

## Covid-19 stress, smoking and heavy drinking behaviors in university students in Singapore

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### Abstract:

**Aims:** Undertaken in Singapore during the COVID-19 pandemic, this cross-sectional study investigates multi-dimensional COVID-19 related stressors and the extent to which these stressors are related to university students' smoking and heavy alcohol use.

**Design/Setting/Participants:** An analytical sample of 2,171 undergraduate students (862 male, 1309 female) in Singapore participated in an online survey.

**Measures:** The COVID-19 Stressors Questionnaire (C19SQ) is a COVID-19 related stress scale that considers the developmental period of emerging adulthood and was administered alongside mental health measures (Generalized Anxiety Disorder 7-Item and Patient Health Questionnaires) and substance use items. Structural equation modeling was used to model the association between four types of COVID-19 related stressors: resource constraints, future uncertainty, health concerns, and social restrictions, and past-month smoking and heavy drinking while accounting for student mental health, parental education, gender and race/ethnicity.

**Results:** COVID-19 Social Restriction stress was associated with an increased likelihood of heavy drinking and smoking behavior, whereas COVID-19 Health Concern stress was associated with decreased likelihood of smoking and heavy drinking. COVID-19 stress related to resource constraints and future uncertainties was not associated with young adult substance use.

**Conclusions:** Our finding that stress related to the social restrictions of COVID-19 was associated with more substance use suggests that clinical intervention efforts should target the pandemic-related consequences of social isolation and loneliness in young adults. Our finding that stress related to concerns about the health of oneself or one's family was protective against substance use highlight areas where public health prevention can focus in the wake of the COVID-19 pandemic for young adults.

## Introduction

During the COVID-19 pandemic, widespread concern was raised among the global community that substance use would disproportionately burden vulnerable groups (Clay & Parker, 2020; McKay & Asmundson, 2020; Rajkumar, 2020; Sun et al., 2020). Emerging adulthood (18–29 years of age) is a vulnerable developmental period for heightened substance use and addiction (Stone, Becker, Huber, & Catalano, 2012; Sussman & Arnett, 2014), and is characterized by multidimensional stressors and transitions (Arnett, 2000; Hutchison, Leigh, & Wagner, 2016). During the pandemic, college age students reported an increase in COVID-19 related stress (Son, Hegde, Smith, Wang, & Sasangohar, 2020). Pandemic-related changes to substance

use in response to COVID-19 related stress have been mixed with some early pandemic studies finding increased overall alcohol consumption (Gritsenko et al., 2020; Yehudai et al., 2020), more problematic alcohol use behavior such as binge drinking (Horigian, Schmidt, & Feaster, 2021; Yehudai et al., 2020), increased alcohol use and cigarette smoking in young adults from Belarus and Russia (Gritsenko et al., 2020), and drug use among young adults in the United States (Horigian et al., 2021). However, other studies have shown reduced substance use in response to COVID-19 stress including less smoking in middle aged samples from the UK and the Netherlands (mean ages 50 and 46 respectively; Bommele et al., 2020; O'Donnell et al., 2021) and decreased drinking behaviors (Grossman et al., 2020). Reasons for these mixed results are unclear. A better understanding of how COVID-19 stress impacts young adult substance use

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behavior is needed to inform responsive prevention and intervention efforts to better support young people in the wake of this pandemic.

There is a long-established body of work linking stress with substance use behaviors (Alexander & Ward, 2018; Brewerton & Brady, 2014; Maclean et al., 2016). The Self-Medication model (Khantzian, 1985, 1997) where psychological stress precedes substance use related coping has been widely utilized and supported in the COVID-19 pandemic literature (Creswell & Bachrach, 2020). Additionally, theories of young people's substance use, such as Kandel's Socialization Theory (1980) and Nurmi's Future Orientation Theory (1989) have highlighted the importance of social environment and young people's future aspirations and expectations on substance use behavior (Brooks et al., 2018; Nurmi, 1989). These theories suggest that stress within the social environment and uncertainty about the future can increase substance use risk among young people. A review of other pandemic and public health crisis research noted that other types of stress, such as limited resource availability and financial constraints, were more likely to be associated with a decrease in substance use (Rehm et al., 2020). Together, this suggests that within the stress-coping framework of the pandemic, COVID-19 related stress could impact substance use, and that the impact on substance use behavior may differ based on the type of stressor experienced.

It has been suggested that using a more nuanced, multidimensional approach to COVID-19 stress can help to better understand its relationship with high-risk behaviors like substance use (McKay & Asmundson, 2020; Taylor et al., 2020a, 2020b; Taylor et al., 2021). Many COVID-19 stressors identified by young adults, including health concerns for themselves and family, isolation and loneliness due to social restrictions, disruptions to routine, and resource constraints (Gritsenko et al., 2020; Son et al., 2020; Yehudai et al., 2020) mirror those of the general population, but other concerns, such as academic stress and uncertainty about the future, are more developmentally and contextually specific to this age group. However, few studies have considered developmental influences when conceptualizing COVID-19 stress. Existing COVID-19 stress scales have been validated using middle aged adult samples (Chandu et al., 2020; Ransing et al., 2020), have conceptualized and measured COVID-19 related stress unidimensionally (Chandu et al., 2020; Ransing et al., 2020; Taylor et al., 2021), and have not been utilized with Asian samples, thus limiting our knowledge of the impact of COVID-19 stress on young Asian adults.

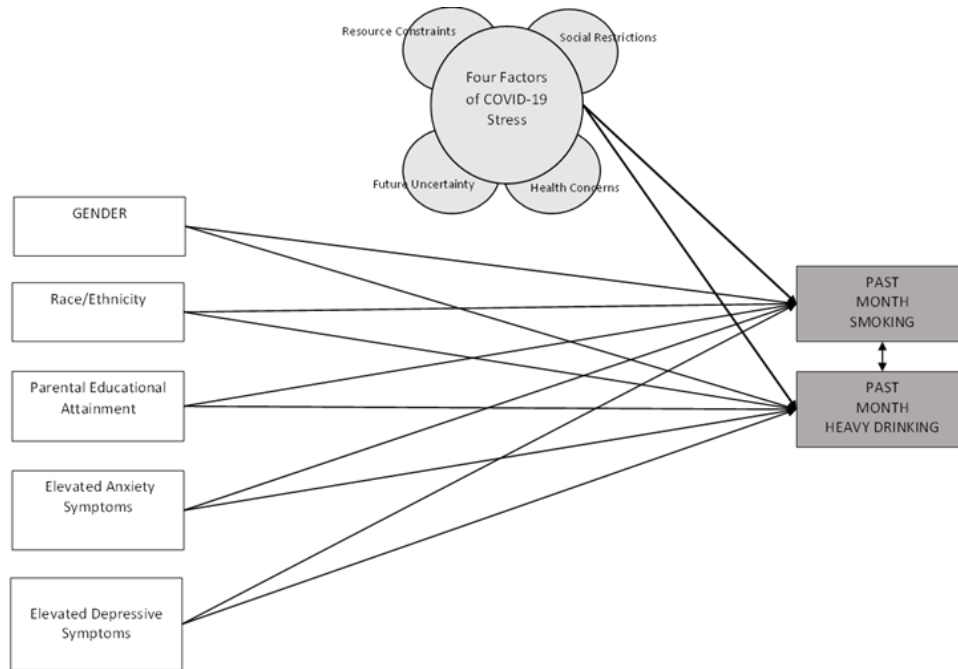
To date little is known regarding how substance use in Singapore has been impacted by the pandemic, and to our knowledge there is no information specifically looking at substance use among young adult college students post-pandemic from this country. An Ipsos marketing poll found that 12% of Singaporeans reported increased alcohol use and 3% reported adopting smoking during the pandemic (Ho, 2021) and an online consumer survey of over 2,000

Singaporeans found that 45% of respondents reported spending more money than usual on alcohol in the past month of the COVID-19 pandemic (MilieuInsight, 2020). It is not known whether these trends in the general population reflect changes to young adult substance use behavior in Singapore.

Prior to the pandemic, college students in Singapore smoked at a higher rate than the general population, and alcohol use among young adults has significantly increased in the last decade (Abdullah et al., 2002; Subramaniam et al., 2019) including binge drinking (Lee et al., 2020). Additionally, both depression and anxiety were on the rise among Singaporean young adults (Chang et al., 2019; Subramaniam et al., 2019), and co-morbid mental health has a strong association with smoking in Singapore (Subramaniam et al., 2012). A multi-country systematic review of mental health consequences of the COVID-19 pandemic found that there has been an increase in anxiety and depression following the pandemic (Vindegaard & Benros, 2020), indicating that these factors will be important to consider when investigating the relationship between COVID-19 stress and young adult substance use.

In addition to considering the role of COVID-19 stress on substance use outcomes, previous research on young adult substance use has identified factors such as family influence, educational attainment, and socio-economic status (Gilman et al., 2003; Subramaniam et al., 2012; Subramaniam et al., 2019), as well as individual factors such as gender, mental health, and race (King et al., 2018; Schmidt et al., 2019; Stone et al., 2012) that influence young adult substance use. We account for these variables in the model of COVID-19 stress and young adult smoking and heavy drinking to disentangle the unique impact of pandemic stress on substance use behavior among young people. See Figure 1 for the conceptual model of the relationship between substance use and COVID-19 stress.

The current study is one of the first studies to address the limitations of unidimensional conceptualization of COVID-19 related stress, samples with middle aged adults, and the underrepresentation of results from Asian countries by considering multidimensional COVID-19 stressors among young adult college students in Singapore. Given other global findings and prior literature suggesting differing stress impacts on substance use, we hypothesized that COVID-19 stress would uniquely contribute to changes in smoking and heavy drinking even after controlling for additional contributing factors such as student mental health and family background, and that different COVID-19 stressors would differentially impact substance use. Specifically, we hypothesized that even after considering other factors related to young people's substance use (e.g., gender, race/ethnicity), stress related to social restrictions and future uncertainty would contribute to increases in substance use while other stressors including resource constraints and health concerns would reduce smoking and drinking among college students in Singapore.

**Figure 1****Conceptual Model of the Relationship between COVID-19 Stress and Substance Use****Methods****Study Design and Setting**

This study was a cross-sectional survey of undergraduate students recruited from Nanyang Technological University (NTU) in Singapore from September to November 2020. NTU is the second largest public university in Singapore serving 24,579 undergraduates during the 2020/2021 academic year. Students from 16 different academic programs were invited via email advertisements through their school/college to complete an online survey including measures related to COVID-19 stress, mental health and substance use.

Singapore recorded the first case of COVID-19 in January 2020 and implemented several mitigation strategies to address the COVID-19 pandemic including travel restrictions, stay at home orders, and public space closures including universities (Lee & Ong, 2020; Wong et al., 2020). During the data collection period there was generally a low number of community cases resulting in a slow easing of social restriction measures at that time. Food and retail businesses reopened. Events such as weddings, solemnizations, and religious events with up to 100 guests were allowed. By October 2020, a maximum of five individuals were allowed in social gatherings. Masks continued to be mandated, both indoors and outdoors. Tertiary education centers, including NTU, were allowed to gradually increase the number of students back on campus. Small classes such as tutorials, seminars, and lab sessions were generally conducted in-person while larger lectures

continued to be online. By December, vaccines were approved and rolled out. Travel outside the country was highly restricted to only specific countries. Multiple negative COVID-19 tests and quarantines (e.g., 14-day Stay-Home-Notice) were required for travel.

**Sample Size and Sampling Procedure**

A total of 2,345 students consented to participate in the study representing about 10% of the undergraduate population. Study inclusion criteria included (a) undergraduate students in 4-year program of study, (b) participant age between 17 and 29 years old, (c) full-time student status, and (d) enrolled in NTU. There were no exclusion criteria. Of the 2,345 students who participated in the survey, six students ages 30 and older were excluded to maintain focus on emerging adulthood, and 168 students were not included in the final analysis due to missing data, resulting in a final analytical sample size of 2,171 participants. A total of 75% of the participants were randomly drawn to receive a \$10 e-voucher at the end of the study. Signed consent from all student participants was obtained through an online information sheet and consent form prior to survey participation. The study was approved by the Institutional Review Board at NTU (IRB 2020-05-035).

**Measures****COVID-19 Stressors Questionnaire (C19SQ)**

COVID-19 stress was measured using the C19SQ, an original instrument developed for the study. The C19SQ (Yong & Suh, 2022) is a 23 item, multidimensional scale of

COVID-19 related stressors pertinent to young adults with four underlying subscales measuring health concerns, resource constraints, future uncertainty, and social restrictions. Participants were asked to rate each item on a 4-point Likert scale (1 – Not at All, 2 – A Little, 3 – Sometimes, 4 – A Lot) regarding how often in the past few weeks they had been concerned about specific ways that COVID-19 impacted their life. The C19SQ was found to have good convergent validity when compared with the Patient Health Questionnaire (PHQ-8), Generalized Anxiety Disorder Questionnaire 7-Item (GAD-7), and College Adjustment Questionnaire (Yong & Suh, 2022).

The Resource Constraints subscale measured the extent to which university students experienced limitations in technological resources, financial difficulties, barriers in accessing medical services, space and privacy concerns, and increased family responsibilities due to COVID-19. This subscale, comprised of six items, had a reliability of  $\alpha = .76$  (Yong & Suh, 2022), e.g. *“During the past few weeks, I worry about money problems because of COVID-19 (e.g. parents losing jobs, loss of income, or difficulty paying)”*. The Future Uncertainty subscale measured students’ worry about the future and their ability to cope. It also measured students’ concerns about fulfilling the requirements of their degrees, their level of achievement, and money problems. There were five items in this subscale and the reliability was  $\alpha = .80$  (Yong & Suh, 2022), e.g. *“During the past few weeks, I worry about what is going to happen in the future (e.g. when COVID-19 will end, how the economy will be impacted, or how things will be different)”*. The Social Restrictions subscale measured students’ perceived reduction in socialization opportunities with friends and family, decreased participation in university and recreational activities, changes in routines, and being less socially connected with friends. With seven items, this subscale had a reliability of  $\alpha = .86$  (Yong & Suh, 2022), e.g. *“During the past few weeks, I worry about losing my freedom to go to different places to travel because of COVID-19”*. The Health Concerns subscale measured the extent that students worried about the health impacts of COVID-19 on themselves and others around them. This included being concerned about the large number of COVID-19 cases, taking health precautions, and whether school was a safe place. This subscale included five items with a reliability of  $\alpha = .90$  (Yong & Suh, 2022), e.g. *“During the past few weeks, I worry about whether school is a safe place because of COVID-19”*. A full copy of the COVID-19 Stressors Questionnaire is available in the online [supplemental appendix](#).

#### **Current Smoking**

Given the low overall rate of smoking in Singapore (Amul & Pang, 2017) and poorer COVID-19 related health outcomes among young adults who smoke (Patanavanich & Glantz, 2020), any smoking by a young adult during the pandemic was considered problematic. A dichotomous current smoking variable was created based on the item *“During the past month how many days did you smoke?”* where the participants who endorsed smoking in the prior month were coded “1”, and those who did not were coded “0”.

#### **Heavy Drinking**

Participants who indicated that they drank during the past month were asked the follow up question *“On the days that you drank alcohol, how many full drinks did you have on average?”* A dichotomous heavy drinking variable was created using a cutoff of five or more drinks to define past-month heavy drinking for both men and women following recommendations from Graham et al. (1998) and Wilsnack et al. (2018).

#### **Race-Ethnicity**

Race-ethnicity was dummy coded into three variables “Malay”, “Indian”, “Other” with Chinese Singaporeans as the reference group.

#### **Gender**

Gender was based on participant self-report, with males coded “1” and females “2”.

#### **Parent Education**

Parent’s education was based on participant report of the highest degree of educational attainment by a parent. Participants selected if either of their parent had achieved “1” Other, “2” GCE ‘O’ or ‘A’ Level or equivalent (10–12 years of formal education), “3” Diploma or equivalent (12–14 years of formal education), and “4” (14 or more years of formal education) resulting in a Bachelor’s or Master’s degree or higher.

#### **Depressive Symptoms**

Depressive symptoms were measured using the Patient Health Questionnaire (PHQ-8; Kroenke et al., 2009) with a modified Likert response scale to create consistency of response options within the study survey. The item related to suicidality was dropped due to the sensitive nature of the item. Participants reported how often they had been bothered by the problem in the last few weeks (1 – Not at All, to 4 – A Lot). A Cronbach’s alpha of  $\alpha = .80$  and above is generally considered to be very good internal consistency. The Cronbach’s alpha for the internal consistency of eight items on the PHQ-8 scale was  $\alpha = .84$ . A cumulative score based on the participants’ responses to the PHQ-8 was calculated with a range of 8–32 ( $M = 17.06$ ,  $SD = 5.07$ ). Since research prior to the pandemic had found elevated rates of depression among young people in Singapore, we dichotomized the cumulative PHQ-8 score based on cutoff values of the mean score plus one standard deviation, to best identify those participants reporting elevated problems with depressive symptoms. Those participants who reported higher levels of problems with depressive symptoms in the past few weeks (scores of 22 or more) were assigned “1” and those with scores less than 22 were assigned “0”.

#### **Anxiety Symptoms**

Anxiety symptoms were measured using the Generalized Anxiety Disorder Assessment (GAD-7; Spitzer et al., 2006), using a modified Likert response option of how often the participant had been bothered by the item in the last few

weeks (1 – Not at All to 4 – A Lot). Cronbach’s alpha for the seven items of the GAD-7 was  $\alpha = .90$ . A cumulative score based on the participants’ responses to the GAD-7 was calculated with a range of 7–28 ( $M = 14.98$ ,  $SD = 5.22$ ). Since anxiety among young adults had already been found to be on the rise in Singapore pre-pandemic, a dichotomous measure was created based on the mean score plus one standard deviation, to best capture those participants who reported elevated problems with symptoms of anxiety. Participants with a cumulative score of 20 or more were assigned “1”, indicating higher reports of frequently being bothered by anxiety symptoms in the prior weeks, and scores of less than 20 were assigned “0”.

### Statistical Analysis

All analyses were conducted using Mplus Version 8.1 (Muthén & Muthén, 2017). We used structural equation modeling (SEM) to test a four-factor latent variable model of differing COVID-19 stressors on smoking and heavy drinking outcomes.

The weighted least square mean and variance (WLSMV) estimator was used in the current SEM because it performs well for categorical and binary variables and is recommended for categorical outcomes (Brown, 2006; Muthén et al., 2015). Model fit was based on recommendations from Kline (2016) and Hu and Bentler (1999). Models were considered well-fitting based on the following: root mean square error of approximation (RMSEA)  $< .05$  (good fit) and  $< .08$  (adequate fit); comparative fit index (CFI)  $> .90$  (good fit); and Tucker-Lewis Index (TLI)  $> .95$  (good fit). Full Information Maximum Likelihood (FIML) estimation was used to account for missing data. There were 168 participants missing data on all covariates, and these were excluded from the analyses, bringing the total sample size to 2,171 for the current analysis. Unstandardized beta coefficients ( $\beta$ ) for significant pathways are presented in text to show the expected linear change in the outcome with each unit change in the predictor controlling for all other variables in the model. Standardized coefficients are presented in the figures for ease of comparability where the standardized  $\beta$  coefficient represents the scaled magnitude of change compared to other variables in the model, ranging from 0 to 1 in strength.

## Results

### Descriptive Results

Participating students ranged from 17–29 years of age ( $M = 21.59$  years), 54.8% were in their first or second year at university, and they reported being primarily Chinese (86.8%), Malay (3.9%), Indian (5.5%) or from another ethnic identity (3.8%). The sample was composed of 60.3% females and 39.7% males. Approximately 38% of participants reported that a parent had attained an educational level of a Bachelor’s degree or higher. About

one out of five participants reported experiencing elevated depression (21.1%) and anxiety (20.5%). Smoking prevalence was low with 3.9% of participants having smoked in the prior month. Heavy drinking in the past month was reported by 13.6% of participating students. Demographics are summarized in Table 1.

**Table 1**

#### Participant Characteristics

Characteristics	<i>n</i>	%
Gender		
Male (1)	862	39.7
Female (2)	1309	60.3
Race		
Chinese	1884	86.8
Malay	85	3.9
Indian	119	5.5
Other	83	3.8
Parental Education		
Other	226	10.4
GCE “O” or “A” level	622	28.7
Diploma or equivalent	501	23.1
Bachelor’s degree or higher	822	37.9
Elevated depressive symptoms (1 <i>SD</i> and higher on PHQ-8)		
Lower depression symptoms	1846	78.9
Elevated depression symptoms	493	21.1
Elevated anxiety symptoms (1 <i>SD</i> and higher on GAD-7)		
Lower anxiety symptoms	1836	79.5
Elevated anxiety symptoms	474	20.5
Past month smoking		
No smoking (past month)	2080	96.1
Smoker	84	3.9
Past month heavy drinking		
No heavy drinking ( $\leq 4$ drinks/occasion)	1282	86.4
Heavy drinking ( $\geq 5$ drinks/occasion)	201	13.6

**Notes:**  $n = 2,339$ ; *SD*: Standard deviation; PHQ: Patient Health Questionnaire; GAD: Generalized Anxiety Disorder Questionnaire.

A bivariate correlational matrix for all study variables can be found in Table 2. Bivariate correlations offer preliminary insight into relationships between study variables but do not account for pertinent covariates that have been identified in the literature. All COVID related stressors were significantly correlated with each other, ranging from ( $r = .60-.76$ ,  $p < .001$ ). In our bivariate correlations, we found that Social Restriction stress was significantly correlated with both smoking ( $r = .15$ ,  $p < .01$ ) and heavy drinking ( $r = .15$ ,  $p < .01$ ). Resource Constraint stress was associated with smoking ( $r = .14$ ,  $p < .05$ ) but not heavy drinking. COVID related Health Concerns and Future Uncertainty were not significantly related to substance use outcomes when investigated at a bivariate level. A full table of bivariate correlations of all study variables can be found in Table 2.

Table 2

Correlation Matrix of Study Variables

	Smoker	Heavy Drinker	C-19 Stress RC	C-19 Stress FU	C-19 Stress SR	C-19 Stress HC	Dep	Anx	Gender (Female)	Chinese	Malay	Indian	Other	Parent Ed
Smoker	1													
Heavy Drinker	.35***	1												
C-19 Stress RC	.14*	.06	1											
C-19 Stress FU	.06	.07	.76***	1										
C-19 Stress SR	.15**	.15**	.66***	.60***	1									
C-19 Stress HC	.01	-.09	.70***	.63***	.67***	1								
Dep	.07	.12**	.35***	.41***	.26***	.21***	1							
Anx	.10*	.07	.39***	.44***	.27***	.24***	.52***	1						
Gender (Female)	-.18***	-.09*	.07**	.10***	-.03	.08**	.08***	.10***	1					
Chinese	-.06	-.04	-.09***	-.12***	-.12***	-.09***	-.06**	-.04	-.01	1				
Malay	.09*	.02	.07**	.08**	.01	.05	.03	.02	.02	---	1			
Indian	-.01	-.02	.06*	.05	.13***	.06*	.05**	.03	-.03	---	---	1		
Other	-.01	.06	.001	.07**	.03	.03	.01	.02	.03	---	---	---	1	
Parent Ed	-.17**	-.05	-.10***	-.02	.04	-.01	.002	.01	.03	-.16***	-.03	.16***	.12***	1

Notes: C-19: Covid-19; RC: Resources Constraints; FU: Future Uncertainty; SR: Social Restrictions; HC: Health Concerns; Dep: elevated depression symptoms; Anx: elevated anxiety symptoms.

All correlation coefficients presented are standardized. \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .

**Measurement Model of Latent COVID-19 Stressors.**

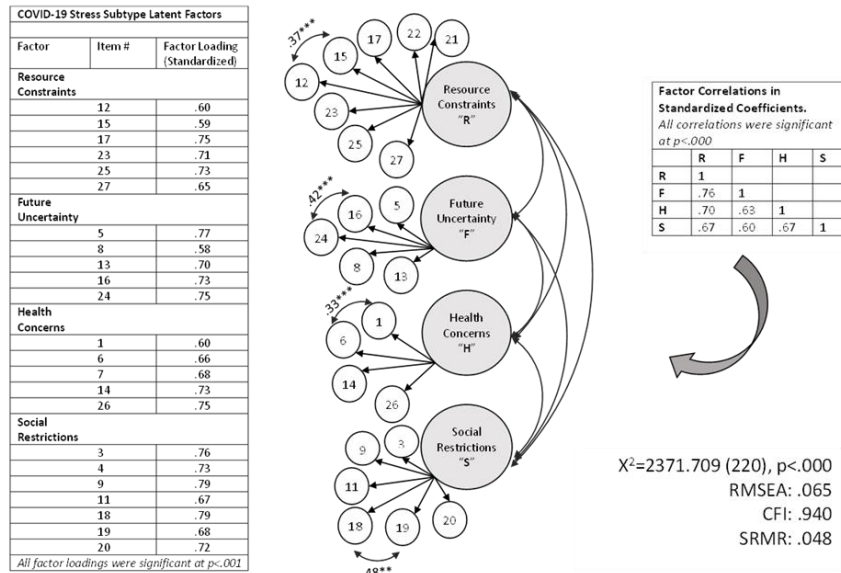
The C19SQ is a 23-item survey with four underlying latent factors. Each item that makes up a latent factor shares a common variance that creates the latent factor of the unique COVID-19 stressor. Figure 2, depicting the measurement model, shows how each item contributes to the underlying latent factor, the strength of the factor loading, and final correlation of the latent factors. The measurement model (Figure 2) fit the data adequately ( $\chi^2 = 2369.521$  (220),  $p < .000$ , CFI = .94, TLI=.93, RMSEA = .065) and was carried forward to the final model (where only latent factors are depicted due to space constraints).

**Structural Equation Model of COVID-19 Stress and Substance Use.**

The final model with the four latent factors, accounting for all covariates, fit the data adequately ( $\chi^2 = 3137.392$  (419),

$p < .000$ , RMSEA = .055, CFI = .916, TLI = .905; see Figure 3). COVID-19 related stressors related to Resource Constraints and Future Uncertainties were not associated with past-month smoking or heavy drinking. Past-month smoking and heavy drinking were uniquely associated with COVID-19 stress related to Social Restrictions and Health Concerns, but in opposite directions, as hypothesized. Young adults with more COVID-19 stress related to Health Concerns were less likely to smoke (unstandardized  $\beta = -.323$ , 95% CI [-.642, -.004]) or drink heavily (unstandardized  $\beta = -.528$ , 95% CI [-.780, -.277]) in the past month. Having higher levels of COVID-19 stress related to Social Restrictions predicted an increased likelihood of past-month smoking (unstandardized  $\beta = .260$ , 95% CI [.068, .451]) and heavy drinking behavior (unstandardized  $\beta = .357$ , 95% CI [.190, .524]) even after controlling for all covariates in the model.

**Figure 2**  
*Measurement Model of COVID-19 Stress Subtype Latent Factors*

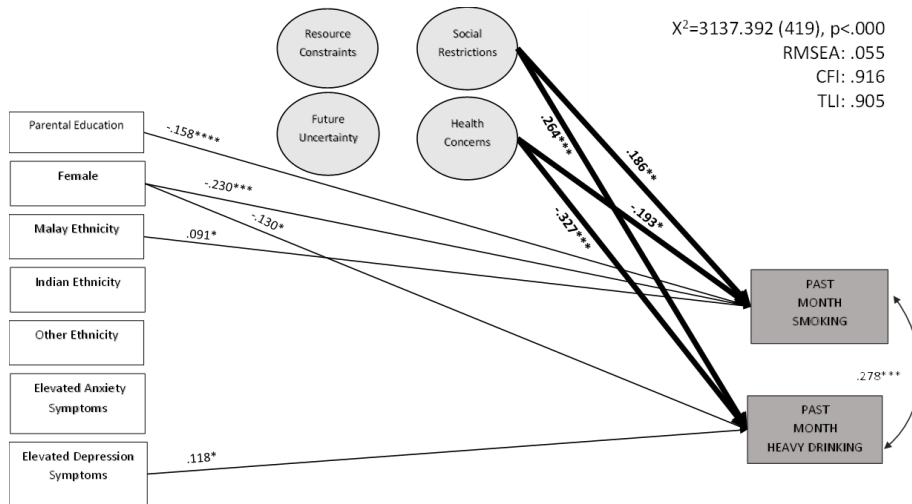


Individual indicators and factor correlations not shown in Full Model – Figure 3.  
\*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$

Past-month smoking was directly associated with being male (unstandardized  $\beta = -.402$ , 95% CI [-.619, -.185]), Malay (unstandardized  $\beta = .493$ , 95% CI [.089, .897]), and having reported lower parental education (unstandardized  $\beta = -.161$ , 95% CI [-.265, -.057]). Past-month heavy drinking was directly associated with being male (unstandardized  $\beta = -.219$ , 95% CI [-.386, -.053]), and having higher depressive

symptoms (unstandardized  $\beta = .292$ , 95% CI [.067, .517]). Figure 3 presents the final structural equation model with significant pathways. All coefficients are presented as standardized in the figure for ease of comparing the relative magnitude (ranging between 0-1) of change associated with the significant pathways.

**Figure 3**  
*Relationship between COVID-19 Stress Subtypes and Substance Use*



All coefficients are presented as standardized, \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ . Bold lines/coefficients designate unique contribution of COVID-19 Stressor on Substance Use Outcomes controlling for covariates. Individual items can be found in the Supplemental Material online.



## Discussion

Using a more nuanced, multidimensional, measure of stress during the pandemic, we build upon prior work with our findings that young adults' substance use behavior in Singapore was differentially impacted by specific types of COVID-19 stress. The current study adds to the growing body of literature linking COVID-19 related stress with increased heavy drinking and smoking among young adults by finding that even after accounting for pertinent covariates such as gender, race/ethnicity, and parent education, young adults' stress related to COVID-19 health concerns was associated with reductions in their reported smoking and heavy drinking while COVID-19 stress related to their experience of social restrictions was associated with increased smoking and heavy drinking. These differential associated impacts of stressors on substance use behaviors may partially explain prior findings seen in the general pandemic substance use literature where studies have found mixed or decreasing substance use results (Bollen et al., 2021; Bonar et al., 2021; Busse et al., 2021; Tetik et al., 2020) including reduced binge and high-risk drinking (Busse et al., 2021; Jackson et al., 2021) and smoking cessation due to the pandemic (Tetik et al., 2020). Our findings underscore that teasing apart specific types of COVID-19 stress is a critical consideration in research and intervention development since different aspects of the stress created by the pandemic may not operate equivalently in regard to substance use behavior.

Our finding that stress related to COVID-19 social restrictions, captured by items pertaining to loss of social connection and not being able to engage in recreational activities, was associated with increased heavy drinking and smoking behavior among university students, aligns with prior work linking loneliness and social isolation with increased substance use among young adults (Gritsenko et al., 2020; Horigian et al., 2021; Taylor et al., 2021). In their study with U.S. and Canadian adults (mean age 51 years), Taylor et al. (2021) found a correlation between using more substances to cope with the stress of self-isolation and more hazardous levels of drinking based on scores from an adapted AUDIT. Our study found a moderate association between COVID-19 social restriction stress and heavy drinking that remained significant even after we controlled for several confounding factors in a sample of young adults.

We also found that stress specific to health concerns, captured by items related to heightened anxiety and fear of COVID-19 for themselves and family, had a small to moderate negative relationship with both heavy drinking and smoking. The more concerned young adults were about COVID-19 health impacts, the less likely they were to engage in heavy drinking and smoking. Smoking cessation as a direct result of increased concern for others well-being has been noted in other smoking literature (Riaz et al., 2018). Young adults with high COVID-19 related health concerns may view their smoking and drinking as high risk for both themselves and others during a pandemic and choose to not engage in the behavior, thus operating as a health promoting factor.

In our multivariate analysis we did not find a significant relationship between COVID-19 stressors related to resource constraints and future uncertainty and substance use. It is possible that the resource constraints were less relevant for university students since many of them may have returned home during this phase of the pandemic, when online classes were possible. Living situation was not assessed in the current study but future work should consider the mitigating effect of household composition on pandemic-related stress. Additionally, the lack of a significant connection between future uncertainty and substance use behavior could be attributed to the younger age of the current sample with most of the sample being in the first or second year of university, when there is less pressure on students for future planning (e.g., internship attainment, job seeking, etc.) This underscores the heterogenous nature of emerging adulthood and the rapid transition of priorities and concerns among young people during this timeframe. Although the bivariate correlations between COVID related health concerns and the substance use outcomes were not as significant as they were in the multivariate analyses, discrepancies like this are common and it is recommended to focus interpretation on models which include theoretically and empirically driven covariates in the final design (O'Neil et al., 2014).

Overall, the association of substance use with mitigation of the stress of the COVID-19 pandemic among Singaporean university students aligns with other studies from the United States, Russia, Belarus and Israel who found similar linkages, suggesting that this phenomenon is cross-cultural. Our findings also build upon those reported by Bommele et al. (2020) with a sample of middle-aged adults, indicating that this mixed substance use response to COVID-19 stress is generalizable to young adults and that substance use varies depending on the stressors experienced.

### Limitations

This study has several limitations, including that study data was collected during a single time frame and that our measure of parent education was reported by the student. While cross-sectional data does not allow us to assume cause-effect relationships, structural equation modeling tests models with hypothesized directional relationships. In the current study we hypothesized a stress-coping model of causality, but it is also possible that increased substance use during the pandemic could increase the amount of reported COVID-19 stress. Another limitation is that the GAD-7 and PHQ-8 used a revised response Likert scale, making direct comparisons of prevalence rates of depression and anxiety with other studies not possible. Our heavy drinking variable was based on participant self-report of the average number of full units consumed on drinking days in the past month. Participants reporting five or more drinks on average per occasion during the past month were coded as heavy drinkers. The reliance on full drinks and lack of frequency of this behavior in the past month may underestimate problematic drinking. Had a more conventional operationalization of heavy drinking been possible we would likely have found a stronger signal, albeit in the same direction, in the association between the COVID-19 stressors and our outcome. Lastly, this was a convenience



sample of undergraduate students. However, the Nanyang Technological University of Singapore is one of six public universities in the city state of Singapore. It is the second largest and a comprehensive university with a population of about 33,000 students across eight colleges and schools. Approximately 85% are local students and 15% are international students from countries all over the world, including, most frequently, Southeast Asian countries. The undergraduate population is estimated to be 29,000. With local students being the majority, the NTU population is possibly representative of university undergraduate students in Singapore. While selection bias cannot be avoided using a non-probabilistic sampling technique, the study advertisement was sent to almost all undergraduate students via their colleges/schools, which aids in minimizing selection biases.

The limitations of this study are offset by several strengths, including a multidimensional, developmentally driven, assessment of COVID-19 related stress, focus on young adults who represent a particularly vulnerable demographic group during the pandemic, focus on expanding knowledge of the pandemic's impact on substance use outcomes in Asian countries, and the inclusion of several theoretically and empirically driven confounding factors in our model.

## Conclusion

That different COVID-19 specific stressors were associated with both an increased and reduced likelihood of heavy drinking and smoking highlights two important entry points for prevention and intervention efforts, which address issues of social restrictions and health concerns. Galea et al. (2020) called for the importance of planning interventions that target pandemic-related consequences of social loneliness, particularly among high-risk, marginalized groups that include the elderly and undocumented immigrants. Our findings suggest that these recommendations could be extended to young adults in university settings since they are also likely to be affected by social isolation and disruption following the pandemic.

During the pandemic, young adults have reported increased motivation to quit smoking (Klemperer et al., 2020). At the same time, increased COVID-19 stress related to health concerns has been found to be associated with a reduction in young adults' likelihood of smoking and heavy drinking in this study. Together, our findings point to the importance of university-based substance use prevention programs that leverage students' pandemic related health concerns. Given that educational institutions have been identified as ideal settings for substance use interventions for young adults (Abdullah et al., 2002), universities have a unique opportunity following the pandemic to provide substance use prevention and intervention services to their students (Klemperer et al., 2020) focused on pandemic-driven health promotion and support for COVID-19 related social isolation as we all move forward from this global pandemic.

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