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## Prior trauma exposure, posttraumatic stress symptoms, and COVID-19 vaccine hesitancy

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### ABSTRACT

Understanding correlates of COVID-19 vaccine intentions is critical for increasing vaccine uptake. Given associations of trauma exposure and posttraumatic stress disorder (PTSD) with alterations in threat sensitivity and health behaviors, we hypothesized they could influence COVID-19 vaccine acceptance and hesitancy and be important variables to consider in the design of vaccination campaigns. Data came from a longitudinal online study of 544 US adults with high levels of pre-pandemic trauma and PTSD, assessed in August/September 2020 and March/April 2021. Individuals reported socio-demographic factors, pandemic factors, lifetime trauma history and PTSD symptoms, and COVID-19 vaccinations or intentions. We estimated bivariate associations between socio-demographics, pandemic factors, and trauma and PTSD symptoms at baseline and follow-up with COVID-19 vaccine acceptance versus hesitancy (i.e., vaccinated against COVID-19 or willing to get vaccinated versus unsure or unwilling to get vaccinated) six months later. Multiple socio-demographics (e.g., race/ethnicity, income, education, political preference) and pandemic factors (e.g., perceived likelihood of infection, household COVID-19 infection) were associated with COVID-19 vaccine hesitancy (27.2% were hesitant). However, trauma history, PTSD symptoms, and other mental health factors were not associated with COVID-19 vaccine acceptance versus hesitancy. Socio-demographic and pandemic-related factors appear more important than trauma or mental health for understanding COVID-19 vaccine intentions.

### 1. Introduction

With coronavirus disease 2019 (COVID-19) vaccinations emerging as the most important tool in curtailing the pandemic, it is critical to understand correlates of COVID-19 vaccine acceptance or hesitancy. Information on individual-level correlates, such as socio-demographics, mental health, and pandemic experiences, can guide communication and intervention efforts to improve vaccine uptake and target hesitant groups. In US samples, being older, male, non-Hispanic White or Asian (versus Black or Latinx), higher income, higher education, and of liberal political preference have been consistently related to lower COVID-19 vaccine hesitancy (Fisher et al., 2020; Malik et al., 2020; Reiter et al., 2020; Szilagyi et al., 2021). Moreover, pandemic experiences such as history of COVID-19 infection, higher perceived likelihood of getting COVID-19, and higher perceived severity of COVID-19 are associated

with lower COVID-19 vaccine hesitancy (Khubchandani et al., 2021; Killgore et al., 2021; Malik et al., 2020; Reiter et al., 2020). Although psychiatric disorders have been linked with greater risk for, and worse outcomes of, COVID-19 (Wang et al., 2020), we know little about associations of mental health with vaccine acceptance or hesitancy.

Mental health factors, including depression, anxiety, and post-traumatic stress disorder (PTSD) symptoms, has been linked with different patterns of protective and risky health-related behaviors (Coughlin, 2012; Lee and Park, 2018), including COVID-19-related protective and risky behaviors (Nishimi et al., 2022). Only a few studies have examined associations between mental health and COVID-19 vaccine hesitancy. One study in March 2020 found history of mental health treatment was associated with greater COVID-19 vaccine hesitancy (Murphy et al., 2021); while another study in September 2020 found any mental illness diagnosis was unrelated to COVID-19 vaccine

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hesitancy (Paul et al., 2021). However, both studies relied on self-reported lifetime history of mental health treatment or diagnoses and did not specifically consider trauma or trauma-related psychopathology. A study in December 2020 found a non-significant negative association between PTSD symptoms and COVID-19 vaccine hesitancy in a community sample (Killgore et al., 2021). While suggestive of lower vaccine hesitancy in individuals with PTSD, this sample had low PTSD symptomology (Primary Care PTSD scale  $M = 1.12$ ,  $SD = 1.5$ ), potentially precluding identification of significant associations. Similarly, higher COVID-19 vaccination anxiety was positively associated with getting vaccinated in a January 2021 Israeli study (Bodner et al., 2022). Together these findings suggest that PTSD symptoms could be associated with lower COVID-19 vaccine hesitancy. In contrast, among 254 vaccinated adults in January 2021, higher peritraumatic distress was associated with greater COVID-19 vaccination hesitancy, indicating psychological symptoms may relate to hesitancy even when individuals have already received vaccinations (Palgi et al., 2021). To date, no studies have reported on associations between probable PTSD and vaccine hesitancy.

The current study examined associations of lifetime trauma and self-reported PTSD symptoms with COVID-19 vaccine acceptance versus hesitancy among a community-based sample of US adults with relatively high levels of pre-pandemic trauma and PTSD. We hypothesized that trauma and PTSD symptoms would be associated with lower COVID-19 vaccine hesitancy, adjusting for socio-demographic, health, and pandemic factors previously linked with vaccine hesitancy (Khubchandani et al., 2021; Killgore et al., 2021; Malik et al., 2020). Secondary analyses examined associations of trauma and PTSD symptoms with general and COVID-19-specific vaccine perceptions, and associations between other mental health symptoms (i.e., depression and anxiety) and COVID-19 vaccine hesitancy.

## 2. Methods

The sample included community-dwelling US adults with high levels of pre-pandemic trauma and trauma-related distress based on sample recruitment. In 2017–2018, 3,631 individuals indicated interest in a remote mobile application-based study for posttraumatic stress; 689 of whom participated in a three-week intervention study in 2017/2018 wherein active and placebo participants showed similar changes in PTSD symptoms (Niles et al., 2020). For the current study, in August/September 2020, all 3,631 individuals were invited to complete a 30-min online Qualtrics survey on mental health and COVID-19 experiences (Nishimi et al., 2022). Of those invited, 896 eligible individuals (over age 18) provided electronic consent and completed the baseline COVID-19 survey. During March/April 2021, 892 (four opted out) of these individuals were invited to complete a 30-min follow-up survey assessing mental health and vaccine perceptions and intentions. Of those invited, 609 (68.3%) individuals completed at least part of the follow-up survey. Individuals received a \$5 Amazon e-gift card for each completed survey. Current analyses included data from August/September 2020 (baseline) and March/April 2021 (follow-up), and 544 individuals with complete data on relevant measures. This study was approved by the Institutional Review Board at the University of California, San Francisco.

### 2.1. Measures

#### 2.1.1. COVID-19 vaccination acceptance versus hesitancy

As COVID-19 vaccines became available in mid-December 2020, at follow-up (March/April 2021), individuals reported whether they had at least one shot of COVID-19 vaccine (yes/no). Those who had not received a shot were asked if a COVID-19 vaccine were available to them today, would they: definitely get the vaccine, probably get the vaccine, not sure if they would get the vaccine, probably NOT get the vaccine, or definitely NOT get the vaccine. This measure was based on the Household Pulse Survey assessment of COVID-19 vaccine hesitancy (US

Census Bureau, 2020). COVID-19 vaccine acceptance versus hesitancy was defined as those with a COVID-19 vaccine shot OR who would definitely or probably get the vaccine (i.e., COVID-19 vaccine acceptance) versus those not sure, or who would probably or definitely NOT get the vaccine (i.e., COVID-19 vaccine hesitancy).

Vaccine perceptions was a secondary outcome, measured using three items of the Vaccine Hesitancy Scale (Larson et al., 2015), assessing level of agreement (1 = strongly disagree to 5 = strongly agree) with statements about the importance, safety, and effectiveness of vaccines in general (not including COVID-19), and COVID-19 vaccines specifically. As item correlations were high within scales ( $r_s = 0.79$ – $0.85$  vaccines in general,  $r_s = 0.81$ – $0.88$  COVID-19 vaccines), we calculated means for vaccines in general and COVID-19 vaccines.

#### 2.1.2. Trauma and PTSD symptoms

Lifetime trauma exposure was assessed at baseline with a modified Trauma History Screen (THS) (Carlson et al., 2011). The THS includes experiences of 14 potentially traumatic events and one other trauma not specified; we added two additional events (life-threatening illness; serious injury, harm, or death you caused someone else). We created an indicator variable for any versus no lifetime trauma and a count variable of total trauma types endorsed (potential range 0–17).

PTSD symptoms were assessed at baseline and follow-up. Past 30-day PTSD symptom severity in relation to one's worst trauma was assessed with the 20-item PTSD Checklist-5 (PCL-5) (Weathers et al., 2013), a validated self-report measure consistent with Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5) criteria (Bovin et al., 2016). We derived total severity sum scores (Cronbach's  $\alpha = 0.96$  at both timepoints) and sum scores for each symptom cluster: intrusions, avoidance, alterations in cognition and mood, and alterations in arousal and reactivity. Total PCL-5 scores  $\geq 33$  indicated probable PTSD (Bovin et al., 2016). Symptom severity and probable PTSD were derived for baseline and follow-up separately, and symptom change was calculated by subtracting baseline from follow-up scores.

#### 2.1.3. Covariates

**Socio-demographic Factors.** Socio-demographic factors reported at baseline included age, gender, sexual orientation, race/ethnicity, educational attainment, current employment status, household income, and political preference. Family and residential variables included marital status, living alone or with others, living with children, residential area type, and US census region.

**Health Factors.** At baseline, individuals reported vulnerabilities to COVID-19, including health conditions (e.g., asthma, immune disorder, serious heart condition) and overweight/obese status. At follow-up, individuals were asked if they were currently pregnant, pregnant in the past year, or planning to become pregnant in the next six months; were planning to become pregnant in the future; or had no plans to become pregnant (including men). At follow-up, individuals reported having any medical conditions making them unable to get the COVID-19 vaccine (yes/no).

**Pandemic Factors.** At baseline and follow-up, individuals reported their perceived likelihood of contracting COVID-19 in the next year (very unlikely, unlikely, neutral, likely, very likely) and severity of their symptoms if contracted (absent, mild, moderate, severe, extreme). At follow-up, individuals reported ever having a COVID-19 test, personal diagnosis of COVID-19, and household diagnosis of COVID-19 since the pandemic began. Individuals reported whether they were an essential worker and whether they provided in-person COVID-19 care or support in employment.

**Mental Health.** Past 30-day depressive and anxiety symptoms were reported at baseline and follow-up with the 21-item Depression Anxiety Stress Scale (DASS-21) (Antony et al., 1998). Depressive and anxiety symptom subscales were separately summed and change scores were calculated.

**Table 1**  
Distribution of covariates by COVID-19 vaccine hesitant versus accepting (N = 544).

	Full Sample, N = 544	COVID-19 Vaccine Accepting, n = 396 (72.8%)	COVID-19 Vaccine Hesitant, n = 148 (27.2%)	Odds of COVID-19 Vaccine Hesitant (Unadjusted)
Covariates	N (%)	N (%)	N (%)	OR (95%CI)
<b>Socio-Demographic Factors</b>				
Age, M (SD)	38.5 (11.0)	38.4 (11.5)	38.5 (9.5)	1.00 (0.98, 1.02)
Gender				
Man	112 (20.6)	83 (21.0)	29 (19.6)	ref <sup>a</sup>
Woman	416 (76.5)	297 (75.0)	119 (80.4)	1.15 (0.72, 1.86)
Non-Binary, Transgender, Other	16 (2.9)	16 (4.0)	0 (0.0)	–
Sexual Orientation				
Heterosexual	445 (81.8)	311 (78.5)	134 (90.5)	ref
Homosexual	33 (6.1)	27 (6.8)	6 (4.1)	0.52 (0.19, 1.20)
Bisexual, Queer, Pansexual, Other	66 (12.1)	58 (14.6)	8 (5.4)	<b>0.32 (0.14, 0.65)**</b>
Race/Ethnicity				
Non-Hispanic White	329 (60.5)	249 (62.9)	80 (54.1)	ref
Black	62 (11.4)	29 (7.3)	33 (22.3)	<b>3.54 (2.03, 6.23)***</b>
Asian	57 (10.5)	52 (13.1)	5 (3.4)	<b>0.30 (0.10, 0.71)*</b>
Latinx	51 (9.4)	35 (8.8)	16 (10.8)	1.42 (0.73, 2.67)
Other or More Than One Race	45 (8.3)	31 (3.8)	14 (9.5)	1.41 (0.69, 2.73)
Educational Attainment				
High School or Less	32 (5.9)	15 (3.8)	17 (11.5)	<b>4.18 (2.00, 8.85)***</b>
Some College/2-yr College Degree	146 (26.8)	93 (23.5)	53 (35.8)	<b>2.10 (1.38, 3.20)**</b>
4-yr College Degree or Grad School	366 (67.3)	288 (72.7)	78 (52.7)	ref
Currently Unemployed (versus Employed)	143 (26.3)	96 (24.2)	47 (31.8)	1.45 (0.96, 2.20) <sup>+</sup>
Annual Household Income				
≤\$50,000 per year	190 (34.9)	124 (31.3)	66 (44.6)	<b>2.93 (1.24, 8.07)*</b>
\$50,001-\$100,000 per year	238 (43.8)	179 (45.2)	59 (39.9)	1.81 (0.77, 4.99)
\$100,001-\$150,000 per year	77 (14.2)	60 (15.2)	17 (11.5)	1.56 (0.58, 4.66)
>\$150,000 per year	39 (7.2)	33 (8.3)	6 (4.1)	ref
Political Preference				
Democrat	283 (52.0)	231 (58.3)	52 (35.1)	ref
Republican	79 (14.5)	43 (10.9)	36 (24.3)	<b>3.72 (2.18, 6.37)***</b>
Independent	132 (24.3)	91 (23.0)	41 (27.7)	<b>2.00 (1.24, 3.22)**</b>
Something Else	50 (9.2)	31 (7.8)	19 (12.8)	<b>2.72 (1.41, 5.16)**</b>
Marital Status				
Married	206 (37.9)	151 (38.1)	55 (37.2)	ref
Single	297 (54.6)	215 (54.3)	82 (55.4)	1.05 (0.70, 1.57)
Separated/Divorced/Widowed	41 (7.5)	30 (7.6)	11 (7.4)	1.01 (0.46, 2.10)
Living with Others (versus Alone)	433 (79.6)	310 (78.3)	123 (83.1)	1.36 (0.85, 2.27)
Living with Children (versus Not)	189 (34.7)	119 (30.1)	70 (47.3)	<b>2.09 (1.42, 3.08)***</b>
Residential Area Type				
Urban	268 (49.3)	201 (50.8)	67 (45.3)	ref
Suburban	204 (37.5)	149 (37.6)	55 (37.2)	1.11 (0.73, 1.68)
Town or Rural	72 (13.2)	46 (11.6)	26 (17.6)	<b>1.70 (0.97, 2.94)<sup>+</sup></b>
Region of Residence				
West	190 (34.9)	144 (36.4)	46 (31.1)	ref
Midwest	79 (14.5)	51 (12.9)	28 (18.9)	<b>1.72 (0.97, 3.03)<sup>+</sup></b>
Northeast	118 (21.7)	93 (23.5)	25 (16.9)	0.84 (0.48, 1.45)
South	157 (28.9)	108 (27.3)	49 (33.1)	1.42 (0.88, 2.28)
<b>Health Factors</b>				
Vulnerable Conditions (versus None)	192 (35.3)	146 (36.9)	46 (31.1)	0.77 (0.51, 1.15)
Overweight/Obese (versus Normal/Underweight)	241 (44.3)	167 (42.2)	74 (50.0)	1.37 (0.94, 2.00)
Pregnancy Status (at Follow-up)				
Pregnant in the past year/next six months	32 (5.9)	18 (4.5)	14 (9.5)	<b>2.06 (0.98, 4.24)<sup>+</sup></b>
Plan to be pregnant in the future	53 (9.7)	45 (11.4)	8 (5.4)	<b>0.47 (0.20, 0.97)<sup>+</sup></b>
No pregnancy plans	459 (84.4)	333 (84.1)	126 (85.1)	ref
Medical Condition contraindicating COVID-19 Vaccine (versus Not) (at Follow-up)	19 (3.5)	9 (2.3)	10 (6.8)	<b>3.12 (1.23, 8.00)*</b>
<b>Pandemic Factors</b>				
Perceived Likelihood of Infection (Baseline), M (SD)	2.68 (1.0)	2.78 (0.9)	2.42 (1.0)	<b>0.67 (0.54, 0.82)***</b>
Perceived Severity if Infected (Baseline), M (SD)	2.65 (0.9)	2.74 (0.9)	2.41 (1.0)	<b>0.68 (0.55, 0.84)***</b>
Perceived Likelihood of Infection (Follow-up), M (SD)	2.20 (0.9)	2.20 (0.9)	2.21 (1.0)	1.01 (0.82, 1.24)
Perceived Severity if Infected (Follow-up), M (SD)	2.55 (0.9)	2.58 (0.9)	2.47 (1.0)	0.87 (0.70, 1.07)
Had a COVID-19 Test (versus Not) (by Follow-up)	335 (61.6)	259 (65.4)	76 (51.4)	<b>0.56 (0.38, 0.82)**</b>
Had COVID-19 (by Follow-up)				
Yes, diagnosed with test	36 (6.6)	27 (6.8)	9 (6.1)	0.89 (0.39, 1.89)
Probably, diagnosed without test	14 (2.6)	9 (2.3)	5 (3.4)	1.49 (0.45, 4.41)
Maybe, suspected COVID-19	74 (13.6)	54 (13.6)	20 (13.5)	0.99 (0.56, 1.71)
No, did not have COVID-19	420 (77.2)	306 (77.3)	144 (77.0)	ref
COVID-19 in a Household Member (by Follow-up)				
Yes, diagnosed with test	50 (9.2)	38 (9.6)	12 (8.1)	0.89 (0.43, 1.71)
Probably, diagnosed without test	6 (1.1)	5 (1.3)	1 (0.7)	0.56 (0.03, 3.54)
Maybe, suspected COVID-19	53 (9.7)	32 (8.1)	21 (14.2)	<b>1.85 (1.01, 3.32)*</b>
No, did not have COVID-19	435 (80.0)	321 (81.1)	114 (77.0)	ref
Essential Employee (versus Not) (by Follow-up)	203 (37.3)	148 (37.4)	55 (37.2)	0.99 (0.67, 1.46)

(continued on next page)

Table 1 (continued)

	Full Sample, N = 544	COVID-19 Vaccine Accepting, n = 396 (72.8%)	COVID-19 Vaccine Hesitant, n = 148 (27.2%)	Odds of COVID-19 Vaccine Hesitant (Unadjusted)
Provide COVID-19 Care (versus Not) (by Follow-up)	51 (9.4)	35 (8.8)	16 (10.8)	0.80 (0.44, 1.53)
<b>Trauma and Posttraumatic Stress Disorder</b>				
Any Lifetime Trauma Exposure (Baseline)	425 (78.1)	311 (78.5)	114 (77.0)	0.92 (0.59, 1.45)
Count of Lifetime Trauma Types (Baseline), M (SD)	3.25 (2.9)	3.23 (2.9)	3.32 (3.2)	1.01 (0.95, 1.08)
Probable PTSD (Baseline)	163 (30.0)	118 (29.8)	45 (30.4)	1.03 (0.68, 1.55)
PTSD Symptoms (Baseline), M (SD)	23.4 (19.4)	23.5 (18.9)	23.1 (20.7)	1.00 (0.99, 1.01)
Probable PTSD (Follow-up)	174 (32.0)	123 (31.1)	51 (34.5)	1.17 (0.78, 1.74)
PTSD Symptoms (Follow-up), M (SD)	23.6 (20.6)	23.1 (20.2)	24.7 (21.6)	1.00 (0.99, 1.01)
PTSD Symptom Change, M (SD)	0.13 (17.2)	-0.4 (16.8)	1.6 (18.2)	1.01 (1.00, 1.02)

COVID-19 vaccine hesitancy was reported at follow-up (March/April 2021), covariates were reported at baseline (August/September 2020) unless otherwise specified. Perceived likelihood of infection (1 = very unlikely to 5 = very likely COVID-19 infection in next year); perceived severity if infected (1 = absent symptoms to 5 = extreme symptoms). Probable PTSD=PCL-5 severity scores ≥33. Unadjusted logistic regressions for each covariate and odds of being COVID-19 vaccine hesitant versus accepting. \*\*\*p < .001, \*\*p < .01, \*p < .05, +p < .10.

<sup>a</sup> Model was estimated excluding non-binary/transgender/others (n = 16) as none of this group were vaccine hesitant.

2.1.4. Analyses

We examined covariates in the sample and by COVID-19 vaccine hesitancy. Next, we performed unadjusted logistic regressions for each covariate and odds of being COVID-19 vaccine hesitant versus accepting. We then conducted separate adjusted logistic regressions for trauma (binary exposure, trauma count) and PTSD symptoms (baseline, follow-up, symptom change) with hesitancy versus acceptance, adjusting for covariates that were associated with hesitancy in unadjusted regressions at p < .05. At our sample size, we determined we had sufficient power (>90%) to detect small effect estimates (e.g., OR = 1.4; cf. Chen et al., 2010). Sensitivity analyses were conducted for PTSD symptom clusters and hesitancy versus acceptance. Sensitivity analyses also examined associations between PTSD symptoms with reception of a COVID-19 vaccine, with COVID-19 vaccine hesitancy among only those who had not yet been vaccinated (n = 368), and with being unsure among those vaccine hesitant (n = 148). Secondary analyses included linear regressions for associations between trauma and PTSD symptoms with average vaccine confidence (in general and for COVID-19 vaccines). Additional secondary analyses were conducted for depressive and anxiety symptoms with COVID-19 vaccine hesitancy. All analyses were conducted in R, v4.0.2.

3. Results

The sample was predominantly female (76.5%) with a mean age of 38.5 (SD = 11.0) and diverse racial/ethnic representation (Table 1). Individuals were highly educated, with a broader range of income and employment as well as family and residential characteristics. By follow-up, 9.2% of individuals had been diagnosed with COVID-19 and 10.3% had a household member diagnosed with COVID-19, in line with population prevalence of COVID-19 at the time (Centers for Disease Control and Prevention, 2020). Perceived likelihood of contracting COVID-19 and perceived severity of illness if infected both decreased on average from baseline to follow-up.

Most individuals had experienced lifetime trauma by baseline (78.1%), and many individuals reported multiple trauma types (M = 3.25, SD = 2.9). Prevalence of probable PTSD was 30.0% at baseline and 32.0% at follow-up, while average symptom severity was 23.4 (SD = 19.4) at baseline and 23.6 (SD = 20.6) at follow-up and symptoms were correlated at r = 0.63 across time. Average symptom severity change was 0.13 points with a wide range (SD = 17.2).

About three-quarters (72.8%) of the sample were accepting of the COVID-19 vaccine (32.4% had a COVID-19 vaccine shot; 14.4% probably and 45.4% definitely would get the COVID-19 vaccine), while 27.2% were hesitant (18.8% were unsure, 6.8% probably, and 14.7% definitely would NOT get the COVID-19 vaccine). Factors associated with higher COVID-19 vaccine hesitancy (p < .05) included: heterosexual sexual orientation (versus other sexual orientation); Black race

(versus non-Hispanic White); non-Hispanic White race (versus Asian); lower education; lower income; Republican, Independent and other political preference (versus Democrat); and living with children. Higher baseline perceived likelihood of COVID-19 infection and higher predicted symptom severity if contracted were associated with lower COVID-19 vaccine hesitancy. Having a COVID-19 test was associated with lower hesitancy, while having a medical condition contraindicating the COVID-19 vaccine or suspected COVID-19 infection among a household member were associated with higher hesitancy.

Lifetime trauma exposure (at baseline), PTSD symptom severity, and probable PTSD at both baseline and follow-up were not associated with COVID-19 vaccine hesitancy versus acceptance, in both unadjusted (Table 1) and adjusted (Table 2) models. PTSD symptom clusters were not associated with COVID-19 vaccine hesitancy in the full sample. Total PTSD symptoms were also not associated with receiving the COVID-19 vaccine or with hesitancy versus acceptance among unvaccinated individuals (n = 368), or with odds of being unsure versus those who would probably or definitely not getting vaccinated among vaccine hesitant individuals (n = 148). Increasing PTSD symptom severity from baseline to follow-up was marginally associated with higher odds of COVID-19 vaccine hesitancy (OR = 1.01, 95%CI 1.00, 1.03, p = .08).

Average vaccine confidence was high for other vaccines (M = 4.3, SD

Table 2

Adjusted logistic regressions for trauma exposure and self-reported PTSD symptoms with COVID-19 vaccine hesitancy versus acceptance (n = 544).

Independent Variable	Odds of COVID-19 Vaccine Hesitance at Follow-up β (95% CI)
<i>Trauma Exposure at Baseline</i>	
Any Lifetime Trauma	0.84 (0.48, 1.48)
Count of Lifetime Trauma Types	1.03 (0.95, 1.12)
<i>PTSD Symptoms at Baseline</i>	
Probable PTSD	1.01 (0.62, 1.63)
PTSD Symptom Severity	1.00 (0.98, 1.01)
<i>PTSD Symptoms at Follow-up</i>	
Probable PTSD	1.13 (0.70, 1.82)
PTSD Symptom Severity	1.00 (0.99, 1.02)
<i>Symptom Change Baseline to Follow-up</i>	
PTSD Symptom Severity Change	1.01 (1.00, 1.03) <sup>+</sup>

Independent variables included in separate individual models adjusted for sexual orientation, race/ethnicity, education, income, political preference, living with children, medical conditions contraindicating COVID-19 vaccines, perceived likelihood of contracting COVID-19, perceived severity of COVID-19 if contracted, COVID-19 test, COVID-19 infection in one's household. Baseline (August/September 2020), Follow-up (March/April 2021). Probable PTSD is PCL-5 severity scores ≥33, reference is no/low PTSD. Change scores are follow-up – baseline symptoms.

\*\*\*p < .001, \*\*p < .01, \*p < .05, +p < .10.

= 0.9) and similar to confidence in COVID-19 vaccines ( $M = 4.2$ ,  $SD = 1.0$ ), with these means being highly correlated ( $r = 0.83$ ). Trauma exposure and PTSD symptoms were not associated with vaccine confidence for other vaccines or COVID-19 vaccines (data not shown). COVID-19 vaccine hesitancy was not associated with depression or anxiety symptoms at baseline, follow-up, or changes in symptoms (data not shown).

#### 4. Discussion

Contrary to expectations, trauma exposure and PTSD symptoms, before (August/September 2020) and after (March/April 2021) vaccines were available, were unassociated with COVID-19 vaccine hesitancy versus acceptance in March/April 2021 among US adults who had high pre-pandemic trauma exposure and PTSD. Socio-demographic, health, and pandemic-related factors were associated with COVID-19 vaccine hesitancy, including factors identified in previous studies such as race/ethnicity, income and education, and political preference.

PTSD symptoms have been linked to risky but also protective behaviors for COVID-19 (Nishimi et al., 2022), possibly due to hypervigilance increasing protective actions and emotion-regulation needs increasing risky actions. However, PTSD symptoms were unassociated with COVID-19 vaccine hesitancy versus acceptance, vaccine confidence in general, or COVID-19 vaccine confidence in particular in March/April 2021. Because PTSD symptoms may relate to both protective and risky COVID-19 behaviors, certain PTSD symptom manifestations may be linked to COVID-19 vaccine hesitancy versus acceptance which overall may have resulted in no association between probable PTSD and vaccine hesitancy. However, supplemental sensitivity analyses across PTSD symptom clusters did not indicate any specific associations. We additionally did not find associations of depressive or anxiety symptoms with COVID-19 vaccine hesitancy. These findings were inconsistent with another US study in April/May 2021, which reported that individuals with depression were less likely to be vaccinated, but also less likely to be resistant to the COVID-19 vaccine (Perlis et al., 2021). In our sample, trauma-related distress and other distress symptoms may have been less salient to vaccine-related perceptions and behaviors than other psychological factors we did not examine, such as threat sensitivity or health anxiety.

Several socio-demographic, health, and pandemic factors were associated with COVID-19 vaccine hesitancy in our study. About 32% of the sample had a COVID-19 vaccine shot by follow-up (March/April 2021), consistent with the US prevalence (32% of US adults had at least one shot; March 31, 2021) (CDC, 2020). About 73% were accepting and 27% were hesitant about the COVID-19 vaccine, also similar to US estimates (69% accepting versus 30% hesitant; February 16–21, 2021) (Pew Research Center, 2021). Consistent with prior studies, we found that Black or Latinx race/ethnicity, lower education and income, Republican political preference, and living with children were associated with greater COVID-19 vaccine hesitancy (Fisher et al., 2020; Khubchandani et al., 2021; Malik et al., 2020; Reiter et al., 2020; Szilagyi et al., 2021). Higher baseline perceptions of COVID-19 infection risk and severity were associated with lower COVID-19 vaccine hesitancy, similar to prior work (Fisher et al., 2020; Malik et al., 2020; Reiter et al., 2020). Interestingly, fewer COVID-19 experiences were associated with COVID-19 vaccine hesitancy in our sample. Future work should examine whether associations of PTSD and threat perceptions with vaccine hesitancy vary across different levels of social determinants. Overall, our findings suggested that COVID-19 vaccine hesitancy was largely related to indicators of social determinants of health (Braveman et al., 2011), such as socio-economic status, race/ethnicity, and political orientation, rather than trauma-related mental health or direct COVID-19 experiences.

Our study has several limitations. Self-reported measures were subject to reporting biases; though we examined mental health at baseline and vaccine intentions six months later, limiting biases due to

concurrent reports. Our primary outcome included receipt of COVID-19 vaccine *and* willingness to get vaccinated, which are separate constructs, as reporting vaccine intention does not necessarily predict uptake (Liao et al., 2011). However, we combined constructs to capture overall acceptance/hesitancy rather than differential access to or availability of vaccines. Sensitivity analyses suggested no associations of trauma or PTSD with either COVID-19 vaccine receipt, or with hesitancy among those unvaccinated. We had a relatively low response rate from the eligible sample, potentially limiting power or inducing selection biases. Generalizability is limited beyond the US-based sample with relatively high levels of trauma symptomology and prevalence (Smith and Cottler 2018), who were likely also treatment-seeking within 2017–2018.

We did not find evidence for an association between trauma or PTSD symptoms and COVID-19 vaccine hesitancy. Although evidence suggests that trauma or mental health may be relevant when designing public health campaigns for behavior change (Freedland et al., 2020), our findings suggest that factors like socio-demographics other than current trauma-related psychological symptomology are influencing vaccine acceptance or hesitancy.

#### Authors' contributions

**Kristen Nishimi:** Conceptualization, Methodology, Data curation, Formal analysis, Software, Visualization, Investigation, Writing – original draft **Brian Borsari:** Conceptualization, Methodology, Funding acquisition, Writing – reviewing and editing **Paige Tripp:** Conceptualization, Methodology, Investigation, Writing – reviewing and editing **Ahmad Jiha:** Conceptualization, Methodology, Investigation, Writing – reviewing and editing **Emily A Dolsen:** Conceptualization, Methodology, Writing – reviewing and editing **Joshua D Woolley:** Conceptualization, Methodology, Writing – reviewing and editing **Thomas C Neylan:** Conceptualization, Methodology, Funding acquisition, Writing – reviewing and editing **Aoife O'Donovan:** Conceptualization, Methodology, Funding acquisition, Investigation, Project administration, Resources, Supervision, Validation, Writing – original draft.

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#### Declaration of competing interest

None.

#### References

- Antony, M.M., Bieling, P.J., Cox, B.J., Enns, M.W., Swinson, R.P., 1998. Psychometric properties of the 42-item and 21-item versions of the Depression Anxiety Stress Scales in clinical groups and a community sample. *Psychol. Assess.* 10, 176–181. <https://doi.org/10.1037/1040-3590.10.2.176>.
- Bodner, E., Bergman, Y.S., Ben-David, B., Palgi, Y., 2022. Vaccination anxiety when vaccinations are available: the role of existential concerns. *Stress Health* 38, 111–118. <https://doi.org/10.1002/smi.3079>.
- Bovin, M.J., Marx, B.P., Weathers, F.W., Gallagher, M.W., Rodriguez, P., Schnurr, P.P., Keane, T.M., 2016. Psychometric properties of the PTSD checklist for diagnostic and statistical manual of mental disorders-fifth edition (PCL-5) in veterans. *Psychol. Assess.* 28, 1379–1391. <https://doi.org/10.1037/pas0000254>.
- Braveman, P., Egerter, S., Williams, D.R., 2011. The social determinants of health: coming of age. In: *Annual Review of Public Health*, 32, pp. 381–398. *Annual Review of Public Health*. Annual Reviews, Palo Alto.

- Carlson, E.B., Smith, S.R., Palmieri, P.A., Dalenberg, C., Ruzek, J.I., Kimerling, R., Burling, T.A., Spain, D.A., 2011. Development and validation of a brief self-report measure of trauma exposure: the Trauma History Screen. *Psychol. Assess.* 23, 463–477. <https://doi.org/10.1037/a0022294>.
- CDC, 2020. COVID Data Tracker. *Cent. Dis. Control Prev.* URL: <https://covid.cdc.gov/covid-data-tracker>, 5.11.21.
- Centers for Disease Control and Prevention, 2020. Coronavirus Disease 2019 (COVID-19) in the U.S.
- Chen, H., Cohen, P., Chen, S., 2010. How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Commun. Stat. B: Simul. Comput.* 39, 860–864. <https://doi.org/10.1080/03610911003650383>.
- Coughlin, S.S., 2012. Anxiety and depression: linkages with viral diseases. *Public Health Rev* 34. <https://doi.org/10.1007/BF03391675>.
- Fisher, K.A., Bloomstone, S.J., Walder, J., Crawford, S., Fouayzi, H., Mazor, K.M., 2020. Attitudes toward a potential SARS-CoV-2 vaccine. *Ann. Intern. Med.* 173, 964–973. <https://doi.org/10.7326/M20-3569>.
- Freedland, K.E., Dew, M.A., Sarwer, D.B., Burg, M.M., Hart, T.A., Ewing, S.W.F., Fang, C. Y., Blozis, S.A., Puterman, E., Marquez, B., Kaufmann, P.G., 2020. Health psychology in the time of COVID-19. *Health Psychol* 39, 1021–1025. <https://doi.org/10.1037/hea0001049>.
- Khubchandani, J., Sharma, S., Price, J.H., Wiblehauser, M.J., Sharma, M., Webb, F.J., 2021. COVID-19 vaccination hesitancy in the United States: a rapid national assessment. *J. Community Health* 46, 270–277. <https://doi.org/10.1007/s10900-020-00958-x>.
- Killgore, W.D.S., Cloonan, S.A., Taylor, E.C., Dailey, N.S., 2021. The COVID-19 vaccine is here—now who is willing to get it? *Vaccines* 9, 339. <https://doi.org/10.3390/vaccines9040339>.
- Larson, H.J., Jarrett, C., Schulz, W.S., Chaudhuri, M., Zhou, Y., Dube, E., Schuster, M., MacDonald, N.E., Wilson, R., SAGE Working Group on Vaccine Hesitancy, 2015. Measuring vaccine hesitancy: the development of a survey tool. *Vaccine* 33, 4165–4175. <https://doi.org/10.1016/j.vaccine.2015.04.037>.
- Lee, S.Y., Park, C.L., 2018. Trauma exposure, posttraumatic stress, and preventive health behaviours: a systematic review. *Health Psychol. Rev.* 12, 75–109. <https://doi.org/10.1080/17437199.2017.1373030>.
- Liao, Q., Cowling, B.J., Lam, W.W.T., Fielding, R., 2011. Factors affecting intention to receive and self-reported receipt of 2009 pandemic (H1N1) vaccine in Hong Kong: a longitudinal study. *PLOS ONE* 6, e17713. <https://doi.org/10.1371/journal.pone.0017713>.
- Malik, A.A., McFadden, S.M., Elharake, J., Omer, S.B., 2020. Determinants of COVID-19 vaccine acceptance in the US. *EclinicalMedicine* 26. <https://doi.org/10.1016/j.eclinm.2020.100495>.
- Murphy, J., Vallières, F., Bentall, R.P., Shevlin, M., McBride, O., Hartman, T.K., McKay, R., Bennett, K., Mason, L., Gibson-Miller, J., Levita, L., Martinez, A.P., Stocks, T.V.A., Karatzias, T., Hyland, P., 2021. Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. *Nat. Commun.* 12, 29. <https://doi.org/10.1038/s41467-020-20226-9>.
- Niles, A.N., Woolley, J.D., Tripp, P., Pesquita, A., Vinogradov, S., Neylan, T.C., O'Donovan, A., 2020. Randomized controlled trial testing mobile-based attention-bias modification for posttraumatic stress using personalized word stimuli. *Clin. Psychol. Sci.* 8, 756–772. <https://doi.org/10.1177/2167702620902119>.
- Nishimi, K., Borsari, B., Marx, B.P., Tripp, P., Woodward, E., Rosen, R.C., Cohen, B.E., Maven, D., Jiha, A., Woolley, J.D., Neylan, T.C., O'Donovan, A., 2022. Posttraumatic stress disorder symptoms associated with protective and risky behaviors for coronavirus disease 2019. *Health Psychol* 41, 104–114. <https://doi.org/10.1037/hea0001157>.
- Palgi, Y., Bergman, Y.S., Ben-David, B., Bodner, E., 2021. No psychological vaccination: vaccine hesitancy is associated with negative psychiatric outcomes among Israelis who received COVID-19 vaccination. *J. Affect. Disord* 287, 352–353. <https://doi.org/10.1016/j.jad.2021.03.064>.
- Paul, E., Steptoe, A., Fancourt, D., 2021. Attitudes towards vaccines and intention to vaccinate against COVID-19: implications for public health communications. *Lancet Reg. Health – Eur.* 1. <https://doi.org/10.1016/j.lanepe.2020.100012>.
- Perlis, R.H., Green, J., Simonson, M.D., Lazer, D., Baum, M., Ognyanova, K., Chwe, H., Druckman, J., Santillana, M., Lin, J., 2021. The COVID States Project# 54: Mental Health in the United States.
- Pew Research Center, 2021. Half of Americans intend to get a COVID-19 vaccine; 19% already have. *Pew Res. Cent. Sci. Soc.* URL: [https://www.pewresearch.org/science/wp-content/uploads/sites/16/2021/03/PS\\_2021.03.05\\_covid-19-vaccines\\_00-01.png](https://www.pewresearch.org/science/wp-content/uploads/sites/16/2021/03/PS_2021.03.05_covid-19-vaccines_00-01.png), 5.11.21.
- Reiter, P.L., Pennell, M.L., Katz, M.L., 2020. Acceptability of a COVID-19 vaccine among adults in the United States: how many people would get vaccinated? *Vaccine* 38, 6500–6507. <https://doi.org/10.1016/j.vaccine.2020.08.043>.
- Smith, N.D., Cottler, L.B., 2018. The epidemiology of post-traumatic stress disorder and alcohol use disorder. *Alcohol Research: Current Reviews* 39, 113–120.
- Szilagy, P.G., Thomas, K., Shah, M.D., Vizueta, N., Cui, Y., Vangala, S., Kapteyn, A., 2021. National trends in the US public's likelihood of getting a COVID-19 vaccine—April 1 to December 8, 2020. *JAMA* 325, 396. <https://doi.org/10.1001/jama.2020.26419>.
- US Census Bureau, 2020. American Community Survey. US Census Bureau.
- Wang, Q., Xu, R., Volkow, N.D., 2020. Increased risk of COVID-19 infection and mortality in people with mental disorders: analysis from electronic health records in the United States. *World Psychiatry* 20. <https://doi.org/10.1002/wps.20806>.
- Weathers, F.W., Litz, B.T., Keane, T.M., Palmieri, P.A., Marx, B.P., Schnurr, P.P., 2013. The PTSD checklist for DSM-5 (PCL-5). Scale Available Natl. Cent. PTSD [Wwwptsdv.gov](http://www.ptsdv.gov).