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## Changes in alcohol use by cannabis use status among adolescents and young adults in the United States: Emerging evidence for both substitution and complementarity

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### Abstract

**Background:** The majority of adolescents and young adults (AYA) who use cannabis also use alcohol. Cannabis use is increasing in the United States (US) and it is not known whether this increase may lead to increased co-use of alcohol and cannabis (e.g., complementarity) or replacement of alcohol with cannabis (e.g., substitution). The current study estimated the prevalence of alcohol use by cannabis use status among US AYA ages 12–25 in 2018 and trends in alcohol use by cannabis use status from 2002 to 2018.

**Methods:** Data were drawn from the 2002–2018 National Survey on Drug Use and Health (NSDUH) public use data files. The analytic sample included AYA ages 12 to 25 (2018 sample, n=26,924; total combined sample 2002–2018, n=576,053). Linear and logistic regression models were run to estimate past-month alcohol use, daily alcohol use, and average quantity of alcohol consumed among AYA with and without past-month cannabis use from 2002 to 2018.

**Results:** In 2018, any alcohol use and daily alcohol use were significantly more common among AYA with versus without cannabis use. Overall, any alcohol use, daily alcohol use, and average drinks per day declined from 2002 to 2018 among AYA who did and did not use cannabis. The speed of decline in any alcohol use, daily alcohol use, and average alcohol drinks per day was

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more rapid among AYA who used cannabis (daily and non-daily) versus did not use cannabis. The rate of decline in average alcohol drinks per day was also more rapid among AYA with daily compared to non-daily cannabis use.

**Conclusions:** Alcohol use remains much more common among AYA with versus without cannabis use. While the current data on alcohol and cannabis use among AYA are more consistent with complementarity effects than substitution effects, these relationships may change as cannabis legalization expands over time.

### Keywords

alcohol; cannabis; youth; young adults; epidemiology

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## INTRODUCTION

Cannabis is a commonly used substance among adolescents and young adults (AYA) and recent data suggest national increases in cannabis use among AYA in the United States (US) over the past several years (e.g., Azofeifa et al., 2016; Goodwin et al., 2018; Hasin, 2018; Zuckermann et al., 2021). At the same time there have been increases in cannabis use, perceptions of risk associated with cannabis use have steadily declined (Pacek et al., 2015, Compton et al., 2016, Azofeifa et al., 2016, Hamilton et al., 2019, Keyes et al., 2019, Fairman et al., 2019).

In contrast to cannabis, there are mixed data regarding changes in alcohol use among AYA over time. Some data show increases in alcohol use among high school students and young adults (Grant et al., 2017), while other data show declines in the use of alcohol (Schulenberg, 2018, Johnston, 2018, NIDA, 2019). Regardless of trends in alcohol use, the majority of AYA who report using cannabis also report alcohol use (Assanangkornchai et al., 2018, Schlienz and Lee, 2018). AYA often report using cannabis and alcohol at the same time (i.e., simultaneous use/in the same sitting; Subbaraman, 2016, Haas et al., 2015) as alcohol may be used to increase THC levels and the subjective effects of cannabis (Lukas and Orozco, 2001). Further, alcohol and cannabis are frequently used together in social situations such as with friends or at parties. The use of both cannabis and alcohol are more likely to occur where there are social norms for their combined use (White et al., 2019) and those who use cannabis in social situations (vs. alone) are more likely to also use alcohol (Spinella et al., 2019). If alcohol use is declining and cannabis use is increasing, and the majority of those who use cannabis also use alcohol, then it is conceivable that the decline in alcohol use may vary by cannabis use status. Yet, few studies to date have examined recent trends in use of alcohol among AYA who use cannabis, compared with those who do not use cannabis.

Alcohol and cannabis use each have potentially harmful effects on AYA including impacting brain development and psychosocial and health consequences (Burggren et al, 2019; Guerri and Pascual, 2019, Salmanzadeh et al., 2020, Meruelo et al., 2017). The use of both alcohol and cannabis is potentially associated with even greater adverse events and negative consequences than the use of either alcohol or cannabis alone. These consequences include risky behaviors such as driving while impaired and risk of fatal motor vehicle crashes,

poorer physical and mental health, psychosocial and academic consequences, and increased risk of escalation from substance use to substance use disorders (Karoly et al., 2020, Schlienz and Lee, 2018, Briere et al., 2011, Asbridge et al., 2012, Sewell et al., 2009, Chihuri et al., 2017, Subbaraman and Kerr, 2015, Shillington and Clapp, 2001, Harrington et al., 2012, Bailey et al., 2019).

Based on the frequency with which alcohol and cannabis are used together among AYA and the greater negative consequences for AYA who use both alcohol and cannabis, understanding whether and how alcohol use patterns have changed among AYA who use cannabis, who constitute a growing proportion of AYA, is critical toward ongoing efforts to inform clinical and public health policy decisions in this rapidly changing substance use landscape.

The overarching goal of this study was to examine alcohol use, including frequency and quantity, by cannabis use status among US AYA (ages 12–25). Specifically, we were interested in examining the current prevalence of alcohol use by cannabis status in the most recent data year, as well as examining trends over time in three alcohol use variables (i.e., any alcohol use, daily alcohol use, average number of alcohol drinks) by cannabis use status. First, the study investigated the prevalence of any past-month alcohol use in 2018 among AYA who did and did not report past-month cannabis use, overall and by demographic characteristics. Second, the study examined trends in the prevalence of any past-month alcohol use by cannabis use status among AYA from 2002 to 2018. Third, the study examined trends in the prevalence of past-month frequent (i.e., daily) alcohol use by cannabis use status among AYA from 2002 to 2018. Fourth, the study investigated trends in the quantity of alcohol (i.e., average number of alcohol drinks) consumed per day over the past month by cannabis use status among AYA from 2002 to 2018. We additionally examined whether results varied for the young adult subgroup (ages 21–25) who were of legal age to consume alcohol (and of legal age to consume cannabis for recreational purposes in some US states (19 states as of 10/1/2021)).

## MATERIALS AND METHODS

### Data Source and Study Population

Data for the current study were drawn from the 2002–2018 National Survey on Drug Use and Health (NSDUH) public use data files (<http://www.icpsr.umich.edu/>). The NSDUH collects annual cross-sectional data from male and female civilian non-institutionalized individuals who are age 12 and older. Data are collected in each of the 50 states and the District of Columbia. See (Center for Behavioral Health Statistics and Quality, 2018) for more details about the NSDUH. The datasets from each year were concatenated adding a variable for the survey year. The analytic sample for this study included youth and young adults ages 12 to 25 for a sample of 26,924 for 2018 and a total combined sample size from 2002 to 2018 of 576,053.

## Measures

**Cannabis use.**—Participants reported how long it had been since their last cannabis use. Individuals reporting using cannabis “Within the past 30 days” were categorized as having past-month cannabis use while those who did not report using cannabis in the past 30 days were classified as having no past-month cannabis use. Participants indicating past month use reported the number of days they used cannabis in the last 30 days and were categorized into two mutually exclusive groups. Participants who reported using cannabis on 25 or more days of the past 30 days were classified as having past-month daily cannabis use and participants who reported using cannabis on 24 or fewer of the past 30 days were classified as having past-month non-daily cannabis use.

**Alcohol use.**—Participants were asked to report the number of days they had one or more alcohol drinks in the past 30 days. Those who reported having one or more alcohol drinks on 1 to 30 days of the past 30 days were categorized as past-month alcohol users. Individuals who reported having one or more alcohol drinks on 25 or more days of the past 30 days were classified as past-month daily alcohol users. Respondents were also asked to report the usual number of drinks they had per day in the past 30 days and this information was used to calculate the average number of drinks consumed per day. The range of number of drinks per day was from 1 to 90. Those who answered “Never used alcohol” or “Did not use alcohol in the past 30 days” were classified as having 0 of drinks per day in the past month.

**Demographics.**—Respondents were asked to provide the following demographic information: gender (male, female), race/ethnicity (Non-Hispanic (NH) White, NH Black, Hispanic, NH Other), marital status (married, widowed/divorced/separated, never married, less than 14 years old), annual total family income (<\$20,000, \$20,000-\$49,999, \$50,000), and education (less than high school, high school graduate, some college, college or higher education, 12–17 years old). The marital status and education variables included categories to take into account the young age of some respondents (i.e., the “less than 14 years old” category for marital status and the “12–17 years old” category for education).

## Statistical Analysis

Data were weighted to reflect the complex design of the NSDUH sample and were analyzed with SAS version 9.4 software.

To capture the current alcohol use among AYA age 12 to 25 at population level in 2018 (Aim 1), frequencies and percentages of demographic characteristics by current cannabis use were calculated, accounting for complex survey weights. Heterogeneity by important demographic characteristics was assessed and cannabis use x covariate product terms were added to weighted logistic regressions to produce stratum-specific odds ratios that adjusted for covariates other than the one included in the interaction. Test results for interaction term between each demographic variable on the multiplicative scale are also provided.

To examine whether the prevalence of current alcohol use changed over time by cannabis use status (Aim 2), the annual prevalence of past-month alcohol use was calculated overall and by current cannabis use status with weights. Crude and adjusted logistic regression

models that included demographic covariates were fit to examine the linear time trend of current alcohol use, with year included as a continuous predictor. To assess the differential time trends between different cannabis use groups, logistic regression models with continuous year as predictor that added year x current cannabis use interaction term were fit and F-test results were included. To examine whether the prevalence of frequent (i.e., daily) alcohol use changed over time by cannabis use status (Aim 3), the similar analytic scheme as above was applied with daily alcohol use in place of current alcohol use.

In addition, to examine whether the average quantity of alcohol consumed changed over time by cannabis use status (Aim 4), the annual means of the alcohol use estimates were generated with weights. Unadjusted and adjusted linear regression models were fit to examine the linear time trend of alcohol use frequency, with year included as a continuous predictor. Differential time trend between different cannabis use groups was tested with linear regression models with continuous year as predictor that added year x current cannabis use interaction term.

All analyses described above were also run limiting the sample to respondents age 21 to 25 to examine results in the subsample for whom alcohol (and cannabis in some states) was legal (sample size of 8,512 for analyses using data from 2018 and a total combined sample size for trend analyses using data from 2002 to 2018 of 179,076).

Finally, analyses were rerun using a stricter definition of daily cannabis use (self-report use of cannabis on 30 out of the past 30 days) and daily alcohol use (self-reported use of alcohol on 30 out of the past 30 days) and results did not substantively differ so results using the definitions described in the Measures section (i.e., daily use defined as 25 or more days out of the past 30) are presented below.

## RESULTS

### Past-month alcohol use among AYA with daily, non-daily, and no cannabis use in 2018

Among the full 2018 sample of respondents, 3.00% of AYA reported past-month daily cannabis use, 12.54% of AYA reported past-month non-daily cannabis use, and 84.49% of AYA reported no past-month cannabis use. Across the full 2018 sample, the odds of past-month alcohol use were significantly higher among AYA who reported past-month non-daily and daily cannabis use (73.35% and 78.17%, respectively) than among those who reported no past-month cannabis use (27.92%;  $p < 0.0001$ , see Table 1).

With regard to the relationship between cannabis use and alcohol use by demographic subgroups, respondents who reported non-daily or daily cannabis use within each gender, marital status, income, race/ethnicity, and education subgroup consistently reported greater prevalences of past-month alcohol use than respondents in the respective demographic subgroup who reported no past-month cannabis use (e.g., more men with daily and non-daily cannabis use reported alcohol use than men with no cannabis use, more women with daily and non-daily cannabis use reported alcohol use than women with no cannabis use; see Table 1).

While all demographic subgroups showed the same pattern of a higher prevalence of alcohol use for subgroup members with cannabis use compared to subgroup members without cannabis use, the strength of the relationship between cannabis use status and alcohol use differed by gender and racial/ethnic subgroups. The relationship between daily cannabis use (versus no cannabis use) and alcohol use was stronger among women compared with men ( $p<0.05$ ) and among NH White individuals compared with NH Black individuals ( $p<0.05$ ). With regard to education subgroups, the relationship between daily cannabis use (versus no cannabis use) and alcohol use was also stronger among those still eligible to be in school (i.e., those age 12–17) compared to the reference group of those who completed college ( $p<0.05$ ). With regard to marital status, the relationship between daily cannabis use (versus no cannabis use) and alcohol use was stronger among young adolescents (i.e., those age 12–14) compared to the reference group of individuals who were married ( $p<0.05$ ). There were no significant differences in the strength of the relationship between daily or non-daily cannabis use and alcohol use across income groups or any other racial/ethnic, marital status, education, or income subgroups suggesting that the greater prevalence of alcohol use reported by those with cannabis use versus no cannabis use was of a similar magnitude among these demographic subgroups.

Among respondents age 21 to 25, the prevalence of alcohol use was higher across all cannabis use groups (see Supplemental Table 1). Similar to the results from the full sample, the odds of past-month alcohol use were significantly higher among young adults who reported past-month non-daily and daily cannabis use than among those who did not use cannabis. There were no demographic subgroup differences in these relationships (see Supplemental Table 1).

### **Trends in past-month alcohol use among AYA with daily, non-daily, and non-cannabis use, 2002–2018**

For every year from 2002 to 2018, the prevalence of past-month alcohol use was higher among those with daily cannabis use (2002: 85.71%, 2018: 78.17%) and non-daily cannabis use (2002: 83.23%, 2018: 73.35%) than AYA who did not use cannabis in the past 30 days (2002: 34.45%, 2018: 27.92%).

Past-month alcohol use decreased among AYA overall from 2002 to 2018 (see Figure 1 and Supplemental Table 2). Alcohol use declined significantly among daily cannabis users (odds ratio (OR)=0.949, 95% confidence intervals (CI)=0.939–0.959), non-daily users (OR=0.960, 95% CI=0.955–0.966) and among those who did not use cannabis (OR=0.981, 95% CI=0.979–0.983). There was a significant year by cannabis status group interaction with regard to alcohol use ( $p<0.001$ , see Supplemental Table 2). In follow-up comparisons of changes in alcohol use over time by specific cannabis statuses, there was a more rapid decline in alcohol use from 2002 to 2018 among those with both daily and non-daily cannabis use compared to those without cannabis use ( $p<0.002$  and  $p<0.001$ , respectively). There was no difference in the speed of decline in alcohol use from 2002 to 2018 between those with daily versus non-daily cannabis use ( $p=0.07$ ). These results did not change after adjusting for demographics.

When conducting the analysis of trends in any alcohol use among just respondents ages 21 to 25, there was a significant year by cannabis status group interaction ( $p<0.001$ ). The prevalence of any alcohol use did not significantly change over time among the full sample or among those who did not use cannabis whereas the prevalence of any alcohol use significantly decreased over time among those ages 21 to 25 with daily and non-daily cannabis use (see Supplemental Table 3). These results did not change after adjusting for demographics.

### **Trends in past-month daily alcohol use among AYA with daily, non-daily, and non-cannabis use, 2002–2018**

For every year of the analytic period, the prevalence of past-month frequent (i.e., daily) alcohol use was higher among daily cannabis users (2002: 8.70%, 2018: 5.67%) than non-daily cannabis users (2002: 5.02%, 2018: 2.37%) and those with no cannabis use (2002: 0.73%, 2018: 0.47%).

There was a decrease in the overall prevalence of daily alcohol use from 2002 to 2018 (see Figure 2 and Supplemental Table 4). Daily alcohol use declined among daily cannabis users (OR=0.947, 95% CI=0.933–0.961), non-daily cannabis users (OR=0.952, 95% CI=0.941–0.964) and among those who did not use cannabis (OR=0.973, 95% CI=0.963–0.984). All results remained the same after adjusting for demographic variables. There was a significant year by cannabis status group interaction with regard to daily alcohol use ( $p<0.001$ , see Supplemental Table 4). The decline in daily alcohol use from 2002 to 2018 among AYA with both daily and non-daily cannabis use was more rapid than the decline among AYA who did not use cannabis ( $ps<0.01$ ). There was no difference in the speed of decline in daily alcohol use from 2002 to 2018 between those with daily versus non-daily cannabis use ( $p=0.58$ ). These results did not change after adjusting for demographics and these results did not change when examining just respondents age 21 to 25 (data not shown).

### **Trends in the number of alcohol drinks per day among AYA with daily, non-daily, and non-cannabis use, 2002–2018**

For every year of the analytic period, the average number of alcohol drinks consumed per day was higher among those with daily cannabis use (2002: mean (M)=5.54, standard error (se)=0.28, 2018: M=3.26, se=0.14) and non-daily cannabis use (2002: M=4.58, se=0.13, 2018: M=2.83, se=0.10), relative to those who did not use cannabis (2002: M=1.42, se=0.02, 2018: M=0.89, se=0.02).

The number of alcohol drinks per day declined overall and among all cannabis use groups from 2002 to 2018 (see Figure 3 and Supplemental Table 5). There was a significant year by cannabis status group interaction with regard to number of alcohol drinks per day ( $p<0.001$ , see Supplemental Table 5). In follow-up comparisons of changes in the number of average drinks per day over time by specific cannabis statuses, there was a greater decline in the number of average drinks per day from 2002 to 2018 among those with daily and non-daily cannabis use compared with those with no cannabis use ( $ps<0.001s$ ). There was also a greater decline in the number of average drinks per day from 2002 to 2018 for those with daily cannabis use compared to those with non-daily cannabis use ( $p<0.001$ ). These results

did not change after adjusting for demographics. These results also did not change when limiting the analyses to respondents age 21 to 25 (data not shown).

## DISCUSSION

The prevalence of any alcohol use, daily alcohol use, and the average number of alcohol drinks per day was significantly higher among US AYA who reported past-month cannabis use, compared with AYA who did not report cannabis use in the past month. Despite declines in alcohol use over time (i.e., from 2002 to 2018) regardless of cannabis use status and more rapid declines among AYA using cannabis, AYA reporting daily and non-daily cannabis use were more than 6 times as likely as AYA who did not use cannabis to report the use of alcohol in 2018.

The pathways underlying the use of alcohol and cannabis are likely numerous and heterogeneous. Alcohol and cannabis may serve as complements (e.g., use of one substance is associated with increased use of another substance) or as substitutes (e.g., use of one substance is associated with declines in use of another substance; Subbaraman, 2016). A combination of both processes may also occur in the same individual (i.e., a person who uses alcohol and cannabis both as complements and as substitutes).

The findings of the current study appear consistent with both a complementary and substitution relationship between alcohol and cannabis among AYA in the US. Specifically, the significantly higher prevalence of any alcohol use among individuals in both the 12–25 and 21–25 age groups who use cannabis, compared to those without cannabis use, is consistent with complementarity. Similarly, a prior study found that among samples of US 12<sup>th</sup> graders, the majority of students who reported using both alcohol and cannabis also reported using both substances simultaneously (Patrick et al., 2018, Patrick et al., 2017) suggesting a complementary relationship. Further, we also found that alcohol use decreased among those 12–25 over time among both those with and without cannabis use, which is not consistent with the pattern expected if co-use is due to complementarity. Yet, the more rapid decline in alcohol use among cannabis users over time observed in the current study may be consistent with substitution of alcohol with cannabis. Further, among those 21–25 (i.e., those who can legally use alcohol and can legally use recreational cannabis in some states), alcohol use only declined among those with cannabis use and not among those with no cannabis use, consistent with substitution. Taking the results together, the large ongoing discrepancies in alcohol use among those with versus without cannabis use (i.e., greater alcohol use by those with cannabis use), even as alcohol use decreases among all AYA, provides evidence more consistent with the complementary use of the two drugs as opposed to the substitution of cannabis for alcohol.

While there may be greater evidence for complementary use of alcohol and cannabis, the fact that there was evidence in these data for both complementarity and substitution in the relationship of cannabis and alcohol, especially among those ages 21 to 25, contributes novel information and suggests a potentially complicated relationship between the two substances. Our results are consistent with a recent study that examined alcohol purchases (as a proxy for alcohol use) in relation to legalization of cannabis for recreational use that found



evidence of both complementarity and substitution (Calvert and Erickson, 2021). Together these studies highlight the need for more research to clarify when and for whom cannabis and alcohol serve as complements versus as substitutes. For example, a single person may use cannabis and alcohol as complements in some contexts and for some reasons and as substitutes in other contexts and for other reasons. Or, some individuals may use cannabis and alcohol as complements while other individuals use them as substitutes. This research should also examine complementarity and substitution by age. While we were not able to directly compare younger and older age groups, there was evidence of complementarity among the full AYA sample and evidence for substitution especially for the subgroup of those ages 21–25 where alcohol decreased among those using cannabis but not among those not using cannabis in contrast to results from the full sample that included those as young as 12 and where alcohol decreased for both those using and not using cannabis.

Within the context of the current study, the determination of mechanisms of alcohol and cannabis use (i.e., substitution and complementarity) is quite broadly speculative since information important in determining substitution versus complementary effects were not available. For example, data were not available to clarify the timing of use of each substance (e.g., whether cannabis and alcohol were used in the same sitting), how much alcohol and/or cannabis was consumed in a setting, whether individuals were “new” users of either substance, or self-reported reasons for using cannabis, alcohol, or using the two substances together. Additional factors that can be considered in future research on alcohol use among those using cannabis include the increasing normalization and acceptability of cannabis use (Carliner et al., 2017).

Studies using varied research methods are needed next to better understand the mechanisms underlying use of alcohol by those using cannabis. First, longitudinal studies could assess detailed timelines of the use, and amount of use, of cannabis and alcohol use for individuals over time. These data would provide information about how the use of each of these two drugs change relative to each other over time in a substitution or complementary way (e.g., decreases in alcohol use as cannabis use by the individual increases may suggest substitution while increases in both alcohol and cannabis together may suggest complementarity). In addition, qualitative studies would provide an opportunity to examine the patterns of cannabis and alcohol use of individuals in greater depth including specific questions about whether an individual uses both in the same sitting and reasons for using alcohol and cannabis alone and in relation to each other (e.g., whether use of one drug leads them to want or ‘crave’ the other drug, whether they have less desire to use one drug after using the other drug). Yet, this method presupposes keen insight into reasons for use and may be limited by biases and memory issues in reporting thoughts and behaviors. Research designs such as these might also be informative in providing new data on more complex patterns of alcohol and cannabis use (e.g., partial versus full substitution of alcohol with cannabis; individuals who demonstrate both substitution effects and complementarity effects).

Future research should also examine patterns of complementary use and substitution in relation to changes in state-level cannabis policy. The legalization of cannabis is occurring rapidly across US states as well as other countries around the world (e.g., Abuhaira et al., 2018; ASTHO, 2019). Thus far, legalization of cannabis for medical use appears to

be associated with increased cannabis use among adults (e.g., Hasin et al., 2017), though findings are inconsistent among studies of adolescents (e.g., Carliner et al., 2017; Cerdá et al., 2018; Sarvet et al., 2018). Legalization of cannabis for recreational use appears to be associated with consistent increases in use among AYA (e.g., Bae and Kerr, 2020; Paschall et al., 2021; Shi et al., 2015). A review of literature on alcohol and cannabis use found that AYA may reduce their alcohol intake in areas with more liberal cannabis policy (i.e., where cannabis may be more widely available; Subbaraman, 2016) suggesting substitution effects. In contrast, a recent study found increases in the co-use of cannabis and alcohol among adolescents with legalization of cannabis for recreational use and greater cannabis availability (García-Ramírez et al., 2021) suggesting a complementary relationship. Research on adults have also found support for both substitution and complementarity in relation to cannabis legalization (Guttmanova et al., 2016). While at present (up through the year 2018 in this study), evidence for complementarity was stronger than for substitution with regard to alcohol use among those using cannabis, it will be critical to evaluate this balance over time as legalization expands; substitution may become more prominent in future years.

The use of cannabis and alcohol as complements versus substitutes has different public health and clinical implications. For example, if cannabis and alcohol act as complements and cannabis use increases among young people, the co-use of cannabis and alcohol, and the negative health and psychosocial consequences of using both substances, may increase along with increases in the prevalence of cannabis and alcohol use disorders and hazardous behavior (e.g., impaired driving from the effects of both cannabis and alcohol; e.g., Karoly et al., 2020, Schlien and Lee, 2018, Briere et al., 2011, Sewell et al., 2009). In that case, public health efforts may benefit from communicating not just the negative consequences of each substance alone but the increased negative consequences conferred by use of both substances together. Similarly, clinicians working with young people with cannabis use should also assess alcohol use, and alcohol use disorders, and consider targeting both substances in treatment (e.g., Champion et al., 2016; Newton et al., 2010). Alternatively, if substitution is predominant, and cannabis use increases among young people, then alcohol-related problems may decline (e.g., accidents), and alcohol use disorders may decrease whereas cannabis-related health problems, cannabis use disorders, and cannabis-related consequences increase. New data are needed to understand the trends in alcohol use related to cannabis use, and the potential consequences in order to develop the most effective public health and clinical programs to reduce the negative consequences of cannabis use, alcohol use, and co-use of cannabis and alcohol by young people.

A number of limitations must be considered. First, some ethnic/racial groups were pooled together to create the NH Other group including subgroups of adolescents with the highest (e.g., Native American individuals) and the lowest (e.g., Asian American individuals) cannabis use prevalences (Wu et al., 2015). Second, the age group for the sample (i.e., 12 to 25 years old) covers a range of developmental stages as well as combining groups of young adults for whom cannabis and/or alcohol are illegal versus legal. We were able to examine results among those age 21–25 in comparison to the full sample, analyses that yielded overall similar patterns of results to those found for the full sample, but, as mentioned earlier, we were not able to directly compare results across different age groups (e.g., 12–20

versus 21–25 years old) due to small sample sizes in the subgroups (e.g., 14 cases of daily cannabis use among those 12–17 years old in 2015). Consequently, we may not have been able to identify trends that differ for youth versus young adults or individuals for whom alcohol and cannabis are legal versus illegal. Comparison these patterns among different age youth and young adults would be an important area for future research with larger sample sizes of youth. Third, the analyses exclude AYA who are in the military, homeless, and/or live outside the US.

Fourth, self-report measures, which were used to assess alcohol and cannabis use, are vulnerable to memory issues, cognitive biases, and underreporting particularly with illicit behaviors (e.g., use of illicit drugs, underage alcohol consumption). Fifth, while this study used repeated cross-sectional data from a nationally representative sample, we were unable to track longitudinal alcohol and cannabis use including how changes in cannabis use impact changes in alcohol use at an individual level. Furthermore, the NSDUH survey did not ask respondents whether alcohol and cannabis were used simultaneously or concurrently, or what motivated them to use these drugs either simultaneously or concurrently. Examining patterns of alcohol-cannabis use, reasons for alcohol use and other alcohol-related variables (e.g., binge drinking, past-month alcohol volume), and other cannabis-related variables (e.g., frequency and quantity of use, reasons for use) among those using cannabis may also improve our understanding of the relationship between alcohol and cannabis use including why some demographic subgroups have stronger (female AYA compared to male AYA) or weaker (NH Black AYA compared to NH White AYA) relationships between cannabis and alcohol use compared to other demographic subgroups. Relatedly, as there were gender and racial/ethnic differences in the prevalence of alcohol use and the prevalence of cannabis use (e.g., Erol and Karpyak, 2015; Greaves and Hemsing, 2020; Hasin et al., 2019) and the current results found gender and racial/ethnic differences in the relationship between alcohol use by cannabis use status, future studies should continue to examine gender and race/ethnicity, as well as related constructs (e.g., gender norms, Hemsing and Greaves, 2020), in analyses of the relationship of alcohol and cannabis including trends in these relationships over time. Notably, these demographic differences were found for the full sample (ages 12–25) but not when analyses were limited to those ages 21–25. Future research should also compare these relationships between age groups to further elucidate where demographic differences in patterns in order to better inform public health and clinical efforts to reduce harms of alcohol use and/or co-use of alcohol and cannabis.

## Conclusions

Alcohol use remains much more common among AYA who use cannabis, compared with those who do not. While alcohol use is decreasing over time among both AYA with and without cannabis use, and there are faster declines in any alcohol use, daily alcohol use, and alcohol drinks per day among AYA who use cannabis compared with those who do not, a large disparity in alcohol use persists by cannabis status. While the current data on alcohol use among AYA who use cannabis use are more consistent with complementarity effects of cannabis and alcohol than substitution effects, these relationships may, or may not, change as cannabis legalization expands over time. Our results also provide preliminary evidence that the nature of these relationships may differ by legal age, and indeed, it is not known

if these patterns would be similar among middle and older adults. The elevated prevalence of alcohol use among cannabis users, especially daily alcohol use by daily cannabis users, suggests that a substantial proportion of AYA who use cannabis are increasingly exposed to the potential combined negative harms of cannabis and alcohol. The significant co-use of cannabis and alcohol among AYA suggests that obtaining this information should be a public health research priority.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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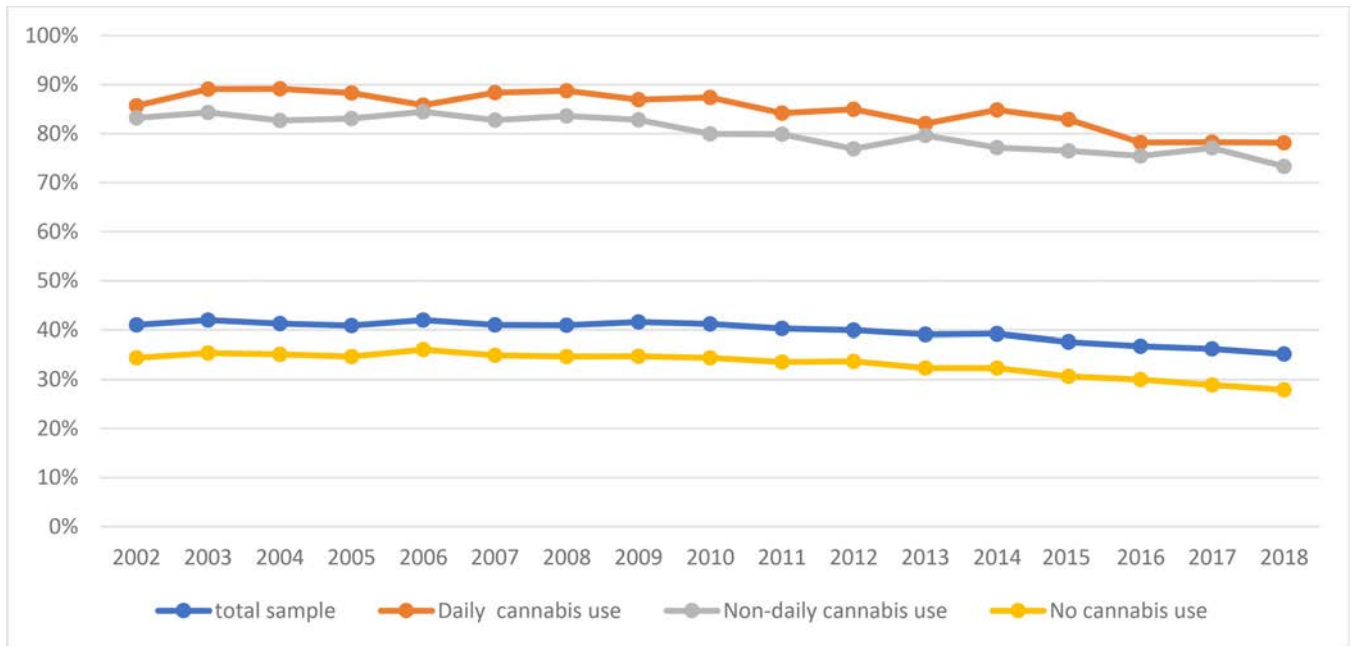
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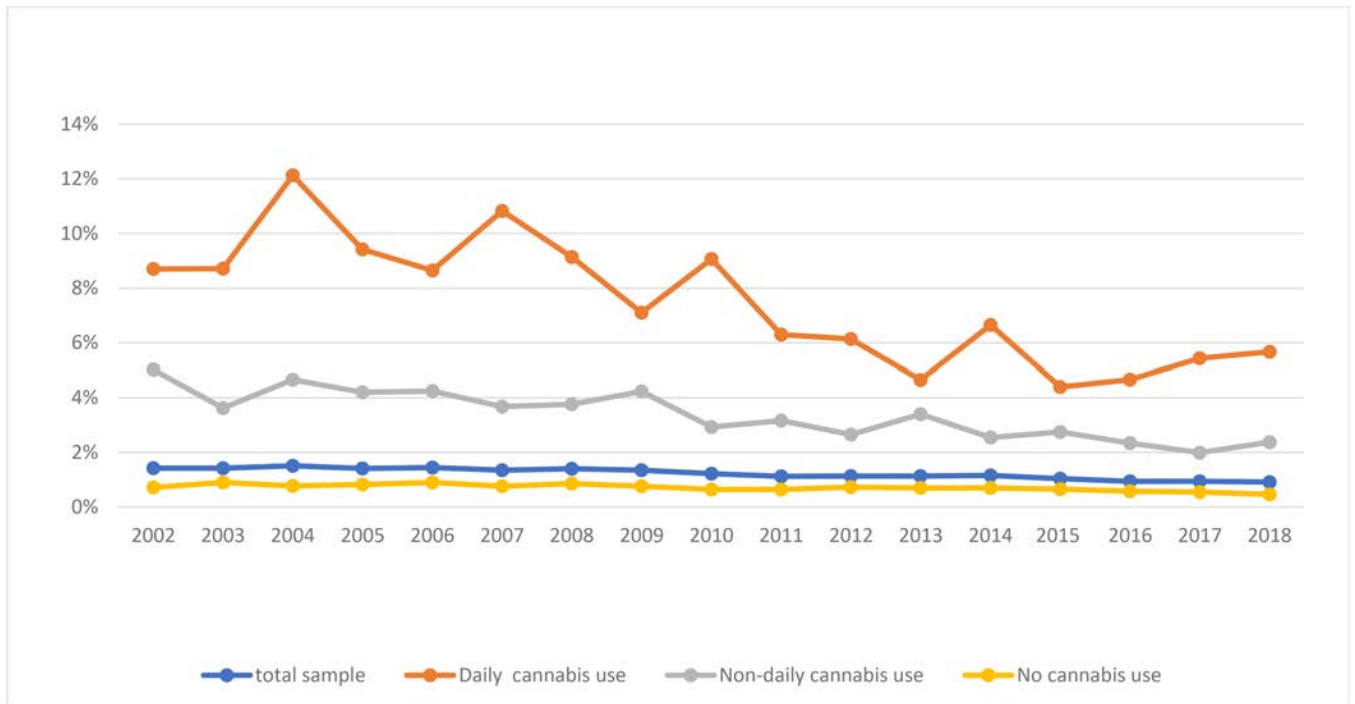
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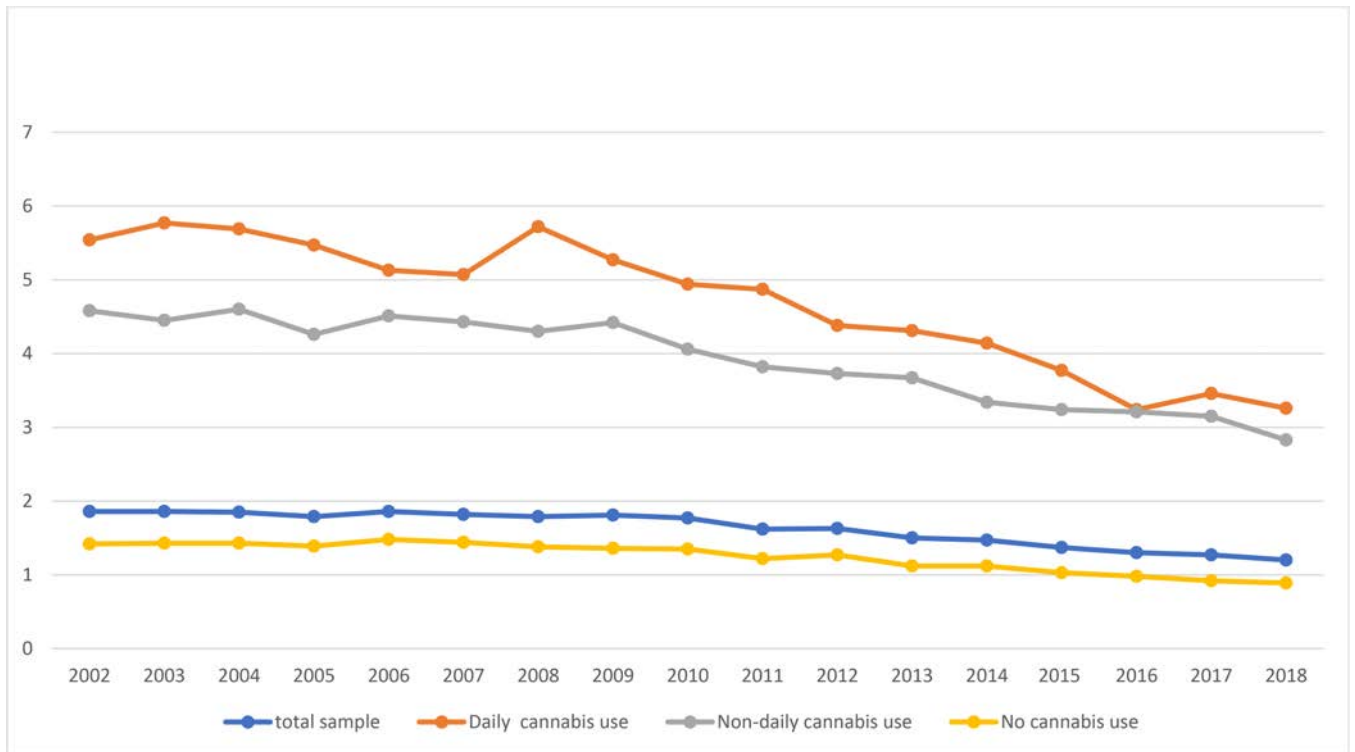


**Figure 1.**  
Prevalence of past-month alcohol use by cannabis use status (National Survey on Drug Use and Health 2002–2018, age 12–25)





**Figure 2.**  
Prevalence of past-month daily alcohol by cannabis use status (National Survey on Drug Use and Health 2002–2018, age 12–25)



**Figure 3.**  
Past-month average number of alcohol drinks per day by cannabis use status (National Survey on Drug Use and Health 2002–2018, age 12–25)

**Table 1.**

Prevalence of past-month alcohol use by past-month cannabis use status and by demographic characteristics (National Survey on Drug Use and Health, 2018, age 12–25)

Characteristic	Unadjusted prevalence of past-month alcohol use by past-month cannabis use status						Daily cannabis use vs. no cannabis use		Non-daily cannabis use vs. no cannabis use	
	N	wt% (s.e.)	N	wt% (s.e.)	Daily cannabis use <sup>2</sup>	wt% (s.e.)	OR (95% CI)	P <sub>int3</sub>	OR (95% CI)	P <sub>int3</sub>
Total sample	5517	27.92 (0.45)	1882	73.35 (1.12)	884	78.17 (1.310)	6.41 (5.53, 7.44)	<0.0001	6.41 (5.53, 7.44)	<0.0001
<i>Gender</i>										
Male	2613	26.73 (0.57)	900	70.17 (1.69)	556	77.23 (1.83)	6.49 (5.16, 8.16)	Ref	5.50 (4.54, 6.66)	Ref
Female	2904	29.10 (0.66)	982	76.58 (1.48)	328	79.86 (2.33)	6.50 (4.59, 9.19)	0.9949	7.63 (6.01, 9.69)	0.0379
<i>Marital status</i>										
Married	601	48.64 (2.29)	73	69.91 (5.64)	30	86.37 (5.79)	10.57 (3.78, 29.54)	Ref	3.63 (1.94, 6.78)	Ref
Widowed/divorced/separated	72	54.28 (6.50)	19	65.58 (12.75)	12	64.68 (17.37)	2.23 (0.55, 9.09)	0.0764	1.65 (0.52, 5.28)	0.2756
Never married	4752	35.11 (0.53)	1761	74.70 (1.13)	837	78.35 (1.33)	6.42 (5.39, 7.66)	0.3484	6.36 (5.44, 7.44)	0.0955
Less than 14 yrs old	92	1.68 (0.22)	29	33.85 (6.94)	5	33.86(13.65)	32.06 (9.88, 103.98)	0.1926	34.41 (17.28, 68.52)	<0.0001
<i>Income</i>										
<\$20,000	1313	31.51 (1.06)	522	74.92 (2.33)	267	78.88 (2.74)	6.56 (4.54, 9.46)	0.7962	6.23 (4.86, 7.97)	0.3332
\$20–49,999	1761	27.34 (0.77)	553	69.59 (1.77)	305	76.40 (2.50)	5.94 (4.47, 7.91)	0.4851	5.41 (4.19, 6.99)	0.0503
\$50,000	2443	26.80 (0.63)	807	74.88 (1.59)	312	79.36 (2.43)	7.07 (4.88, 10.26)	Ref	7.37 (5.88, 9.24)	Ref
<i>Race/ethnicity</i>										
Non-Hispanic White	3389	33.11 (0.67)	1092	79.41 (1.09)	508	80.08 (1.91)	5.04 (3.81, 6.67)	Ref	6.83 (5.85, 7.97)	Ref
Non-Hispanic Black	512	18.81 (0.86)	221	56.60 (3.11)	136	69.33 (3.87)	6.51 (4.27, 9.92)	0.3661	4.61 (3.34, 6.36)	0.0274
Hispanic	1059	23.62 (0.88)	372	70.32 (2.55)	148	81.74 (3.21)	11.26 (6.41, 19.79)	0.026	6.41 (4.46, 9.20)	0.7349
Non-Hispanic Other	557	23.10 (0.96)	197	71.33 (4.30)	92	76.47 (4.89)	10.61 (5.74, 19.62)	0.0379	8.86 (4.80, 16.36)	0.4116
<i>Education</i>										
Less than high school	364	23.08 (1.39)	154	61.54 (3.43)	113	60.09 (4.61)	5.34 (3.60, 7.93)	0.6098	5.44 (4.12, 7.19)	0.7766
HS graduate	1229	36.67 (1.00)	419	68.75 (2.81)	284	78.72 (2.20)	6.69 (5.15, 8.71)	0.3255	4.15 (3.21, 5.35)	0.6091
Some college	2161	53.59 (0.88)	703	86.18 (1.44)	321	84.02 (2.27)	4.59 (3.20, 10.55)	0.8808	5.43 (4.26, 6.94)	0.767
College or grad	1121	73.78 (1.53)	238	93.42 (1.88)	75	92.20 (3.34)	4.25 (1.71, 10.55)	Ref	4.92 (2.57, 9.42)	Ref
12–17 years old	642	5.51 (0.25)	368	51.68 (2.69)	91	63.67 (4.67)	19.86 (12.91, 30.56)	0.0027	12.77 (9.99, 16.32)	0.0116

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Key: CI, confidence interval; OR, odds ratio; s.e., standard error; wt%, weighted percentage

<sup>1</sup> Non-daily cannabis use was defined as the report of using cannabis on 24 days or fewer of the past 30 days

<sup>2</sup> Daily cannabis use was defined by the report of using cannabis on 25 days or more of the past 30 days.

<sup>3</sup>  $\beta$  point is the p-value for the interaction of cannabis use status (either non-daily cannabis use versus no cannabis use or daily cannabis use versus no cannabis use) and demographic subgroups