# Assessing the Public Health Impacts of Legalizing Recreational Cannabis Use in the USA

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**A major challenge in assessing the public health impact of legalizing cannabis use in Colorado and Washington State is the absence of any experience with legal cannabis markets. The Netherlands created a *de facto* legalized cannabis market for recreational use, but policy analysts disagree about how it has affected rates of cannabis use. Some US states have created *de facto* legal supply of cannabis for medical use. So far this policy does not appear to have increased cannabis use or cannabis-related harm. Given experience with more liberal alcohol policies, the legalization of recreational cannabis use is likely to increase use among current users. It is also likely that legalization will increase the number of new users among young adults but it remains uncertain how many may be recruited, within what time frame, among which groups within the population, and how many of these new users will become regular users.**

Recreational cannabis use was banned under the Single Convention on Narcotic Drugs in 1961.[1,2] By the end of the 1960s, however, cannabis use and arrests for possession and use had risen among young adults in the USA. Concerns about the adverse effects of criminal records on the lives of young people led some US states to depenalize or decriminalize cannabis use in the 1970s.[2] Depenalization replaced imprisonment with fines or diversion into treatment while decriminalization removed criminal penalties for use from the statute.[1,3]

High rates of cannabis use among adolescents in the late 1970s produced a conservative reaction to liberal cannabis policies in the 1980s.[4,5] Arrests for cannabis use increased and remained high well into the 2000s.[1,6] In the 1990s, advocates of more liberal cannabis policies campaigned to legalize the medical use of cannabis. In 1996 Californians approved a citizen-initiated referendum to legalize cannabis for medical use, very broadly defined. By the end of the 2000s, 20 states and territories in the USA allowed medical cannabis use in some form. In 2012, citizens in Colorado and Washington State voted to legalize recreational cannabis use and its commercial sale to adults. Citizens of Alaska and Oregon followed suit in 2014 and those in the District of Columbia voted to allow adults to grow cannabis for their own use and give it to friends.

In this article we discuss how we should assess the possible effects of these policy changes. We begin with an account of the effects of policy changes that preceded the legalization of recreational use: decriminalization of personal use in Australia, the Netherlands, and the USA in the 1970s, 1980s, and 1990s; and the creation of *de facto* legal retail cannabis markets in the Netherlands in the 1980s and in some US states in the early 2000s under the guise of providing marijuana for medical use. We describe the results of the studies of their effects on rates of cannabis use and cannabis-related harm. We then ask, in light of this experience, and historical experiences with the effects of more liberal alcohol policies: What may we expect to happen to cannabis use and cannabis-related harm after the legalization of commercial sales of cannabis for recreational use? What adverse and beneficial effects should we assess when evaluating the effects of this policy?

## DEPENALIZATION AND DECRIMINALIZATION OF CANNABIS USE

In Australia and the USA a number of states have reduced or removed criminal penalties for cannabis use while the remaining states retained them. The availability of national household surveys of drug use enabled researchers to compare trends in cannabis use among young adults between states that had and had not legislated to reduce or remove criminal penalties for cannabis use.[1,7] These studies generally did not find large differences in rates of increase in cannabis use in states that had and had not decriminalized cannabis. This was the case in Australia in the late

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1980s and early 1990s (e.g., refs. 8,9); the Netherlands in the 1980s[10]; the USA in the 1970s and 1980s[3]; and later in Europe[11,12] (see ref. 1 for a detailed review).

Various explanations have been offered for these findings. One was that there was in fact very little difference in law enforcement practices between jurisdictions that had legislated to remove or reduce criminal penalties and those that nominally retained them.[7] Another explanation was that criminal penalties for cannabis use had very little deterrent effect because so few users were arrested in states that nominally retained these penalties and enforced the law.[7] Finally, small sample sizes in each state in the household surveys in Australia in the 1980s and early 1990s provided limited statistical power to detect differential changes in cannabis use between states that had and had not reduced the severity of criminal penalties.[13]

A more nuanced view has been provided by more recent analyses of Australian data on cannabis use. These have used larger survey samples to observe the effects of these policies over longer periods of time.[14–17] They have also used more sophisticated statistical methods to examine the effects of cannabis penalties while controlling for any effects of differences in cannabis price and enforcement of laws against cannabis use. Their findings suggest that criminal penalties may marginally discourage some people from using cannabis but do not influence how much cannabis is consumed by those who do use.

### Constraints on cannabis liberalization

There is a simple reason why the most common cannabis reforms have involved very modest changes in penalties for personal cannabis use: most developed countries have signed International Drug Control Treaties, such as the Single Convention,[1,2] that require them to restrict the use of cannabis to medical and scientific purposes. The treaties are also interpreted as requiring nation states to make it a criminal offense to use, possess, produce, and sell cannabis but they allow latitude in the penalties that may be imposed for this offense.[18] There is no doubt, however, that they prevent states that have signed them from creating a legal cannabis market for recreational use.[1,2]

### *De facto* cannabis legalization in the Netherlands

In the 1970s and 1980s the Netherlands creatively used a constitutional exemption allowed in the Single Convention to initially allow cannabis use and then small-scale retail sales to be decriminalized and made *de facto* legal.[1,2] In 1976 state prosecutors issued a statement that they would not prosecute persons for the possession and use of up to 30 grams of cannabis, effectively making possession and use of these small quantities of cannabis legal *de facto*.[19,20] The Dutch authorities later extended this policy to the sale of small amounts of cannabis in coffee shops,[10,19] thereby creating a *de facto* legal retail cannabis market.[1]

Over the next decade guidelines were used to regulate the retail cannabis market in the Netherlands.[19] Coffee shops that sold cannabis products were prohibited from: 1) advertising; 2) selling hard drugs; 3) selling cannabis to minors; 4) selling amounts greater than a specified quantity; and 5) allowing public disturbances in their vicinity.[10] In the mid-1990s, the licensing system limited the number and location of coffee shops, gave local government control over where cannabis could be sold, and reduced the quantity of cannabis that could be legally sold and/or possessed to 5 grams.[20]

The architects of Dutch policy chose *de facto* legalization because *de jure* legalization was seen to be contrary to international treaties, and hence, likely to attract criticism from neighboring countries and defenders of the international drug control treaties.[19] The Dutch government argued that their policy still complied with the international drug control treaties because cannabis use and sale remained illegal; the authorities simply used the expediency principle (contained in the Netherlands' constitution) to give a low priority to enforcing these laws if certain conditions were met.[1,2] This argument was accepted by the guardian of the drug control treaties, namely, the International Narcotic Control Board, until the late 1990s but thereafter was strongly criticized for failing to comply with the treaties.[2,21]

### Impacts of Dutch policy on rates of cannabis use

Analysts disagree about the effects that the Netherlands' policy had on cannabis use among young adults. MacCoun and Reuter[10,22] compared cannabis use between the Netherlands, USA, Denmark, and Germany and concluded that *de facto* decriminalization had not increased cannabis use in the Netherlands. They argued, however, that cannabis use increased among youth between 1992 and 1996 as a result of the *de facto* legalization of commercial sales and a rapid growth in the number of coffee shops. For example, lifetime cannabis use among Dutch youth aged 18 to 20 increased from 15% in 1984 to 44% in 1996, while use in the past month increased from 8.5% to 18.5% over the same period.[10] Abraham *et al.*[23] criticized MacCoun and Reuter for comparing data from cities in the Netherlands with data from whole nations. Korf[20] argued that trends in recent cannabis use in the Netherlands were very similar to that in other European countries and the USA. Room *et al.*,[1] who reviewed later evidence, concluded that the case was "still open" on whether *de facto* legalization had increased cannabis use among Dutch youth.

MacCoun[24] recently evaluated Dutch policy using more extensive survey data from the Netherlands and the rest of Europe. He maintains that the evidence indicated that cannabis use increased when coffee shop numbers expanded and declined after the number of coffee shops was reduced and the quantity of cannabis that could be sold was reduced to 5 g in the late 1990s. He also pointed to other evidence for an increase, namely, survey evidence that Dutch youth initiated cannabis user earlier, and that there were higher rates of treatment for cannabis dependence in the Netherlands than elsewhere in Europe. MacCoun stressed that the Dutch cannabis policy fell short of full legalization because cannabis prices in the Netherlands did not differ from those in other EU countries and in the USA where retail sales remain illegal.

### The legalization of medical cannabis use in the USA

In 1996 California passed a citizen-initiated referendum, Proposition 215, that allowed the medical use of cannabis (marijuana) for a broad set of indications. These included, in addition to

nausea, weight loss, pain, and muscle spasm, any "serious medical condition" for which cannabis provided relief.[15] By mid-2013, 20 US states (and the Federal District of Columbia) had enacted laws that allowed the medical use of cannabis under some conditions.[25,26]

In order to ensure a legal supply of cannabis for medical users, around half of these states subsequently allowed dispensaries to sell cannabis to persons with a range of medical conditions, if they had a doctor's written "recommendation." During the 2000s, the expansion of for-profit dispensaries effectively legalized the commercial supply of cannabis in California and Colorado.

The effects of broadly defining medical use in California are reflected in the characteristics of 4,117 patients of dispensaries in the San Francisco-Bay Area during 2001–2007. They were predominantly male (77%) with an average age of 32. Most (89%) started using cannabis before the age of 19 and 90% were daily smokers.[27] In a survey of a representative sample of 7,525 adults in California, 5% of adults reported "medical cannabis" use in the past year,[28] primarily for chronic pain. The highest prevalence of medical use was among young adults aged 18 to 24 years (9%) and the lowest among those over the age of 65 (2%). These data raise questions about how "medical" this use is in California. They also suggest that much of the self-described medical use is for indications other than those for which there is some evidence of efficacy, namely, cancer-related nausea and vomiting, some types of pain, and spasticity in multiple sclerosis.[29–32]

## THE PUBLIC HEALTH EFFECTS OF LEGALIZING MEDICAL CANNABIS

### Effects on adolescent cannabis use

A major community concern has been that the legalization of medical marijuana will increase cannabis use among adolescents by: increasing their access to more potent cannabis, at a cheaper price than the black market; increasing the social acceptability of using cannabis; and lowering the perceived risks of using cannabis.[33,34] Researchers have assessed these concerns by comparing trends in cannabis use among young people in states that have and have not legalized medical cannabis use (using large-scale household and school-based national surveys of drug use).

Wall *et al*.[35] used data from a household survey to compare cannabis use among adolescents living in states that did and did not allow medical marijuana use. They found higher average rates of cannabis use and lower perceived riskiness of use among adolescents in medical marijuana states but their analysis did not take account the fact that these states reported higher rates of cannabis use before medical cannabis use was made legal.

Cerda *et al*.[33] also examined a number of indicators of cannabis use (use in the past year; use in the past 30 days; near daily use; and use meeting criteria for a cannabis use disorder) in the National Epidemiologic Survey of Alcohol and Related Conditions (NESARC) conducted in 2004–2005. They compared these outcomes in the eight US states that had legalized medical marijuana by 2004 with that in states which had not. They found higher rates of cannabis use on all indicators in the medical marijuana states, but these data were cross-sectional so it was not possible to tell whether medical marijuana laws had increased cannabis use, or the higher rates of cannabis use in the medical marijuana states were a consequence of greater social tolerance of cannabis use in these states that also explained why their citizens had voted to legalize medical cannabis use.

A number of studies have attempted to discriminate between these possibilities by conducting difference-in-difference analyses of survey data that take into account preexisting differences between states with and those without medical marijuana laws in cannabis use and social attitudes towards cannabis use. Harper *et al*.[36] applied this method of analysis to the data used by Wall *et al*.[35] They found no differences in rates of change in cannabis use, or in the perceived risks of cannabis use, between states that allowed medical marijuana and those that did not.

Choo *et al*.[37] compared adolescent cannabis use among American high school students in US states that did or did not allow medical marijuana use using data from the Youth Risk Behavioral Surveillance Survey. They did not find any significant difference in rates of cannabis use in the past month between states that had or had not legalized medical marijuana. Lynne-Landsman *et al*.[34] also used the Youth Risk Behavior Survey to assess adolescent marijuana use before and after medical marijuana laws were introduced. They also found no significant differences in rate of change in cannabis use before and after the introduction of medical marijuana laws.

Scheurmeyer *et al*.[38] compared trends in cannabis use and attitudes towards cannabis use within Colorado with trends in states that did not allow medical cannabis use. They used the National Survey on Drug Use and Health to examine trends in cannabis use and perceived riskiness of cannabis use among young adults in Colorado before and after commercial medical cannabis sales were allowed in 2009. They found a decline in the proportion of young adults in Colorado who perceived cannabis use as risky, an increase in their reported ease of access to cannabis, and higher rates of cannabis use and dependence in Colorado after commercialization of medical cannabis sales. They also showed that the rates of change in these indicators were larger in Colorado than in US states that had not allowed medical cannabis use.

Many of these studies share the same limitations. First, not all state medical marijuana laws have been as liberal in allowing access to cannabis for medical use as California, Colorado, and Washington.[26,34] It would be an error, therefore, to expect all medical marijuana states to show similar changes in cannabis use among youth. Second, not all states have allowed commercial marijuana markets to sell marijuana for medical use. One would expect a larger impact on cannabis use in states that have legalized cannabis supply for very broadly defined medical indications than in states in which only small numbers of patients use cannabis for strictly defined purposes.[39] Schuermeyer *et al*. provide suggestive evidence for such an effect that needs replication and extension.[38] Third, in many of these analyses it has been only 1–5 years since medical marijuana use was legalized in the states under study. This may be too short a time to detect increases in cannabis use or cannabis-related harm among young people. Fourth, in national household surveys sample sizes for individual states are often small, limiting the statistical power of state-level analyses to detect increases in cannabis use among youth.

**Table 1 What are the health effects of cannabis?**

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| *1. Adverse effects of acute use* |
| • Cannabis does not produce fatal overdoses like opioids do. |
| • Driving a vehicle while intoxicated doubles the risk of being in a car crash; combining cannabis and alcohol greatly increases the risk of a car crash. |
| • Women who use cannabis during pregnancy have babies with a reduced birth weight. |
| • Some naive cannabis users have very unpleasant psychological experiences, such as heightened anxiety and psychotic symptoms. |
| *2. Adverse effects of chronic use* |
| • Regular cannabis use from adolescence into adulthood has been associated with the risk of developing a dependence syndrome (around 1 in 10 among those who ever use and 1 in 6 among those who start in adolescence). |
| • Regular cannabis users in adolescence and young adulthood double their risks of experiencing psychotic symptoms and disorders. The risk is higher in those users who have a personal or family history of such disorders, who initiate in their mid-teens. |
| • Regular adolescent cannabis users have lower educational attainment than nonusing peers. |
| • Regular use that begins in adolescence and continues throughout young adulthood appears to produce cognitive impairment but it is unclear how reversible it is. |
| • Regular adolescent cannabis users are more likely to use other illicit drugs for reasons that remain a subject of debate. |
| • All of these relationships have persisted after controlling for plausible confounders in well-designed longitudinal studies but some researchers still question whether these adverse effects are causally related to regular cannabis use. |
| *3. Physical health outcomes* |
| • Regular cannabis smokers have higher risks of developing chronic bronchitis but have not shown impaired respiratory function in all studies. |
| • Cannabis smoking by middle-aged adults probably increases the risks of myocardial infarction. |
| • The effects of cannabis use on respiratory cancers remain unclear because it has been difficult to disentangle the effects of cannabis and tobacco smoking. |

### Effects of medical cannabis laws on cannabis-related harm

The most probable adverse health effects of acute and chronic cannabis use are summarized in **Table 1**. These are based on a review of epidemiological studies of recreational cannabis users conducted over the past 20 years.[40] Given the short time that medical cannabis use has been commercialized in some US states, the most likely adverse health effects are those of acute use. For understandable reasons, the outcome that has attracted the most research attention is the impact of medical marijuana laws on motor vehicle fatalities.

### Effects on motor vehicle fatalities

The availability of toxicological data on drivers and passengers killed in car crashes in the USA has enabled researchers to investigate whether there has been an increase in the proportion of cannabis-impaired drivers involved in car crashes in US states that do and do not allow medical cannabis use. Masten and Guenzburger[41] found increases in the percentage of both fatal crash-involved drivers and fatally injured drivers who tested positive for cannabinoids in California, Hawaii, and Washington after medical cannabis use was legalized. They also found that the increase in prevalence occurred shortly after the legalization of medical cannabis but did not increase further thereafter. Interpretation of their data was complicated by the fact that the proportion of fatalities tested for cannabis and other drugs was very low in medical marijuana states before medical cannabis laws were enacted. This proportion increased steeply after the medical marijuana laws were passed because cannabis-impaired driving was now an offense. This may mean that the increased rate of detection reflects, at least in part, an increased postmortem testing in states that allowed medical cannabis use.

Anderson *et al.*[42] examined changes in the role of alcohol in car crashes over the period 1990–2010 in US states that had and had not legalized the medical use of cannabis. They reported a decrease of between 8 and 11% in total traffic fatalities and in fatalities in which alcohol was detected at levels indicative of impairment (blood alcohol concentration greater than 0.08%). These decreases were larger in crashes involving young adult males. Other data they presented suggested that this could reflect a substitution of cannabis for alcohol among young males. Data on cannabis prices, for example, showed that cannabis was cheaper in medical marijuana states. The latter states also showed larger reductions in alcohol consumption reported in surveys and in beer sales (the preferred beverage of young adult males) than states that had not legalized medical cannabis.

### Other effects of legalizing medical cannabis use

A small number of other studies have examined relationships between the legalization of medical cannabis use and more positive health outcomes. Anderson *et al.*,[43] for example, reported steeper declines in suicide rates in males aged 20 to 30 in US states that legalized medical marijuana than in those that had not. A similar analysis of state trends in opioid overdose deaths found that states that had legalized medical marijuana had significantly lower rates of these deaths than states without such laws and that this difference had increased over time.[44] By contrast,

Sevigny *et al.*[26] reported small increases in average cannabis potency in states that allowed medical cannabis use, and found that the largest increases were in states that allowed commercial cannabis dispensaries.

These studies have so far reported correlations between the passage of medical marijuana laws and changes in time series data on some health outcomes. They have not established a causal relationship between medical cannabis legalization and these improved health outcomes. More detailed analyses are needed to assess 1) whether these trends persist over the longer term and 2) whether these associations are better explained by factors other than medical marijuana laws, such as unmeasured differences between the populations in the prevalence of other risk factors for suicide or opioid overdose and the effects of other policies in states that have and have not legalized medical cannabis use (e.g., greater reductions in rates of opioid prescribing).[45]

## ASSESSING THE EFFECTS OF LEGALIZING RECREATIONAL CANNABIS USE IN THE USA

In 2012, citizen-initiated referenda legalized recreational cannabis use in Colorado and Washington State. In Colorado, 54% of voters passed a proposal to amend the state constitution to allow recreational cannabis use for adults over the age of 21.[46] It specified that cannabis would be taxed and regulated by Department of Revenue. In Washington State, 53% of voters endorsed a proposal to legalize recreational cannabis use for adults over 21 years, with cannabis to be taxed and regulated by the Liquor Control Board. In November 2014 the states of Alaska and Oregon and the District of Columbia passed similar citizen-initiated referenda to legalize recreational cannabis use by adults. The details of the ways in which recreational cannabis use will be regulated in the latter states remain to be specified. Colorado and Washington State implemented the legalization of cannabis sales for recreational use in 2013 and 2014, respectively.[47,48]

## HOW WILL CANNABIS LEGALIZATION WORK IN COLORADO AND WASHINGTON STATE?

In Colorado, regulations allow adults over the age of 21 to purchase up to 28.5 g from each supplier but this limit is nominal because there is no register of sales.[48] Regulations allow the vertical integration of the limited number of producers, processors, and sellers. Most of those licensed to grow and sell cannabis for recreational use were involved in supplying medical cannabis. Cannabis products are taxed on their weight (not on their THC content), with a 15% tax imposed at production and another 10% at point of sale. Medical marijuana is tax-exempt and home cultivation is allowed for personal use and not taxed. Drug-impaired driving is prohibited, with the state law defining it as driving with greater than or equal to 5 nanograms/mL of THC in blood.[49]

In Washington State a 28.5 g purchase limit has also been imposed per store but without any register of purchasers. Licenses will be required for producers, processors, and sellers and vertical integration is *not* allowed. Cannabis is taxed on weight, with a 25% tax imposed at production, another 15% from production to retailer, and a further 10% on sales.[50] Medical marijuana is allowed to continue under existing laws but home cultivation is not allowed. Drug-impaired driving is also prohibited and also defined as 5 nanograms/mL of blood.

Colorado and Washington have unsurprisingly implemented regulatory systems like those that have been used to regulate alcohol.[51] Advocates of cannabis legalization have often argued that cannabis is less harmful than alcohol,[52] and cannabis is used for similar reasons as alcohol, in similar social settings. US state governments have regulatory systems for alcohol that can be more easily adapted to regulate recreational cannabis use than designing a new regulatory system from scratch.

Alcohol policy analysts would argue that most alcohol regulatory regimes give a low priority to protecting public health.[53] They have often been captured by alcohol producers and sellers who manipulate these regimes to maximize their profits and protect their interests.[54] Others argue that cannabis legalization will be exploited by the tobacco industry and other large-scale commercial interests to promote cannabis use in much the same way that they promoted tobacco smoking.[55] Commercialization of sales and an expansion of cannabis production and distribution are likely outcomes of licensed sellers seeking to maximize their incomes by promoting cannabis use, increasing the number of new users, and increasing levels of use among existing users.[54] Recent Christmas promotion offers by marijuana retailers in Colorado exemplify the fears of these critics.[56]

## HOW MIGHT LEGALIZATION AFFECT RATES OF CANNABIS USE?

After legal cannabis production has expanded to meet current demand, cannabis prices are likely to gradually fall below current black market prices.[6,57] This is likely to occur for a number of reasons: in jurisdictions where cannabis is a legal commodity, production and distribution costs will no longer include a black market premium to cover the risk of arrest or drug market violence. Moreover, as the market matures, cannabis producers will become more efficient at growing and processing cannabis and will pass these efficiencies on to consumers in the form of lower prices; and different sellers will compete for customers by offering lower prices. Allowing licensees to be involved in production, processing, wholesale, and retail sales, as is presently the case in Colorado, will increase efficiency of production and reduce costs.[57]

The proposed forms of taxation in both states will not maintain cannabis prices at current black market levels.[57] The regulatory systems in both states unwittingly provide incentives to increase the THC content of cannabis products. Because cannabis is taxed on weight, anything that increases THC content effectively reduces the rate of tax.[54] The proposed regulatory schemes in Colorado and Washington, in short, do not apply any of the lessons learned from regulating alcohol and tobacco to protect public health, namely, the desirability of restricting the number of producers and sellers, tightly regulating promotion, and using taxes to discourage heavy use of the most potent products.[58,59]

According to basic principles of economics, the use of any commodity will increase if its price falls. It is accordingly a safe prediction that cannabis use will increase after the legalization of

recreational use.[7] What is uncertain is by how much, which type of users will increase their use the most (e.g., current users, new users, or some mix of the two),[6,57] and over what time period will any such increases be expected to occur.[6,57]

One may most confidently predict, given our experience with the effects of reduced alcohol prices,[53,60] that a reduction in cannabis price will increase use among current users.[6] These users will be able to buy more of their favorite drug for the same price that they paid under prohibition and their use will also be less clandestine because it is now legal. If heavier use among current users increases the prevalence of cannabis dependence, then reduced prices will lead, after a 5–10 year delay, to an increase in the number of cannabis users who seek help for problems related to their use.

It is less clear whether, and if so, when, lower cannabis prices will increase the initiation of new users. Any increases in new users may take time to occur, if experience with alcohol use after the Repeal of National Alcohol Prohibition in 1932 is any guide.[61] Alcohol use increased very slowly after Repeal for a number of understandable reasons.[61] It took time for alcohol producers to increase alcohol production after Repeal. Average incomes fell in the USA during the Great Depression, constraining increases in alcohol consumption. After Repeal many US states introduced restrictive alcohol regulations (e.g., state liquor monopolies) that provided a further brake on alcohol consumption. Social norms about the acceptability of alcohol use also changed slowly after Repeal. For example, many young adults who were nondrinkers during Prohibition continued to abstain long after Repeal. For all these reasons per capita alcohol use in the USA did not reach pre-Prohibition levels until well after World War II.[61–63]

Similar factors may moderate increases in cannabis use after legalization. Cannabis production has been slow to increase because both Colorado and Washington State have restricted the number of licensed producers in the interests of simplifying regulation initially. Incomes have remained low in the USA as a lingering after-effect of the global financial crisis of 2008 and after 60 years of cannabis prohibition and strong social disapproval of use, it may take time for cannabis use to become as socially acceptable as alcohol use is now.

The most conspicuous difference between the situations after repeal of cannabis and alcohol prohibition is the absence of a public health-oriented approach to regulating cannabis sales. There is another factor that may nonetheless slow the growth of retail cannabis markets in Colorado and Washington, at least in the short term; namely, the conflict between US federal law and state legalization. Under US federal law legal suppliers of cannabis could be prosecuted for drug trafficking and their assets seized under proceeds of crime legislation. The US Department of Justice signaled via a memo in 2013 that it will not enforce federal law in Colorado and Washington for the moment but will monitor the situation carefully to ensure that cannabis is being sold and promoted in ways that do not endanger public health or public order, e.g., allowing cannabis sales to minors; promoting heavy cannabis use; and trafficking cannabis to neighboring states that still prohibit cannabis use and sale.[64] The possibility remains that the Department of Justice could enforce federal law in these states if it thought these priorities were not being respected. Fear of federal intervention may provide some brake on promotional activities by cannabis retailers in Colorado and Washington while this federal policy remains in place. But this federal policy could change if more states legalize cannabis use.

If the promotion of cannabis use is constrained in these ways, then the initiation of new cannabis users may be delayed. If so, there will be a further lag before there is any increase in the number of persons presenting to health services seeking assistance in dealing with their cannabis use. From recent Australian experience, it may take as long as a decade before those who initiate cannabis use in adolescence present to addiction treatment services in their late 20s and early 30s.[65] These possibilities suggest that opponents of cannabis legalization would be wise not to predict large and immediate increases in cannabis use and cannabis-related harm after legalization. For the same reasons, it may take as long as 10 years before evaluations of legalizing recreational cannabis use produce clear results on its effects and rates of cannabis use and harms related to use.

## HOW SHOULD WE EVALUATE THE US CANNABIS POLICY EXPERIMENTS?

The greatest concern about cannabis legalization is that it will increase cannabis use among young people, and in particular, initiate adolescent users who would not otherwise have used cannabis. As argued above, there may be a delay before any such increase in use can be seen. An increase in adolescent cannabis use is likely to be preceded by changes in the perceived risks and social acceptability of cannabis use among young people. In the 1980s and 1990s in the Monitoring the Future Surveys,[66,67] changes in the perceived risks and social acceptability of cannabis use predicted increases and decreases in use among youth 1–2 years later. An early warning of increased use may therefore be larger changes in these attitudes in states that have legalized cannabis. This sort of evaluation could be complicated by national changes in youth attitudes towards cannabis, if other US states quickly follow the examples of Alaska, Colorado, Oregon, and Washington.

Another early predictor of later increased use may be increased frequency of use among youth who already use the drug. This could be detected by asking about the frequency of cannabis use among youth who are treated for cannabis problems. This will continue to be under parental and legal coercion because cannabis use under the age of 21 years will be illegal in Colorado and Washington State. We may also see heavier cannabis use among youth who are counseled in high schools for conduct or school problems, who are in the juvenile justice system, and who seek treatment for mental health problems, such as anxiety, depression, and psychoses.

As argued above, readier access to cheaper and more potent cannabis products is likely to increase frequency of use among current users over the legal age of 21 years. The cannabis-related harms that may increase among these young adults would include: increased convictions for cannabis-impaired driving; increased car crashes involving cannabis-intoxicated drivers; and

increased emergency room attendances for the effects of cannabis intoxication and the acute adverse effects from using high THC content cannabis products. An increase in the number of children treated for the adverse effects of accidentally ingesting high potency cannabis consumables may be another early indicator of increased access to cannabis in the community.

We may see increased help-seeking among older cannabis users, with a time lag of up to a decade, as argued above. An earlier indication of emerging cannabis use problems among adults may come from surveys in which all respondents (including users and nonusers) are asked whether they have had reasons to express concerns to a family member or a friend about their use of cannabis. Similar questions have tracked population trends in the prevalence of problem alcohol use.[68]

### Potential positives of cannabis legalization

Evaluations of the effects of cannabis legalization will also need to assess potential health benefits of the policy. An important possibility raised by advocates of legalization is that alcohol-related harm will be reduced if substantial numbers of young males use cannabis instead of alcohol. This would be the case if cannabis and alcohol proved to be substitutes in young adults. Anderson *et al.*'s[42] examination of road crashes in states that have and have not legalized medical cannabis use raised this possibility, as has Anderson *et al.*'s study[43] of the effects of medical marijuana legalization on suicide rates in males aged 20 to 30. If, however, alcohol and cannabis prove to be complements rather than substitutes, increased cannabis use in combination with alcohol could increase fatal car crashes involving both drugs.

A major positive of cannabis legalization will be that it will be easier to undertake research on the health effects of recreational cannabis use. It will be much easier to study regular users and address questions that have been difficult to answer, such as: What doses of THC and CBD do daily and nondaily cannabis users typically use? To what extent are cannabis users able to titrate their doses of THC when they use more potent cannabis products? Does their ability to titrate vary with route of administration? If the conflict between federal and state drug laws can be resolved then it will also be easier to investigate how medically useful cannabis and cannabinoids are, after we remove the distorting effects of cannabis prohibition on "medical use."

## CONCLUSIONS

The legalization of recreational cannabis use in the USA is a large-scale public health experiment whose outcomes may remain uncertain for a decade. The pathway to this policy experiment was facilitated by citizen-initiated referenda over the past decade in several US states that have legalized medical cannabis use using a very liberal definition of what constitutes medical cannabis use, and legalized commercial cannabis supply via dispensaries. These laws created *de facto* legal cannabis markets by making cannabis legally accessible to anyone willing to obtain a letter of recommendation from the doctors who advertise their specialization in providing them.

Evaluations of the effects of medical cannabis laws have not so far found any marked increases in cannabis use or in cannabis-related harm. But many evaluations of these laws have failed to distinguish between very different forms of medical cannabis provision. The absence of evidence of any impact to date is not compelling evidence that there will be no increases in the future. It is probably still too early to conclude that the legalization of medical cannabis use has had no effects on cannabis use or cannabis-related harm, especially in those states with liberal definitions of medical use and poorly regulated commercial supply of cannabis.

The process of creating legal cannabis markets for recreational use in the USA is at an even earlier stage, making it much too soon to assess whether these policies have increased cannabis use and cannabis-related harm. Future evaluations of these policy experiments should look for evidence of: more favorable attitudes towards cannabis use among young people; increased use among youth who are seeking help for cannabis use and mental health problems or involved in the criminal justice system; and increased heavy use among current cannabis users.

It may well be a decade before we can decide whether the legalization of cannabis use has increased population cannabis use and harms related to such use. This time frame will also be required to assess whether increased access to cannabis has reduced or amplified alcohol-related harm among youth.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest.




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