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Sociopolitical, mental health, and sociodemographic correlates of COVID-19 vaccine hesitancy among young adults in 6 US metropolitan areas

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ABSTRACT

Given the need to increase COVID-19 vaccine uptake among US young adults, we examined the extent of COVID-19 vaccine hesitancy in this population and related factors. We analyzed Fall 2020 survey data from 2,453 young adults (ages 18–34) across 6 US metropolitan statistical areas (MSAs; $Mean_{age}$ = 24.67; 55.8% female; 5.4% Black, 12.7% Asian, 11.1% Hispanic; 75.5% college degree or higher). Multivariable linear regression examined correlates of COVID-19 vaccine hesitancy (index score of willingness and likelihood of being vaccinated), including sociopolitical factors (MSA, political orientation, COVID-related news exposure), COVID-19 symptoms and testing, mental health (e.g., COVID-related stress), and sociodemographics. 45.3% were "extremely willing" to get the vaccine (19.8% very, 14.2% somewhat, 3.7% don't know, 7.0% a little, 10.1% not at all); 40.2% were "extremely likely" to get vaccinated (22.1% very, 14.2% somewhat, 5.2% don't know, 7.9% a little, 10.3% not at all). Greater vaccine hesitancy was significantly related to living in specific MSAs (i.e., Atlanta, Oklahoma City, San Diego, Seattle vs. Minneapolis or Boston), identifying as Republican or "no lean" (vs. Democrat), and reporting less COVID-related news exposure and less COVID-related stress, as well as identifying as older, female, Black or other race, having less (vs. greater) than a college education, being married/cohabitating, and having children in the home. Interventions to improve COVID-19 vaccine uptake among hesitant young adults should include communication that address concerns, particularly among women, minority groups, and those from certain geographic regions and/or differing political orientations, and require identifying communication channels that appeal to these groups.

1. Introduction

COVID-19 was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (WHO, 2020). As of April 22, 2022, there have been over 505 million confirmed cases and 6.2 million deaths worldwide; the US alone has experienced over 80 million cases and 982,000 deaths (WHO, 2021b). Public health authorities have worked to develop, test, and implement effective COVID-19 vaccines to curb the pandemic, resulting in 322 vaccine candidates, with 25 in phase III clinical trials, and 18 approved for use (Tregoning et al., 2021). In the US, 3 vaccines are authorized for emergency use or FDA-approved (i.e., Pfizer-BioNTech COVID-19 vaccine, Moderna COVID-19 vaccine, Johnson and Johnson/Janssen COVID-19 vaccine as of December 11, 2020; January 31, 2021; and February 27, 2021, respectively) (US FDA, 2021a; US FDA, 2021b; Johnson & Johnson, 2021; US, 2022) and are widely available. However, as of April 23, 2022, 22.5% of the total US population have yet to receive their first COVID vaccine dose, 34.0% have not been fully vaccinated, and 54.4% have not received their booster dose (CDC, 2021).

Before the emergence of COVID-19, the WHO categorized vaccine

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hesitancy (i.e., being unsure about receiving a vaccine (Edwards et al., 2021; Murphy et al., 2021) as one of the top 10 threats to global health in 2019 (WHO, 2021a). Vaccination is one of the most cost-effective strategies to reduce infectious diseases, but vaccine hesitancy threatens to create a reemergence of disease. Thus, COVID-19 vaccine hesitancy is a barrier that public health officials must overcome to reduce the spread and impact of COVID-19. Moreover, understanding hesitancy toward COVID-19 vaccination has implications beyond the COVID-19 pandemic, as doing so may also inform future research aimed at reducing hesitancy toward other vaccines and promoting vaccine uptake.

Vaccine hesitancy is complex, and research across the globe has identified various correlates (2021a). Political affiliation has important implications for vaccine hesitancy in the US, with individuals identifying as moderate/conservative or Republican (compared to moderate/liberal or Democrat) reporting greater hesitancy (Mesch and Schwirian, 2015); this has been particularly salient with regard to COVID-19 and vaccination efforts (Khubchandani et al., 2021; Reiter et al., 2020; PNHP, 2021). Exposure to COVID-related news is also related to vaccine hesitancy, with those reporting greater news exposure indicating lower hesitancy, and differences depending on news source (e.g., TV, social media) (Murphy et al., 2021; Bendau et al., 2021).

Contextual-level sociopolitical factors, such as geographic location, may also impact COVID-19 vaccine hesitancy. For instance, states and local jurisdictions vary with regard to the restrictiveness of COVID-19 related orders (e.g., stay-at-home and business closure orders) (Crouse, 2008; Gilmore et al., 2020; Maharaj and Kleczkowski, 2012; The National Academy for State Health Policy, 2022; Korevaar et al., 2020; ACS, 2020). Additionally, there were vast differences in COVID-19 incidence rates across states and over time, especially throughout 2020 (US News & World Report, 2021; Frey, 2021). Living in locations experiencing different levels of restrictiveness and incidence rates may be associated with vaccine hesitancy, as living in states with more (vs. less) restrictive policies is related to less hesitancy (Gilmore et al., 2020; Crouse, 2008) and policy and incidence rates may impact one's perceived risk of getting COVID-19, which impacts vaccine hesitancy (Butter et al., 2021; Machida et al., 2021).

Prior research has found mixed results regarding vaccine hesitancy and the experience of COVID-19 symptoms (i.e., cough, fever, fatigue, loss of smell, headache[27]) or diagnosis. Greater vaccine hesitancy was associated with *not* being tested for or diagnosed with COVID-19 in one US study (Reiter et al., 2020), but with testing positive and having severe symptoms in separate study; (Savoia et al., 2021) yet, another study found no association between confirmed or suspected COVID-19 infection and vaccine hesitancy (Murphy et al., 2021). These mixed findings underscore the need for additional research.

Stress related to the COVID-19 pandemic has also been studied, with mixed findings. One study found that those experiencing greater negative mental health impacts due to the pandemic reported less vaccine hesitancy (Gerretsen et al., 2021). Findings from another study somewhat aligned, documenting that those who reported feeling agitated, sad, and anxious due to social distancing on some days (vs. no days) had lower COVID-19 vaccine hesitancy; however, those who reported the same feelings every day (vs. no days) were more vaccine hesitant (Soares et al., 2021). In addition to stress, depressive and anxiety symptoms have also been examined in relation to vaccine hesitancy, with some studies indicating that those reporting depressive or anxiety symptoms are less vaccine hesitant (Murphy et al., 2021; Urrunaga-Pastor et al., 2021), but others documenting no association between mental health and COVID-19 vaccine hesitancy (Murphy et al., 2021; Butter et al., 2021). Unfortunately, the percent of adults reporting depressive and anxiety symptoms increased during the pandemic in the US (from 36.4% to 41.5% from August 2020 to February 2021), with the largest increases in young adults (ages 18–29), which could have implications for COVID-19 vaccine hesitancy (Vahratian et al., 2020).

International research (specifically Australia, UK, Portugal, Japan, US) has also documented greater COVID-19 vaccine hesitancy among certain sociodemographic groups, for example, those who are female (Edwards et al., 2021; Murphy et al., 2021; Reiter et al., 2020; Khubchandani et al., 2021; Soares et al., 2021; Fisher et al., 2020; Machida et al., 2021; Urrunaga-Pastor et al., 2021) younger, (Murphy et al., 2021; Butter et al., 2021; Machida et al., 2021; Soares et al., 2021; Fisher et al., 2020; Robertson et al., 2021), lower income (Edwards et al., 2021; Reiter et al., 2020; Machida et al., 2021) unmarried, (Reiter et al., 2020; Machida et al., 2021), and who have children in the home (Khubchandani et al., 2021; Soares et al., 2021). Findings in the US also underscore historical factors (e.g., medical racism) contributing to medical mistrust among certain racial/ethnic minority groups, particularly Black Americans, which may relate to the association between Black Americans and higher COVID-19 vaccine hesitancy (Reiter et al., 2020; Fisher et al., 2020; Manning, 2020; Stoler et al., 2021).

Research to date has been limited in its inclusion of a broad range of potentially important factors related to vaccine hesitancy (Murphy et al., 2021; Fisher et al., 2020; Robertson et al., 2021), particularly related to COVID-19 given its recency. Thus, to add to the literature, which can ultimately inform interventions to reduce vaccine hesitancy and increase vaccine uptake, this study examined correlates of COVID-19 vaccine hesitancy among young adults in 6 US metropolitan statistical areas (MSAs: Atlanta, Boston, Minneapolis, Oklahoma City, San Diego, Seattle), which differed in terms of COVID-19 related state orders (e.g., stay-at-home orders; Fig. 1) (Moreland et al., 2020). For example, California represented the state with the greatest level of restrictions and duration of stay-at-home orders, followed by Washington and Minnesota, while Oklahoma had the lowest level of restrictions (Moreland et al., 2020). The 6 states also varied greatly in terms of their COVID-19 incidence rates per month throughout the pandemic (Frey, 2021). The current study examined the following correlates of vaccine hesitancy: sociopolitical factors (i.e., geographic location, political orientation, COVID-related news exposure), COVID symptoms/testing, mental health (i.e., COVID-related stress, symptoms of depression and anxiety), and sociodemographics.

2. Methods

2.1. Study design

This study analyzed Fall 2020 (Wave 5 [W5]) data from the Vape shop Advertising, Place characteristics and Effects Surveillance (VAPES) study, a 2-year, 5-wave longitudinal cohort study exploring vape retail, policy, and impacts on young adults (ages 18–34). In Fall 2018, VAPES recruited 3,006 young adults from the 6 aforementioned MSAs, which differ in terms of tobacco and marijuana legislative contexts (Public Health Law Center, 2020), as well as COVID-19 related state orders (Moreland et al., 2020). See Fig. 1 for snapshots of the COVID-related orders of the 6 corresponding states, as well as their sociopolitical contexts. The parent study is detailed elsewhere (Berg et al., 2021) and was approved by the Emory University Institutional Review Board.

2.2. Participants & recruitment

Advertisements posted on social media (i.e., Facebook, Reddit) targeted individuals by: 1) using indicators reflecting those eligible (i.e., ages 18–34, living in one of the 6 MSAs as indicated by residential zip code, English speaking); 2) identifying activities of interest that appeal to young adults (e.g., sports/athletics, entertainment, technology), as well as tobacco-related interests; and 3) using relevant ad imagery (e.g., racially/ethnically diverse, socializing in bars and/or outdoor spaces, professional work settings).

After clicking an ad, potential participants were directed to a webpage with a study description and consent form. Once individuals consented, they were screened for eligibility; this screen also included questions regarding gender, race, ethnicity, and past 30-day use of

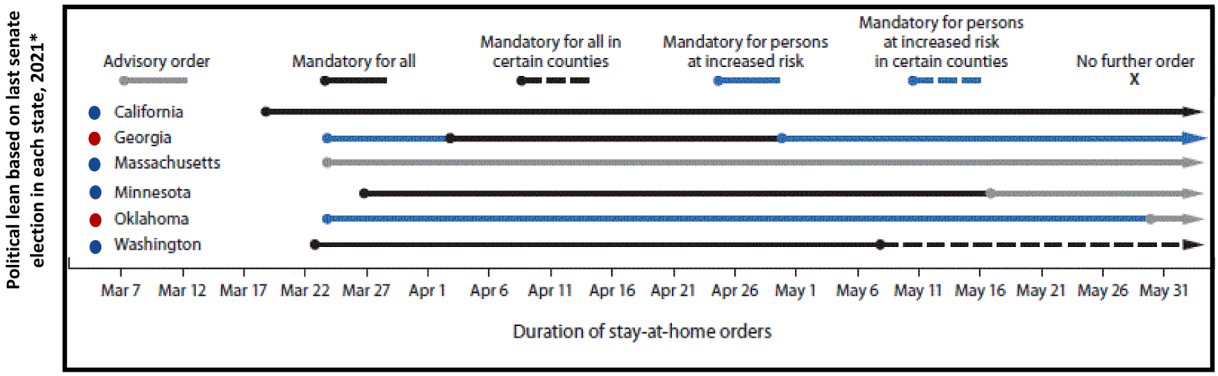

Fig. 1. Political lean and type/duration of COVID-19 state stay-at-home orders (March 1–May 31, 2020)ˆ in the 6 states* Blue = Democrat; Red = Republicanˆ . (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Source: https://www.cdc.gov/mmwr/volumes/69/wr/mm6935a2.htm

cigarettes and e-cigarettes. This information was used to facilitate reaching recruitment targets of subgroups for each MSA. Specifically, purposive, quota-based sampling was used to ensure sufficient proportions of the sample represented e-cigarette and cigarette users (roughly one-third each) to achieve the parent study objectives (i.e., examine changes in use behaviors over time) and to obtain roughly equal numbers of men and women and approximately 40% racial/ethnic minorities (to explore subgroup differences). Subgroup enrollment was capped by MSA. Eligible individuals who were allowed to advance were routed to the online Wave 1 (W1) survey (administered via Alchemer), which included questions obtaining name and contact information (e.g., email address). Once completed, participants were notified that they would be asked to confirm their participation 7 days later by clicking a "confirm" button included in an email sent to them. This email reiterated study procedures and timeline. When participants clicked "confirm," they were officially enrolled into the study. They were then emailed their first incentive ($10 Amazon e-gift card).

Of the 10,433 Facebook and Reddit users who clicked on ads, 9,847 consented, of which 2,751 (27.9%) were not allowed to advance because they were: 1) ineligible (n = 1,427); and/or 2) excluded in order to reach subgroup target enrollment (n = 1,279). Of those allowed to advance to the survey, the proportion of completers versus partial completers was 48.8% (3,460/7,096) and 51.2% (3,635/7,096), respectively. Partial completers were deemed ineligible for the remainder of the study. The majority of partial completers (n = 2,469, 67.9%) only completed the initial sociodemographic section of the survey. Of the 3,460 who completed the W1 survey, 3,006 (86.9%) confirmed participation at the 7-day follow-up. (See previous work for additional information) (Berg et al., 2021).

This study analyzed data from W1 (Fall 2018; n = 3,006) and W5 (Fall 2020; n = 2,476; 82.4% retention). Current analyses focus on 2,453 participants (99.1% of the 2,476) with complete data on the variables of interest at W5.

3. Measures

Outcome variable: COVID-19 vaccine hesitancy. Using measures adapted from the literature (Fridman et al., 2021), at W5, we asked: "If there was a vaccine for COVID-19 approved by the FDA: 1) how willing would you be to get the vaccine? and 2) how likely would you be to actually get the vaccine?" Responses included: 0="extremely," 1="very," 2="somewhat," 3="don't know," 4="a little," and 5="not at all." The mean of these 2 variables yielded a vaccine hesitancy score (range: 0–5, correlation of 2 items: $r = 0.86$), with higher scores representing higher vaccine hesitancy.

Independent variables. *Sociopolitical factors*: At W1, participants were coded to MSA using their residential address zip code. At W5, political orientation was assessed using measures adapted from national polls (Pew Research Center, 2022), specifically by asking participants how they would identify politically (1="strong Democrat" to 7="strong Republican"); responses were categorized as Democrat, no lean (referent group), and Republican. We assessed COVID-related news exposure at W5 also using measures adapted from national polls (Jurkowitz and Mitchell, 2020); we asked participants how closely they follow COVID-19 related news, via newspaper, television, radio, or internet (1="not at all closely" to 4="very closely").

COVID symptoms/testing/diagnosis: At W5, we asked participants if they had ever experienced any COVID-related symptoms and/or been tested for COVID. Participants were categorized as: no symptoms or test, had symptoms but did not get tested or tested but negative result (referent group), or tested positive.

Mental health: At W5, COVID-related stress was assessed by asking participants to indicate their level of agreement (1="strongly disagree" to 5="strongly agree") to 3 statements: "The COVID-19 pandemic has: 1) been extremely stressful for me; 2) distracted me from doing other important things in my life; and 3) made me feel very lonely and distant from people" (Romm et al., 2021; Romm et al., 2022). These items were used to create a mean score, with higher scores reflecting greater COVID-related stress (Cronbach's alpha = 0.80). Depressive and anxiety symptoms were assessed at W5 using the Patient Health Questionnaire – 4 item scale (PHQ-4), which includes 2 items assessing depressive symptoms (e.g., feeling down, depressed, or hopeless) and 2 assessing anxiety symptoms (e.g., feeling nervous, anxious, or on edge) in the past 2 weeks (0="not at all" to 3="nearly every day"; score range 0–6, respectively; overall Cronbach's alpha = 0.86) (Kroenke et al., 2009).

Sociodemographic covariates. At W1, participants reported their age, gender, race, ethnicity, sexual orientation, educational attainment, relationship status, and whether they had children in their home.

3.1. Data analysis

Descriptive statistics were used to characterize the sample. Then, bivariate analyses (i.e., ANOVA, Pearson correlations, t-tests) were conducted to examine relationships between independent variables and vaccine hesitancy. Next, multivariable linear regression models were built and run in a stepwise manner examining (by block): 1) sociodemographics (age, gender, sexual orientation, race, ethnicity, education, relationship status, children in the home); 2) sociopolitical factors (MSA, political orientation, COVID-related news exposure); 3) COVID-19 symptoms/testing; and 4) psychosocial factors (COVID-related stress, depressive symptoms, anxiety symptoms) as correlates of vaccine hesitancy. All analyses were conducted using SPSS version 26.0 with significance level set at alpha < 0.05.

4. Results

4.1. Participant characteristics

Participants were 24.67 years old (SD = 4.69) on average, and were 55.8% female; 31.0% sexual minority; 5.4% Black, 12.7% Asian, and 11.1% Hispanic (Table 1). Regarding COVID-19 vaccine hesitancy, 45.3% of participants reported being extremely willing to get the vaccine, 19.8% very, 14.2% somewhat, 3.7% didn't know, 7.0% a little, and 10.1% not at all. In addition, 40.2% reported being extremely likely to get the vaccine, 22.1% very, 14.2% somewhat, 5.2% didn't know, 7.9% a little, and 10.3% not at all. The average vaccine hesitancy index score was 1.53 (SD = 1.69; scale 0–5), on a scale of 0 (extremely likely/willing) to 5 (not at all likely/willing).

In terms of sociopolitical factors, the proportion of participants in each MSA ranged from 10.2% (Oklahoma City) to 20.5% (Atlanta and Boston, respectively). Overall, 73.4% identified as Democrat, 12.4% Republican, and 14.2% no lean, and the mean score of COVID-related news exposure was 3.24 (SD = 0.75; scale 1–4), reflecting relatively high exposure. Additionally, 43.7% never had COVID-19 symptoms or a COVID-19 test; 53.6% experienced COVID-19 symptoms but were not tested or received a negative result; and 2.7% tested positive. Regarding mental health, the average COVID-related stress score was 3.94 (SD = 0.99; scale 1–5); PHQ-4 scores for depressive and anxiety symptoms were 1.80 (SD = 1.72; scale 0–6) and 2.23 (SD = 1.90; scale 0–6), respectively.

4.2. Bivariate results

Bivariate comparisons (Table 1) indicated that significant correlates ($p < .05$) of greater vaccine hesitancy included residing in Oklahoma City and Atlanta (see footnotes for details), identifying as Republican or no lean (vs. Democrat), less COVID-related news exposure, reporting no COVID symptoms or test *or* testing positive (vs. experiencing COVID symptoms but not getting tested or receiving negative results), lower COVID-related stress, and fewer anxiety and depressive symptoms, as well as being older, female, heterosexual, Black (vs. all other races) and Other race (vs. Asian), married/cohabitating, having less than a college degree, and having children in the home.

4.3. Multivariable linear regression results

Because multivariable linear regression findings did not vary across steps of model building, only coefficients from the final model are presented (Table 2). Significant correlates ($p < .05$) of higher vaccine hesitancy included living in Atlanta, Oklahoma City, San Diego, or Seattle (vs. Minneapolis; Beta [B] range: 0.22 in San Diego to 0.26 in Oklahoma), not identifying as Democrat (vs. no political lean; B = -0.80), less COVID-related news exposure (B = -0.40), and less COVID-related stress (B = -0.15), as well as being older (B = 0.02), female (B = 0.34), Black or other race (vs. White; B = 1.47 and B = 0.21, respectively), education less than a college degree (vs. ≥ college degree; B = -0.28), married/cohabitating (B = 0.15), and having children in the home (B = 0.40).

5. Discussion

This study examined sociopolitical factors, experiences with COVID symptoms and testing, mental health, and sociodemographic factors as potential correlates of COVID-19 vaccine hesitancy in a sample of US young adults from 6 diverse metropolitan areas. There was relatively low vaccine hesitancy in this sample; for example, 62.3% were extremely/very likely to get vaccinated, 14.2% somewhat, 7.9% a little, and 10.3% not at all (and 5.2% "don't know"). These results indicate slightly less hesitancy compared to a national survey of US adults (recruited via mTurk and social media) conducted in June 2020, which found that 52% were very likely to get the vaccine, 27% somewhat, 15%

Table 1
Participant characteristics and bivariate associations with vaccine hesitancy.

		Bivariate Associations with Vaccine Hesitancy §	
Variables	**N (%) or M (SD)**	**M (SD) or r**	**p**
Outcome: Vaccine hesitancy index score, M (SD)	1.53 (1.69)	–	–
Sociodemographics			
Age, M (SD) and r	24.67 (4.69)	0.11	*<0.001*
Gender,[1] N (%) and M (SD)			*<0.001*
Male	1015 (41.4)	1.38 (1.59)	
Female	1369 (55.8)	1.68 (1.75)	
Other	69 (2.8)	0.96 (1.36)	
Sexual orientation, N (%) and M (SD)			*<0.001*
Heterosexual	1692 (69.0)	1.62 (1.71)	
Sexual minority	761 (31.0)	1.34 (1.61)	
Race,[2] N (%) and M (SD)			*<0.001*
White	1748 (71.3)	1.44 (1.67)	
Black	133 (5.4)	3.10 (1.75)	
Asian	312 (12.7)	1.24 (1.34)	
Other	260 (10.6)	1.71 (1.73)	
Hispanic, N (%) and M (SD)	272 (11.1)	1.67 (1.64)	0.164
No	2181 (88.9)	1.52 (1.69)	
Education, N (%) and M (SD)			*<0.001*
No college degree	600 (24.5)	1.90 (1.84)	
College degree or higher	1853 (75.5)	1.42 (1.61)	
Relationship status, N (%) and M (SD)			*<0.001*
Married/living with partner	894 (36.4)	1.75 (1.80)	
Other	1559 (63.6)	1.41 (1.60)	
Children in the home, N (%) and M (SD)	490 (20.0)	2.30 (1.93)	*<0.001*
No	1963 (80.0)	1.34 (1.56)	
Sociopolitical factors			
Metropolitan statistical area (MSA),[3] N (%) and M (SD)			*<0.001*
Atlanta	504 (20.5)	1.72 (1.81)	
Boston	504 (20.5)	1.30 (1.54)	
Minneapolis	428 (17.4)	1.23 (1.54)	
Oklahoma City	251 (10.2)	1.98 (1.81)	
San Diego	384 (15.7)	1.60 (1.66)	
Seattle	382 (15.6)	1.69 (1.69)	
Political orientation,[4] N (%) and M (SD)			*<0.001*
Democrat	1800 (73.4)	1.20 (1.47)	
No lean	348 (14.2)	2.43 (1.85)	
Republican	305 (12.4)	2.51 (1.93)	
COVID-related news exposure*, M (SD) and r	3.24 (0.75)	-0.28	*<0.001*
			<0.001

(*continued on next page*)

Table 1 (*continued*)

		Bivariate Associations with Vaccine Hesitancy [§]	
COVID symptoms/testing, [5] N (%) and M (SD)			
No symptoms or test	1047 (43.7)	1.75 (1.79)	
Symptoms, no test or negative test	1284 (53.6)	1.32 (1.57)	
Positive test	65 (2.7)	1.88 (1.66)	
Mental health factors, M (SD) and r			
COVID-related stress^	3.94 (0.99)	-0.21	*<0.001*
Depressive symptoms [£]	1.80 (1.72)	-0.06	*0.002*
Anxiety symptoms [£]	2.23 (1.90)	-0.07	*0.001*

[§] P-values based on t-tests and ANOVAs (per Mean [M] and standard deviation [SD]) for categorical predictors and Pearson correlations (r) for continuous predictors. *1 item (range: 1–4); higher scores = more news exposure. ^3 items averaged (range: 1–5); higher scores = greater stress. [£]2 items for depressive and anxiety symptoms, respectively, summed (range: 0–6); higher scores = more symptoms. *#1–5.* Greater hesitancy: 1) females vs. male/other; 2) Black vs. all others; 3) Oklahoma City vs. Boston/Minneapolis/Seattle; Atlanta vs. Boston/Minneapolis; San Diego/Seattle vs. Minneapolis; 4) Republican/No lean vs. Democrat; and 5) no symptoms/test and positive test vs. symptoms with no or negative test. Italics indicate significant findings.

unlikely, and 7% definitely not (Khubchandani et al., 2021). This may be because our sample is comprised of a young, relatively well-educated sample of adults – and these factors correlate with less COVID vaccine hesitancy (Khubchandani et al., 2021; Soares et al., 2021; Fisher et al., 2020).

As anticipated, there were political and regional differences in vaccine hesitancy. Republicans reported the greatest hesitancy, while Democrats reported the least, as found previously (Reiter et al., 2020; Khubchandani et al., 2021). Perhaps relatedly, those residing in Atlanta and Oklahoma City reported the highest vaccine hesitancy, consistent with research suggesting that more lenient COVID-19 policies may be associated with greater vaccine hesitancy (Crouse, 2008; Gilmore et al., 2020; Moreland et al., 2020). In addition, greater COVID-19 news exposure correlated with less vaccine hesitancy, coinciding with prior studies (Murphy et al., 2021; Bendau et al., 2021). This might suggest that news exposure results in greater knowledge/understanding of COVID-19 related risks – or that higher vaccine hesitancy may lead individuals to withdraw from certain information sources, which may also be related to one's political orientation, educational background, or other relevant factors. Considering news/information source is critical, as research has documented less trust in certain news sources (e.g., newspapers, television, radios, and government agencies) among those with greater hesitancy (Murphy et al., 2021) or identifying as conservative (Mitchell et al., 2014). Accordingly, those with more hesitancy or conservative identities may be more likely to get their news from social media (vs. those mentioned above) (Murphy et al., 2021) or from conservative outlets (Hmielowski et al., 2020), which have been prone to spread misinformation throughout the pandemic (Ball and Maxmen, 2020). Thus, both political party and news exposure are important factors related to vaccine hesitancy, but understanding the mechanisms and course of these associations is critical for interrupting the corresponding misinformation and mistrust issues (Reno et al., 2021).

Hesitancy may also be related to the extent to which one has been personally impacted by COVID-19, either by experiencing symptoms or a positive test or knowing someone who has. Prior studies have mixed findings: some indicate more testing correlating with lower hesitancy (Reiter et al., 2020), some show differing associations depending on symptom severity (Savoia et al., 2021), and some indicate no association

Table 2
Multivariable linear regression analysis identifying correlates of vaccine hesitancy.

Variables	B	SE	95% CI	p
Sociodemographics				
Age	0.02	0.01	*(0.001, 0.030)*	*0.032*
Female	0.34	0.06	*(0.215, 0.465)*	*<0.001*
Sexual minority	−0.01	0.07	(−0.133, 0.143)	0.864
Race (ref: White)				
Black	1.47	0.11	*(1.21, 1.76)*	*<0.001*
Asian	−0.04	0.10	(−0.21, 0.16)	0.714
Other	0.21	0.10	*(0.01, 0.40)*	*0.038*
Hispanic (ref: non-Hispanic)	0.14	0.10	(−0.07, 0.32)	0.161
> College degree (ref: < College degree)	−0.28	0.08	*(−0.44, −0.15)*	*<0.001*
Married/living with partner (ref: single/other)	0.15	0.07	*(0.01, 0.28)*	*0.045*
Children in the home (ref: no)	0.40	0.08	*(0.27, 0.59)*	*<0.001*
Sociopolitical factors				
Metropolitan statistical area (MSA) (ref: Minneapolis)				
Atlanta	0.25	0.10	*(0.02, 0.42)*	*0.017*
Boston	0.12	0.10	(−0.10, 0.29)	0.250
Oklahoma City	0.26	0.12	*(0.04, 0.52)*	*0.035*
San Diego	0.22	0.11	*(0.02, 0.44)*	*0.043*
Seattle	0.24	0.11	*(0.03, 0.45)*	*0.023*
Political orientation (ref: No lean)				
Democrat	−0.80	0.09	*(−0.99, −0.63)*	*<0.001*
Republican	0.19	0.12	(−0.06, 0.40)	0.113
COVID-related news exposure	−0.40	0.04	*(−0.48, −0.31)*	*<0.001*
COVID symptoms/testing (ref: symptoms, no test or negative test)				
No symptoms or test	0.11	0.06	(−0.01, 0.22)	0.061
Positive test	−0.10	0.06	(−0.22, 0.01)	0.069
Mental health factors				
COVID-related stress	−0.15	0.03	*(−0.22, −0.09)*	*<0.001*
Depressive symptoms	−0.02	0.03	(−0.07, 0.03)	0.541
Anxiety symptoms	0.02	0.02	(−0.02, 0.07)	0.337
Adjusted R-square	0.243			

Notes. SE = Standard Error; CI = Confidence Interval. Italics indicate significant findings.

(Murphy et al., 2021; Urrunaga-Pastor et al., 2021). However, current findings indicated no association between having symptoms/being tested and vaccine hesitancy, although this may be in part due to the small proportion of our sample that tested positive (2.7%) as well as the limited detail regarding reasons for not being tested (e.g., access barriers versus volition).

Current findings support previous findings that greater COVID-related stress correlated with less hesitancy (Bendau et al., 2021). In this analysis, those who reported more stress (i.e., experienced the pandemic as stressful, being distracted from important things, and lonely) may be more willing to take the vaccine in order to curb the pandemic and return to pre-pandemic life, including seeing friends and family (Khubchandani et al., 2021; Bendau et al., 2021; Urrunaga-Pastor et al., 2021). Moreover, bivariate analyses indicated that reporting more depressive and anxiety symptoms correlated with less vaccine hesitancy; however, they did not significantly contribute to the multivariable model, likely due to the COVID-related stress factor accounting for such

impacts in the model (i.e., multicollinearity, as suggested in prior research[27]). Collectively, these findings reiterate the importance of addressing mental health in the context of vaccine promotion efforts (Vahratian et al., 2020; Ettman et al., 2020), for example, by integrating mental health screening and the provision of mental health resources into vaccine delivery programs.

Findings regarding sociodemographic correlates are also noteworthy. Individuals identifying as Black or other race (vs. White) reported greater vaccine hesitancy, aligning with previous research (Reiter et al., 2020; Fisher et al., 2020; Robertson et al., 2021), perhaps due to limited access to primary care, misconceptions about cost and adverse effects, experience in culturally insensitive healthcare settings, and lack of trust from prior unethical healthcare research and underrepresentation in vaccine trials (Murphy et al., 2021; Schneider et al., 2001; Razai et al., 2021; Momplaisir et al., 2021). In addition, consistent with previous studies, being female, less educated, and having children in the home correlated with greater vaccine hesitancy (Khubchandani et al., 2021; Soares et al., 2021). Interestingly, in this sample of young adults (ages 20–36 in Fall 2020), those who were older were more hesitant, seemingly contradictory to findings from general adult population studies indicating that being older is associated with less vaccine hesitancy (Murphy et al., 2021; Machida et al., 2021). However, some studies have found that those in their 30′s and 40′s (vs. those younger and older) report greater vaccine hesitancy (Reiter et al., 2020; Fisher et al., 2020). Current results also indicated that those married/cohabitating were more hesitant, contradicting other findings (Reiter et al., 2020; Machida et al., 2021). These findings regarding age and relationship status may be related to concerns about the vaccine's impact on fertility, pregnancy, and/or other factors particularly relevant to those who are married and/or in their 30′s and 40′s (Hsu et al., 2021; Diaz et al., 2021).

Current results have implications for research and practice. Public health authorities may consider targeting vaccine education campaigns to certain groups (e.g., females, minority groups, certain sociopolitical groups). However, each of these target populations has inherently distinct and complex reasons for vaccine hesitancy not easily addressed, and also in need of further in-depth examination. Moreover, the current political and informational landscape in the US and globally requires thorough examination of the types of information (and misinformation) leading to differences in vaccine hesitancy among certain populations. Findings also highlight the role of geographic location on influencing vaccine hesitancy, and underscore the importance of accounting for contextual factors potentially influencing individuals' sociopolitical values (e.g., political orientation, news exposure).

6. Limitations

First, this study sample has limited generalizability: the sample was ages 18–34 and drawn from only 6 MSAs at baseline, was recruited via social media, and included an oversampling of cigarette and e-cigarette users. Thus, findings may not generalize to young adults from the respective MSAs or the US, older adults, etc., and there may be implications of oversampling cigarette and e-cigarette users, although prior research suggests no association among tobacco use and vaccine hesitancy (Yang et al., 2021). Second, there are limitations to the measures, specifically limited comprehensiveness of COVID-19 vaccine hesitancy measures and potential correlates (as this was not the focus of the parent study). Relatedly, these data were collected prior to the availability of COVID vaccines in the US; thus, the vaccine hesitancy items assessed a hypothetical scenario. Finally, the cross-sectional nature of these analyses precludes us from drawing causal inferences or linking hesitancy to vaccine uptake.

7. Conclusion

Public health efforts to improve COVID-19 vaccine uptake should consider factors that influence individuals' likelihood of getting vaccinated, particularly sociopolitical factors, one's experiences with COVID symptoms/testing, mental health, and sociodemographics. Thus, such efforts might target vaccine promotion campaigns to specific populations, including women, racial/ethnic minorities, and those identifying as Republican or in geographic areas leaning Republican. Moreover, a particularly important consideration is one's news exposure and sources, underscoring the need to identify and intervene on misinformation sources.

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9. Disclosure statement

The authors declare no conflicts of interests.

10. Data availability statement

Data not publicly available (available upon request).

Ethical approvals

Institutional Review Board approvals were obtained from Emory University.

CRediT authorship contribution statement

Katharina E. Klinkhammer: Conceptualization, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Katelyn F. Romm:** Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Deanna Kerrigan:** Writing – review & editing. **Karen A. McDonnell:** Writing – review & editing. **Amita Vyas:** Writing – review & editing. **Yan Wang:** Methodology, Formal analysis, Writing – review & editing. **Yan Ma:** Methodology, Formal analysis, Writing – review & editing. **Carla J. Berg:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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