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Factors associated with COVID-19 vaccination status: A cross-sectional study of California students in higher education

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ABSTRACT

To examine the factors associated with coronavirus vaccine hesitancy among students in higher education, we conducted a cross-sectional mixed-methods study between June and August 2021 among California students in higher education (n = 4444). We collected information on vaccination status, socio-demographics, and attitudes towards coronavirus vaccination.

After adjusting for social demographics and social network characteristics, compared to those with household members who were vaccinated, those who had household members who were unvaccinated had 0.11 (95% CI 0.09 – 0.14) times the odds of being vaccinated. Political identification was related to vaccination status: compared to those who did not identify with any particular party, those who identified as progressive had 12.5 (95% CI 3.70 – 50.0) times the odds of being vaccinated. Asians had higher odds (OR = 1.54; 95% CI 1.08 – 2.04) of being vaccinated compared to whites and men were marginally less likely to be vaccinated (OR = 0.79; 95% CI 0.61 – 1.00). However, age, parental education, and educational status were unrelated to vaccination status. Social and demographic factors may be associated with the decision to remain vaccinated among young adults. Public health messages should utilize social networks to encourage vaccination uptake among young adults.

1. Introduction

The novel Coronavirus (COVID-19) emerged during the winter of 2019/2020 and spread globally (CDC, 2023). By summer 2022 there had been 561.9 million people infected and with more than 6.3 million deaths (COVID-19 Dashboard). More than 700,000 US college students have tested positive for COVID-19 (Tracking coronavirus cases at US Colleges and Universities, 2022) and there were more than 6,000 COVID-19 deaths and nearly 17 million infections among young adults aged 18–29 (CDC, 2022). By the end of the first year of the pandemic, vaccines had been developed and were available to adults in the US under the Food and Drug Administration's Emergency Use Authorization (CDC, 2023). By August 2021, the FDA had fully approved one vaccine (Comirnaty and Pfizer-BioNTech COVID-19 Vaccine, 2021) and a second was fully approved by January 2022 (Spikevax and Moderna COVID-19 Vaccine, 2022). Public health experts had initially calculated 70–90% of the population needed to have immunity to the virus to reach herd immunity (Kadkhoda, 2021; Mallela et al., 2022; Plans-Rubió, 2022). Additionally, virus mutations may impede vaccine effectiveness, slowing the process of reaching herd immunity. Therefore, public health efforts have been focused on decreasing transmission rates through personal hygiene, social distancing and mask wearing, and increasing vaccination rates across all eligible populations. By early June 2022, about 60% of young adults in the US, aged 18–24, were fully vaccinated (See how vaccination is going in your state, 2022), and 28% of unvaccinated adults were between 18 and 29 (KFF, 2021).

An important consideration in vaccination intervention is vaccine hesitancy, defined as "a delay in acceptance or refusal of vaccination despite availability of vaccination services" (MacDonald, 2015). Vaccine hesitant people are a diverse, non-homogenous group (MacDonald, 2015; Peretti-Watel et al., 2015), and vaccine hesitancy is a complex decision-making process influenced by perceptions and calculations of risk and health operating in a context of trust and confidence in the healthcare system (Peretti-Watel et al., 2015). Studies on COVID-19 vaccination beliefs and status among college students observed about one quarter of the young adult and college population delaying vaccination (Baack et al., 2021; Elliott and Yang, 2022; Mayan et al., 2021). Studies identified concerns among women and two suggested college women were less likely to vaccinate (Elliott and Yang, 2022; Brunson et al., 2021) compared to males. Many studies have consistently shown

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higher rates of vaccine hesitancy among non-white students compared to White students (Gurley et al., 2021; Moye et al., 2022; Holt et al., 2022). Research has shown differences in vaccination hesitancy by political views and political affiliation (Brunson et al., 2021; Holt et al., 2022; Sharma et al., 2021), with Republican students showing greater hesitancy and lower vaccination rates compared to others. Religion has also been identified as a reason for COVID-19 vaccine hesitation (Sarwar et al., 2021). Perceived risk was explored by researchers but was inconclusive with two studies suggesting hesitancy was related to perceptions of low risk or low severity of disease (Brunson et al., 2021; Qiao et al., 2020) and another study showed no difference (Holt et al., 2022).

Trends in vaccine hesitancy among college students worldwide were similar. One review found that most college students will get vaccinated (Moye et al., 2022) and many cited reasons for delaying vaccination included health literacy; low risk perception; lack of trust; and, availability (Moye et al., 2022; Geng et al., 2022). In the US, college students had similar reasons for delaying COVID-19 vaccination including a desire to "wait and see" (Adams et al., 2021; Bonnema et al., 2021), concerns about side effects (Elliott and Yang, 2022; Moye et al., 2022; Adams et al., 2021; Wotring et al., 2021), a belief that there needs to be more research (Elliott and Yang, 2022; Wotring et al., 2021; Silva et al., 2021), low trust in the safety of the vaccine (Adams et al., 2021; Wotring et al., 2021), and believing others needed the vaccine more (Adams et al., 2021). There was also a relationship between information source and vaccine hesitancy, with unvaccinated students being less likely to get their information from public health sources (Elliott and Yang, 2022) and more likely to be exposed to negative news and reporting (Wotring et al., 2021).

As campuses prepared for students to return (repopulate), attention was focused on reducing risks, including increasing vaccination rates. The current study drew from a large, diverse student sample from California, the largest state in the US at a critical time of campus repopulation amidst the Delta strain COVID surge (CDC, 2023) and institutionally imposed vaccine mandates (Smith, 2021; Zinshteyn, 2021). The study aimed to answer three questions: 1) What was the vaccination status among college students? 2) What, if any, were the relationships between vaccination status and student demographic or social indicators? 3) What factors were associated with vaccination hesitancy among unvaccinated college students in higher education?

2. Methods

2.1. Study design

This cross-sectional mixed-methods study explored factors influencing vaccination status among California college students. Eligibility was restricted to students who were enrolled or planning to enroll in any type of institution of higher education in the State of California for Fall 2021. Students were recruited to participate via social media (Twitter, Facebook, LinkedIn, and Instagram) and via email. The researchers emailed 403 marketing, communications, instruction, and health center administrators representing 81 colleges with a request to share the study invitation with students via email and on social media. Our study sample included students from public universities (94%), community colleges (4%), and other institutions, including private universities and vocational institutes (3%).

2.2. Procedures

The survey covered COVID-19 vaccination status and vaccine hesitancy, beliefs towards vaccination mandates and repopulation (i.e., returning to campus after an extended period of online courses); individual demographics, and eligibility screening and exit questions. In total, there were thirty-four questions shown to all respondents including, three screening, two exit, and five open-ended questions. The survey was anonymous and no personally identifiable information was collected; however, there were indirect identifiers such as major and college affiliation. There were no incentives offered for participation. The median survey completion time was 5.7 min, with an interquartile range of 6.5 min. The study was approved by the researchers' Institutional Review Board.

2.3. Measures

2.3.1. Outcome

Vaccination status was assessed using the following question and response options: Have you received a COVID-19 vaccine? 1) Yes – Johnson & Johnson. One dose only, 2) Yes – Pfizer or Moderna. First and second dose, 3) Yes – Pfizer or Moderna, first dose only, 4) Other vaccine, and 5) No.

2.3.2. Independent variables

Socio-demographic items assessed included race/ethnicity [Asian, Black, Hispanic/Latino, white, other race, two or more races], age, gender [gender non-binary, gender non-confirming, man, transgender man, transgender woman, woman, not listed], sexual orientation [asexual, bisexual/pansexual, gay, heterosexual/straight, lesbian, queer, other], educational status [undergraduate student, graduate student, or other (vocational/trade)], parental education [high school diploma (or equivalent), some college, associate/technical degree, bachelor's degree, graduate/post-graduate degree], and political affiliation [Democrat, Green Party, Independent, Libertarian, No affiliation, Progressive, Republican, Other]. Participants also answered questions about social-network characteristics including vaccination status [yes, no, unsure] of household members, family members, and friends, and sources of news information. Sources of news information were presented in a "select all that apply" list and were further categorized as none, single source (health authority, friends and family, social media, traditional media, or other), or multiple sources.

2.3.3. Missing values

The proportion of missing values for covariates ranged from 9.3% (family vaccination status) to 46.2% (age). These were analyzed using the missing variable indicator method and presented in the results. In sensitivity analyses, we used a complete case analysis of only the participants for whom all covariates were present. We also examined associations using multiple imputation methods for the covariates with the largest proportions of missing data, specifically age, ethnicity, gender, sexual orientation, educational status, parent's education, parent's income and party identification.

2.4. Data analysis

Vaccination status was examined as a dichotomous variable: participants who selected 'No' were categorized as not vaccinated, and those who selected any of the other options were classified as vaccinated. Chi-squared tests were used to examine bivariate associations between the categorical independent variables and vaccination status. Logistic regression was used to model odds ratios (ORs) of vaccination status (no vs yes) for each independent variable. Any variable which attained a p-value of < 0.10 in bivariate logistic regression analyses was a candidate for inclusion in the multivariable models. The first multivariable model assessed sociodemographic characteristics, whereas the second multivariable model also included social network characteristics in addition to the sociodemographic characteristics. All statistical tests were two-sided. Statistical analyses were conducted using SAS Software (SAS, 2014).

Qualitative survey data were analyzed to answer the research question exploring factors influencing vaccination hesitancy among unvaccinated college students, obtained through five open-ended survey questions covering beliefs about policies mandating vaccination and campus repopulation. Analyses were restricted to unvaccinated students

because the authors were interested in identifying barriers to vaccination uptake among currently unvaccinated students. The six steps of thematic analysis were used to develop common themes in the qualitative responses (Terry et al., 2017; Braun and Clarke, 2006). To gain familiarity with the data, (step 1) all responses were imported and read in full, jotting notes in the margins. To generate codes (step 2), margin notes were distilled into words and short phrases, which evolved into codes. Data were uploaded into MAXQDA (MAXQDA, 2017) and all responses were read and coded. Once coded, patterns were explored and initial themes were developed (step 3). Refining the themes (step 4) was iterative and with each discussion among the researchers, the themes evolved through additions and clarification. For the fifth step, themes were named and defined, taking into consideration how everything fit together to tell a story about COVID-19 vaccination hesitancy. Deciding how to tell this story was at the center of step 6, reporting on and presenting the results. While each of the six steps of thematic analysis were followed, the process was iterative and non-linear with multiple rounds of review and refining until presentation decisions were solidified.

3. Results

3.1. Quantitative Results

A total of 4,444 participants provided complete information on their vaccination status. Among these, 18% of participants had not been vaccinated. The average age (standard deviation) of participants was 24.5 (7.7) years, range: 15 – 83 years, with 18–21 being the largest (22.3%) age group represented. Most participants (51.1%) identified as woman gender, with 2.5% identifying as gender minority. Table 1 outlines the sociodemographic and social network characteristics of the study population.

In the crude logistic regression models, ethnicity was associated with vaccination status, with Asian students more likely to be vaccinated compared to whites, and remained significant after adjusting for sociodemographic and social network characteristics: aOR (95% CI): 1.54 (1.08 – 2.04). Political identification was also significantly associated with vaccination status. After controlling for sociodemographic and social network characteristics, compared to those with no political identification, those who identified as progressive were 12.5 (95% CI 3.70 – 50.00) times more likely to be vaccinated, those who identified as Democrats aOR 2.63 (95% CI 2.04 – 3.57), and Republicans aOR 0.63 (95% CI 0.41 – 0.94) times as likely to be vaccinated (Table 2).

Vaccination status of household members, family, and friends were significantly associated with vaccination status and persisted after controlling for all covariates. The aOR of being vaccinated were 0.19 (0.11 – 0.34) times those among students with unvaccinated friends compared to those with friends who were vaccinated. Similarly strong associations were observed for unvaccinated family and household members, as shown in Table 2.

Source of news information was also associated with vaccination status. Compared to those who had multiple sources of news information, those whose single source was a health authority were more likely to be vaccinated, aOR (95% CI) 1.54 (95% CI 1.19 – 2.00). Slightly lower associations were observed for those whose single source of information was social media or friends and family. Conversely, those whose single source was from 'Other' sources, e.g., conducting their own research were 0.54 (95% CI 0.33 – 0.88) times as likely to be vaccinated. (Table 2). Gender, sexual orientation, and income were associated with vaccination status for certain groups only relative to the reference groups, while age, educational status, and were unassociated with vaccination status (Table 2).

Sensitivity analyses using the complete case analysis method and multiple imputation yielded largely similar results. The notable exception was for Asian race in the final model that was no longer significantly associated with vaccination status using multiple imputation.

To answer the third research question (factors influencing vaccine

Table 1
Participant Descriptive Statistics in the California College Repopulation Survey, 2021.

Variables	ALL[1]	Vaccination Status		*P*-Value[2]
		No N = 813 (18%)[1]	Yes N = 3631 (82%)[1]	
Sociodemographic Characteristics				
Race/Ethnicity				< 0.001
Asian	869 (19.6)	71 (8.2)	798 (91.8)	
Black	96 (2.2)	20 (20.8)	76 (79.2)	
Hispanic/Latino	466 (10.5)	90 (19.3)	376 (80.7)	
White	1197 (26.9)	181 (15.1)	1016 (84.9)	
Other[3]	366 (8.2)	119 (32.5)	247 (67.5)	
Two or more races	424 (9.5)	74 (17.5)	350 (82.6)	
Decline to state	1026 (23.1)	258 (25.2)	768 (74.9)	
Age (in years)			<0.001	
15 – 17	59 (1.3)	9 (15.3)	50 (84.8)	
18 – 21	989 (22.3)	148 (15.0)	841 (85.0)	
22 – 25	694 (15.6)	123 (17.7)	571 (82.3)	
26 – 29	284 (6.4))	52 (18.3)	232 (81.7)	
≥ 30	365 (8.2)	48 (13.2)	317 (86.9)	
Decline to state	2053 (46.2)	433 (21.1)	1620 (78.9)	
Gender				< 0.001
Gender minority	111 (2.5)	18 (16.2)	93 (83.9)	
Man	1120 (25.2)	211 (18.8)	909 (81.2)	
Woman	2269 (51.1)	341 (15.0)	1928 (85.0)	
Decline to state	944 (21.2)	243 (25.7)	701 (74.3)	
Sexual Orientation				< 0.001
Bisexual/pansexual	381 (8.6)	30 (7.9)	351 (92.1)	
Heterosexual	2522 (56.8)	449 (17.8)	2073 (82.2)	
Homosexual	129 (2.9)	11 (8.5)	118 (91.5)	
Other[4]	246 (5.5)	42 (17.1)	204 (82.9)	
Prefer not to state	276 (6.2)	64 (23.2)	212 (76.8)	
Decline to state	890 (20.0)	217 (26.7)	673 (75.6)	
Education Status				< 0.001
Undergraduate	2770 (62.3)	492 (17.8)	2278 (82.2)	
Graduate	649 (14.6)	70 (10.8)	579 (89.2)	
Vocational/Trade	51 (1.2)	8 (15.7)	43 (84.3)	
Decline to state	974 (21.9)	243 (25.0)	731 (75.1)	
Parental Education				<0.001
High school or less	661 (14.9)	109 (16.5)	552 (83.5)	
Some college/associate's	995 (22.4)	203 (20.4)	792 (79.6)	
Bachelor's degree	835 (18.8)	125 (15.0)	710 (85.0)	
Master's degree or higher	596 (13.4)	62 (10.4)	534 (89.6)	
Decline to state	1357 (30.5)	314 (23.1)	1043 (76.9)	
Parents' Annual Income ($)				<0.001

(*continued on next page*)

Table 1 (*continued*)

Variables	ALL[1]	Vaccination Status: No N = 813 (18%)[1]	Vaccination Status: Yes N = 3631 (82%)[1]	*P*-Value[2]
≤ 25,000	558 (12.6)	94 (16.7)	464 (83.2)	
> 25,000 –75,000	973 (21.9)	172 (17.7)	801 (82.3)	
>75,000 – 150,000	868 (19.5)	128 (14.8)	740 (85.3)	
> 150,000	469 (10.6)	73 (15.6)	396 (84.4)	
Decline to state	1576 (35.5)	346 (22.0)	1230 (78.1)	
Political Identification				<0.0001
Democrat	1631 (36.7)	130 (7.8)	1501 (92.0)	
Independent	187 (4.2)	41 (21.9)	146 (78.1)	
Progressive	137 (3.1)	3 (2.2)	134 (97.8)	
Republican	222 (5.0)	95 (42.8)	127 (57.2)	
Other[5]	261 (5.9)	73 (28.0)	188 (72.0)	
None	722 (16.3)	168 (23.3)	554 (76.7)	
Decline to state	1284 (28.9)	303 (23.6)	981 (76.4)	
Social Network Characteristics				
Family Vaccination Status				<0.0001
Yes	3363 (75.7)	378 (11.2)	2985 (88.8)	
No	199 (4.5)	136 (68.4)	63 (31.7)	
Unsure	471 (10.6)	149 (31.6)	322 (68.3)	
Decline to state	411 (9.3)	150 (36.5)	261 (63.5)	
Household Member Vaccination Status				<0.0001
Yes	2745 (61.8)	141 (5.1)	2604 (94.9)	
No	1272 (28.6)	546 (42.9)	726 (57.1)	
Decline to state	427 (9.6)	126 (29.5)	301 (70.5)	
Friends Vaccination Status				
Yes	3209 (72.2)	405 (12.6)	2804 (87.4)	<0.0001
No	104 (2.3)	75 (72.1)	29 (27.9)	
Unsure	445 (10.0)	128 (28.8)	317 (71.2)	
Decline to state	686 (15.4)	205 (29.9)	481 (13.2)	
News Information Sources, Multiple Sources				
Friends & family				
Yes	1819 (40.9)	336 (18.5)	1483 (81.5)	0.80
No	2625 (59.1)	477 (18.2)	2148 (81.8)	
Health authorities				
Yes	3251 (73.2)	536 (16.5)	2715 (83.5)	< 0.001
No	1193 (26.9)	277 (23.2)	916 (76.8)	
Social media				
Yes	1200 (27.0)	163 (13.6)	1037 (86.4)	< 0.001
No	3244 (73.0)	650 (20.0)	2594 (80.0)	
Traditional media				
Yes	2108 (47.4)	385 (18.3)	1723 (81.7)	0.96
No	2336 (52.6)	428 (18.3)	1908 (81.7)	
Other sources[6]				
Yes	356 (8.0)	109 (30.6)	247 (69.4)	<0.001
No	4088 (92.0)	704 (17.2)	384 (82.8)	
News Information Sources, Single Source (n = 1534)				
Friends & family				0.28
Yes	185 (12.1)	24 (13.0)	161 (87.0)	
No	1349 (87.9)	217 (16.1)	1132 (83.9)	
Health authority				0.002
Yes	904 (58.9)	120 (13.3)	784 (86.7)	
No	630 (41.1)	121 (19.2)	509 (80.0)	
Social media				
Yes	85 (5.5)	9 (10.6)	76 (89.4)	0.18
No	1449 (94.5)	232 (16.0)	1217 (84.0)	
Traditional media				
Yes	250 (16.3)	43 (17.2)	207 (82.8)	0.48
No	1284 (83.7)	198 (15.4)	1086 (84.6)	
Other sources[6]				
Yes	110 (7.2)	45 (40.9)	65 (59.1)	< 0.001
No	1424 (92.8)	196 (13.8)	1228 (86.2)	

[1] Values in table are Ns and percentages.
[2] Chi-squared test of proportions.
[3] Other Race/Ethnicity includes Native Hawaiian and Pacific Islanders, Native Americans, as well as others such as "Californian" and "American". Those who did not respond to the survey question were coded as Unknown.
[4] Other Sexual Orientation includes asexual and queer.
[5] Other Political Affiliation includes Green Party, Libertarian, and apolitical.
[6] Other sources of news include doing own research, work emails, and Google.

hesitancy among unvaccinated), researchers analyzed both quantitative and qualitative data. The most common responses for delaying vaccination among the 18% who were unvaccinated were concerns about side effects (61%) and the pace of vaccine development (49%). The least common concerns were fear of injections (6%) and an underlying medical condition (8%) (Fig. 1). Analyzing the 1,229 qualitative responses, submitted by 402 unvaccinated students, led to three themes: 1) calculating personal risk, 2) demanding my rights, and 3) lack of trust in authority and experts. Following, each theme is described, and exemplary quotes are included to highlight respondent perspectives.

3.2. Qualitative results

3.2.1. Calculating personal risk

Qualitative responses exemplified how students calculated personal risk regarding COVID-19 disease and vaccination. Some believed the vaccine was not necessary because they were at low risk, as stated by one who wrote, "Science indicates my age group will recover from COVID 19 without issues." Similarly, another said, "Encourage vaccines for those at risk, but don't require them for healthy low risk demographics. I'd be open to providing a physical from my physician to prove I am low risk." Others offered views about achieving herd immunity: "The vast majority of those who support the COVID vaccine have already been vaccinated, and this effort has largely been sufficient in protecting society as whole."

Table 2
Odds Ratios and 95% Confidence Intervals for Vaccination Status (Yes vs No) among California College Students in the California College Repopulation Survey Study, 2021.

Variable	Crude model	Model 1 (Sociodemographic)	Model 2 (Sociodemographic + Social Network)
Race/Ethnicity			
Asian	2.00 (1.49–2.70)	2.17 (1.59 – 2.94)	1.54 (1.08–2.04)
Black	0.68 (0.40 – 1.14)	0.64 (0.37 – 1.11)	0.78 (0.39–1.56)
Hispanic/Latino	0.75 (0.56 – 0.98)	0.66 (0.49 – 0.90)	0.79 (0.55–1.14)
White	1.00	1.00	1.00
Other race[1]	0.37 (0.28–0.48)	0.40 (0.30—0.55)	0.41 (0.28–0.59)
Two or more races	0.84 (0.63 – 1.14)	0.81 (0.58–1.08)	0.83 (0.57–1.22)
Declined to state	0.53 (0.43 – 0.65)	0.59 (0.40 – 0.88)	0.65 (0.40–1.05)
Age (in years)			
15 – 17	1.19 (0.57–2.50)	0.93 (0.49–2.04)	1.06 (0.46–2.44)
18 – 21	1.00	1.00	1.00
22 – 25	1.22 (0.94 – 1.59)	0.82 (0.76 – 1.09)	0.76 (0.55–1.06)
26 – 29	0.96 (0.67—1.37)	0.85 (0.58 – 1.25)	0.99 (0.62–1.59)
≥ 30	1.43 (0.99 – 2.04)	1.22 (0.83 – 1.82)	1.37 (0.87–2.17)
Declined to state	0.81 (0.65 – 1.01)	0.81 (0.63 – 1.04	0.89 (0.66–1.2)
Gender			
Gender minority	0.92 (0.54–1.54)	0.76 (0.41–1.39)	0.87 (0.41–1.85)
Man	0.76 (0.63 – 0.92)	0.91 (0.74–1.12)	0.79 (0.61 – 1.00)
Woman	1.00	1.00	1.00
Declined to state	0.51 (0.42 – 0.61)	0.97 (0.6–1.56	0.93 (0.53–1.61)
Sexual Orientation			
Bisexual/ pansexual	2.50 (1.72–3.70)	2.13 (1.41–3.23)	1.82 (1.14–3.03)
Heterosexual	1.00	1.00	1.00
Homosexual	2.33 (1.23–4.35)	1.64 (0.85–3.23)	1.75 (0.85–3.57)
Other[2]	1.05 (0.74 – 1.49)	1.01 (0.68–1.49)	0.93 (0.58–1.47)
Declined to state	0.68 (0.57 – 0.81)	1.37 (0.94 – 2.00)	1.37 (0.88–2.08)
Education Status			
Undergraduate	1.00	1.00	1.00
Graduate	1.79 (1.37 – 2.33)	1.49 (1.11–2.04)	1.35 (0.95–1.89)
Vocational	1.16 (0.54 – 2.50)	1.14 (0.5–2.56)	0.9 (0.35–2.33)
Declined to state	0.65 (0.55 – 0.78)	0.99 (0.61–1.59)	1.28 (0.72–2.27)
Parental Education			
High school or less	1.00	1.00	1.00
Some college/ associate's	0.77 (0.60 – 0.96)	0.87 (0.66–1.15)	0.81 (0.59–1.14)
Bachelor's degree	1.12 (0.85–1.49)	0.98 (0.72–1.35)	0.800 (0.56–1.15)
Master's degree or higher	1.69 (1.22 – 2.38)	1.47 (1.01–2.13)	1.15 (0.75–1.79)
Declined to state	0.65 (0.52 – 0.83)	1.06 (0.75–1.49)	1.00 (0.67–1.49)
Parents' Annual Income ($)			
≤ 25,000	1.00	1.00	1.00
> 25,000 –75,000	1.10 (0.79 – 1.54)	1.01 (0.69–1.49)	0.68 (0.48–0.97)
>75,000 – 150,000	0.94 (0.42 – 1.25)	0.9 (0.67–1.22)	0.81 (0.55–1.19)
> 150,000	1.18 (0.88–1.56)	1.06 (0.77–1.47)	0.72 (0.46–1.14)
Declined to state	0.72 (0.36 – 0.93)	1.02 (0.71–1.47)	0.85 (0.55–1.32)
Political Identification			
Democrat	3.57 (2.70 – 4.55)	3.57 (2.78–4.76)	2.63 (2.04–3.57)
Independent	1.08 (0.74 – 1.59)	1.23 (0.83–1.85)	1.25 (0.78 – 2.00)
Progressive	14.3 (4.17 – 50.00)	12.5 (3.85–33.33)	12.5 (3.7 – 50.00)
Republican	0.40 (0.29–0.55)	0.47 (0.33–0.65)	0.63 (0.41–0.94)
Other[3]	0.78 (0.56 – 1.08)	0.88 (0.63–1.23)	1.02 (0.68–1.52)
None	1.00	1.00	1.00
Declined to state	0.98 (0.79 – 1.22)	1.22 (0.83–1.79)	1.16 (0.74–1.85)
Family Vaccination Status			
Yes	1.00	N/A[5]	1.00
No	0.06 (0.04 – 0.08)		0.22 (0.15–0.32)
Unsure	0.27 (0.22 – 0.34)		0.64 (0.49–0.85)
Declined to state	0.22 (0.18–0.28)		0.54 (0.36–0.82)
Household Member Vaccination Status			
Yes	1.00	N/A[5]	1.00
No	0.07 (0.06 – 0.89)		0.11 (0.09–0.14)
Declined to state	0.13 (0.10 – 0.17)		0.28 (0.19–0.41)
Friends Vaccination Status			
Yes	1.00	N/A[5]	1.00
No	0.06 (0.04 – 0.09)		0.19 (0.11–0.34)
Unsure	0.36 (0.28 – 0.45)		0.53 (0.39–0.71)
Declined to state	0.34 (0.28–0.42)		0.80 (0.56–1.25)
News Information Sources			
None	0.37 (0.28 – 0.49)	N/A[5]	0.7 (0.44–1.11)
Single source – health authority	1.45 (1.16 – 1.79)		1.54 (1.19 – 2.00)
Since source – friends and family	1.47 (0.95–2.27)		1.85 (1.67–3.13)
Single source – social media	1.85 (0.93 – 3.70)		3.03 (1.35–7.14)
Since source – traditional media	1.06 (0.75 – 1.49)		1.32 (0.87 – 2.00)
Single source – other[4]	0.32 (0.22 – 0.47)		0.54 (0.33–0.88)
Multiple sources	1.00		1.00

[1] Other Race/Ethnicity includes Native Hawaiian and Pacific Islanders, Native Americans, as well as others such as "Californian" and "American". Those who did not respond to the survey question were coded as Unknown.
[2] Other Sexual Orientation includes asexual and queer.
[3] Other Political Affiliation includes Green Party, Libertarian, and apolitical.
[4] Other sources of news include doing own research, work emails, and Google.
[5] Only included in Model 2.

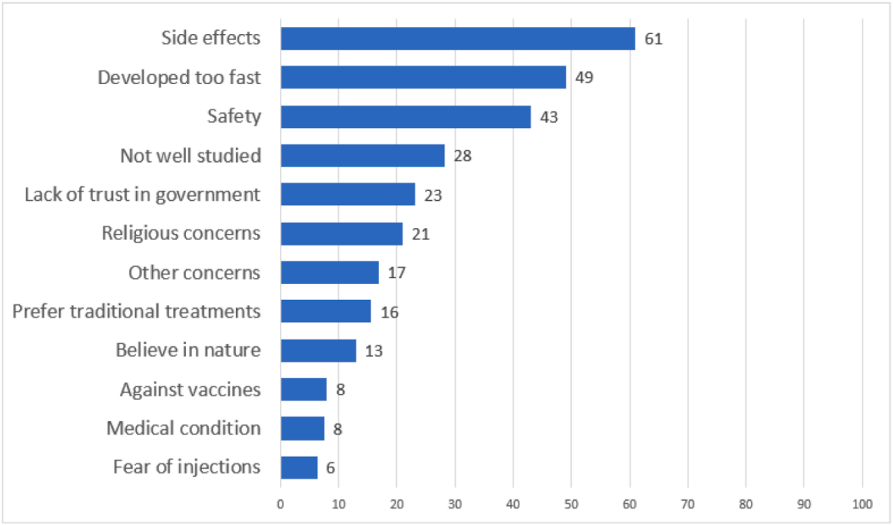

Fig. 1. Percent of participants reporting specific vaccination concerns among those who were not vaccinated (n = 813), among California College Students in the California College Repopulation Survey Study, 2021.

Some respondents justified personal risk based on their apprehension to new vaccines. One wrote broadly, "I am a health-conscious person who is driven to take agency for my own health. Vaccines were developed in a short window of time, obviously due to the nature of the events that have transpired". Another was more specific, "As a woman, I'm mainly concerned about the effects on fertility and menstruation. I support science and vaccines generally, but I can't risk those aspects of my health." Others shared their beliefs towards immunity and health with responses such as: "I believe my body will fight it off. I don't like to put things in my body that may cause me harm."

Responses also identified information sources that shaped calculations of personal risk. Some wrote about family. One said, "Many friends and family had harsh heart adverse reactions until there is more study I will [not] take the risk of getting sick from the shot!" Others wrote about doing their own research such as, "This is a very personal choice. I do my research, educate myself, there are vaccine injuries, true and informed consent is knowing all the risks."

3.2.2. *Demanding my rights*

The second theme, characterized by an underlying belief that personal rights were being violated, was primarily contextualized in response to vaccine mandates. Many unvaccinated respondents believed in their right to choose to be vaccinated, or not, as conveyed by a respondent who wrote, "I am extremely disappointed in the system for this violation of rights and forcing medical interventions on students. I pay you for your service to provide me with an education not to make medical decisions on my behalf."

Relatedly, respondents shared beliefs in the right to an educational experience they sought: "If you refuse to provide me an adequate education, by which I mean in-person classes, I will sue the university, as I am paying full tuition, just like other students." A final perspective on personal rights capitalized on American values of individual liberties, illustrated by responses such as, "The best thing about our country is to have the freedom to believe in what we want or feel's safe."

3.2.3. *Lack of trust in authority and experts*

The third theme captured the overall lack of trust in authority, including government and public health leadership. Some expressed frustration with government response to the pandemic overall, observed by statements such as, "This is a virus and will continue to mutate. I think the government on all levels has gone overboard with their demands and threats of exclusion from society. This is yet another step by governments to segregate and control citizens." Others described apprehension and lack of trust in vaccine developers, as captured by the following response, "There is no accountability for the so-called coronavirus "vaccine," or any vaccines for that matter." They continued,

> Vaccine manufacturers have been given immunity from liability in case their vaccines go wrong, so there really is no incentive for the manufacturers to manufacture safe and effective vaccines since they can literally get away with putting poison on the market. Furthermore, the coronavirus "vaccines" are not even safe. According to VAERS data, this year's vaccine-related deaths far exceed the number of vaccine-related deaths last year.

4. Discussion

In this study, we found statistically significant relationships between vaccination status and student demographics, including race, political identification, and social networks.

Results were largely consistent with other research on college student COVID-19 vaccination beliefs, but there were some differences. For example, our finding that Asians were more likely to be vaccinated compared to whites is consistent with national data (Wrigley-Field et al., 2022). Our findings of women being more likely to be vaccinated in addition to sexual orientation minorities were consistent with the findings of Soulakova et al (Soulakova et al., 2023), but they found racial/ethnic differences in vaccination rates, which were not statistically significant in this study (Soulakova et al., 2023). Conversely, our study did not reveal any differences between Black and white students, inconsistent with previously reported findings (Gurley et al., 2021). However, our sample of Black students was small (n = 96; 2.2%), which may have limited our ability to detect a significant difference.

We observed strong relationships between family, friend, and household vaccination status. These findings are consistent with other research on this topic (Alshurman et al., 2021; Bruine de Bruin et al., 2019; Kecojevic et al., 2021), underscoring the significance of social connections in influencing vaccination choices. Further, our findings noting relationships between vaccination status and news/information source and political affiliation was consistent with other research (Brunson et al., 2021; Holt et al., 2022; Sharma et al., 2021) validating the key roles of media and political discourse in individual decisions.

Among unvaccinated students, the most cited concerns were about side effects and the speed of vaccine development. The three qualitative themes provided further insight into COVID-19 vaccine hesitancy including risk, rights, and trust. Evident in each theme was

individualism (Bazzi et al., 2021) and the important role and influence of knowledge, communication, and trust. The more people understand infectious disease, vaccine development, and vaccine theory, the more likely they are to be vaccinated (Mayan et al., 2021; Geng et al., 2022). In this study, students described their support of science, while questioning the science of COVID-19 immunity and vaccination in their evaluation of personal risk, suggesting an opportunity to enhance scientific literacy (Van den Broucke, 2020).

Relatedly, access to credible information is essential and public health communication has a key role to help spread accurate information tailored to specific audiences. For college students in particular, friends, family, and social expectations are significant in informing beliefs and influencing behaviors (Jaffe et al., 2022). Interventions tailored to college students should intentionally incorporate the influence of social networks.

Trust in authorities to implement and enforce policies and practices that support individual and collective health was another key influence on peoples' beliefs in this study and in others (Geng et al., 2022; Adams et al., 2021). The striking political divide in the US exists among college students as well. We are at a critical time in terms of living with COVID-19 and building (or re-establishing) trust in our institutions. Trust is essential to ongoing efforts to mitigate the negative impact of COVID-19 as well as future pandemics or public health phenomenon. Educators and public health professionals should continue to strengthen trust in public health institutions and leadership through open communication, transparency, and localized efforts to authentically engage communities in health promotion (Halma and Guetzkow, 2023; Wallerstein et al., 2020; Van Herwerden et al., 2022). Public health professionals can demonstrate commitment to population health by confronting the challenges of mistrust directly. Simultaneously, public health professionals must work to strengthen the public health infrastructure through policy and legislation that will further codify the essential and complex role of public health in promoting population health.

Our study has several limitations. First, the study population over sampled state universities and future studies should seek more responses from a range of academic institutions. Second, the survey was conducted in the summer and eligible respondents may not have been checking their school email if they were not enrolled in a summer class. Third, likely because our demographic questions were included at the end of the survey, an appreciable proportion of participants were missing information on key covariates. Complete case analysis methods and multiple imputation methods revealed largely similar conclusions, nevertheless, the results should be interpreted with caution. Fourth, restricting the qualitative data analysis to unvaccinated students may have limited the broad exploration of vaccine hesitancy, but understanding hesitation among unvaccinated students was important in the context of increasing vaccination rates to support campus repopulation. Lastly, the timing of the survey may have influenced student perspectives as the study began prior to full FDA approval and concluded just following the first fully approved vaccine. As a result, during data collection some students were completing the survey with a university vaccine mandate as a possibility and some students completed the survey knowing a vaccine mandate would be enforced. The changing expectations for students likely influenced perspectives captured in the survey.

Despite these study limitations, our study has many strengths. As one of the largest to examine vaccine hesitancy among college students, in the largest state in the US, we were able to examine vaccine attitudes among an ethnically diverse young adult population when transmission rates were high, vaccines accessible, and mandates being proposed. We found that social networks and political affiliation were strongly related to vaccination status among college students. Their words reflect the power of knowledge, building and sustaining trust, and the impact of social networks on health promotion. To increase vaccination rates, public health messages must be informative, tailored to address trust, responsive to social network influences, and directly related to the concerns among different populations.

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.

Data availability

Data will be made available on request.

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