Full length article

Cannabis use disorder among people using cannabis daily/almost daily in the United States, 2002–2016

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ABSTRACT

Background: Cannabis use disorder (CUD) prevalence among people reporting past-year cannabis use declined from 2002–2016. We examined whether similar reductions in CUD were observed among people reporting daily/almost daily cannabis use. We expected that CUD prevalence among people reporting daily/almost daily use would not decrease.
Methods: We used 2002–2016 National Survey on Drug Use and Health (NSDUH) data, including 22,651 individuals using cannabis 300 + days in the past year. CUD was defined using DSM-IV criteria for cannabis abuse and/or dependence. Age categories included: 12–17, 18–25, and 26 + . Annual prevalence of CUD, cannabis dependence, cannabis abuse, and each individual abuse/dependence items accounted for the complex survey design. Differences in trends over time were examined by age group.
Results: From 2002–2016, the prevalence of CUD among people reporting daily/almost daily cannabis use decreased by 26.8% in adolescents, by 29.7% in ages 18–25, and by 37.5% in ages 26 + . Prevalence of DSM-IV cannabis dependence decreased significantly among adolescents (-43.9%) and young adults (-26.8%) but remained stable in adults 26 + . Reductions in most dependence items were observed in young adults, with less consistent patterns in adolescents and adults 26 + . Prevalence of DSM-IV cannabis abuse decreased overall and for each abuse item across all age groups.
Conclusions: Contrary to expectations, CUD prevalence decreased significantly across all ages reporting daily/almost daily cannabis use between 2002–2016. Cannabis dependence prevalence decreased for adolescents and young adults and was stable only among adults ages 26 + reporting daily/almost daily cannabis use. Potential drivers of this decrease should be further explored.

1. Introduction

Cannabis use disorder (CUD) is associated with psychiatric and substance use comorbidity and impairment resulting in decreased quality of life (Hasin et al., 2016). While some evidence suggests that the prevalence of CUD in the total adult population in the United States has increased since the beginning of the new century (Hasin et al., 2015), other studies suggest that this prevalence has been stable in adults (Azofeifa et al., 2016; Compton et al., 2016), but has decreased among adolescent (ages 12–17 years) and young adult (ages 18–25 years) populations (Azofeifa et al., 2016). There is also evidence that the prevalence of CUD has decreased among people with past-year cannabis use in the last two decades (Compton et al., 2016; Hasin et al., 2015). This reduction in the prevalence of CUD among people using cannabis has been observed in all age groups, falling from 27% to 24%

among adolescents, from 20% to 15% among young adults, and from 11% to 9% in adults 26 years and older (Azofeifa et al., 2016; Compton et al., 2016). These decreases in CUD prevalence are unexpected, particularly as there has been an increase in the potency of available cannabis in the past two decades (ElSohly et al., 2016) as well as an increase in the prevalence of daily/almost daily cannabis use (used 300 or more days in the past year) during this time period (Azofeifa et al., 2016; Compton et al., 2016). For example, in those ages 18–25, the prevalence of daily/almost daily cannabis use in the past year increased 48.8%, from 4.3% to 6.4% from 2002 to 2014 and in those ages 26 and older, the prevalence increased by 150% from 0.8% in 2007 to 2.0% in 2014 (Azofeifa et al., 2016). Only among adolescents has the prevalence of using cannabis daily/almost daily remained relatively stable during this period (Azofeifa et al., 2016; Mauro et al., 2018).

A number of explanations have been offered for these observed

decreases in CUD among people with past-year cannabis use. First, the makeup of new and existing daily users may have changed in light of the shifting social and legal environment around cannabis use (ProCon.org, 2019). It is possible that a segment of those using cannabis may have shifted to more frequent cannabis use, thus increasing the prevalence of daily/almost daily cannabis use in the general population. Second, cannabis use patterns and characteristics of new and long-term cannabis users may partially explain the unexpected trends in those with past-year cannabis use. The prevalence of initiation of cannabis use in adults has increased since 2010 (Compton et al., 2016) and new cannabis users might be more likely to use cannabis less intensively and have less psychopathology than existing users as cannabis use becomes more socially normalized (Compton et al., 2016). Therefore, people initiating cannabis use more recently, who may be less likely to develop CUD symptoms, would eventually lower the prevalence of CUD among people reporting past-year cannabis use overall.

However, because people using cannabis daily are at highest risk of developing CUD (Compton et al., 2009) due to their frequent use, and also given the increases in cannabis potency (ElSohly et al., 2016), the prevalence of CUD among those using cannabis daily could be expected to have remained stable or increased as this population has grown over time. In contrast, evidence of a decrease in the prevalence of CUD, particularly in the highest risk group of those using cannabis daily/almost daily, might suggest changes in the validity of items measuring CUD in the context of legislative efforts to legalize cannabis use. This might indicate that decreases in the prevalence of CUD are artifactual, rather than reflecting changes in the characteristics of those using cannabis daily/almost daily. To date, no study has examined the general health profile of people using cannabis daily/almost daily and the trends in the prevalence of CUD in this population.

To better understand the observed decreases in CUD among people using cannabis, we used data from the National Surveys on Drug Use and Health (NSDUH) 2002–2016 to explore these proposed explanations for declining CUD. We focused on those using cannabis daily/almost daily given their elevated risk for CUD (Compton et al., 2009). We first examined changes in the prevalence of CUD among people reporting daily/almost daily cannabis use over time. We hypothesized that in those using cannabis daily/almost daily, the prevalence of CUD would remain stable or increase over the study period, given their higher risk of CUD (Compton et al., 2009). Second, we explored whether there have been changes in the prevalence of psychopathology or in the overall health of the population of those using cannabis daily/almost daily that might explain changes in the prevalence of CUD in this sample. Lastly, we described trends in cannabis abuse and dependence criteria to identify which specific criteria items may be driving any observed changes in the prevalence of CUD among of those using cannabis daily/almost daily over the study period.

2. Methods

2.1. Data source and sample

We used data from the National Surveys on Drug Use and Health (NSDUH), years 2002–2016. The NSDUH is a nationally and state representative sample of residents of households, non-institutional group quarters, and civilians living on military bases, ages 12 or older (CBHSQ, 2018). Weighted interview annual response rates in NSDUH vary from 68%–77% (CBHSQ, 2017; Odom et al., 2004). NSDUH used an in-person audio computer-assisted self-interview (ACASI) to collect information about substance use and other sensitive topics to increase the level of honest reporting (Morral et al., 2003). In 2015, NSDUH introduced changes that were designed to more closely reflect the actual population distributions by state and age group, improving the precision of estimates for older age groups. The sample redesign was not expected to result in changes to the prevalence estimates of cannabis use and abuse/dependence variables (CBHSQ, 2016). Participants

Table 1
Changes in the prevalence of cannabis use disorder [a], cannabis dependence, and cannabis abuse among people reporting daily/almost daily cannabis use, by age group.

	12–17 years Prevalence (95% CI)	18–25 years Prevalence (95% CI)	26+ years Prevalence (95% CI)
CUD[a]			
2002–2003	64.5 (59.2, 69.5)	45.4 (42.0, 48.7)	25.1 (20.7, 30.2)
2015–2016	47.2 (39.7, 54.9)	31.8 (28.9, 34.9)	15.7 (13.6, 18.1)
Difference 2002-2003 vs. 2015–2016	−17.3*	−13.5*	−9.4*
% Change	26.8	29.7	37.5
Cannabis dependence			
2002–2003	44.9 (39.2, 50.8)	34.7 (31.8, 37.7)	13.6 (10.1, 17.9)
2015–2016	25.2 (19.2, 32.4)	25.4 (23.0, 27.8)	12.0 (9.7, 14.6)
Difference 2002–2003 vs. 2015-2016	−19.7*	−9.3*	−1.6
% Change	43.9	26.8	11.8
Cannabis abuse			
2002–2003	55.0 (49.0, 60.8)	30.3 (27.4, 33.4)	16.3 (12.8, 20.4)
2015–2016	40.0 (32.6, 47.8)	17.0 (14.4, 20.0)	6.8 (5.7, 8.2)
Difference 2002–2003 vs. 2015–2016	−15.0*	−13.3*	−9.4*
% Change	27.3	43.9	57.7

[a] CUD = cannabis use disorder, i.e., DSM-IV cannabis dependence or/and abuse.
* Significant at 95% confidence.

ages 12 or older were included in our sample if they reported using cannabis daily/almost daily (N = 22,651).

2.2. Measures

2.2.1. Daily or almost daily Cannabis use

This measure was based on the total number of days a person used cannabis in the past year. Participants were classified as using cannabis daily or almost daily if they used cannabis 300 or more days in the past year.

2.2.2. Cannabis use disorder (CUD)

This measure was defined as meeting DSM-IV (APA, 2000) criteria for cannabis dependence (meeting at least three of the six criteria) in the past year and/or abuse (meeting at least one of the four criteria). Cannabis abuse prevalences were calculated independently from whether or not participants met the dependence criteria.

Individual items used in the DSM-IV abuse and dependence criteria were also analyzed separately. Items were categorized as "Yes"/"No" based on responses to questions detailed in Supplemental Table 1.[1] Dependence criteria included the following items: *Spent a great deal of time over a period of a month getting, using, or getting over the effects*; *Unable to keep set limits*; *Tolerance; Unable to cut down cannabis use*; *Continue to use despite health problems; and Gave up participation in important activities*.

Abuse criteria included the following items: *Recurrent use resulting in failure to fulfill major role obligations; Recurrent cannabis use in hazardous situation*; *Recurrent cannabis use and related legal problems*; and *Continued use despite persistent or recurrent social or interpersonal problems*.

2.2.3. Age

Age was categorized as: 12–17 years (adolescents), 18–25 years (young adults), and 26 or older (adults 26+).

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[1] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:…

2.2.4. Psychopathology and overall health

To examine whether changes in the prevalence of psychopathology and overall health in the population of those using cannabis daily/almost daily might explain changes in the prevalence of CUD in this group of users, we used the following two measures:

Access to mental health treatment or perceived need but did not receive mental health treatment (available only for those 18 or older, years 2002–2016): we estimated annual prevalences of mental health needs using responses to questions on: 1) Received any mental health treatment in past year; 2) Perceived need but did not receive mental health treatment in past year. We created a binary variable coded "1″ if the person responded "Yes" to any of these two questions, and "0″ if otherwise.

Health problems as indicated by a doctor (available for years 2005–2014): We estimated the annual prevalence of health problems using information on whether a doctor within the past year had told the person that she/he had any of the following: depression, anxiety, asthma, cirrhosis of the liver, bronchitis, diabetes, heart disease, hepatitis, high blood pressure, HIV/AIDS, lung cancer, pancreatitis, pneumonia, sexually transmitted disease, sinusitis, sleep apnea, stroke, tinnitus, tuberculosis, and ulcers. We created a binary variable coded "1″ if the person endorsed having at least one of these health conditions, and "0″ if otherwise. We conducted analyses for subgroups of past-year health problems: mental health, respiratory, digestive, cardiovascular, and infectious diseases. The formatting of these questions changed in 2015 and 2016, therefore, we do not include prevalences for these two years.

2.2.5. Driving under the influence of illegal drugs (with/without alcohol)

We used a measure on past-year driving under the influence of any illegal drug (which included cannabis in the NSDUH) by combining estimates with/without alcohol use. Participants were asked: "During the past 12 months, have you driven a vehicle while you were under the influence of a combination of alcohol and illegal drugs used together" and "During the past 12 months, have you driven a vehicle while you were under the influence of illegal drugs illegal drugs only?". If a person responded affirmatively to any of these two questions was coded as "1″; "0″ otherwise. The formatting of these questions changed in NSDUH 2016, therefore, we do not include the prevalence for 2016.

2.3. Statistical analysis

Weighted prevalences of CUD and yearly trends were estimated using the complex survey design information in NSDUH. Cannabis abuse and dependence trends, as well as trends for each specific abuse and dependence item, were calculated among those daily/almost daily cannabis use in the past year, by age group. Percent changes in the prevalence of CUD, abuse, dependence and individual items were calculated as the difference between average prevalence for years 2002–2003 and average prevalence in years 2015–2016. The annual change in the prevalence of CUD and of individual items, was tested in logistic regression models using dummy variables for each year that compare each year's prevalence against that of 2002.

3. Results

3.1. Prevalence of CUD

From 2002–2016, there was a reduction in the prevalence of CUD among individuals using cannabis daily/almost daily in the past year across all age groups (Table 1, Fig. 1). The CUD prevalence decreased by 26.8% in adolescents ages 12–17, by 29.7% in ages 18–25, and by 37.5% in adults 26 + .

3.2. DSM-IV Cannabis dependence

Reductions in the prevalence of cannabis dependence were observed among adolescents and young adults (43.9% and 26.8%, respectively) (Table 1, Fig. 1). Although there was evidence of a reduction in the prevalence of cannabis dependence in adults 26 + from 2010 to 2016, the prevalences in recent years were not significantly different from those in 2002–2003 based on pairwise comparisons.

3.3. Trends for DSM-IV Cannabis dependence items

In those ages 12–17, there were observed reductions in the following two dependence items: "*Continue to use despite health problems*" (88.7% reduction), and "*Spent a great deal of time over a period of a month getting, using, or getting over the effects*" (14.1% reduction) (Table 2). There was also evidence of reductions since 2002 for the item "*Gave up participation in important activities*" (47.3% reduction). In those 18–25 years, there were reductions in the prevalence of all dependence items, except for the "*Tolerance*" item. Among adults 26 + there were reductions in the prevalence of the items, *"Spent a great deal of time over a period of a month getting, using, or getting over the effects*" and "*Unable to cut down cannabis use.*" There were no major changes in the prevalence of "*Tolerance*" across any of the age groups.

3.4. DSM-IV Cannabis abuse in past-year

From 2002–2003 to 2015–2016 there was a reduction in the prevalence of cannabis abuse across all age groups, with reductions being more pronounced in older adults (57.7% reduction) followed by younger adults (43.9% reduction) and then by adolescents (27.3% reduction) (Table 1, Fig. 1).

3.5. Trends for DSM-IV Cannabis abuse items

There were significant reductions in all specific cannabis abuse items among those 12–17 years (Table 2) and in young adults. There were also reductions in two items among adults 26 +: "*Recurrent cannabis use in hazardous situation*" (68.1% reduction) and "*Continued use despite persistent or recurrent social or interpersonal problems*" (88.1% reduction).

3.6. Prevalence of health measures and of driving under the influence of illegal drugs (With/Without alcohol)

There were no significant reductions in the prevalence of *Perceived need/access to mental health treatment* or the prevalence of *Health problems as indicated by a doctor* among of those using cannabis daily/near daily in any age group (Supplemental Tables 2 and 3).[2] We also did not find evidence of significant reductions in prevalences of past-year health problems when examining health clusters separately (mental health, respiratory, digestive, cardiovascular, and infectious diseases health problems). In contrast, we found evidence of significant decreases (26%, 29% and 38% change in adolescents, those 18–24 and 26 +, respectively) in the past-year prevalence of self-reported driving under the influence of illegal drugs (with/without alcohol) across all age groups.

4. Discussion

Using repeated cross-sections of nationally representative data from the NSDUH, we found that the prevalence of DSM-IV CUD among people reporting past-year daily/almost daily cannabis use decreased

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[2] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:…
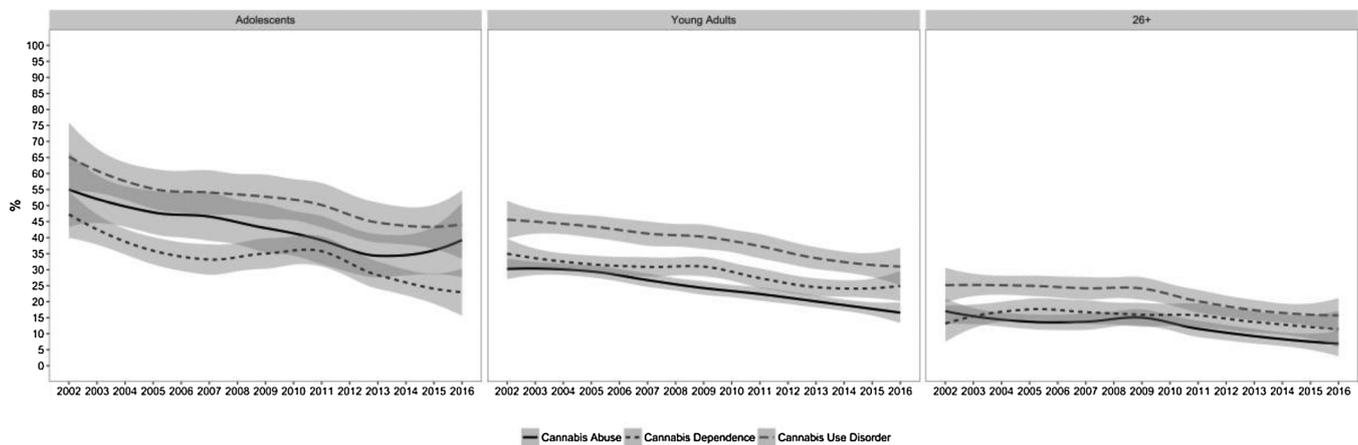
Fig. 1. Trends in the prevalence of DSM-IV cannabis use disorder, cannabis dependence, and cannabis abuse among people reporting daily/near daily cannabis use, by age group.
Dependence or/and abuse. Shaded area corresponds to confidence intervals (smoothed) for the point estimates.

between 2002–2016. Among those with past-year daily/almost daily cannabis use, there were reductions in the prevalence of DSM-IV cannabis abuse across all age groups, with reductions observed for all individual abuse items in adolescents and young adults. There were also reductions in the prevalence of DSM-IV cannabis dependence among adolescents and young adults, but not in adults ages 26 + . Reductions in most DSM-IV dependence items were observed in young adults while reductions in only a few dependence items were found for adolescents and older adults.

Our findings contradict our hypothesis that the prevalence of DSM-IV CUD would be stable, or increase, among those using cannabis daily/almost daily. There could be several potential mechanisms behind the decreases in the prevalence of CUD among of those with past-year daily/almost daily use of cannabis. First, the new national cannabis policy environment, with 33 states legalizing medical use and 10 states allowing recreational use of cannabis (ProCon.org, 2019), may have played a role in reducing stigma and perceptions of risk associated with cannabis use (Azofeifa et al., 2016; Cerda et al., 2017; Compton et al., 2016). In the context of decreasing perceived risk of cannabis use overall (Pacek et al., 2015) and increasing support of legalization (McCarthy, 2018) these laws could, in turn, be associated with changes in social attitudes towards cannabis use resulting in fewer conflicts with relatives and friends around cannabis use. This could explain reductions in the abuse item "*Continued use despite persistent or recurrent social or interpersonal problems*", which reflects difficulties in interactions with others due to cannabis use.

The new policy environment, including decriminalization of use and possession of specified amounts of cannabis, may have also led to fewer cannabis-related problems with the law, because, for example, it may be legal for adults in certain states to carry specific amounts of cannabis. Indeed, the item "*Recurrent cannabis use and related legal problems*" has been removed from the list of substance use disorder items in DSM-5 because of its poor fit with other substance use disorder criteria (Hasin et al., 2013). Nevertheless, reductions in stigma, harmful perceptions, and legal problems are less likely to explain the observed decreases in these items among adolescents, the majority of whom do not know if their state permits medical cannabis use (Mauro et al., 2019), and for whom cannabis use is not usually recommended or approved in states that permit medical or recreational use (Ryan et al., 2017). Moreover, reductions in stigma and harmful perceptions would not explain the observed decreases in other abuse and dependence items not likely to be affected by changes in social and legal norms (e.g., "*Continue to use despite health problems*").

Second, if new national cannabis policies helped to reduce stigma and harmful perceptions of cannabis use (Schuermeyer et al., 2014;

Ryan et al., 2017), this may have resulted in a sector of the population that is healthier overall starting to use cannabis more often, and therefore entering our sample of people using cannabis daily/near daily. This new population of people reporting daily/near daily use may have diluted the prevalence of cannabis abuse/dependence over time if they were less likely (e.g., due to having less psychopathology) to endorse items such as having problems fulfilling major role obligations due to cannabis use, being able to keep set limits and to cut down cannabis use, and continuing cannabis use despite it causing or worsening health problems. This is aligned with previous literature (Compton et al., 2016) suggesting that decreases in CUD could be attributable to recent onset cannabis users (within the past year), who may use cannabis less intensely and have fewer psychiatric conditions than people who have used cannabis for longer. Nevertheless, we did not find evidence of changes in the prevalence of health measures among of those using cannabis daily/almost daily over time. Our results did not show reductions in the prevalence of mental health needs or overall health problems, suggesting that the sample using cannabis daily/near daily in recent years was not on the whole healthier than those at the beginning of the study period. Moreover, the explanation that more recent users use cannabis less intensively loses strength when describing trends in people using cannabis daily/almost daily, given that they use cannabis on a routine basis. It is still possible that, on average, people reporting recent onset of daily/almost daily use used less potent cannabis or used cannabis fewer times per day compared with long-term users, which would lower their risk of CUD. Because NSDUH did not offer information on the frequency of cannabis use per day and/or the average potency of cannabis used, we were unable to examine this hypothesis in this study.

It is also possible that people were already using cannabis on a routine basis before legislation changes, but that social stigma and fear associated with reporting an illegal behavior to a federal contractor prevented them from endorsing frequent cannabis use, resulting in reporting bias (Gordis, 2014). As stigma decreased, people may have become more willing to report more frequent cannabis use. This would dilute the prevalence of CUD among those with daily/almost daily cannabis use, if their risk of CUD was lower than among those whose reporting of cannabis was unaffected by social factors.

Finally, as the cannabis market becomes increasingly regulated, better information about cannabis use risks may be available, such as risks of driving under the influence of cannabis and of health problems that can be worsened with cannabis use, which may have led to the use of cannabis under conditions that are less likely to result in harmful situations. Although driving under the influence of illegal drugs (with/without alcohol) remained high among those with daily/almost daily

Table 2
Prevalence of cannabis abuse/dependence items among people reporting daily/almost daily cannabis use, by year and age group.

a) Ages 12–17

	Cannabis abuse items Prevalence (95%CI)				Cannabis dependence items Prevalence (95%CI)					
	Failure role obligations	Hazardous situations	Law problems	Cont. use despite social problems	Spent a lot of time	Unable to keep limits	Tolerance	Unable to cut down	Cont. use despite health problems	Gave up social activities
2002	31.90 (25.3,39.3)	29.82 (22.2,38.7)	16.37 (10.4,24.7)	25.34 (18.4,33.8)	92.67 (87.6,95.8)	13.37 (8.9,19.5)	70.11 (63.1,76.3)	9.73 (6.1,15.1)	28.83 (22.9,35.6)	35.05 (27.8,43.1)
2003	25.16 (18.9,32.7)	27.02 (20.3,35)	16.57 (10.8,24.6)	22.51 (15.7,31.3)	88.41 (81.4,93)	11.63 (6.5,20)	68.98 (61.5,75.6)	11.49 (7.2,17.8)	20.69* (14.7,28.3)	26.51 (19.7,34.7)
2004	25.55 (19.8,32.3)	20.82 (14.8,28.5)	12.35 (7.8,19.0)	17.86 (12.9,24.2)	87.18 (80.3,91.9)	9.48 (6.2,14.3)	66.28 (58.1,73.6)	9.84 (5.9,16.1)	13.91 (9.0,21.0)	32.98 (26.2,40.6)
2005	32.00 (23.8,41.5)	24.94 (18.0,33.5)	22.75 (15.7,31.8)	22.49 (15.4,31.7)	87.40 (80,92.3)	12.35 (7.6,19.4)	74.09 (65.7,81)	9.17 (5.5,14.9)	26.58 (19.8,34.6)	33.04 (24.7,42.5)
2006	32.35 (25,40.7)	19.03* (13.5,26.1)	14.35 (9.1,22.0)	26.12 (18.7,35.3)	88.33 (83.2,92)	12.61 (7.2,21.1)	67.68 (57.8,76.2)	12.00 (6.8,20.3)	21.34 (16.9,26.6)	27.38 (20.4,35.7)
2007	25.68 (17.9,35.3)	18.08* (12.8,24.9)	12.89 (7.6,21.0)	20.60 (14.4,28.7)	85.01* (77.9,90.1)	6.9* (4.6,10.2)	65.96 (56.9,74)	9.36 (5.6,15.2)	16.16* (10.2,24.7)	24.34 (17.5,32.8)
2008	29.36 (22.2,37.8)	14.3* (9.9,20.2)	11.43 (7.4,17.2)	21.42 (16.3,27.6)	87.03 (78.3,92.6)	6.5* (3.2,12.6)	76.57 (67.7,83.6)	6.55 (3.4,12.2)	20.53 (13.9,29.2)	31.70 (24.7,39.7)
2009	23.06 (17.1,30.3)	16.76* (11.7,23.5)	11.75 (7.6,17.9)	24.0 (17.3,32.3)	89.48 (81.1,94.4)	12.40 (7.7,19.4)	66.25 (58.7,73)	12.29 (7.2,20.3)	21.01 (14.7,29.1)	26.39 (19.2,35.1)
2010	20.89* (14.5,29.1)	21.31 (16.0,27.8)	14.75 (9.7,21.9)	21.78 (15.8,29.2)	91.35 (86.9,94.4)	10.64 (7.2,15.4)	71.48 (63.3,78.5)	7.37 (4.7,11.5)	17.82* (12.2,25.2)	26.76 (19.5,35.6)
2011	28.84 (20.4,39)	17.48* (11.7,25.3)	16.33 (10.4,24.7)	22.81 (15.5,32.3)	86.16 (76.6,92.2)	11.55 (7.2,18.1)	65.12 (54.6,74.3)	9.38 (5.0,16.9)	18.75 (11.9,28.3)	32.10 (23.2,42.5)
2012	16.79* (10.8,25.2)	13.26* (8.9,19.4)	9.09 (5.6,14.4)	21.24 (14.5,30.1)	88.14 (82.0,92.4)	8.57 (5.1,14.1)	69.28 (62.5,75.3)	15.10 (11.1,20.2)	12.96* (8.2,19.8)	22.23* (16.1,29.8)
2013	17.87* (11.6,26.6)	14.95* (9.2,23.3)	10.56 (6.7,16.2)	17.18 (11.4,25.1)	87.25 (80.8,91.7)	13.92 (8.5,22)	66.55 (57.6,74.4)	10.52 (6.2,17.4)	10.57* (6.0,18.0)	17.71* (11.9,25.5)
2014	11.97* (7.5,18.5)	6.07* (3.4,10.7)	5.91* (2.8,12.2)	16.14 (10.9,23.3)	83.91 (73.6,90.7)	7.51 (3.9,13.9)	61.58 (50.8,71.3)	7.49 (3.7,14.5)	6.02* (2.8,12.3)	13.17* (8.7,19.5)
2015	14.42* (9.5,21.4)	15.98* (9.6,25.3)	9.16 (4.6,17.5)	14.40 (8,24.6)	84.35* (76.2,90.1)	9.66 (5.3,17.0)	62.01 (52.4,70.7)	7.12 (3.9,12.7)	10.02* (5.6,17.3)	21.47* (15.0,29.7)
2016	27.19 (18.3,38.4)	18.44 (11.1,29.0)	9.67 (4.8,18.5)	18.09 (11.6,27.0)	79.5* (70.7,86.2)	10.41 (5.3,19.5)	66.07 (55.8,75)	6.99 (3.4,13.9)	14.4* (8.9,22.4)	24.53 (16.3,35.2)
Difference 2002–2003 vs. 2015–2016	−16.47*	−18.13*	−10.66*	−13.15*	−12.78*	−4.32	−9.56	−4.86	−21.96*	−14.57
% change	57.71	63.79	64.72	54.96	14.11	34.56	13.74	45.81	88.67	47.34

b) Ages 18–25

	Cannabis abuse items Prevalence (95%CI)				Cannabis dependence items Prevalence (95%CI)					
	Failure role obligations	Hazardous situations	Law problems	Cont. use despite social problems	Spent a lot of time	Unable to keep limits	Tolerance	Unable to cut down	Cont. use despite health problems	Gave up social activities
2002	16.24 (13.0, 20.1)	13.83 (11.4,16.6)	5.88 (4.4,7.8)	11.98 (9.7,14.7)	84.88 (82,87.4)	17.16 (14.0,20.9)	59.15 (54.6,63.6)	16.74 (13.4,20.8)	16.95 (14.1,20.2)	25.27 (21.4,29.5)
2003	16.33 (13.0,20.3)	12.91 (10.4,15.9)	5.35 (3.6,7.9)	11.94 (9.1,15.6)	85.69 (82.1,88.7)	17.79 (14.7,21.4)	59.99 (55.0,64.8)	16.44 (13.2,20.4)	17.41 (14.3,21.0)	25.93 (22.4,29.9)
2004	13.91 (10.9,17.5)	14.69 (11.5,18.6)	8.2 (5.9,11.4)	14.09 (11.5,17.2)	84.50 (80.7,87.7)	15.18 (12.1,19)	54.41 (49.6,59.1)	13.16 (10.1,16.9)	19.24 (15.6,23.5)	23.36 (19.0,28.3)
2005	15.21 (12.2,18.8)	12.91 (10.1,16.4)	6.89 (4.5,10.4)	12.59 (9.7,16.2)	82.30 (78.8,85.4)	14.91 (12.6,17.6)	61.37 (57.5,65.1)	13.41 (10.8,16.6)	20.10 (17.0,23.6)	23.54 (20.1,27.3)

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Table 2 (continued)

b) Ages 18–25

	Cannabis abuse items Prevalence (95%CI)				Cannabis dependence items Prevalence (95%CI)					
	Failure role obligations	Hazardous situations	Law problems	Cont. use despite social problems	Spent a lot of time	Unable to keep limits	Tolerance	Unable to cut down	Cont. use despite health problems	Gave up social activities
2006	10.6 (8.3,13.5)*	9.53 (7.5,12.1)*	6.65 (4.7,9.4)	10.64 (8.3,13.6)	84.48 (80.6,87.7)	12.39* (9.7,15.7)	57.96 (53.1,62.7)	10.84* (8.3,14.0)	19.48 (16.0,23.5)	19.37* (16.6,22.5)
2007	13.89 (10.9,17.5)	12.74 (9.9,16.3)	8.8 (6.6,11.7)	9.91 (7.8,12.6)	84.37 (81.2,87.1)	13.85 (11.3,16.8)	60.13 (55.8,64.3)	13.55 (10.9,16.7)	16.46 (13.0,20.6)	22.38 (18.3,27)
2008	12.88 (10.3,16.0)	11.63 (9.1,14.7)	7.57 (5.8,9.9)	12.89 (10.3,16.1)	85.67 (81.4,89.1)	14.92 (12,18.4)	62.31 (58,66.5)	13.34 (10.9,16.2)	16.46 (13.6,19.7)	22.29 (19.1,25.8)
2009	10.28 (7.9,13.2)*	9.49 (7.2,12.4)*	4.7 (3.3,6.6)	8.29* (6.3,10.8)	84.13 (81.0,86.8)	14.23 (11.7,17.2)	56.96 (52.3,61.5)	11.64* (9.4,14.3)	12.31* (10.2,14.8)	19.97 (16.5,24)
2010	10.01 (7.6,13.0)*	7.92 (6.4,9.8)*	3.96 (2.7,5.7)	10.06 (7.8,13)	84.57 (81.4,87.3)	16.32 (13.2,20.0)	58.44 (54.7,62.1)	12.22 (9.3,15.9)	9.57* (7.4,12.3)	17.69* (14.7,21.1)
2011	9.08 (7.1,11.6)*	10.88 (8.0,14.6)	5.65 (4.2,7.5)	9.62 (7.4,12.4)	86.48 (83.1,89.3)	16.66 (13.5,20.4)	59.76 (54.9,64.4)	14.67 (12.0,17.9)	15.31 (12.3,18.9)	18.05* (14.8,21.8)
2012	10.46 (7.8,13.9)*	8.27 (6.1,11.1)*	3.75 (2.5,5.5)	10.45 (7.8,14)	87.76 (85.2,89.9)	12.07* (9.2,15.8)	55.57 (51.3,59.8)	8.74* (6.6,11.5)	11.64* (8.9,15)	16.39* (13.4,19.9)
2013	7.03 (5.3,9.2)*	5.89 (4.2,8.2)*	4.86 (3.4,6.9)	9.23 (7.3,11.6)	82.94 (79.8,85.6)	12.89 (10.3,16)	55.80 (51.6,59.9)	10.72* (8.7,13.1)	9.34* (7.3,11.9)	13.39* (11.1,16.1)
2014	9.41 (7.6,11.5)*	6.59 (4.6,9.4)*	2.98* (1.9,4.7)	7.6* (5.9,9.8)	80.68 (76.5,84.2)	14.65 (11.8,18)	59.52 (54.5,64.3)	13.91 (10.6,18.1)	8.29* (6.5,10.5)	14.51* (12.0,17.4)
2015	8.61* (6.4,11.6)	4.95* (3.8,6.5)	3.53* (2.3,5.5)	6.44* (4.7,8.8)	79.71* (75.9,83)	13.36 (10.7,16.6)	58.16 (53.6,62.5)	13.15 (10.5,16.3)	11.98* (9.3,15.4)	15.67* (12.9,18.9)
2016	7.47 (5.3,10.4)	6.69* (4.7,9.5)	4.05 (2.5,6.4)	7.19* (5.1,10.1)	78.2* (74.2,81.7)	13.77 (10.7,17.6)	57.16 (53.5,60.8)	10.49* (7.8,14)	11.12* (8.3,14.8)	13.26* (10.6,16.5)
Difference 2002–2003 vs. 2015–2016	−12.06*	−11.99*	−3.00*	−7.92*	−8.91*	−5.81*	−2.41	−6.57*	−8.12*	−15.94*
% change	74.06	89.68	53.43	66.18	10.45	33.25	4.04	39.57	47.24	62.25

c) Ages 26 and older

	Cannabis abuse items Prevalence (95%CI)				Cannabis dependence items Prevalence (95%CI)					
	Failure role obligations	Hazardous situations	Law problems	Cont. use despite social problems	Spent a lot of time	Unable to keep limits	Tolerance	Unable to cut down	Cont. use despite health problems	Gave up social activities
2002	7.23 (3.6,13.9)	5.82 (2.8,11.6)	2.76 (1.4,5.4)	5.52 (3,9.9)	62.57 (54.3,70.2)	8.61 (4.9,14.7)	24.59 (18.3,32.2)	13.40 (6.4,25.9)	7.76 (4.6,12.8)	8.33 (4.6,14.7)
2003	2.81 (1.1,6.7)	9.93 (6.1,15.7)	3.19 (1.1,8.8)	5.68 (2.6,12.2)	70.23 (60.4,78.5)	9.78 (5.7,16.3)	33.48 (25.5,42.6)	15.62 (10.6,22.5)	9.82 (5.9,16)	9.92 (5.6,16.9)
2004	4.2 (1.8,9.6)	10.55 (5.8,18.3)	0.83 (0.3,2.7)	7.92 (3.7,16.2)	55.74 (46.3,64.7)	10.08 (5.8,16.9)	28.37 (20.0,38.6)	13.66 (8.1,22.2)	14.21 (9.5,20.8)	9.88 (6.2,15.3)
2005	3.34 (1.4,7.8)	4.05 (1.4,11.1)	3.66 (1.4,9.5)	2.49 (1.1,5.4)	52.60 (40.6,64.4)	13.89 (8.4,22)	30.38 (22.4,39.8)	13.66 (7.9,22.5)	7.05 (3.9,12.5)	12.07 (6.8,20.6)
2006	5.3 (3.1,9.0)	8.66 (4.7,15.4)	3.15 (1.1,8.6)	5.53 (2.6,11.3)	63.09 (54.3,71.1)	17.06 (11.5,24.6)	36.79* (29.3,45)	17.69 (11.7,25.9)	12.85 (8.6,18.9)	14.36 (10.0,20.3)
2007	3.8 (2.1,7.0)	7.45 (3.5,15.4)	1.91 (0.6,5.6)	3.88 (1.9,7.6)	57.34 (49.2,65.1)	9.59 (5.7,15.8)	24.07 (18.0,31.3)	6.79 (4.0,11.3)	7.10 (4.5,11.1)	7.64 (4.5,12.7)
2008	4.91 (2.3,10.0)	12.67 (8.4,18.7)*	2.47 (0.9,6.4)	1.62 (0.7,3.9)	55.50 (46.6,64.1)	11.05 (6.9,17.2)	24.43 (18.9,30.9)	11.80 (7.0,19.2)	12.58 (7.9,19.5)	14.92 (10.1,21.6)
2009	4.06 (2.1,7.8)	11.22 (7.8,16.0)	0.82 (0.3,2.5)	7.66 (4.1,13.8)	65.81 (57.5,73.3)	12.91 (7.6,21.0)	34.30 (27.3,42.1)	11.94 (7.1,19.5)	10.29 (6.5,15.9)	8.85 (5.4,14.1)
2010	3.02 (1.4,6.4)	8.25 (4.3,15.1)	1.46 (0.7,3.2)	6.64 (3.5,12.3)	60.38 (52.5,67.8)	8.98 (5.4,14.6)	33.11 (25.3,42.0)	12.20 (7.7,18.8)	8.41 (4.7,14.5)	9.96 (6.5,14.9)

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Table 2 (*continued*)

c) Ages 26 and older

	Cannabis abuse items Prevalence (95%CI)				Cannabis dependence items Prevalence (95%CI)					
	Failure role obligations	Hazardous situations	Law problems	Cont. use despite social problems	Spent a lot of time	Unable to keep limits	Tolerance	Unable to cut down	Cont. use despite health problems	Gave up social activities
2011	5.71 (3.9,10.6)	5.07 (2.5,10.2)	1.69 (0.6,4.6)	3.45 (1.6,7.1)	59.56 (52.1,66.6)	10.05 (6.4,15.5)	34.60 (27.3,42.8)	11.73 (8.3,16.4)	7.59 (4.5,12.7)	10.72 (6.7,16.7)
2012	2.88 (1.5,5.4)	4.56 (2.7,7.6)	0.69* (0.2,2.1)	4.47 (2.5,7.9)	60.51 (54.3,66.4)	8.44 (4.9,14.2)	33.40 (26.3,41.4)	9.86 (6.5,14.7)	8.88 (5.6,13.9)	7.47 (4.9,11.2)
2013	3.2 (1.8,5.7)	5.33 (3.1,9.0)	0.45* (0.1,1.5)	3.21 (1.8,5.7)	53.69 (44.8,62.4)	6.67 (4.3,10.2)	31.15 (24.0,39.3)	8.13 (5.3,12.3)	7.01 (4.6,10.6)	9.35 (4.5,18.4)
2014	2.39 (1.4,4.1)	4.97 (3.1,7.8)	1.76 (0.9,3.4)	3.58 (2.2,5.7)	57.66 (51.8,63.3)	7.35 (5.7,9.4)	30.75 (26.2,35.7)	8.59 (6.2,11.8)	7.03 (5.1,9.6)	7.54 (5.6,10.0)
2015	4.07 (2.7,6.0)	3.70 (2.4,5.7)	0.66* (0.3,1.5)	2.32 (1.2,4.5)	53.47 (47.4,59.4)	8.86 (6.4,12.1)	30.93 (27.1,35.0)	10.77 (7.8,14.7)	7.59 (5.5,10.3)	7.35 (5.5,9.7)
2016	2.2* (1.5,3.3)	3.44 (2.2,5.3)	1.53 (0.9,2.7)	2.21 (1.5,3.2)	53.35 (48.2,58.4)	8.31 (6.3,10.9)	27.02 (23.3,31.1)	5.69 (4.0,7.9)	7.15 (5.1,10.0)	6.51 (5.1,8.3)
Difference 2002–2003 vs. 2015–2016	−3.47	−5.37*	−2.93	−4.94*	−17.54*	−0.48	3.11	−7.6*	−1.51	−2.69
% change	69.02	68.13	98.49	88.13	26.42	5.27	10.71	52.34	17.12	29.42

* Significant change (p < 0.05). Specific year prevalences are compared to the 2002 prevalence.

cannabis use (above 36% in adults), we found evidence of an important decrease in this prevalence over time, suggestive of a change in this behavior among people reporting frequent use. This is consistent with evidence suggesting a reduction in the prevalence of driving under the influence of cannabis among those using cannabis in the U.S. (Azofeifa et al., 2015). In addition, more widely available information on cannabis use could also lead to better knowledge on when, how, and at which dose to use cannabis to keep cannabis use within set limits, prevent giving up social activities and continue fulfilling major role obligations despite cannabis use. Also, better information on treatment availability for CUD can reduce the stigma of CUD treatment and improve access to treatment, which is low among adults (Kerridge et al., 2017), potentially leading to reductions in CUD symptoms. These explanations for reductions in CUD were not explored in the current study, but warrant future examination.

In contrast to results in younger participants, we did not observe a significant reduction in the prevalence of DSM-IV cannabis dependence in adults ages 26+. Although there were important reductions in the prevalence of items "Unable to keep set limits", "Continue to use despite health problems", and "Gave up participation in important activities" in younger participants (% decline > 33%), there were smaller (not significant) changes in adults 26+ for these items (5.3%, 17.1% and 29.4%, respectively). It is possible that the adult population reporting recent onset of daily/almost daily use was more similar, in regards to endorsement of these items, to people reporting long-term daily/almost daily use. Also, it is possible that in adults using cannabis daily/almost daily, the endorsement of these items is less responsive to changes in social norms or available information about cannabis use risks. Given that four out of the six dependence items were stable among adults and that three or more items are needed for meeting dependence, it is expected that the prevalence of cannabis dependence would not dramatically change over the study period in this population.

It is important to note that tolerance was the only item that did not decrease over time in any age group. Given that tolerance is a physiologic response to repeated use that would likely not depend on context, it was not expected that tolerance would be affected by changes in social contexts, stigma, and/or personal motivations. Some evidence indicates that those using cannabis regularly can develop tolerance (with diminished responses for cognitive and physiologic functions) after repeated administration of Δ9- tetrahydrocannabinol (THC) (Colizzi and Bhattacharyyam, 2018). It is possible that other more physiologic items, such as the presence of withdrawal symptoms, would also have been less affected by the three mechanisms described above. However, the NSDUH survey does not include a withdrawal item for cannabis use, which prevented us examining it in this study.

Limitations are noted. First, the *frequency of cannabis use* measure did not capture in detail all use patterns; for example, there was no information on the number of times used per day, amount used, and/or the average potency of cannabis used (e.g., it is different to use one low-THC joint per day vs. three high-THC joints per day). It is possible that more recent daily/almost daily users on average use less potent cannabis or lower amounts of cannabis per day compared with long-term users. Second, we did not account for access to treatment for CUD in our analyses, which may explain in part the reductions in CUD. However, since prevalence of treatment for CUD is very low (Kerridge et al., 2017), this is unlikely to explain these reductions. Third, NSDUH excluded people who were homeless and people residing in institutions, which could lead to underestimates in CUD. Fourth, NSDUH did not have questions on craving or withdrawal symptoms, items added to the DSM-5 criteria for CUD, and therefore we could not compare our trend results with those estimating the prevalence of CUD using the DSM-5 criteria. Fifth, NSDUH modules on mental health differed by age, and we did not assess changes in adolescents.

In conclusion, we found evidence that among people reporting daily/almost daily cannabis use, there were important reductions in the prevalence of CUD from 2002 to 2016. These reductions across ages 12+ were also observed separately for cannabis abuse for all ages and dependence for ages 12-25. We described three potential mechanisms by which these prevalences could have decreased over time, based on individual DSM-IV CUD item change patterns. Further research examining whether structural, socio-demographic, and other factors may be linked to reductions in CUD prevalences could shed light on the underlying mechanisms and inform efforts to reduce the risk of CUD among people who use cannabis.

5. Contributors

All authors have contributed significantly to the work and agree with the submission. Dr. Santaella-Tenorio and Dr. Martins designed the study. Dr. Santaella-Tenorio conducted all data analysis with assistance from Levy and Segura. Dr. Santaella-Tenorio and Levy wrote the first full draft of the manuscript. All authors critically reviewed and edited all sections of the manuscript. All authors have approved the final article.

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.2019.107621.

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