

Longitudinal Correlates of Increased Alcohol Use Among Adolescents and Young Adults During the COVID-19 Pandemic

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Abstract

Aims: The objective of this study is to longitudinally assess sociodemographic and psychological correlates of increased alcohol use during the coronavirus disease of 2019 (COVID-19) period among adolescents and young adults.

Methods: Pre-COVID period is defined as the 1-year period on or before 31 March 2020, and during-COVID period is defined as the period from 1st April 2020 to 30 March 2021. Univariable logistic regression models are used to evaluate the association of demographic characteristics, Area Deprivation Index (ADI), rurality, changes in Patient Health Questionnaire (PHQ-9) and Generalized Anxiety Disorder (GAD-7) scale severity, and the risk of increased alcohol consumption (binge drinking, number of drinks and drinking regularity) from pre-COVID to during-COVID period.

Results and conclusion: Our study found that worsened anxiety symptoms, older age, being in college and current cigarette smoking status were associated with increased alcohol use among youth during the pandemic year. Socioeconomic position (measured by ADI) and rural status were not found to be associated with increased alcohol use among adolescents and young adults.

INTRODUCTION

The coronavirus disease of 2019 (COVID-19) pandemic upended normal life across all age spectra and presented as an abrupt disruption to education, employment and living conditions (Chaturvedi *et al.*, 2021). These disruptions, together with the fear associated with contracting COVID-19 infection and death, compounded anxiety and stress (Sharma *et al.*, 2020). A recent meta-analysis suggested that one in four youth globally experienced clinically elevated depression symptoms, whereas one in five youth experienced clinically elevated anxiety symptoms (Racine *et al.*, 2021). Evidence indicates negative affective states and anxiety triggered by social conditions are risk factors for substance use in young people, similar to adults (Sinha, 2008). The increase in anxiety and depression due to the pandemic, and the associations between these conditions and alcohol use, have led to concerns about the impact of the COVID-19 pandemic on alcohol use in youth (Clay and Parker, 2020; McKay and Asmundson, 2020).

The longitudinal studies so far provide mixed results on the direction and the magnitude of changes in alcohol consumption, particularly among adolescents and young adults. Some studies reflected increased use (Oksanen *et al.*, 2021;

Bollen *et al.*, 2022; Patrick *et al.*, 2022), whereas others observed decreases in level of drinking (Evans *et al.*, 2021; Jaffe *et al.*, 2021; Pelham 3rd *et al.*, 2021; Ryerson *et al.*, 2021; Vasconcelos *et al.*, 2021) among young people. Yet, most of these studies were conducted in small convenience samples and follow-up was limited to only a few weeks to months.

Research examining potential risk factors reported poor overall mental health, depression, anxiety and associated increases in alcohol consumption (Sallie *et al.*, 2020; Tran *et al.*, 2020; Garnett *et al.*, 2021; Guignard *et al.*, 2021; Jacob *et al.*, 2021). Indeed, events that are stressful (Park *et al.*, 2004), traumatic and anxiety-invoking could trigger the onset of problematic alcohol consumption (Elsayed *et al.*, 2018; Cloutier *et al.*, 2019). In addition, the use of other substances such as tobacco and cannabis also appear to be relevant along the spectrum of alcohol use among adolescents and young adults. In a longitudinal study during the pandemic, college students who experienced a relatively low meaning of life (which could be independently associated with depressive states), perceived more general and COVID-19 stress and were associated with more alcohol use (Jaffe *et al.*, 2021). Given the COVID-19 pandemic was a traumatic and stressful event for many and was associated with increased anxiety and

depression severity (Liao *et al.*, 2021; Thorisdottir *et al.*, 2021; Varma *et al.*, 2021), we hypothesized that it has contributed to changes in alcohol use.

Furthermore, from a socioecological perspective, a dynamic interplay of the factors at the individual and environment/community level may contribute to individual outcomes (alcohol use in this case; McLeroy *et al.*, 1988). Because the pandemic has affected income, employment and financial stability, along with physical and social isolation (Nicola *et al.*, 2020), changes in alcohol consumption during the ongoing pandemic could potentially be associated with socioeconomic status and urban versus rural residence.

Overall, the existing data suggest that the pandemic has had a widespread impact on affective state, stress and alcohol use; however, data are limited and conflicting among adolescents and young adult populations. To address these evidentiary gaps, we studied associations between demographic factors (including socio-demographic factors), changes in the severity of psychological distress and changes in alcohol use before and after the onset of COVID-19 in adolescents and young adults. We hypothesized a positive association between increased alcohol use and greater severity of depression and anxiety symptoms, as well as demographic factors such as area-based socioeconomic disadvantage and living in a rural area.

METHODS

Study setting

Mayo Clinic consists of a large academic medical center and associated health system spanning five states (Minnesota, Wisconsin, Iowa, Florida and Arizona) in the USA. The study was reviewed and approved by the local institutional review board prior to any research-related activities.

Sample

The study population consisted of 2216 individuals aged 16–20, as of 30 March 2019, with noted research authorization in their electronic medical records (EMR). These individuals also had annual data on their alcohol use (as measured by self-reported surveys during their clinical visits), the Patient Health Questionnaire (PHQ-9) to assess depressive symptoms (Kroenke *et al.*, 2001) and the Generalized Anxiety Disorder (GAD-7) scale to assess anxiety symptoms (Spitzer *et al.*, 2006) from 1 April 2019 to 30 March 2021. We partitioned data into two-time points: pre-COVID, defined as the 1-year period on or before 31 March 2020, and during-COVID, defined as the period from 1st April 2020 to 30 March 2021.

Measures

Primary outcome

The primary outcome was change in alcohol use, reflected by an increase, no change or decrease in drinking regularity, frequency and binge drinking regularity. Data were collected through self-reported responses to three questions about alcohol use during the clinical visit. Drinking regularity was categorized as: never, monthly or less, 2–4 times a month, 2–3 times a week or 4 or more times a week. Drinking frequency was categorized into 1 or 2, 3 or 4, 5 or 6, 7–9 or 10 or more drinks per drinking day. Binge drinking regularity was categorized as never, less than monthly, monthly, weekly or daily or almost daily.

Independent Variables

Independent variables included demographic characteristics of patients including area-based socioeconomic disadvantage and rurality of patients' residence and changes in depression and anxiety over the previously mentioned periods.

Demographic characteristics (age, gender and race/ethnicity), smoking status (any smoking during study period) and education status (highest during the study period) were extracted from the EHRs.

Socioeconomic position was measured by the Area Deprivation Index (ADI; Singh, 2003) and the rurality (USDA, 2020) of the patients' residence. Because these patients were young adults and adolescents, traditional measures of socioeconomic status, such as income, typically used for adults were not applicable; these variables came closest to reflecting socioeconomic status for patients in our cohort. ADI scores were obtained from 5-year American Community Survey (ACS) estimates. ACS is an annual survey conducted by the US Census Bureau that provides population-level estimates that are representative of the noninstitutionalized US population. In-depth survey methods can be found on the US Census Bureau website (ACS, 2020). We used 17 block-group indicators, representing income, employment, housing and education, to compute ADI scores for all US Census block groups (Kurani *et al.*, 2022). All block groups were ranked by ADI scores. Each block group was assigned to a quintile of ADI scores from the least deprived 20% of block groups (quintile 1) to the most deprived 20% of block groups (quintile 5). Weights that were assigned to each variable in the ADI. A geographic hot spot map of block group ADI scores in Minnesota, Iowa and Wisconsin ($n = 11,230$) was created and has been previously described (Kurani *et al.*, 2020). Rurality was ascertained from patient zip codes to identify corresponding Rural–Urban Commuting Area (RUCA) codes. Based on published definitions (Johnson *et al.*, 2018; USDA, 2020), the RUCA codes classified areas as urban or rural.

Depression and anxiety symptoms were assessed by PHQ-9 and GAD-7, respectively, both self-reported scales with strong internal and test–retest reliability as well as construct and factor-structure validity (Kroenke *et al.*, 2001; Spitzer *et al.*, 2006; Kroenke *et al.*, 2010). GAD-7 was categorized into four levels (0–4: minimal anxiety, 5–9: mild anxiety, 10–14: moderate anxiety and 15–21: severe anxiety) and PHQ-9 was categorized into five levels (0–4: none-minimal depression, 5–9: mild depression, 10–14: moderate depression, 15–19: moderately severe depression, 20–27: severe depression; Kroenke *et al.*, 2001; Spitzer *et al.*, 2006).

Statistical analyses

For each patient, we calculated the maximum value for each of the three alcohol consumption metrics, PHQ-9, and GAD-7 measurement within each time point then took the difference between time points. For each of the three alcohol consumption metrics, we used univariable logistic regression models to assess the individual effects on the risk of increased consumption from age, gender, race, ethnicity, ADI quintile, smoking status, change in PHQ-9 categories (increased, not increased or unknown), change in GAD-7 categories (increased, not increased or unknown) and rural status at the zip code with the longest duration during the study period. To choose the approximate best models for risk of increase in each of the three alcohol consumption metrics, we used a backward

model selection to fit a sequence of models beginning with a complete model, i.e. all effects, and sequentially removing one effect at a time according to the results of the Wald test for individual parameters. The selected model is the last in this sequence where all effects have $P < 0.05$. We categorized age into three groups (16–18 years old, 19 years old and 20 years old). Data management and statistical analyses were performed in SAS Studio 3.81 (SAS Institute Inc., Cary, North Carolina) and R 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria). There was no correction for multiple comparisons as this was an exploratory, hypothesis generating study.

RESULTS

The demographic characteristics ($N = 2216$) are described in Table 1. The study population was mostly female (81%), white (90%) and urban dwelling (62%).

Patterns of Alcohol use behaviors

The proportion of the study population reporting no changes in alcohol use behaviors during the pandemic was 58.5% for alcohol regularity, 62.2% for number of alcohol drinks and 74.6% for alcohol binge drinking (Table 1). The proportion reporting an increase for these behaviors was 28.6, 17.9 and 17.0%, respectively. The remaining individuals reported decreases in these behaviors.

Drinking Regularity

There were 2194 individuals who had both pairs of drinking regularity measurements. Age, education, increased PHQ-9 and increased GAD-7 all showed significant associations with drinking regularity in the univariable models (all $P < 0.001$). Participants who were 19 compared to 20, 20 compared to 16 to 18, some college or associates compared to high school and increased GAD-7 were more likely to increase their alcohol regularity (all $P \leq 0.024$). In final multivariable models, older age, higher education and GAD-7 remained significantly associated with an increase in drinking regularity (all $P \leq 0.01$; Table 2).

Number of Drinks

There were 1121 participants who had both pairs of the number of drinks measurements. Gender, ADI quintile and smoking status showed significant associations with number of drinks in the univariable models (all $P \leq 0.04$). Males, those living in the third and fourth most deprived ADI quintiles compared to the least deprived, and smokers were more likely to report increase their alcohol drinks (all $P \leq 0.041$). In the multivariable model, male gender remained significantly associated with an increase in number of drinks ($P = 0.008$; Table 3).

Binge Drinking

There were 1899 participants who had both pairs of binge drinking measurements. Age, education, GAD-7 and smoking status showed significant associations in the univariable models (all $P \leq 0.003$). Participants who were 19 and 20 compared to 16 to 18, some college compared to high school, increased GAD-7 and smokers were more likely to report increase in binge drinking (all $P \leq 0.003$). In

Table 1. Summary statistics on patient characteristics ($N = 2216$)

Characteristic	<i>n</i> (%)
Age (as of 30 March 2019)	
16–18	901 (40.7%)
19	648 (29.2%)
20	667 (30.1%)
Gender	
F	1787 (80.6%)
M	429 (19.4%)
Race	
American Indian	16 (0.7%)
Asian or Pacific	46 (2.1%)
Black or African American	72 (3.2%)
White	1986 (89.6%)
Unknown	96 (4.3%)
Ethnicity	
Hispanic	147 (6.6%)
Not Hispanic or Latino	2044 (92.2%)
Unknown	25 (1.1%)
Education level (highest)	
HS	972 (43.9%)
Some college	878 (39.6%)
Associates	239 (10.8%)
Bachelor	118 (5.3%)
Advanced	5 (0.2%)
Declined to answer	4 (0.2%)
Area Deprivation Index quintile (1 = least deprived, 5 = most deprived) ^a	
1 = least deprived	400 (23.2%)
2	584 (33.9%)
3	423 (24.5%)
4	244 (14.2%)
5 = most deprived	73 (4.2%)
Change in PHQ category	
Not increased	1594 (71.9%)
Increased	528 (23.8%)
Unknown	94 (4.2%)
Change in GAD category	
Not increased	1225 (55.3%)
Increased	368 (16.6%)
Unknown	623 (28.1%)
Smoking status ^b	
No	1856 (84.9%)
Yes	330 (15.1%)
Rural	
Urban	1445 (65.2%)
Rural	771 (34.8%)
Change in alcohol regularity ^c	
Decreased	284 (12.9%)
No change	1283 (58.5%)
Increased	627 (28.6%)
Change in alcohol drinks ^d	
Decreased	223 (19.9%)
No change	697 (62.2%)
Increased	201 (17.9%)
Change in alcohol binge ^e	
Decreased	161 (8.5%)
No change	1416 (74.6%)
Increased	322 (17.0%)

^a $N = 1724$ because 492 were missing an ADI quintile. ^b $N = 2186$ because 30 were missing a smoking status. ^c $N = 2194$ because 22 were missing a change in alcohol regularity. ^d $N = 1121$ because 1095 were missing a change in alcohol drinks. ^e $N = 1899$ because 317 were missing a change in alcohol binge. Changes reported from pre-COVID (1 April 2019 to 31 March 2020) to during-COVID (1 April 2020 to 30 March 2021).

the multivariable model, older age, an increase in GAD-7 severity and smoking status remained significantly associated with an increase in binge drinking (all $P \leq 0.03$; Table 4).

Table 2. Odds ratio estimates for effects of characteristics on increases in alcohol regularity from pre-COVID to COVID from univariable models and backward selection multivariable model among those younger than 21 at start of study period

Characteristic	Level	Mean (SD) or no. (%)		Univariable		Multivariable	
		Increased	Not increased	P	OR	P	OR
Age (N = 2194)	16–18 (as of 30 March 2019)	197 (22.1)	696 (77.9)	<0.001	0.66 (0.52, 0.82; P < 0.001)	<0.001	0.61 (0.46, 0.81; P < 0.001)
	19	230 (36.0)	408 (64.0)		1.30 (1.03, 1.65; P = 0.024)		1.22 (0.92, 1.61; P = 0.16)
Gender (N = 2194)	20 (ref)	200 (30.2)	463 (69.8)	0.54	1.0		1.0
	F (ref)	511 (28.9)	1259 (71.1)		1.0		NI
	M	116 (27.4)	308 (72.6)		0.93 (0.73, 1.18; P = 0.54)		
Race (N = 2099)	American Indian	6 (37.5)	10 (62.5)	0.31	1.47 (0.53, 4.07; P = 0.46)		NI
	Asian or Pacific	9 (20.0)	36 (80.0)		0.61 (0.29, 1.28; P = 0.19)		
	Black or African American	16 (22.5)	55 (77.5)		0.71 (0.41, 1.25; P = 0.24)		
	White (ref)	570 (29.0)	1397 (71.0)		1.0		
Ethnicity (N = 2169)	Hispanic	37 (25.5)	108 (74.5)	0.38	0.84 (0.57, 1.24; P = 0.38)		NI
	Not Hispanic or Latino (ref)	585 (28.9)	1439 (71.1)		1.0		
Education (N = 2190)	HS (ref)	227 (23.6)	737 (76.5)	<0.001	1.0	0.01	1.0
	Some college	292 (33.6)	577 (66.4)		1.64 (1.34, 2.02; P < 0.001)		1.40 (1.10, 1.80; P = 0.007)
	Associates	77 (32.5)	160 (67.5)		1.56 (1.15, 2.13; P = 0.005)		1.52 (1.06, 2.18; P = 0.021)
	Bachelor/Advanced	31 (25.8)	89 (74.2)		1.13 (0.73, 1.75; P = 0.58)		0.91 (0.54, 1.52; P = 0.71)
ADI quintile (N = 1706)	1 = Least deprived (ref)	125 (31.6)	270 (68.3)	0.73	1.0		NI
	2	164 (28.3)	416 (71.7)		0.85 (0.64, 1.12; P = 0.26)		
	3	115 (27.6)	302 (72.4)		0.82 (0.61, 1.11; P = 0.20)		
	4	71 (29.5)	170 (70.5)		0.90 (0.64, 1.28; P = 0.56)		
	5	20 (27.4)	53 (72.6)		0.81 (0.47, 1.42; P = 0.47)		
PHQ (N = 2194)	Increased	170 (32.8)	349 (67.2)	0.05	1.30 (1.05, 1.61; P = 0.016)		NI
	Not increased (ref)	431 (27.2)	1151 (72.8)		1.0		
	Unknown	26 (28.0)	67 (72.0)		1.04 (0.65, 1.65; P = 0.88)		
GAD (N = 2194)	Increased	134 (36.9)	229 (63.1)	<0.001	1.57 (1.23, 2.02; P < 0.001)	0.001	1.69 (1.26, 2.27; P < 0.001)
	Not increased (ref)	329 (27.1)	885 (72.9)		1.0		1.0
	Unknown	164 (26.6)	453 (73.4)		0.97 (0.78, 1.21; P = 0.81)		0.99 (0.77, 1.29; P = 0.97)
Smoking status (N = 2164)	No (ref)	524 (28.5)	1313 (71.5)	0.93	1.0		NI
	Yes	94 (28.8)	233 (71.2)		1.01 (0.78, 1.31; P = 0.93)		
Rural (N = 2194)	Urban (ref)	404 (28.2)	1028 (71.8)	0.60	1.0		NI
	Large rural	223 (29.3)	539 (70.7)		1.05 (0.87, 1.28; P = 0.60)		

Abbreviations: NI, not included; OR, odds ratio; SD, standard deviation. Reference categories are 20-year-olds, females, whites, not Hispanic or Latino, Least deprived or ADI quintile = 1, non-smoker, not increased PHQ, not increased GAD and Urban. Multivariable sample size (n = 1600).

DISCUSSION

We explored predictors of increased alcohol use during the COVID-19 pandemic among adolescents and young adults. Overall, the majority of the youth in our sample did not increase their alcohol regularity, consumption or frequency of binge drinking. Worsened anxiety symptoms, older age,

education level (being in college) and current cigarette smoking status were associated with increased alcohol use during the pandemic year compared to the previous non-pandemic year.

Studies longitudinally assessing the mental health predictors of problematic alcohol use among youth during the first year

Table 3. Odds ratio estimates for effects of characteristics on increases in alcohol drinks from pre-COVID to COVID from univariable models and backward selection multivariable model among those younger than 21 at start of study period

Characteristic	Level	Mean (SD) or no. (%)		Univariable		Multivariable	
		Increased	Not increased	P	OR	P	OR
Age (N = 1121)	16–18 (as of 2019 Mar 30)	57 (19.3)	239 (80.7)	0.77	1.15 (0.79, 1.67; P = 0.47)		NI
	19	62 (17.8)	286 (82.2)				
	20 (ref)	82 (17.2)	395 (82.8)				
Gender (N = 1121)	F (ref)	152 (16.6)	763 (83.4)	0.02	1.0	0.008	1.0
	M	49 (23.8)	157 (76.2)				
Race (N = 1086)	American Indian	4 (44.4)	5 (55.6)	0.14	3.61 (0.96, 13.57; P = 0.058)		NI
	Asian or Pacific	5 (19.2)	21 (80.8)				
	Black or African American	2 (7.7)	24 (92.3)				
	White (ref)	186 (18.1)	839 (81.8)				
Ethnicity (N = 1113)	Hispanic	7 (11.9)	52 (88.1)	0.22	0.60 (0.27, 1.35; P = 0.22)		NI
	Not Hispanic or Latino (ref)	192 (18.2)	862 (81.8)				
Education (N = 1120)	HS (ref)	73 (20.6)	282 (79.4)	0.11	1.0		NI
	Some college	95 (18.5)	418 (81.5)				
	Associates	21 (14.4)	125 (85.6)				
	Bachelor/Advanced	12 (11.3)	94 (88.7)				
ADI quintile (N = 879)	1 = Least deprived (ref)	29 (13.4)	188 (86.6)	0.03	1.0		NI
	2	53 (17.2)	255 (82.8)				
	3	44 (21.4)	162 (78.6)				
	4	28 (26.9)	76 (73.1)				
	5	6 (13.6)	38 (86.4)				
PHQ (N = 1121)	Increased	52 (19.8)	211 (80.2)	0.24	1.21 (0.85, 1.72; P = 0.29)		NI
	Not increased (ref)	138 (16.9)	677 (83.1)				
	Unknown	11 (25.6)	32 (74.4)				
GAD (N = 1121)	Increased	41 (20.0)	164 (80.0)	0.69	1.18 (0.79, 1.75; P = 0.42)		NI
	Not increased (ref)	112 (17.5)	528 (82.5)				
	Unknown	48 (17.4)	228 (82.6)				
Smoking status (N = 1102)	No (ref)	152 (16.8)	754 (83.2)	0.04	1.0		NI
	Yes	45 (23.0)	151 (77.0)				
Rural (N = 1121)	Urban (ref)	127 (17.0)	622 (83.0)	0.23	1.0		NI
	Large rural	74 (19.9)	298 (80.1)				

Abbreviations: OR, odds ratio; SD, standard deviation. Reference categories are 20-year-olds, females, whites, not Hispanic or Latino, Least deprived or ADI quintile = 1, non-smoker, not increased PHQ, not increased GAD and Urban. Multivariable sample size (n = 834).

of the COVID-19 pandemic are limited. A recent study by Venanzi and colleagues found that symptoms of depression, greater pandemic-related stress assessed by Pandemic Stress Questionnaire (PSQ) and intolerance of uncertainty predicted 3-month follow-up alcohol use severity in young adults (aged 18–25; Venanzi *et al.*, 2022). Our longitudinal study makes

a novel contribution to the literature by exploring changes in participants' drinking behavior between the pre-pandemic and pandemic year (across a span of 2 years), demonstrating that an increase in anxiety severity independently predicted patterns of problematic alcohol use (Drinking Regularity and binge drinking) among adolescents and young adults.

Table 4. Odds ratio estimates for effects of characteristics on increases in alcohol binge from pre-COVID to COVID from univariable models and backward selection multivariable model among those younger than 21 at start of study period

Characteristic	Level	Mean (SD) or no. (%)		P	Univariable		Multivariable	
		Increased	Not increased		OR	P	OR	
Age (N = 1899)	16–18 (as of 30 March 2019)	94 (12.9)	636 (87.1)	<0.001	0.64 (0.48, 0.86; P = 0.004)	<0.001	0.52 (0.37, 0.74; P < 0.001)	
	19	114 (20.4)	446 (79.6)		1.11 (0.83, 1.48; P = 0.48)		0.96 (0.69, 1.35; P = 0.83)	
Gender (N = 1899)	20 (ref)	114 (18.7)	495 (81.3)	0.37	1.0		1.0	
	F (ref)	268 (17.3)	1279 (82.7)		1.0		NI	
	M	54 (15.3)	298 (84.7)		0.86 (0.63, 1.19; P = 0.37)			
Race (N = 1821)	American Indian	2 (16.7)	10 (83.3)	0.13	0.93 (0.20, 4.29; P = 0.93)		NI	
	Asian or Pacific	7 (16.7)	35 (83.3)		0.93 (0.41, 2.12; P = 0.87)			
	Black or African American	3 (5.0)	57 (95.0)		0.25 (0.08, 0.79; P = 0.019)			
Ethnicity (N = 1879)	White (ref)	301 (17.6)	1406 (82.4)	0.48	1.0		NI	
	Hispanic	17 (14.7)	99 (85.3)		0.83 (0.49, 1.41; P = 0.48)			
Education (N = 1897)	Not Hispanic or Latino (ref)	303 (17.2)	1460 (82.8)	<0.001	1.0		NI	
	HS (ref)	100 (12.9)	674 (87.1)		1.0			
	Some college	169 (21.3)	624 (78.7)		1.82 (1.39, 2.39; P < 0.001)			
	Associates	35 (16.4)	179 (83.6)		1.32 (0.87, 2.00; P = 0.20)			
ADI quintile (N = 1464)	Bachelor/Advanced	18 (15.5)	98 (84.5)	0.44	1.24 (0.72, 2.13; P = 0.44)		NI	
	1 = Least deprived (ref)	55 (16.2)	284 (83.8)		1.0			
	2	93 (18.2)	419 (81.8)		1.15 (0.80, 1.65; P = 0.47)			
	3	50 (14.1)	304 (85.9)		0.85 (0.56, 1.29; P = 0.44)			
	4	38 (19.6)	156 (80.4)		1.26 (0.80, 1.99; P = 0.33)			
PHQ (N = 1899)	5	10 (15.4)	55 (84.6)	0.67	0.94 (0.45, 1.95; P = 0.87)		NI	
	Increased	83 (18.3)	370 (81.7)		1.13 (0.86, 1.50; P = 0.38)			
	Not increased (ref)	226 (16.5)	1142 (83.5)		1.0			
GAD (N = 1899)	Unknown	13 (16.7)	65 (83.3)	0.002	1.01 (0.55, 1.86; P = 0.97)	0.005	1.80 (1.25, 2.58; P = 0.002)	
	Increased	75 (23.9)	239 (76.1)		1.74 (1.28, 2.38; P < 0.001)		1.0	
	Not increased (ref)	161 (15.2)	895 (84.8)		1.0		1.0	
Smoking status (N = 1875)	Unknown	86 (16.3)	443 (83.7)	0.003	1.08 (0.81, 1.44; P = 0.60)	0.03	1.06 (0.75, 1.49; P = 0.75)	
	No (ref)	255 (15.9)	1351 (84.1)		1.0		1.0	
Rural (N = 1899)	Yes	63 (23.4)	206 (76.6)	0.86	1.62 (1.19, 2.21; P = 0.003)		1.54 (1.05, 2.25; P = 0.026)	
	Urban (ref)	208 (16.8)	1027 (83.2)		1.0		NI	
	Large rural	114 (17.2)	550 (82.8)		1.02 (0.80, 1.31; P = 0.86)			

Abbreviations: NI, not included; OR, odds ratio; SD, standard deviation. Reference categories are 20-year-olds, females, whites, not Hispanic or Latino, Least deprived or ADI quintile = 1, non-smoker, not increased PHQ, not increased GAD and Urban. Multivariable sample size (n = 1380).

Our study findings also align with pre-pandemic literature that anxiety among adolescents and young adults is associated with problematic substance use. Studies outside the context of COVID-19 have found that college enrollment has been associated with an increased risk of alcohol use (Quinn and Fromme, 2011). We found that college-aged young adults may have been particularly at higher risk of increased alcohol

use patterns during the pandemic. Mental health problems were already high among emerging adults even prior to the pandemic (Oswalt *et al.*, 2020); the emergence of the pandemic could have contributed added psychiatric burden on this population leading to problematic drinking. Given our data are limited to 2 years and two-time points, it is difficult to infer that the associations we found are in relation to

ongoing COVID-19. In addition, psychiatric disorders and co-occurring substance use (alcohol use in this case) evolve over time and may be associated with other life factors that are not fully explored in our study. However, our study provides a preliminary indication of such an association. Longer longitudinal studies assessing change in trajectories over time could provide more clear answers.

Our study has both clinical and research implications. Given that we are still in the pandemic and, mounting evidence indicates that college students/young adults are an important demographic that experienced significantly increased anxiety, depression and alcohol use, our findings have practical implications for clinicians and health care providers. For example, adolescents and young adults should be periodically screened for depression, anxiety and substance use, and the treatment should be individualized based on the assessment of social determinants of health.

Our study has some potential limitations that should be noted. Most notably, selection bias is a concern as the study population is limited to individuals who received healthcare at two points and also completed the alcohol use questionnaires. This type of selection can induce collider bias because both the independent exposure variables and the alcohol use outcomes likely influence seeking healthcare and completing the alcohol use questionnaires. Therefore, the observed changes in alcohol use and the effect estimates should be interpreted with caution. We analyzed data extracted from existing medical records, which are prone to errors including missing data. Substance use, including alcohol use, is typically underreported due to social stigma associated with substance use screening and reporting (Harrison *et al.*, 2007). Our sample was mostly white, limiting generalizability to other diverse patient groups albeit located in five different states. The EHR does not utilize validated measures to capture substance use; however, our study could circumvent this limitation since we are measuring the change in substance use in the same individuals to capture changes between April 2019–March 2020 and April 2020–March 2021. Despite these limitations, our study has many strengths such as large sample size and a longitudinal study design. We also accounted for area-level characteristics at a granular level (block group), which is a novel approach, particularly for this age group to better understand how individuals' areas of residence can impact their alcohol use. In addition, data were collected at the time of a clinic visit, limiting participant recall bias.

CONCLUSION

The current study found that most of adolescents and young adults did not increase alcohol use during the pandemic. Those with worsened anxiety compared to the pre-pandemic year were more likely to report problematic alcohol use.

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