID-19 information backlash were associated with more positive COVID-19 vaccination beliefs, indicating that COVID-19 information backlash may *not* have detrimental effects on beliefs and attitudes. It also possibly suggests that people can manage their negative sentiments toward more general (albeit potentially overwhelming and confusing) COVID-19 information and are able to distinguish these negative sentiments from their beliefs and decision-making about COVID-19 vaccination. On the other hand, negative sentiments toward COVID-19 research *does* appear to have detrimental effects on beliefs about COVID-19 vaccination. Those who are particularly hesitant to get vaccinated may believe that science is to blame for both the ongoing conflicting and confusing COVID-19 information in the media *and* perceived shortcomings of the COVID-19 vaccines (see Table 3).

Further analyses also identified the most important determinants of cognitive effects and public confidence over and above demographic characteristics (e.g., party identification) – news source variety and evaluation of news sources. Those who rated liberal news sources favorably were more likely to indicate higher levels of confidence in science and government and lower levels of COVID-19 information backlash and COVID-19 science backlash than those who rated conservative news sources favorably. Positive evaluation of conservative news sources was a strong driver for COVID-19 information backlash and COVID-19 science backlash. Interestingly, given the positive association between COVID-19 information backlash and positive COVID-19 beliefs, the link between positive evaluation of conservative news sources and COVID-19 information backlash could present effective pathways for health promotion (see Table 4).

Health promotion efforts could include pro-vaccine messages that reinforce existing positive COVID-19 vaccination beliefs, establish confidence in science and government, and resolve negative cognitive effects stemming from previous conflicting public health messaging about COVID-19 and the vaccine. Making salient, or acknowledging, widespread COVID-19 information backlash (e.g., acknowledging that COVID-19 information has been overwhelming and confusing) among those who prefer conservative news sources may actually strengthen positive COVID-19 vaccination beliefs. The reverse could also be true – those who indicate higher levels of confidence in science and government may prefer liberal news sources and those who indicate higher levels of COVID-19 science backlash may prefer conservative news sources. The correlational nature of the data limits our ability to draw such conclusions and we can only point to such possibilities. Experimental studies are needed to determine causal relationships in this context.

4.1. Limitations

Due to the cross-sectional nature of this study, this research provided only a snapshot of COVID-19 vaccination beliefs at a single point in time. Furthermore, this research was conducted at a time when COVID-19 vaccines were still in development (October 2020) and findings thus solely represent COVID-19 vaccination attitudes and beliefs at that point in time (asking participants to think about the time when COVID-19

vaccines *would* become available to the public). The timing of the study has implications for other measures, as well. Public confidence, for example, may have become more polarized over time according to the specific pandemic responses at the state levels. Therefore, this research cannot assess how COVID-19 vaccination beliefs, public confidence, and news consumption habits evolved over time. Other notable limitations apply to the survey measures used in this research. For example, the alpha values for the public confidence measure ($\alpha = 0.90$) and the news consumption habits measure ($\alpha = 0.93$) were high, indicating that participants' responses were consistent across individuals, institutions, and news sources. We encourage cautious interpretation of our findings until future studies replicate and put forth plausible reasons for why we found these response patterns in the population. In addition, a two-factor structure emerged from the factor analyses for the positive and negative evaluations of news sources. The authors interpreted these clusters to reveal 13 liberal-leaning news sources and only three conservative-leaning news sources. Future research in this area would benefit from the inclusion of additional conservative news sources. Importantly, current findings cannot sufficiently indicate whether or why participants identified news sources as "liberal-leaning" or "conservative-leaning," which should be taken into consideration when interpreting results.

5. Suggestions for future research

Researchers are encouraged to replicate this study in a representative sample of U.S. adults, as well as in underrepresented populations in particular. Such studies should also test whether attitudes and beliefs changed over time, or whether they changed altogether. It is plausible that confirmation bias over time has made COVID-19 vaccination beliefs in the population less malleable and more consistent with increasingly politicized news media framing. Furthermore, future research should seek to replicate and further investigate why participants' high or low faith in one individual or institution was consistent with high or low faith in other individuals or institutions in this study and why the news tended to be endorsed (or not endorsed) as a whole rather than individual news sources. Since cause-and-effect relationships could not be established in this study, researchers are encouraged to examine causal relationships between COVID-19 vaccination attitudes and beliefs and news consumption habits in the population.

6. Conclusions

In order to increase COVID-19 vaccination rates in the U.S. population, efforts should be undertaken to reinforce positive beliefs about COVID-19 vaccination. Scientists and health officials should aim to increase public confidence through the dissemination of accurate and consistent health information about COVID-19 vaccination, using conservative-leaning news sources and social media in particular, and possibly by acknowledging and influencing sentiments indicative of COVID-19 science backlash and COVID-19 vaccine ambivalence in the population.

Author statement

Jennifer A. Lueck: Conceptualization, Methodology, Investigation, Software, Formal analysis, Writing – original draft Preparation, Funding acquisition; **Timothy Callaghan:** Software, Formal analysis, Writing – Reviewing and Editing.

Declaration of competing interest

None.

Appendix

News consumption measures

News source variety

Please indicate *how often you access* the following news sources in any given week in order to receive news information (Mo-Sun) [never, hardly ever, only now and then, some of the time, most or all of the time].

1. PRINT version of a national daily newspaper such as the New York Times or USA today
2. PRINT version of a LOCAL newspaper
3. The local television news in your area
4. The television broadcast of a national cable or network news show on a station like CNN, Fox News, or CBS
5. Website of a national or local newspaper
6. A website of a TV news organization such as CNN, Fox, or CBS
7. A website of a radio news organization such as NPR
8. A portal website like Google News, AOL, or Topix that gathers news from many different sources
9. A website of an international news organization such as the BBC or The Guardian, or a foreign language news site
10. A website that offers a mix of news and commentary, such as the Drudge Report or Huffington Post
11. A news podcast from an organization such as NPR or the New York Times
12. Twitter updates from a news organization or individual journalist
13. YouTube videos from a national or international news organization (e.g., BBC, The Guardian, CNN, Fox, CBS, Al-Jazeera)
14. YouTube videos providing news and news commentary (e.g., The Young Turks, Vox, AJ+, BuzzFeed, InfoWars, NowThis, Breitbart, The Blaze, etc.)
15. Other social media (e.g., Facebook)

News evaluation

Specifically, how *favorably* would you rate each of these following news sources? [very unfavorably, somewhat unfavorably, indifferent, somewhat favorably, very favorably, don't know/not familiar with this source].

1. Fox News
2. MSNBC
3. CNN
4. New York Times
5. NPR
6. BBC/The Guardian
7. Huffington Post
8. Al-Jazeera
9. The Young Turks
10. Vox
11. Buzzfeed
12. Breitbart
13. Twitter
14. Yahoo News
15. Google News
16. Facebook

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