Adolescents' Use of Free Time and Associations with Substance Use from 1991 to 2019

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Abstract

Background: Understanding time trends in risk factors for substance use may contextualize and explain differing time trends in substance use.

Methods: We examined data (N=536,291; grades 8/10/12) from Monitoring the Future, years 1991-2019. Using Latent Profile Analyses, we identified six time use patterns: one for those working at a paid job and the other five defined by levels of socialization (low/high) and engagement in structured activities like sports (engaged/disengaged), with the high social/engaged group split further by levels of supervised social activities. We tested associations between time use profiles and past two-week binge drinking as well as past-month alcohol use, cigarette use, cannabis use, other substance use, and vaping. We examined trends and group differences overall and by decade (or for vaping outcomes, year).

Results: Prevalence of most substance use outcomes decreased over time among all groups. Cannabis use increased, with the largest increase in the group engaged in paid employment. Vaping substantially increased, with the highest nicotine vaping increase in the high social/ engaged group with less supervision and the highest cannabis vaping increase in the highly social but otherwise disengaged group. Substance use was lowest in the low social groups, highest in the high social and employed groups.

Conclusions: While alcohol, cigarette, and other substance use have declined for all groups, use remained elevated given high levels of social time, especially with low engagement in structured

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activities or low supervision, or paid employment. Cannabis use and vaping are increasing across groups, suggesting the need for enhanced public health measures.

Keywords

Adolescent; Alcohol; Cannabis; Cigarettes; Vaping; Time Use; Epidemiology

1. INTRODUCTION

Substance use among adolescents, such as drinking alcohol, smoking cigarettes, or using cannabis, has a broad array of potential adverse physical and mental health sequelae. Heavy and prolonged use of substances can lead to sleep disturbances (Kwon et al., 2019), unintentional injuries, academic problems, psychosocial issues (Pediatrics, 2019), and substance use disorders (Chassin et al., 2014). Fortunately, adolescent use of many substances has been declining since the 1990s, with the exceptions of cannabis (Han et al., 2017; Johnston et al., 2020) and vaping including cannabis, nicotine, or other substances used through heated aerosols in electronic cigarettes (Miech et al., 2020).

The factors underlying different substance use trends remain poorly understood. Some known risk factors for elevated adolescent substance use, including unsupervised time with friends (Flannery et al., 1999; Lee and Vandell, 2015), have also declined since the 1990s, along with other social behaviors such as dating and partying (Borodovsky et al., 2021; Twenge and Park, 2019). Examining patterns of how adolescents spend their time may illuminate the extent to which unsupervised or unstructured social time with peers and other activities are linked to shifting trends in substance use. In particular, the decline in unmonitored social time with peers presents one possible explanation for declining adolescent alcohol and cigarette use, given that parental monitoring is linked to lower substance use (Haas et al., 2018; Rusby et al., 2018; Smith et al., 2017), and social venues, like parties, can make substances more accessible and socially desirable (de Jong et al., 2020; Price Wolf et al., 2019). Further, as cannabis use and vaping remain prevalent among most groups of adolescents, understanding trends in a broad array of substances with heterogeneous temporal trajectories may help to illuminate relationships between time use and substance use and inform initiatives aimed at reversing these rising trends.

Past-month alcohol use peaked in 1996 for those in grade 8 (26.2%) before dropping to 7.3% in 2016, and for those in grade 10, prevalence peaked in 1991 (42.8%) before dropping to 18.4% by 2019 (Johnston et al., 2020). Grade 12 saw a similar decline, with 54.0% prevalence in 1991 and 29.3% in 2019. A similarly strong decades-long decline occurred for cigarette use; the prevalence of past month use peaked in 1996 for adolescents in grades 8 and 10 and 1997 for those in grade 12. Prevalence then declined to a low of 1.9% in 2017 for grade 8 and 3.4% and 5.7% in 2019 for grades 10 and 12. At the same time, however, cannabis and vaping have not declined. Indeed cannabis use has been slowly increasing among adolescents in recent years (Johnston et al., 2020), while vaping has increased more rapidly, with over one in five adolescents in grade 10 and one in four adolescents in grade 12 vaping nicotine in the past 30 days as of 2019 (Miech et al., 2019). Increases in vaping are especially concerning given that acute health effects, such as e-cigarette or vaping product

use-associated lung injury, have been documented among adolescents (Adkins et al., 2020; Lozier et al., 2019), and these devices can administer high doses of a substance like delta-9 tetrahydrocannabinol (THC), amplifying risk of harm (Spindle et al., 2019).

Uncovering links between complex patterns of time use and substance use outcomes could reveal new opportunities for intervention and education of adolescents surrounding substances, helping to promote declines in use. Therefore, this study had several aims. First, we estimated the overall association between varied patterns of adolescent time use and alcohol, cigarettes, cannabis, other substance use, and vaping. Second, we estimated time trends in substance use by patterns of adolescent time use to understand shifts in prevalence, either overall or specific to certain time use groups. Third, we tested for heterogeneity in the relation between time use groups and substance use by decade since 1991 in order to articulate ways that these patterns may have changed over time. Finally, given the recency and potential importance of vaping, we examined the links between patterns of adolescent time use and nicotine and cannabis vaping by year since 2017.

2. METHODS

We used data from 536,291 adolescents in the Monitoring the Future (MTF) study (grades: 8/10/12, years: 1991-2019) (Johnston et al., 2020). Data were gathered through annual nationally-representative surveys of adolescents. Schools were chosen with a multi-stage random sampling design. These data feature survey weighting that accounts for this complex survey design and the selection probabilities of respondents. Selected schools were invited to participate for two years, and those that declined participation were replaced with schools with similar urbanicity, size, and geographic location. Self-administered questionnaires were given to students. Students received one of several survey versions called subforms. By grade and year, student response rates ranged from 79% (e.g., grade 12 in 2017) to 91% (e.g., grade 8 in 2012). The Institutional Review Boards of University of Michigan and Columbia University approved the study protocol and analytic aims, respectively.

2.1. Measures

Time Use.—We examined seventeen ordinal variables that covered a broad variety of adolescent time use domains (social, academic, recreational, etc.). Full items are available in Supplemental Table 1, including the variables that were combined into more comprehensive measures (e.g., combining items asking about reading newspapers and reading magazines into a comprehensive measure of reading periodicals). Social media use, one of the time use items, was only available from 2009 onward.

We examined patterns of adolescent time use with Latent Profile Analysis (LPA) in Mplus (Asparouhov and Muthén, 2014; Vermunt, 2010) using the 17 time use-related items described above (Masyn, 2013). In order to balance analytic metrics, interpretability, and preservation of a usably large sample in each time use group, we selected a six-group structure. These six groups were defined by patterns of social time, engagement in organized activities (such as sports), and paid employment. Apart from the group of adolescents working a substantial number of hours per week at a paid job (11 hours or more), time use groups were defined by combinations of amounts of social time (low vs high) and

level of engagement in organized activities (engaged vs disengaged). Those with high social time and high engagement were split further by levels of unsupervised activities (less vs more supervised). These groups, hereafter called time use groups, are summarized in Supplemental Table 2, with accompanying analytic metrics in Supplemental Tables 3 and 4.

Substance Use.—Seven binary substance use outcomes were examined: past-month cigarette smoking, alcohol use, cannabis use, other substance use, nicotine vaping and cannabis vaping (all coded as 1 occasion of use vs. none in the past month), as well as past two-week binge drinking (any vs. none in the past two weeks). Cigarette smoking, alcohol use, binge drinking, and cannabis use were each assessed with a single item. Other substance use was assessed with past-month use of any of the following: LSD, hallucinogens besides LSD, "crack", other forms of cocaine, amphetamines, tranquilizers, other narcotics, inhalants, steroids, heroin use with a needle, heroin use without a needle, and use of other injectable substances. Nicotine vaping and cannabis vaping data were available from 2017 onward. Full substance use items and response options are available in Supplemental Table 5.

Covariates.—Models accounted for the following covariates: grade (8th/10th/12th), highest level of parental education (less than high school, high school or some college, college graduate), sex (female/male), urbanicity (Metropolitan Statistical Area vs. not), race/ethnicity (White, Black, Hispanic/Latino, Multiracial, or Other), and school type (public, private Non-Catholic, private Catholic).

2.2. Statistical Analysis

We used a three-step process to examine the distribution and trends in time use profiles (Asparouhov and Muthén, 2014; Vermunt, 2010). First, we used the seventeen time use-related predictors to identify latent patterns of how adolescents spent their time. Second, we determined measurement error for the variable identifying most likely time use group membership. Third, we estimated outcomes using the most likely group and the measurement error determined in step 2 (Asparouhov and Muthén, 2014). This approach was used to examine the distribution and trends in time use-related variables. For logistic regression, however, we analyzed models using modal class assignment without incorporating measurement error, as the models were unable to simultaneously incorporate both the latent profile uncertainty and the survey weights.

Survey-weighted logistic regressions examined substance use outcomes (cigarette use, alcohol use, binge drinking, cannabis use, other substance use, vaping nicotine, and vaping cannabis) by time use group, adjusting for covariates. Additionally, we assessed interaction by decade (1991-1999, 2000-2009, 2010-2019) for the first five outcomes and by year (2017, 2018, 2019) for the vaping outcomes. We visualized prevalence of these outcomes by time use group and decade (or for vaping outcomes, year) to further highlight shifts over time.

3. RESULTS

Weighted proportions of demographic characteristics for each of the six groups are reported in Table 1. Descriptively, notable demographic differences by time use group include the higher rates of private school in the low social/engaged group, the high proportion of female adolescents in the high social/disengaged group, and the high levels of grade 12 and white students in the workers group. Figure 1 shows trends in the weighted proportions of students in each of these six groups from 1991 to 2019. These trends demonstrate a decades-long decline in socialization and paid employment among US adolescents. The variable means for each time use variable were mapped by the six groups (Supplemental Figure 1) to examine group patterns, and also by decade (Supplemental Figure 2) to identify prevalence shifts, which were minimal.

Across the sample, 15.0% reported any past two-week binge drinking while 27.4% drank alcohol in the past month. Approximately 14.7% of adolescents smoked cigarettes in the past month and 12.6% reported any past-month cannabis use. Over 8.6% reported past-month use of other substances, while 12.3% reported nicotine vaping and 6.2% reported cannabis vaping from 2017 onward.

3.1. Temporal Heterogeneity in Substance Use

Figure 2 shows the shifting prevalence of substance use across decades, including a decline in cigarette, alcohol, binge drinking, and other substance use, as well as an increase in cannabis use for all six time use groups. Substance use prevalence decreases across decades were largest for the groups defined by significant paid employment or high levels of social time, either with low engagement in other activities or lower levels of supervision, though these groups had the highest initial prevalence of each variety of substance use. These decreases were consistently smallest for the groups defined by low levels of peer socialization, though these groups had very low prevalence of each form of substance use. Cannabis use, however, increased across decades. Figure 3 maps substance use average prevalences by time use group and decade, showing that this increase in cannabis use was lowest for the low social / disengaged group (1.7 percentage point increase) and highest for the workers group (6.1 percentage point increase).

Table 2 shows temporal heterogeneity in the associations between each non-vaping substance use outcome and time use (all interactions between decade and time use group predicting outcomes, p<.001). For past-month cigarette and alcohol use, associations were strongest from 2000 to 2009. For all other outcomes, associations were strongest in either 1991-1999 or 2000-2009 depending on the time use group. All associations were typically weakest from 2010-2019.

Figure 4 shows how time use groups varied in the extent to which the prevalence of vaping has shifted over time, with the highest nicotine vaping increase in the high social/engaged group with less supervision (18.4 percentage-point increase from 2017 to 2019) and the highest cannabis vaping increase in the highly social but otherwise disengaged group (13.2 percentage-point increase from 2017 to 2019). By 2019, vaping of both substances was highest in the high social/engaged group with less supervision.

3.2. Substance Use by Time Use Group

Table 2 shows that all substance use from 1991 onward was lowest in the groups defined by low levels of social engagement with peers but high engagement in structured activities like sports. For all substance use outcomes, the low social/disengaged group had slightly elevated substance use compared to the low social/engaged group (e.g., adjusted odds ratio [aOR] for cigarette use = 2.01, 95% CI: 1.88, 2.16, adjusting for sex, race/ethnicity, grade, urbanicity, parental education and school type).

The group with the next-highest odds of each substance use outcome was the high social/ engaged group with more supervision, which had between two and five times the odds of each outcome compared to the low social/engaged group. This group was followed by the workers group and the high social/disengaged group, both of which had between four and ten times the odds of each outcome compared to the reference group. The highest odds of substance use were nearly always seen in the high social/engaged group with less supervision (e.g., aOR for binge drinking vs low social/engaged group: 13.03, 95% CI: 12.32, 13.77).

Table 3 shows that cross-group patterns for vaping since 2017 were similar to cross-group patterns in other substance use. For example, vaping of either nicotine or cannabis was lowest in the groups with low levels of social behaviors. Similar to other outcomes, vaping was highest in the groups characterized by high levels of socialization with peers or paid employment.

4. DISCUSSION

This study examined the associations between patterns of adolescent time use and substance use, and explored changes over time since 1991. The six time use profiles we identified differed by degree of social engagement, supervised activities, engagement in structured activities, and employment. While the relative positioning of group differences was consistent over time, cigarette, alcohol, other substance use and binge drinking have consistently declined for all groups, especially over the past decade, likely in part due to effective interventions such as family education programs and school based behavioral programs (Biglan and Van Ryzin, 2019; Bo et al., 2018; Liu et al., 2020). Substance use decreases were largest for the high social groups with lower levels of engagement in activities (like sports) or more unsupervised activities (like parties), as well as those spending significant time at a paid job, the groups with the highest overall prevalence of substance use.

Cannabis use and vaping, however, have increased in prevalence. These increases were largest in the highly social groups with lower levels of engagement in structured activities (like sports) or more unsupervised activities (like parties), and those spending time at a paid job. . Adolescents with low socialization and minimal engagement in structured activities had higher substance use than those with low socialization and high engagement. The associations between time use groups and substance use outcomes were weaker from 2010 to 2019 than in earlier decades, but still remained substantially greater than null. For cannabis use and vaping in particular, the decreasing strength of associations over time

reflects the rapidly rising substance use prevalence in the reference group of adolescents who are low social/engaged. This group had a small absolute increase in cannabis use and vaping compared to other groups, but on a relative scale, the prevalence of cannabis use and of vaping more than tripled in their respective timespans. Thus, associations between time use groups for these outcomes had a consistently growing denominator over time, leading to weaker odds ratios even as prevalence of cannabis use and vaping grew for the whole sample. Taken together, while the prevalence of substance use varied drastically between the groups described above, the trends in substance use tended to be relatively consistent across groups. Further research is needed to investigate the factors driving these universal trends in adolescent substance use.

Substance use was typically highest among workers and those with high levels of socialization, either with minimal engagement elsewhere or more unsupervised activities like parties. Social settings where adolescents interact with peers (e.g., parties) provide opportunities for substance use, especially in the absence of adult supervision, and these social settings may produce peer pressure for adolescents to engage in substance use in order to fit in (Caldwell and Darling, 1999; Lee and Vandell, 2015; Schuler et al., 2019). As for the group defined by paid employment, not only did they also have a relatively high amount of social time with peers, but their job may influence access to and risk factors for substance use. Job stress may lead to substance use as a coping mechanism, and more generally, the income that comes with paid work facilitates affordability of substances. Employed adolescents may also interact with older teens and adults who use substances, giving social opportunities for substance use not available to unemployed adolescents. Employed adolescents are, themselves, an older group compared to other time use groups based on grade composition, which likely accounts for some elevated use, though use remained substantially elevated in associations controlling for grade.

Additionally, early employment has been conceptualized as part of "precocious development", which refers to the tendency among certain adolescents to engage in what may be called a "pseudoadulthood" marked by accelerated engagement in adult behaviors, often accompanied by increased substance use (Bachman et al., 2013; Safron et al., 2001). Sources of emotional support and alternative methods of coping should be bolstered for adolescents participating in this "precocious development", thereby reducing this potential stress and hopefully limiting substance use. Additionally, adolescents participating in paid employment may come from families with lower socioeconomic status, and this lower SES is a risk factor for elevated substance use through decreased engagement in enjoyable substance-free activities (Lee et al., 2018; Leventhal et al., 2015). Further analyses are needed to test this hypothesis, as these data lacked information on family income. Still, providing employed adolescents the time and opportunities to participate in such activities may yield subsequent reductions in substance use.

While most substance use declined during the study period, cannabis use and vaping were notable exceptions. The prevalence of cannabis use has been increasing, particularly among adolescents with high levels of unsupervised social activities. Peer networks and influence play a role in adolescent cannabis use through a variety of mechanisms (Ali et al., 2011), especially at social events where there may be a desire to connect with peers and attain

higher social status (Caouette and Feldstein Ewing, 2017; Tucker et al., 2014). Social group members may even be similar to one another with respect to patterns of cannabis use, as adolescents tend to choose friends with similar cannabis use behaviors (de la Haye et al., 2013). Interventions to mitigate potential harms associated with cannabis use might leverage this social component with peer-led or peer-focused treatments that address the desire for social acceptance and support (Caouette and Feldstein Ewing, 2017).

Messaging and interventions that prioritize norms promoting avoidance of substances in social settings may be needed, particularly given that perceived cannabis use disapproval from close peers is linked to reduced adolescent cannabis use (Wu et al., 2015). Motivational interviewing (MI) interventions that encourage individuals to re-evaluate social norms have been linked to reductions in cannabis use (Blevins et al., 2018). Brief interventions, which are designed to address cannabis use in young people, incorporate MI and have been shown to significantly reduce cannabis use disorder symptoms and increase cannabis abstinence (Halladay et al., 2019). These approaches may be particularly valuable among those who spent substantial time socializing with peers (Blevins et al., 2018; D'Amico et al., 2018). While effective psychosocial interventions for high levels of cannabis use exist (Calomarde-Gómez et al., 2021; Winters et al., 2021), they remain insufficiently disseminated, and improved education is needed concerning cannabis. Existing health education may not adequately communicate the risks of cannabis use, or the need for effective use of reduction and avoidance strategies. Effectively and accurately articulating the potential hazards of cannabis use and possible prevention strategies in a non-stigmatizing manner is a vital step towards adolescent well-being.

Additional interventions are also needed to address the rapid rise of adolescent vaping. In the span of just 3 years from 2017 to 2019, nicotine vaping prevalence increased from 6.9% to 16.9% of adolescents, mirroring trends seen elsewhere (Miech et al., 2019), while cannabis vaping increased from 3.4% to 9.8% between 2017 and 2019. This increase was greatest in the high social groups with low engagement in structured activities like sports or more unsupervised activities. Interventions that account for the strong social component of vaping are needed, especially as exposure to social influences and access to e-cigarettes are often reported by adolescents as barriers to quitting (Kong et al., 2021). Recent efforts to disseminate anti-vaping messages through peer-led programs of adolescents have shown early success, with reduced adolescent vaping and lower intention to use a vaping device (Wyman et al., 2021). Other approaches that target norms, beliefs, and information about vaping for adolescents include web-based interventions (Berg et al., 2021; Hieftje et al., 2021) and one-on-one counselling for vaping cessation with the understanding that vaping may be entangled with other substance use behaviors (Berg et al., 2021).

Still, cigarette, alcohol, and other substance use have declined among adolescents. Further research should examine reasons why cannabis use and vaping are rising while other substance use is declining. It may be that these other substance use behaviors have been substituted with cannabis and vaping as cultural norms shift over time. Still, declines in cigarette, alcohol, and other substance use were largest in the groups at greatest risk for these behaviors, namely the groups defined by high socialization or paid employment. Efforts should be made to further implement and sustain successful

interventions. For alcohol prevention, this includes family or community based interventions that engage caregivers to establish norms and boundaries around drinking (Das et al., 2016), universal school-based prevention programs (Hennessy and Tanner-Smith, 2015), and brief interventions that prioritize motivational interviewing and goal-setting exercises (Tanner-Smith and Lipsey, 2015). For smoking prevention, resources should be allocated to sustain the highly effective government anti-smoking public education program known as "The Real Cost" (Duke et al., 2019) as well as school and family-based prevention programs that address social norms and pressures (Das et al., 2016; Thomas et al., 2015). Continuing to support these multifaceted approaches should continue the strong downward trends seen in most substance use outcomes among US adolescents.

The results from this work can be juxtaposed against our other work (currently under review) that linked these groups to depressive and other internalizing symptoms (Kreski et al., 2022). Of the groups defined by socialization with peers, the low social group had the highest depressive symptoms, even though in the present study they consistently had low substance use. Thus, time use is one factor, at least for the socializing time groups, where reduced or lower overall substance use may be juxtaposed against elevated mental health concerns. This may be connected to a divergence between substance use and depressive symptoms that has occurred among adolescents over the last few decades at the population-level (Kann et al., 2018; Keyes et al., 2019; Mojtabai and Olfson, 2020). Drinking, cigarette smoking, and other forms of substance use have declined from 1991 onward, while markers of poor mental health such as feeling sad or hopeless, suicidal ideation, and suicidal plans have increased from the late 2000s onward (Kann et al., 2018). These shifting trends are particularly surprising given that historically substance use and internalizing symptoms have often co-occurred (Swendsen and Merikangas, 2000). Continued examinations of adolescent time use may further illuminate factors contributing to these these divergent trends.

This study has certain limitations relating to the survey. No set of items could be fully comprehensive of the ways in which adolescents spend their time. Additionally, these data do not include the years 2020 or 2021, and so could not capture social behaviors that would apply to adolescents in pandemic quarantines (e.g., time spent zooming with friends socially in a given week). In terms of time use groups, while we could document the shifting prevalence of these groups, we could not disentangle the underlying reasons for the shifts in time use group prevalence. As for substance use, we were unable to examine harmful use or subjective dimensions of substance use for each outcome.

5. CONCLUSION

Substance use is elevated among adolescents who spend high levels of social time with peers, particularly with low levels of engagement in other activities or lower supervision, as well as adolescents who spend time at a paid job. However, the overall trends in substance use have declined over the past decades for all adolescents, with the exception of cannabis use and vaping. Interventions for cannabis use and vaping are urgently needed for adolescents, with an emphasis on unsupervised social settings. We must continue to monitor patterns of adolescent time use to understand emerging trends in substance use to better design and focus effective interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclosure of interest:

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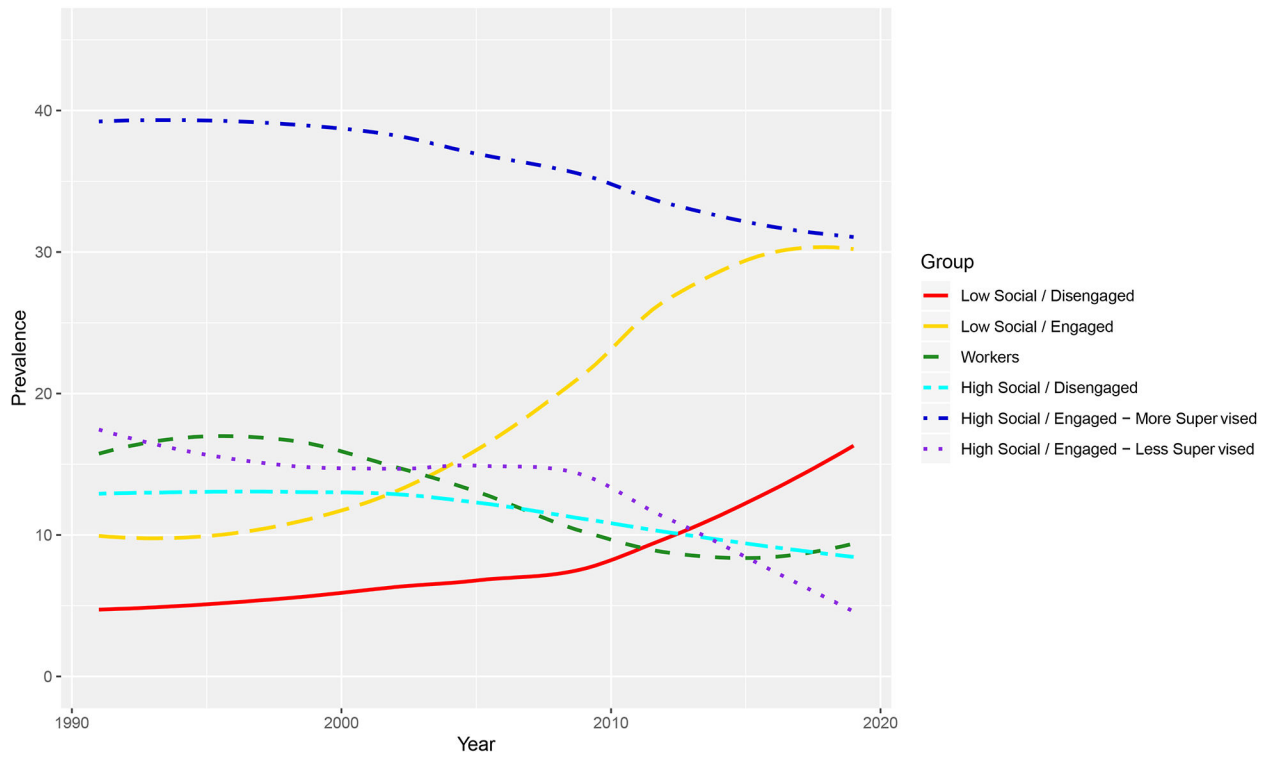
Figure 1:
Prevalence (%) of time use groups among US adolescents by year, 1991-2019
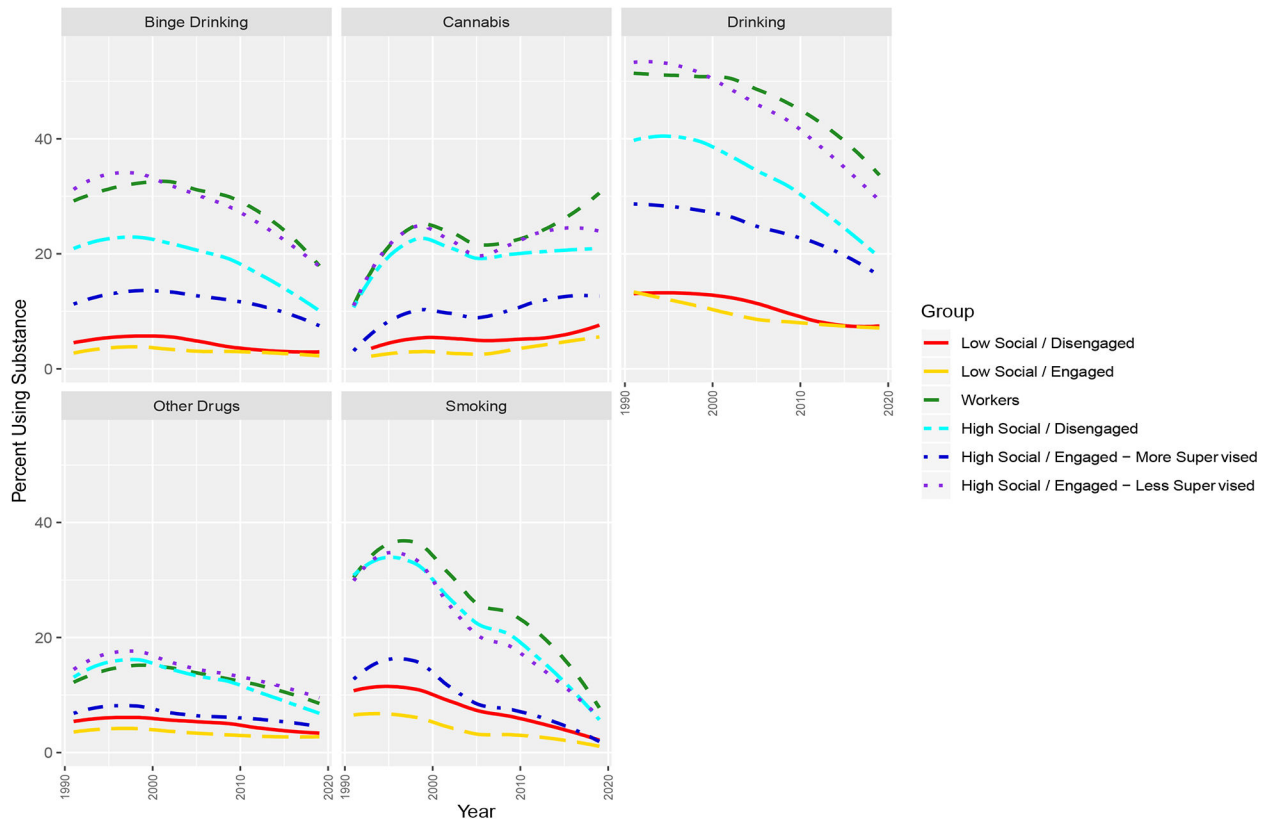
Figure 2: Past month substance use trends by time use group among US adolescents by year, 1991-2019

*Small cell sizes led to censoring of 1991 and 1992 cannabis data for certain groups.

Figure 3:
Past month substance use prevalence by time use group and decade, 1991-2019

Figure 4: Past month vaping prevalence by time use group and year, 2017-2019
*Small cell sizes led to censoring of 2017 and 2018 cannabis vaping data the low social/disengaged group.

Table 1:

Demographic characteristics* by time use group among US adolescents, MTF 1991-2019

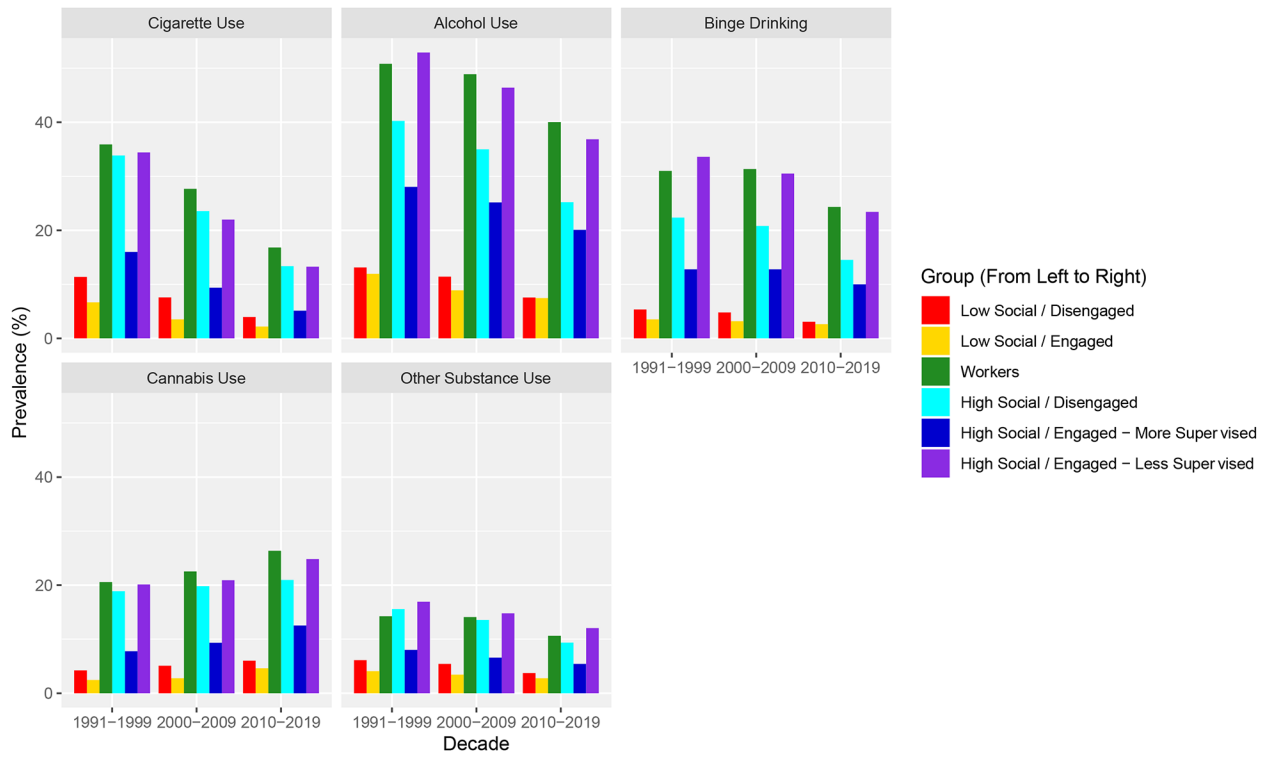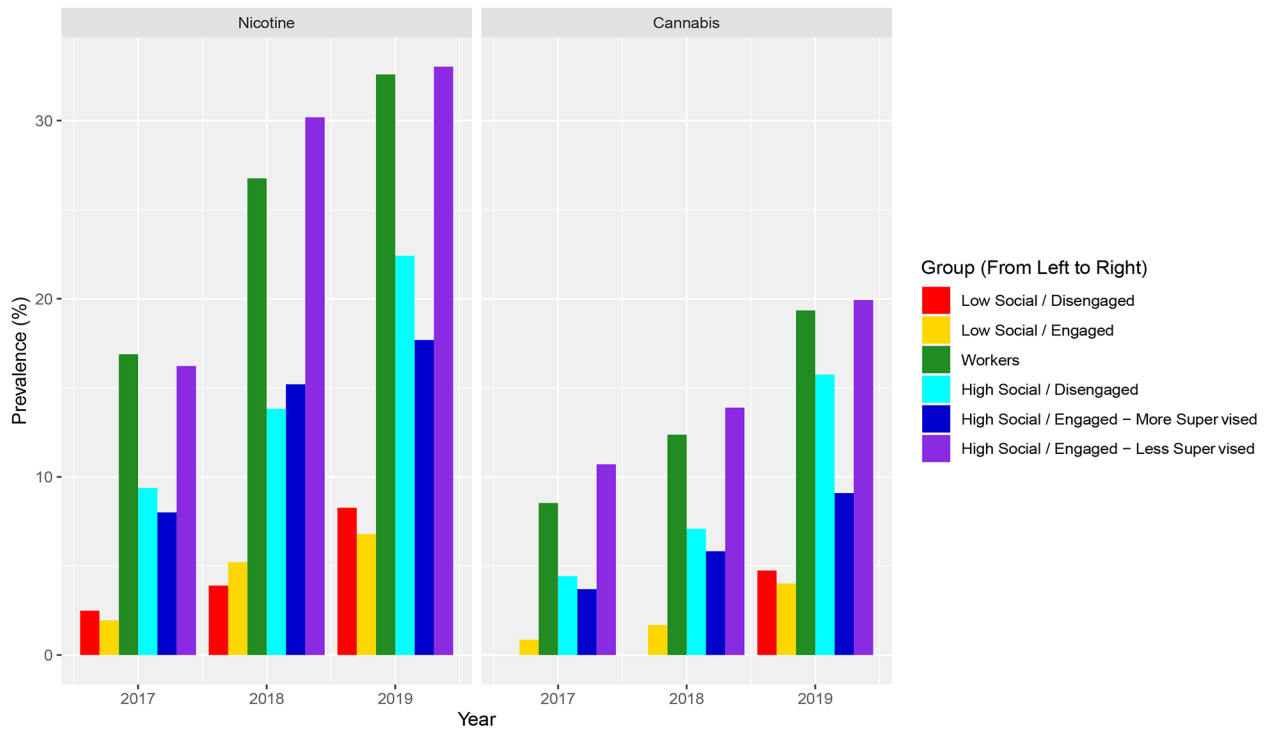| Characteristic (Sample Size n and percentages)		Group					
		1 Low Social/ Disengaged %	**2** Low Social/ Engaged %	**3** Workers	**4** High Social/ Disengaged %	**5** High Social/Engaged – More Supervised %	**6** High Social/Engaged – Less Supervised%
Sample Size (n)		N=41174	N=92373	N=68845	N=62931	N=204571	N=66397
Sample Proportion		7.76	17.49	12.93	11.67	37.96	12.19
School Type	Public	95.33	89.28	94.83	96.13	90.07	92.24
	Private Catholic	2.79	5.43	3.37	2.57	5.93	4.88
	Private Non-Catholic	1.88	5.29	1.80	1.30	4.01	2.88
Sex	Male	43.10	50.76	53.78	34.00	46.99	50.41
	Female	52.34	45.81	42.23	61.63	49.45	45.79
	Missing	4.56	3.42	3.99	4.36	3.57	3.80
Grade	8	49.78	53.85	16.85	45.39	51.78	40.34
	10	41.38	38.56	41.47	45.22	40.27	46.30
	12	8.84	7.59	41.68	9.38	7.95	13.36
Race/Ethnicity	White	47.70	57.78	62.86	48.46	58.84	59.34
	Black	12.01	9.79	11.15	15.58	13.14	12.30
	Hispanic/Latino	21.36	15.24	13.76	21.20	14.17	16.02
	Multiracial	2.82	2.78	1.48	1.86	2.08	1.65
	Other	11.48	10.85	7.25	8.45	8.06	6.75
	Missing	4.63	3.56	3.50	4.44	3.72	3.95
Urbanicity	Non-MSA **	24.27	21.33	25.33	23.58	21.29	22.28
	MSA **	75.73	78.67	74.67	76.42	78.71	77.72
Parental Education	Less than High School	12.23	6.13	8.77	12.79	5.58	6.85
	High School Grad	34.76	29.89	43.23	41.49	32.85	35.89
	College Grad	36.44	54.49	41.89	33.61	54.35	50.07
	Missing	16.58	9.48	6.11	12.11	7.22	7.19

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*
All chi-squares comparing demographics by group significant, p<.0001

**
MSA – Metropolitan Statistical Area

Table 2:

Odds ratios (and 95% confidence intervals) for the relationship between time use group and each substance use outcome, 1991-2019 by decade, adjusted*

	Overall			1991-1999			2000-2009			2010-2019		
Past 30-day Cigarette Use												
Low Social/Disengaged	2.01	(1.88,	2.16)	1.89	(1.68,	2.13)	2.25	(2.01,	2.53)	1.81	(1.59,	2.05)
Workers	9.05	(8.57,	9.55)	7.00	(6.44,	7.61)	8.15	(7.43,	8.94)	6.18	(5.55,	6.88)
High Social / Disengaged	9.31	(8.82,	9.83)	7.87	(7.23,	8.57)	8.78	(8.01,	9.63)	6.95	(6.25,	7.73)
High Social / Engaged – More Supervision	3.25	(3.09,	3.42)	2.77	(2.56,	3.01)	2.99	(2.73,	3.27)	2.50	(2.27,	2.75)
High Social / Engaged – Less Supervision	8.94	(8.47,	9.44)	7.30	(6.72,	7.93)	7.82	(7.12,	8.59)	6.40	(5.73,	7.15)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-	-	-	-	-
Past 30-day Alcohol Use												
Low Social/Disengaged	1.14	(1.08,	1.20)	1.14	(1.03,	1.26)	1.29	(1.17,	1.42)	0.99	(0.91,	1.08)
Workers	6.64	(6.39,	6.90)	5.69	(5.30,	6.10)	6.66	(6.22,	7.13)	5.25	(4.92,	5.59)
High Social / Disengaged	5.39	(5.18,	5.61)	5.18	(4.82,	5.57)	5.40	(5.04,	5.78)	4.00	(3.73,	4.28)
High Social / Engaged – More Supervision	3.43	(3.31,	3.55)	2.94	(2.76,	3.13)	3.47	(3.26,	3.70)	3.16	(2.99,	3.34)
High Social / Engaged – Less Supervision	8.54	(8.22,	8.87)	7.71	(7.20,	8.26)	8.31	(7.78,	8.89)	6.75	(6.31,	7.22)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-	-	-	-	-
Past Two-Week Binge Drinking												
Low Social/Disengaged	1.39	(1.28,	1.51)	1.64	(1.40,	1.92)	1.48	(1.28,	1.71)	1.15	(1.01,	1.32)
Workers	9.66	(9.13,	10.22)	9.43	(8.49,	10.48)	9.34	(8.47,	10.31)	7.58	(6.90,	8.32)
High Social / Disengaged	8.01	(7.56,	8.48)	8.45	(7.60,	9.40)	7.84	(7.10,	8.64)	5.94	(5.39,	6.55)
High Social / Engaged – More Supervision	4.50	(4.27,	4.75)	4.24	(3.84,	4.68)	4.45	(4.05,	4.88)	4.16	(3.81,	4.54)
High Social / Engaged – Less Supervision	13.03	(12.32,	13.77)	13.31	(12.01,	14.75)	12.2	(11.07,	13.44)	10.29	(9.37,	11.31)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-	-	-	-	-
Past 30-day Cannabis Use												
Low Social/Disengaged	1.48	(1.38,	1.59)	1.80	(1.50,	2.15)	1.80	(1.57,	2.06)	1.26	(1.15,	1.39)
Workers	5.72	(5.41,	6.04)	7.91	(7.00,	8.93)	7.19	(6.50,	7.96)	5.08	(4.69,	5.50)
High Social / Disengaged	6.63	(6.27,	7.02)	9.46	(8.38,	10.69)	8.40	(7.59,	9.29)	5.21	(4.80,	5.65)
High Social / Engaged – More Supervision	2.96	(2.82,	3.11)	3.35	(2.99,	3.75)	3.58	(3.27,	3.93)	2.98	(2.79,	3.18)

	Overall		1991-1999		2000-2009		2010-2019	
High Social / Engaged – Less Supervision	6.74	(6.37, 7.13)	9.01	(8.01, 10.15)	8.40	(7.59, 9.30)	6.15	(5.66, 6.69)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-
Past 30-day Other Substance Use								
Low Social/Disengaged	1.53	(1.42, 1.65)	1.60	(1.38, 1.86)	1.63	(1.42, 1.87)	1.36	(1.21, 1.53)
Workers	4.79	(4.51, 5.07)	4.58	(4.12, 5.10)	4.64	(4.19, 5.13)	3.78	(3.40, 4.19)
High Social / Disengaged	4.64	(4.37, 4.93)	4.72	(4.23, 5.26)	4.53	(4.10, 5.01)	3.55	(3.19, 3.96)
High Social / Engaged – More Supervision	2.17	(2.06, 2.29)	2.16	(1.95, 2.40)	2.00	(1.82, 2.19)	1.99	(1.83, 2.17)
High Social / Engaged – Less Supervision	5.37	(5.07, 5.68)	5.22	(4.69, 5.80)	4.94	(4.48, 5.45)	4.61	(4.17, 5.09)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-

*
Adjusted for several covariates related to demographic factors, including sex (binary male/female), race and ethnicity (White, Black, Hispanic/Latino, Multiracial, or Other), grade (8th, 10th, 12th), urbanicity (whether an adolescent resided in a Metropolitan Statistical Area), highest level of parental education (less than high school, high school graduate, college graduate, and school type (public, private Non-Catholic, private Catholic).

**
Interaction between decade and time use group predicting each substance use outcome p<.001 for all outcomes

Table 3:

Odds ratios (and 95% confidence intervals) for the relationship between time use group and each vaping outcome, 2017-2019 by year, adjusted [*]

	Overall		2017		2018		2019	
Past 30-day Nicotine Vaping								
Low Social/Disengaged	1.13	(0.92, 1.41)	1.38	(0.83, 2.29)	0.86	(0.59, 1.24)	1.20	(0.86, 1.67)
Workers	5.69	(4.76, 6.81)	8.78	(5.97, 12.92)	4.89	(3.70, 6.46)	5.26	(3.93, 7.03)
High Social / Disengaged	3.97	(3.25, 4.85)	6.03	(3.97, 9.17)	2.96	(2.21, 3.97)	3.95	(2.91, 5.36)
High Social / Engaged – More Supervision	3.55	(3.07, 4.10)	4.65	(3.34, 6.47)	3.43	(2.74, 4.30)	3.14	(2.53, 3.88)
High Social / Engaged – Less Supervision	7.35	(6.13, 8.81)	10.20	(6.90, 15.10)	7.03	(5.22, 9.47)	6.25	(4.68, 8.35)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-
Past 30-day Cannabis Vaping								
Low Social/Disengaged	1.26	(0.90, 1.76)	0.72	(0.32, 1.63)	1.19	(0.65, 2.18)	1.35	(0.85, 2.13)
Workers	5.84	(4.61, 7.39)	10.04	(6.36, 15.87)	6.58	(4.26, 10.17)	4.32	(3.07, 6.08)
High Social / Disengaged	4.65	(3.57, 6.05)	5.94	(3.46, 10.22)	4.25	(2.73, 6.63)	4.41	(2.94, 6.60)
High Social / Engaged – More Supervision	3.32	(2.66, 4.15)	4.65	(2.96, 7.30)	3.76	(2.61, 5.40)	2.71	(1.94, 3.80)
High Social / Engaged – Less Supervision	7.92	(6.16, 10.20)	14.50	(8.75, 24.03)	8.48	(5.35, 13.44)	5.71	(3.87, 8.42)
Ref = Low Social/Engaged	-	-	-	-	-	-	-	-

[*] Adjusted for several covariates related to demographic factors, including sex (binary male/female), race and ethnicity (White, Black, Hispanic/Latino, Multiracial, or Other), grade (8th, 10th, 12th), urbanicity (whether an adolescent resided in a Metropolitan Statistical Area), highest level of parental education (less than high school, high school graduate, college graduate), and school type (public, private Non-Catholic, private Catholic).

[**] Interaction between year and time use group predicting each outcome: p=0.0644 for nicotine; p=0.0075 for cannabis