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What Does Adolescent Substance Use Look Like During the COVID-19 Pandemic? Examining Changes in Frequency, Social Contexts, and Pandemic-Related Predictors

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A B S T R A C T

Purpose: The overarching goal of this study was to provide key information on how adolescents' substance use has changed since the corona virus disease (COVID)-19 pandemic, in addition to key contexts and correlates of substance use during social distancing.
Methods: Canadian adolescents (n = 1,054, M_{age} = 16.68, standard deviation = .78) completed an online survey, in which they reported on their frequency of alcohol use, binge drinking, cannabis use, and vaping in the 3 weeks before and directly after social distancing practices had taken effect.
Results: For most substances, the percentage of users decreased; however, the frequency of both alcohol and cannabis use increased. Although the greatest percentage of adolescents was engaging in solitary substance use (49.3%), many were still using substances with peers via technology (31.6%) and, shockingly, even face to face (23.6%). Concerns for how social distancing would affect peer reputation was a significant predictor of face-to-face substance use with friends among adolescents with low self-reported popularity, and a significant predictor of solitary substance use among average and high popularity teens. Finally, adjustment predictors, including depression and fear of the infectivity of COVID-19, predicted using solitary substance use during the pandemic.
Conclusions: Our results provide preliminary evidence that adolescent substance use, including that which occurs face to face with peers, thereby putting adolescents at risk for contracting COVID-19, may be of particular concern during the pandemic. Further, solitary adolescent substance use during the pandemic, which is associated with poorer mental health and coping, may also be a notable concern worthy of further investigation.

IMPLICATIONS AND CONTRIBUTION

Since COVID-19-related social distancing began, the frequency of adolescent alcohol and cannabis use has increased. Substance use is occurring in multiple contexts, including face to face with friends. Predictors include greater peer reputation concerns, self-reported popularity, and depressive symptoms. Furthermore, solitary substance use is a marker for heightened COVID-19-related fears.

Substance use remains a salient activity among North American adolescents. In 2019, more than 40% of Canadian adolescents aged 13–18 years engaged in alcohol use, with the frequency of drinkers (66.0%) and binge drinkers (28.2%) peaking in grade 12. Furthermore, 22.0% and 22.7% of adolescents have used cannabis products and e-cigarettes (vapes) in the past year (40.4% and 34.9% for grade 12s) [1]. Developmental theories of adolescence and adolescent substance use [2–4] point to this time in life as one of substance use exploration and identify developmentally salient predictors

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including social pressures and rewards, mood disruptions, and parental modelling. This is concerning given that adolescent substance use can lead to substance use disorders, dependence, and poorer physical and mental health [5,6].

Current rates of adolescent substance use have likely been affected, however, by the corona virus disease (COVID)-19 pandemic. On March 11, 2020, the World Health Organization declared the COVID-19 outbreak a global pandemic, which resulted in strict social distancing measures in many geographic regions, including the closure of secondary schools.

Given that most adolescents consume substances for social reasons and may be less likely to do so alone [7,8], this behavior may be limited during the COVID-19 pandemic. This assumes, however, that (1) all adolescents are abiding by social distancing guidelines and (2) social contexts for substance use can only occur in face-to-face settings. Regarding the former, some adolescents may not feel that the consequences of contracting the corona virus are as severe as that of older adults. Research indicates that adolescents perceive themselves to be less at risk for various health outcomes [9] and are more willing to take risks in the face of social rewards than adults [10]. Thus, adolescents may be willing to meet up with peers during the COVID-19 pandemic, potentially with or without parents' knowledge. Regarding the latter point, technology has drastically changed the way we interact with one another, and thus, we are able to build social contexts that do not require face-to-face interaction. Notably, research indicates that 92% of adolescents report going online daily [11]. In addition, there is an emphasis on connecting socially via electronic means during the pandemic, which may encourage adolescents to use these means to maintain social connections. Thus, they may be engaging in substance use with their friends via video chat, text, or by posting to social networking sites.

Further, adolescents concerned with maintaining their peer reputation may be especially likely to maintain social substance use during the COVID-19 crisis. Popularity in adolescence is associated with engagement in mild-to-moderate risk behaviors, like drinking, which communicates a fun, cool, and mature image to peers [12–14]. Additional research demonstrates that popular adolescents with strong motives to maintain or enhance their reputation are at a heightened risk of substance use [15,16]. Thus, more popular adolescents who are especially concerned with how COVID-19-related social distancing will affect their reputation may be at heightened risk for social substance use.

In contrast, a minority of adolescents tend to use substances primarily for coping reasons [8,17]. These adolescents experience trait negative emotionality, a "tendency towards depression, anxiety, and poor reaction to stress" [18], and tend to engage in solitary substance use [19]. Solitary substance use in adolescence, particularly alcohol use, has garnered notable attention because it is associated with more frequent and heavy consumption and risk of alcohol use disorder [20]. During social distancing, individuals are faced with increased stress and loneliness, which may have a profound impact on mental health [21,22]. Adolescents who are feeling more depressed, anxious, and fearful for their safety due to the COVID-19 pandemic may engage in solitary substance use as a form of coping.

Finally, there may exist a subset of adolescents who are engaging in substance use with their families during self-distancing, including parents. A recent study demonstrated that 20% of 15- to 16-year-old Norwegian adolescents drank with their parents during their last alcohol use episode [23] and that this was associated with less frequent past-month binge drinking [23], potentially because of the opportunity for parents to model and coach moderate substance use. Thus, as compared to other substance-using adolescents, those who have used alcohol with parents while social distancing are likely engaging in less binge drinking, and other substance use (cannabis, vaping) that may not be as normative in the home as alcohol.

The goal of this study is to provide key information regarding how adolescents' substance use has changed since the COVID-19 crisis and examine developmentally salient predictors of adolescents' substance use patterns during social distancing. Adolescents from the province of Ontario, Canada completed an online survey containing measures of their substance use behavior both directly before (retrospective) and after the initial onset of the COVID-19 pandemic and related social distancing measures, in addition to their concerns and fears regarding the pandemic and self-distancing. We hypothesized the following:

H1: Although overall percentages and frequencies may have decreased in the weeks since the COVID-19-related social distancing began, adolescents will still be using substances, including alcohol, cannabis, and vaping products;

H2: Most adolescents who use substances during the COVID-19 crisis will do so within a peer context (i.e., face-to-face or using technology) as opposed to a solitary context;

H3: Adolescents higher in self-reported popularity will be more likely to engage in peer substance use during the COVID-19 crisis, especially when they feel greater concern for how social distancing will affect their reputation;

H4: Adolescents who feel more depressed, anxious, and fearful for their safety due to the COVID-19 crisis will be more likely to engage in solitary substance use than less depressed, anxious and fearful adolescents;

H5: Adolescents who consume substances with their parents during the COVID-19 crisis will be most likely to engage in alcohol use as compared to other substance use behaviors (H5a) and will engage in more alcohol use and less binge drinking, cannabis use, and vaping than adolescents who do not report drinking with their parents (H5b).

Method

Recruitment

Recruitment and data collection occurred from 4th April to 13th April 2020, approximately 3 weeks after Canadian citizens were encouraged to engage in social distancing. An advertisement was posted to our research laboratory's Instagram page and promoted on 16- to 18-year-old Ontarians' Instagram pages for one week. Adolescents younger than 16 years of age were not recruited in this way due to logistical issues of having to secure online parental consent. We further e-mailed the survey link to a group of adolescents ($n = 155$; 14–18 years of age) who are currently completing a longitudinal survey for the authors and for whom those under age 16 had already received parental consent. Reimbursement included entry into a draw to win one of $10–$50 gift cards or AirPods.

Participants

A total of 1,316 high school students completed our study, with 121 coming from our pool of pre-existing participants. Data from 262 participants were removed because they failed to correctly complete validation questions (e.g., "To respond to this question, please select strongly agree"). Our final sample

Table 1
Participant demographics

Demographics	% (*n*)
Gender	
Female	76.4 (805)
Male	21.9 (231)
Nonbinary/gender fluid	1.2 (12)
Prefer not to answer	.6 (6)
Ethnicity	
White/European	65.7 (693)
Asian	15.3 (161)
Black North American/African	3.9 (41)
Latino	3.1 (33)
Other	11.0 (116)
Prefer not to answer	.9 (10)
Guardians during social distancing	
Two parents in same house	67.6 (713)
Two parents in different homes	5.9 (62)
Mother only	14.6 (154)
Father only	2.7 (28)
Parent and step-parent	7.3 (77)
Grandparents	.9 (10)
Foster care	.6 (6)
Older sibling(s)	.4 (4)

consisted of 1,054 participants aged 14–18 years (M_{age} = 16.68, standard deviation [SD] = .78). See Table 1 for further demographic information.

Measures and procedure

Ethics was obtained by the lead authors' University Ethics Board. The 15-minute online survey contained a letter of information and request for informed consent, which was followed by demographic questions and the measures described in the following section.

Substance use behavior. Participants reported retrospectively the number of days "in the past 3 weeks before the COVID-19 crisis" and "since the COVID-19 crisis (e.g., the past 3 weeks)" on which they engaged in: (1) any alcohol use; (2) binge drinking (consuming 4 (females)/5 (males) or more drinks in one sitting [6]); (3) marijuana use (e.g., using joints, edibles); and (4) vaping (range = 0–21 days). Retrospective substance use measures of this nature have shown good predictive validity among adolescents, even one year later [24]. Further, participants checked off all social contexts in which they had used substances: (1) alone; (2) virtually with friends (e.g., over text, video or audio chat); (3) with physically present friends; and/or (4) physically present parents, with 0 = no use in this context and 1 = use in this context at least once. Finally, participants reported if they had shared pictures or videos of them using substances privately to friends (e.g., text) or as a social media post, with 0 = no sharing since the pandemic and 1 = sharing of one or more posts.

Fear of COVID-19 virus. Three items that assess worries about the infectivity of COVID-19 were taken from a larger COVID-19 stress scale [25]. The items—"How likely is it that you could become infected with the COVID-19 virus?" ,"If you did become infected with COVID-19, to what extent are you concerned that you will be severely ill?" and "How likely is it that someone you know could become infected with the COVID-19 virus?" —were measured on a 4-point scale from "not at all" to "very much." Internal consistency was .53.

COVID-19-related reputation concerns. On a 4-point scale, ranging from "not at all" to "very much," participants responded to an item created to measure COVID-19-related reputation concerns—"I am worried about how social distancing will affect my ability to keep up my reputation with my friends."

Depression and anxiety. We used the 6-item depression (α = .88) and 6-item anxiety (α = .92) subscales of the Brief Symptom Inventory [26]. Participants were asked to think about the past 7 days and rank their experience of each feeling such as "hopeless about the future" (depression item) and "nervousness or shakiness inside" (anxiety item) on a 5-point scale ranging from "not at all" to "extremely".

Self-reported popularity. Consistent with past research [15], we used one item to measure self-reported popularity. The item read "Think about the kids in your grade at your school. How popular are you compared to the rest of your grade (not just your friends)?" The 10-point scale contained the following anchors: "least popular" and "most popular."

Analytic plan

Hypotheses were tested using the statistical software SPSS, version 26. To examine H1, we first transformed participants'

Table 2
Percentage of substance using adolescents and mean number of substance-using days in the 3 weeks before versus 3 weeks into the COVID-19 pandemic

	Total sample (n = 1,054)			Females (n = 805)			Male (n = 231)		
	Pre-COVID-19	During COVID-19	*p*-value	Pre-COVID-19	During COVID-19	*p*-value	Pre-COVID-19	During COVID-19	*p*-value
Substance users, % (*n*)									
Alcohol	28.6 (301)	30.4 (320)	.23	29.2 (235)	30.1 (242)	.65	25.5 (59)	30.7 (71)	.13
Binge drinking	**15.7 (165)**	**9.8 (103)**	.00	**15.3 (123)**	**10.3 (83)**	.00	**16.9 (39)**	**7.8 (18)**	.00
Cannabis	**17.0 (179)**	**13.8 (145)**	.00	**16.4 (132)**	**13.4 (108)**	.00	18.6 (43)	15.2 (35)	.17
Vaping	**16.6 (175)**	**11.5 (121)**	.00	**15.9 (128)**	**10.7 (86)**	.00	**19.0 (44)**	**14.7 (34)**	.03
Number of substance-using days, M(SD)									
Alcohol	**.76 (1.77)**	**.96 (2.14)**	.02	**.77 (1.82)**	**.96 (2.17)**	.03	.73 (1.64)	.92 (2.06)	.34
Binge drinking	.41 (1.41)	.33 (1.34)	.25	.41 (1.46)	.36 (1.43)	.27	.45 (1.30)	.25 (1.02)	.75
Cannabis	**.94 (3.28)**	**1.10 (3.76)**	.01	**.89 (3.19)**	**1.07 (3.70)**	.01	1.14 (3.62)	1.17 (3.85)	.88
Vaping	1.59 (4.81)	1.30 (4.48)	.49	1.52 (4.67)	1.27 (4.49)	.92	1.86 (5.34)	1.45 (4.60)	.31

Bolded % (*n*) indicates significant differences in percentage of substance use before and during the COVID-19 pandemic, as indicated by McNemar's tests; Bolded M (SD) indicates significant differences in frequency of substance use before and during the COVID-19 pandemic, as indicated by repeated measures ANOVAs.
ANOVA = analysis of variance.

Table 3
Percentage of substance using adolescents and mean number of substance using days across social context

Social context of substance use	%(*n*) of users				%(*n*) of users based on substance used			
	Total	Females	Males	Gender difference· X^2, *p*	Alcohol	Binge drinking	Cannabis	Vaping
Endorsement of individual items								
With friends via technology	31.6 (134)	32.4 (101)	29.4 (30)	.31, .58	77.6 (104)	38.8 (52)	46.3 (62)	46.3 (62)
With friends face-to-face	23.6 (100)	**21.5 (67)**	**31.4 (32)**	4.14, .04	67.0 (67)	29.0 (29)	55.0 (55)	39.0 (39)
Alone	49.3 (209)	**46.2 (144)**	**57.8 (59)**	4.20, .04	67.0 (140)	31.6 (66)	48.3 (101)	43.1 (90)
With parents	42.0 (178)	**46.5 (145)**	**30.4 (31)**	8.14, .00	93.3 (166)	25.8 (46)	19.1 (34)	14.6 (26)
Sent substance use posts to peers	36.2 (157)	**40.4 (130)**	**23.5 (25)**	9.45, .00	78.3 (119)	37.5 (57)	39.5 (60)	38.2 (58)
Categories of adolescents					M number of days used (SD)			
With friends only	13.4 (57)	12.5 (39)	15.7 (16)	.68, .41	1.05 (1.34)^{a,b}	.21 (1.10)^{a}	2.86 (6.06)^{a}	2.79 (6.67)
Alone only	20.8 (88)	**17.3 (54)**	**28.4 (29)**	5.93, .02	1.59 (2.65)^{c}	.52 (1.45)^{b}	2.06 (4.61)^{b}	3.15 (6.26)^{a}
With parents only	27.8 (118)	**31.3 (97)**	**18.6 (19)**	5.92, .02	2.18 (2.14)^{a,d}	.36 (1.08)^{c}	.69 (3.05)^{a,c}	.62 (3.09)^{a,b}
In multiple contexts	38.0 (161)	39.1 (122)	37.3 (38)	.11, .74	3.38 (3.38)^{b,c,d}	1.48 (2.71)^{a,b,c}	4.55 (6.57)^{b,c}	5.33 (7.89)^{b}

Total n of substance users = 424, *n* substance-using girls = 312, *n* substance-using boys = 102; Bolded percentages note significant gender differences as identified by X^2 tests of independence; Means in the same column that are denoted by the same subscript are significantly different from one another ($p < .05$) as indicated by a Tukey's HSD post hoc test in a multivariate ANOVA.
ANOVA = analysis of variance; SD = standard deviation.

frequency scores for our four substance use variables—alcohol use, binge drinking, cannabis use, and vaping—into dichotomous variables with 0 = never used and 1 = used one or more times. We then used McNemar's test to examine if the proportion of adolescents who used each substance changed from pre-COVID to 3 weeks post-COVID. To examine changes in substance use frequency, we ran four repeated measures analyses of variances (ANOVAs) with the number of days of alcohol use, binge drinking, cannabis use, and vaping as the outcome variables. All participants, including those with scores of 0 (no substance-using days), were included in these analyses. We controlled for demographic variables, including age, gender (0 = male; 1 = female), and ethnicity (0 = non-white; 1 = white).

To examine H2, we compared the percentage of substance-using adolescents who reported using alone versus with friends (either face-to-face or via technology). We further categorized substance-using adolescents based on the contexts in which they had used substances and compared the percentage of participants that fell within each group. To identify potential gender differences in substance use contexts, we ran a series of X^2 tests of independence.

To test H3 and H4, we ran a series of binary logistic regressions with the following dichotomous dependent variables: whether or not adolescents had used (1) substances alone; (2) with friends using technology; (3) face to face with friends; (4) with parents; and (5) if they had sent posts of their substance use to peers. In all models, we controlled for demographic variables and participants' mean number of substance-using days in the 3 weeks before the pandemic. In the models testing H3, we entered self-reported popularity, social distancing–based reputation concerns and the interaction between these variables as predictors. Predictor variables were grand-mean centered. We plotted significant interactions above (+1 SD), below (−1 SD), and at the mean for each predictor [27] and used the PROCESS Macro for SPSS to estimate the simple slope at each conditional level of the moderator (i.e., reputation concerns) [28]. In the models testing H4, we entered depression, anxiety, and COVID-19 fear as predictors.

To test H5, we examined the percentage of adolescents who had consumed alcohol versus other substances with their parents during the COVID-19 crisis (H5a) and the percentage of adolescents who had consumed substances with their parents versus in other social contexts (H5b). We also ran a series of multivariate ANOVAs with the main predictor variable being social context of substance use and the outcome variables being days of alcohol use, binge drinking, cannabis use, and vaping during COVID-19. Demographic variables and frequency of pre-COVID-19 substance use were included also as covariates.

Results

Adolescent substance use rates

As shown in Table 2, the percentage of adolescents who used alcohol did not change significantly from pre- COVID to post-COVID (28.6%–30.1%, $p = .23$). In contrast, the frequency of alcohol use (i.e., average number of alcohol-using days) increased significantly ($F(1, 1{,}029) = 5.23$, $p = .02$). Although gender was not a significant moderator of this effect ($F(1, 1{,}029) = .09$, $p = .76$), analyses separated by gender revealed this increase was only significant for girls ($F(1, 799) = 4.61$, $p = .03$) and not for boys ($F(1, 225) = .93$, $p = .34$). Further, the percentage of adolescents who binge drank and vaped dropped significantly (5.9% decrease for binge drinking, from 15.7% to 9.8%, $p < .01$ and 5.1% decrease for vaping, from 16.6% to 11.5%, $p < .01$), and there were no significant frequency changes in either behavior (binge drinking: $F(1, 1{,}029) = 1.34$, $p = .25$; vaping: $F(1, 1{,}029) = .49$, $p = .49$). Finally, the percentage of cannabis using adolescents decreased for girls only (3% decrease, from 16.4% to 13.4%, $p < .01$) and yet, the frequency of cannabis use (average number of cannabis using days) increased significantly from pre-COVID to post-COVID ($F(1, 1{,}029) = 8.04$, $p = .01$). Again, although gender was not a significant moderator of this effect ($F(1, 1{,}029) = .64$, $p = .42$), analyses separated by gender revealed this increase was only significant for girls ($F(1, 799) = 8.04$, $p = .01$) and not for boys ($F(1, 225) = .02$, $p = .88$).

Contexts of substance use

In contrast to H2, the largest percentage of substance-using adolescents (49.3%) had engaged in solitary substance use since the COVID-19 pandemic compared to 23.6% and 31.6% who had used with friends face-to-face and via technology, respectively. Further, a sizeable percentage of adolescents used substances

Table 4
Binary logistic regressions predicting social contexts of substance use during COVID-19 pandemic

	SU alone			SU with friends via technology			SU with friends face-to-face			Sent posts of SU to friends			SU with parents		
	Exp(*B*)	95% CI	*p*	Exp(*B*)	95% CI	*p*	Exp(*B*)	95% CI	*p*	Exp(*B*)	95% CI	*p*	Exp(*B*)	95% CI	*p*
Model 1 (hypothesis 3)															
Gender	**1.59**	**1.04–2.44**	.03	.81	.49–1.36	.43	1.65	1.00–2.72	.05	**.44**	**.26–.75**	.00	.71	.46–1.09	.12
Age	**1.32**	**1.03–1.69**	.03	**1.57**	**1.18–2.09**	.00	.82	.61–1.10	.19	**1.36**	**1.05–1.76**	.02	**1.44**	**1.15–1.79**	.00
Ethnicity	.72	.48–1.09	.12	.86	.54–1.38	.53	.95	.57–1.58	.85	.81	.53–1.25	.35	**.41**	**.27–.61**	.00
Pre-COVID substance use	**1.20**	**1.17–1.24**	.00	**1.16**	**1.13–1.19**	.00	**1.15**	**1.12–1.18**	.00	**1.14**	**1.11–1.17**	.00	**1.03**	**1.00–1.06**	.03
Reputation concerns	**1.16**	**1.01–1.33**	.03	1.13	.96–1.32	.16	1.08	.91–1.29	.36	1.10	.95–1.28	.20	.99	.87–1.12	.86
Self-reported popularity	.98	.90–1.06	.61	**1.14**	**1.03–1.26**	.01	1.04	.93–1.15	.53	**1.14**	**1.04–1.25**	.00	1.02	.95–1.10	.57
Popularity X rep concerns	**1.08**	**1.02–1.14**	.01	.96	.90–1.03	.28	**.91**	**.85–.98**	.01	1.01	.95–1.08	.73	.96	.91–1.01	.09
Model 2 (hypothesis 4)															
Gender	**1.86**	**1.20–2.87**	.01	.93	.55–1.56	.77	**1.71**	**1.02–2.85**	.04	**.52**	**.31–.89**	.02	.72	.47–1.12	.15
Age	1.27	.99	.06	**1.52**	**1.14–2.02**	.00	.81	.60–1.09	.16	**1.31**	**1.01–1.68**	.04	**1.42**	**1.14–1.77**	.00
Ethnicity	.68	.45–1.04	.07	.83	.52–1.33	.45	.93	.56–1.55	.79	.78	.51–1.20	.25	**.40**	**.27–.60**	.00
Pre-COVID substance use	**1.20**	**1.16–1.23**	.00	**1.16**	**1.13–1.19**	.00	**1.15**	**1.11–1.18**	.00	**1.14**	**1.11–1.17**	.00	**1.03**	**1.00–1.05**	.04
Fear of COVID-19	**1.45**	**1.02–2.07**	.04	1.15	.78–1.70	.49	1.13	.74–1.74	.58	1.25	.87–1.80	.22	.93	.68–1.27	.65
Depression	**1.57**	**1.21–2.04**	.00	1.07	.80–1.42	.67	.96	.70–1.31	.77	1.30	1.00–1.69	.05	1.08	.86–1.37	.50
Anxiety	.83	.66–1.03	.10	1.03	.80–1.31	.83	1.07	.82–1.41	.61	.91	.73–1.14	.41	.99	.81–1.21	.93

Bolded Exp(*B*) and 95% CIs indicate significant effects at $p < .05$; gender reference group = boys; ethnicity reference group = nonwhite.
CI = confidence interval; SU = substance use.

with parents during the COVID-19 pandemic (42.0%) (see Table 3). Finally, boys were significantly more likely to use substances alone (57.8%) and face-to-face with peers (31.4%) than girls (46.2% and 21.5%, respectively), $X^2(1) = 4.20$ and 4.14, p's $= .04$, and girls were significantly more likely to use substances with parents (46.5%) and to send posts of substance use to peers (40.4%) than boys (30.4% and 23.5%, respectively), $X^2(1) = 8.14$ and 9.45, p's $< .01$.

We further categorized adolescents into four groups based on their combination of contexts for substance use since social distancing: alone only, with friends only, with parents only, and in multiple contexts. Again, contrary to H2, the percentage of adolescents that had only engaged in solitary use (20.8%) was higher than those who only used with friends (13.4%; see Table 3). Even if we removed the 20.5% of adolescents in the "Substance Use Alone" category who had sent a picture or video to friends privately or via social media, thus making their substance use more social in nature, the percentage of solitary substance using adolescents (16.5%) would still be slightly higher than the percentage of those using only with friends (13.4%).

Predictors of adolescents' context of substance use

Table 4 shows the binary logistic models that predict the five different substance use context variables. In line with H3, adolescents higher in self-reported popularity were significantly more likely to engage in peer substance use, including using with friends via technology ($Exp(B) = 1.14$, $p = .01$) and sending substance use posts ($Exp(B) = 1.14$, $p < .01$). Further, an interaction between self-reported popularity and social distancing–related reputation concerns predicted face-to-face substance use with friends. Simple slopes analysis revealed that only among adolescents with low popularity did reputation concerns predicted a greater likelihood of using substances in face-to-face contexts with friends ($B = .28$, standard error [SE] $= .13$, $p = .03$; average popularity: $B = .08$, SE $= .09$, $p = .38$; high popularity: $B = -.13$, SE $= .11$, $p = .24$; see Figure 1). Interestingly, this interaction also predicted solitary substance use. Only among adolescents with average and high popularity did reputation concerns predicted a greater likelihood of using substances alone ($B = .15$, SE $= .07$, $p = .03$ and $B = .32$, SE $= .10$, $p < .01$, respectively; low popularity: $B = -.02$, SE $= .10$, $p = .86$; see Figure 1).

Further, consistent with H4, adolescents with greater fears of COVID-19 ($Exp(B) = 1.45$, $p = .04$) and more depressive symptomology ($Exp(B) = 1.57$, $p < .01$) were significantly more likely to engage in solitary substance use only (see Table 4).

Substance use patterns of adolescents who use with parents

In line with H5a, 93.3% of adolescents who used substances with their parents during the COVID-19 pandemic used alcohol, while only 25.8%, 19.1%, and 14.6% reported they binge drank, used cannabis, and vaped. Further supporting H5b, results of a significant multivariate ANOVA (Wilk's $\Lambda = .89$, $F(4, 410) = 3.70$, $p < .01$) demonstrated that social context was significantly associated with frequency of alcohol use ($F = 12.43$, $p = .00$), binge drinking ($F = 10.93$, $p < .01$), cannabis use ($F = 11.63$, $p < .01$), and vaping ($F = 11.67$, $p < .01$). A post hoc Tukey's test revealed that, in line with H5b, adolescents who only used substances with their parents during social distancing engaged in more drinking ($p = .05$) and less cannabis use ($p = .04$) than

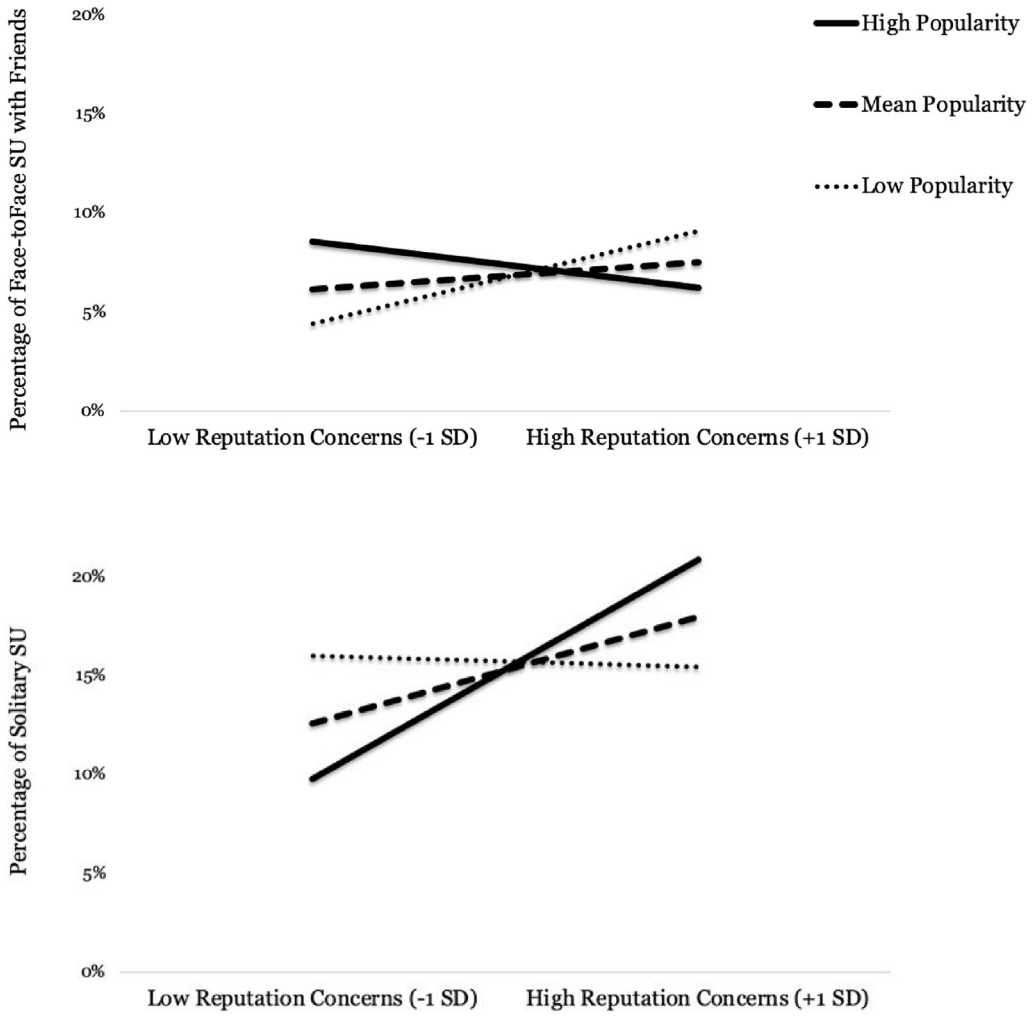

Figure 1. Interaction between self-reported popularity and reputation concerns due to COVID-19 social distancing predicting likelihood of substance use face-to-face with friends and alone.

adolescents who only used with friends and significantly less vaping ($p = .02$) than adolescents who only used alone (see Table 3 for statistics). Further, adolescents who have used substances in multiple contexts since the COVID-19 pandemic have engaged in significantly more alcohol use and binge drinking (p's $< .01$) than all other categories of adolescents, more cannabis use than adolescents who use alone and with their parents (p's $< .01$), and more vaping than adolescents who use with their parents ($p < .01$).

Discussion

Results shed light on adolescent substance use patterns, contexts, and correlates during the beginning of the COVID-19 pandemic. Despite emergency stay-at-home orders, a notable percentage of adolescents engaged in substance use in various contexts, including face-to-face. Specifically, while the percentage of adolescents who engaged in binge drinking, vaping, and cannabis use (girls only) significantly decreased from pre-COVID to 3 weeks post-COVID social distancing orders, there was not a significant change for percentage of alcohol users. Further, the frequency of alcohol and cannabis use increased. Perhaps with school being asynchronous and many leisure activities canceled, adolescents had more unstructured time, which is associated with antisocial behavior including substance use [29]. Further, research has shown that many adolescents procure substances from their own home, including alcohol [30,31] whereas vaping materials are generally obtained through peer networks [32] and thus were perhaps less accessible. Finally, adolescents in our study were likely spending more time with family, including parents, and less time in contexts conducive to binge drinking (e.g., parties).

Another notable finding is that there were still a significant number of adolescents who reported using with friends. However, social use of substances was not limited to face-to-face interactions; 31.6% of substance-using participants reported using substances in virtual contexts with friends and 36.2% reported sharing alcohol-related posts. However, in contrast with H2, more adolescents reported using substances alone than using with friends in either virtual or face-to-face contexts. This is surprising because substance use during adolescence typically occurs in the context of peers [33].

It is critical to note that solitary substance use in our study was related to both increased COVID-19 fears and depressive symptomology. Given that many adolescents were more isolated than pre-pandemic, it is possible that solitary substance use was of particular importance as a coping strategy among teens who are struggling to deal with negative feelings. Prospective studies suggest that first onset of depression typically occurs in early adolescence [34,35], and thus, it is possible that adolescent coping via solitary substance use is a marker of more severe mental health concerns [18–20].

Our results also suggest a surprisingly large number of adolescents were using substances with parents during the COVID-19 crisis. Lower rates of heavy drinking, cannabis use and vaping were reported when adolescents used substances with parents as compared to other contexts. However, research demonstrates that although adolescents who drink with parents may engage in more moderate drinking with parents, they are more likely to engage in high risk drinking outside of the home, potentially because of parents' demonstrated approval [36] and possible provision of alcohol [37,38]. What is unclear given our study design, however, is how much of these parental attitudes and behaviors were already present before the pandemic. One possible concern is that these permissive attitudes and behaviors either maintained or initiated during the first 3 weeks of social distancing orders will extend past the end of the pandemic and may have long-lasting effects on substance use in this age group.

Findings also indicate that adolescents higher in self-reported popularity were more likely to engage in peer substance use during the COVID-19 pandemic, including via technology and sending posts to friends. These findings are in line with Popularity Socialization Hypothesis [39], which suggests that popular adolescents play the biggest role in modeling mild-to-moderate risk behaviors. Further, self-reported popularity predicted context of substance use among adolescents who had strong concerns for how social distancing would affect their peer reputations; Adolescents with average to high popularity were more likely to engage in solitary substance use while adolescents with low popularity were more likely to engage in face-to-face substance use with peers. It is possible that with reduced opportunities to engage in substance use with friends, more popular adolescents were attempting to uphold group norms via solitary substance use as well. Indeed, Social Identity Perspective [40] identifies that more prototypical group members who uphold group norms are rewarded by the group with increased trust and power over decisions. On the other hand, low-popularity adolescents, who may have less confidence that their friendships can withstand social distancing, may be more willing to engage in risky behavior, such as face-to-face substance use during a pandemic, to maintain their social status.

Limitations and future Directions

This study is not without limitations. First, examining change in drinking in the same survey with retrospective measurement of past behavior may lead to errors in self-report. It is also possible that since this study was conducted relatively close to the start of the pandemic, we may not have captured adolescents' established routines. Future research should examine adolescent substance use trends across time as the pandemic continues to affect daily life. Further, we had more statistical power to detect significant effects among girls (76.4% of the sample) than boys. Therefore, results demonstrating that change in alcohol and cannabis frequency were significant for girls only must be interpreted with caution given also we found no moderating effects of gender for these effects. Finally, given that these data were collected from a primarily Caucasian, Canadian sample, it is unclear how these results may generalize to different cultures and populations.

Despite limitations, this study sheds important light on substance use trends and correlates among adolescents during the COVID-19 pandemic. Results provide preliminary evidence that adolescent substance use, and in particular, solitary use, may be of concern. As the pandemic continues to evolve, it is important to continue to monitor the effects on adolescents, in particular as related to their substance use and mental health.

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