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Cannabis use disorders among adults in the United States during a time of increasing use of cannabis

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ABSTRACT

Background: Using U.S. National Surveys on Drug Use and Health (NSDUH) data, researchers found that prevalence of cannabis use among adults increased in recent years, but prevalence of DSM-IV cannabis use disorder (CUD) was stable. Examining trends of all individual CUD criteria and of CUD severity may elucidate reasons for the lack of increases in CUD.

Methods: Data were from 749,500 persons aged 18 or older who participated in the 2002–2017 NSDUH. Descriptive analyses and logistic regressions were applied.

Results: Among adults during 2002–2017, past-year prevalence of DSM-IV CUD remained stable at 1.5% to 1.4%, but cannabis use increased from 10.4% to 15.3%, daily/near daily use increased from 1.9% to 4.2%, and mild DSM-5 CUD increased from 1.4% to 1.9%. Among adult cannabis users, past-year prevalence of DSM-IV CUD decreased from 14.8% to 9.3%, daily/near daily use increased from 18.0% to 27.2%, and DSM-5 moderate (4–5 criteria) and severe (6+ criteria) CUD decreased from 4.3% to 3.1% and from 2.4% to 1.3%, respectively. Examining trends in individual CUD criteria during 2002–2017 among adults overall revealed increases in two criteria (tolerance; spending a lot of time getting/using cannabis or getting over cannabis effects) and decreases/no changes in other criteria; among adult cannabis users, there was no change in one criterion (tolerance) and decreases in other criteria.

Conclusions: DSM-5's single dimension CUD measure may be more sensitive to diagnosis prevalence changes than the separate DSM-IV cannabis dependence and abuse categories. Future diagnostic approaches to assessing CUD may benefit from quantitatively oriented criteria.

1. Introduction

Laws and policies related to cannabis use have been shifting markedly worldwide. Canada, India, Mexico, Spain, Germany, and the Netherlands have decriminalized the possession of small quantities of cannabis, and Uruguay and Canada have fully legalized cannabis use for nonmedical purposes by adults (Cox, 2018). In the U.S. by 2019, 33 states and the District of Columbia (DC) had legalized medical cannabis use, and 10 states and DC had legalized cannabis for nonmedical use by adults (ProCon.org (ProCon, 2019). Changes in overall social acceptability of cannabis use as reflected in these laws and policies may have impacted the prevalence of cannabis use and related consequences (Compton et al., 2016; Grucza et al., 2016; Hasin et al., 2015; Hasin, 2018; Sarvet et al., 2018). For example, one recent study reported that among adults from 2002 to 2014, the prevalence of cannabis use increased from 10.4% to 13.3% (Compton et al., 2016). This increase in cannabis use was associated with increasing legal and social acceptance, greater cannabis availability, and declining risk perceptions of cannabis use (Compton et al., 2016).

In contrast, this same study found that the prevalence of cannabis use disorders (CUD) among adults based on assessments of individual diagnostic criteria from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) (American Psychiatric Association (APA, 1994) remained stable at 1.5% throughout 2002–2014, using data from the National Surveys on Drug Use and Health (NSDUH) (Compton et al., 2016). Moreover, another recent study using NSDUH data reported falling rates of cannabis dependence among daily or near daily users from 26.5% in 2002–2004 to 16.1% in 2014–2016 (Davenport, 2018). It is puzzling that rates of CUD remained stable, and the rates of cannabis dependence even declined among regular users

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during the time of increasing cannabis potency (Compton et al. 2004; ElSohly, 2015) and increasing frequency of cannabis use (Compton et al., 2016; Davenport, 2018; Williams et al., 2017). Furthermore, other national surveys show marked increases in CUD across the time frame of 2001–2002 to 2012–2013 (Hasin et al., 2015, 2016).

The purpose of this study was to elucidate possible reasons for the lack of an increase in DSM-IV CUD among adults overall in the NSDUH. First, we extended prior analyses beyond 2002–2014 by including 2015–2017 NSDUH data to determine if the lack of an increase in CUD persisted. We assessed trends in past-year cannabis use, initiation, use frequency, and CUD among adults overall and among adult cannabis users. Second, we examined trends in separate DSM-IV cannabis abuse and dependence diagnoses as well as in all individual CUD criteria among adults overall and among adult cannabis users to understand whether trends in specific CUD criteria may have contributed to the overall lack of an increase in DSM-IV CUD. Third, because a key feature of DSM-5 is the assessment of substance use disorder severity (American Psychiatric Association (APA, 2013), we explored trends in meeting "approximations" of mild (2–3 criteria), moderate (4–5 criteria), and severe (6 or more criteria) DSM-5 CUD based on the nine criteria assessed by the NSDUH that overlap with the DSM-5 CUD criteria. In addition, we estimated the total numbers of adults with past-year cannabis use, initiation, DSM-IV abuse, dependence, and use disorders as well as the number meeting approximate DSM-5 severity categories between 2002 and 2017.

Because of increasing legal and social acceptance and declining perceived harmfulness of cannabis use over time (Compton et al., 2016), we hypothesized that the prevalence of endorsing the specific CUD criteria of "tolerance" and "spending a lot of time getting or using cannabis or getting over the effects of cannabis" as operationalized in NSDUH would increase, consistent with the increasing frequency of cannabis use. By contrast, we also hypothesized that the prevalence of endorsing individual diagnostic CUD criteria related to perceived consequences from cannabis use, such as "role impairment" (using cannabis caused serious problems with major role obligations) and "hazardous use", would not increase.

2. Methods

2.1. Data source

We examined data from adults aged 18 or older who participated in the 2002–2017 NSDUH, conducted by the Substance Abuse and Mental Health Services Administration (SAMHSA). NSDUH provides nationally and state representative data on cannabis use and CUD among the US civilian, noninstitutionalized population aged 12 or older. NSDUH data collection protocol was approved by the Institutional Review Board at RTI International. The annual mean weighted response rate of the 2002–2017 NSDUH was 63.6%. Cannabis use and CUD related NSDUH data have the following key strengths: consistent survey design, methodology, and questionnaire content since 2002 (Compton et al., 2016; Grucza et al., 2016), good validity and reliability of measures for CUD and other substance use disorders (Jordan et al., 2008; Substance Abuse and Mental Health Services Administration (SAMHSA, 2010), and large sample sizes, allowing detection of changes in CUD across each year since 2002. Additional details regarding NSDUH methods are provided elsewhere (Substance Abuse and Mental Health Services Administration (SAMHSA, 2018).

2.2. Measures

NSDUH collected cannabis use and use frequency in the past 12 months. "Daily or near daily users" were past-year cannabis users reporting on average using 5 or more days per week, 20 or more days per month, or 240 or more days in the past 12 months (Compton et al., 2016).

Table 1
DSM cannabis use disorder (CUD) diagnostic questions in the 2002–2017 National Surveys on Drug Use and Health (NSDUH; Note: NSDUH lacks DSM-5 Criterion 4 "Craving" and Criterion 11 "Withdrawal").

DSM-IV Dependence Criterion 1 and DSM-5 CUD Criterion 10 *(based on an affirmative response to either of the questions)*
- During the past 12 months, did you need to use more marijuana or hashish than you used to in order to get the effect you wanted?
- During the past 12 months, did you notice that using the same amount of marijuana or hashish had less effect on you than it used to?

DSM-IV Dependence Criterion 3 and DSM-5 Criterion 1 *(based on an affirmative response to both questions)*
- During the past 12 months, did you try to set limits on how often or how much marijuana or hashish you would use?
- Were you able to keep to the limits you set, or did you often use marijuana or hashish more than you intended to?

DSM-IV Dependence Criterion 4 and DSM-5 CUD Criterion 2 *(based on an affirmative response to the first and a negative response to the second)*
- During the past 12 months, did you want to or try to cut down or stop using marijuana or hashish?
- During the past 12 months, were you able to cut down or stop using marijuana or hashish every time you wanted to or tried to?

DSM-IV Dependence Criterion 5 and DSM-5 CUD Criterion 3 *(based on an affirmative response to either of the questions)*
- During the past 12 months, was there a month or more when you spent a lot of your time getting or using marijuana or hashish?
- During the past 12 months, was there a month or more when you spent a lot of your time getting over the effects of the marijuana or hashish you used?

DSM-IV Dependence Criterion 6 and DSM-5 CUD Criterion 7 *(based on an affirmative response to the question)*
- This question is about important activities such as working, going to school, taking care of children, doing fun things such as hobbies and sports, and spending time with friends and family. During the past 12 months, did using marijuana or hashish cause you to give up or spend less time doing these types of important activities?

DSM-IV Dependence Criterion 7 and DSM-5 CUD Criterion 9 *(based on an affirmative response to both questions)*
- During the past 12 months, did you have any problems with your emotions, nerves, or mental health that were probably caused or made worse by your use of marijuana or hashish?
- Did you continue to use marijuana or hashish even though you thought it was causing you to have problems with your emotions, nerves, or mental health?
- *(or based on an affirmative response to both questions)*
- During the past 12 months, did you have any physical health problems that were probably caused or made worse by your use of marijuana or hashish?
- Did you continue to use marijuana or hashish even though you thought it was causing you to have physical problems?

DSM-IV Abuse Criterion 1 and DSM-5 CUD Criterion 5 *(based on an affirmative response to the question)*
- Sometimes people who use marijuana or hashish have serious problems at home, work or school — such as: neglecting their children, missing work or school, doing a poor job at work or school, losing a job or dropping out of school. During the past 12 months, did using marijuana or hashish cause you to have serious problems like this either at home, work, or school?

DSM-IV Abuse Criterion 2 and DSM-5 CUD Criterion 8 *(based on an affirmative response to the question)*
- During the past 12 months, did you regularly use marijuana or hashish and then do something where using marijuana or hashish might have put you in physical danger?

DSM-IV Abuse Criterion 3 (not included in DSM-5) *(based on an affirmative response to the question)*
- During the past 12 months, did using marijuana or hashish cause you to do things that repeatedly got you in trouble with the law?

DSM-IV Abuse Criterion 4 and DSM-5 CUD Criterion 6 *(based on an affirmative response to both questions)*
- During the past 12 months, did you have any problems with family or friends that were probably caused by your use of marijuana or hashish?
- Did you continue to use marijuana or hashish even though you thought it caused problems with family or friends?

NSDUH estimated past 12-month CUD based on assessments of individual DSM-IV diagnostic criteria, including dependence criteria (spending a lot of time getting, using or getting over the effects of cannabis; using more cannabis than intended; tolerance to the effects of cannabis; inability to cut down or stop using cannabis; continued use of cannabis despite mental health or physical problems related to use;

giving up or neglecting activities because of cannabis use) and abuse criteria (neglecting major roles because of cannabis; use of cannabis in hazardous situations; recurrent legal problems because of cannabis use; continued use of cannabis despite social or interpersonal problems related to use) (American Psychiatric Association (APA, 1994). Table 1 presents the specific NSDUH questionnaire items measuring each of the DSM-IV cannabis dependence and abuse criteria.

To approximate DSM-5 diagnoses, we examined the prevalence of endorsing any two or more of the nine assessed CUD criteria that overlap with DSM-5 CUD criteria: We excluded the DSM-IV criterion about legal problems because DSM-5 excluded it (American Psychiatric Association (APA, 2013), and we could not assess DSM-5 criteria for cannabis craving and withdrawal symptoms (American Psychiatric Association, 2013; Gorelick et al., 2012; Hasin et al., 2008) because the 2002–2017 NSDUH did not collect them. Similarly, we examined the prevalence of meeting mild (2–3 criteria), moderate (4–5 criteria), and severe (6+ criteria) DSM-5 CUD based on the nine assessed CUD criteria in the survey that were queried in identical ways across 2002–2017.

2.3. Statistical analyses

For each year, we estimated 12-month prevalence of cannabis use, initiation rates among eligible adults (those who had never used cannabis prior to 12 months ago), daily or near daily cannabis use, any DSM-IV CUD, DSM-IV cannabis dependence, DSM-IV cannabis abuse, and mean number of days of cannabis use in the past year. Moreover, we estimated the 12-month prevalence of meeting each of the 10 individual DSM-IV CUD criteria (six for cannabis dependence and four for cannabis abuse) among adults and among adult cannabis users. Furthermore, we assessed 12-month prevalence of meeting at least any two of the nine assessed DSM-5 CUD criteria and of meeting mild, moderate, and severe DSM-5 CUD among adults, adult cannabis users, and adult daily or near daily cannabis users.

For percentage estimates, bivariable logistic regression models were applied to estimate prevalence, test for differences between estimates for 2002 and each year in 2003–2017, and to test p values of beta coefficients of the year variable to assess trends. For mean numbers of days of cannabis use, linear regression models were applied to examine differences between estimates for 2002 and for each year in 2003–2017 and to test p values of beta coefficients of the year variable to assess trends. SUDAAN (Research Triangle Institute (RTI, 2015) software was used for our analyses to account for the complex sample design and sampling weights of NSDUH data. Results for each of the years examined in the study are presented in Appendix Tables and summary results for the 2002–2017 trends are in the main Tables.

3. Results

3.1. Trends in Cannabis use, initiation, daily or near daily use, and mean number of days of use

Based on 749,500 sampled persons aged 18 or older from the 2002–2017 NSDUH (Table 2, Table 5, and Appendix Table 1), the prevalence of past-year cannabis use among adults in the U.S. increased from 10.4% (or 21.9 million) in 2002 to 15.3% (or 37.8 million) in 2017, a 72.6% increase in the number of U.S. adult cannabis users. The past-year initiation rate doubled from 0.7% (or 0.8 million) in 2002 to 1.4% (or 1.8 million) in 2017. The prevalence of daily or near daily use more than doubled from 1.9% (or 3.9 million) in 2002 to 4.2% (or 10.3 million) in 2017. During this time, the mean number of days of cannabis use almost doubled from 10.0 days to 19.3 days among adults overall and increased 31.2% from 97.9 days to 128.4 days among adult cannabis users.

3.2. Trends in DSM-IV Cannabis use disorder (CUD)

During 2002–2017, the prevalence of DSM-IV CUD remained similar at about 1.4–1.5% among adults. However, the prevalence of DSM-IV CUD declined from 14.8% to 9.3% among adult cannabis users, declined from 7.4% to 2.4% among past-year cannabis initiates, declined from 15.1% to 9.6% among cannabis users who were non-past-year initiates, and declined from 33.4% to 19.5% among daily or near daily cannabis users.

During 2002–2017, the prevalence of DSM-IV cannabis dependence remained stable at about 0.9–1.0% among adults but declined from 9.2% to 6.4% among adult cannabis users, declined from 9.4% to 6.6% among cannabis users who were non-past-year initiates, and declined from 23.2% to 14.7% among daily or near daily cannabis users. During 2002–2017, the prevalence of DSM-IV cannabis abuse declined from 0.6% to 0.4% among adults, declined from 5.6% to 2.9% among adult cannabis users, declined from 5.7% to 3.0% among cannabis users who were non-past-year initiates, and declined from 10.2% to 4.8% among daily or near daily cannabis users.

3.3. Trends in each individual Cannabis use disorder diagnostic criterion

Examining individual DSM-IV diagnostic criteria, among adults during 2002–2017 (Table 3, Appendix Table 2), the prevalence of reporting spending a lot of time getting, using or getting over the effects of cannabis increased from 2.9% to 3.8%. The prevalence of reporting tolerance to cannabis increased from 1.8% to 2.9%. The prevalence of reporting neglecting major roles in order to use cannabis declined from 0.5% to 0.4%. The prevalence of reporting hazardous cannabis use declined from 0.5% to 0.4%. Trends in the prevalence of the other four dependence criteria and two abuse criteria were not significant. Among adult cannabis users during 2002–2017 (Table 4, Appendix Table 3), the prevalence of reporting cannabis tolerance remained stable, but the prevalence of reporting meeting each of the other five dependence criteria and the four abuse criteria significantly decreased.

3.4. Trends in DSM-5 cannabis use disorder

Among adults overall during 2002–2017 (Tables 5–6, Appendix Table 4), the prevalence of meeting an approximate-DSM-5 CUD diagnosis (at least any two of the nine assessed criteria) increased from 2.1% (or 4.4 million) to 2.6% (or 6.4 million). The prevalence of mild CUD among adults increased from 1.4% (or 2.9 million) in 2002 to 1.9% (or 4.7 million) in 2017. Overall, the mean number of DSM-5 criteria endorsed by adults increased from 0.09 in 2002 to 0.10 in 2017. In contrast, the prevalence of moderate and severe CUD among adults in 2002 did not differ from those from 2017, and the numbers of adults with moderate and severe CUD remained similar between 2002 and 2017.

Among adult cannabis users, the prevalence of meeting an approximate-DSM-5 CUD diagnosis decreased from 20.1% in 2002 to 16.8% in 2017. Moreover, between 2002 and 2017, the prevalence of mild CUD among adult users remained unchanged around 12.4–13.3%. However, during this time period, the prevalence of moderate and severe CUD among adult cannabis users decreased from 4.3% to 3.1% and from 2.4% to 1.3%, respectively. The mean number of DSM-5 criteria endorsed by adult users decreased from 0.83 to 0.66. Among adult daily or near daily cannabis users, the prevalence of mild, moderate, and severe CUD all decreased during 2002–2017.

4. Discussion

According to the NSDUH data, past-year cannabis use, initiation, and use frequency increased among U.S. adults during 2002–2017, consistent with an increasing number of states legalizing medical and nonmedical cannabis use in the U.S. and with a decrease in perceived

Table 2
12-month prevalence of cannabis use, initiation, use disorders, and use frequency (N = 749,500[1]).

12-month prevalence of cannabis use, initiation, and use disorders	12-month prevalence, weighted percentage (95% confidence interval)		Examined all 16 years of data during 2002-2017: β coefficents, *p* values for the overall trends
	2002	2017	
Cannabis use among adults [2]	10.4 (9.97-10.82)	15.3 + (14.85-15.78)	β = 0.0329; $p < 0.0001$ **
Initiation rate among eligible adults [3]	0.7 (0.60-0.76)	1.4 + (1.26-1.58)	β = 0.0459; $p < 0.0001$ **
Daily/near daily use[6] among adults[2]	1.9 (1.73-2.02)	4.2 + (3.94-4.40)	β = 0.0587; $p < 0.0001$ **
Daily/near daily use[6] among adult users	18.0 (16.73-19.28)	27.2 + (25.91-28.57)	β = 0.0350; $p < 0.0001$ **
DSM-IV CUD in adults [2]	1.5 (1.40-1.69)	1.4 (1.30-1.54)	β = -0.0064; $p = 0.0080$
CUD in users[5]	14.8 (13.60-16.14)	9.3 + (8.55-10.00)	β = -0.0390; $p < 0.0001$ **
CUD in initiates[4]	7.4 (5.08-10.54)	2.4 + (1.42-3.86)	β = -0.0742; $p < 0.0001$ **
CUD in non-initiate[4]-users[5]	15.1 (13.85-16.48)	9.6 + (8.85-10.40)	β = -0.0381; $p < 0.0001$ **
CUD in daily/near daily users[5]	33.4 (29.76-37.34)	19.5 + (17.62-21.45)	β = -0.0579; $p < 0.0001$ **
DSM-IV cannabis dependence in adults[2]	0.9 (0.86-1.06)	1.0 (0.88-1.08)	β = -0.0006; $p = 0.8443$
dependence in users[5]	9.2 (8.33-10.11)	6.4 + (5.81-7.01)	β = -0.0310; $p < 0.0001$**
dependence in initiates[4]	2.6 (1.54-4.30)	1.3 (0.69-2.56)	β = -0.0264; $p = 0.1102$
dependence in non-initiate[4]-users[5]	9.4 (8.55-10.41)	6.6 + (6.03-7.30)	β = -0.0308; $p < 0.0001$**
depedence in daily/near daily users[6]	23.2 (20.22-26.54)	14.7 + (13.00-16.50)	β = -0.0483; $p < 0.0001$**
DSM-IV cannabis abuse in adults[2]	0.6 (0.49-0.70)	0.4 + (0.38-0.51)	β = -0.0174; $p = 0.0001$ **
abuse in users[5]	5.6 (4.78-6.66)	2.9 + (2.47-3.33)	β = -0.0466; $p < 0.0001$ **
abuse in initiate[4]	4.8 (2.80-8.01)	1.0 + (0.47-2.17)	β = -0.1104; $p < 0.0001$ **
abuse in non-initiate[4]-users[5]	5.7 (4.78-6.73)	3.0 + (2.54-3.45)	β = -0.0447; $p < 0.0001$ **
abuse in daily/near daily users[6]	10.2 (7.96-13.02)	4.8 + (3.86-5.96)	β = -0.0547; $p < 0.0001$ **
Mean number of days of cannabis use in the past 12 months	weighted mean number of days (95% confidence interval)		Examined all 16 years of data during 2002-2017: β coefficents, p values for the overall trends
	2002	2017	
among adults[2]	10.0 (9.41-10.53)	19.3 + (18.42-20.13)	β = 0.6192; $p < 0.0001$**
among users[5]	97.9 (93.68-102.06)	128.4 + (124.21-132.59)	β = 2.0674; $p < 0.0001$**

Notes: [1]Data source: Substance Abuse and Mental Health Services Administration's the 2002–2017 National Surveys on Drug Use and Health (NSDUH) data. Weighted prevalence estimates are reported. SAMHSA requires that any description of overall sample sizes based on the restricted-use NSDUH data files be rounded to the nearest 100 to minimize potential disclosure risk. [2]Adults: Adults aged 18 or older in the U.S. [3]The eligible adults (denominator used for calculating initiation rate) are those who never used cannabis prior to 12 months ago. [4] The 12-month initiates were those who used cannabis for the first time in their lives within the past 12 months. [5]Users: adults aged 18 or older who had past-year cannabis use in the U.S. [6] Daily/near daily users: Cannabis users who used cannabis 5 + days each week, 20 + days each month, or 240 + days in the past 12 months. + Difference between the estimate in which the footnote symbol appears and the 2002 estimate (the reference year) is statistically significant at the .05 level. Bivariable logistic regression models were applied for testing differences in percentage estimates above. Linear regression models were applied for testing differences in the mean numbers of days of cannabis use above. CUD = cannabis use disorders. **These trends were statistically significant even after a Bonferroni correction (Since we tested a total of 21 hypotheses for the overall trends with a desired $\alpha = 0.05$, the Bonferroni correction would test each individual hypothesis at $\alpha = 0.05/21 = 0.0023$).

harmfulness of cannabis use over time (Compton et al., 2016; Hasin, 2018; ProCon.org (ProCon, 2019). Increases persisted during the years 2015 through 2017, confirming and extending findings from our earlier study of 2002–2014 (Compton et al., 2016). Among adults during 2002–2017, the prevalence of cannabis use increased from 10.4% to 15.3%, cannabis initiation increased from 0.7% to 1.4%, and the prevalence of daily or near daily cannabis use more than doubled, increasing from 1.9% to 4.2%.

Similar to our earlier study, which was also based on NSDUH data (Compton et al., 2016), we found that the prevalence of DSM-IV CUD

Table 3
12-month prevalence of meeting individual DSM-IV diagnostic criteria for cannabis use disorders among adults (N = 749,500[1]).

DSM-IV criteria for cannabis use disorders	12-month prevalence, weighted percentage (95% confidence interval)		Examined all 16 years of data during 2002-2017: β coefficents, *p* values for the overall trends
	2002	2017	
Dependence Criteria			
Spending a lot of time	2.9 (2.76-3.14)	3.8 + (3.58-3.98)	β = 0.0234; $p < 0.0001$ **
Using more than intended	0.6 (0.49-0.66)	0.6 (0.54-0.68)	β = 0.0052; $p = 0.1801$
Tolerance	1.8 (1.68-1.96)	2.9 + (2.69-3.04)	β = 0.0324; $p < 0.0001$**
Unable to cut down or stop	0.6 (0.47-0.66)	0.5 + (0.44-0.57)	β = -0.0046; $p = 0.2685$
Continued use despite mental or physical harm	0.6 (0.54-0.74)	0.7 (0.58-0.74)	β = -0.0059; $p = 0.1097$
Neglecting activities	0.7 (0.65-0.84)	0.7 (0.66-0.84)	β = -0.0079; $p = 0.0137$
Abuse Criteria			
Role impairment	0.5 (0.43-0.61)	0.4 + (0.32-0.43)	β = -0.0183; $p < 0.0001$**
Hazardous use	0.5 (0.46-0.61)	0.4 + (0.32-0.45)	β = -0.0285; $p < 0.0001$**
Legal problems	0.2 (0.16-0.27)	0.2 (0.15-0.22)	β = -0.0159; $p = 0.0142$
Continued use despite social problems	0.4 (0.31-0.47)	0.3 (0.29-0.40)	β = -0.0100; $p = 0.0406$

Notes: [1]Data source: Substance Abuse and Mental Health Services Administration's the 2002–2017 National Surveys on Drug Use and Health (NSDUH) data. Weighted prevalence estimates are reported. SAMHSA requires that any description of overall sample sizes based on the restricted-use NSDUH data files be rounded to the nearest 100 to minimize potential disclosure risk. + Difference between the estimate in which the footnote symbol appears and the 2002 estimate (the reference year) is statistically significant at the .05 level. Bivariable logistic regression models were applied for testing differences in percentage estimates above. **These trends were statistically significant even after a Bonferroni correction (Since we tested a total of 10 hypotheses for the overall trends with a desired $\alpha = 0.05$, the Bonferroni correction would test each individual hypothesis at $\alpha = 0.05/10 = 0.005$).

Table 4
12-month prevalence of meeting individual DSM-IV diagnostic criteria for cannabis use disorders among past-year adult cannabis users (N = 145,500[1]).

DSM-IV criteria for cannabis use disorders	12-month prevalence, weighted percentage (95% confidence interval)		Examined all 16 years of data during 2002-2017: β coefficents, *p* values for the overall trends
	2002	2017	
Dependence Criteria			
Spending a lot of time	28.4 (26.90-29.97)	24.8+ (23.64-25.97)	β= -0.0084; $p < 0.0001$**
Using more than intended	5.5 (4.77-6.31)	4.0 + (3.53-4.44)	β= -0.0241; $p < 0.0001$**
Tolerance	17.6 (16.38-18.79)	18.8 (17.81-19.79)	β = 0.0033; $p = 0.1057$
Unable to cut down or stop	5.4 (4.57-6.36)	3.3+ (2.89-3.76)	β= -0.0337; $p < 0.0001$ **
Continued use despite mental or physical harm	6.1 (5.25-7.07)	4.3+ (3.82-4.82)	β= -0.0353; $p < 0.0001$ **
Neglecting activities	7.1 (6.28-8.00)	4.9+ (4.35-5.47)	β= -0.0378; $p < 0.0001$ **
Abuse Criteria			
Role impairment	5.0 (4.20-5.89)	2.4+ (2.09-2.84)	β= -0.0471; $p < 0.0001$ **
Hazardous use	5.1 (4.45-5.84)	2.5+ (2.13-2.95)	β= -0.0572; $p < 0.0001$ **
Legal problems	2.0 (1.52-2.59)	1.2+ (0.95-1.47)	β= -0.0436; $p < 0.0001$ **
Continued use despite social problems	3.7 (3.04-4.52)	2.2+ (1.92-2.61)	β= -0.0384; $p < 0.0001$ **

Notes: [1]Data source: Substance Abuse and Mental Health Services Administration's the 2002–2017 National Surveys on Drug Use and Health (NSDUH) data. Weighted prevalence estimates are reported. SAMHSA requires that any description of overall sample sizes based on the restricted-use NSDUH data files be rounded to the nearest 100 to minimize potential disclosure risk. +Difference between the estimate in which the footnote symbol appears and the 2002 estimate (the reference year) is statistically significant at the .05 level. Bivariable logistic regression models were applied for testing differences in percentage estimates above. **These trends were statistically significant even after a Bonferroni correction (Since we tested a total of 10 hypotheses for the overall trends with a desired $\alpha = 0.05$, the Bonferroni correction would test each individual hypothesis at $\alpha = 0.05/10 = 0.005$).

among U.S. adults in 2002 did not differ from that in 2017. Detailed analyses of trends in each of the diagnostic criteria revealed that among adults during 2002–2017, the prevalence of reporting spending a lot of time getting, using or getting over the effects of cannabis increased from 2.9% to 3.8%, and the prevalence of reporting tolerance to cannabis increased from 1.8% to 2.9%. By contrast, among adults during 2002–2017, the prevalence of reporting neglecting major roles in order to use cannabis declined from 0.5% to 0.4%, and the prevalence of reporting hazardous cannabis use declined from 0.5% to 0.4%. These offsetting increases in two criteria and decreases in two others help explain the lack of an increase in past-year DSM-IV CUD in adults during 2002–2017. Under DSM–IV, a cannabis dependence diagnosis requires three or more out of the six dependence criteria to be present within a 12-month period, while a cannabis abuse diagnosis is based on any one or more of the four abuse criteria (and only diagnosed in the absence of cannabis dependence) (American Psychiatric Association (APA, 1994). Although the two increasing criteria had much larger changes compared to the two decreasing criteria, because the presence of DSM-IV cannabis dependence requires the presence of three or more dependence criteria, the increases in reporting the two dependence criteria were not sufficient to have had a detectable impact on the diagnosis of cannabis dependence.

We did find that the prevalence of meeting an approximate DSM-5 CUD diagnosis, which required meeting any two or more of the nine assessed DSM-5 criteria, increased from 2.1% to 2.6% from 2002 to 2017 among adults. Moreover, we found that the prevalence of mild

Table 5
Trends in cannabis use disorder severity (meeting at least any two or more of the nine DSM-5 criteria (legal problems removed)) and the number of endorsed DSM-5 criteria among adults (N = 749,500[1]) and among adults with past-year cannabis use (N = 145,500[1]).

Meeting DSM-5 criteria for a cannabis use disorder	12-month prevalence, weighted percentage (95% confidence interval)		Examined all 16 years of data during 2002-2017: β coefficents, *p* values for the overall trends
	2002	2017	
Any 2+ criteria of nine DSM-5 criteria in adults	2.1 (1.93-2.25)	2.6 + (2.42-2.73)	β = 0.0155; $p < 0.0001$ **
Any 2-3 criteria of the nine DSM-5 criteria in adults	1.4 (1.26-1.52)	1.9 + (1.78-2.04)	β = 0.0251; $p < 0.0001$ **
Any 4-5 criteria of the nine DSM-5 criteria in adults	0.5 (0.38-0.53)	0.5 (0.41-0.54)	β= -0.0053; $p = 0.1966$
Any 6+ criteria of the nine DSM-5 criteria in adults	0.3 (0.21-0.31)	0.2 (0.16-0.24)	β= -0.0175; $p = 0.0019$ **
Any 2+ criteria of the nine DSM-5 criteria in adult users	20.1 (18.76-21.45)	16.8+ (15.89-17.72)	β= -0.0169; $p < 0.0001$ **
Any 2-3 criteria of the nine DSM-5 criteria in adult users	13.3 (12.22-14.49)	12.4 (11.65-13.28)	β= -0.0050; $p = 0.0342$
Any 4-5 criteria of the nine DSM-5 criteria in adult users	4.3 (3.69-5.03)	3.1+ (2.68-3.53)	β= -0.0343; $p < 0.0001$**
Any 6+ criteria of the nine DSM-5 criteria in adult users	2.4 (2.00-2.97)	1.3 + (1.04-1.54)	β= -0.0455; $p < 0.0001$**
Any 2+ criteria of the nine DSM-5 criteria in adult daily/near daily users	48.7 (44.5-52.91)	36.8 + (34.39-39.30)	β= -0.0425; $p < 0.0001$**
any 2-3 criteria of the nine DSM-5 criteria in adult daily/near daily users	31.7 (28.36-35.26)	27.3 + (25.11-29.61)	β= -0.0191; $p < 0.0001$**
any 4-5 criteria of the nine DSM-5 criteria in adult daily/near daily users	10.4 (8.30-13.06)	6.8 + (5.60-8.16)	β= -0.0451; $p < 0.0001$**
any 6+ criteria of the nine DSM-5 criteria in daily/near daily users	6.5 (5.20-8.20)	2.7 + (2.12-3.53)	β= -0.0637; $p < 0.0001$**
Mean number of symptoms meeting DSM-5 (nine) criteria	Weighted mean number of endorsed criteria (95% confidence interval)		Examined all 16 years of data during 2002-2017: β coefficents, *p* values for the overall trends
	2002	2017	
Adults	0.09 (0.081-0.093)	0.10+ (0.096-0.108)	β = 0.0011; $p < 0.0001$ **
Adult users	0.83 (0.784-0.883)	0.66+ (0.634-0.698)	β= -0.0130; $p < 0.0001$ **

Notes: [1]Data source: Substance Abuse and Mental Health Services Administration's the 2002–2017 National Surveys on Drug Use and Health (NSDUH) data. Weighted prevalence estimates are reported. SAMHSA requires that any description of overall sample sizes based on the restricted-use NSDUH data files be rounded to the nearest 100 to minimize potential disclosure risk. +Difference between the estimate in which the footnote symbol appears and the 2002 estimate (the reference year) is statistically significant at the .05 level. Bivariable logistic regression models were applied for testing differences in percentage estimates above. **These trends were statistically significant even after a Bonferroni correction (Since we tested a total of 14 hypotheses for the overall trends with a desired $\alpha = 0.05$, the Bonferroni correction would test each individual hypothesis at $\alpha = 0.05/14 = 0.0036$).

Table 6
The numbers of adults with cannabis use, initiation, DSM-IV abuse, dependence, and use disorders as well as meeting severity categories of the nine DSM-5 criteria (legal problems removed) for a cannabis use disorder in the U.S. between 2002 and 2017, N = 95,500[1].

Cannabis use and cannabis use disorders in the past 12 months	*Number in thousands* (standard error)		*p* value for the difference between the 2 years
	2002	2017	
Cannabis use	21,850 (480)	37,841 (657)	$p < 0.0001$ **
Cannabis initiation	823 (48)	1829 (107)	$p < 0.0001$ **
Daily or near daily cannabis use	3927 (159)	10,300 (299)	$p < 0.0001$ **
DSM-IV cannabis use disorders	3239 (158)	3500 (150)	$p = 0.1936$
DSM-IV cannabis abuse	1233 (109)	1085 (83)	$p = 0.0165$
DSM-IV cannabis dependence	2006 (107)	2415 (123)	$p = 0.7382$
Any 2+ criteria of the nine DSM-5 criteria for a cannabis use disorder	4385 (174)	6350 (194)	$p < 0.0001$ **
Any 2-3 criteria of the nine DSM-5 criteria	2909 (138)	4708 (164)	$p < 0.0001$ **
Any 4-5 criteria of the nine DSM-5 criteria	943 (77)	1164 (85)	$p = 0.6498$
Any 6+ of the nine DSM-5 criteria	533 (55)	479 (49)	$p = 0.0670$

Notes: [1]Data source: Substance Abuse and Mental Health Services Administration's the 2002 and 2017 National Surveys on Drug Use and Health (NSDUH) data. Weighted prevalence estimates are reported. SAMHSA requires that any description of overall sample sizes based on the restricted-use NSDUH data files be rounded to the nearest 100 to minimize potential disclosure risk. Daily or near daily users: Cannabis users who used cannabis 5+days each week, 20+ days each month, or 240+ days in the past 12 months. **These trends were statistically significant even after a Bonferroni correction (Since we tested a total of 10 hypotheses for the overall trends with a desired $\alpha = 0.05$, the Bonferroni correction would test each individual hypothesis at $\alpha = 0.05/10 = 0.0050$).

CUD among adults increased, and the mean number of DSM-5 criteria endorsed by adults increased. Increases in the two individual criteria may also explain why an approximation of DSM-5 mild CUD increased because it requires only 2 criteria to be diagnosed. These findings also suggest that the single dimension measure used in DSM-5 may be more sensitive to changes in CUD than the separate cannabis dependence and abuse diagnoses of DSM-IV, although several studies have reported that concordance between DSM-5 CUD and DSM-IV cannabis abuse or dependence is substantial (Compton et al., 2013; Copeland et al., 2017).

Good validity and reliability have been found for DSM-IV CUD measured by the NSDUH (Jordan et al., 2008; Substance Abuse and Mental Health Services Administration (SAMHSA, 2010). Comparison with other work also suggests the validity of NSDUH results. For example, we found that the past-year prevalence of meeting approximate-DSM-5 CUD among US adults was 2.6% in 2012 and in 2013 based on NSDUH data (shown in Appendix Table 4). A separate US household population study also conducted in 2012–2013 found a very similar 2.54% past-year prevalence of DSM-5 CUD among US adults (Hasin et al., 2016). Hasin and colleagues' study (2016) included a larger set of questions to ascertain CUD compared to NSDUH and included both cannabis craving and withdrawal criteria (American Psychiatric Association (APA, 2013). Although the 2002–2017 NSDUH did not include the DSM-5 CUD criteria for craving and withdrawal, previous research has documented that these criteria are correlated with other CUD criteria (Hasin et al., 2013, 2016) and that the addition of craving as a criterion in DSM-5 does not substantially affect the likelihood of a CUD diagnosis (Peer et al., 2013), which may explain the similar estimates from two different data sources. Furthermore, we found both population and percentage increases in meeting mild DSM-5 CUD among adults between 2002 and 2017. Although future research is needed to confirm these findings using the full set of 11 DSM-5 criteria, the prevalence of CUD among adults based on NSDUH data could not be lower than what we report using the limited set of nine criteria.

In contrast to the findings for the overall adult population, among cannabis users, we found declining trends in DSM-IV CUD, findings that are consistent with earlier studies (Compton et al., 2016; Grucza et al., 2016; Hasin et al., 2015; Hasin, 2018). We extended these results by documenting declining trends among adult cannabis users in individual CUD criteria, identifying declining prevalence in all criteria except for cannabis tolerance (which remained stable). Consistent with and extending the findings of Davenport and colleagues (2018), we found that the prevalence of DSM-IV CUD consistently declined between 2002 and 2017 among cannabis initiators, among non-initiate cannabis users, and especially among daily or near daily cannabis users, although the mean number of days of cannabis use increased from 97.9 days to 128.4 days among cannabis users during this time. Furthermore, our study documented decreases in approximate DSM-5 (overall, moderate, and severe) CUD among adult cannabis users as well as decreases in approximate DSM-5 (overall, mild, moderate, and severe) CUD among adult daily or near daily cannabis users between 2002 and 2017. Thus, the apparently anomalous results of a reduced CUD prevalence cannot be explained only by the increasing proportion of initiators or experimental-only users over time.

Our results suggest that current work to screen patients for CUD may need to be modified. CUD criteria are based on adults' self-reported symptoms, which themselves are subjective (Morrison, 2014). Among adult cannabis users, CUD may be under-diagnosed and under-treated over time because the criteria do not include a cannabis use quantity-frequency measure. Yet, daily cannabis use is substantially concordant with diagnostic criteria (Compton et al., 2013) and may be less sensitive than subjective measures to reporting bias in the face of shifting attitudes toward cannabis. Consistent with DSM-IV and DSM-5 CUD criteria, NSDUH does not include daily cannabis use as a criterion for CUD classification, and our results show that less than 20% of daily or near daily adult cannabis users were classified as having CUD in 2017. With the increases in state medical and nonmedical cannabis legalization, many people are using cannabis daily or almost daily without reporting CUD. Because self-reported symptoms of CUD could be impacted by the increasing legal and social acceptance for cannabis use and by declining perceived harmfulness of cannabis use, more objective measures of severity, quantity, and frequency are urgently needed. In addition, research is needed to examine whether and how decreases in moderate and severe CUD among adult cannabis users and among adult cannabis daily or near daily users are related to growing public perceptions that cannabis is harmless and the increasing legal and social acceptance of cannabis use.

For patients who use cannabis, whether for purported medical purposes or for nonmedical purposes, querying about cannabis use quantity and frequency and about adverse outcomes related to cannabis use may be useful components of an individualized clinical evaluation. A previous study highlighted the importance of capturing the symptoms of social and occupational impairment as a consequence of frequent use (Kubarych et al., 2014). An earlier study found that a cannabis use quantity-frequency measure showed excellent psychometric properties and supported its consideration for inclusion in a future DSM as a criterion for CUD (Compton et al., 2009). Our results also suggest the importance of querying quantity and frequency of cannabis use as an easily ascertained, objective, and clinically important behavior. Perhaps future diagnostic systems could consider adding such objective measures as part of the nomenclature, much as specific thresholds for binge and heavy alcohol use are widely used in public health approaches to addressing harms caused by alcohol.

This study has several limitations, in addition to the limited number of CUD diagnostic questions covered in the NSDUH questionnaires. NSDUH

excluded homeless persons not living in shelters or those residing in institutions (e.g. those incarcerated), which may lead to underestimates in cannabis use and CUD. Moreover, while NSDUH consistently queried respondents across 2002–2017 with an identical panel of diagnostic items, the survey may underestimate CUD because of the ways in which diagnostic criteria are queried. For example, the NSDUH operationalization for the hazardous use criterion (DSM-IV Criterion 2 and DSM-5 Criterion 8) does not include the common behavior of "driving under the influence of cannabis", nor is a specific item included for having a "persistent desire… to cut down or control cannabis use" (part of the DSM-IV Criterion 4 and DSM-5 Criterion 2). Furthermore, because of the cross-sectional nature of NSDUH data, this study could not establish either temporal or causal relationships. In addition, study results may not apply to subjects from countries other than the U.S. where social attitudes and laws regarding cannabis may differ, and, finally, NSDUH is a self-reported survey and is subject to recall and social desirability biases.

5. Conclusions

Based on NSDUH data, we find that among U.S. adults, despite increases in use of cannabis from 2002 to 2017, there was no increase in DSM-IV CUD, while the prevalence of meeting an approximate DSM-5 CUD diagnosis (meeting at least any two of the nine DSM-5 criteria) increased, and the prevalence of DSM-5 mild CUD increased. Our results suggest that the single dimension measure used in DSM-5 may be more sensitive to changes in CUD than the separate cannabis dependence and abuse diagnoses of DSM-IV. Furthermore, the lack of increase in DSM-IV CUD was primarily because of decreases in the conditional prevalence of most individual CUD criteria.

Future research should examine whether changes in the prevalence of criteria in other substance use disorders are influenced by social acceptability or by perceptions of substance-related adverse consequences or harms. Our findings particularly suggest the need to move towards more quantitatively oriented criteria for diagnosing CUD.

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CRediT authorship contribution statement

Wilson M. Compton: Conceptualization, Writing - original draft. **Beth Han:** Conceptualization, Data curation, Formal analysis, Writing - original draft. **Christopher M. Jones:** Conceptualization, Writing - review & editing. **Carlos Blanco:** Conceptualization, Writing - review & editing.

Declaration of Competing Interest

Unrelated to the submitted work, Compton reports ownership of stock in General Electric Co., 3 M Co., and Pfizer Inc. Han, Jones, and Blanco have no conflicts to disclose.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.05.008.

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