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Adolescent drug use before and during U.S. national COVID-19 social distancing policies

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ABSTRACT

Background: How adolescent substance use and perceived availability of substances have changed during the COVID-19 pandemic remain largely unknown. Substantial reduction in availability of substances would present a unique opportunity to consider the supply-side hypothesis that reductions in drug availability will lead to reductions in drug prevalence.

Methods: Longitudinal data come from Monitoring the Future and are based on responses from 582 adolescents who were originally surveyed as part of a national sample of 12th grade students in early 2020, one month before social distancing policies began. They were surveyed again after social distancing policies were implemented, in the summer of 2020.

Results: Perceived availability of marijuana and alcohol declined across the two survey waves at the largest levels ever recorded in the 46 years of the project, by an absolute 17 %, $p < .01$ and 24 %, $p < .01$, respectively. Despite these declines, prevalence levels did not significantly change across the two waves for marijuana use in the past 30 days or for binge drinking in the past two weeks. Perceived availability of vaping devices significantly declined, from 73 % to 63 %, as did nicotine vaping prevalence in the past 30 days, from 24 % to 17 %.

Conclusions: Perceived availability of marijuana, alcohol, and vaping devices declined at historic rates during the pandemic of 2020. Lack of accompanying reductions in prevalence for marijuana and binge drinking demonstrates the substantial challenges facing a supply-side approach to the reduction of adolescent use of these substances.

1. Introduction

To what extent have substance use levels among adolescents changed since U.S. social distancing policies began in response to the COVID-19 pandemic? The social distancing policies enacted in the Spring of 2020 were intentionally designed to limit adolescent interactions with people outside their home and to keep physical distance (6 feet) from others (Honein et al., 2020). If successful, these policies would be expected to reduce adolescent substance use. They would reduce access to substances by disrupting sources of supply such as substance-using peers and adults outside the home and, in addition, reduce opportunities to use substances while unmonitored by adults, such as at parties and informal social gatherings. U.S. social distancing policies that were implemented abruptly in the Spring of 2020, which varied in both their extent and compliance, serve as a natural experiment that can inform both public policy and drug theory.

Changes in drug prevalence in relation to changes in substance availability are of particular importance for the field. One central assumption in many drug theories and drug policies is that reduction in the availability of substances will lead to reduction in their use (National Research Council, 2001; Office of National Drug Control Policy, 2016; Smart, 1980). This assumption has been difficult to evaluate among U.S. adolescent populations because availability of the most commonly used substances has changed little in past decades. For example, from 1975 to 2019 the percentage of all 12th grade students who report they could easily get marijuana has never changed more than two percentage points in a single year, and has remained at 79 % or higher for the entire period (Miech et al., 2020a). Social distancing has potential to decrease substance availability among adolescents at an unprecedented level and, if so, provide a unique opportunity to empirically consider the extent to which such a decrease tracks with changes in substance use prevalence.

Table 1 lists four hypotheses about substance use prevalence and

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Table 1
Study Hypotheses.

		Prevalence of Substance	
		Decrease	Steady/Increase
Availability of Substance	Decrease	(1) Constriction of Supply	(3) Persevering
	Steady/ Increase	(2) Constriction of Use Opportunities	(4) No changes during social distancing

availability that this study tests. Hypothesis #1 we label "Constriction of Supply." It posits that both substance use prevalence and substance availability will be substantially lower during as compared to before the implementation of social distancing policies. It builds on the proposition, described above, that decreases in availability of substances will lead to decreased prevalence of their use.

Hypothesis #2 we label "Constriction of Use Opportunities." In this scenario adolescent substance use declines as a result of fewer substance use opportunities, such as parties and informal social gatherings with peers. As these opportunities decrease, adolescents would have less exposure to substance-using peer networks that and adults who provide opportunities for youth to initiate and continue use of substances (Kosterman et al., 2000). Importantly, the decrease in substance use prevalence is not a result of declines in substance availability, which for this hypothesis are assumed to remain the same before and during social distancing as adolescents and their suppliers continue to find ways to obtain substances.

Hypothesis #3 we label the "Persevering" hypothesis. It posits that substance use prevalence among adolescents will remain the same or even increase after social distancing begins, even though adolescents face greater difficulty obtaining their preferred substances. Adolescents may redouble their substance procurement efforts so that they can continue using substances at the levels at which they used in the past. In addition, adolescents may move to more solitary substance use (Dumas et al., 2020; Terry-McElrath et al., 2021). Social distancing policies might even increase substance use to the extent that they lead to feelings of isolation and loneliness that some adolescents address through increased substance use (Patrick et al., 2011, 2016, 2019).

Hypothesis #4 is the final study hypothesis, which we label "No Changes during Social Distancing." As the name indicates, it posits that availability and prevalence of adolescent substance use are the same before and during social distancing.

To empirically evaluate these four hypotheses we use survey data that assessed adolescent substance use and availability from the same individuals both before social distancing policies were implemented and also when they were in force. The data also contain self-reported measures of the extent to which adolescents socially distanced, which would be expected to modify use and availability of substances. We empirically evaluate these hypotheses for three high-prevalence forms of substance use: marijuana use, binge drinking, and nicotine vaping.

2. Materials and methods

Data for this study come from Monitoring the Future (MTF) which annually surveys nationally-representative, cross-sectional samples of U. S. 12th grade students. For a detailed description of MTF, including the complex multistage sampling design, see Bachman et al. (2015). At the baseline survey for this current study personnel from the University of Michigan administered MTF surveys in classrooms and students self-completed questionnaires during a normal class period. The University of Michigan Institutional Review Board approved the study. Informed consent (either passive consent or active [i.e., written] consent, per school policy) was obtained from parents for students younger than 18 years and from students aged 18 years or older.

Data collection for the baseline, 12th grade 2020 sample started on February 11, 2020 and was halted prematurely on March 15, 2020 as a result of the COVID-19 pandemic. At the time of the halt MTF had collected 3770 surveys from 12th grade students in 36 schools distributed across all nine of the U.S. Census geographical divisions. The response rate within schools was 79 %, with almost all nonresponse due to students absent on the day of the survey administration. In total, the sample size before surveying had to be halted as a result of the pandemic was about one-quarter the size of a regular data collection.

Detailed analyses indicate that the baseline, curtailed MTF 2020 sample did not differ from the nationally-representative results from previous years in terms of sociodemographics and prevalence of substances that have had stable prevalence in recent years. For example, in 2020 the sample percentage female was 51 %, which falls within the range of 51%–53% from 2017 to 2019, and the percentage who ever used marijuana was 38 %, which falls within the range of 37%–38% from 2017 to 2019 (Miech et al., 2020a).

To examine drug use and availability during the pandemic, MTF undertook a summer follow-up survey in 2020. All students who had been surveyed at baseline and provided useable contact information (n = 1741) and were 18 years or older as of the follow-up survey were invited to participate in a web-based follow up between July 16 and August 10, 2020. Respondents received a $10 check with the invitation and were sent an additional $25 if they completed the survey within ten days of receipt or $15 if they completed it after 10 days.

A portion of students chose not to provide contact information at baseline. Those who did versus did not provide useable contact information at baseline did not significantly differ in their levels of perceived availability for marijuana, alcohol, or vaping devices At baseline their prevalence levels were about 30 % lower for each of the outcomes of past 30-day marijuana use, past 2-week binge drinking, and past 30-day nicotine vaping. To take into account these lower levels of substance use the analysis of the follow-up survey used attrition weights that increase the influence of follow-up respondents who used these substances at baseline in comparison to those who did not (discussed in the '2.1 Statistical Analysis' section below).

The number of respondents to the follow-up summer survey was 582, which is 15 % of the baseline sample of 3,770. The baseline characteristics of the weighted follow-up sample matched closely those of the complete baseline sample, as detailed in Table 2.

Table 2 includes the question wording, response categories, and sample size for the study. All measures are self-reported. The reporting intervals for the study's prevalence measures are limited to the last month (last two weeks for binge drinking) so that the follow-up measures refer to the time period after social distancing measures were implemented, and the same reporting intervals are used at baseline for direct comparability. The measure of social distancing comprises of three levels: an "extreme" level for those who reported no meetings with friends since the start of the pandemic, a "none to medium" for those who reported they "never," "rarely", or only "sometimes" wore facemasks and stayed six feet apart when with others who do not live with them, and a "high" level for everyone else in between. The modal age of the follow-up sample was 18 (56 %), with 42 % age 19 and 2% age 20.

2.1. Statistical analysis

The analysis uses multiple imputation to handle missing data (Rubin, 1996) and uses the chained equations algorithm (Raghunathan et al., 2001) with 20 imputed data sets. At baseline all variables had completion levels of 91 % or higher, and at follow-up completion levels for all

Table 2
Baseline Characteristics of Weighted Follow Up Sample, with Comparison to Baseline Values of Full, Baseline Sample.

	Follow up sample (n = 582)	Baseline (n = 3770)
Used marijuana in past 30 days Question: "On how many occasions (if any) have you used marijuana (weed, pot) or hashish (hash, hash oil) in the past 30 days?" Coded 1 for any response greater than zero.	.23 (.17–.28)	.21 (.18–.25)
Binged drank in past two weeks Question: "Think back over the LAST TWO WEEKS. How many times have you had five or more drinks in a row? (A "drink" is a bottle of beer, a glass of wine, a wine cooler, a shot glass of liquor, a mixed drink, etc.)" Coded 1 for any response greater than zero.	.17 (.12–.22)	.17 (.12–.21)
Vaped nicotine in past 30 days Question: "On how many DAYS (if any) have you vaped NICOTINE during the last 30 days?" Coded 1 for any response greater than zero.	.24 (.19–.29)	.25 (.19–.31)
Availability of Substances		
Easy to get marijuana[a] Question: How difficult do you think it would be for you to get each of the following types of drugs, if you wanted some… Marijuana (pot, weed)?" Coded 1 for marked response of "Fairly Easy" or "Very Easy"	.76 (.67–.85)	.75 (.69–.80)
Easy to get alcohol[b] Question: How difficult do you think it would be for you to get each of the following types of drugs, if you wanted some… Alcohol?" Coded 1 for marked response of "Fairly Easy" or "Very Easy"	.86 (.77–.95)	.81 (.77–.85)
Easy to get vaping device[a] Question: "To "vape" is to use a device such as a JUUL, vape-pen, e-cigarette, e-hookah, or e-vaporizer to inhale a vapor into the lungs. How difficult do you think it would be for you to get each of the following, if you wanted some… Vaping device (JUUL, e-cigarette, e-pen, etc.)?" Coded 1 for marked response of "Fairly easy" or "Very Easy"	.73 (.63–.82)	.75 (.70–.80)
Female Question: "What is your sex?" Coded 1 for response of 'female.'	.51 (.45–.57)	.50 (.45–.54)
Non-Hispanic White Question: How to you describe yourself (Select one or more responses)? Coded 1 for respondents who marked only "White (Caucasian)" and did not mark Hispanic.	.48 (.42–.54)	.49 (.33–.64)
Grade point average Question: Which of the following best describes your average grade so far in high school? 1="A (93–100)" 2="A- (90–92) 3="B+ (87–89)" 4="B (83–86)" 5="B- (80–82)" 6="C+ (77–79)" 7="C (73–76)" 8="C- (70–72)" 9="D (69 or below)"	3.38 (3.08–3.69)	3.22 (2.93–3.50)
Parent has college degree Questions: "What is the highest level of schooling your father completed?" and "What is the highest level of schooling your mother completed?" Coded 1 for a marked response of "Completed college" or "Graduate or professional school after college" for either father or mother	.52 (.46–.58)	.54 (.44–.64)
Social distancing practices at follow up[c]		
Extreme Question: "Have you met friends in person since the pandemic started"? Coded 1 for response of "No."	.20 (.16–.25)	n/a
High Questions: "When you are with your friends who do not live with you, how often do you stay six feet apart from them?" and "When you are with your friends who do not live with you, how often do you wear a facemask?" (Questions asked only of those who had met with friends in person since the pandemic started). Coded 1 for respondents whose answers were "Always or almost always" or "Often" for both questions.	.18 (.14–.23)	n/a
None to medium Coded 1 for respondents who answers to either of the questions above for category above included "Never", "Rarely," or "Sometimes."	.61 (.55–.67)	n/a

Note: None of the estimates significantly differed across the two columns at $p < .05$.
[a] Question asked of a randomly-selected one-third of sample at baseline and of all respondents at follow up.
[b] Question asked of a randomly-selected one-sixth of sample at baseline and of all respondents at follow up.
[c] Reported means are percentage of respondents in each category. Combined percentages do not add to 100 % because of rounding.

variables were 93 % or higher. We report estimates with imputed values for the dependent variables of past 30-day marijuana use, binge drinking in the past two weeks, and past 30-day nicotine vaping, and also perform a sensitivity analysis that excluded observations with imputed values for the dependent variables.

All statistical analyses used Stata MP 16.1 software and are weighted to be nationally-representative. The sampling weights for the baseline survey take into account school selection probability by U.S. geographic areas, probability within the geographic area, and differential number of students across schools. Responses are also weighted by region of the country (West, Midwest, Northeast and South) and, within each region, by metropolitan/non-metropolitan status so that the impact of these factors on the analysis is proportional to their size in the nation. Substance use levels and demographics did not inform the sampling weights.

Analysis of the follow-up sample used the sampling weight multiplied by an attrition weight to take into account nonresponse. The attrition weight was calculated so that respondents with characteristics associated with lower probability of response had increased influence in the analyses and vice-versa. Specifically, the attrition weight was the inverse of the probability of response to the follow-up, modeled as a function of all baseline variables listed in Table 2. The sample for this attrition analyses included all baseline respondents, including those who did not provide contact information as well as those who did but did not respond to the follow-up survey.

Respondents to the follow-up survey contributed up to two observations (one from each survey wave) to the analysis pool. Comparisons of single variables across survey waves used Wald tests in the estimation of standard errors and took into account non-independence of responses from the same individuals. Multivariable regressions focused on dichotomous variables and used generalized estimating equations ("GEE", Diggle et al., 1995; Liang and Zeger, 1986) with specification of a binomial distribution and a logit link.

3. Results

All follow-up respondents were asked if their school building closed down before the end of the school year, to which 99 % reported that it

Table 3
Prevalence of Substance Use and Perceived Availability of Substances, Overall and by Social Distancing Levels.

		Social Distancing Levels		
	Total Sample	None to medium	High	Extreme
Prevalence				
Marijuana use in past 30 days				
Pre-pandemic	.23 (.17−.28)	0.26 (.19−.33)	0.20 (.08−.33)	0.15 (.05−.25)
During pandemic	.20 (.15−.25)	0.21 (.15−.27)	0.25 (.09−.40)	0.11 (.02−.21)
Binge drinking in past two weeks				
Pre-pandemic	.17 (.12−.22)	0.20 (.14−.27)	0.14 (.02−.26)	0.10 (.01−.19)
During pandemic	.13 (.09−.17)	0.19 (.13−.26)	0.04 (.00−0.08)	0.03 (-.01−.07)
Nicotine vaping in past 30 days				
Pre-pandemic	.24 (.19−.29)	0.32 (.25−.40)	0.17 (.06−.28)	0.06 (.01−.12)
During pandemic	.17** (.13−.22)	0.25 (.19−.32)	0.07 (.02−.12)	0.03 (-.01−.07)
Availability[a]				
Marijuana[b]				
Pre-pandemic	.76 (.67−.85)	.82 (.69−.94)	.75 (.54−.96)	.59 (.41−.77)
During pandemic	.59** (.54−.65)	.66** (.59−.74)	.56 (.43−.69)	.43 (.30−.56)
Alcohol[c]				
Pre-pandemic	.86 (.77−.95)	.96 (.90−1.01)	.83 (.62−1.03)	.66 (.41−.92)
During pandemic	.62** (.55−.68)	.69** (.61−.77)	.58* (.45−.71)	.43 (.31−.56)
Device for vaping nicotine[b]				
Pre-pandemic	.73 (.64−.82)	.81 (.71−.92)	.74 (.57−.90)	.51 (.29−.74)
During pandemic	.63* (.57−.69)	.75 (.68−.82)	.56 (.42−.70)	.34 (.22−.45)

* $p < .05$.
** $p < .01$.
[a] Availability defined as percentage of respondents reporting that it was "fairly easy" or "very easy" to get substance or vaping device.
[b] Question asked of a randomly-selected one-third of sample at baseline and of all respondents at follow up.
[c] Question asked of a randomly-selected one-sixth of sample at baseline and of all respondents at follow up.

had. This response indicates that essentially all survey respondents had been subject to some type of social distancing policies.

Table 3 presents prevalence and availability of substances before and after social distancing policies were implemented. The first column of estimates reports results for the total follow-up sample. For both past 30-day marijuana use and binge drinking, prevalence did not significantly change. However, for both substances perceived availability significantly decreased over the two survey waves. Specifically, the percentage of 12th grade students who reported they could "fairly easily" or "very easily" obtain marijuana decreased from 76 % to 59 %. For alcohol the comparable prevalence levels were 86 % to 62 %. Results for these two drugs are consistent with the "Persevering" hypothesis, which predicts steady or increasing changes in prevalence and a decrease in availability.

For nicotine vaping both prevalence and availability significantly decreased. The percentage of 12th grade students who vaped nicotine in the past 30 days declined from 24 % to 17 %, and the percentage reporting they could "fairly easily" or "very easily" obtain a vaping device declined from 73 % to 63 %. These results are consistent with the "Constriction of Supply" hypothesis, which predicts a decrease in both prevalence and availability.

Table 3 results, which are shown in Fig. 1, present additional findings by social distancing levels at follow-up. These comprise three groups defined as: "extreme," consisting of adolescents who reported not meeting any friends in person since the pandemic started (20 % of the sample); "high," consisting of adolescents who reported that they "always or almost always" both stayed six feet apart and also wore a facemask when with friends who did not live with them (18 % of the sample); and "none to medium" consisting of adolescents who reported lower levels of social distancing (61 % of the sample). Across all three substances, the adolescents at the lower levels of social distancing reported substantially higher levels of both pre-pandemic substance use and perceived availability.

For marijuana use and nicotine vaping, each of the three social distancing groups show the same patterns observed in the overall sample. Marijuana prevalence was little changed and perceived marijuana availability decreased in each of the "extreme," "high, and "none to medium" social distancing groups. These results show support for the "Persevering" hypothesis at all levels of social distancing.

For nicotine vaping both prevalence and availability of vaping devices decreased in each of the three social distancing groups. These results show support for the "Constriction of Supply" hypothesis at all levels of social distancing.

Changes in binge drinking prevalence across the two survey waves differed across the social distancing groups. Consistent with the results for the overall sample, findings for the "none to medium" social distancing group indicated no change in prevalence across the two waves despite a substantial decrease in alcohol availability. This "none to medium" group comprises the majority of the respondents, and therefore drives much of the findings for the overall sample when all social distancing groups are combined. These results indicate that this social distancing group provides support for the "Persevering" hypothesis.

In contrast, for the "high" and "extreme" social distancing groups, prevalence levels decreased across the two survey waves. In conjunction with the decrease in alcohol availability, these results support the "Constriction of Supply" hypothesis within these two social distancing groups.

Tables 4 and 5 present multivariable regressions of substance use and availability as a function of survey wave, social distancing group, and selected controls. These models confirm the patterns of results observed in the bivariate results in Tables 3 and 4. The findings for marijuana use show no change in prevalence across the two waves (Table 4), despite a significantly decline in availability (Table 5). The pattern for nicotine vaping shows a significant decrease across the two waves in both prevalence (Table 4) and availability (Table 5).

The pattern for binge drinking differs across social distancing groups. For the "none to medium" social distancing group no difference in binge drinking across waves was present, as indicated by an odds ratios of 0.92 for the "second survey wave" indicator (which references the "none to medium" group in the context of the multiplicative interaction term). Alcohol availability declined for this group across the two waves, as it did for all three social distancing groups (Table 5). For the "high" and "extreme" social distancing groups the models support a decrease across the two waves in both prevalence (with a significant value of 0.44 for the multiplicative interaction term), and availability of alcohol (Table 5).

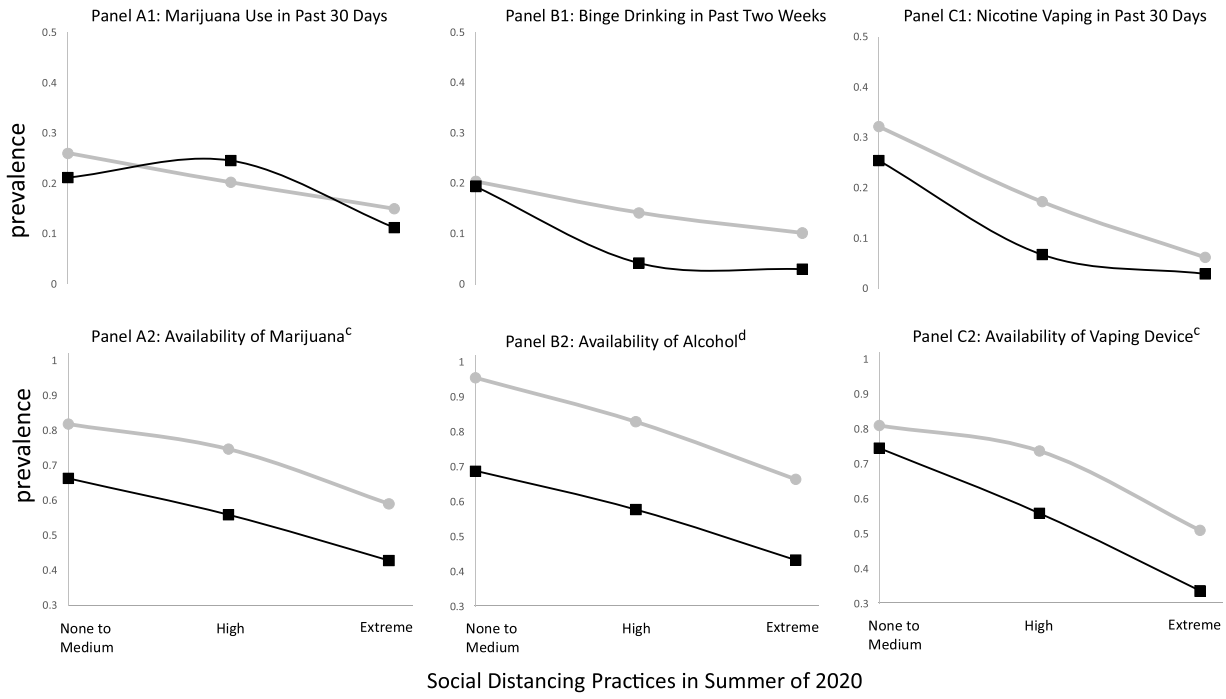

Fig. 1. Prevalence of Substance Use and Substance Availability Before and During the 2020 Pandemic, by Level of Social Distancing in Summer of 2020. [a]Assessed between February 11 and March 15, 2020; [b]Assessed between July 16 and August 10, 2020; [c]Question asked of a randomly-selected one-third of sample as baseline and all respondents at follow-up; dQuestion asked of a randomly-selected one-sixth of sample at baseline and of all respondents at follow up.

Table 4
Prevalence of Substance Use as A Function of Survey Wave, Social Distancing, and Controls.

	30-Day Marijuana Use		Binge Drinking in Past Two Weeks		30-Day Nicotine Vaping	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Second survey wave	.84	.83	.92	.92	.64**	.63**
	(.60–1.18)	(.57–1.20)	(.60–1.40)	(.60–1.40)	(.47–.88)	(.46–.88)
Social Distancing Practices[a]	.73	.60*	.65	.64	.35**	.36**
	(.50–1.06)	(.40–.90)	(.39–1.07)	(.39–1.07)	(.22–.55)	(.23–.59)
(Second survey wave) x			.44*	.44*		
(Social Distancing Practices)			(.20–.96)	(.20–.96)		
Female		1.07		1.06		.63
		(.62–1.84)		(.57–1.97)		(.37–1.09)
White		.86		1.60		2.35*
		(.45–1.65)		(.84–3.04)		(1.21–4.54)
Grade point average		1.32**		1.22*		1.11
		(1.11–1.56)		(1.02–1.46)		(.94–1.31)
Parent has college		.66		1.13		.89
education		(.32–1.35)		(.51–2.50)		(.42–1.88)
Constant	.35**	.17**	.26**	.09**	.50**	.28*
	(.24–.50)	(.07–.44)	(.17–.39)	(.03–.27)	(.36–.70)	(.11–.75)

[a] Coded 0 for none to medium, 1 for high, and 2 for extreme.
* $p < .05$.
** $p < .01$.

As a sensitivity analysis we also computed all estimates without observations that had imputed values for the dependent outcomes of past 30-day marijuana use, binge drinking in the past two weeks, and past 30-day nicotine vaping. At both survey waves these variables were 93 % complete or higher. These sensitivity analyses resulted in no changes in the significance levels for comparisons across survey waves for any of the study outcomes (available from the authors upon request).

4. Discussion

This study set out to examine how U.S. adolescent substance use prevalence and availability changed during the pandemic. To address this question, we used a national sample of U.S. 12th grade students who were surveyed both before and after the implementation of social distancing policies.

Results for the overall sample indicate the largest decreases in substance use availability ever recorded in the 46 consecutive years it has been monitored by Monitoring the Future. For marijuana a decline from 76 % to 59 % in the percentage of 12th grade students who could "fairly easily" or "very easily" get marijuana is quite striking. This 17 percentage point decline compares with 2% as the previous, largest single year, absolute change since 1975 for this outcome (Miech et al., 2020b). For alcohol the 24 percentage point decline in availability, from 86 % to 62 %, is also striking and compares with 1% as the previous, largest year-to-year change since first measured in 1999 (Miech et al., 2020b). These results therefore point to the pandemic as a unique opportunity to

Table 5
Prevalence of Perceived Substance Use Availability as A Function of Survey Wave, Social Distancing, and Controls.

	Marijuana Availability[a]		Alcohol Availability[b]		Vaping Device Availability[a]	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Second survey wave	0.50**	0.48**	0.26**	0.24**	0.55**	0.56*
	(0.35–0.71)	(0.34–0.69)	(0.13–0.50)	(0.12–0.50)	(0.33–0.92)	(0.33–0.94)
Social Distancing	0.61**	0.59**	0.58**	0.65**	0.44**	0.48**
Practices[c]	(0.46–0.83)	(0.42–0.81)	(0.42–0.78)	(0.47–0.90)	(0.33–0.59)	(0.35–0.65)
Female		1.12		1.28		1.06
		(0.67–1.87)		(0.75–2.16)		(0.65–1.74)
White		1.17		1.61		1.51
		(0.62–2.18)		(0.88–2.93)		(0.85–2.67)
Grade point average		1.19*		0.89		0.94
		(1.01–1.41)		(0.76–1.04)		(0.81–1.10)
Parent has college		1.03		1.02		1.38
education		(0.59–1.80)		(0.53–1.96)		(0.77–2.46)
Constant	3.98**	2.05	8.82**	9.14**	5.20**	4.09**
	(2.44–6.49)	(0.72–5.82)	(4.59–16.94)	(3.16–26.40)	(2.99–9.05)	(1.61–10.35)

[a] Question asked of a randomly-selected one-third of sample at baseline and of all respondents at follow up.
[b] Question asked of a randomly-selected one-sixth of sample at baseline and of all respondents at follow up.
[c] Coded 0 for none to medium, 1 for high, and 2 for extreme.

assess the proposition that decreases in substance availability will lead to decreases in substance use prevalence.

Support for and against the four hypotheses of this study vary by substance and by social distancing levels. The "Perseverance" hypothesis, which predicts that adolescent drug use prevalence would continue unchanged despite decreased availability (hypothesis #3), is supported in analysis of marijuana and alcohol use in the total sample. Availability of both of these substances decreased by a record amount, yet overall prevalence was little changed. The percentage of 12th grade students who had used marijuana in the past 30 days was 23 % before the pandemic and 20 % during, while for binge drinking the respective prevalence levels were 17 % and 13 %. For neither outcome did prevalence significantly decrease in the sample as a whole.

In contrast, the "Constriction of Supply" hypothesis (#2) finds support in analysis of nicotine vaping. As predicted by the hypothesis, for this outcome significant declines took place across the survey waves both in prevalence, from 24 % to 17 %, and in availability of vaping devices, from 73 % to 63 %.

Changes in binge drinking varied by social distancing group. While prevalence of binge drinking did not significantly decrease in the total sample across the two waves, this is in part because of the small level of change among the "none to medium" social distancing group. Within the two other social distancing groups of "high" and "extreme," binge drinking prevalence did significantly decrease, as indicated by the multiplicative interaction terms in the study's regression models, and as indicated in Fig. 1. Consequently, these results are consistent with the "Constriction of Supply" hypothesis (#1) among adolescents at higher levels of social distancing, who experienced both decreased availability and decreased alcohol prevalence. An important caveat is that these findings apply specifically to a subgroup and not to the total sample.

In all, the results of this study support three main conclusions. First, overall U.S. adolescent substance use prevalence decreased surprisingly little during the pandemic by the summer of 2020. Despite social distancing efforts to sharply limit adolescent interactions with others, prevalence of marijuana use and binge drinking continued as they did before the pandemic. This finding is consistent with evidence from Canada, where adolescent use of marijuana may have actually increased during the pandemic (Dumas et al., 2020).

A second main conclusion is that record decreases in availability of substances did not track with decreases in prevalence. These results underscore the substantial challenges facing a supply-side strategy for the reduction of adolescent substance use. Part of the reason the large decreases in availability did not translate into prevalence reduction is that availability levels were so high to start with. At baseline, more than three quarters of all adolescents reported they could easily get marijuana or alcohol. Even with the substantial declines in availability by the second survey wave, the majority of adolescents still reported they could easily obtain them. In addition, the results of this study suggest that adolescents may step up their efforts to obtain these substances if availability becomes more difficult. Given these factors, efforts to reduce substance prevalence through supply reduction would be expected, if successful, to face an extended period in which availability declines are not matched by any reductions in prevalence. Unknown is the threshold at which associated prevalence declines begin to take place, as well as the cost to get to that threshold.

A third main conclusion is that changes in substance use prevalence during the pandemic were substance-specific. Each of the three substances in this study has its own unique pattern of changes in prevalence and availability across the two survey waves. This result is consistent with the more general finding that adolescent drugs of abuse vary widely in terms of their historical trajectories of prevalence. Each substance responds to its various determinants in a unique way, a list of determinants that now includes global pandemics.

These study findings point to at least two topics that warrant future research. First, low levels of pre-pandemic drug use at baseline were strong, prospective predictors of high social distancing months later. This result suggests that social distancing behaviors likely overlap with concepts such as conscientiousness and rule-following. Extension of existing work on the determinants and moderators of these psychological factors to the study of adolescent substance use during the pandemic hold high potential to yield new insights. A second potential avenue for future research is to focus on subgroups of adolescents of theoretical and policy interest, such as adolescents with high impulsivity, low parental monitoring, or specific genetic characteristics. The pandemic offers a unique opportunity to examine the extent to which these factors are sensitive to social/historical context, as well as their role in efforts to reduce adolescent drug use through supply reduction.

We note four limitations of this study. First, participants who did versus did not return the follow-up survey differed in their initial, baseline prevalence levels of substance use. To reduce this potential influence on the study results the analyses weighted the follow-up respondents so that those with study characteristics associated with lower probability of follow-up response had increased influence in the analyses and vice-versa. This procedure calibrates the analyses so that the weighted follow-up sample very closely resembles the original, full baseline sample on all characteristics of the study (documented in Table 2). Another possibility is that adolescents who returned the survey may be those whose drug behaviors were most or least constrained by social distancing policies. To take into account this potential bias the study included questions about social distancing and presents results

stratified by social distancing levels. In addition, the analyses took into account social distancing levels in the multivariable models.

A second limitation is that macrosocial factors other than the pandemic may have independently and concurrently influenced changes in substance use prevalence and availability across the two survey waves. In particular, nicotine vaping prevalence may have declined as a result of factors such as the national "Tobacco to 21" law that went into effect in early 2020 (U.S. Congress, 2019), as well as the negative publicity surrounding vaping-induced lung injuries (Centers for Disease Control and Prevention, 2019; Krishnasamy et al., 2020). Monitoring trends in nicotine vaping prevalence in the coming years will indicate if the decline noted in this study was specific to 2020 – consistent with a unique role for the 2020 pandemic – or if the decline continues – consistent with a role for factors other than the pandemic.

A third limitation is that this study is limited to a follow-up period of four to seven months. Results may differ at different lengths of follow-up. A fourth limitation is that the study does not focus on other, less prevalent types of substance use such as cocaine.

5. Conclusion

Perceived availability of marijuana, alcohol, and vaping devices among adolescents declined during the pandemic at the steepest levels ever recorded in the past four decades in the U.S. Lack of accompanying reductions in prevalence for marijuana and binge drinking demonstrates the substantial challenges facing a supply-side approach to the reduction of adolescent use of these substances.

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Contributors

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Declaration of Competing Interest

The authors report no declarations of interest.

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