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Psychological factors associated with substance use initiation during the COVID-19 pandemic



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ABSTRACT

The 2019 outbreak of the novel coronavirus (COVID-19) has had a devastating impact. Given the on-going nature of the outbreak, the deleterious toll on mental health, including substance use, is unknown. Negative reinforcement models of substance use posit that elevations in stress from the COVID-19 pandemic will elicit a corresponding motivation to downregulate COVID-19-related stress reactivity via substance use for a subset of the population. The current study sought to evaluate: (1) if COVID-19-related worry and fear were associated with substance use coping motives; and (2) how levels of COVID-19-related worry and fear differ between pre-COVID-19 substance users, COVID-19 substance initiators, and abstainers. Participants were 160 adults recruited nationally between April-May 2020 for an online study. Results indicated that COVID-19-related worry was associated with substance use coping motives. Additionally, compared to abstainers, pre-COVID-19 substance users and COVID-19 substance initiators demonstrated the highest levels of worry and fear. Examination of differences suggested that the COVID-19 substance initiators had the highest COVID-19-related worry and fear for all substances except for opioids, with effect size estimates ranging from small to medium. The results of this study suggest that COVID-19-specific psychological factors appear to be involved in substance use behavior.

1. Introduction

The outbreak of the 2019 novel coronavirus (COVID-19) has had a devastating global impact, causing upwards of 4 million infections and over 300,000 deaths (Guan et al., 2020; Sun et al., 2020). One ensuing consequence of COVID-19 is the substantial negative economic impact, which has resulted in loss of employment and income for millions of people worldwide (Zhou et al., 2020). Given the devastating consequences of COVID-19, increases in psychological symptoms and disorders, including depression, anxiety, stress, worry, and substance use, among others, have been observed (Pfefferbaum and North, 2020; Wang et al., 2020; Yao et al., 2020), and a recent report emphasizes the importance of considering substance use problems in the context of COVID-19 (Volkow, 2020). Specifically, COVID-19 is hypothesized to interfere with substance use disorder treatment, causing the potential for increases in withdrawal symptoms and relapse (Dubey et al., 2020; Ornell et al., 2020; Vecchio et al., 2020). Further, those with substance use problems appear to be particularly vulnerable to the negative effects of COVID-19. For instance, those with opioid use disorder may be particularly vulnerable to COVID-19 respiratory symptom

complications (Slat et al., 2020), and preliminary drug therapies for COVID-19 may be less effective for those with substance use disorders (Ghosh et al., 2020). Importantly, increases in psychological symptoms appear to be associated with exacerbated COVID-19 symptom severity and progression, such that those with greater substance use behaviors (e.g. tobacco) and worry in response to the virus are more likely to have poorer disease outcomes (Liu et al., 2020a; Yao et al., 2020). Despite initial evidence documenting these associations, the psychological impact of COVID-19 for substance use is largely unknown.

Negative reinforcement models of substance use posit that elevations in negative affect in response to disasters, including stress, worry, and anxiety, will increase motivation to use substances in an effort to lessen negative affective states (i.e. using substances to cope; Baker et al., 2004; Bravo et al., 1990; David et al., 1996). Although the literature concerning substance use in the context of COVID-19 is only nascent, past research from other large-scale disasters suggests that, in general, increases in substance use are observed following disaster exposure (Goldmann and Galea, 2014; North et al., 2011, 2002; Vetter et al., 2008). Further, some studies have found that anxiety and post-traumatic stress disorder (PTSD) associated with disaster are

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associated with increases in substance use in an effort to downregulate aversive emotional states (Cepeda et al., 2010). Given the observed increases in anxiety, depression, and stress in response to the COVID-19 (Pfefferbaum and North, 2020; Wang et al., 2020), individuals may similarly use substances to cope with the increased negative affect in response to the current pandemic. These maladaptive coping mechanisms sit in the larger context of COVID-19 social distancing and “stay-at-home” measures; factors that may limit opportunity for healthier emotion regulation strategies, including social interaction, physical activity, and opportunities for behavioral activation (e.g., exercise with friends at parks).

The majority of work focused on substance use in the context of disaster exposure has focused on predictors of increased substance use (Joseph et al., 1993; Parslow and Jorm, 2006). Yet, there is less work that has empirically examined those who *initiate* substance use following a disaster, including COVID-19. That is, for those who did not use a substance prior to the COVID-19 outbreak, are worry and fear associated with the initiation of substance use following the outbreak? Conceptually, worry and fear are distinct constructs with different mechanisms, such that fear can exist without worry, but worry is dependent on having some level of fear (Behar et al., 2009; Borkovec et al., 2004; Levy and Guttman, 1976). It is possible that increased COVID-19-associated worry and fear may contribute to substance use initiation, but research has not examined how individual differences in such psychological factors may differ between those who used substances before COVID-19, those who began using substances after the COVID-19 outbreak, and those who do not use substances. Further, as suggested by negative reinforcement models of substance use (Baker et al., 2004; Garey et al., 2020), using substances to cope with increased negative emotion (i.e., coping motives) may be specifically related to the initiation and maintenance of substance use problems (Hussong et al., 2011).

The aims of the current study were twofold. First, we examined if COVID-19 worry and fear differ across three groups of substances users: abstainers, pre-COVID-19 users, and COVID-19 initiators. Substances of interest included alcohol, cigarettes, cannabis, e-cigarettes, stimulants, and opioids, as these are reported to be the most commonly used and abused substances (National Institute of Drug Abuse, 2020). Second, we tested how worry and fear about COVID-19 related to coping motives for substance use. It was hypothesized that COVID-19 initiators would evince the highest levels of COVID-19-related worry and fear, and that these constructs would be associated with substance use coping motives.

2. Method

2.1. Participants

The present study included 160 participants (43.48% female, $M_{\text{age}} = 37.93$ years, $SD = 11.22$). Study eligibility criteria included being 18–65 years old and having an mTurk account. Exclusion criteria included being younger than 18 or older than 65, being a non-English speaker (to ensure comprehension of the study questions), and inability to give informed, and voluntary, written consent to participant.

2.2. Measures

Demographics. Participants provided data regarding age, sex (1 = Male, 2 = Female), gender identity, sexual orientation, educational level (1 = Less than High School to 9 = Doctorate), race, ethnicity, marital status, height, weight, and U.S. state of residence. Demographic information was used to characterize the sample whereas age and sex were included as covariates.

COVID-19 Screening and Symptoms. Participants were asked to provide information regarding COVID-19 diagnosis (“Have you been diagnosed with COVID-19?”), exposure to confirmed cases (“Have you

been exposed to someone who has confirmed COVID-19?”), and international travel (“Have you traveled to/from an area with community spread COVID-19 within the past 3 months?”). This information was used for descriptive purposes.

Substance Use. Participants provided information about alcohol, cigarette, cannabis, e-cigarette, stimulant, opioid, and other drug use prior to the COVID-19 outbreak. Specifically, participants were asked, “Prior to the COVID-19 outbreak, did you use...” and responses were coded 0 = No and 1 = Yes. Participants were then asked, “Since the COVID-19 outbreak, how have your...habits changed since the virus outbreak?” Responses were scored on a 5-point scale: 0 = no change, 1 = using a little more, 2 = using a lot more, 3 = using a little less, 4 = using a lot less. Individuals who reported not using substances prior to the COVID-19 outbreak but reported using “a little more” or “a lot more” since the outbreak were considered COVID-19 initiators. Individuals who reported using a substance prior to the COVID-19 outbreak were considered pre-COVID-19 substance users, and those that reported no substance use prior to the outbreak and no change in substance use post-outbreak were considered substance abstainers.

Substance Use Motives. Substance use motives were measured using a modified 10-item version of the Drinking Motives Questionnaire-Revised (Cooper, 1994). The modified substance use motives questionnaire was anchored to the most used substance (e.g., alcohol, cigarettes, cannabis smoking/vaping, stimulants, opioids, or other substance). Participants completed the whole measure, but only the substance use motive items assessed coping motives (4 items; “To forget your worries”; $\alpha = 0.94$), rated on a 5-point Likert type scale ranging from 1 (*Almost never/never*) to 5 (*Almost always/always*), were used in the current analysis.

COVID-19 Worry. Informed by established measures of worry (Meyer et al., 1990), the COVID-19 Worry Index is a 15-item measure developed by the current research team to assess worry about contracting COVID-19, related symptoms, and associated health consequences. Respondents are asked to rate their worry about each item (e.g., “I worry that I will come into contact with someone that has COVID-19.”). Responses are rated on a scale ranging from 1 (*Not at all*) to 7 (*A great deal*), and responses were summed for a total score, with higher scores indicating greater COVID-19-related worry. The COVID-19 Worry Index demonstrated excellent internal consistency ($\alpha = 0.96$) in the present study.

COVID-19 Fear. The Fear of COVID-19 Scale is a 7-item measure developed by our team and is designed to assess the extent to which respondents experience anxiety-related symptoms in response to thinking about contracting COVID-19. Example items include “My hands become clammy when I think about COVID-19” and “When watching news and stories about COVID-19 on social media, I become nervous or anxious.” Responses are rated on a 5-point Likert type scale ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*), and responses were summed for a total score, with higher scores indicating greater COVID-19-related fear. The Fear of COVID-19 Scale demonstrated excellent internal consistency ($\alpha = 0.92$) in the current study.

2.3. Procedure

Participants were recruited nationally via Amazon Mechanical Turk (MTurk) between April and May 2020 for a study on the relationship between COVID-19 and mental health. Interested participants click on the link to be screened for eligibility and are then directed to the anonymous online survey. MTurk uses unique worker IDs to prevent duplicate responses. Prior to completing the survey, participants indicated that they consented to participate by checking a box, but were not required to provide a signature per IRB exemption. The survey took approximately 30 minutes to complete and consisted of a battery of questionnaires regarding COVID-19 exposure and symptoms, fear and worry about COVID-19, substance use behavior pre COVID-19 and during COVID-19, and affective states. Participants were compensated

\$4.00 through their MTurk account commensurate to their participation. A number of quality assurance checks were included in the survey, including requiring participants to have a >90% approval rate, location matching to collected IP address, and speed checks, ensuring that participants did not complete the survey in less than half the median response time. The study protocol was approved by the Institutional Review Board at the University of Houston.

2.4. Data analytic plan

Data analyses were completed using SPSS version 25. First, descriptive, and bivariate relations were examined among study variables. Second, independent one-way, between subjects Analysis of Covariance (ANCOVA) were conducted to evaluate mean differences in (a) worry about COVID-19 and (b) fear about COVID-19 between three levels of substance use: abstainers, pre-COVID-19 substance users, and COVID-19 substance use initiators. Separate ANCOVA models were run for each substance use variable, including alcohol, cigarettes, cannabis, e-cigarettes, stimulants, and opioids for the two dependent variables. Age (Poudel and Gautam, 2017) and sex (McHugh et al., 2017) were included as covariates in the ANCOVA models given their *a priori* associations with substance use variables. Partial eta squared (η_p^2) served as an index of effect size of mean differences (Richardson, 2011); small = .01, medium = .06, and large = .14. Post hoc LSD tests were conducted to examine the specificity and directionality among the associations of all dependent variables across groups for significant group differences. A Bonferroni correction was employed. Based on this correction, alpha was adjusted to .004 (i.e., .05/12). Additionally, given the small and unequal sample sizes in each cell, as recommended, a strict focus on effect size (Hedge's *g*) was utilized (Sullivan and Feinn, 2012; Vadillo et al., 2016). Hedge's *g* is an ideal measure of effect size, as it quantifies the mean differences while correcting for small sample sizes to reduce bias, and is recommended when sample sizes are unequal and/or fall below $n=20$ for each cell (Hedges, 2016). Effect size guidelines for Hedge's *g* were: small = 0.20, medium = 0.50, and large = 0.80 (Cohen, 1992). Finally, to evaluate the simultaneous predictive power of worry about COVID-19 and fear about COVID-19 on coping motives, a regression model, including all participants regardless of substance use status (the dimensional nature of the measure allowed scores of 0), was conducted. Model fit was evaluated with the *F* statistic and squared semi-partial correlations (sr^2) were used as measures of effect size.

3. Results

3.1. Descriptive statistics

For participant demographic characteristics, see Table 1. In terms of COVID-19 diagnosis, 5.8% were diagnosed with COVID-19 and most of those diagnosed (80%) reported a moderate intensity of symptoms (sick, but not admitted to the hospital for more than 24 h). Over half of the sample (57.2%) reported no pre-existing conditions. For the remainder of the sample, the following pre-existing conditions were reported: diabetes (17.3%), hypertension (13.3%), asthma (12.7%), autoimmune disease (2.3%), cardiovascular disease (2.3%), other existing medical conditions (2.3%), cerebrovascular disease (1.2%), kidney disease (1.2%), liver disease (1.2%), malignant tumor (1.2%), and respiratory disease/condition (1.2%).

Concerning substance use, 43.1% of participants endorsed using alcohol prior to the COVID-19 outbreak, 21.9% reported using cigarettes, 12.5% reported using cannabis, 8.8% reported using e-cigarettes, 5.0% reported using stimulants, and 3.1% reported using opioids. In terms of COVID-19 substance use initiation, an additional 8.8% reported drinking alcohol since the COVID-19 outbreak, 6.9% started smoking cigarettes, 5.0% started using cannabis, 4.4% started using e-cigarettes, 5.6% started using stimulants, and 5.6% started using

Table 1
Participant characteristics.

Variable	M/n (SD/%)
State	
Alabama	1 (0.6 %)
Alaska	1 (0.6 %)
Arizona	1 (0.6 %)
Arkansas	1 (0.6 %)
California	15 (9.3 %)
Colorado	6 (3.7 %)
Connecticut	1 (0.6 %)
Florida	10 (6.2 %)
Georgia	5 (3.1 %)
Hawaii	3 (1.9 %)
Idaho	2 (1.2 %)
Illinois	6 (3.7 %)
Indiana	9 (5.6 %)
Iowa	2 (1.2 %)
Kansas	1 (0.6 %)
Kentucky	3 (1.9 %)
Louisiana	1 (0.6 %)
Maine	1 (0.6 %)
Maryland	2 (1.2 %)
Michigan	2 (1.2 %)
Minnesota	2 (1.2 %)
Mississippi	1 (0.6 %)
Missouri	4 (2.5 %)
Nebraska	1 (0.6 %)
Nevada	4 (2.5 %)
New Hampshire	1 (0.6 %)
New Jersey	6 (3.7 %)
New Mexico	1 (0.6 %)
New York	17 (10.5%)
North Carolina	4 (2.5 %)
Ohio	4 (2.5 %)
Oklahoma	1 (0.6 %)
Oregon	1 (0.6 %)
Pennsylvania	9 (5.6 %)
Rhode Island	1 (0.6 %)
South Carolina	1 (0.6 %)
Tennessee	2 (1.2 %)
Texas	16 (9.9 %)
Utah	2 (1.2 %)
Virginia	4 (2.5 %)
Washington	5 (3.1 %)
West Virginia	2 (1.2 %)
Education	
High School (or Equivalent)	10 (6.1%)
Some College	19 (11.5%)
Associate's Degree	16 (9.7%)
Bachelor's Degree	84 (50.9%)
Master's Degree	32 (19.4%)
Doctoral Degree	4 (2.4%)
Race	
White/Caucasian	109 (65.1%)
Black/African American	21 (12.7%)
Asian	21 (12.7%)
Multiracial	6 (3.6%)
Native American/Alaska Native	4 (2.4%)
Other	1 (0.6%)
Declined	3 (1.8%)
Ethnicity	
Latinx/Hispanic	34 (20.6%)
Non-Latinx/Hispanic	128 (77.6%)
Declined	3 (1.8%)

opioids.

3.2. Psychological risk factors

Alcohol Use. Defined alcohol use groups did not differ in mean COVID-19 worry ($F(2,155) = 3.39, p = .04, \eta^2 = .04$). Hedge's *g* effect size estimates indicate a small to moderate mean difference between abstainers and pre-COVID-19 users ($g = .34$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .58$), and a

Table 2
Raw mean estimates by substance use class.

	Covid-19 Worry		COVID-19 Fear	
	Mean	SD	Mean	SD
Alcohol				
Abstainer (n=77)	51.64	24.53	16.97	6.96
Pre-COVID-19 User (n=69)	59.49	22.01	18.42	6.31
COVID-19 Initiator (n=14)	65.29	15.44	20.79	5.55
Cigarettes				
Abstainer (n=114)	53.92	23.29	17.39	6.73
Pre-COVID-19 User (n=35)	60.51	23.57	18.94	6.39
COVID-19 Initiator (n=11)	66.36	16.54	20.27	6.00
Cannabis				
Abstainer (n=132)	54.69	24.10	17.86	6.78
Pre-COVID-19 User (n=20)	58.20	14.46	16.90	5.16
COVID-19 Initiator (n=8)	76.50	14.91	21.75	6.88
E-Cigarettes				
Abstainer (n=139)	55.08	23.71	17.53	6.81
Pre-COVID-19 User (n=14)	61.93	21.01	19.86	5.43
COVID-19 Initiator (n=7)	67.43	8.81	22.00	2.23
Stimulants				
Abstainer (n=143)	54.29	23.08	17.52	6.52
Pre-COVID-19 User (n=8)	67.50	20.04	20.50	7.13
COVID-19 Initiator (n=9)	76.89	13.32	22.11	6.70
Opioids				
Abstainer (n=146)	54.90	23.09	17.41	6.63
Pre-COVID-19 User (n=5)	77.80	16.95	24.20	4.21
COVID-19 Initiator (n=9)	65.56	20.76	22.89	3.30

small mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .27$). Similar findings emerged for COVID-19 fear, such that alcohol use groups did not differ in their reported COVID-19 mean scores ($F(2,155) = 2.23, p = .11, \eta^2 = .03$; see Table 2 for raw mean differences). *Hedge's g* effect size estimates indicate a small mean difference between abstainers and pre-COVID-19 users ($g = .22$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .56$), and a small to medium mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .38$).

Cigarette Use. For COVID-19 worry, there were no statistically significant differences by cigarette use group in the ANCOVA model ($F(2,155) = 2.15, p = .12, \eta^2 = .03$). *Hedge's g* effect size estimates indicate a small to medium mean difference between abstainers and pre-COVID-19 users ($g = .28$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .54$), and a small to medium mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .26$). For COVID-19 fear, there were no statistically significant differences by cigarette use group ($F(2,155) = 1.58, p = .21, \eta^2 = .02$). *Hedge's g* effect size estimates indicated a very small mean difference between abstainers and pre-COVID-19 users ($g = .15$), a small to medium mean difference between abstainers and COVID-19 initiators ($g = .43$), and a small mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .21$).

Cannabis Use. For COVID-19 worry, there were no statistically significant differences by cannabis use ($F(2,155) = 3.50, p = .03, \eta^2 = .04$). *Hedge's g* effect size estimates indicate a very small mean difference between abstainers and pre-COVID-19 users ($g = .17$), a large mean difference between abstainers and COVID-19 initiators ($g = 1.04$), and a large mean difference between pre-COVID-19 users and COVID-19 initiators ($g = 1.25$). Additionally, for COVID-19 fear, there were no statistically significant differences by cannabis use ($F(2,155) = 1.60, p = .21, \eta^2 = .02$). *Hedge's g* effect size estimates indicated a very small mean difference between abstainers and pre-COVID-19 users ($g = .15$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .57$), and a large mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .85$).

E-Cigarette Use. For COVID-19 worry, there were no statistically significant differences by e-cigarette status ($F(2,155) = 1.39, p = .25,$

$\eta^2 = .02$). *Hedge's g* effect size estimates indicate a small to medium mean difference between abstainers and pre-COVID-19 users ($g = .29$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .53$), and a small to medium mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .30$). For COVID-19 fear, there were no statistically significant differences by e-cigarette use ($F(2,155) = 2.09, p = .13, \eta^2 = .03$). *Hedge's g* effect size estimates indicated a small to medium mean difference between abstainers and pre-COVID-19 users ($g = .34$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .67$), and a small to medium mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .46$).

Stimulant Use. For COVID-19 worry, there were not statistically significant differences by stimulant use ($F(2,155) = 5.40, p = .01, \eta^2 = .07$). *Hedge's g* effect size estimates indicated a medium to large mean difference between abstainers and pre-COVID-19 users ($g = .58$), a large mean difference between abstainers and COVID-19 initiators ($g = 1.00$), and a medium to large mean difference between pre-COVID-19 users and COVID-19 initiators ($d = .56$). For COVID-19 fear, there were no significant differences by stimulant use ($F(2,155) = 2.57, p = .08, \eta^2 = .03$). *Hedge's g* effect size estimates indicated a small to medium mean difference between abstainers and pre-COVID-19 users ($g = .45$), a medium to large mean difference between abstainers and COVID-19 initiators ($g = .70$), and a small to medium mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .23$).

Opioid Use. For COVID-19 worry, there were not statistically significant differences by opioid use ($F(2,155) = 3.24, p = .04, \eta^2 = .04$). *Hedge's g* effect size estimates indicated a large mean difference between abstainers and pre-COVID-19 users ($g = 1.00$), a small to medium mean difference between abstainers and COVID-19 initiators ($g = .46$), and a medium to large mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .63$). For COVID-19 fear, there were also not statistically significant differences by opioid use status ($F(2,155) = 5.41, p = .01, \eta^2 = .07$). *Hedge's g* effect size estimates indicated a large mean difference between abstainers and pre-COVID-19 opioid users ($g = 1.03$), a large mean difference between abstainers and COVID-19 initiators ($g = .84$), and a small to medium mean difference between pre-COVID-19 users and COVID-19 initiators ($g = .36$).

Substance Use Motives. For coping motives, the model was statistically significant ($R^2 = .31, F(2, 156) = 34.23, p < .001$) and worry about COVID-19 was a statistically significant predictor ($b = .10, se = .02, p < .001$). However, COVID-19 fear was not a statistically significant predictor of coping motives ($b = .09, se = .08, p = .23$).

4. Discussion

Available work on COVID-19, although highly limited in scope, has suggested that the pandemic is associated with clinically significant elevations in psychiatric symptoms, including anxiety, depression, stress, and substance use (Pfefferbaum and North, 2020). The aim of the current study was to build from past work and examine how COVID-19-related worry and fear differed between those who initiated substance use during the COVID-19 outbreak, those who used substances prior to the outbreak, and those who abstained across a variety of substances including alcohol, cigarettes, cannabis, e-cigarettes, stimulants, and opioids. Effect size magnitudes suggested differences in COVID-19-related worry and fear by substance use class.

Overall, the results generally supported hypotheses, such that, across substances, levels of COVID-19-related worry and fear were highest among those people who initiated substances during the COVID-19 pandemic compared to those who used substances prior and those who never used. Effect sizes for the mean differences indicated small to medium mean differences between the groups, with the largest differences between the COVID-19 initiators and the abstainers. Given how salient these psychological concerns are currently, it is likely that these effect sizes are clinically meaningful (Citrome, 2014; Keefe et al.,

2013) and suggest that both worry and fear may be potential risk candidates for substance use initiation and maintenance during the COVID-19 pandemic. These results sit on the backdrop of other work focused on disasters suggesting that coping-oriented substance use increases after a disaster due to increased psychological distress (Goldmann and Galea, 2014; Vetter et al., 2008).

Of note, for opioid use, levels of COVID-19-related worry and fear were highest for the pre-COVID-19 users compared to COVID-19 initiators and abstainers. Although these results were not in line with hypotheses, there are several plausible explanations for this finding. Past research consistently documents the short-term efficacy for opioids to dampen negative affect states (Garland et al., 2013). Therefore, it is possible that, for those that initiated opioids during the COVID-19 outbreak, their levels of worry and fear are lowest because of the acute negative affect reduction; this effect would not exist for pre-COVID-19 users due to long-term potential tolerance (Chang et al., 2007). It is also possible that the method by which opioids are commonly acquired (i.e. prescription from physician) is less accessible as a result of limited in-person health screening.

It is also worth noting that cannabis use appeared to be associated with the largest effects across groups. Given the widespread use (both legal and illicit) of cannabis use (Pisanti and Bifulco, 2017) as well as past work among trauma-exposed samples documenting increases in cannabis use following trauma (Bonn-Miller et al., 2014; Elliott et al., 2015), it may be particularly important to focus on cannabis use. Specifically, previous work suggests that traumatic event exposure may be specifically related to cannabis initiation (Werner et al., 2016), and that using cannabis in response to stress has been specifically linked to increased likelihood of developing a substance use disorder (Hyman and Sinha, 2009). These data urge further focus on cannabis use in the context of COVID-19.

In terms substance use motives, results suggested that COVID-related worry, but not fear, was associated with coping motives. Although somewhat surprising, these results are in line with past work suggesting that worry, but not fear, is prospectively associated with affect-oriented substance use (Shoal et al., 2005). Additionally, previous social anxiety-substance use models suggest that future oriented fear, or worry, is associated with substance use (Buckner et al., 2013). Therefore, it is possible that, when both worry and fear are considered together, individuals may be using substances because they are worried about the future more than the current situation (i.e., worry being more prominent than fear).

The results of this study may have important clinical implications. COVID-19 has been associated with a drastic increase in mental health service utilization (Liu et al., 2020a). Given the observed difference in COVID-19-related worry and fear, assessing these constructs in a clinical context may shed light on those at highest risk for substance use, and ultimately, substance use problems. By identifying these individuals early, clinicians may implement prevention efforts to reduce consequences associated with affect-oriented coping in response to COVID-19. As the outbreak continues to evolve, it may be important to develop targeted interventions for COVID-19-specific mental health and substance use problems.

The current study does have limitations that warrant comment. First, the data are cross sectional, prohibiting causal and temporal claims about risk factors for substance use initiation. Future studies examining these associations over time is warranted. Additionally, substance use was assessed using self-report measures. Replicating the findings using complementary substance use screening measures (i.e., urine toxicology) may help to offer a more complete analysis of the mental health-substance use patterns. Further, the sample was largely White, non-Hispanic, and highly educated, which may not be indicative of the most vulnerable individuals (Yancy, 2020). Thus, replicating the findings across more diverse groups will increase the generalizability of the findings. It is also possible that the current study was underpowered to detect the statistically significant effects, particularly given the

sample size of each group (Abdullah et al., 2015; Maxwell, 2004). Additionally, it is important to note that, while *Hedge's g* is an appropriate measure of effect size with unequal sample sizes and small sample sizes, it is possible these estimates are biased. Although it is important to replicate and extend the findings from the current study with larger samples, previous research argues that effect size estimates are central to understanding *how* different groups are, and offers a comprehensive point of analysis (Sullivan and Feinn, 2012). Finally, the sample was unselected in terms of COVID-19 symptoms and diagnosis, and only a small number of participants in the current study endorsed symptoms and/or diagnosis. It is possible that the relationship between worry, fear, and substance use may differ among those who have had symptoms of the virus compared to those who have not, and future research in this area may be fruitful.

Overall, the current study evaluated if COVID-19-related worry and fear differed between substance abstainers, pre-COVID-19 users, and COVID-19 initiators, and if these constructs were associated with coping-related motives for substance use. Results generally suggest the COVID-19 initiators evince the highest levels of COVID-19-related worry and fear. Additionally, worry, but not fear, appears to be associated with substance use motives. These results provide preliminary evidence that COVID-19-related worry and fear may be putative risk factors for substance use initiation in the face of COVID-19, and these results may provide critical clinical information for helping individuals cope with this pandemic.

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Author statement

All authors contributed to the study design and conceptualization. AHR and JMS conducted data analyses and wrote the first draft of the manuscript. LG and MJZ provided critical edits throughout the process, and all authors approved the final version of the manuscript.

CRedit authorship contribution statement

Andrew H. Rogers: Conceptualization, Data curation, Formal analysis, Project administration, Writing - original draft. **Justin M. Shepherd:** Conceptualization, Data curation, Formal analysis, Project administration, Writing - original draft. **Lorra Garey:** Conceptualization, Supervision, Writing - review & editing. **Michael J. Zvolensky:** Conceptualization, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare no conflicts of interest.

References

- Abdullah, L., Davis, D.E., Fabricant, P.D., Baldwin, K., Namdari, S., 2015. Is there truly "no significant difference"? Underpowered randomized controlled trials in the orthopaedic literature. *JBJS* 97, 2068–2073. <https://doi.org/10.2106/JBJS.O.00012>.
- Baker, T.B., Piper, M.E., McCarthy, D.E., Majeskie, M.R., Fiore, M.C., 2004. Addiction motivation reformulated: an affective processing model of negative reinforcement. *Psychol. Rev.* 111, 33–51. <https://doi.org/10.1037/0033-295X.111.1.33>.
- Behar, E., DiMarco, I.D., Hekler, E.B., Mohlman, J., Staples, A.M., 2009. Current theoretical models of generalized anxiety disorder (GAD): conceptual review and treatment implications. *J. Anxiety Disord.* 23, 1011–1023. <https://doi.org/10.1016/j.janxdis.2009.07.006>.
- Bonn-Miller, M.O., Babson, K.A., Vandrey, R., 2014. Using cannabis to help you sleep: Heightened frequency of medical cannabis use among those with PTSD. *Drug Alcohol Depend.* 136, 162–165. <https://doi.org/10.1016/j.drugalcdep.2013.12.008>.
- Borkovec, T.D., Alcaine, O.M., Behar, E., 2004. Avoidance theory of worry and generalized anxiety disorder. In: Heimberg, R.G., Turk, C.L., Mennin, D.S. (Eds.), *Generalized Anxiety Disorder: Advances in Research and Practice*, Eds. Guilford Press, pp. 77–108.

- Bravo, M., Rubio-Stipec, M., Canino, G.J., Woodbury, M.A., Ribera, J.C., 1990. The psychological sequelae of disaster stress prospectively and retrospectively evaluated. *Am. J. Community Psychol.* 18, 661–680. <https://doi.org/10.1007/BF00931236>.
- Buckner, J.D., Heimberg, R.G., Ecker, A.H., Vinci, C., 2013. A biopsychosocial model of social anxiety and substance use. *Depression Anxiety* 30, 276–284. <https://doi.org/10.1002/da.22032>.
- Cepeda, A., Valdez, A., Kaplan, C., Hill, L.E., 2010. Patterns of substance use among Hurricane Katrina evacuees in Houston, Texas. *Disasters* 34, 426–446. <https://doi.org/10.1111/j.1467-7717.2009.01136.x>.
- Chang, G., Chen, L., Mao, J., 2007. Opioid tolerance and hyperalgesia. *Med. Clin.* 91, 199–211. <https://doi.org/10.1016/j.mcna.2006.10.003>.
- Citrome, L., 2014. Quantifying clinical relevance. *Innov. Clin. Neurosci.* 11, 26–30.
- Cohen, J., 1992. A power primer. *Psychol. Bull.* 112, 155–159.
- Cooper, M.L., 1994. Motivations for alcohol use among adolescents: development and validation of a four-factor model. *Psychol. Assess.* 6, 117–128.
- David, D., Mellman, T.A., Mendoza, L.M., Kulick-Bell, R., Ironson, G., Schneiderman, N., 1996. Psychiatric morbidity following Hurricane Andrew. *J. Trauma Stress* 9, 607–612. <https://doi.org/10.1007/BF02103669>.
- Dubey, M.J., Ghosh, R., Chatterjee, S., Biswas, P., Chatterjee, S., Dubey, S., 2020. COVID-19 and addiction. *Diabetes Metab. Syndr.* 14, 817–823. <https://doi.org/10.1016/j.dsx.2020.06.008>.
- Elliott, L., Golub, A., Bennett, A., Guarino, H., 2015. PTSD and Cannabis-related coping among recent veterans in New York City. *Contemp. Drug Probl.* 42, 60–76. <https://doi.org/10.1177/0091450915570309>.
- Garey, L., Olofsson, H., Garza, T., Rogers, A.H., Kauffman, B.Y., Zvolensky, M.J., 2020. Directional effects of anxiety and depressive disorders with substance use: a review of recent prospective research. *Curr. Addict. Rep.* <https://doi.org/10.1007/s40429-020-00321-z>.
- Garland, E.L., Froeliger, B., Zeidan, F., Partin, K., Howard, M.O., 2013. The downward spiral of chronic pain, prescription opioid misuse, and addiction: cognitive, affective, and neuropsychopharmacologic pathways. *Neurosci. Biobehav. Rev.* 37, 2597–2607. <https://doi.org/10.1016/j.neubiorev.2013.08.006>.
- Ghosh, A., Roub, F., Bisaga, A., 2020. Drug treatment of SARS-Cov2: potential effects in patients with substance use disorders (SUD). *J. Psychosom. Res.* 135, 110159. <https://doi.org/10.1016/j.jpsychores.2020.110159>.
- Goldmann, E., Galea, S., 2014. Mental health consequences of disasters. *Annu. Rev. Public Health* 35, 169–183. <https://doi.org/10.1146/annurev-publhealth-032013-182435>.
- Guan, W.-J., Ni, Z.-Y., Hu, Y., Liang, W.-H., Ou, C.-Q., He, J.-X., Liu, L., Shan, H., Lei, C.-L., Hui, D.S.C., Du, B., Li, L.-J., Zeng, G., Yuen, K.-Y., Chen, R.-C., Tang, C.-L., Wang, T., Chen, P.-Y., Xiang, J., Li, S.-Y., Wang, J.-L., Liang, Z.-J., Peng, Y.-X., Wei, L., Liu, Y., Hu, Y.-H., Peng, P., Wang, J.-M., Liu, J.-Y., Chen, Z., Li, G., Zheng, Z.-J., Qiu, S.-Q., Luo, J., Ye, C.-J., Zhu, S.-Y., Zhong, N.-S., 2020. China Medical Treatment Expert Group for Covid-19, 2020. Clinical characteristics of coronavirus disease 2019 in China. *N. Engl. J. Med.* 382, 1708–1720. <https://doi.org/10.1056/NEJMoa2002032>.
- Hedges, L.V., 2016. Distribution theory for glass's estimator of effect size and related estimators. *J. Educ. Stat.* 10.3102/10769986006002107.
- Hussong, A.M., Jones, D.J., Stein, G.L., Baucom, D.H., Boeding, S., 2011. An internalizing pathway to alcohol and substance use disorders. *Psychol. Addict. Behav.* 25, 390–404. <https://doi.org/10.1037/a0024519>.
- Hyman, S.M., Sinha, R., 2009. Stress-related factors in cannabis use and misuse: implications for prevention and treatment. *J. Subst. Abuse Treat.* 36, 400–413. <https://doi.org/10.1016/j.jsat.2008.08.005>.
- Joseph, S., Yule, W., Williams, R., Hodgkinson, P., 1993. Increased substance use in survivors of the Herald of Free Enterprise disaster. *Br. J. Med. Psychol.* 66, 185–191. <https://doi.org/10.1111/j.2044-8341.1993.tb01740.x>.
- Keefe, R.S.E., Kraemer, H.C., Epstein, R.S., Frank, E., Haynes, G., Laughren, T.P., McNulty, J., Reed, S.D., Sanchez, J., Leon, A.C., 2013. Defining a clinically meaningful effect for the design and interpretation of randomized controlled trials. *Innov. Clin. Neurosci.* 10, 4S-19S.
- Levy, S., Guttman, L., 1976. Worry, fear, and concern differentiated. *Isr. Ann. Psychiatry Relat. Discipl.* 14, 211–228.
- Liu, S., Yang, L., Zhang, C., Xiang, Y.-T., Liu, Z., Hu, S., Zhang, B., 2020a. Online mental health services in China during the COVID-19 outbreak. *Lancet Psychiatry* 7, e17–e18. [https://doi.org/10.1016/S2215-0366\(20\)30077-8](https://doi.org/10.1016/S2215-0366(20)30077-8).
- Maxwell, S.E., 2004. The persistence of underpowered studies in psychological research: causes, consequences, and remedies. *Psychol. Methods* 9, 147–163. <https://doi.org/10.1037/1082-989X.9.2.147>.
- McHugh, R.K., Votaw, V.R., Sugarman, D.E., Greenfield, S.F., 2017. Sex and gender differences in substance use disorders. *Clin Psychol Rev.* <https://doi.org/10.1016/j.cpr.2017.10.012>.
- Meyer, T.J., Miller, M.L., Metzger, R.L., Borkovec, T.D., 1990. Development and validation of the penn state worry questionnaire. *Behav. Res. Ther.* 28, 487–495. [https://doi.org/10.1016/0005-7967\(90\)90135-6](https://doi.org/10.1016/0005-7967(90)90135-6).
- National Institute of Drug Abuse, 2020. Most commonly used addictive drugs. [WWW Document]. URL <https://www.drugabuse.gov/publications/media-guide/most-commonly-used-addictive-drugs> on 2020, August 3.
- North, C.S., Ringwalt, C.L., Downs, D., Derzon, J., Galvin, D., 2011. Postdisaster course of alcohol use disorders in systematically studied survivors of 10 disasters. *Arch. Gen. Psychiatry* 68, 173–180. <https://doi.org/10.1001/archgenpsychiatry.2010.131>.
- North, C.S., Tivis, L., McMillen, J.C., Pfefferbaum, B., Spitznagel, E.L., Cox, J., Nixon, S., Bunch, K.P., Smith, E.M., 2002. Psychiatric disorders in rescue workers after the Oklahoma City bombing. *Am. J. Psychiatry* 159, 857–859. <https://doi.org/10.1176/appi.ajp.159.5.857>.
- Ornell, F., Moura, H.F., Scherer, J.N., Pechansky, F., Kessler, F.H.P., von Diemen, L., 2020. The COVID-19 pandemic and its impact on substance use: implications for prevention and treatment. *Psychiatry Res.* 289, 113096. <https://doi.org/10.1016/j.psychres.2020.113096>.
- Parslow, R.A., Jorm, A.F., 2006. Tobacco use after experiencing a major natural disaster: analysis of a longitudinal study of 2063 young adults. *Addiction* 101, 1044–1050. <https://doi.org/10.1111/j.1360-0443.2006.01481.x>.
- Pfefferbaum, B., North, C.S., 2020. Mental Health and the Covid-19 Pandemic. *N. Engl. J. Med.* <https://doi.org/10.1056/NEJMp2008017>. null.
- Pisanti, S., Bifulco, M., 2017. Modern history of medical cannabis: from widespread use to prohibitionism and back. *Trends Pharmacol. Sci.* 38, 195–198. <https://doi.org/10.1016/j.tips.2016.12.002>.
- Poudel, A., Gautam, S., 2017. Age of onset of substance use and psychosocial problems among individuals with substance use disorders. *BMC Psychiatry* 17. <https://doi.org/10.1186/s12888-016-1191-0>.
- Richardson, J.T.E., 2011. Eta squared and partial eta squared as measures of effect size in educational research. *Educ. Res. Rev.* 6, 135–147.
- Shoal, G.D., Castaneda, J.O., Giancola, P.R., 2005. Worry moderates the relation between negative affectivity and affect-related substance use in adolescent males: a prospective study of maladaptive emotional self-regulation. *Personal. Individ. Differ.* 38, 475–485. <https://doi.org/10.1016/j.paid.2004.05.005>.
- Slat, S., Thomas, J., Lagisetty, P., 2020. Coronavirus disease 2019 and opioid use—a pandemic within an epidemic. *JAMA Health Forum* <https://doi.org/10.1001/jamahealthforum.2020.0628>. e200628–e200628.
- Sullivan, G.M., Feinn, R., 2012. Using effect size—or why the P value is not enough. *J. Grad. Med. Educ.* 4, 279–282. <https://doi.org/10.4300/JGME-D-12-00156.1>.
- Sun, K., Chen, J., Viboud, C., 2020. Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: a population-level observational study. *Lancet Digit. Health* 2, e201–e208. [https://doi.org/10.1016/S2589-7500\(20\)30026-1](https://doi.org/10.1016/S2589-7500(20)30026-1).
- Vadillo, M.A., Konstantinidis, E., Shanks, D.R., 2016. Underpowered samples, false negatives, and unconscious learning. *Psychon. Bull. Rev.* 23, 87–102. <https://doi.org/10.3758/s13423-015-0892-6>.
- Vecchio, S., Ramella, R., Drago, A., Carraro, D., Littlewood, R., Somaini, L., 2020. COVID19 pandemic and people with opioid use disorder: innovation to reduce risk. *Psychiatry Res.* 289, 113047. <https://doi.org/10.1016/j.psychres.2020.113047>.
- Vetter, S., Rossegger, A., Rossler, W., Bisson, J.I., Endrass, J., 2008. Exposure to the tsunami disaster, PTSD symptoms and increased substance use – an internet based survey of male and female residents of Switzerland. *BMC Public Health* 8, 92. <https://doi.org/10.1186/1471-2458-8-92>.
- Volkow, N.D., 2020. Collision of the COVID-19 and addiction epidemics. *Ann. Intern. Med.* <https://doi.org/10.7326/M20-1212>.
- Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C.S., Ho, R.C., 2020. Immediate psychological responses and associated factors during the initial stage of the 2019 Coronavirus Disease (COVID-19) epidemic among the general population in China. *Int. J. Environ. Res. Public Health* 17. <https://doi.org/10.3390/ijerph17051729>.
- Werner, K.B., McCutcheon, V.V., Agrawal, A., Sartor, C.E., Nelson, E.C., Heath, A.C., Bucholz, K.K., 2016. The association of specific traumatic experiences with cannabis initiation and transition to problem use: differences between African-American and European-American women. *Drug Alcohol Depend.* 162, 162–169. <https://doi.org/10.1016/j.drugalcdep.2016.03.003>.
- Yancy, C.W., 2020. COVID-19 and African Americans. *JAMA.* <https://doi.org/10.1001/jama.2020.6548>.
- Yao, H., Chen, J.-H., Xu, Y.-F., 2020. Patients with mental health disorders in the COVID-19 epidemic. *Lancet Psychiatry* 7, e21. [https://doi.org/10.1016/S2215-0366\(20\)30090-0](https://doi.org/10.1016/S2215-0366(20)30090-0).
- Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., Si, H.-R., Zhu, Y., Li, B., Huang, C.-L., Chen, H.-D., Chen, J., Luo, Y., Guo, H., Jiang, R.-D., Liu, M.-Q., Chen, Y., Shen, X.-R., Wang, X., Zheng, X.-S., Zhao, K., Chen, Q.-J., Deng, F., Liu, L.-L., Yan, B., Zhan, F.-X., Wang, Y.-Y., Xiao, G.-F., Shi, Z.-L., 2020. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 579, 270–273. <https://doi.org/10.1038/s41586-020-2012-7>.