The adverse public health effects of non-medical cannabis legalisation in Canada and the USA

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Cannabis consumption is legally prohibited in most countries in the world. Several countries are legalising cannabis for adult consumption. It is important to monitor the public health effects of these policy changes. In this paper, we summarise the evidence to date on the legalisation of adult non-medical cannabis use in Canada and the USA. We describe regulatory models for cannabis legalisation, changes in cannabis products and pricing, effects on the illicit cannabis market, changes in cannabis use, and changes in cannabis-related physical and mental health harms. We discuss the challenges in assessing the effects of cannabis legalisation on public health outcomes and emphasise the importance of continuous and rigorous monitoring of adverse health effects to inform the design of public health policies and regulations.

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Introduction

The production and retail sale of cannabis for adult non-medical cannabis use has been legalised in the USA since 2014, and Canada since 2018. In this paper, we refer to this policy as adult cannabis legalisation. Washington State and Colorado were the first US states to legalise adult cannabis use in 2014; a total of 24 US states have now done so. Canada legalised adult cannabis use in 2018, under a nominally more restrictive and public-health oriented form of regulation than many US states.[1] Given these recent developments, it is important to address the following questions: what models have been adopted to regulate cannabis in the USA and Canada? What have been the short-term effects of these approaches to cannabis legalisation on the range of cannabis products for sale, their prices, and the illicit cannabis market? How has legalisation of retail sales affected cannabis use among youth and young adults? Has legalisation increased the prevalence of cannabis-related harms to physical and mental health? What are the limitations of the available data and the major constraints on further commercialisation of legal cannabis markets? What might be the longer-term effects of cannabis legalisation if these constraints are reduced?

In this paper, we aim to address these questions. Our approach assumes that the commercialisation of cannabis production and sales will increase adult access to cannabis. We also assume that for-profit cannabis companies will promote cannabis use, especially the regular use of more potent cannabis products.[2] We also assume that the harms of cannabis use will increase with the prevalence of regular use, based on the effects of regulatory policies on alcohol.[3,4]

In assessing the public health effects of cannabis legalisation, we looked for evidence of an association between cannabis legalisation and a change in a health outcome as well as evidence that would exclude alternative explanations for this association (ie, increased attention by clinicians to cannabis use).

We followed the methodological approach of two US National Academies of Science, Engineering, and Medicine (NASEM) reports,[5,6] which reviewed and summarised the conclusions of systematic reviews and included findings from high-quality studies published after these reviews. With the use of the NASEM approach, we summarised the findings of systematic reviews on the effects of cannabis legalisation in North America on a range of different health outcomes.[7–13] We also briefly summarised primary studies of robust design that have been published since the most recent reviews.[14–19] A summary of selected reviews (12 reviews of moderate[8,11,20–27] to high quality[28,29]) is presented in the panel.

Adult cannabis legalisation in the USA

Colorado and Washington State were the first US states to legalise adult cannabis use in 2014.[30] 24 US states have since legalised adult cannabis use; about half of the US population now live in states where it is legal for adults to use cannabis for non-medical purposes.[31]

Alcohol policies have informed the most popular model for cannabis regulation in US states that have legalised adult use.[1,32,33] The popularity of this approach is based on the mistaken assumption that alcohol policy has been a public health success[3] and the ease with which alcohol regulatory models can be adapted to the control of cannabis.[32]

The regulations in Washington State illustrate this approach.[30] A Liquor and Cannabis Board licenses cannabis producers, processors, and sellers. Only adults older than 21 years (the minimum legal age for alcohol purchase) can purchase up to a maximum of 28·5 g (an ounce). The tax on sales price was set at 37·5% at retail with an additional 9·5% state tax. A proportion of cannabis taxes were earmarked for education and prevention. Cannabis-impaired driving was defined as a combination of 5 ng/mL Δ-9-tetrahydrocannabinol (THC) in blood together with behavioural evidence of driving impairment.[30]

Most US states that have legalised adult cannabis use since 2014,[34] have allowed for-profit businesses to produce, distribute, and sell various cannabis products (herbal, edibles, and extracts). The states have varied, however, in how they have regulated cannabis. For

***Panel*: Summary of selected reviews on public health effects of cannabis legalisation**

Cannabis use

Hall et al (2019)[29]

- In the USA in states that have legalised recreational cannabis use, the frequency of use has increased among adults who already used cannabis. The frequency of use remained generally stable among adolescents and adults younger than 21 years.

Hall et al (2023)[8]

- Legalisation is associated with increased adult cannabis use but not with increased adolescent use in Canada.
- Past 3-month cannabis use among adults increased modestly from 14% in 2018, to 20% in 2020, with the largest increases in the 25–44 age group.
- Last-year use increased from 22% in 2018, to 25% in 2021, among adults in the Canadian Cannabis Survey.
- There was mixed evidence on whether use increased in adolescents under the legal purchase age. Student surveys found no substantial changes.
- The prevalence of daily or near-daily use remained stable at about 6–8% of adults who used cannabis.

Lachance et al (2022)[27]

- Findings from longitudinal studies of the USA and Canada showed an increase in reported cannabis use among adolescents and young adults after recreational legalisation, but no change in frequency of consumption.

Leung et al (2019)[20]

- Among adults, the frequency of cannabis use, including daily or near-daily use has increased in states in the USA that legalised adult use.
- Among adolescents aged 12–17 years, there was no increase in prevalence of use after medical or recreational legalisation introduction.

Melchior et al (2019)[21]

- Data from large national surveys showed no marked changes in adolescent use after medical and recreational legalisation in the USA.

O'Grady et al (2022)[22]

- There was no change in adolescent cannabis use associated with recreational cannabis legalisation in the USA.
- Recreational cannabis legalisation might be associated with increases in prevalence of cannabis use among young adults in the USA.

Smart et al (2019)[11]

- Few early studies provide mixed evidence—some increases in use among adolescents in some states but not others, and no change for adults overall.
- However, these studies have major limitations: short follow-up periods that might not reflect longer-term effects; only examined the first states to legalise that all had prior medical markets; and used the date of legalisation rather than full retail implementation to assess effects.

Cannabis use disorder (CUD)

Hall et al (2023)[8]

- In Canada, one study found a statistically significant increase in the diagnosed prevalence of CUD (from 18% to 24%) among psychiatric patients in a Québec hospital in the 5 months after legalisation.
- However, another study of Ontario hospitalisations found no increases in CUD-related admissions after commercialised cannabis sales.

O'Grady et al (2022)[22]

- Very little evidence on the prevalence of CUD in the USA; no marked change in young adult CUD (one study only); and increased CUD in adolescents (two studies, one with probable risk of bias).

Cannabis-related arrests

Hall et al (2019)[8] *and (2023)*[29]

- There was a substantial decrease in cannabis-related arrests associated with medical cannabis legalisation and recreational cannabis legalisation in the USA and Canada. There were no changes in arrest rates for other drug offences, indicating that the decline was specific to legal status changes for cannabis.

Maternal use and adverse health outcomes

Wilson et al (2022)[25]

- There was evidence of an increase in cannabis use, cannabis use disorder, and cannabis treatment admissions during the preconception, pregnancy, and breastfeeding periods after adult legalisation in the USA.

Emergency hospital visits and acute poisoning

Allaf et al (2023)[28]

- Increased acute poisoning in the USA and Canada.
- Overall: relative risk 3·56 (95% CI 2·43–5·20); medical cannabis legalisation: relative risk 3·67 (95% CI 2·36–5·71); recreational cannabis legalisation: relative risk 3·49 (95% CI 2·22–5·48); paediatric: relative risk 4·31 (95% CI 2·30–8·07); and all ages: relative risk 2·63 (95% CI 1·78–3·88).

Hall et al (2023)[8]

- There were substantial increases in cannabis-related emergency department (ED) visits, calls to poison control centres, and hospitalisations after retail sales expanded.
- Increases were particularly notable for acute psychiatric symptoms in young adults, and unintentional cannabis ingestion in children, which rose sharply after edibles became available in Canada.
- For example, one Ontario study found an 18% reduction in ED visits in the first 17 months after legalisation with strict retail controls, but a subsequent 22% increase after retail store expansion.
- ED visits for paediatric poisonings in Ontario increased more than nine times after commercial edibles sales began compared with the period before legalisation.

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Leung et al (2019)[20]
- ED visits related to acute adverse effects of cannabis (ie, psychiatric symptoms, hyperemesis, and cardiovascular events) have increased in Colorado after medical legalisation and further after recreational legalisation (eg, cyclic vomiting syndrome increased from 16 per 100 000 population in 2010, to 22 in 2014).
- Hospitalisations related to cannabis use and dependence increased after medical legalisation in Colorado.
- Unintentional paediatric poisonings related to cannabis, especially from edibles, increased sharply after recreational legalisation (eg, 0·8% increase per month in 2007–13 period).

Walker et al (2023)[24]
- Recreational cannabis legalisation was associated with increased rates of cannabis-related hospitalisations in both Canada and the USA.
- Rates of cannabis-related ED visits increased after both recreational legalisation and commercialisation in Canada.
- Greater increases in ED visits were observed in older adults aged 45–64 years and in women.

Motor-vehicle accidents

Hall et al (2019)[29]
- Some studies have found increased detections of Δ-9-tetrahydrocannabinol (THC) in fatally injured drivers after legalisation in some US states, but the total number of crash fatalities did not differ substantially between states that have and have not legalised recreational cannabis.
- It is unclear to what extent the increased THC detections reflect increased cannabis-impaired driving.

Hall et al (2023)[8]
- Self-reported driving under the influence of cannabis declined somewhat among past-year cannabis users in Canada.
- However, there were conflicting findings from surveys and toxicology data. One study found increases in drivers injured in crashes testing positive for THC after legalisation, but analyses of ED records in Alberta and Ontario found no increase in traffic injury presentations.

Leung et al (2019)[20]
- Evidence is conflicting on whether overall motor-vehicle crash fatality rates and prevalence of cannabis-impaired driving have increased after legalisation.
- Some studies report no substantial changes in fatal motor-vehicle crash rates in Washington and Colorado compared with states without legalisation. Others report a temporary increase in fatal motor-vehicle crashes after implementation of commercial legalisation.
- Studies examining cannabis toxicology testing in drivers involved in motor-vehicle crashes provide mixed results, with some showing increases and others no change after legalisation.

Walker et al (2023)[24]
- Nearly all injury studies examined the effect on total rates of motor-vehicle crash fatalities, rather than cannabis-involved incidents specifically.
- The effect of recreational legalisation alone on motor-vehicle crash fatalities was mixed, with one USA study finding no change.
- Several USA studies evaluating both recreational legalisation and commercialisation periods or commercialisation alone found increases in fatal motor-vehicle crash incidents.
- Among studies assessing USA states separately, some found the effects differed across states.

Windle et al (2022)[26]
- Medical cannabis legalisation was associated with decreased fatal motor crashes (range from −3·5% to −9·3%).
- Recreational cannabis legalisation was associated in increased fatal motor crashes (from 3·6% to 5·9% after recreational cannabis legalisation; from 2·5% to 13·9% after retail sales).

Mental health

Hall et al (2019)[29] *and (2023)*[8]
- Evidence on the effect of medical or recreational cannabis legalisation on mental health is scarce and inconclusive in Canada and the USA.

Walker et al (2023)[24]
- No clear changes in overall rates of self-harm, assault, or death by suicide after recreational legalisation or commercialisation. However, some studies have noted increases in some subgroups (eg, an increase in death by suicide among individuals aged 15–24 years in Washington State after commercialisation).

Effect on other substance use

Smart et al (2019)[11]
- Inconsistent evidence in adolescents and young adults; some studies show an increase in use of alcohol and binge drinking and others show a decrease after medical cannabis legalisation in the USA.

Walker et al (2023)[24]
- There were increased alcohol-related hospitalisations after commercial expansion of cannabis in Colorado, USA.

Pacula et al (2022)[23]
- There is mixed evidence on the possible association of medical cannabis legalisation and recreational cannabis legalisation with alcohol use in the USA.

example, they differ in how they license producers, distributors, and retailers, in which Government departments they administer the laws (eg, Health, Treasury), in the ways in which cannabis products are taxed, and in whether residents are allowed to grow cannabis for their own use.[6]

Adult cannabis legalisation in Canada

Canada's federal Government implemented a more public health-oriented variation of the US models of cannabis legalisation.[7,8] The policy was aimed to protect public health, displace the illicit cannabis market, and protect young people.[35] The legislation included bans on advertising, required plain packaging, and warning labels on all cannabis products. Legalised herbal cannabis production and retail sales began on Oct 17, 2018,[36] with the sales of extracts and edibles started a year later. Several years before the legalisation of non-medical adult cannabis use in Canada, a liberal medical cannabis programme allowed commercial retail sales of cannabis on a medical recommendation, and presented a quasi-legalisation system.[37] For this reason, cannabis legalisation in Canada was a gradual process that might not generate a sharp change from the date of its implementation in 2018, in patterns of cannabis use and cannabis-related harms.

The Canadian federal Government licenses and regulates cannabis producers whereas provincial Governments regulate retail sales, license retailers, and specify a minimum legal age of purchase that most provinces set at 19 years, while Québec set it at 21 years.[38] Government retail monopolies for cannabis were established in some provinces that had alcohol monopolies (such as Québec), whereas others introduced private retail systems. Taxes from cannabis sales are shared between federal and provincial Governments.[8]

The effects of legalisation on cannabis prices and products

Adults older than 21 years in US states with adult cannabis legalisation and individuals aged 19 years or older in most Canadian provinces can legally purchase a wide range of regulated cannabis products without criminal consequences. The number of people arrested for cannabis offences has substantially decreased in Canada[7,39] and in the US states that have legalised adult use.[39,40]

Cannabis prices have steeply declined as more legal cannabis retail outlets have opened. Prices declined by 50% or more in the early-adopter US states[1] and they continue to decline in many jurisdictions.[6,41,42] Declining prices and increases in the number of adult cannabis retail outlets have greatly increased adult access to cannabis products in Canada[43,44] and the USA.[45]

Legalisation of cannabis production and commercial sales have increased access to more diverse and more potent cannabis products[6,46] than the cannabis flower and hash products that dominated illicit cannabis markets.[47,48] These new products include pre-rolled joints, cannabis-infused edibles (eg, candies, chocolates, cookies, and gummies), cannabis-based beverages, and cannabis extracts and concentrates that might contain 70% or more THC.[48,49] The cannabis industry argues that it is no riskier to use more potent products than herbal cannabis because users titrate their THC doses,[49] although there is only weak evidence to support this claim.[50]

The public health effects of cannabis legalisation

Trends in cannabis use

In USA household surveys, an increased number of adults older than 25 years report using cannabis, and many report doing so more often, since the legalisation of adult cannabis use.[12,51] Daily and near-daily cannabis use have increased in the USA, and the proportion of people who use cannabis who do so daily is now larger than the proportion of daily consumers of alcohol.[52] There have not been marked increases in the prevalence of cannabis use among adolescents and adults younger than 21 years;[12,53–55] however, in this age group the perceived risks of using cannabis have declined since the legalisation.[51]

Assessing national changes in cannabis use in Canada is more difficult because annual population surveys of cannabis use that asked the same questions were not done regularly in the two decades before adult legalisation introduction. Instead, surveys were done at varying intervals and asked about cannabis use in different ways.[56] Rotermann and Macdonald[57] estimated that the prevalence of cannabis use in the past year increased from 6% in 1985, to 14% in 2004, but it was unclear whether cannabis use had increased between 2004 and the legalisation of cannabis in 2018.[8,56] A meta-analysis of these surveys found considerable heterogeneity in their estimates of the prevalence of cannabis use in the previous year, but found a statistically significant increase in annual prevalence from 9% in the years before cannabis legalisation (1985–2017) to 25% in the 3 years after cannabis legalisation (2018–21).[58] The analysis also found a steady increase in the prevalence of annual cannabis use between 1985 and 2021, from 6% to 27%.[58]

Surveys of cannabis use were done in representative adult and adolescent (ie, secondary student) population samples in Ontario—Canada's most populous province—between 2001 and 2019. These surveys provided data on the 18 years before legalisation and the first year after legalisation.[59,60] In Ontario, cannabis legalisation was not associated with an increase in cannabis initiation among adolescents, but it was associated with an increase in daily cannabis use and cannabis dependence among adolescents.[60] There were similar changes in cannabis use among adults in Ontario;[60] cannabis legalisation was not associated with an increase in cannabis initiation but it was associated with an increase in daily cannabis use and in symptoms of cannabis dependence.

The Canadian Cannabis Survey[61] found that the percentage of adults who reported cannabis use in the past 12 months increased from 22% in 2018, to 26% in 2023. The largest increase in cannabis use in the past year was among those aged 20–24 years.[61,62] The estimated prevalence of past year use among individuals aged

16–19 years fluctuated but the prevalence of daily and near-daily use did not change significantly (appendix p 2).[61] Two narrative reviews of evidence on the effects of cannabis legalisation on youth in Canada have found no evidence of major increases in the prevalence of cannabis use among youth.[63,64]

Acute adverse health effects

The best evidence on the acute adverse health effects of legalisation has come from analyses of trends in health service utilisation episodes in Ontario's general population between Jan 1, 2016, and March 31, 2021.[65,66] During this time span, three distinct periods can be distinguished in terms of legal access to cannabis retail outlets: a period preceding legalisation (January, 2016 to September, 2018); the early period of legalisation when there was a small number of legal cannabis sales outlets (October, 2018 to January, 2020); and a third period in which the number of legal cannabis retail outlets rapidly increased (February, 2020 to March, 2021). In multiple studies, Myran and colleagues[14,17,65,67,68] have reported that the respective rates of various adverse health outcomes predominantly increased in the period before legalisation, decreased immediately after legalisation was implemented (when there were few legal cannabis retail outlets), and sharply increased as the number of legal cannabis retail outlets increased.

Child poisonings

Increases in emergency department attendances for cannabis-related poisonings in children have been consistently reported in the USA and Canada since adult cannabis legalisation.[18,66,69–71] In Massachusetts, USA, the incidence of poison control calls for cannabis exposure in children has increased following the legalisation of medical[70] and recreational[68] cannabis. Cannabis exposure among children has also increased in neighbouring states where adult cannabis use was not legalised.[69]

In Ontario, Myran and colleagues[67] found that Emergency Department attendances by children for the unintentional ingestion of cannabis products increased sharply after the legalisation of edible cannabis products in Canada in 2019. Similar increases were seen in Alberta and British Columbia, but not in Québec which did not allow the sale of cannabis edibles and had a legal age of purchase of 21 years. These findings have been supported by a systematic review of studies in Canada and the USA where the relative risk of paediatric Emergency Department visits after legalisation was 4·31 (95% CI 2·30–8·07).[28]

Adverse cannabis effects in adults

Studies of Emergency Department attendances by adults in Ontario for cannabis-related problems, such as intoxication and symptoms of cannabis use disorders, hyperemesis, and cannabis-related problems in pregnant women, have reported similar trends to childhood poisonings. These studies have found an increasing trend in these outcomes before legalisation, minimal changes in the period immediately after legalisation, and then a sharp increase in the outcome as the number of cannabis retail outlets increased.[14,17,65,68]

See Online for appendix

Motor-vehicle crash injuries and deaths

In Canada, fewer cannabis consumers (mostly less than 15%) report driving within several hours of using cannabis in national Canadian surveys;[8,59] concentrations of THC detected in the blood of people injured in car crashes in British Columbia, however, have increased since legalisation.[72] It is unclear to what extent the increased THC detection reflects an increased prevalence of cannabis impaired driving or heavier cannabis use among individuals who drive after using cannabis.[26]

Callaghan and colleagues[73] did not find any association between adult cannabis legalisation and Emergency Department attendances for car-crash injuries, but their study included only the first year of legalisation in Canada (2015–19). Myran and colleagues,[15] by contrast, found an association between Emergency Department attendances for cannabis-related car crashes and access to legal retail cannabis outlets, much like that shown in their studies of other adverse health outcomes. Another large study examined the association between motor-vehicle crash injuries in Emergency Department in Ontario and Alberta and hospitalisations in Ontario, Alberta, British Columbia, Manitoba, Saskatchewan, Nova Scotia, New Brunswick, Newfoundland, and Prince Edward Island between 2010 and 2020. The study did not find any increase in emergency department attendances or hospitalisations for car-crash injuries after cannabis legalisation, but interpretation of the findings was complicated by a reduction in crash injuries during the COVID-19 pandemic in 2020 because of reduced driving.[74] A study by the Canadian Institute of Actuaries analysed accidents claims in ten Canadian regions over the period from 2016 to 2019.[75] After accounting for regional differences in trends, the study found no statistically significant changes in the average cost per claim or in the frequency of claims in the first year after cannabis legalisation in Canada.[75]

Studies of the effects of cannabis legalisation on motor-vehicle crashes in the USA have also produced conflicting findings.[12] Detections of THC in motor-vehicle crash fatalities have increased since legalisation in some US states,[12,26] but accident fatality rates have not consistently differed between US states that have and have not legalised adult use, or before and after cannabis legalisation.[76]

Chronic adverse effects of cannabis legalisation

Cannabis dependence

In the USA, two series of population surveys of drug use have produced inconsistent findings on changes in

symptoms of cannabis use disorders after the introduction of adult cannabis legalisation.[12] The National Epidemiologic Survey of Alcohol and Related Conditions survey series showed an increase in cannabis use disorder symptoms[77] but the National Household Survey of Drug Use and Health reported a decrease in the proportion of cannabis users who met criteria for cannabis use disorders.[78]

Other indicators of cannabis use disorders (CUDs) also show inconsistent results. Data on acute medical treatment episodes for symptoms of cannabis use disorders suggest that the prevalence of these disorders has increased, also among older adults, in states that have legalised medical and adult cannabis use.[79,80] By contrast, the number of people who seek specialist addiction treatment for CUDs in the USA has declined since cannabis legalisation.[12,81] The latter seems to be in part because fewer people enter treatment for cannabis use disorders as an alternative to a court attendance for a cannabis offence[82] since the introduction of adult cannabis legalisation.

Whether the increased use of more potent cannabis products has increased the risk of cannabis use disorders is unclear.[83] People who report use of cannabis extracts report more dependence symptoms and mental distress than individuals who use herbal cannabis.[84,85] Treatment-seeking for cannabis use disorders has been associated with the potency of cannabis products.[86]

Mental health disorders

Psychoses could possibly increase after introduction of adult cannabis legalisation. Epidemiological evidence exists that the risk of developing these disorders is approximately doubled in people who use cannabis daily in adolescence and young adulthood.[87] Studies of trends in Emergency Department attendances and hospitalisations for psychotic disorders in Canada and the USA since cannabis legalisation have produced inconsistent findings.[12] A study[73] of Emergency Department attendances for transient cannabis-induced psychosis and schizophrenia in Alberta and Ontario did not find any increase in the first year after adult legalisation; however, this study was completed before the number of retail cannabis stores increased. The rates of both types of Emergency Department presentations were increasing before cannabis was legalised, perhaps because of increased access to cannabis under the liberal medical cannabis policies that preceded adult legalisation in these provinces.[8] Myran and colleagues,[16] by contrast, reported the same change in Emergency Department attendances for cannabis-related psychoses in Ontario as other adverse outcomes in adults between January, 2014, and September 2021. The authors reported an increase in psychoses before legalisation, a decrease in incidence in the first year of legalisation, and a rapid increase in presentations as the number of retail outlets increased.

In the USA, Elser and colleagues[88] evaluated the association between state policies on medical and adult cannabis use and health-care utilisation for psychoses for the period 2003–17. Health insurance claims data for people aged 16 years and older in all 50 US states did not show a significant increase in rates of psychosis-related health outcomes in states that had legalised medical and adult cannabis use.

In epidemiological studies, there is a modest association (odds ratio [OR] about 1·5) between regular cannabis use and depression but is unclear whether the relationship is causal.[89–92] In US surveys, regular cannabis use has increased at a faster rate among people who report symptoms of anxiety and depressive disorders,[51] but the evidence on the effects of cannabis legalisation on trends in Emergency Department admissions for depression is mixed.[12] Cannabis-related Emergency Department visits were also associated with incident health-care visits for anxiety disorders.[93] In Ontario, Canada, the rates of Emergency Department visits for cannabis-involved anxiety disorders increased gradually between 2008 and 2022,[94] but this increase was not associated with the legalisation of recreational cannabis.[94]

Physical health

Given the similarities between cigarette and cannabis smoke, cardiovascular diseases and cancers can occur in cannabis users who smoke herbal cannabis regularly for many years.[92,95] Epidemiological studies suggest cannabis use might increase risks of cancer and chronic cardiovascular diseases, including myocardial infarction, although it is uncertain whether these relationships are causal.[92,95,96] It might be too soon to detect large increases in the incidence of respiratory or other cancers as a possible consequence of adult cannabis legalisation, given that these diseases typically occur after decades of tobacco smoking, and very few people who smoke cannabis have had such long cannabis smoking histories. A detectable increase in cardiovascular disease is more likely among older adults because there is suggestive evidence that heavy cannabis smoking acutely increases cardiovascular disease risk in older adults, a sub-population in which cannabis use has increased since adult legalisation.[97]

Challenges in assessing the effects of legalisation on cannabis use and harms

Studies assessing the effects of cannabis legalisation on public health outcomes in Canada and the USA have faced major challenges.

First, US states and some Canadian provinces have implemented different cannabis regulations that might differentially affect patterns of cannabis use. For example, US states and Canadian provinces differ in how they license and regulate the number, density, and location of cannabis retail stores, and how they tax cannabis

products.[7,33] Two reviews from 2023 and 2024, have nonetheless found an association between increased access to cannabis retail stores and increased cannabis use and cannabis-related harms among adults.[98,99]

Second, there are limitations in the survey data used to assess the effects of legalisation on patterns of cannabis use. In the USA, for example, the two major population surveys of self-reported cannabis use[10] were not designed to provide robust comparisons of differences in patterns of cannabis use between states that have or have not legalised adult or medical cannabis use. Canada has been conducting national surveys of cannabis use since 2018, the year before cannabis legalisation. Self-reported cannabis use in these surveys might also have been affected by legalisation, if for example, participants are more likely to disclose their use of cannabis after legalisation.

Third, administrative datasets are available on general population-based health service utilisation of Canadian provinces but so far studies have only been reported from a subset of Canadian provinces (eg, Ontario).[65] Analyses of comparable data from other provinces should be a high priority. International classification of diseases codes provide little information on specific adverse public health effects of cannabis. The recording can also be affected by cannabis legalisation if, for example, health professionals are more likely to ask their patients about their cannabis use, patients are more willing to disclose using cannabis, and cannabis mentions are more likely to be coded after legalisation.

Fourth, the most common research designs used to assess whether a health outcome has changed since the introduction of the legalisation have been pre-post comparisons. These comparisons are complex because some outcomes (eg, cannabis use) were increasing before the introduction of adult cannabis legalisation, in part because of the liberal medical cannabis access provisions that preceded adult cannabis legalsation.[12] When there has been a change in health outcomes since legalisation, it can be difficult to state whether legalisation, or some other factors, have been responsible because of the absence of comparable data from jurisdictions that have not legalised adult cannabis use.[12] A major challenge in inferring that cannabis legalisation is the most plausible explanation of any changes in health outcomes is deciding on the role of ascertainment bias in health encounters, biases in self-reported cannabis use in surveys, a continuation of secular trends evident before legalisation, and the effects of other events (such as the COVID-19 pandemic) that coincided with cannabis legalisation in North American settings.[12]

A provisional assessment of the evidence

First, cannabis use, and especially daily use, has increased among adults in Canada and the USA since cannabis legalisation, perhaps more so in the USA where legalisation has been in effect in some states longer than in Canada. Public health campaigns about cannabis use should include messages about the risks of regular cannabis use.[100]

Second, child poisonings from the ingestion of cannabis products have increased in Canada and the USA, most markedly since the legal sales of cannabis edibles. These risks could be reduced by avoiding packaging edible cannabis products in ways that are attractive to children and by limiting the THC doses that these products contain, as has happened in some US states.

Third, the evidence on cannabis-related car crashes is conflicting. Challenges remain in distinguishing between biomarkers of recent cannabis use by drivers and cannabis-related impairment, and in accounting for the effects of increased testing for THC. Nonetheless, it would be prudent public health policy to discourage people who use cannabis from driving within several hours of using cannabis.[100]

Fourth, symptoms of CUDs reported by adults in some surveys have increased in Canada and the USA. Adult Emergency Department presentations have increased in Canada and the USA for cannabis intoxication and symptoms of CUDs. The extent of the increase might have been amplified by a greater willingness on the part of medical staff to ask about cannabis use and for patients to report their cannabis use. Treatment-seeking for CUDs has declined in the USA because of the reduction in legally coerced treatment since adult legalisation introduction. Public health education is needed to help cannabis consumers and communities to recognise the symptoms of CUDs and to encourage people with symptoms to seek help.

Fifth, there is mixed evidence on the association between cannabis legalisation and changes in incidence of mental health disorders (eg, schizophrenia); and an ongoing debate regarding the causal epidemiological relationship between cannabis use and psychoses.[101] In Canada the prevalence of psychosis cases presenting for treatment was increasing before adult cannabis legalisation, possibly reflecting increased access to more potent cannabis. Myran and colleagues[16] have found suggestive evidence of an increase in Emergency Department attendances for psychoses since cannabis commercialisation in Ontario, but this effect has not yet been found in analyses of US-based health-care utilisation data. Mental health services should nonetheless discourage cannabis use by people with psychoses, anxiety, and depression.[102] The table shows the summary of evidence on the effects of cannabis legalisation on different indicators. The description of studies that informed this summary table are presented in the appendix (pp 3–7).

Possible future effects of cannabis legalisation

Evidence on the probable adverse public health effects of cannabis legalisation in North America has been mixed and the most consistent changes have been moderate.

	Observed changes after legalisation	Is there plausible causal relationship?
Adult cannabis use	Increased daily use among adults.	Yes: adults who were using cannabis have more access to cannabis since legalisation and adult use has been normalised.
Adolescent cannabis use	No marked changes in adolescent use.	Uncertain: there was no marked increase in adolescent cannabis use in the US states that had legalised adult cannabis use and expansion of retail sales. Perceptions of the risks of using cannabis have declined among adolescents in the USA.
Cannabis use disorder	Probable increase in symptoms of CUD and ED presentation for CUD symptoms in adults.	Uncertain: the increase might be attributed in part to patients being more likely to report cannabis use-related problems and in part to greater access to more potent cannabis products.
Emergency hospital visits and acute poisonings	Substantial increases in cannabis-related emergency hospital visits, calls to poison control centres, and hospitalisations, especially for child poisoning from ingestion of cannabis products.	Yes: child poisoning has markedly increased in both the USA and Canada since the increased sales of cannabis edibles. ED attendance has also increased among adults in Ontario for cannabis intoxication. Children mistake these products as confectionary, and adults take larger doses of THC than intended in edibles.
Cannabis-related arrests	Substantial decrease in cannabis-related arrests.	Yes: cannabis use or possession is no longer a universal offence in legalisation jurisdictions, so the legal basis for most arrests are gone.
Car accidents	Mixed evidence on changes in crash fatality rates and cannabis-related motor-vehicle accidents.	Uncertain: unclear if there has been an increased in cannabis-impaired driving.
Mental health	Mixed evidence on the effect of legalisation on mental health outcomes. Rapid increase in ED presentation of psychoses observed in Ontario after the expansion of retail sales, but no significant increase in psychoses in the US states with legal medical or adult cannabis use.	Uncertain: the observed increase might be partly attributed to increased reporting of cannabis use by patients and partly to increased use of higher THC cannabis products; observing effects of cannabis legalisation on mental health outcomes might take longer.

CUD=cannabis use disorder. ED=emergency department. THC= Δ 9-tetrahydrocannabinol.

Table: **Summary of observed changes in selected outcomes after cannabis legalisation and assessments of the plausibility of a causal relationship**

Some advocates of cannabis legalisation have argued[103] that it is unlikely to see any future increases in adverse public health effects after cannabis legalisation, but this conclusion is premature.[104]

First, cannabis legalisation is still early in its implementation in North America.[12] The policy has been operating for 10 years in the first two US states to legalise adult use, Colorado and Washington State, but for a much shorter time in most of the other US states that have legalised adult cannabis use. In many of these states, it has taken several years to licence cannabis producers and retailers, and longer for cannabis production and sales to scale up to meet existing demand.

Adult cannabis sales have been legal for 6 years in Canada and the sale of cannabis edibles and extracts has been allowed for 5 years. Although it appears that legal cannabis markets have reached plateaus for expansion and volume, they continue to evolve with cannabis firms consolidating and the prices of cannabis products continuing to decline in many provinces.[6,12,46] There is also likely to be a lag between any increases in the prevalence of regular cannabis use and the identification of any longer-term adverse health effects of regular use, such as an increased prevalence or a greater chronicity of mental and physical health disorders.

Second, there have been constraints on the full commercialisation of cannabis markets in both Canada and the USA. In the USA, federal cannabis prohibition remains in effect, preventing large-scale cannabis production, national cannabis distribution, and interstate trade in cannabis products.[1] The prohibition has also made it difficult for cannabis firms to use banking services and receive funding from capital markets and the alcohol and tobacco industries. This regulation has prevented the cannabis industry from enjoying the same commercial freedom as the alcohol industry. In Canada, public health regulations on promotions, brands, and packaging nominally constrain the ability of cannabis companies to promote cannabis use but studies suggest that these are often circumvented or ignored.[8,105]

In both countries, the cannabis industry is lobbying to lower cannabis taxes and liberalise cannabis regulation, supposedly to enable the legal industry to better compete with the illicit cannabis market. In the USA, the industry is lobbying for cannabis to be removed from the federal Controlled Substances Act, and for state governments to reduce cannabis taxes and override local government restrictions on the location of cannabis retail outlets. In Canada, the industry is pushing for a relaxation of restrictions on cannabis advertising and a legal change that would allow the use of cannabis brand names and branded packaging.[106] In case these lobbying efforts are successful, it could increase commercialisation and promotion of cannabis use.

Major alcohol and tobacco firms have invested billions of dollars in Canadian cannabis businesses.[1] This phenomenon has not yet occurred in the USA because cannabis is still a Schedule 1 drug under federal law, but it will be possible if federal law is changed (eg, by removing cannabis from the Controlled Substances Act). This change would also provide strong constitutional protection for the promotion of cannabis products to adults.

The future of legal recreational cannabis

A major determinant of the public health effects of cannabis legalisation will be its effects on alcohol use, but to date the literature is mixed.[33] The alcohol industry can be expected to advocate for policy changes that will enable them to promote the complementarity of alcohol and cannabis use (eg, by allowing the sale and consumption of cannabis-based beverages in alcohol outlets and bars, and allowing the alcohol industry to invest in cannabis companies).

Another concern is about the longer-term public health effect of lower cannabis prices and increased potency.[12]

Search strategy and selection criteria

We searched systematic reviews and original studies on Embase, PubMed (including MEDLINE), Scopus, Web of Science, and Cochrane Library. The search terms used included: "cannabis" (with its related terms) AND "legalisation" (with related terms), AND "public health effects" (with related terms). There was no restriction on language, location, and publication year. The first search was done in January, 2024, and updated in August, 2024. The quality of reviews was assessed with the use of AMSTAR (A MeaSurement Tool to Assess systematic Reviews;[19] appendix p 8). We included reviews that were published in peer-reviewed journals and scored moderate to high AMSTAR scores (appendix p 9). A summary of selected reviews (12 reviews of moderate to high quality) is presented in the panel. These reviews included between 19 and 64 original studies and reported the effects of cannabis legalisation on cannabis use (n=7), cannabis use disorder (n=4), cannabis-related arrests (n=2), maternal cannabis use (n=1), emergency department visit and acute poisoning (n=4), motor-vehicle accidents (n=5), mental health (n=3), and other substances use (n=3).

Prices of legally sold cannabis products have fallen steeply, whereas their potency has increased in many US states and Canada. These changes might increase regular cannabis use and the harms associated with it.[12] Prices might decline even further if biotechnology companies can produce cannabinoids via large-scale biosynthesis[107] that removes the need for large-scale cannabis cultivation and the costly processes of extracting cannabinoids and testing cannabis products for contaminants.

Legal recreational cannabis markets in Canada and in many states in the USA might not reach maturity for more than a decade. Once that maturity is reached, it will be possible to assess whether cannabis legalisation has increased cannabis use and harms and whether it has reduced or increased the use of alcohol, tobacco, and opioids. Whether cannabis legalisation has had any adverse effects on social inequity if, for example, intensive cannabis use is more common in the socially disadvantaged groups who benefit from eliminating criminal penalties for adult cannabis use, will also be possible to assess.[6]

Conclusions

Adult cannabis legalisation in Canada and the USA has increased adult access to potent cannabis products often at a lower cost than available on the illicit market. These changes appear to have increased daily cannabis use among adult cannabis consumers in the USA and Canada. There have been increased Emergency Department attendances by adults reporting adverse effects of cannabis use and increased childhood poisonings from the ingestion of cannabis products in both countries.

Methodologically stronger studies will be necessary to evaluate the effects that legalisation has had on cannabis use, mental disorders, and public health more broadly. Overall, it is key to rigorously monitor the adverse public health effects of cannabis legalisation to inform the design of effective public health policies and regulations in North America and in other regions that decide to legalise cannabis. This monitoring will require more studies of health service utilisation for cannabis-related problems with the use of record linkage, repeated population surveys of patterns of cannabis use and self-reported adverse effects in representative samples of the population (eg, the national Canadian surveys), and importantly, longitudinal studies of the effects that adult legalisation has on patterns of cannabis use and cannabis-related harm in adolescents and adults.

Contributors

TMY: literature search, design, data extraction, data interpretation, visualisation, project administration, validation, and writing—review and editing. EH: conceptualisation, design, data interpretation, and writing—preparation of the original draft, review, and editing. BF: data interpretation, design, and writing—review and editing. DD: data extraction, design, data interpretation, validation, and writing—review and editing. WH: conceptualisation, design, literature search, data interpretation, supervision, writing—preparation of the original draft, review, and editing.

Declaration of interests

WH declares advising WHO on health risks of cannabis (2016–22); contributing evidence on the safety and effectiveness of medical cannabis use (Australian Department of Health 2017–21); and expert testimony in 2024 for the prosecution on the risks of adolescent cannabis use in a criminal case. EH declares receiving compensation for scientific writing and grants from WHO, European Union Drugs Agency, and German Ministry of Health; received a grant from German Society for Addiction Research and Therapy for a treatment practice guideline of Cannabis Use Disorders; and received royalties or licenses from Hogrefe Publishing for T*reatment manual on Cannabis Use Disorders*. BF received research and scientific development support from the Canadian Centre on Substance Use and Addiction, the Correctional Service of Canada, and the Max Planck Society; and was employed by Health Canada (2021–22). All other authors declare no competing interests. The funders did not have any roles in this paper.

References

1 Hall W, Stjepanović D, Caulkins J, et al. Public health implications of legalising the production and sale of cannabis for medicinal and recreational use. *Lancet* 2019; **394:** 1580–90.

2 Chan GCK, Hall W. Estimation of the proportion of population cannabis consumption in Australia that is accounted for by daily users using Monte Carlo Simulation. *Addiction* 2020; **115:** 1182–86.

3 Babor T, Caulkins J, Fischer B, et al. Drug policy and the public good. Oxford University Press, 2018.

4 Babor TF, Casswell S, Graham K, et al. Alcohol: no ordinary commodity: research and public policy. Oxford University Press, 2022.

5 National Academies of Sciences Engineering and Medicine. The health effects of cannabis and cannabinoids: the current state of evidence and recommendations for research. National Academies Press, 2017.

6 National Academies of Sciences Engineering and Medicine. Cannabis policy impacts public health and health equity. The National Academies Press, 2024.

7 Gibbs B, Reed T, Wride S. Cannabis legalisation—Canada's experience: public first. 2021. https://www.publicfirst.co.uk/wp-content/uploads/2021/10/REPORT-Cannabis-in-Canada-Public-First-October-2021.pdf (accessed Nov 16, 2024).

8 Hall W, Stjepanović D, Dawson D, Leung J. The implementation and public health impacts of cannabis legalization in Canada: a systematic review. *Addiction* 2023; **118:** 2062–72.

9 Isorna M, Pascual F, Aso E, Arias F. Impact of the legalisation of recreational cannabis use. *Adicciones* 2023; **35:** 349–76.

10 Sevigny EL, Greathouse J, Medhin DN. Health, safety, and socioeconomic impacts of cannabis liberalization laws: An evidence and gap map. *Campbell Syst Rev* 2023; **19:** e1362.

11 Smart R, Pacula RL. Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: Findings from state policy evaluations. *Am J Drug Alcohol Abuse* 2019; **45:** 644–63.

12 Manthey J, Hayer T, Jacobsen B, et al. Effects of legalizing cannabis. Technical report. Hamburg: "Institut für interdisziplinäre Sucht- und Drogenforschung (ISD). 2023. https://www.drugsandalcohol.ie/38753/ (accessed 29 July, 2024).

13 Boury H, Hall W, Fischer B. Developments and changes in primary public health outcome indicators associated with the legalization of non-medical cannabis use and supply in Canada (2018): a comprehensive overview. *Int J Ment Health Addict* 2022; 1–15.

14 Myran DT, Gaudreault A, Konikoff L, Talarico R, Liccardo Pacula R. Changes in cannabis-attributable hospitalizations following nonmedical cannabis legalization in Canada. *JAMA Network Open* 2023; **6**: e2336113.

15 Myran DT, Gaudreault A, Pugliese M, Manuel DG, Tanuseputro P. Cannabis-involved traffic injury emergency department visits after cannabis legalization and commercialization. *JAMA Network Open* 2023; **6**: e2331551.

16 Myran DT, Pugliese M, Roberts RL, et al. Association between non-medical cannabis legalization and emergency department visits for cannabis-induced psychosis. *Mol Psychiatry* 2023; **28:** 4251–60.

17 Myran DT, Roberts R, Pugliese M, et al. Acute care related to cannabis use during pregnancy after the legalization of nonmedical cannabis in Ontario. *CMAJ* 2023; **195:** e699–708.

18 Myran DT, Tanuseputro P, Auger N, Konikoff L, Talarico R, Finkelstein Y. Pediatric hospitalizations for unintentional cannabis poisonings and all-cause poisonings associated with edible cannabis product legalization and sales in Canada. *JAMA Health Forum* 2023; **4**: e225041-e.

19 Shea BJ, Reeves BC, Wells G, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* 2017; **358:** j4008.

20 Leung J, Chiu V, Chan GCK, Stjepanović D, Hall WD. What have been the public health impacts of cannabis legalisation in the USA? A review of evidence on adverse and beneficial effects. *Curr Addict Rep* 2019; **6:** 418–28.

21 Melchior M, Nakamura A, Bolze C, et al. Does liberalisation of cannabis policy influence levels of use in adolescents and young adults? A systematic review and meta-analysis. *BMJ Open* 2019; **9:** e025880.

22 O'Grady MA, Iverson MG, Suleiman AO, Rhee TG. Is legalization of recreational cannabis associated with levels of use and cannabis use disorder among youth in the United States? A rapid systematic review. *Eur Child Adolesc Psychiatry* 2022.

23 Pacula RL, Smart R, Lira MC, Pessar SC, Blanchette JG, Naimi TS. Relationships of cannabis policy liberalization with alcohol use and co-use with cannabis: a narrative review. *Alcohol Res* 2022; **42**: 06.

24 Walker M, Carpino M, Lightfoot D, et al. The effect of recreational cannabis legalization and commercialization on substance use, mental health, and injury: a systematic review. *Public Health* 2023; **221:** 87–96.

25 Wilson S, Rhee SH. Causal effects of cannabis legalization on parents, parenting, and children: A systematic review. *Prev Med* 2022; **156:** 106956.

26 Windle SB, Socha P, Nazif-Munoz JI, Harper S, Nandi A. The impact of cannabis decriminalization and legalization on road safety outcomes: a systematic review. *Am J Prev Med* 2022; **63:** 1037–52.

27 Lachance A, Bélanger RE, Riva M, Ross NA. A systematic review and narrative synthesis of the evolution of adolescent and young adult cannabis consumption before and after legalization. *J Adolesc Health* 2022; **70:** 848–63.

28 Allaf S, Lim JS, Buckley NA, Cairns R. The impact of cannabis legalization and decriminalization on acute poisoning: a systematic review. *Addiction* 2023; **118:** 2252–74.

29 Hall W, Stjepanović D, Caulkins J, et al. Public health implications of legalising the production and sale of cannabis for medicinal and recreational use. *Lancet* 2019; **394:** 1580–90.

30 Pardo B. Cannabis policy reforms in the Americas: a comparative analysis of Colorado, Washington, and Uruguay. *Int J Drug Policy* 2014; **25:** 727–35.

31 Graham M, Chiu V, Stjepanović D, Hall W. A provisional evaluation of Australia's medical cannabis program. *Int J Drug Policy* 2023; **122:** 104210.

32 Hall W. Alcohol and cannabis: Comparing their adverse health effects and regulatory regimes. *Int J Drug Policy* 2017; **42:** 57–62.

33 Pacula R, Pessar S, Zhu J, Kritikos A, Smart R. Federal regulations of cannabis for public health in the United States. Leonard D Schaeffer Center for Health Policy & Economics. 2022. https://healthpolicy.usc.edu/research/federal-regulations-of-cannabis-for-public-health-in-the-u-s/ (accessed Nov 16, 2024).

34 University of Georgia Law Library. Marijuana Law in the United States: Legalized Marijuana for Recreational Use. 2024. https://libguides.law.uga.edu/c.php?g=522835&p=3793319. (accessed Oct 9, 2024).

35 Parliament of Canada. An Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts. 2018. https://www.parl.ca/LegisInfo/en/bill/42-1/C-45 (accessed Nov 7, 2024).

36 Bowal P, Kisska-Schulze K, Haigh R, Ng A. Regulating cannabis: a Comparative exploration of Canadian legalization. *Am Bus Law J* 2020; **57:** 677–733.

37 Fischer B, Kuganesan S, Room R. Medical marijuana programs: implications for cannabis control policy—observations from Canada. *Int J Drug Policy* 2015; **26:** 15–19.

38 Gagnon F, Chapados M, Morin R. The non-medical cannabis regime in Québec: a public health analysis. 2021. https://www.inspq.qc.ca/en/publications/2829 (accessed Aug 23, 2024).

39 Fischer B, Robinson T, Albrecht H-J. Primary crime-related outcome indicators associated with recreational cannabis legalization: a comprehensive literature and data review. *Crime Law Soc Change* 2024; **82:** 685–715.

40 Gunadi C, Shi Y. Association of recreational cannabis legalization with cannabis possession arrest rates in the US. *JAMA Network Open* 2022; **5**: e2244922-e.

41 Flowhub. 2024 marijuana industry statistics and data insights: how the industry is performing and where it's headed. 2024. https://flowhub.com/cannabis-industry-statistics (accessed Aug 23, 2024).

42 Caulkins JP. Radical technological breakthroughs in drugs and drug markets: the cases of cannabis and fentanyl. *Int J Drug Policy* 2021; **94:** 103162.

43 Myran DT, Friesen EL, Dickson S, Konikoff L, Arora G, Tanuseputro P. Access to legal cannabis market in Canada over the four years following non-medical cannabis legalisation. *Drug Alcohol Rev* 2023; **42:** 1114–19.

44 Robinson T, Jutras-Aswad D, Fischer B. Exploring the role of primary regulation differences for cannabis legalization outcomes—preliminary data from two Canadian provinces. *Drugs: Education, Prevention and Policy* 2024; published online Apr 5. https://doi.org/10.1080/09687637.2024.2333348.

45 Dilley JA, Johnson JK, Colby AM, et al. Cannabis retail market indicators in five legal states in the United States: A Public Health Perspective. *Clin Ther* 2023; **45:** 778–86.

46 Rosenberg M, Ayonrinde O, Conrod P, Levesque L, Selby P. Legislative review of the Cannabis Act, in Final Report of the Expert Panel. 2024. https://www.canada.ca/en/health (accessed Nov 16, 2024).

47 Kilmer B, Pérez-Dávila S. Nine Insights From 10 Years of Legal Cannabis for Nonmedical Purposes. *Clin Ther* 2023; **45:** 496–505.

48 Pacula RL, Blanchette JG, Lira MC, Smart R, Naimi TS. Current U.S. State Cannabis Sales Limits Allow Large Doses for Use or Diversion. *Am J Prev Med* 2021; **60:** 701–05.

49 Hall W, Leung J, Carlini BH. How should policymakers regulate the tetrahydrocannabinol content of cannabis products in a legal market? *Addiction* 2023; **118:** 998–1003.

50 Leung J, Stjepanović D, Dawson D, Hall WD. Do cannabis users reduce their THC dosages when using more potent cannabis products? A Review. *Front Psychiatry* 2021; **12:** 630602.

51 Hasin D, Walsh C. Trends over time in adult cannabis use: a review of recent findings. *Curr Opin Psychol* 2021; **38:** 80–85.

52 Caulkins JP. Changes in self-reported cannabis use in the United States from 1979 to 2022. *Addiction* 2024; **119:** 1648–52.

53 Dilley JA, Richardson SM, Kilmer B, Pacula RL, Segawa MB, Cerdá M. Prevalence of cannabis use in youths after legalization in Washington State. *JAMA Pediatr* 2019; **173:** 192–93.

54 Anderson DM, Fe HT, Liang Y, Sabia JJ. Recreational marijuana laws and teen marijuana use, 1993–2021. *JAMA Psychiatry* 2024; **81:** 840–42.

55 Coley RL, Carey N, Kruzik C, Hawkins SS, Baum CF. Recreational cannabis legalization, retail sales, and adolescent substance use through 2021. *JAMA Pediatr* 2024; **178:** 622–25.

56 Fischer B, Jutras-Aswad D, Hall W. Outcomes associated with nonmedical cannabis legalization policy in Canada: taking stock at the 5-year mark. *CMAJ* 2023; **195:** e1351–53.

57 Rotermann M, Macdonald R. Analysis of trends in the prevalence of cannabis use in Canada, 1985 to 2015. *Health Rep* 2018; **29:** 10–20.

58 Bahji A, Kaur S, Devoe D, Patten S. Trends in Canadian cannabis consumption over time: a two-step meta-analysis of Canadian household survey data. *Can J Addict* 2022; **13:** 6–13.

59 Imtiaz S, Nigatu YT, Ali F, et al. Cannabis legalization and driving under the influence of cannabis and driving under the influence of alcohol among adult and adolescent drivers in Ontario, Canada (2001–2019). *Drug Alcohol Depend* 2024; **255:** 111060.

60 Imtiaz S, Nigatu YT, Sanches M, et al. Effects of cannabis legalisation on patterns of cannabis consumption among adolescents in Ontario, Canada (2001–2019). *Drug Alcohol Rev* 2024; **43:** 764–74.

61 Canadian Cannabis Survey. Cannabis use for non-medical purposes among Canadians (aged 16+). Ottawa: Health Canada. 2024. https://health-infobase.canada.ca/cannabis/ (accessed Oct 03, 2024).

62 Goodman S, Dann MJ, Fataar F, Abramovici H. How have cannabis use and related indicators changed since legalization of cannabis for non-medical purposes? Results of the Canadian Cannabis Survey 2018–2022. *Int J Drug Policy* 2024; **127:** 104385.

63 Rubin-Kahana DS, Crépault J-F, Matheson J, Le Foll B. The impact of cannabis legalization for recreational purposes on youth: a narrative review of the Canadian experience. *Front Psychiatry* 2022; **13:** 984485.

64 Kourgiantakis T, Vicknarajah R, Logan J, et al. Understanding youth and young adult cannabis use in Canada post-legalization: a scoping review on a public health issue. *Subst Abuse Treat Prev Policy* 2024; **19:** 30.

65 Myran DT, Pugliese M, Tanuseputro P, Cantor N, Rhodes E, Taljaard M. The association between recreational cannabis legalization, commercialization and cannabis-attributable emergency department visits in Ontario, Canada: an interrupted time-series analysis. *Addiction* 2022; **117:** 1952–60.

66 Myran DT, Cantor N, Finkelstein Y, et al. Unintentional pediatric cannabis exposures after legalization of recreational cannabis in Canada. *JAMA Network Open* 2022; **5:** e2142521-e.

67 Myran DT, Tanuseputro P, Auger N, Konikoff L, Talarico R, Finkelstein Y. Edible cannabis legalization and unintentional poisonings in children. *N Engl J Med* 2022; **387:** 757–59.

68 Myran DT, Roberts R, Pugliese M, Taljaard M, Tanuseputro P, Pacula RL. Changes in emergency department visits for cannabis hyperemesis syndrome following recreational cannabis legalization and subsequent commercialization in Ontario, Canada. *JAMA Network Open* 2022; **5:** e2231937-e.

69 Argandykov D, Raybould TA, Gervasini A, Hwabejire J, Flaherty MR. Recreational cannabis legalization and pediatric exposures in Massachusetts, United States. *Inj Prev* 2024; **30:** 437–40.

70 Chen B, Fullerton L, Smolinske S, Seifert S, Tuuri R. The impact of legalizing recreational cannabis on the children of a neighboring state. *Pediatr Emerg Care* 2024; **40:** 904–09.

71 Whitehill JM, Harrington C, Lang CJ, Chary M, Bhutta WA, Burns MM. Incidence of pediatric cannabis exposure among children and teenagers aged 0 to 19 years before and after medical marijuana legalization in Massachusetts. *JAMA Network Open* 2019; **2:** e199456-e.

72 Brubacher JR, Chan H, Erdelyi S, Staples JA, Asbridge M, Mann RE. Cannabis legalization and detection of tetrahydrocannabinol in injured drivers. *N Engl J Med* 2022; **386:** 148–56.

73 Callaghan RC, Sanches M, Murray RM, Konefal S, Maloney-Hall B, Kish SJ. Associations between Canada's cannabis legalization and emergency department presentations for transient cannabis-induced psychosis and schizophrenia conditions: Ontario and Alberta, 2015–2019. *Can J Psychiatry* 2022; **67:** 616–25.

74 Walker M, Saarela O, Mann R, Carpino M, Cusimano MD. The effect of recreational cannabis legalization on rates of traffic injury in Canada. *Addiction* 2023; **118:** 1517–26.

75 Lyubchich V. Assessing the impact of marijuana decriminalization on vehicle accident experience. Document 222163. Canadian Institute of Actuaries. 2022. https://www.cia-ica.ca/publications/rp222163e/ (accessed Nov 16, 2024).

76 Lane TJ, Hall W. Traffic fatalities within US states that have legalized recreational cannabis sales and their neighbours. *Addiction* 2019; **114:** 847–56.

77 Hasin DS, Shmulewitz D, Sarvet AL. Time trends in US cannabis use and cannabis use disorders overall and by sociodemographic subgroups: a narrative review and new findings. *Am J Drug Alcohol Abuse* 2019; **45:** 623–43.

78 Compton WM, Han B, Jones CM, Blanco C, Hughes A. Marijuana use and use disorders in adults in the USA, 2002–14: analysis of annual cross-sectional surveys. *Lancet Psychiatry* 2016; **3:** 954–64.

79 Aletraris L, Graves BD, Ndung'u JJ. Assessing the impact of recreational cannabis legalization on cannabis use disorder and admissions to treatment in the United States. *Curr Addict Rep* 2023; **10:** 198–209.

80 Perez-Vilar S, Freyria Duenas P, Radin R, et al. State Cannabis legalization and trends in cannabis-related disorders in US older adults, 2017 to 2022. *JAMA Network Open* 2024; **7**(6): e2417634-e.

81 Mauro PM, Gutkind S, Askari MS, et al. Associations between cannabis policies and state-level specialty cannabis use disorder treatment in the United States, 2004–2019. *Drug Alcohol Depend* 2024; **257:** 111113.

82 Mennis J, Stahler GJ, Mason MJ. Cannabis legalization and the decline of cannabis use disorder (CUD) treatment utilization in the US. *Curr Addict Rep* 2023; **10:** 38–51.

83 Leung J, Chan GCK, Hides L, Hall WD. What is the prevalence and risk of cannabis use disorders among people who use cannabis? A systematic review and meta-analysis. *Addict Behav* 2020; **109:** 106479.

84 Petrilli K, Hines L, Adams S, Morgan CJ, Curran HV, Freeman TP. High potency cannabis use, mental health symptoms and cannabis dependence: triangulating the evidence. *Addict Behav* 2023; **144:** 107740.

85 Petrilli K, Ofori S, Hines L, Taylor G, Adams S, Freeman TP. Association of cannabis potency with mental ill health and addiction: a systematic review. *Lancet Psychiatry* 2022; **9:** 736–50.

86 Freeman TP, van der Pol P, Kuijpers W, et al. Changes in cannabis potency and first-time admissions to drug treatment: a 16-year study in the Netherlands. *Psychol Med* 2018; **48:** 2346–52.

87 Hasan A, von Keller R, Friemel CM, et al. Cannabis use and psychosis: a review of reviews. *Eur Arch Psychiatry Clin Neurosci* 2020; **270:** 403–12.

88 Elser H, Humphreys K, Kiang MV, et al. State Cannabis legalization and psychosis-related health care utilization. *JAMA Network Open* 2023; **6**: e2252689-e.

89 Lev-Ran S, Roerecke M, Le Foll B, George TP, McKenzie K, Rehm J. The association between cannabis use and depression: a systematic review and meta-analysis of longitudinal studies. *Psychol Med* 2014; **44:** 797–810.

90 Hoch E, Volkow ND, Friemel CM, Lorenzetti V, Freeman TP, Hall W. Cannabis, cannabinoids and health: a review of evidence on risks and medical benefits. *Eur Arch Psychiatry Clin Neurosci* 2024; published online Sept 19. https://doi.org/10·1007/s00406–024–01880–2.

91 Lowe DJE, Sorkhou M, George TP. Cannabis use in adolescents and anxiety symptoms and disorders: a systematic review and meta-analysis. *Am J Drug Alcohol Abuse* 2024; **50:** 150–61.

92 WHO. The health and social effects of nonmedical cannabis use. 2016. https://www.who.int/publications/i/item/9789241510240 (accessed Sept 27, 2024).

93 Myran DT, Harrison LD, Pugliese M, et al. Development of an anxiety disorder following an emergency department visit due to cannabis use: a population-based cohort study. *EClinicalMedicine* 2024; **69:** 102455.

94 McCarthy SDS, Xiao J, Pugliese M, Perrault-Sequeira L, Myran DT. Changes in cannabis involvement in emergency department visits for anxiety disorders after cannabis legalization: a repeated cross-sectional study. *Lancet Reg Health Am* 2024; **36:** 36.

95 Chandy M, Nishiga M, Wei T-T, Hamburg NM, Nadeau K, Wu JC. Adverse Impact of Cannabis on Human Health. *Annu Rev Med* 2024; **75**: 353–67.

96 Ghasemiesfe M, Barrow B, Leonard S, Keyhani S, Korenstein D. Association between marijuana use and risk of cancer: a systematic review and meta-analysis. *JAMA Network Open* 2019; **2:** e1916318-e.

97 Holt A, Nouhravesh N, Strange JE, et al. Cannabis for chronic pain: cardiovascular safety in a nationwide Danish study. *Eur Heart J* 2024; **45:** 475–84.

98 Cantor N, Silverman M, Gaudreault A, et al. The association between physical availability of cannabis retail outlets and frequent cannabis use and related health harms: a systematic review. *Lancet Reg Health Am* 2024; **32:** 100708.

99 Manthey J, Jacobsen B, Hayer T, et al. The impact of legal cannabis availability on cannabis use and health outcomes: a systematic review. *Int J Drug Policy* 2023; **116:** 104039.

100 Fischer B, Robinson T, Bullen C, et al. Lower-risk cannabis use guidelines (LRCUG) for reducing health harms from non-medical cannabis use: a comprehensive evidence and recommendations update. *Int J Drug Policy* 2022; **99:** 103381.

101 D'Souza DC, DiForti M, Ganesh S, et al. Consensus paper of the WFSBP task force on cannabis, cannabinoids and psychosis. *World J Biol Psychiatry* 2022; **23:** 719–42.

102 Fischer B, Hall W, Fidalgo TM, et al. Recommendations for reducing the risk of Cannabis use-related adverse psychosis outcomes: a public mental health-oriented evidence review. *J Dual Diagn* 2023; **19:** 71–96.

103 Armentano P. The verdict is in: marijuana legalization has been a success story for states (Op-Ed). Marijuana Moment. 2024. https://www.marijuanamoment.net/the-verdict-is-in-marijuana-legalization-has-been-a-success-story-for-states-op-ed/ (accessed Sept 25, 2024).

104 Hall W, Lynskey M. Why it is probably too soon to assess the public health effects of legalisation of recreational cannabis use in the USA. *Lancet Psychiatry* 2016; **3:** 900–06.

105 Sheikhan NY, Pinto AM, Nowak DA, et al. Compliance with cannabis act regulations regarding online promotion among Canadian commercial cannabis-licensed firms. *JAMA Network Open* 2021; **4**: e211655.

106 Cannabis Council of Canada. Cannabis industry submission to cannabis act review calls for immediate financial relief and for governments to bring down the walls of stigmatization. 2022. https://cannabis-council.ca/media/cannabis-industry-submission (accessed Sept 15, 2024).

107 Luo X, Reiter MA, d'Espaux L, et al. Complete biosynthesis of cannabinoids and their unnatural analogues in yeast. *Nature* 2019; **567:** 123–26.