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Cannabis Policy Impacts Public Health and Health Equity

Steven Teutsch, Yasmin Hurd, and Elizabeth Boyle, *Editors*

Committee on the Public Health Consequences of Changes in the Cannabis Policy Landscape

Board on Population Health and Public Health Practice

Health and Medicine Division

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This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their review of this report:

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report nor did they see the final draft before its release. The review of this report was overseen by **LINDA C. DEGUTIS,** Yale School of Public Health, and **ERIC B. LARSON,** University of Washington. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

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Preface

The landscape of cannabis legalization in the United States has been changing dramatically. Cannabis is now available throughout the United States, with policies that vary significantly in terms of public health protection. In most states, legalization occurred through ballot initiatives and public ad campaigns often financed by wealthy donors. Voters acknowledged cannabis's widespread use, its large illegal market, the criminalization of seemingly minor infractions, and discrimination in enforcement. Today, changes in the classification of cannabis under the federal Controlled Substances Act are pending, as is a possible change in the definition of "hemp." These sweeping changes are occurring when many of the health consequences of cannabinoids remain quite uncertain. And those changes are coupled with a disturbing legacy of discrimination during the "war on drugs," with associated devastating consequences for individuals and communities of color in particular. The legalization of an increasingly powerful intoxicating drug has necessitated a greater fusion of public health and drug policy in the states.

In the face of this complexity, how, then, is one to assess the consequences of the changes in cannabis policy for public health and social equity? This was the charge to the Committee on the Public Health Consequences of Changes in the Cannabis Landscape. The 2017 report of the National Academies of Sciences, Engineering, and Medicine, *The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research*, focuses on the health effects and potential therapeutic benefits of cannabis, noting the paucity of high-quality studies on its health effects. Regrettably, little has changed in this regard since that

report was published, and scant to no research exists on the explosion of new cannabis and cannabinoid products. The present report focuses on the public health consequences of cannabis policies that have not been examined by the National Academies.

States have received little federal guidance on how to proceed regarding the health impact of cannabis on the public and communities. Other than two memoranda deferring to states, the federal government has been noticeably missing from this dialogue. Yet cannabis can cause real harms, as multiple investigators, families, and various groups attested to our committee. The tools of public health—assessment, policy development, and assurance—can provide the critical health information decision makers need to protect the public health and make amends for past cannabis-related inequities, but those tools are only slowly being applied.

With legalization by states now widespread, it is time to ask about its impact, especially given the large variation in state policies. These natural experiments provide a rich but very complex set of experiences for analysis, but these policies are all of relatively recent vintage. Consequently, available products, use patterns, and markets have not yet stabilized. Facing these challenges, the committee reviewed what is known about these policies, formulated recommendations where possible, and delineated a path forward. With a strong commitment to policy research and the application of traditional public health tools, we fully anticipate that better and more consistent policies will unfold.

This report would not have been possible without the deep expertise, wide range of perspectives, and strong commitment of all the committee members. Elizabeth Boyle, study director, and her National Academies colleagues, Khala Hurst-Beatty, Alexandra McKay, and Mia Saltrelli, labored long and hard to tie together all the disparate pieces of this report. We are deeply grateful to all of them. Lastly, we want to express our appreciation to our sponsors, the Centers for Disease Control and Prevention and the National Institutes of Health, without whose vision this study would not have been possible.

Steven Teutsch, Chair
Yasmin Hurd, Vice Chair
Committee on the Public Health Consequences of
Changes in the Cannabis Landscape

Acronyms and Abbreviations

ACOG	American College of Obstetricians and Gynecologists
APHA	American Public Health Association
ASTHO	Association of State and Territorial Health Officials
BAC	blood alcohol content
CAERS	Adverse Event Reporting System
CBD	cannabidiol
CDC	Centers for Disease Control and Prevention
CFSAN	Center for Food Safety and Applied Nutrition
CSA	Controlled Substances Act
CSTE	Council of State and Territorial Epidemiologists
DEA	Drug Enforcement Administration
DFC	Drug-Free Communities
DND	daily/near-daily
DSM	*Diagnostic and Statistical Manual of Mental Disorders*
ED	emergency department
ELTRR	Federal Plan for Equitable Long-Term Recovery and Resilience
EPA	Environmental Protection Agency
EVALI	e-cigarette or vaping product use–associated lung injury

FAERS	FDA Adverse Event Reporting System
FBI	Federal Bureau of Investigation
FBN	Federal Bureau of Narcotics
FDA	Food and Drug Administration
HHS	U.S. Department of Health and Human Services
ICPS	International Cannabis Policy Study
IRCCA	Institute for the Regulation and Control of Cannabis
JJ-TRIALS	Juvenile Justice Translational Research on Interventions for Adolescents in the Legal System
LST	Life Skills Training (program)
MLPA	minimum legal purchase age
NAACP	National Association for the Advancement of Colored People
NACCHO	National Association of County and City Health Officials
NCSL	National Conference of State Legislators
NGA	National Governors Association
ng/mL	nanograms per milliliter
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NSDUH	National Survey on Drug Use and Health
OLCC	Oregon Liquor and Cannabis Commission
OMB	Office of Management and Budget
ONDCP	Office of National Drug Control Policy
ROBIS	Risk Of Bias In Systematic Reviews
SAMHSA	Substance Abuse and Mental Health Services Administration
THC	tetrahydrocannabinol
THCA	tetrahydrocannabinolic acid
UCR	Uniform Crime Reporting
USDA	U.S. Department of Agriculture
USP	U.S. Pharmacopeia
USPSTF	U.S. Preventive Services Task Force

Key Terms

Cannabis	"Cannabis" is a broad term that can be used to describe products (e.g., cannabinoids, marijuana, hemp) derived from the Cannabis sativa plant. These products exist in various forms and are used for various purposes (e.g., medical, industrial, social). The all-encompassing word "cannabis" has been adopted as the standard terminology within scientific and scholarly communities. The committee uses the term "cannabis" rather than "marijuana" throughout this report.
Cannabis abuse and dependence	Cannabis "abuse" and "dependence" are terms that are derived from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*). *DSM-IV* was based on seven criteria related to symptoms, duration, and impact on daily functioning. A diagnosis of cannabis abuse required meeting one or more of four criteria, and cannabis dependence required meeting three or more of the seven total criteria.
Cannabis club or cannabis social club	Cannabis clubs are typically formal, nonprofit associations of adult cannabis users who produce and distribute that substance close to or at cost among themselves.[1]

[1] Pardal, M. (Ed.). 2022. *The cannabis social club*. London: Routledge.

Cannabinoid hyperemesis syndrome	Cannabinoid hyperemesis syndrome is a condition in which a patient experiences cyclical nausea, vomiting, and abdominal pain after using cannabis. This disorder is characterized by (1) several years of preceding cannabis use, predating the onset of illness; (2) a cyclical pattern of hyperemesis every few weeks to months, at which time the patient is still using cannabis; and (3) resolution of the symptoms after cessation of cannabis use, confirmed by a negative urine drug screen.[2]
Cannabis industry	The legal cannabis industry includes companies involved with the cultivation, processing, manufacturing, distribution, sale, and marketing of cannabis or cannabinoids for medical or adult use. Pharmaceutical manufacturers of Food and Drug Administration (FDA)–approved cannabis products are not typically considered part of the cannabis industry.
Cannabis use	"Cannabis use" refers to any use of cannabis for medical or other purposes.
Cannabis use disorder	Cannabis use disorder is a clinical diagnosis in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (*DSM-*). *DSM-5* combines elements of *DSM-IV* and dependence into a single category of "cannabis use disorder" with varying degrees of severity—mild (presence of 2–3 criteria), moderate (4–5 criteria), and severe (6+ criteria).
Collateral consequences	Penalties occurring because of a criminal encounter, which include loss of certain civil rights, such as voting, have long been a part of the experience of punishment in the United States and may play a role in perpetuating health disparities in marginalized groups.[3]

[2] Chu, F., and M. Cascella. 2023. *Cannabinoid hyperemesis syndrome*. Treasure Island, FL: StatPearls Publishing.

[3] Adapted from: Lhamon, C., Patricia Timmons-Goodson, Debo P. Adegbile, Gail L. Heriot, Peter N. Kirsanow, David Kladney, Karen Narasaki, and Michael Yaki. 2019. *Collateral consequences: The crossroads of punishment, redemption, and the effects on communities*. Washington, DC: United States Commission on Civil Rights.

Decriminalization	Decriminalization describes policies that remove the criminal status and criminal penalties associated with simple cannabis possession (typically small amounts) and use.[4]
Harm reduction	A series of approaches that reduce health and safety consequences for individuals and society associated with drug use or other behaviors.
Health equity	Health equity refers to everyone having the opportunity to attain their full health potential, and no one being disadvantaged from achieving this potential because of any socially defined circumstance.
Legalization	Legalization removes criminal and monetary penalties for the supply of cannabis for adult use purposes, in addition to removing these penalties for possession and use.[4]
Public health	Public health describes what society does collectively to ensure conditions in which people can be healthy.[5]
Social equity	Social equity requires valuing everyone equally through focused and ongoing societal efforts to address avoidable inequalities and historical and contemporary injustices.

[4] Adapted from: Pacula, R. L., and R. Smart. 2017. Medical marijuana and marijuana legalization. *Annual Review of Clinical Psychology* 13:397-419.

[5] Institute of Medicine. 1988. *The future of public health*. Washington, DC: The National Academies Press.

Summary[1]

More than half of all U.S. states have legalized cannabis,[2] fueled by therapeutic use, social acceptance, a desire for relaxed drug policies, enforcement skepticism, potential tax revenues, and racial justice concerns. The commercial markets created by state legalization require the development of complex policies—surrounding cultivation, processing and manufacturing, distribution, marketing, and sales—to promote public health and health equity. Because cannabis is illegal federally, the federal government has had minimal involvement in cannabis policies within the states. The limited federal guidance on cannabis has focused on its sale—not on public health. Further, federal policies have complicated the efforts of state governments to develop cannabis policies that protect public health. These federal policies include the 2018 Agriculture Improvement Act (2018 Farm Bill), which removed hemp and other cannabinoids from the Controlled Substances Act, creating a lucrative industry for intoxicating cannabis products designated legally as hemp.[3] Public health leadership on cannabis policy is needed, not just in those states with legalized cannabis but nationwide.

[1] This summary does not include references. Citations for the content herein are provided in the full report.

[2] "Cannabis" is a broad term that can be used to describe products (e.g., cannabinoids, marijuana, hemp) derived from the Cannabis sativa plant. These products exist in various forms and are used for various purposes (e.g., medical, industrial, social). The all-encompassing word "cannabis" has been adopted as the standard terminology within scientific and scholarly communities. The committee uses the term "cannabis" rather than "marijuana" throughout this report.

[3] The 2025 Agricultural Improvement Act may include an updated definition of "hemp" to include only nonintoxicating products (see https://crsreports.congress.gov/product/pdf/IN/IN12381 [accessed July 3, 2024]).

STUDY CONTEXT

As of April 24, 2023, 38 states, three territories, and the District of Columbia allowed cannabis for medical use, and as of November 8, 2023, 24 states had passed legislation legalizing adult nonmedical cannabis supply and use for those over 21 years of age.[4] In addition, 9 states had approved measures allowing for the sale of products with low delta-9-tetrahydrocannabinol (THC) and high cannabidiol (CBD) in limited medical situations (see Figure S-1). In many cases, cannabis was legalized through ballot initiatives influenced by political campaigns financed by wealthy donors. Cannabis legalization has allowed commercial markets and sales to create a for-profit industry that requires regulation.

Initially, states enacted legislation legalizing medical use out of compassion for patients seriously ill with AIDS or cancer for whom cannabis was thought to ease suffering. As this process unfolded, it was furthered by exaggeration of the medical or therapeutic benefits of cannabis and minimizing of its harms. Cannabis legalization for adult, nonmedical use occurred as the result of greater social acceptance, a desire for less paternalistic drug policies, hopes of eliminating the illegal market and reducing profits of drug dealers, enthusiasm for a source of new tax revenue, and a growing skepticism regarding the effort and expense involved in enforcing cannabis penalties. Social justice was another critical factor, given the large racial inequities in cannabis arrests.

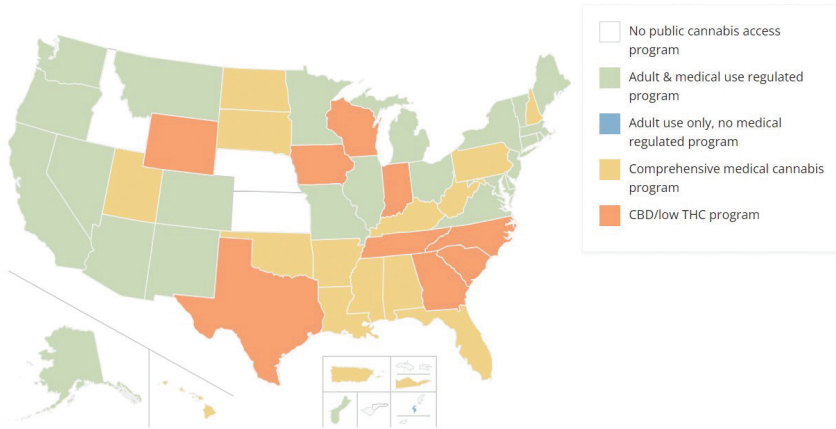


FIGURE S-1 Map of state-level cannabis legalization.
NOTES: CBD = cannabidiol; THC = delta-9-tetrahydrocannabinol. The map does not include state policies instituted in response to the 2018 Agriculture Improvement Act (PL-115-334).
SOURCE: National Conference of State Legislatures.

[4] Some state medical cannabis laws allow use among those under 21 years of age.

Cannabis use has both benefits and harms. Therapeutic benefits include treating chemotherapy-induced nausea and vomiting (via oral cannabinoids such as nabilone and dronabinol), management of chronic pain in adults, and improving patient-reported spasticity symptoms in multiple sclerosis (via oral cannabinoids such as nabiximols and nabilone). Harms include increased risk of motor vehicle collisions; development of schizophrenia or psychosis (particularly for those with other risk factors); respiratory symptoms, including increased chronic bronchitis; and lower birthweight in offspring exposed prenatally.

The federal government is working on a change to cannabis policy. Under the Controlled Substances Act (CSA) scheduling of cannabis, botanical cannabis[5] is currently categorized as Schedule I, meaning it has a high abuse potential and no accepted medical use. On May 21, 2024, the Drug Enforcement Administration proposed a rule[6] that would shift the scheduling of cannabis to Schedule III, meaning it has moderate abuse potential and a currently accepted medical use. Rescheduling would reduce barriers to cannabis research, but it would not legalize it federally, and state medical and adult use programs would remain illegal under federal law. The Food and Drug Administration could approve medical use of a botanical cannabis product by prescription, through its drug approval process, but it is unclear whether that will happen. The impact on state cannabis programs remains unclear, as does the impact on public health.

STUDY CHARGE AND APPROACH

The need for a comprehensive public health review of cannabis policy prompted the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health to commission the National Academies of Sciences, Engineering, and Medicine to convene an ad hoc committee charged with describing cannabis and cannabinoid availability in the United States; assessing regulatory frameworks for the cannabis industry, with an emphasis on social equity; and identifying strengths and weaknesses of public health surveillance systems for cannabis. The committee was asked to recommend a harm reduction approach to cannabis policy and set a policy research agenda for the next 5 years. Notably, the committee was not asked to review the health effects of cannabis consumption (the topic of a National Academies report in 2017); rather, the charge to this committee focused on the health implications of cannabis policy. Figure S-2 presents the organization of the report.

[5] Cannabinoid drugs fall within different areas of the Controlled Substances Act. Cesamet™ (nabilone), synthetically derived delta-9-THC in powder form, is Schedule II, and Marinol® (dronabinol), synthetically derived delta-9-THC in liquid form, is Schedule III. Epidiolex, highly purified, naturally derived CBD, is Schedule V.

[6] 21 CFR Part 1308, https://www.regulations.gov/document/DEA-2024-0059-0001 (accessed July 4, 2024).

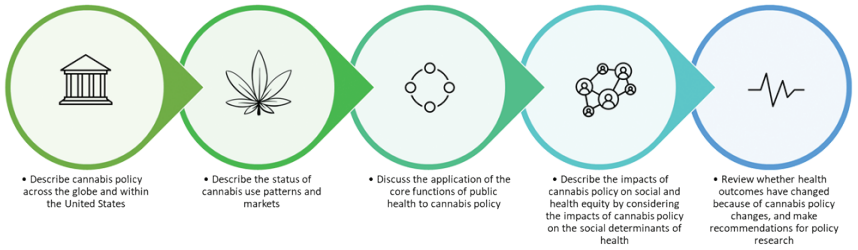


FIGURE S-2 Organization of the report.

The committee interpreted its charge overall as considering a public health approach to cannabis policy. A public health approach aims to improve the health of entire communities, requiring that factors influencing health outcomes for large groups be considered. Among these essential factors are social and health equity. Social and health equity have some commonalities, but also must be distinguished: "social equity" often focuses on addressing racism and other forms of discrimination, while "health equity" refers to creating systems in which all people have an equal opportunity to achieve their health potential. The two concepts are deeply intertwined: achieving health equity requires dismantling systemic inequalities that create barriers to accessing resources and opportunities, barriers that ultimately hinder individuals and communities from reaching their full health potential. Therefore, addressing social justice issues, such as structural racism, directly impacts health equity by disrupting the mechanisms through which health inequities persist. This committee was tasked with developing recommendations for "strengthening a harm reduction approach, which would minimize harms of various regulatory models, including but not limited to social, employment, education, and health impacts." Harm reduction is a series of approaches that reduce health and safety risks associated with drug use or other behaviors to individuals and society. Although harm reduction services and approaches can have important implications for public health, the committee believed a broader set of recommendations—a public health approach—was needed to encompass the core public health functions.

RECOMMENDATIONS

Review of Cannabis Policy

Policy development is critical to minimizing the potential harms of cannabis use and promoting health equity. Cannabis policies can inform cultivation, manufacturing, marketing and sales, and consumption or use, and regulation can bring about both benefits and harms (Figure S-3).

FIGURE S-3 Conceptual framework: Where public health policy can intervene to prevent the harms and promote the benefits of cannabis use.

State policies, coupled with the current ambiguous definition of "hemp" in the 2018 Farm Bill, have led to a largely unregulated market for semi-synthetic intoxicating cannabinoids (Box S-1).

BOX S-1
Public Health Challenge Due to the Definition of "Hemp" in the 2018 Agricultural Improvement Act

The 2018 Agriculture Improvement Act (PL-115-334), often called the "2018 Farm Bill," redefined "hemp" and removed it from the Controlled Substances Act. The 2018 Farm Bill defines "hemp" as

> *the plant Cannabis sativa L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a [delta-9-tetrahydrocannabinol] concentration of not more than 0.3 percent on a dry weight basis.* (PL-115-334 § 297A)

The inclusion of cannabinoids and derivatives in this definition has led to the sale of naturally occurring cannabinoids, such as CBD, delta-9-THC (if the dry weight is less than 0.3 percent), and tetrahydrocannabinolic acid (THCa), as well as semisynthetic intoxicating cannabinoids, such as delta-8-THC. Semisynthetic cannabinoids raise public health concerns because they are not well studied, and the products may contain harmful by-products. For example, delta-8-THC production uses strong acids and solvents such as toluene and heptane.

A booming industry now exists for largely unregulated hemp-derived products, which competes with legal cannabis markets. States are trying to regulate these new products but face legal challenges and inconsistent court rulings. Some states have banned or restricted hemp products, and a group of attorneys general is urging Congress to act.

Recommendation 2-1: Congress should refine the definition of "hemp" to state clearly that no form of tetrahydrocannabinol or semisynthetic cannabinoid derived from hemp is exempt from the Controlled Substances Act.

Several aspects of alcohol and tobacco policy are important for public health protection. These include a state monopoly, restrictions on physical retail availability, pricing, tax strategies, restrictions and requirements for retail operations, product design restrictions and requirements, measures to limit youth access and exposure, and reduction of cannabis-impaired driving.

Alcohol and tobacco are regulated through state and federal policies. The federal government plays a role in public health policies in such areas as product safety, the establishment of limits on advertising, product labeling, and restrictions on sales to those under age 21. Cannabis is more challenging to regulate than are alcohol or tobacco, although the substances have some important shared aspects. The cannabis plant contains over a hundred cannabinoids, with plant hybrids having unique and inconsistent chemical profiles and health impacts. Extracts from the cannabis plant can be incorporated into many different products that can be used through many modes of administration, all with different intoxicating profiles. Cannabis concentrates, for example, usually contain more than 60 percent delta-9-THC, but some contain more than 90 percent. Some cannabinoids, such as tetrahydrocannabiphorol, are more potent than delta-9-THC.

During this time of rapid change in cannabis legalization, there is a clear need for the federal government to weigh in on behalf of the public's health. Existing state cannabis policies were developed without a public health strategy. State-to-state variations in regulations limit public health efforts to prevent harmful use. In contrast, some countries, such as Canada and Uruguay, have adopted more measured approaches with stricter government control over cannabis products and how they are sold or consumed. Such stricter regulatory frameworks may better protect public health.

While all states have minimum age requirements for cannabis use (21 years in adult use states), enforcement through random checks—a method proven effective for tobacco and alcohol use—is limited. Advertising restrictions are also weak. Most states allow cannabis advertising with some limitations on who sees it (not necessarily age-restricted) and where it is placed (e.g., not near schools). As a result, millions of children are exposed to procannabis messages. In contrast with stricter countries, some U.S. states permit advertising with enticements such as coupons, health claims, and depictions of product use without limitations on targeting people outside the state or using public platforms such as billboards. Packaging is regulated to prevent child appeal, but with weak enforcement, so cannabis is frequently promoted to young people in the United States.

State-level cannabis legalization is illegal under federal law unless cannabis, like tobacco and alcohol, is removed from the Controlled Substances Act. Still, given that the federal government has been allowing the states to create commercial markets for cannabis, federal agencies could assist those states that have chosen to legalize. The Council on State and Territorial Epidemiologists, a nonprofit organization of member states and territories representing public health epidemiologists that includes the CDC, has guidance and resources on public health surveillance. Similar guidance could be created for other public health functions.

Recommendation 2-2: In conjunction with other federal agencies, the Centers for Disease Control and Prevention should conduct research on and develop best practices for protecting public health for states that have legalized cannabis, drawing from tobacco and alcohol policies. These best practices should encompass marketing restrictions (e.g., on advertising and packing), age restrictions, physical retail and retail operating restrictions, taxation, price restrictions, product design, and measures to limit youth access. Other strategies for protecting public health that warrant identification of best practices include reducing cannabis-impaired driving, promoting state retail monopoly, and encouraging cultivation practices that limit contamination of both products and the environment. The best practices should be reconsidered and updated periodically as new research emerges.

Recommendation 2-3: The National Governors Association, the National Council of State Legislatures, and other public health stakeholders should develop model legislation concerning best practices related to marketing restrictions (e.g., on advertising and packaging), age restrictions, physical retail and retail operating restrictions, taxation, price restrictions, product design, and measures to limit youth access, as well as strategies for reducing cannabis-impaired driving, promoting state retail monopoly, and encouraging cultivation practices that limit contamination of both products and the environment. Once the Centers for Disease Control and Prevention's best practices have been developed, they should be incorporated into the model legislation.

Cannabis Use Patterns and Markets

Cannabis use is increasing in many populations. Public perception of risk has declined while availability has surged, leading to a near doubling of past-year cannabis use among adults in the last two decades. Notably, more people have reported daily or near-daily cannabis use than alcohol use in 2022. Cannabis use is socially stratified. Those with a college education

have the lowest prevalence of use; additionally, those at or below the poverty line have a higher prevalence of use than those with two times the federal poverty level. While dried flower remains the most commonly used product, concentrates, edibles, and vape oils are gaining in popularity, with many people using multiple products and administration methods. Moreover, the THC concentration of products consumed today has increased markedly.

Understanding of the dynamics of the legal versus illegal cannabis markets is complicated by the lack of precise data on cannabis consumption in the United States. The limited studies that have been conducted suggest a shift toward purchasing cannabis from legal markets, particularly in states such as Washington and Oregon. Reduction in the size of the illegal cannabis market is shaped by multiple factors, ranging from the regulatory environment to enforcement activities. Reducing the size of the illegal cannabis market takes time.

Core Public Health Functions

Analysis of the core public health functions—assessment, policy development, and assurance—applied to cannabis policy underscores the need for a more comprehensive public health approach in the United States (Box S-2). Public health involvement in policy development is uneven and often limited to traditional public health roles, such as primary prevention. Other policies, such as those related to zoning, marketing restrictions, and product quality testing, also benefit from public health considerations. Public health needs to be fully engaged in all cannabis policy discussions. Inadequate inclusion of public health in cannabis policy decisions has led to poor application of the core public health functions in states that have legalized cannabis for adult or medical use.

Currently, cannabis surveillance data are collected and analyzed by various entities with limited coordination. Despite their limitations, diverse data sources, such as surveys, health records, and mortality statistics, are available, related mainly to the products used. A centralized, adaptable system could identify cannabis-related public health issues rapidly. Consistent use and application of the essential components of a public health surveillance system—data collection, analysis, and dissemination—would create a more comprehensive picture of cannabis use and its health impacts, ultimately informing practical public health actions. The CDC's cannabis strategy is missing several elements, such as approaches to data dissemination, a link to action, and regular evaluation. Collaboration with federal partners such as the departments of Agriculture and Commerce is also needed to gain an understanding of cannabis cultivation, production, and sales.

BOX S-2
Public Health Approach to Cannabis Policy

Assessment

- Conduct surveillance of or assess and monitor the health impacts of cannabis.
- Investigate the causes of any identified harms from cannabis use.

Policy Development

- Build and mobilize partnerships between cannabis regulators and public health authorities.
- Inform, educate, and empower communities to develop cannabis-related public health campaigns.
- Develop cannabis policies centered on protecting public health that are not influenced by the regulated industry.
- Equitably enforce cannabis policies designed to ensure compliance.

Assurance

- Protect the public from the potential harms of cannabis (accidental ingestion or poisoning, crashes from impaired driving, secondhand smoke, and environmental impacts).
- Protect those who use cannabis from potential harm and ensure access to treatment.
- Build and support a diverse and skilled public health workforce for cannabis policy.
- Improve and innovate cannabis public health functions through ongoing evaluation, research, and continuous quality improvement.
- Build and maintain a strong organizational infrastructure for cannabis and public health.

SOURCE: Adapted from Ghosh et al., 2016.

Recommendation 4-1: The Centers for Disease Control and Prevention, in conjunction with its federal, state, tribal, and territorial partners, should create an adaptable public health surveillance system for cannabis. This surveillance system should include, at a minimum, cannabis cultivation and product sales, use patterns, and health impacts. It should also include all the essential components of a public health surveillance system: a surveillance plan, data collection, data analysis, data interpretation, data dissemination, a link to action, and regular evaluation.

The influence of the burgeoning legal cannabis industry on policy development raises concerns about potential bias. Lobbying efforts by the industry have demonstrably impacted regulations, as seen in Colorado's opposition to pesticide restrictions and Washington's thwarted attempts to limit THC concentration. Further complicating matters are documented conflicts of interest, such as revolving-door practices in regulatory bodies (e.g., Colorado) and financial entanglements (e.g., Washington, Ohio). These examples highlight the current lack of safeguards against industry influence, allowing lobbying and conflicts to impede the development of robust public health protections.

Assurance of public health policies in states where cannabis sales are legalized includes consumer protection strategies, but these strategies vary widely in quality control methods and the contaminants tested. The U.S. Pharmacopeia (USP), an independent, scientific nonprofit organization, sets standards for the quality, safety, and purity of various products, including medicines, food ingredients, and dietary supplements. USP has established procedures for testing product identity, composition, and contaminants and for validating analytical methods. Its laboratory testing methods include several cannabinoid compounds. In addition, USP has developed reference standards for ensuring accurate identification and measurement of product constituents and for addressing sampling considerations to improve representative analysis, product labeling, and appropriate packaging and storage conditions. USP is also developing a cannabis inflorescence (flower) monograph for the *Herbal Medicines Compendium*, which will include scientifically valid methods; information on physical reference standards; and acceptance criteria for establishing the identity of cannabis chemotypes, the content of cannabinoids and terpenes, and limits on contaminants.

Recommendation 4-2: The U.S. Pharmacopeia has established product quality and analytical standards for cannabis inflorescence (flower) and is developing standards for cannabis extracts incorporated into pills and edibles. As these standards are completed, state cannabis regulators should adopt and enforce them to ensure the safety and quality of all legal cannabis products.

Training and public health messaging can improve public knowledge about cannabis. Clinicians report discomfort in discussing cannabis use with patients, which is a problem given that cannabis use impacts clinical care. Cannabis can interact with other drugs and medications, and its use is a risk factor for chronic disease. The U.S. Preventive Services Task Force recommends screening adult patients for substance use, which would identify cannabis use and could improve clinical care for patients who use cannabis.

Several states require training on regulations, product knowledge, and responsible sales practices for individuals working in retail cannabis sales. Since many people who use cannabis trust cannabis retail staff, staff need to be trained on the health effects and harms associated with cannabis use. The CDC or another public health authority could create an online training model that could be updated regularly.

Recommendation 4-3: State cannabis regulators should require training and certification for all staff at cannabis retail outlets who interact with customers. The training should address the effects of cannabis on humans, prevention of sales to minors, warnings about cannabis-impaired driving, cannabis use in pregnancy, high-concentration or high-potency products, and how to identify signs of impairment. The effectiveness of the training should be assessed and the content updated as new scientific information about the positive and negative impacts of cannabis emerges.

Colorado and other states have developed targeted public health campaigns, which are essential for improving knowledge about cannabis and its potential harms. Developing and evaluating education campaigns is time- and resource-intensive. Leadership from the CDC could help guide the states toward developing campaigns that are more likely to improve knowledge.

Recommendation 4-4: The Centers for Disease Control and Prevention (CDC), in coordination with other relevant agencies, should develop and evaluate targeted public health campaigns directed mainly toward parents and vulnerable populations (e.g., youth, those who are or are likely to become pregnant, adults over age 65) about the potential risks of cannabis; how to identify risky behavior, such as the use of cannabis in combination with alcohol or prescription drugs; and risk mitigation strategies, such as lower-risk use guidelines and safe storage. These public health campaigns should include discouraging unhealthy use, such as the use of cannabis in combination with other substances (alcohol, tobacco, or drugs), and the increased risk associated with the use of high-concentration or high-potency products.

Continued evaluation of the public health and societal impacts of changes in cannabis policy is critical as the policy landscape rapidly evolves. Currently, the Office of National Drug Control Policy is prohibited from studying the impacts of cannabis legalization because, as of July 2024, cannabis is classified as a Schedule I substance under the Controlled Substance Act, and botanical cannabis has no FDA-approved medical use.

Recommendation 4-5. Congress should remove restrictions on the Office of National Drug Control Policy (ONDCP) from studying the impacts of cannabis legalization. The ONDCP should be allowed to support research on the impacts of changes in cannabis policy.

Cannabis Policy and Health Equity

Changes in cannabis policy may influence health equity in many ways. Some public health experts have posited that cannabis legalization could reduce social inequities, and therefore the health inequities to which they contribute, by mitigating the adverse consequences of the criminalization of cannabis use, possession, and sales, which have historically been experienced disproportionately by minoritized populations. The commercial cannabis industry also may contribute to health inequities. Disproportionate marketing to minoritized groups or overconcentration of retailers within lower-income communities or communities of color may lead to unequal distribution of the health impacts of cannabis use. The committee evaluated the impacts of cannabis policy on health equity by considering the harms of cannabis prohibition within the criminal justice system; a critique of the social equity programs adopted in some states; and the impacts of cannabis policies on the social determinants of health, economic stability, education access and quality, health care access and quality, neighborhoods and the built environment, and the social and community context.

Racial inequalities in arrests contribute to health inequities since the stigma of a criminal record can influence the health of that individual and their family. The collateral consequences following criminal encounters can limit economic security, employment, housing, business, and educational opportunities. Throughout the liberalization of cannabis policy, racial disparities in cannabis arrests may have increased. Comparing cannabis possession arrests in 2002–2004 and 2017–2019, arrests decreased for White people and increased for Black people. Evaluation of the impact of changes in cannabis policy on equity is hampered by a lack of data on cannabis arrests and sentencing. The committee had difficulty evaluating cannabis arrests because of incomplete data, the challenges of which have been discussed in prior reports of the National Academies.

Recommendation 5-1: Jurisdictions responsible for the enforcement of cannabis laws should endeavor to regularly gather and report detailed data concerning the use of criminal enforcement tools to enforce cannabis policies. These tools include:

- **arrests,**
- **sentences,**
- **incarceration (pre- and postadjudication), and**

- **diversion programs (e.g., drug courts, law enforcement–assisted diversion, treatment programs).**

These data should be available to the public and should include details about the specific cannabis violation (e.g., impaired driving, illicit trafficking, distribution to minors, possession, possession with intent to distribute, probation or parole violation) and the demographics of those in contact with law enforcement (e.g., race, sex, age, criminal history).

Most states that have legalized cannabis use and/or sales have implemented social equity measures to help those harmed by cannabis policing (22 of 24 adult-use states as of January 2024). These measures include criminal justice reforms, such as record relief and resentencing; technical and financial assistance for cannabis businesses; and community reinvestment. While these initiatives are well intended, implementation challenges must be addressed to ensure that they are meeting their stated goals and not having unintended consequences.

Recommendation 5-2: State cannabis regulators should systematically evaluate and, if necessary, revise their cannabis social equity policies to ensure that they meet their stated goals and minimize any unintended consequences. Policy makers should meaningfully engage affected community members when developing or revising these policies.

Record relief provisions that clear a criminal of cannabis-related charges can help improve access to employment, educational opportunities, and housing. In states that have implemented record relief provisions for cannabis offenses, automatic or government-initiated relief has proven to be more effective than petition-based relief.

Recommendation 5-3: Where states have legalized or decriminalized adult use and sales of cannabis, criminal justice reforms should be implemented, and records automatically expunged or sealed for low-level cannabis-related offenses.

Changes in cannabis policy have complex and sometimes contradictory impacts on neighborhoods and the social environment. Studies suggest that cannabis retail outlets may be more likely to be located in communities with higher rates of poverty or communities of color, which could contribute to health inequities.

Cannabis legalization has brought opportunities to address issues regarding access to health care. As of 2022, punitive prenatal drug use policies existed in nearly half of U.S. states. Drug testing in pregnancy is

applied inequitably, particularly to communities of color, and may deter those who use cannabis from seeking prenatal care. Pregnant people who use cannabis will benefit from clinical and social support; education about fetal risk; and referral to nonjudgmental, evidence-based interventions or specialty treatment as needed, rather than being arrested or reported to child protective systems.

PUBLIC HEALTH IMPACTS OF CANNABIS POLICY

One of the most prominent public health concerns related to cannabis policy is the rise of high-concentration and high-potency THC products. The risks associated with THC consumption increase as the dose increases, and legalizing products that deliver high doses potentially increases adverse cannabis-related harms. Indeed, high-concentration THC products are associated with a higher risk of psychosis and cannabis use disorder. More research is urgently needed to describe the relationship between THC dose and adverse effects to better inform public policy.

The committee also reviewed 14 systematic reviews evaluating the public health impacts of cannabis policy. The variations in legalization across states provide an opportunity to conduct policy research. Better capture of the differences in how policies are implemented among the states and improvements in policy analysis databases and surveillance systems are needed to support analysis of essential outcomes of policy changes. The committee found limited or only suggestive evidence that the perceived risk of cannabis use declines after legalization, that use among adults increases, that traffic collisions increase, and that hospital visits related to cannabis use increase. For all other outcomes, the committee judged the evidence to be insufficient. The committee then used this information and the analysis presented throughout this report to develop a research agenda (Box S-3).

Recommendation 6-1: The National Institutes of Health; the Centers for Disease Control and Prevention; state, local, and tribal health authorities; and private entities should support a research agenda focused on:

- **public health outcomes of different approaches to cannabis regulation,**
- **efficacy of tests used to determine cannabis impairment,**
- **health effects of cannabis use (by product, amount, and frequency) by specific populations,**
- **health effects of emerging cannabis products, and**
- **mitigation of the risks of cannabis use.**

BOX S-3
Cannabis Policy Research Agenda

Public health outcomes of different approaches to cannabis regulation: It is critical to examine how state and local cannabis regulations—including those related to licensing, zoning, product types, product additives, advertising, and pricing—influence public health outcomes and health equity. Aspects of this needed research include investigating how these regulations affect cannabis use patterns (age of initiation, frequency, intensity, product type, concentration, and administration method), rates of heavy cannabis use, cannabis use disorder diagnoses, cannabis-related emergency department visits and hospitalizations, cannabis-related comorbid physical health and mental health outcomes, and traffic-related injuries and deaths associated with cannabis use. Studying how THC caps influence use patterns and health outcomes could improve guidelines and inform effective regulations.

Efficacy of tests used to detect cannabis impairment: Blood tests for THC, which are commonly used in law enforcement and employment screening, do not distinguish between recent and past use. Additionally, validation of field sobriety tests and objective, unbiased, and practical methods for discriminating between drivers who are or are not impaired by cannabis is critical in ensuring equitable enforcement of laws on driving under the influence.

Health effects of cannabis use by specific populations: It is critical to understand the specific health risks and benefits of cannabis use across different populations. Examples of populations critical to monitor include:

- pregnant persons, considering both potential risks to the fetus and potential benefits for managing pregnancy ailments;
- youth and young adults because of the impacts of cannabis on the developing brain;
- veterans, including how cannabis use may interact with posttraumatic stress disorder symptoms and overall mental health; and
- older adults and adults with chronic conditions, including the use of cannabis and cannabinoids for managing chronic conditions and the potential risks of drug interactions.

Health effects of emerging cannabis products: There is a great need to understand the health risks of emerging synthetic and semisynthetic cannabinoids and high-concentration products. In particular, research into dose–response relationships for different cannabis products is needed.

Mitigation of the risks of cannabis use: Evaluating risk-mitigation strategies for cannabis use and their effectiveness is crucial so that public health can understand which educational and other strategies are most effective at reducing problematic use and minimizing harm.

CONCLUSION

The rapidly changing landscape of cannabis legalization—with state-by-state variations, an influx of new products, and federal policy changes with uncertain implications—presents a complex challenge for public health. This report considers a public health approach to cannabis policy, which is critically needed to protect public health and promote health equity. While ongoing research is crucial, applying the core public health functions—assessment, policy development, and assurance—now will lead to better and more consistent policies for cannabis legalization and improved public health and health equity.

1

Introduction

Cannabis[1]—federally known as "marijuana"—is currently a Schedule I drug under the Controlled Substances Act (CSA, PL 91–513)—meaning it has high abuse potential and no federally accepted medical use. This categorization has long been controversial because of the drug's perceived social and medical benefits, as well as the racism and classism common in the broader conversations about drug policy in the United States (Montgomery and Allen, 2023). Now, as a result of sweeping policy changes at the state level and the removal of hemp from the CSA, extensive markets for cannabis products can be found throughout the country, even in states that have not chosen to legalize cannabis (Chapekis and Shah, 2024; Elbein, 2024). The limited federal involvement in state-specific cannabis legalization has allowed the establishment of commercial markets for cannabis that neglect consideration of public health (Jernigan et al., 2021).

Although some states decriminalized cannabis in the 1970s and 1980s, the drug was first legalized by a state in 1996, with California Proposition 215 (MacCoun and Reuter, 2001). California Proposition 215 legalized cannabis for medical use only, but it ushered in a wave of new state medical cannabis programs over the next two decades, which evolved in 2012 to the first successful passage of legal cannabis possession for anyone over

[1] "Cannabis" is a broad term that can be used to describe products (e.g., cannabinoids, marijuana, hemp) derived from the Cannabis sativa plant. These products exist in various forms and are used for various purposes (e.g., medical, industrial, social). The all-encompassing word "cannabis" has been adopted as the standard terminology within scientific and scholarly communities. The committee uses the term "cannabis" rather than "marijuana" throughout this report.

21 in Colorado and Washington state, and the establishment of a regulatory structure for retail sales. As of April 24, 2023, 38 states, three territories, and the District of Columbia allowed the medical use of cannabis products (Figure 1-1). As of November 8, 2023, 24 states had passed legislation legalizing cannabis sales and use by adults over 21 years of age.[2] Approved measures in nine additional states allow the sale of products with low delta-9-tetrahydrocannabinol (THC) high cannabidiol (CBD) products in limited medical situations (NCSL, 2024a, 2024b). Although not all states have voted to legalize cannabis, cannabis is sold throughout the United States and online, mainly as a result of the definition of "hemp" in the 2018 Agriculture Improvement Act (PL-115-334).

Cannabis policy changes have been influenced by political campaigns that are often financed by wealthy donors (Gunther, 2024; NFIA, 2017). Initially, state medical programs were implemented out of compassion for patients seriously ill with AIDS or cancer for whom cannabis was thought to ease suffering (Goldberg, 1996). This process was furthered by proponents who exaggerated the medical or therapeutic benefits of cannabis and minimized its harms (Jernigan et al., 2021). Greater social acceptance of cannabis use and growing skepticism about the effort and expense involved in enforcing cannabis penalties also contributed (Felson et al., 2019). National survey data suggest a near-total reversal of public

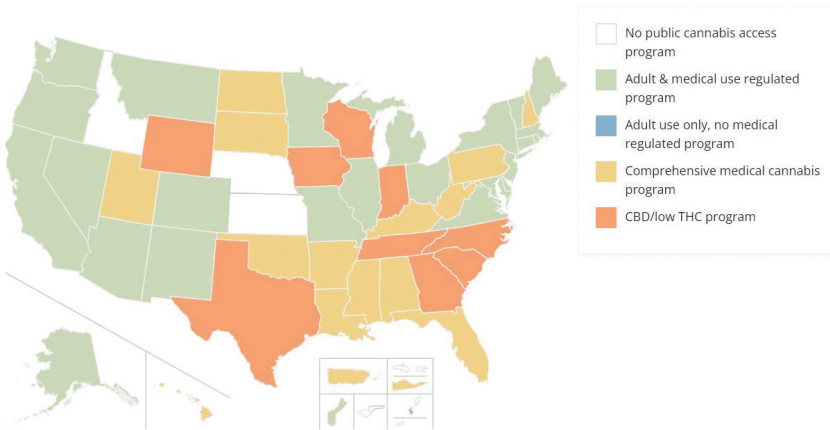


FIGURE 1-1 Map of state-level cannabis legalization.
NOTE: CBD = cannabidiol; THC = delta-9-tetrahydrocannabinol. The map does not include state policies instituted in response to the 2018 Agriculture Improvement Act (PL-115-334).
SOURCE: National Conference of State Legislatures.

[2] Some state medical cannabis laws allow use among those under 21 years of age.

opinion on cannabis legalization over the last 50 years, with the proportion of survey respondents who support legalization increasing from 12 percent in 1969 to 70 percent in 2023 (Saad, 2023). Ballot initiatives in Colorado and Washington were supported by a broad swath of policy perspectives, including those of civil liberties organizations and drug policy reform groups (Martin, 2012).

More recently, cannabis policy reforms have been associated with strategies designed to adjust for the large racial inequalities in arrests for violations of cannabis prohibition. Although national arrest statistics have gaps in race and ethnicity data, it appears that White people are less likely to be arrested for cannabis use than are members of communities of color (Bunting et al., 2013; Resing, 2019). Cannabis policy reforms are supported by 85 percent of Black people (Edwards, 2022), as well as civil rights groups such as the National Chapter of the National Association for the Advancement of Colored People (NAACP, 2019), which have supported cannabis decriminalization and regulation of adult cannabis use.

Legalization has led to the widespread availability of cannabis. At least 79 percent of Americans now live in a county with a medical or adult-use cannabis retail outlet; this figure is an underestimate because of the availability of hemp products (Chapekis and Shah, 2024) (Figure 1-2). In many states, cannabis retailers are more concentrated in neighborhoods characterized by historical disadvantage (Amiri et al., 2019; Matthay et al., 2022; Shi et al., 2016). Retail access to cannabis is associated with calls to poison control, cannabis use in pregnancy, cannabis use–related hospitalizations during pregnancy, and increased cannabis use by adults (Cantor et al., 2024). Many people now worry that changes in cannabis policy, which in part have been touted as improving social justice, may be contributing to health inequities (Cantor et al., 2024).

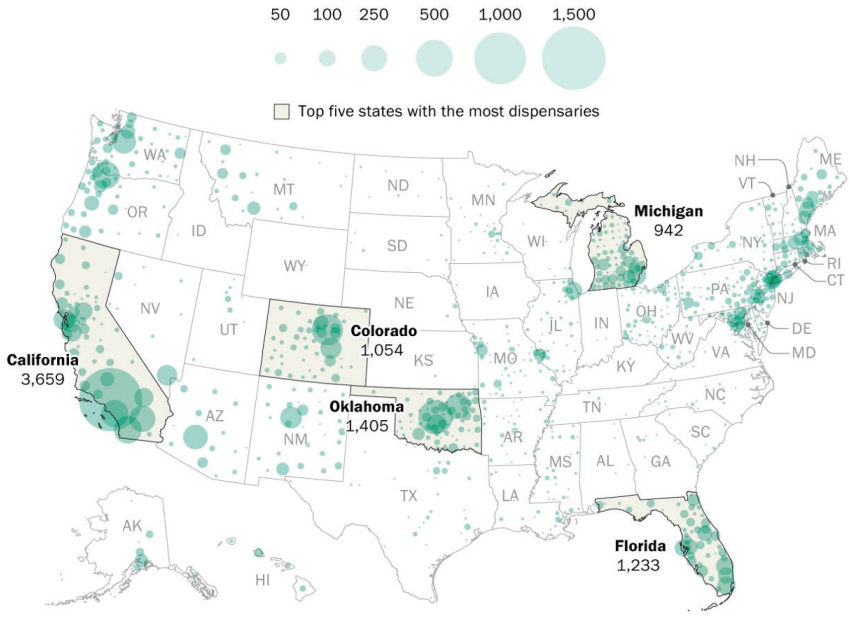
CANNABIS USE AND HEALTH

People use cannabis for many reasons, both recreational and medicinal. Its intoxicating effects can be relaxing, invoke euphoria, and improve sociability and sensory perception. However, it is common for cannabis to impair short-term memory, worsen anxiety, and impair perception and motor skills (Agrawal et al., 2014). Acute outcomes, such as poisoning due to accidental overconsumption or cannabinoid hyperemesis,[3] are also associated with cannabis use. Harms from cannabis use may come from the impacts of the drug itself or other constituents. For example, cannabis is often consumed

[3] "Cannabinoid hyperemesis syndrome" is a condition where a patient experiences cyclical nausea, vomiting, and abdominal pain after using cannabis, and it can cause intense pain (Chu and Cascella, 2023).

Cannabis dispensaries are common along the coasts and in a few specific states

Number of cannabis dispensaries in each county



Note: Includes dispensaries that sell cannabis for both recreational and medical purposes, as well as those selling cannabis products containing low amounts of THC or CBD-only products.
Source: Pew Research Center analysis of SafeGraph data for cannabis dispensaries in the U.S. (N=14,932) as of June 23, 2023.

PEW RESEARCH CENTER

FIGURE 1-2 Map of cannabis retailers.
NOTES: SafeGraph curates information about millions of places of interest around the globe (https://www.safegraph.com [accessed March 24, 2024]). The Pew analysis includes those retail outlets that sell cannabis (including low-THC cannabis products) for medical or adult use but does not include outlets selling cannabis products marketed as "hemp" or "derived from hemp." CBD = cannabidiol; THC = delta-9-tetrahydrocannabinol.
SOURCE: Chapekis and Shah, 2024, Pew Research Center analysis of cannabis retail store locations from SafeGraph.

by smoking, and cannabis smoke has a strikingly similar profile to tobacco smoke in terms of its physical and chemical properties (Graves et al., 2020). Much as with tobacco, there are growing public health concerns about exposure to secondhand cannabis smoke. Toxicological studies have shown that even brief exposure to secondhand cannabis smoke may impact blood

vessel linings (Wang et al., 2016). One study in New York City found biomarkers of cannabis exposure in 20 percent of children enrolled in the study (Sangmo et al., 2021).

A prior report of the National Academies of Sciences, Engineering, and Medicine (2017) comprehensively reviews the literature on the health impacts of cannabis use. It categorizes the evidence reviewed into one of five categories: conclusive, substantial, moderate, limited, and no or insufficient. The report offers more than 100 conclusions on both the harms and the therapeutic effects of cannabis consumption (NASEM, 2017).

The 2017 report cites evidence of therapeutic benefit for a handful of conditions, despite many more purported medical benefits. There was conclusive evidence of therapeutic benefit for the use of oral THC-like cannabinoids (such as nabilone and dronabinol) in treating chemotherapy-induced nausea and vomiting. Substantial evidence supported the use of cannabis for managing chronic pain in adults and the effectiveness of oral cannabinoids (nabiximols and nabilone) in improving patient-reported spasticity symptoms in multiple sclerosis (NASEM, 2017).

NASEM (2017) also cites evidence for many harms associated with cannabis use. Substantial evidence linked cannabis use with an increased risk of motor vehicle collisions and the development of schizophrenia or psychosis, with the highest risk seen among frequent users. Furthermore, substantial evidence linked long-term cannabis smoking with respiratory issues, including increased chronic bronchitis, as well as lower birthweight in offspring exposed prenatally (NASEM, 2017). Evidence for many more potential harms was classified as moderate or limited (Annex Table 1-1). The 2017 report also notes many data gaps, although given that the literature searches for that study were completed in June 2016, some of those data gaps may now have been filled.

CHANGES IN CANNABIS PRODUCTS AND USE

At the same time that cannabis legalization has been occurring within the states, patterns of cannabis use have changed and new cannabis products have emerged, generating public health concerns. New cannabis products include those with high concentrations of delta-9-THC and those with cannabinoids that are less well studied (Box 1-1). According to the National Survey on Drug Use and Health (NSDUH), in 2002, 11.0 percent of the noninstitutionalized U.S. population aged 12 years or older reported past-year cannabis use. In 2019, that figure had risen to over 17 percent. The NSDUH began using new methods in 2020 and again in 2021, making comparisons with prior years difficult, but an increase in past-year cannabis use for the same population appears to have continued from 2021 (19.1 percent) to 2022 (21.9 percent) (Figure 1-3).

BOX 1-1
Cannabis and Cannabinoids: A Primer

The cannabis plant contains more than 100 "phytocannabinoids," compounds that are unique to the cannabis plant, and hundreds of compounds not unique to the plant, such as terpenes and flavonoids (Hanus et al., 2016). Although sometimes referred to as "hemp" or "marijuana," all cannabis plants fall within the same genus: Cannabis (McPartland, 2018). U.S. law distinguishes hemp and marijuana based on the concentration of delta-9-tetrahydrocannabinol (THC) in industrial hemp, defined in the United States as having ≤0.3% delta-9-THC on a dry-weight basis (2018 Agriculture Improvement Act [PL-115-334]).

Delta-9-THC: Delta-9-THC is the most well-studied cannabinoid. Its therapeutic effects include the ability to reduce nausea, increase appetite, and decrease chronic pain. "Dronabinol," a synthetic version of delta-9-THC, and "nabilone," a THC-like drug, are approved by the U.S. Food and Drug Administration (FDA) for treating nausea and vomiting caused by chemotherapy, and dronabinol is approved for treating anorexia in AIDS patients. However, delta-9-THC can induce intoxication, affect cognition, impair motor function, and lead to physiological dependence after chronic exposure. The biological effects of delta-9-THC are attributed primarily to the compound's actions as a cannabinoid receptor type 1 (CB1) agonist (NASEM, 2017).

Cannabidiol (CBD): CBD is not a CB1 receptor agonist and does not engender the constellation of effects of delta-9-THC. Epidiolex®, a purified form of CBD, is approved for oral administration by the FDA for the treatment of specific seizure disorders in patients 1 year of age or older. There is tremendous consumer interest in CBD's therapeutic benefits. However, its off-label benefits are not well studied, and CBD can elicit side effects such as dry mouth, diarrhea, reduced appetite, drowsiness, and fatigue. CBD can also interact with other medications, such as blood thinners (Huestis et al., 2019).

Cannabinoids can be classified based on how they are derived:

Naturally occurring: Cannabinoids such as delta-9-THC and CBD, as well as cannabigerol (CBG), cannabichromene (CBC), pure hemp seed oil, and pure hemp protein powder, are naturally derived from the cannabis plant.

Semisynthetic: Semisynthetic cannabinoids are derived by chemically altering natural cannabinoids, such as CBD. Some may occur naturally in the plant at very low concentrations, such as delta-8-THC. Examples of semisynthetic cannabinoids include delta-8-THC, delta-10-THC,

BOX 1-1 Continued

tetrahydrocannabiphorol (THCP), THC-O-acetate, tetrahydrocannabivarin (THCV), and hexahydrocannabinol (HHC). Some semisynthetic cannabinoids, particularly THC isomers, produce effects similar to those of delta-9-THC, in part because of their actions as CB1 receptor agonists (Cooper and Haney, 2008).

Synthetic: Synthetic cannabinoids are not derived from the cannabis plant. Some of these compounds that are available on the unregulated drug market, like the compounds identified in illicit synthetic cannabinoid products such as K2 or Spice, are highly potent and intoxicating.

One important change is the increased prevalence of use among adults over age 65. In 2002, only 0.6 percent of adults over age 65 reported using cannabis in the past year; by 2019, that figure had risen to 5 percent, although this increase could be due to the aging of the population that uses cannabis. On the other hand, NSDUH estimates of past-year use are relatively constant across time for 12- to-17-year-olds. The percentage of 12- to-17-year-olds who used cannabis in the past year decreased

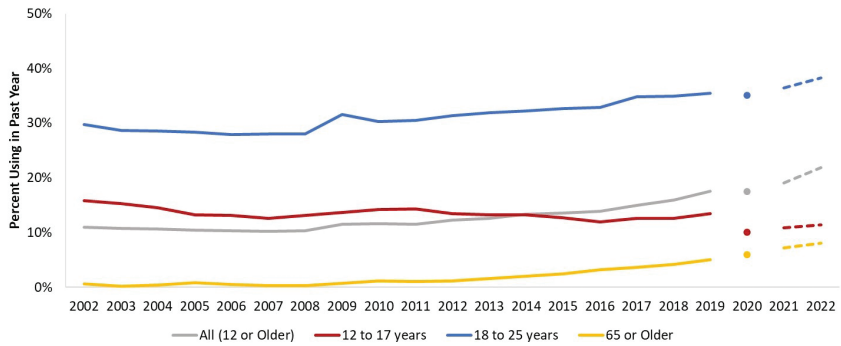


FIGURE 1-3 Self-reported past-year cannabis use by age, 2002–2022.
NOTE: Dot and dashed lines represent changes in the National Survey on Drug Use and Health (NSDUH) survey design and method of administration.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee using data estimated from the NSDUH.

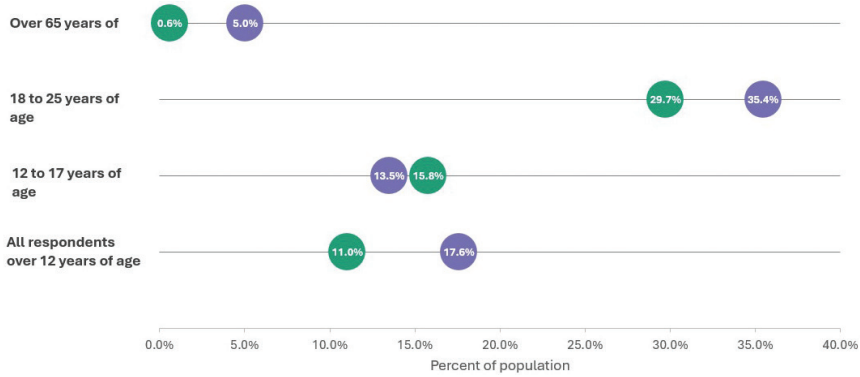


FIGURE 1-4 Self-reported past-year cannabis use, comparing 2002 with 2019.
NOTES: Includes all age groups except 12- to 17-year-olds. Green dots = 2002; purple dots = 2019.
SOURCE: Generated by the committee using data from the National Survey on Drug Use and Health analyzed by Seema Hemant Choksy Pessar, consultant to the committee.

slightly from 2002 to 2019 (Figure 1-4) and remained consistent in 2021 (10.8 percent) and 2022 (11.4 percent). It is also important to note that cannabis use is socially stratified. Those with a college education have the lowest prevalence of use; additionally, those at or below the poverty line have a higher prevalence of use than those with two times the federal poverty level (see Chapter 3). It is important to note as well that national estimates of the prevalence of cannabis use may not represent what is occurring within states where cannabis has been legalized.

There are many types of cannabis products, which can be consumed through many routes of administration. The most common approach to using cannabis is by inhalation following either combustion (e.g., smoking cannabis flower or hashish, commonly rolled together with tobacco in European countries) or vaporization (e.g., heating oils, waxes, or plant material) (Figure 1-5).[4] Cannabis can also be consumed orally (e.g., pills, capsules, edibles, beverages), while other products are manufactured to be absorbed through the skin (e.g., lotions, oils) or other membranes (e.g., suppositories). Cannabis products differ based on the concentration of delta-9-THC or the other cannabinoids that they contain.

[4] While flower products are typically consumed via smoking, it is also possible to vaporize them.

FIGURE 1-5 Examples of cannabis products.
NOTES: Top left quadrant, right to left: honey butane wax, cannabis flower, hashish, and cannabis concentrate resin. Top right: cannabis vapes. Bottom left: rolled cannabis. Bottom Right: Cannabis flowers, tinctures, and edibles.
SOURCES: Drug Enforcement Agency images (top left quadrant), Shutterstock (top right and bottom left quadrants), iStock (bottom right quadrant).

PHARMACOKINETICS AND METHOD OF ADMINISTRATION

Several factors may impact the effects of cannabis use (Box 1-2), including pharmacological factors such as the route of administration, the dose of THC consumed, and an individual's tolerance (Brunton and Knollmann, 2022; Pomahacova et al., 2009; Spindle et al., 2018). The ratio of THC to CBD or other cannabinoids also may influence the effects of cannabis (Freeman et al., 2019; Zeyl et al., 2020). Other factors impact a person's likelihood of developing a harmful relationship with cannabis, such as the person's mindset or the setting in which the drug is consumed (Becker, 1953; Vakharia, 2024).

The route of administration impacts the intoxicating effects of cannabis. Inhalation rapidly delivers THC from the lungs to the brain and results in effects being felt in seconds to minutes and intoxicating effects lasting for 1–3 hours. The route of administration influences cannabinoid absorption, metabolism (pharmacokinetics), and effects. Delta-9-THC is rapidly absorbed by the lungs and brain after inhalation, producing near-instantaneous effects that dissipate 2–3 hours after exposure. When smoking cannabis, much of the delta-9-THC is lost to sidestream smoke and pyrolysis

BOX 1-2
Pharmacological Terms Important to Understanding Cannabis Intoxication

Concentration or strength: "Concentration" refers to the relative amount (percent) of the active ingredient, typically delta-9-tetrahydrocannabinol (THC), per weight or volume (Brunton and Knollman, 2022).

Potency: Much of the cannabis literature colloquially uses the term "potency" to refer to the concentration of delta-9-THC in a cannabis product. In pharmacology, however, "potency" refers to an inherent pharmacological characteristic of a drug that defines the amount (dose) required to achieve a certain effect (Brunton and Knollmann, 2022). Within the framework of pharmacological principles, the potency of delta-9-THC is constant regardless of the finished product or preparation. Different forms of THC may have different potencies because of different levels of agonism for the cannabinoid receptor type 1 (CB1) receptor. For example, tetrahydrocannabiphorol (THCP) is more potent than delta-9-THC.

Dose: Dose is the amount of a cannabinoid administered at a given time. The route of administration can impact the dose consumed. If an entire edible is consumed, the dose is equal to the milligrams of delta-9-THC in the edible. It is more challenging to determine dosing when smoking or vaping cannabis. An estimated 70 percent of the delta-9-THC is lost to sidestream smoke and pyrolysis during cannabis smoking (Pomahacova et al., 2009). Vaporizing cannabis (vaping) is a more efficient delivery method. Still, some THC is lost to sidestream smoke when vaping (Spindle et al., 2018).

Tolerance: Tolerance occurs when people use a drug regularly and it loses its effect over time. Tolerance is observed among those who use cannabis frequently, and they require higher doses of the drug to experience its effects.

(see Box 1-2; NIDA, 1990; Pomahacova et al., 2009), whereas vaping cannabis yields significantly higher delta-9-THC concentrations absorbed into the bloodstream (Budney et al., 2024; Pomahacova et al., 2009; Van der Kooy et al., 2008). These differences result in higher delta-9-THC blood levels and more pronounced intoxicating effects after vaping compared with smoking for the same sample of cannabis (i.e., sample weight and delta-9-THC concentration) (Spindle et al., 2018). Differences in metabolism can also influence the differences in effects of delta-9-THC between inhaled and oral modes of administration.

Oral ingestion results in slower absorption and more delayed peak concentrations. Ingestion can take roughly 30 minutes to 2 hours to induce

intoxicating effects, which can be felt for 5–8 hours (Huestis, 2007; Jernigan et al., 2021; NASEM, 2017). Oral delta-9-THC administration undergoes first-pass metabolism in the liver, leading to slower absorption of delta-9-THC and its active metabolites (see Figure 1-6). Effects after oral delta-9-THC administration are delayed and prolonged compared with inhalation, with peak effects occurring about 60 minutes after ingestion and lasting 4–12 hours, depending on a variety of factors, including dose and drug preparation (Karschner et al., 2009; Newmeyer et al., 2016, 2017; Sholler et al., 2021).

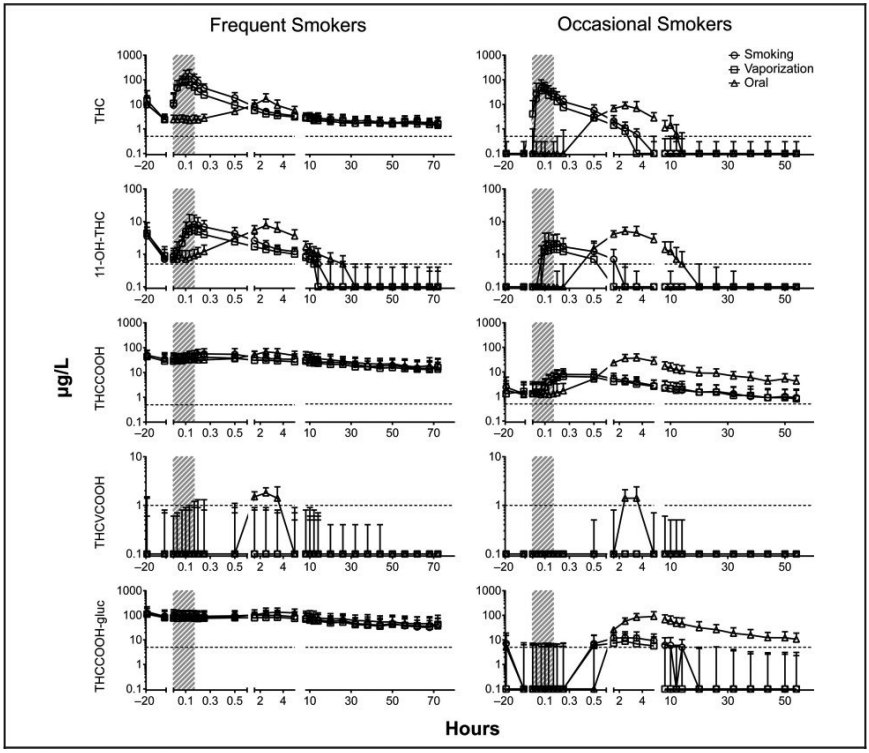


FIGURE 1-6 Mean + standard deviation blood cannabinoid concentrations in 11 frequent and 9 occasional cannabis smokers following administration of cannabis containing 6.9 percent THC via smoked, vaporized, and oral routes.
NOTES: Shaded area designates 10-minute smoking times. The dotted line is the limit of quantification data presented on a log scale. Δ9-tetrahydrocannabinol (THC); 11-hydroxy-THC (11-OH-THC); 11-nor-9-carboxy-THC (THCCOOH); 1-nor-9-carboxy-THCV (THCVCOOH); 11-nor-9-carboxy-THC-glucuronide (THCCOOH-gluc).
SOURCE: Newmeyer et al., 2016.

Different pharmacokinetic profiles may contribute to differences in the positive or adverse outcomes of cannabis use across product types and delivery methods. For example, hospital emergency visits due to cannabis-induced intoxication, acute psychiatric symptoms, and cardiovascular incidents occur more often with oral administration relative to inhalation (Monte et al., 2019; Muheriwa-Matemba et al., 2024). Additionally, pharmacokinetics and intoxicating effects of delta-9-THC vary as a function of demographic variables, such as sex, age, and frequency of cannabis use. In people who use cannabis frequently, for example, cannabis consumption results in more significant blood THC levels but less intoxication compared with people who use cannabis occasionally (Figure 1-7). Men and women also metabolize delta-9-THC differently and exhibit varying effects from cannabis on such measures as anxiety and abuse liability (Desrosiers et al., 2015) (Figure 1-7). These differences impact acute and long-term risks associated with cannabis use among these demographic groups (Budney et al., 2024; Chiang and Hawks, 1990; Cooper and Haney, 2014; Lake et al., 2023; Pomahacova et al., 2009; Sholler et al., 2021; Van der Kooy et al., 2008).

Some forms of cannabis contain very high concentrations of delta-9-THC; these forms are often referred to as concentrates and are called dabs, wax, and shatter. Concentrates usually contain 60 percent delta-9-THC but can contain as much as 90 percent delta-9-THC and are of public health concern (Bero et al., 2023; Hasin et al., 2023). No systematic pharmacokinetic comparisons have been made between inhalation of delta-9-THC by

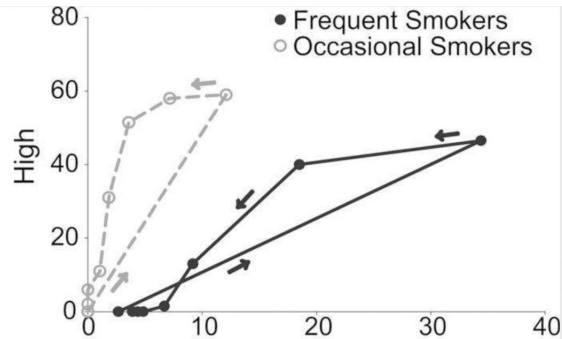


FIGURE 1-7 Median visual analog scale scores in function of tetrahydrocannabinol (THC) concentrations for 14 frequent and 11 occasional cannabis smokers following controlled smoking of a 6.8 percent THC (54 mg) cannabis cigarette.
SOURCE: Desrosiers et al., 2015. Copyright © 2015, Published by Oxford University Press 2015. This work is written by (a) U.S. government employee(s) and is in the public domain in the United States.

combustion of plant material (smoking) versus inhalation of concentrates. Nonetheless, the highly concentrated nature of dabs, wax, and shatter makes it possible to consume a higher dose of delta-9-THC because more of the intoxicating compound is delivered in a much smaller volume of product relative to plant material (Loflin and Earleywine, 2014; Raber et al., 2015), although the dose can be titrated. Concentrates are also heated to a very high temperature (Raber et al., 2015), producing highly concentrated vapor or aerosols that can be administered in few inhalations, whereas smoked cannabis requires the combustion of a relatively larger volume of material (Loflin and Earleywine, 2014; Raber et al., 2015).

FEDERAL ROLE IN CANNABIS POLICY

The federal role in cannabis policy is complex. As noted earlier, although now widely available in most states, cannabis has been classified as Schedule I under the CSA (PL 91–513), the primary policy in the United States for control of illicit drugs, from 1970, when the act was first passed, through the time of this writing (June 2024), although the Biden administration has recommended that it be rescheduled to Schedule III. Since cannabis is a Schedule I drug under the CSA, its manufacture, distribution, or possession remains a criminal violation under federal law, enforceable by the Drug Enforcement Administration (DEA) and other law enforcement agencies. The ability of states to implement cannabis policies stems from the concept of federalism, or "the division and sharing of power between the national and state governments" (CRS, n.d., para 1.). Other countries where cannabis is legal, such as Canada and Uruguay, have had much more involvement from their federal governments (see Chapter 2 for comparisons with other countries). The end of this chapter provides a more detailed history of cannabis policy in the United States.

Department of Justice Actions Toward State Cannabis Policy

The Ogden Memo was written in 2009 to address uncertainty regarding the federal role in enforcing cannabis policy in states that were early to legalize cannabis for medical use. It emphasized that because federal criminal enforcement typically is concerned with large-scale illicit drug trafficking, federal prosecutors generally should not focus on "individuals whose actions are in clear and unambiguous compliance with existing state laws providing for the medical use of marijuana" (Ogden, 2009, p. 2). The Ogden Memo also noted, however, that federal prosecutors should be concerned with cannabis activity connected to unlawful firearm possession, violence, sales to minors, illegal possession of other drugs, and ties to other criminal activity.

The Ogden Memo was followed by the Cole Memo in 2013, issued in response to the legalization of cannabis for adult use in Colorado and Washington. It stressed that federal prosecutors should "focus . . . efforts on certain enforcement priorities that are particularly important to the federal government" (Cole, 2013, p. 1). The priorities included distributing to minors, funding criminal organizations, crossing state lines, being a cover for other crimes, fueling violence, impairing driving, cultivating public lands, and possessing or using public property; it also emphasized that criminal prosecution should not be prioritized for individuals compliant with state laws (Cole, 2013). Later, Attorney General Sessions (2018) rescinded the Cole Memo, giving federal prosecutors the power to enforce federal cannabis laws in states that had legalized cannabis. This shift created uncertainty for the cannabis industry in those states, although later, Attorney General Barr stated he would not prosecute companies complying with the Cole Memo, and Congress has withheld money from the Department of Justice for cannabis prosecutions (Patton, 2020). Another federal policy action began in 2014 when Congress passed an appropriations rider, which prohibited the Department of Justice from using taxpayer dollars to enforce laws against medical cannabis programs (Lampe, 2024).

2018 Agriculture Improvement Act

The 2018 Agriculture Improvement Act (PL-115-334), often called the 2018 Farm Bill, has created enormous regulatory confusion concerning the legality of cannabinoids. This bill revised the definition of "hemp" so the crop could be sold legally without being subject to the CSA (Gottron et al., 2019). The 2018 Farm Bill defines "hemp" as "the plant Cannabis sativa L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a [delta-9-THC] concentration of not more than 0.3 percent on a dry weight basis" (PL-115-334, § 297A). This definition has created legal uncertainties that have facilitated the production and sale of cannabinoids derived from hemp, creating a lucrative industry (Skodzinski, 2024) that is largely unregulated and competes with the regulated state-legal cannabis industry (Johnson, 2023; Johnson and Willner, 2023). The inclusion of the terms "all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers" has led to the sale of intoxicating cannabis products, especially in states that have not chosen to legalize cannabis (Demko, 2024).

State legislators and regulatory bodies are grappling with the challenge of regulating the burgeoning market for hemp-derived THC derivatives. Efforts to restrict their sale have been met with legal resistance. Court rulings on the issue have thus far been inconsistent, leaving the extent of

state regulatory authority unclear. A recent example is a preliminary injunction issued by a federal judge in Arkansas, which halted the implementation of a state law banning intoxicating hemp products (Demko, 2024). As of November 2023, 17 states had successfully banned delta-8-THC, and 7 had severely restricted its sale (Johnson and Willner, 2023). Recently, a bipartisan group of state attorneys general wrote to Congress asking it to act regarding what they term intoxicating hemp products and expressing concern that a public health crisis is looming (Demko, 2024; Elbein, 2024). Although the 2025 Agricultural Improvement Act may include an updated definition of "hemp" to encompass only nonintoxicating products, which would help address this confusion, that new Farm Bill had not passed as of July 2024 (Johnson, 2024).

Revised Cannabis Scheduling under the Controlled Substances Act

In 2022, the executive branch announced that the U.S. Department of Health and Human Services (HHS) and the Department of Justice would review the scheduling of botanical cannabis[5] under the CSA (White House, 2022). Drug scheduling is a complex science policy process. HHS conducts an evaluation and makes a scheduling recommendation to the DEA in the form of an "eight-factor analysis" in accordance with the CSA (21 USC §§ 811[a–c], 812[b]). The eight-factor analysis weighs a drug's potential for abuse, scientific backing, public health risks, dependence potential, and history of use. The analysis results inform decisions required for a drug scheduling recommendation, which reflects the drug's potential for abuse, whether it has a federally accepted medical use in the United States, and its relative safety or ability to produce physical dependence compared with other drugs, as provided under 21 USC § 812(b). The process used by HHS to determine whether cannabis has a currently accepted medical use differed from that used in prior attempts to reschedule cannabis. Typically, currently accepted medical uses are determined using criteria that are most applicable to a drug with ample evidence from clinical trials. The usual approach to evaluation of a currently accepted medical use "left no room for an evaluation of (1) whether there is widespread medical use of a drug under the supervision of licensed health care practitioners under State-authorized programs and, (2) if so, whether there is credible scientific evidence supporting such medical use" (21 CFR Part 1308.2). As a result, HHS used a two-factor analysis to take into account the current widespread medical use of cannabis under

[5] Cannabinoid drugs fall within different areas of the CSA. Cesamet™ (nabilone), synthetically derived delta-9-THC in a powder form, is Schedule II, and Marinol® (dronabinol), synthetically derived delta-9-THC in liquid form, is Schedule III. Epidiolex, highly purified naturally derived cannabidiol, is Schedule V (DOJ/DEA, 2020).

the supervision of clinicians under state-authorized programs (21 CFR Part 1308.2; Budney et al., 2024).

Following its review, in August 2023, HHS recommended that the DEA change the scheduling of cannabis from Schedule I to Schedule III, and on April 30, 2024, the DEA announced that it accepted HHS's proposal (HHS, 2023; Lampe, 2024; Miller et al., 2024). The change would have significant consequences should the White House Office of Management and Budget (OMB) approve that recommendation. Businesses in the legal cannabis industry cannot deduct many business expenses from their federal taxes. Rescheduling could change that situation because the limitations on federal tax deductions apply only to Schedule I and II substances. Moreover, cannabis is currently banned from interstate commerce, and a change to federal scheduling could make federal authorities less inclined to target cannabis businesses that transact cross-border sales (Sacirbey, 2023).

The most significant benefit of rescheduling cannabis from Schedule I to Schedule III would be in the reduction of, but not elimination of, the barriers to medical research on the therapeutic impacts of the plant (Wallack and Hudak, 2016). Schedule III drugs do not require separate researcher registration and have less stringent laboratory controls and more limited reporting requirements; therefore, more researchers may be willing to conduct research on the drug (Wallack and Hudak, 2016).

Rescheduling cannabis would create additional policy confusion. First, changing the schedule of cannabis would not make botanical cannabis a Food and Drug Administration (FDA)–approved prescription drug; FDA drug approval entails a different application process. Second, the state medical programs would still operate in violation of the CSA. Schedule III substances have accepted medical uses but have federal requirements for prescription and sale that differ significantly from the methods used in most state medical cannabis programs (Lampe, 2024). Schedule III substances require FDA approval before they can be prescribed by a physician and marketed as a medication. Moreover, if one or more cannabis products obtained FDA approval, manufacturers and distributors would need to register with the DEA and comply with regulatory requirements that apply to Schedule III substances. Cannabis users would need to obtain valid prescriptions for the substance from clinicians and obtain cannabis from a pharmacist (Lampe, 2024).

Exactly how the rescheduling of cannabis to Schedule III would impact state medical programs is unknown and would depend on how the FDA managed the rescheduling and how the courts interpreted the law. Assuming there was no further act by Congress to legalize cannabis, its supply and adult use would remain illegal under federal law, penalties would decrease, and medical access might increase across the states (since the federal government would have determined that cannabis has a currently accepted medical use).

Overall, then, rescheduling of cannabis is a complex issue. Although the DEA had accepted the HHS proposal to reschedule cannabis as of April 2024, reclassification is still in the early stages. DEA must wait for review of the decision by the OMB, a period of public comment on the decision, and review by an administrative judge before posting the final rule on rescheduling (Lampe, 2024; Miller et al., 2024).

STUDY CHARGE AND APPROACH

The need for a comprehensive public health review of cannabis policy prompted the CDC and the National Institutes of Health (NIH) to commission the National Academies to convene an ad hoc committee charged with describing cannabis and cannabinoid availability in the United States; assessing regulatory frameworks for the cannabis industry, with an emphasis on equity; and describing strengths and weaknesses of medical and nonmedical surveillance systems for cannabis. The committee was asked to recommend a strategy for minimizing harms associated with cannabis policy and set a policy research agenda for the next 5 years. The committee's statement of task is provided in Box 1-3. The committee included experts in public health surveillance, drug policy, epidemiology, policy analysis, neuroscience, health equity, pharmacoepidemiology, public policy, economics, psychiatry, psychology, pediatrics, and history (see Appendix A for the full biography of the committee members).

Interpretation of the Statement of Task

Notably, the statement of task does not ask the committee to conduct a comprehensive review of the health effects of cannabis that would update the 2017 National Academies report (NASEM, 2017). Instead, the committee was asked to review the public health impacts of changes in cannabis policy, an area omitted from the charge to the 2017 committee. The National Academies has not reviewed cannabis policy for more than 40 years. The prior report on that topic, *An Analysis of Marijuana Policy*, was prompted by increases in cannabis use and suggestions for policy reforms (NRC, 1982). The committee that produced that report recommended considering alternative policies, including partial prohibition, as well as further research on the effects of cannabis use and different policy approaches (NRC, 1982). Given the many changes in cannabis policy since the publication of the 1982 report, an update is sorely needed.

This committee did not consider decisions about cannabis legalization, scheduling, or prohibition to be within its purview. Instead, the committee believed its task was to address the question: Now that states have been legalizing cannabis, what public health measures should be undertaken to protect public health?

BOX 1-3
Statement of Task

An ad hoc committee of the National Academies of Sciences, Engineering, and Medicine will review the public health impacts of cannabis and cannabinoid use, both medical and non-medical, among adults in the states and localities where it is legal. Specifically, the committee will:

- Describe the status of cannabis availability and use, including various product types (e.g., concentrates, edibles, dabs, vaping cartridges) and component cannabinoids (e.g., cannabidiol) in the US. Assess how different regulatory models have influenced the makeup of the cannabis industry, as well as product safety, composition and potency, dosage/serving size, availability, quality control, and labeling and marketing.
- Discuss the implications for public health of the various regulatory models. Where relevant, describe how lessons from other countries and from tobacco, alcohol, and other regulated products or industries can inform U.S. regulations and whether they have or have not been applied.
- Assess these regulatory frameworks through a social and equity lens, exploring outcomes such as employment, tax revenues, and other economic indicators; environmental impact of the cannabis and hemp agriculture; encounters with the justice system; impact on the unregulated market; and availability of community prevention and treatment resources for cannabis use disorder. Include, as appropriate social and equity impact of decriminalization and incarceration for cannabis possession.
- Describe strengths and weaknesses of existing state or national surveillance and pharmacovigilance systems for adult and medicinal use and other data sources and identify key public health outcomes that could serve as sentinels for adverse exposure and health consequences. Such outcomes might include, but are not limited to, harmful exposures, adverse cancer outcomes and interactions with cancer treatments, low-birth weight, motor vehicle accidents, worker impairment and injury, poisonings in children, hospitalizations for acute mental health problems or for cardiovascular disease, indoor air quality, and use/co-use of other substances including alcohol and tobacco. Review what is known about whether these outcomes have changed in states and localities that have changed their regulatory approach to cannabis and cannabinoids. Data sources may include information on the medical conditions for which cannabis is prescribed by physicians or recommended by dispensaries, self-reported reasons for cannabis use, and beneficial health outcomes.

BOX 1-3 Continued

- Make comparisons throughout, as appropriate, to the illicit unregulated market.
- Provide recommendations for strengthening a harm reduction approach, which would minimize harms, of various regulatory models, including but not limited to social, employment, education, and health impacts.
- Make recommendations for policy research for the next 5 years.

Although the committee was asked to develop recommendations related to "strengthening a harm reduction approach, which would minimize harms, of various regulatory models, including but not limited to social, employment, education, and health impacts" the committee interpreted that task more broadly. It identified "harm reduction" as a series of approaches that reduce health and safety consequences for individuals and society associated with drug use or other behaviors (Vakharia, 2024). Additionally, while harm reduction services and approaches can have important implications for public health, the committee believed a broader set of recommendations, or a public health approach, was needed to respond to its statement of task.

Finally, although the statement of task refers explicitly to "adults," the committee determined that any public health approach to cannabis policy would need a significant focus on youth. It is well known that for other substances, experimentation in adolescence may lead to lifelong use, which increases the potential for impacts on health and well-being.

Study Approach

The committee developed its public health approach to cannabis policy based on the published literature and the presentations and discussions during its large public meetings in fall 2023 and winter 2023–2024. In these public sessions, the committee heard from various stakeholders, including the CDC, NIH, and FDA; state cannabis regulators; public health officials; people impacted by adverse outcomes of cannabis use; those who grow cannabis and make cannabis products; and academic researchers studying cannabis policy, health effects, harm reduction, treatment, and primary prevention.

Social equity is central to the committee's statement of task. This area often focuses on addressing racism and other forms of discrimination, but it is highly intertwined with health equity. Systems of power (which are influenced by social equity), individual factors, and physiological pathways all influence health equity. "Systems of power" are policies, processes,

and practices that determine who gets resources and better opportunities for health. These systems can promote health equity or perpetuate inequities in such areas as access to basic needs, humane housing, meaningful work, and reliable transportation. "Individual factors" concern people's responses to social, economic, and environmental conditions through their attitudes, skills, and behaviors and the interaction of those factors with biological predisposition. "Physiological pathways" refers to a person's biological, physical, cognitive, and psychological abilities (Peterson et al., 2021). The committee considers these issues throughout this report.

In carrying out this study, the committee considered the core public health functions (Box 1-4). A public health approach to cannabis policy

BOX 1-4
Public Health Approach to Cannabis Policy

Assessment

- Conduct surveillance of or assess and monitor the health impacts of cannabis.
- Investigate the causes of any identified harms from cannabis use.

Policy Development

- Build and mobilize partnerships between cannabis regulators and public health authorities.
- Inform, educate, and empower communities to develop cannabis-related public health campaigns.
- Develop cannabis policies centered on protecting public health that are not influenced by the regulated industry.
- Equitably enforce cannabis policies designed to ensure compliance.

Assurance

- Protect the public from the potential harms of cannabis (accidental ingestion or poisoning, crashes from impaired driving, secondhand smoke, and environmental impacts).
- Protect those who use cannabis from potential harm and ensure access to treatment.
- Build and support a diverse and skilled cannabis public health workforce.
- Improve and innovate cannabis public health functions through ongoing evaluation, research, and continuous quality improvement.
- Build and maintain a strong organizational infrastructure for cannabis and public health.

SOURCE: Adapted from Ghosh et al., 2016.

differs from other public policy–making approaches. Public health policy aims to improve the health of entire communities, not just individuals, which requires considering factors that influence health outcomes for large groups, such as access to healthy food or safe environments (Castrucci, 2021; Jernigan et al., 2021). Ideally, public health decisions are based on scientific research and data on the most effective interventions for preventing disease and promoting health within communities. Public health policy must often balance individual freedoms with promotion of the greater good. For example, smoking restrictions limit the personal choice of the smoker but reduce unhealthy exposures for everyone. Public health issues often are complex, requiring collaboration among government sectors such as education, transportation, and housing. Public health policy development also requires understanding community needs and wants and considering the economic impact, feasibility, and acceptability of implementing policies and programs. Public health policy is meant to be more preventive than reactive, aiming to prevent health problems before they occur.

Public health can inform many aspects of cannabis policy, such as policies on how cannabis is cultivated, processed, marketed, or sold, in addition to where it is sold and marketed, to whom, in what type of packaging, and under what circumstances. Public health policies can similarly target consumers, directly regulating how and where products can be consumed and under what circumstances. In intervening in these areas, the goals of public health policy are to mitigate the harms of legal markets while promoting the benefits of cannabis (Figure 1-8).

The committee found it difficult to delineate the differences between medical and adult-use policies and their public health consequences; therefore, this report focuses primarily on policies that legalize possession and some forms of supply to adults. Additionally, the two categories of use overlap across different policy regimes. Some people living in states with legal adult use will purchase cannabis without a recommendation from a medical provider to self-medicate for trouble sleeping or to unwind. On the other hand, some states with medical programs have such relaxed policies for obtaining cannabis for medical use that they do not differ significantly from adult-use states

FIGURE 1-8 Conceptual framework of areas in which public health policy can intervene to mitigate the harms and promote the benefits of cannabis.

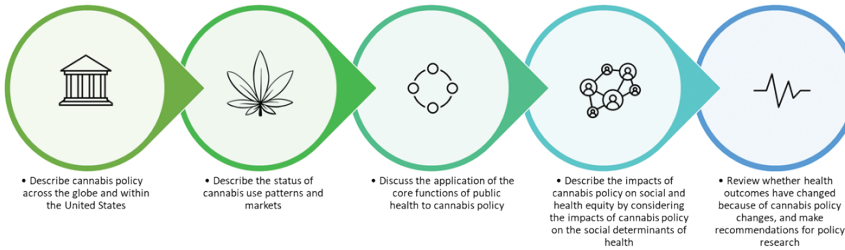


FIGURE 1-9 Organization of the report.

(Pacula et al., 2014). Another source of confusion in any policy analysis is that the legal uncertainties posed by the 2018 Farm Bill have led to the availability of cannabis in most states (CANNRA, 2023; Elbein, 2024; Gottron et al., 2019; Johnson, 2023; Johnson and Willner, 2023; Rossheim et al., 2024).

ORGANIZATION OF THE REPORT

Figure 1-9 provides an overview of the steps taken by the committee to address its charge. The report is organized around this framework. Following the overview of the study's public health and social context in this chapter, Chapter 2 reviews the U.S. approach to cannabis policy making compared with those of other countries. Chapter 3 examines cannabis use and markets in the United States. Chapter 4 applies core public health concepts to cannabis policy and considers how the harms associated with that policy can be mitigated. Chapter 5 describes the impacts of cannabis policy on social and health equity. Finally, Chapter 6 reviews the literature evaluating the public health impacts of cannabis policy and provides research recommendations.

HISTORY OF CANNABIS POLICY IN THE UNITED STATES

Discussion of public policies related to cannabis use depends on a comprehensive understanding of the drug's chemistry and physiological effects. As mentioned previously, the plant itself and the products derived from it have evolved over the past few decades. However, because public policy is influenced by historical context as well, a review of the history of cannabis policy is essential for understanding the current U.S. policy landscape.

Early State Cannabis Control Policies, ~1860s to ~1940s

For much of U.S. history, state governments have led the way in cannabis regulatory activity, building on traditions of local control of public health and safety and given constitutional authority under the 10th Amendment. State legislative activity has generally preceded corresponding federal policies.

Consumer protection laws governing the sale of dangerous drugs first emerged in the 1860s, and the earliest of these (New York in 1860 and Wisconsin in 1862) included cannabis in the substances placed under regulatory control (Rathge, 2017). Despite pressure for uniform rules across states, individual legislatures generally retained control, so cannabis legislation varied widely among states. In 1911, Massachusetts became the first state to restrict cannabis possession as states began to move from a consumer protection regulatory framework to a more explicit effort to prohibit all nonmedical sales and possession (Rathge, 2017). Moves by state legislatures and some local governments to effectively ban nonmedical cannabis in the first three decades of the 20th century were rooted in multiple impulses, including anti-immigrant sentiment toward Mexicans, a growing temperance movement intolerant of intoxicants such as cannabis and alcohol, and social elitism (Belenko, 2000; Courtright, 2012; Musto, 1991). Recent detailed historical accounts raise questions regarding the prominently hypothesized role of explicit racism in early legislative enactments of these state laws, concluding that the shift from regulation to prohibition was deeply influenced by anxiety over cannabis use among youth and moralistic concerns regarding the effects of cannabis intoxication, including a perceived link to violence and madness (Campos, 2018; Fisher, 2021). But it is undeniable that racism played a role in the unequal enforcement and implementation of prohibition once it became enacted.

By the time of the federal Marijuana Tax Act in 1937, every state had passed some version of prohibition of nonmedical cannabis (Fisher, 2021). A movement toward more uniform state laws produced a draft narcotic act in 1925, which included cannabis prohibitions that were left to the discretion of the states in later drafts (Bonnie and Whitebread, 1974). Even today, an emphasis on states' authority is at the root of considerable variation in cannabis policy across the country.

Evolution of Federal Control Policies

For as long as federal drug regulation has existed, cannabis has been part of it. The 1906 Pure Food and Drugs Act, for example, required label disclosure of 11 dangerous drugs, including cannabis (Jernigan et al., 2021; Young, 1989). Nine years later, the Treasury Department banned the importation of cannabis for purposes other than medical (Campos, 2018). Both federal actions assumed a medical market for cannabis that was protected by law. Well into the 1930s, U.S. pharmaceutical firms continued to cultivate cannabis and produce cannabis products for medical use. Over time, the need for a reliable supply of a product of uniform quality prompted the transition to domestic cultivation. Historical research suggests that, while this medical market was durable, having started in the 1840s, it was neither large nor growing, as physicians gradually came to favor medicines produced under standardized laboratory conditions that required far less paperwork to prescribe.

The Marijuana Tax Act of 1937 imposed a tax on cannabis, most notably on its import and export, but also on its cultivation, sale, and possession (CBP, 2019). As noted above, the 1937 federal law followed, rather than preceded, most state-level cannabis control laws. Recent scholarship grounded in the archival and documentary evidence suggests further that federal legislation was spurred in part by the felt need to protect domestic production of hemp as a strategic material for national defense without its diversion for adult use (McAllister, 2019). In addition, while the promotion of public support for passage of the Marijuana Tax Act played upon racially coded fears of criminality, there appears to have been little initial investment in federal enforcement capacity (Galliher, 1977; McAllister, 2019).

Although the 1937 act ostensibly protected medical use, the Federal Bureau of Narcotics (FBN) (the predecessor of the Drug Enforcement Administration [DEA]) pressed for the demedicalization of cannabis. The removal of cannabis from the United States Pharmacopeia in 1942 followed several years of active lobbying against its medical legitimacy by FBN chief Harry Anslinger (Rathge, 2017). U.S. officials also participated in international efforts to demedicalize cannabis, such as the 1952 statement from the World Health Organization (WHO, 1952) Expert Committee on Habit-Forming Drugs that there was "no justification for the medical use of cannabis preparations" (p. 11) and WHO's 1955 report *The Physical and Mental Effects of Cannabis*, which concluded, "not only is marihuana [sic] smoking per se a danger but [its] use eventually leads the smoker to turn to intravenous heroin injections" (as quoted in Bewley-Taylor et al., 2014, p. 21).

Controlled Substances Act of 1970

The incorporation of cannabis into a comprehensive system of federal drug regulation occurred relatively late, with the adoption of the Controlled Substances Act (CSA) of 1970 (PL 91–513). The CSA was part of a larger package of federal drug legislation that consolidated the patchwork of existing federal drug laws and created a series of five schedules into which controlled substances would be placed (see Box 1-5). Scheduling assignments were based on a drug's or chemical's potential for abuse or dependence, as well as federally accepted medical use, and guided regulation of the manufacturing, distribution, and possession of the scheduled chemicals. Cannabis was classified among the Schedule I drugs, reflecting the decades-long process of its demedicalizing, as well as the judgments of then-president Richard Nixon and Attorney General John Mitchell, both of whom opposed cannabis and saw it as a gateway to use of more dangerous drugs and an unproductive lifestyle, as well as being closely associated with political and social radicalism (Downs, 2016).[6]

[6] An early version of scheduling, the United Nations Single Convention on Narcotic Drugs (1961), had also controlled cannabis in the most stringent schedules, reserved for substances with serious risk of abuse and extremely limited medical or therapeutic value.

BOX 1-5
Schedules of Drugs in the Controlled Substances Act

- **Schedule I** drugs, substances, or chemicals are defined as drugs with no currently accepted medical use and a high potential for abuse. Some examples of Schedule I drugs are heroin, lysergic acid diethylamide (LSD), marijuana (cannabis), 3,4-Methylenedioxymethamphetamine (ecstasy), methaqualone, and peyote.
- **Schedule II** drugs, substances, or chemicals are defined as drugs with a high potential for abuse, with use potentially leading to severe psychological or physical dependence. These drugs are also considered dangerous. Some examples of Schedule II drugs are combination products with less than 15 milligrams of hydrocodone per dosage unit (Vicodin), cocaine, methamphetamine, methadone, hydromorphone (Dilaudid), meperidine (Demerol), oxycodone (OxyContin), fentanyl, Dexedrine, Adderall, and Ritalin.
- **Schedule III** drugs, substances, or chemicals are defined as drugs with a moderate to low potential for physical and psychological dependence. Schedule III drugs have less potential for abuse than Schedule I and Schedule II drugs, but more than Schedule IV drugs. Some examples of Schedule III drugs are products containing less than 90 milligrams of codeine per dosage unit (Tylenol with codeine), ketamine, anabolic steroids, and testosterone.
- **Schedule IV** drugs, substances, or chemicals are defined as drugs with a low potential for abuse and low risk of dependence. Some examples of Schedule IV drugs are Xanax, Soma, Darvon, Darvocet, Valium, Ativan, Talwin, Ambien, and Tramadol.
- **Schedule V** drugs, substances, or chemicals are defined as drugs with lower potential for abuse than Schedule IV drugs, and consist of preparations containing limited quantities of certain narcotics. Schedule V drugs are generally used for antidiarrheal, antitussive, and analgesic purposes. Some examples of Schedule V drugs are cough preparations with less than 200 milligrams of codeine or per 100 milliliters (Robitussin AC), Lomotil, Motofen, Lyrica, and Parepectolin.

SOURCE: DEA, 2020.

National Commission on Marijuana and Drug Abuse, 1972

The CSA authorized the creation of a National Commission on Marijuana and Drug Abuse, known popularly as the Shafer Commission. The commission's final report, released in 1972, strongly recommended state and federal decriminalization of the possession of small amounts of cannabis for personal use (Nahas and Greenwood, 1974). The same report

encouraged the National Institutes of Health and Food and Drug Administration (FDA) to consider supporting cannabis research. In the same year, the National Organization for the Reform of Marijuana Laws filed a petition with the Bureau of Narcotics and Dangerous Drugs (now the DEA) to reschedule cannabis to Schedule II, enabling legal physician prescription. That petition ultimately failed, as did subsequent petitions to do the same in 1995, 2002, and 2011.

Interest in the therapeutic utility of cannabis reemerged in the 1960s and 1970s, spurred on the laboratory front by the isolation of tetrahydrocannabinol (THC) in 1964 and the synthesis of THC in 1967, and more popularly by advocacy from patient groups and a renewed appreciation of plant-based medicine (Dufton, 2017; Taylor, 2008, 2022). In 1978, the Compassionate Investigational New Drug (IND) program allowed access to medical cannabis for a limited number of patients (Clark et al., 2011). Nevertheless, federal policy on medical cannabis saw only modest changes in the later 1970s.

Federal Approvals of Cannabinoid Drugs, 1980 to the Present

Federal approval of synthetic cannabinoids for medical use represented the next policy evolution in the remedicalization of cannabis. In 1980, the National Cancer Institute supported the use of dronabinol as an investigational antinausea drug for chemotherapy patients (Sawtelle and Holle, 2021). In 1985, the FDA approved dronabinol to treat nausea and vomiting associated with cancer chemotherapy (IOM, 1999). FDA approvals since then include other indications and formulations for dronabinol, the THC analog nabilone, and cannabidiol (FDA, 2023; Todaro, 2012).

Cannabis for Research

Research supporting the process of cannabis remedicalization has long been hindered by significant problems in obtaining reliable supplies of raw material for study (Taylor, 2022). In 2020, a change in DEA rulemaking allowed for multiple sources of cannabis supply for researchers, who for more than a half-century had relied solely on a single federally approved source at the University of Mississippi (DEA, 2020). Now, several other cultivation facilities have DEA licenses,[7] but they may not yet meet federal research requirements imposed by the FDA. Federal support of medical cannabis research received further attention with the passage of the Medical Marijuana and Cannabidiol Research Expansion Act of 2022, which aims to encourage medical research on cannabis (Purcell et al., 2022).

[7] https://www.deadiversion.usdoj.gov/drugreg/marihuana.html (accessed August 10, 2024)

State Cannabis Policies Since 1973

Passage of the CSA standardized federal policy around cannabis and other controlled substances. Almost immediately afterward, state-level policy initiatives emerged to challenge the federal government's presumed policy dominance.

State-Level Decriminalization, 1973–1978

In the 1970s, states began to adopt policies following the Shafer Commission's recommendation that possession of cannabis for personal use be decriminalized. Although sometimes mistakenly used interchangeably, decriminalization and legalization are different policy options (see Box 1-6). The movement for state-level decriminalization began in Oregon in 1973 with the elimination of criminal penalties for the possession of less than 1 ounce of cannabis, which was instead subject to a $100 civil fine. Ten more states adopted so-called decriminalization laws in the 1970s and early 1980s. However, these laws varied widely in the quantities designated as permissible, terms for punishing repeat offenders, and even the inclusion of possession as a crime (Pacula et al, 2003; Dufton, 2017; Hillsman, 2017). Therefore, some state decriminalization policies failed to meet even the Shafer Commission's relatively modest standard for decriminalization. It is difficult to determine the consequences of these decriminalization policies, partly because they varied so widely.

State-Level Medical Cannabis (1978–1996)

In 1978, New Mexico adopted the first post-CSA law authorizing cannabis for specific therapeutic uses. Unlike decriminalization laws,

BOX 1-6
Decriminalization and Legalization

Decriminalization: Decriminalization describes policies that remove the criminal status and criminal penalties associated with simple cannabis possession (typically small amounts) and use.

Legalization: Legalization removes criminal and monetary penalties for the supply of cannabis for adult use purposes, in addition to removing these penalties for possession and use.

SOURCE: Pacula and Smart, 2017.

New Mexico's Controlled Substances Therapeutic Research Act was intended to protect scientific research. The New Mexico model deferred to, rather than challenged, federal policy dominance by essentially creating a state-level version of the federal research program described above. More than 20 states followed New Mexico's lead, although most never created research programs. In practice, the administrative burden of such programs limited their scope (Randall and O'Leary, 1999). In 1979, Illinois took an alternative approach, passing legislation that gave physicians with a controlled substances license the authority to prescribe cannabis for patients with debilitating conditions (Public Act 098-0122, 2014). A few other states[8] adopted similar legislation between 1981 and 1996.

State medical cannabis programs tended to be bureaucratically complicated and costly to run (Randall and O'Leary, 1999). The 1985 FDA approval of dronabinol described above may have dampened enthusiasm for further medical cannabis programs. There was also a growing antidrug sentiment in the 1980s, along with momentum for increased prosecutorial action from the government (Chaiken and McDonald, 1988; Mold, 2021; Pascual, 2021, p. 1760). Taken together, these factors contributed to reducing state interest in medical cannabis programs.

State-Level Medical Cannabis, 1996 to the Present

In 1996, by ballot initiative, California voters passed Proposition 215, the Compassionate Use Act, allowing for medical cannabis use outside of FDA-approved indications and formulations (Uniform Controlled Substances Act, 2017). The ideas behind Proposition 215 were not new. However, the successful use of the ballot initiative broke a political logjam around medical cannabis. Initiative supporters enjoyed a substantial fundraising advantage and deployed their resources in a politically savvy public campaign. By activating popular support for patients' rights and creating an exemption from prosecution for patients and caregivers, Proposition 215 challenged federal policy dominance in ways no previous state policy had done. Clinical providers were allowed to recommend cannabis for any illness where it could provide relief, thus access was widely available.

Proposition 215 ushered in the "ballot initiative era" of medical cannabis policy. While the federal government remained explicitly opposed to such actions, voters expressed a different view. Of the states that have authorized medical cannabis use, most did so through a ballot initiative (Orenstein and Glantz, 2020). The resulting medical cannabis policies varied widely. Some were thinly veiled legal adult-use programs, while others had more complex requirements (Pacula and Smart, 2017; Pacula et al., 2015).

[8] Connecticut, New Hampshire, Vermont, Virginia, and Wisconsin.

Ballot initiatives on medical cannabis continued into the 2010s (Orenstein and Glantz, 2020). State legislatures gradually established more precise definitions of legal and medical use, with greater attention to state licensing and regulation of a legal supply chain. The Ogden Memorandum gave states considerable cover to build licensed cannabis retailer systems and to bring those who use medical cannabis and prescribers into a regulated system (Kleiner, 2014; Ogden, 2009). With these changes came a remarkable growth in the number of patients enrolled in state medical cannabis programs (Boehnke et al., 2022). Over time, state policies on medical cannabis, while still highly variable, have moved toward greater comprehensiveness and detail (Pacula and Smart, 2017).

State-Level Cannabis Legalization, 2012 to the Present

In 2012, Colorado and Washington state passed first-of-their-kind legislation to legalize cannabis possession for adults and authorize the creation of commercial sources of supply. Alaska and Oregon followed suit with ballot initiatives in 2014, after which the pace of change accelerated; as of April 2024, 24 states had legalized some form of adult-use commercial markets. While state laws vary, they share an emphasis on legal commerce, with attention to cultivation, processing, and retail and wholesale sales. This cannabis market has no historical precedent in the long history of cannabis in the United States. There are, however, similarities with the relegalization of alcohol following passage of the 21st Amendment. Despite differences between these drugs, valuable insights can be gleaned from the historical precedent of alcohol relegalization (Box 1-7).

Historical Patterns of Enforcement of Cannabis Law

The evolution of state and federal cannabis legislation is only one part of the historical story: these laws have been given meaning and real-world significance through their enforcement. Contemporary social equity provisions of cannabis legalization programs make clear the recognition that enforcement of cannabis law has historically had significant harmful impacts on individuals and communities. Furthermore, equity perspectives explicitly recognize that the harms of cannabis law enforcement have been borne disproportionately by communities of color and marginalized people, both socially and economically (Kilmer et al., 2021), which may contribute to health inequalities.

The policing of cannabis is more than a century old, dating back to the earliest state and local prohibitions on nonmedical sale and possession (Rathge, 2017). Arrests and convictions impact only a small portion of the population that has been involved in the illegal sale or possession of cannabis. Long ago, researchers demonstrated that actual patterns of enforcement behavior were subject to significant bias due to organizational priorities,

BOX 1-7
Lessons of Prohibition and Its Repeal

There is only one clear precedent in U.S. history for the commercialization of a formerly prohibited intoxicating substance on the scale of cannabis—the relegalization of alcohol following the repeal of national alcohol prohibition in 1933.

Policy Heterogeneity. With both alcohol and cannabis, management of the process of commercialization has been left to the states (more formally, in the case of alcohol, with the 21st Amendment explicitly allowing states to decide whether and how alcohol might still be legally restricted). Both alcohol and cannabis legalization proceeded unevenly across states and yielded highly heterogeneous regulatory structures (Mississippi, for example, did not repeal its statewide alcohol prohibition until 1966). The critical difference, of course, is that state-level regulation of commercial alcohol markets took place with formal federal approval (in the form of a Constitutional amendment and congressional legislation). In contrast, state-level regulation of cannabis commercial markets is being undertaken in the context of continued federal prohibition. Therefore, one can reasonably argue that cannabis legalization remains vastly less stable than alcohol relegalization as a policy proposition. Moreover, supply structures, such as state monopolies, that were legally permissible for alcohol in 1933 have not been deemed a legal option for cannabis under the current federal policy.

Regulatory Orientation. The relegalization of alcohol has been studied far less extensively than the experiment with alcohol prohibition itself. Nonetheless, what is known is that commercial markets in alcohol were subject to complex and strict state-level regulatory regimes, many of which were explicitly designed to moderate overall alcohol consumption. For example, most states barred liquor advertising from depicting "subject matter nor illustrations inducing minors or immature persons to drink" (Harrison and Laine, 1936, p. 70). In addition, a number of states adopted full or partial state alcohol monopolies, a practice initially oriented toward promoting consumer health and safety (in addition to state revenue). Consequently, most reliable estimates show that per capita alcohol consumption in the United States did not return to preprohibition levels until around 1970—roughly four decades after repeal. The regulatory conservativism toward alcohol has since been substantially loosened through both legislative and judicial action, and it appears clear

that commercial cannabis markets are being introduced in a legal and policy environment far less favorable to strict regulatory control.

Legalization and Market Consolidation. The relegalization of alcohol also yielded a remarkable consolidation of the industry, compared not only with the prohibition-era illicit market but also with the preprohibition industry. More than 1,500 preprohibition breweries were replaced by fewer than half that number in the immediate aftermath of repeal. That number eventually dwindled to just 100 by 1980 (with the five largest brewers controlling three-quarters of the market). Production of distilled liquor consolidated even more rapidly, with four corporations controlling four-fifths of the market by the end of the 1930s. Market consolidation reflected broad trends in American industry, to be sure, but a complex regulatory environment tended to further privilege producers that could compete at scale. Consolidation has been persistent, despite periodic efforts to restrain it; a 2022 Treasury Department report laments the continued inability of small alcohol producers to compete successfully (USDT, 2022). To date, the prohibition of interstate commerce in cannabis (owing to ongoing federal prohibition) has limited similar market consolidation; a shift to federal legal status for cannabis would be almost certain to accelerate that process rapidly absent explicit limiting efforts by Congress.

Persistence of Illicit Markets. The relegalization of alcohol did not eliminate an illicit alcohol market. The strict regulatory orientation of most state governments, together with continuing pockets of "dry" counties, helped sustain illegal market alcohol production and distribution. One reliable 1936 estimate suggested that illicit production equaled about 50 percent of licit production. Not until the 1970s did levels of Treasury enforcement of illicit alcohol production finally decrease to insignificance (McGahan, 1991).

Social Equity Considerations. The end of alcohol prohibition took place in a sociocultural environment far less attentive to social equity than is the case for the contemporary cannabis policy landscape. Efforts to address the negative impact of the enforcement of alcohol prohibition appear to have included no consideration of the inherent social equity dimensions. However, some state governors did issue blanket pardons to alcohol offenders still in state prisons at the time of repeal.

SOURCES: Hall, 2010; McGahan, 1991; Mikos, 2021; Pennock and Kerr, 2005; Room, 2008, 2020; Stockwell et al., 2020; Title, 2022.

political pressure, cultural attitudes, and public opinion (DeFleur, 1975; Reiss, 1971; Skolnick, 1966).

Patterns of bias in cannabis law enforcement have evolved over time. Cannabis policing in the 1920s and 1930s was highly localized and episodic, reflecting patterns of generally low law enforcement interest, with occasional moments of higher priority. During this period, cannabis arrests appear to have constituted a small proportion of overall drug law enforcement activity. The policing of opiates and cocaine had the highest priority, and cannabis arrests were often incidental to enforcement activity directed at these substances. Moreover, racial disproportion in these early years is not particularly apparent (Campos, 2018; Rathge, 2018).

During the 1940s and 1950s, while cannabis remained a secondary concern for law enforcement, racial disproportion in drug enforcement took on far more significance (Frydl, 2013). Many states classed cannabis as a "narcotic," and simple possession could be a felony offense. Mandatory minimum drug sentencing laws, adopted in the 1950s by the federal government and many individual states, generally included cannabis (Frydl, 2013). Consequently, while overall levels of cannabis arrests remained low, legal sanctions increased, and racial disproportion emerged as a significant problem.

The first significant prioritization of cannabis law enforcement emerged with the general rise of cannabis use among college- and high school–age populations in the 1960s. Public concern over youth consumption led law enforcement to take a specific interest in cannabis, and the result was a substantial increase in arrests and convictions in that decade. California led the way, with a startling 20-fold increase in the number of cannabis arrests from 1962 to 1972, 95 percent of which were for felony charges and most for possession (Lassiter, 2023; Polson, 2021). In Chicago, officers reported pressure from their superiors to focus arrest activities on white youth and marijuana (DeFleur, 1975). As enforcement priorities shifted toward cannabis, the proportion of drug arrests involving cannabis increased—accounting for more than half of all drug arrests by 1967 (DOJ, 1968; Dufton, 2017; Lassiter, 2023).

This surge of cannabis enforcement activity, with its focus on younger White people from suburban areas, is largely forgotten today but yielded substantial numbers of felony arrests and convictions for simple possession. Drug enforcement was overwhelmingly biased toward racial minorities in this period, but cannabis enforcement represented an interesting exception. Cannabis arrests were a mechanism for targeting "hippie" groups and political activists, and school grounds and college campuses were a convenient enforcement target in the cultural battle over the drug (Dufton, 2017; Lassiter, 2023; Sanders, 1975; Smith, 1969).

The same social trends that encouraged nascent decriminalization efforts in the 1970s also led several states to reclassify cannabis in their criminal statutes, separating it from the general category of "narcotics" and reducing formerly draconian penalties for cannabis possession (Dufton, 2017; Lassiter, 2023). Changes to California law, for example, now allowed

district attorneys to opt into a misdemeanor charge for cannabis; in some jurisdictions, misdemeanor charges became the norm for individuals with no prior convictions or with small amounts in possession. Concerns that cannabis law enforcement could alienate a whole generation of Americans (Hills, 1970), with a particular focus on shielding middle-class White youth from the criminal justice system, gradually led not only to a reduction in criminal penalties but also to a pause in the growth of cannabis arrests nationally (Lassiter, 2023). Arrests peaked in 1973 at 200 per 100,000 residents and stayed roughly level until the mid-1980s, then actually fell through the early 1990s, as did the relative share of cannabis arrests in total drug arrest activity (Beckett and Herbert, 2008).

The next historical chapter of cannabis law enforcement emerged in the 1990s, marked by historically unprecedented levels of arrests. Data from the Federal Bureau of Investigation's Uniform Crime Report show that cannabis arrests began rising in 1992 and by 1994 had surpassed previous 1970s-era peaks. This pattern of increase in enforcement activity continued through 2007. A few features of the 1992–2007 enforcement era stand out. First, cannabis possession offenses were the main driver of increased arrest totals; relegated to a lower priority in the past, strict enforcement of possession laws emerged as standard enforcement practice. In New York City, this change in priority sent cannabis possession arrests soaring, from a mere 774 in 1991 to more than 50,000 in the year 2000 (Geller and Fagan, 2010). Cannabis arrests once again rose to more than half of all drug arrests nationally (Golub et al., 2007; King and Mauer, 2006) (Figure 1-10).

Second, the 1992–2007 enforcement period featured significant racial disproportion, as numerous contemporary studies confirmed (Beckett et al., 2005, 2006; Cole, 1999; Tonry, 2011)—the highest levels of racial disproportion in the history of U.S. cannabis law enforcement. Racial disproportion entered every phase of the process, including initial stop, arrest, pretrial detention, charge, and final disposition (Geller and Fagan, 2010; Golub et al., 2007). Whether this disproportion is understood as a reflection of drug markets or enforcement tactics (Coker, 2002; Tonry, 1995) or of explicit racial bias (Alexander, 2010; Beckett et al., 2005, 2006), or as a broader consequence of institutional racism (Cole, 1999; Lynch and Campbell, 2011), it remains true that because of these enforcement patterns, the impact of cannabis enforcement was not experienced evenly.[9]

[9] The extreme racial disproportion in cannabis arrests during this latter period reflects a historical truism that drug law enforcement has always reflected particular social control agendas, equally true whether the focus was on "hippies" on college campuses in the 1960s or urban minority youth in the 1990s. Antidrug policies have always patterned themselves around larger social and political agendas, while resting upon a foundation of sentiment opposing the drugs themselves. In the case of the 1992–2007 period, cannabis continued to be framed as a dangerously addictive drug, a gateway drug, and a source of violent behavior. In a 2002 letter to state and local prosecutors, the White House Office of National Drug Control Policy averred that no drug matches the threat posed by marijuana (Lassiter, 2023).

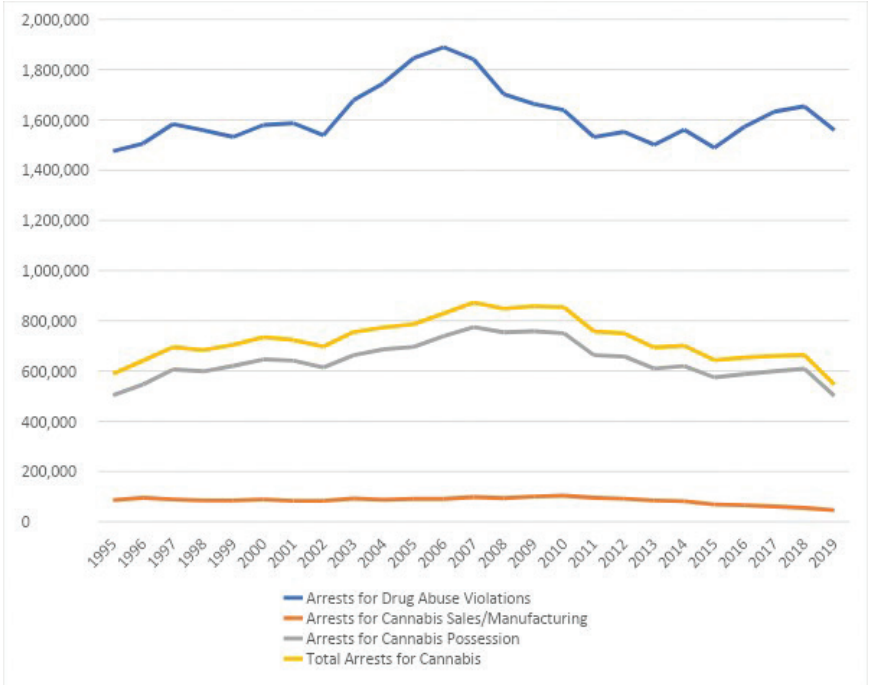


FIGURE 1-10 Drug arrests in the United States, 1995–2019.
NOTES: The numbers of cannabis arrests were calculated by multiplying the percentage of drug arrests by the proportion of drug arrests attributed to cannabis possession (%) and cannabis sales (%). (Federal Bureau of Investigation (FBI) data refer to cannabis arrests as "marijuana.") Because of the FBI's hierarchy rule, these figures underestimate total drug arrests.
SOURCE: Generated by the committee using annual data from the Federal Bureau of Investigation's Uniform Crime Report (https://ucr.fbi.gov/crime-in-the-u.s [accessed July 7, 2024]); see Angell, 2017, for the 2016 breakdown of arrest type.

It is important to note that the period with the highest levels of cannabis arrests (1992–2007) was also a time of increasing consequences for the arrested person. During this era, the collateral penalties occurring because of a criminal arrest or conviction, apart from the actual sanction for the offense, increased dramatically. Collateral consequences limit certain civil rights. For example, voting has long been part of the experience of punishment in the United States and may play a role in perpetuating health disparities in marginalized groups. These consequences were largely the result of a series of laws passed by Congress—such as the Anti-Drug Abuse Act of 1988, the Personal Responsibility and Work Opportunity Reconciliation Act of 1996, and the 1998 Drug-Free Student Loan Provisions

of the Higher Education Act[10]—that collectively limited or cut off access to federally funded health care programs, federal education aid, federally subsidized housing, welfare and food stamp benefits, and more (Chin, 2002; Silva, 2015).

Conclusion

This brief survey of historical patterns in cannabis law enforcement suggests that the contemporary period of adult-use cannabis legalization emerged out of a precise historical moment during which criminal justice activity, collateral consequences of drug law convictions, and racial inequity in cannabis law enforcement were all at historically high levels.

History demonstrates that cannabis policy is a complex and contested sociopolitical landscape. The following chapters delve deeper into this critical issue, exploring core public health concepts as they relate to cannabis, examining usage patterns and markets, and analyzing the impact of current and potential cannabis policies on public health outcomes. Understanding of these various dimensions of cannabis policy can allow society to move toward a more informed and equitable approach to cannabis regulation.

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[10] Federal student aid is now allowed among those with a drug conviction (see https://studentaid.gov/help-center/answers/article/do-drug-convictions-affect-ability-to-get-federal-student-aid [accessed August 14, 2024]), but state aid may still have restrictions.

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ANNEX TABLE 1-1 Therapeutic Effects and Benefits of Cannabis Identified in a 2017 National Academies Report

Outcome	Conclusion 2017
Therapeutic Use	
Chemotherapy-induced nausea and vomiting	There is conclusive evidence that oral cannabinoids are effective antiemetics in the treatment of chemotherapy-induced nausea and vomiting.
Chronic pain	There is substantial evidence that cannabis is an effective treatment for chronic pain in adults. In adults with chronic pain, patients who were treated with cannabis or cannabinoids (nabiximols and nabilone) were more likely to experience a clinically significant reduction in pain symptoms.
Respiratory Disease	
General respiratory health	There is moderate evidence of a statistical association between cannabis smoking and improved airway dynamics with acute use but not with chronic use. There is moderate evidence of a statistical association between cessation of cannabis smoking and improvement in respiratory symptoms.
Chronic bronchitis	There is substantial evidence of a statistical association between long-term cannabis smoking and worse respiratory symptoms and more frequent chronic bronchitis episodes.
Forced vital capacity (FVC)	There is moderate evidence of a statistical association between cannabis smoking and higher forced vital capacity (FVC).
Chronic obstructive pulmonary disease (COPD)	There is limited evidence of a statistical association between occasional cannabis smoking and increased risk of developing chronic obstructive pulmonary disease (COPD) when controlled for tobacco use. There is insufficient evidence to support or refute a statistical association between cannabis smoking and hospital admissions for COPD.
Asthma	There is insufficient evidence to support or refute a statistical association between cannabis smoking and asthma development or asthma exacerbation.
Injury and Death	
All-cause mortality	There is insufficient evidence to support or refute a statistical association between self-reported cannabis use and all-cause mortality.
Motor vehicle collisions	There is substantial evidence of a statistical association between cannabis use and increased risk of motor vehicle crashes.
Occupational injury	There is insufficient evidence to support or refute a statistical association between general, nonmedical cannabis use and occupational accidents or injuries. It is unclear whether and how cannabis use is associated with all-cause mortality or occupational injury.
Pediatric poisonings	There is moderate evidence of a statistical association between cannabis use and increased risk of overdose injuries, including respiratory distress, among pediatric populations in U.S. states where cannabis is legal.

ANNEX TABLE 1-1 Continued

Outcome	Conclusion 2017
Cancer	There is moderate evidence that smoking cannabis *does not* increase the risk for cancers often associated with tobacco use, such as lung, head, and neck cancers. There is limited evidence of a statistical association between current, frequent, or chronic cannabis smoking and nonseminoma-type testicular germ cell tumors. Evidence was insufficient for all other cancers evaluated by the committee.
Cardiometabolic risk	
Acute myocardial infarction	There is limited evidence of a statistical association between cannabis smoking and the triggering of acute myocardial infarction. There is no evidence to support or refute a statistical association between the chronic effects of cannabis use and the risk of acute myocardial infarction.
Stroke	There is limited evidence of a statistical association between cannabis use and ischemic stroke or subarachnoid hemorrhage.
Immunity	
Immune competency	There is insufficient data to draw overarching conclusions concerning the effects of cannabis smoke or cannabinoids on immune competence.
Anti-inflammatory properties	There is limited evidence to suggest that regular exposure to cannabis smoke may have anti-inflammatory activity.
Human immunodeficiency virus (HIV)	There is insufficient evidence to support or refute a statistical association between cannabis or cannabinoid use and adverse effects on immune status in individuals with human immunodeficiency virus (HIV).
Prenatal & Perinatal Outcomes	
Pregnancy complications for the mother	There is limited evidence of a statistical association between maternal cannabis smoking and pregnancy complications for the mother.
Fetal growth and development	There is substantial evidence of a statistical association between maternal cannabis smoking and the lower birth weight of the offspring.
Neonatal conditions	There is limited evidence of a statistical association between maternal cannabis smoking and admission of the infant to the neonatal intensive care unit (NICU).
Downstream impact	There is insufficient evidence to support or refute a statistical association between maternal cannabis smoking and later outcomes for the offspring (e.g., sudden infant death syndrome, cognition/academic achievement, and later substance use).

(*continued*)

ANNEX TABLE 1-1 Continued

Outcome	Conclusion 2017
Psychosocial	
Academic achievement	There is limited evidence of a statistical association between cannabis use and impaired academic achievement and education outcomes.
Learning, memory, and attention	There is limited evidence to suggest that there are impairments in cognitive domains of learning, memory, and attention in individuals who have stopped smoking cannabis.
Mental Health	
Anxiety	There is limited evidence of a statistical association between near daily cannabis use and increased symptoms of anxiety.
Bipolar disorder	There is moderate evidence of a statistical association between cannabis use and increased symptoms of mania and hypomania in individuals diagnosed with bipolar disorders.
Depression	There is moderate evidence of a statistical association between cannabis use and a small increased risk for the development of depressive disorders.
Posttraumatic stress disorder (PTSD)	There is limited evidence of a statistical association between cannabis use and increased severity of PTSD symptoms among individuals with PTSD.
Psychoses	There is substantial evidence of a statistical association between cannabis use and the development of schizophrenia or other psychoses, with the highest risk among those that use most frequently.
Schizophrenia	There is substantial evidence of a statistical association between cannabis use and the development of schizophrenia or other psychoses, with the highest risk among those who use most frequently.
Social Anxiety	There is moderate evidence of a statistical association between cannabis use and increased risk of developing social anxiety disorder.
Suicidality	There is moderate evidence of a statistical association between cannabis use and increased incidence of suicidal ideation and suicide attempts, as well as increased incidence of suicide completion, with a higher incidence among those who use cannabis heavily.
Substance Use	
Alcohol	There is moderate evidence to suggest a link between cannabis use and the development of substance dependence or a substance abuse disorder for such substances as alcohol, tobacco, and other illicit drugs.
Cannabis use disorder	There is substantial evidence that initiating cannabis use at an earlier age is a risk factor for the development of problem cannabis use. There is also an association between increases in cannabis use frequency and the development of problem cannabis use.
Tobacco	There is limited evidence that cannabis use increases the rate of initiating other drug use, primarily tobacco.
Other illicit substances	There is moderate evidence to suggest a link between cannabis use and the development of substance dependence or a substance abuse disorder for such substances as alcohol, tobacco, and other illicit drugs.

SOURCE: Adapted from NASEM, 2017.

2

Overview of Cannabis Policy

Policy development, a crucial element in minimizing potential harms from cannabis legalization and promoting health equity, has been a cornerstone of many major public health achievements (CDC, 1999, 2011). Policies that influence the cannabis supply chain can greatly influence public health (Hall and Pacula, 2003; Kilmer, 2019). While many alternative models exist—ranging from allowing home cultivation to licensing for-profit companies to produce and sell cannabis—each with its potential harms and benefits (Figure 2-1), states that have legalized cannabis have chosen commercial models.

If a jurisdiction legalizes cannabis, policies that manage the legal supply chain are needed to protect public health. The legal supply chain, which covers everything from cultivation and processing to distribution and conditions of retail sale, takes a variety of forms (Blanchette et al., 2022a; Caulkins and Kilmer, 2016). Legal cannabis production can include small-scale production, such as home cultivation and cannabis clubs or social clubs, the latter being typically formal, nonprofit associations of adult cannabis users who produce and distribute cannabis close to or at cost among themselves (Decorte et al., 2017; Pardal, 2022). In contrast, large-scale commercial production for distribution in retail outlets offers better opportunities for regulation of production, retail sales, and possession or use, but also entails more complexities than small-scale production (Caulkins and Kilmer, 2016).

Legal commercial markets ideally include policies on cultivation, product manufacturing, marketing and sales, and consumption or use (Figure 2-2). Different agencies regulate cultivation, pesticides used, products

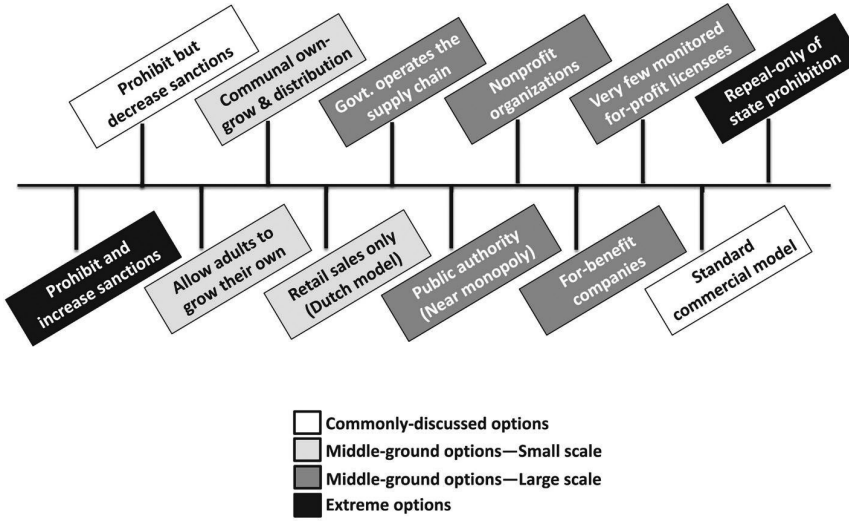

FIGURE 2-1 Twelve alternatives to status quo prohibition of cannabis supply. SOURCE: Caulkins and Kilmer, 2016.

produced and distributed, the individuals and organizations that are allowed to participate in the market, how each is allowed to operate, and how legalization is implemented. For example, product safety and quality are influenced by decisions related to the cultivation of cannabis, the cannabinoid extraction process, and any other chemicals used to produce the final product. Policies around sales and marketing can educate consumers about products; for example, labeling can reduce accidental consumption and provide consumers with information about dosing and prevention of harmful use. Policies on advertising and promotion shape who can see them, where they are allowed, and what the advertisements must contain. Another consideration relates to licenses, the number and types of outlets where cannabis can be sold and how, and the circumstances in which the

FIGURE 2-2 Conceptual framework of where public health policy can intervene to prevent the harms and promote the benefits of cannabis use.

product can be sold—for example, whether it can be sold with food, with or without other intoxicants, and whether consumption can occur on premises. Another consideration is the geographic location and density of cannabis retail outlets.

To evaluate cannabis policy in the United States, the committee considered regulatory regimes worldwide. It then evaluated cannabis policies within the United States, describing observed variations in cannabis policies related to public health. The committee chose to evaluate the variation in state policies because systematically collecting local policy data within and across states was infeasible, and information on compliance with state regulations is scarce. Where available, the committee also considered the limited evidence on the implications of local public health regulations. The committee then considered alternative regulation models, such as those for tobacco and alcohol in the United States and for cannabis in Canada and Uruguay.

CANNABIS REGULATORY REGIMES ACROSS THE WORLD

As of 2021, 64 countries had provisions in national law or had developed guidelines allowing medical use of cannabinoid products (UNODC, 2022). Several countries have adopted or tolerated alternatives to the legalization of the entire supply chain, which offer opportunities to grow or sell cannabis for adult use but do not allow commercial cultivation and production of cannabis (Kilmer and Pacula, 2017; UNODC, 2022). In Spain, Belgium, and 11 other countries in Europe, for example, cannabis clubs and nonprofit collectives allow adults to cultivate, produce, and distribute cannabis collaboratively among themselves (Pardal, 2022). In the Netherlands, the cultivation, production, sale, and possession of cannabis are illegal, yet cannabis sales for personal use at coffee shops are tolerated (Government of the Netherlands, n.d.b). Thus, coffee shops must acquire the product from illegal sources. Some municipalities license coffee shops for selling cannabis. Additionally, court decisions in some countries (e.g., Mexico) have created ambiguity around the legality of home growing (Pardal, 2022). Thus, there has been considerable variability internationally in alternatives to prohibition and models of supply.

Pilot experiments in cannabis regulation offer potential insights into the public health effects of different regulatory models. In particular, the Netherlands and Switzerland have passed laws authorizing studies on cannabis regulation. The Government of the Netherlands (2019) is currently running a 4-year study whereby 10 growers are legally allowed to produce cannabis to sell to coffee shops in 10 municipalities; the researchers will then evaluate the impact of this experiment on public health and crime. Furthermore, in Switzerland, through the Ordinance on Pilot Trials under the

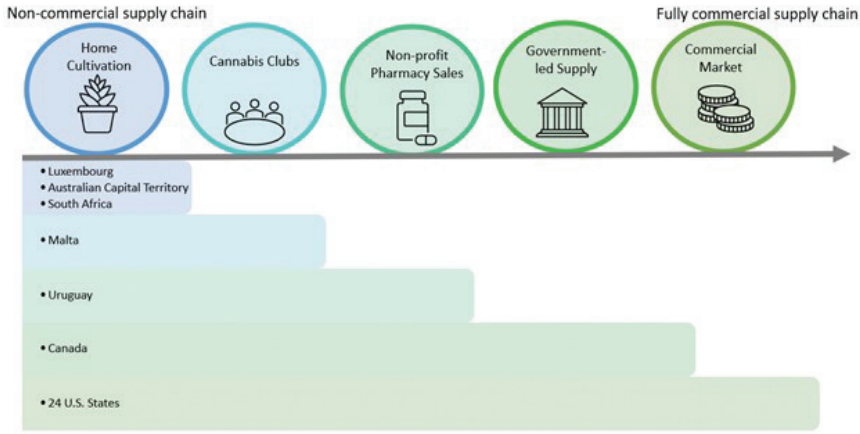

FIGURE 2-3 Many different cannabis legalization models have been undertaken worldwide, with different levels of commercialization.
NOTES: Luxemburg, Australian Capital Territory Only, and South Africa allow only home cultivation; Malta allows home cultivation and cannabis clubs; Canada has a mix of government-run supply and commercial markets; and all the U.S. states that have legalized cannabis have fully commercial markets.

Federal Narcotics Act, cantons, municipalities, and organizations (including universities) will be able to conduct trials to investigate the impact of different cannabis distribution channels (pharmacy distribution, cannabis social clubs, and nonprofit retail outlets), and to test cannabis products of different tetrahydrocannabinol (THC) concentration levels (FOPH, 2023).

In contrast, as of April of 2024, Canada, Luxembourg, Malta, Uruguay, South Africa, one state in Australia, and 24 states in the United States have legalized cannabis supply to and possession for adults. However, their approaches differ meaningfully (Figure 2-3). Luxembourg, the Australian Capital Territory, and South Africa[1] have legalized home cultivation and possession for personal use. Malta has gone a step further: it allows home cultivation as well as the operation of nonprofit cannabis clubs, which are allowed to grow and supply cannabis to their members (Pardal, 2022). Uruguay uses a hybrid approach, with legalization for nonprofits and a highly government-regulated form of for-profit legalization. Home cultivation, cannabis clubs, and retail sales in pharmacies are allowed; however, the government controls large-scale cannabis cultivation, and the product and retail operations are highly regulated (Cerdá and Kilmer, 2017). Canada

[1] On May 28, 2024, South African lawmakers legalized cannabis for personal use. The sale and creation of a legal market for cannabis are prohibited (Sabaghi, 2024).

also takes a hybrid approach to the government's involvement in the supply of cannabis in the adult-use market, allowing models to vary by province, with some provinces restricting retail sales to government-run stores and others allowing private retail sales or a combination of both. Finally, the United States represents the fully commercial option on the supply regulation spectrum, with the private sector conducting cultivation, production, and retail sales. In addition, most states also allow some form of home production and sharing.

CANNABIS REGULATION IN THE UNITED STATES

Cannabis regulation in the United States is complicated by the lack of federal involvement in the drug's legalization. In most areas of public health regulation, U.S. states have historically had a federal partner that has assisted in the regulation of broad market factors such as product quality assurance (through the Food and Drug Administration [FDA]), testing (through the FDA and the U.S. Department of Agriculture [USDA]), prevention (through the Centers for Disease Control and Prevention [CDC]), and industry structure (through the Federal Trade Commission). States have the authority to regulate products under the 10th Amendment of the U.S. Constitution, which establishes that the federal government's powers are restricted to those delegated by the Constitution and that the states have all remaining powers. While state authorities have limits (e.g., through preemption, through federal drug scheduling, in use of federal funds), they nonetheless have significant experience and history in regulating legal commodities and behaviors that impact public health, from alcohol and tobacco to sugary drinks, safe driving practices, and pesticides used in agriculture.

Local governments also have several mechanisms available for regulating cannabis within their jurisdictions, such as zoning restrictions determining where retail outlets can be located, regulations regarding the types of products that can be sold, rules on additives or ingredients that can be contained in products sold (e.g., flavoring bans), restrictions on advertising, and taxation (Caulkins and Kilborn, 2019; Dilley et al., 2017; Payán et al., 2021). At times, local authorities have implemented stricter regulations than those adopted by the state. Thus, defining "cannabis public health regulations" within any state is complicated because state policies alone do not necessarily define the local regulatory environments.

Tribal sovereignty presents a unique challenge in cannabis policy for the United States. Within states that have legalized cannabis, tribes retain the authority to establish their own decisions and rules related to legalization, potentially creating a situation in which federal prohibition remains in effect on tribal lands after the state has legalized cannabis. This challenge stems from the inherent sovereignty of federally recognized tribes, which

generally exempts them from state laws within reservation boundaries. Similarly, tribes possess the legal authority to license, regulate, and even legalize cannabis activities on their reservations, even if recreational marijuana sales are not legal in the surrounding state. Importantly, some state statutes explicitly exclude Native American tribes from participating in cannabis licensing processes, creating a potential conflict with tribal sovereignty (Mooney, 2022).

Since the first states legalized cannabis for adult use in 2012, there have been efforts to describe the regulatory frameworks that have either already been adopted by individual states or might be considered by states adopting adult-use policies in the future (Barry and Glantz, 2016; Blanchette et al., 2022a; Ghosh, 2016; Pacula et al., 2014a). Because 14 of the first 16 adult-use laws were passed by states through ballot measures (Schauer, 2021), legislators and regulatory agencies were assigned responsibilities based on broad notions of how the populace wanted the markets to operate; they were not carefully designed market systems. Moreover, state agencies were given relatively short periods within which to establish these markets. Initial regulations, therefore, focused on setting up licenses and legal supply chains and addressing voters' objectives in initiatives to eliminate the illicit market, including the involvement of gangs and other actors engaged in the trafficking of illegal drugs. The early regulations also included a few broad public health objectives, such as preventing the distribution of cannabis to underage people, making a safe product available, and preventing impaired driving. As more time passed, regulators in these early-adopting states began to grapple with some of the more challenging public health aspects of cannabis policy—product regulation and testing, marketing restrictions, and warnings. The delay in addressing some of these public health issues has made it challenging for researchers to understand which state policies are the most effective at promoting public health.

Impact of The 2018 Agriculture Improvement Act

The 2018 Agriculture Improvement Act (2018 Farm Bill) has had a profound impact on the cannabis landscape in the United States and confuses any policy analysis at this time. As discussed in Chapter 1, this legislation redefined "hemp," allowing its legal sale without its being subject to the Controlled Substances Act (Gottron et al., 2019). According to the 2018 Farm Bill, "hemp" is now defined as "the plant Cannabis sativa L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a [delta-9-THC] concentration of not more than 0.3 percent on a dry weight basis" (PL-115-334, § 297A). This definition has led to legal ambiguities, facilitating the production and sale of cannabinoids derived

from hemp and leading to a largely unregulated, multibillion-dollar industry (Skodzinski, 2024) that competes with the regulated state-legal cannabis industry (Johnson, 2023; Johnson and Willner, 2023). The inclusion of the terms "all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers" has also led to the sale of intoxicating cannabis products, especially in states that have not chosen to legalize cannabis (Demko, 2024).

One cannabinoid that has garnered tremendous consumer interest is cannabidiol (CBD). A purified form of CBD, Epidiolex®, is approved for oral administration by the FDA for the treatment of infantile refractory epileptic syndromes. Consumers have also demonstrated interest in CBD's other potential benefits, such as its antianxiety and anti-inflammatory properties. CBD is added to dietary supplements, foods, drinks, and health and beauty products. In 2018 and 2019, CBD sales proliferated despite regulatory uncertainty. The FDA has said that it is "unlawful" under the Federal Food, Drug, and Cosmetic Act (21 USC §§301 et seq.) to market CBD products as or in dietary supplements and formed a working group to determine a legal pathway for CBD (Johnson, 2019). As of January of 2023, the FDA is working with Congress to develop a new regulatory pathway for CBD following years of FDA review related to CBD product regulation (Johnson, 2023). In July 2023, several members of Congress requested information from stakeholders on how to "provide a legal pathway" for marketing CBD products (Johnson, 2023).

The primary concern for public health, though, is the unregulated market of cannabis products that contain delta-9-THC or similar compounds. Among those concerns are an abuse of the "dry-weight" delta-9-THC definition of hemp (Williams, 2021); the sale of cannabis flower containing notable concentrations of naturally occurring tetrahydrocannabinolic acid (THCA), a precursor to delta-9-THC; and the sale of cannabis products that contain synthetic derivatives of CBD, such as delta-8-THC (CANNRA, 2023).

Because federal guidance has been limited, the cannabis industry is shrouded in uncertainty and conflicting interpretations. For example, some cannabis businesses have tried to leverage the dry-weight concentration of delta-9-THC (0.3 percent) specified in the 2018 Farm Bill by applying it to products created with hemp (Williams, 2021). Cannabis edibles in the form of chocolates or gummy candies allow producers to leverage the "dry weight" distinction because chocolates and gummy candy contain little water. A 5-g gummy candy can contain roughly 15 mg of delta-9-THC (5-g candy × 0.3% = 0.015 g = 15 mg delta-9-THC) and remain within the dry-weight definition of hemp. For comparison, a standard cannabis edible in Colorado contains 10 mg delta-9-THC (Johnson et al., 2023). Legal experts advising the cannabis industry have stated that "dry weight" does not apply to final products, although the practice appears to be common (Williams, 2021).

Another legal uncertainty concerns the USDA's testing protocols for hemp. The USDA requires that cannabis plants be tested for total THC (including THCA and delta-9-THC concentrations) [total THC = %delta-9-THC + (%THCA × 0.877)] days before harvest) (USDA, 2021a,b). However, some growers claim the THC concentration changes between the sampling and harvest dates. Additionally, there are accounts of laboratories reporting delta-9-THC separately from THCA and then convincing law enforcement to ignore the THCA content (Sacirbey, 2024).

A major issue with uncertainties associated with the 2018 Farm Bill is the proliferation of delta-8-THC products throughout the United States. Delta-8-THC occurs naturally in cannabis at minimal concentrations, but it can be chemically synthesized from hemp-derived CBD. Although the size of the delta-8-THC market is unknown, its growth concerns those in the legal cannabis industry, public health, and state lawmakers (Skodzinski, 2024). Unlike the state-regulated cannabis industry, the products are not regulated or taxed, causing state governments to lose tax revenue. Most important, the products are not usually subject to established public health regulations for product safety or restrictions on sales to those under age 21 (Elbein, 2024). Delta-8-THC raises safety concerns for many reasons. Its production uses potentially harmful solvents, such as toluene and heptane, and may create harmful by-products from the reaction. There continues to be much regulatory uncertainty over "hemp-derived THC." Although a ruling in a federal court supported the industry's opinion that delta-8-THC is not subject to the Controlled Substances Act (Kroll, 2022), more recent Drug Enforcement Administration communications stated that THC derivatives synthetically derived from CBD, such as delta-8-THC, are federally illegal (Jaeger, 2023).

State legislators and regulatory bodies are grappling with the challenge of regulating the burgeoning market for hemp-derived THC products. Efforts to restrict their sale have faced legal resistance in some places. Court rulings on the issue have thus far been inconsistent, leaving state regulatory authority unclear. A recent example is a preliminary injunction issued by a federal judge in Arkansas, which halted the implementation of a state law banning intoxicating hemp products (Demko, 2024). As of November 2023, 17 states had successfully banned delta-8-THC, and 7 had severely restricted its sale (Johnson and Willner, 2023). Recently, a bipartisan group of state attorneys general wrote to Congress asking it to act regarding what they termed "intoxicating hemp products," expressing concern that a public health crisis is looming (Demko, 2024; Elbein, 2024).

Areas of Cannabis Regulation Most Pertinent for Public Health

Health is essential in public policy development, including areas not traditionally considered by public health professionals (Hall and Jacobson,

2018). Many aspects of a chosen cannabis supply framework could influence public health outcomes. However, relatively few cannabis policies have been formally and systematically compared across states until recently (see Chapter 4).

The current state of cannabis regulation in the United States is complex because of the lack of federal involvement. Analysis reveals variations in regulations (advertising restrictions, product types, THC concentration limits), as well as enforcement (age verification, product safety). The patchwork of federal, state, and local regulations makes it challenging to study the effectiveness of different regulatory approaches within the states. While initial regulations focused on establishing legal markets, the focus has shifted toward addressing public health concerns such as ensuring product safety, limiting exposure to and use by youth, and preventing impaired driving.

Lessons from tobacco and alcohol control can provide frameworks for thinking about cannabis policy, and each has been well studied. Studies have compared different regulatory models of the tobacco industry's influence on youth access to cigarettes, and on the early initiation and popularity of smoking (CDC, 2012; Chaloupka, 1999; DeCicca et al., 2022; Higgins et al., 2019). Similar literature exists for alcohol and alcohol-related harms (Cook, 2007; Nelson et al., 2013, 2015; Office of the Surgeon General et al., 2007; Toomey and Wagenaar, 1999). Evidence about cannabis regulations is limited because the variation in state regulatory approaches to adult use has been well documented only recently (APIS, 2023a; Blanchette et al., 2022b; Schauer, 2021). While analogies can and have been made to tobacco and alcohol (Barry and Glantz, 2018; Hall, 2017; Orenstein and Glantz, 2018; Pacula et al., 2014b; Steinberg et al., 2020), there are important differences among cannabis products. The cannabis plant is more than a cannabinoid, with plant hybrids having unique chemical profiles (Procaccia et al., 2022). The cannabinoid mixtures within different plant hybrids can have different health effects, and there is therapeutic value in consuming particular cannabinoids when trying to manage some medical symptoms and conditions (Lynch and Campbell, 2011; Wang et al., 2021). Tobacco and alcohol do not have health benefits and thus are vastly different. Thus, it is difficult to know in advance the extent to which specific regulatory strategies targeting alcohol or nicotine and tobacco would be similarly effective for cannabis.

In 2019, researchers from Boston University and RAND organized a group of public health experts and asked them to nominate and rank state-level cannabis regulatory policies they believed (based on their knowledge of the scientific literature studying cannabis, alcohol, tobacco, and opioids) were likely to be the most effective at achieving three public health objectives associated cannabis legalization: (1) minimizing excess use of cannabis by the general population, (2) limiting youth use, and (3) reducing

cannabis-impaired driving (Blanchette et al., 2022a). Through a modified Delphi process, the group of public health experts identified state regulations likely to achieve the public health aims (see Table 2-1): the adoption of a state monopoly, restrictions on physical retail availability, tax strategies, retail price and operating restrictions, and product design restrictions and requirements. Policies on youth access and advertising restrictions were also deemed likely to be highly effective in reducing youth access. For

TABLE 2-1 Median Efficacy Ratings from a Modified Delphi Process

	Median efficacy rating (ranking)		
Policy	**General population rating (rank)**	**Youth rating (rank)**	**Impaired driving rating (rank)**
State monopoly	5.0 (1)	5.0 (1)	4.0 (1)
Physical retail availability restrictions	4.5 (2)	4.0 (3)	4.0 (1)
Taxes	4.5 (2)	4.5 (2)	3.5 (4)
Retail price restrictions	4.0 (4)	4.0 (3)	3.5 (4)
Retail operations restrictions and requirements	4.0 (4)	4.0 (3)	3.0 (6)
Product design restrictions and requirements	3.5 (6)	3.5 (8)	3.0 (6)
Advertising restrictions	3.5 (6)	4.0 (3)	2.5 (8)
Cultivation and manufacturing Operations restrictions and requirements	3.0 (8)	2.5 (11)	1.5 (13)
Delivery restrictions of recreational cannabis to consumers	3.0 (8)	3.0 (9)	1.5 (13)
Penalties for adults who possess cannabis for personal use	2.5 (10)	2.0 (13)	1.5 (13)
Clean air and smoke free laws	2.5 (10)	3.0 (9)	2.0 (11)
Packaging and labeling restrictions and requirements	2.5 (10)	2.5 (11)	2.5 (8)
Cannabis possession limits	2.5 (10)	2.0 (13)	2.0 (11)
Impaired driving laws	2.0 (14)	2.0 (13)	4.0 (1)
Youth policies	2.0 (14)	4.0 (3)	2.5 (8)
Home cultivation restrictions	2.0 (14)	2.0 (13)	1.5 (13)
Medical marijuana restrictions and requirements	2.0 (14)	2.0 (13)	1.5 (13)
Track-and-trace requirements	2.0 (14)	2.0 (13)	1.0 (18)

NOTE: Panelists rated the relative efficacy (based on the other policy options) using a scale from 1 = "less effective" to 5 = "more effective."
SOURCE: Blanchette et al., 2022a.

the explicit goal of reducing cannabis-impaired driving, the group further deemed regulations on impaired driving to be highly important. The panel excluded two critical public health strategies—minimum unit pricing and primary prevention efforts—because of presumed implementation challenges (Blanchette et al., 2022a).

Given the presumed effectiveness of these regulations, the committee next describes how states legalizing cannabis have considered these regulatory options and discusses how they tie into the broader framework proposed in Figure 2-1. Data on the impact of state and local regulations on the cannabis industry are very scarce and limited, especially regarding the density and location of retail outlets. Hence, this discussion focuses on the impact of regulations on the cannabis industry in those areas in which data are available. The committee then contrasts the U.S. regulatory approach with the approaches implemented by other countries to identify potential avenues for public health benefits.

State Monopoly

State monopolies or government-controlled systems, can be applied to all or a segment of the cannabis supply chain, such as cultivation, processing, wholesale purchasing, or retail sales. While no U.S. state has yet adopted a monopoly model for cannabis because of concerns of legal entanglement with the federal government, two states (Vermont and New Hampshire) have proposed such a model while deliberating on ways to regulate supply. This might be a viable model for some states if the federal government reversed its policy, as state monopolies have been used for alcohol sales in some states. Studies evaluating alcohol monopolies suggest that state monopolies limit problems from commercial markets, such as exposure to a large number of outlets and the marketing of those outlets; monopolies also may maintain higher prices and limit general access and sales (Holder, 1993; Room, 1987; Wagenaar and Holder, 1995).

Physical Retail Availability Restrictions

Restrictions on physical retail availability can be imposed using several regulatory tools, including limits on the absolute number and types of outlets allowed, local zoning laws influencing the location of outlets, setback limits, whether on-premises consumption is allowed, and restrictions on the hours or days of sales. States and—to a more considerable extent—local jurisdictions have implemented regulations in each area.

State approaches to regulating the number of retail outlets vary considerably. As shown in Figure 2-4, earlier-adopting states have allowed higher outlet density per 100,000 adults, while later-adopting states generally

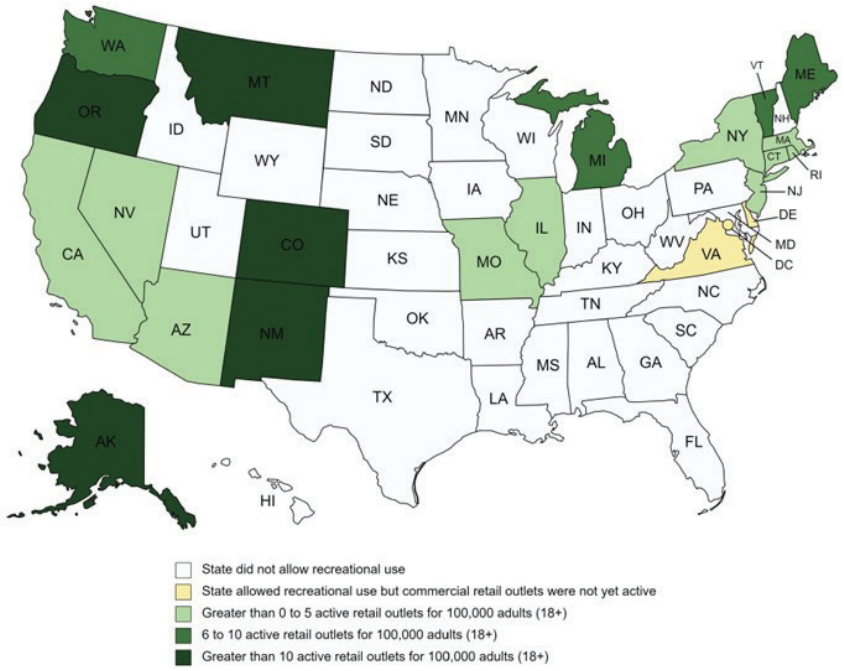

FIGURE 2-4 Outlet density in legal nonmedical cannabis states as of January 2023. SOURCE: Joy Zhu collected data from state cannabis licensing agency websites for the National Institute on Alcohol Abuse and Alcoholism–funded Marijuana Policy Scale project (1R01AA026268-01: PI: Tim Naimi).

have imposed more restrictions on the number of outlets per capita. Seven states (Arizona, Connecticut, Illinois, Nevada, Rhode Island, Virginia, and Washington) impose a cap on the total number of retail outlets allowed.

States impose laws or rules regarding retail storefronts and place limitations on where these businesses can operate. These laws are often created to strike a balance among accommodating the burgeoning cannabis industry; preventing oversaturation of the market in certain areas; and addressing concerns about public safety, youth exposure, and "community aesthetics." Laws are common that require retail cannabis businesses to remain a specific distance from public areas and child-centered institutions—typically 500–1000 feet from schools, childcare centers, and community centers. Certain states also have regulations that prohibit retail stores from locating within a specified distance of religious institutions or places of worship, such as churches and synagogues. States also generally allow localities to increase setback requirements, thus placing further limitations on store access.

Local jurisdictions restrict retail stores as well; these regulations vary widely, from all-out bans on outlets to permitting unlimited outlets (Dilley et al., 2017; Matthay et al., 2022; Payán et al., 2021). The density of retail outlets is lower in jurisdictions that place limits on or ban retail outlets and (to a lower extent, and only in some studies) in jurisdictions with location restrictions and buffers between outlets (Bostean et al., 2023; Matthay et al., 2022).

As with alcohol, additional limits on the availability of physical retail outlets, including restrictions on on-premises consumption, hours, and days of sale, are typically state or local policies. Eight states allow on-premises consumption with a license (APIS, 2023b). Additionally, states limit the types of products sold and the quantities in which they can be sold (Schauer, 2021). These limits are discussed in greater detail in the section on product design.

Taxes

Taxation has played an important role in keeping the retail prices of alcohol and tobacco high, which lowers use and reduces harm (IOM, 2007; NASEM, 2018). Recently, however, alcohol taxes have been reduced when adjusted for inflation, as a result of industry lobbying (Blanchette et al., 2020). In the case of cannabis, taxation has been less impactful in keeping retail prices high. Cannabis taxes are a percentage of the price. Thus, taxes have been lower because of the tremendous price declines seen in the wholesale marketplace as a result of legalization (Davenport, 2021; Kilmer and Pérez-Dávila, 2023; Smart et al., 2017). Distribution of tax revenues can potentially fund programs to mitigate public health and public safety risks associated with cannabis, making this an important opportunity for improving health and social equity (Schauer, 2021).

Most states impose sales and excise taxes based on the value of the total products sold (an ad valorem tax, based on the product's price or weight; see Figure 2-5). In states such as Alaska and Montana, where no statewide sales tax is applied to any product, cannabis products are also exempt from sales tax. Additional states, including Colorado, Maine, and New York, exempt cannabis products from their existing state sales tax that generally applies to other products (APIS, 2023b). However, most states impose a sales tax on cannabis products in the same percentage range as that imposed on all other products (around 6–8 percent). Most excise taxes (based on the product's weight or the total value) fall in the range of 10–15 percent. Montana and Virginia impose slightly higher excise tax rates of 20 percent and 21 percent, respectively. Washington state places a 37 percent tax on its products—the highest legally imposed excise tax among all states (APIS, 2023b).

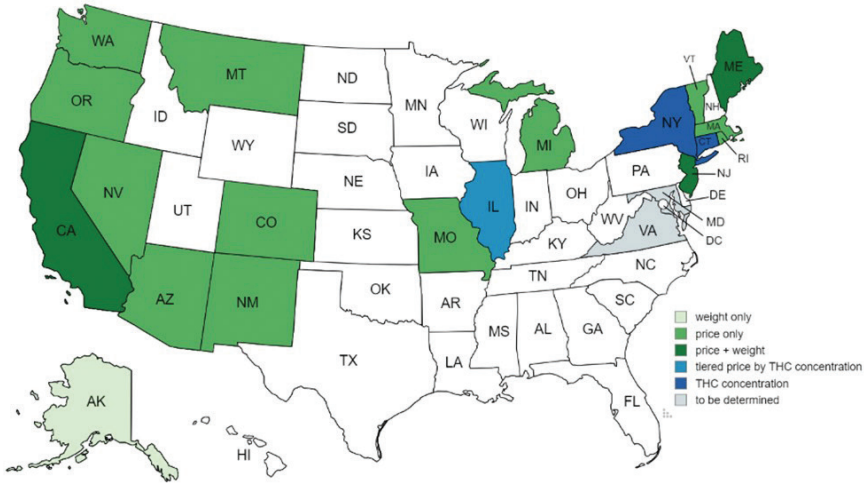

FIGURE 2-5 State taxation of cannabis.
NOTE: As of January 1, 2023, retail sales of cannabis for adult use had not yet begun in Maryland or Virginia.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee based on information from the National Institute on Alcohol Abuse and Alcoholism Alcohol Policy Information System (APIS), https://alcoholpolicy.niaaa.nih.gov/cannabis-policy-topics/recreational-use-of-cannabis-volume-1/104 (accessed April 22, 2023).

While taxing a product based on weight or price is typical for tobacco, alcohol taxation is based instead on the ethanol content of a drink. Only three states to date have imposed something akin to an ethanol-based tax for cannabis. New York and Connecticut impose excise taxes based on the concentration of THC in the cannabis product sold to discourage consumers' purchase of higher-concentration cannabis products, which can carry greater health risks (Hines et al., 2020; Noble et al., 2019; Petrilli et al., 2022; Wilson et al., 2019). Illinois uses a step-based taxation system, whereby cannabis flower and other products with less than 35 percent THC are taxed at a lower (10 percent) excise tax rate than that imposed on products containing greater than 35 percent THC (25 percent) (APIS, 2023b).

The revenue from excise taxes imposed on cannabis products can be used for a variety of objectives beyond public health. New Jersey, for example, imposes a social equity excise fee levied at wholesale at 0.33 percent of the average retail price per ounce for the first 9 months of operation, after which the fee is imposed on a sliding scale from $10 to $60 per ounce, depending on the average statewide retail price for cannabis (N.J.

Admin. Code § 17:30-3.4). Local jurisdictions can also benefit from excise and wholesale cannabis taxes, which can be used for such purposes as education, public safety, and criminal justice reform. However, most states do not mandate such allocations at the state level, allowing municipalities to decide where to disperse the funds (Tax Policy Center, n.d.; Schauer, 2021).

Retail Price Restrictions

States can modulate cannabis prices by taxing cannabis products (discussed above) and by setting minimum pricing standards that establish a floor price below which a cannabis product cannot be sold. Alcohol policy provides important insights about the potential impact of minimum THC unit pricing policies (Humphreys, 2017). The introduction of a minimum alcohol unit price in Scotland in 2018 was associated with reduced alcohol purchases, particularly among the top fifth of households that purchased the greatest amount of alcohol (O'Donnell et al., 2019). Increases in alcohol prices in England were also associated with reduced alcohol use and reduced alcohol-related emergency room visits, injuries, and deaths (Purshouse et al., 2010). A recent World Health Organization (2022) report summarizes the empirical and simulation evidence evaluating the impacts of minimum unit pricing for alcohol in various high-income countries, including provinces of Canada and Australia. WHO concluded that these policies, when set at a price that is passed on to the consumer, do lead to reductions in alcohol consumption, alcohol-related traffic collisions, sexually transmitted diseases, and declines in violence and crime.

According to data from the Alcohol Policy Information System, as of January 1, 2023, 12 of the 21 states where adult use of cannabis was legal had imposed pricing controls. Pricing controls are regulations on pricing that limit the ability of retail stores within those jurisdictions to offer cannabis at a discounted price or at a loss to attract customers (APIS, 2023b). States also have other regulatory levers available to keep stores from offering cannabis at a discounted price, such as bans on happy hours or giveaways.

Retail Operating Restrictions

A range of restrictions can be placed on retail outlets that will influence their operations. In addition to retail price restrictions, these include rules regarding hours or days of operation, minimum legal purchase ages, maximum sales limits, rules on home delivery, mandatory employee training, cash-only purchases, and more. The retail operating restrictions imposed are influenced by where cannabis is sold. For example, the ability to use loss leaders is much reduced when cannabis is sold mostly in cannabis-only stores, as opposed to grocery or convenience stores. As many of these rules

are applied at the local rather than state level, information on the degree to which such rules are applied and their effectiveness at addressing public health concerns is limited.

State-level policy regarding customer age restrictions is consistent across all jurisdictions. In no state is a person under age 21 allowed to purchase cannabis, with certain states, such as Colorado, offering exceptions for those over age 18 with a medical cannabis card (Schauer, 2021). Furthermore, people under age 21 may not be employed by a retail cannabis store, and many states, such as Washington, specifically mandate that all employees be trained on these rules to ensure that they are implemented regularly (Washington State Legislature, Initiative 502). States also universally prohibit employees from openly consuming cannabis products on the premises of the retail outlet.

Hours of operation are often not imposed at the state level; numerous states leave this mandate to municipalities and local governments. There are exceptions, however. A few states set statewide hours during which it is illegal for a retail cannabis store to have its doors open. In New York state, for example, cannabis retail stores cannot be open between 2 a.m. and 8 a.m. (New York Cannabis Law 9 § 116.7). Other states require retail cannabis businesses to be open for a minimum period; otherwise, they risk forfeiture of their retail license. In Washington state, if a cannabis retailer is not open at least 3 days a week for at least 5 hours a day between the hours of 8 a.m. and 12 a.m., its license will be taken under the pretense of the business not being "fully operational" (Washington State Legislature Initiative 502).

As of January 1, 2023, six states with legal cannabis prohibit home delivery statewide, while another ten impose restrictions or limits on home delivery services (APIS, 2023b). In the states that allow it, home delivery represents a growing percentage of online sales for large online stores and local brick-and-mortar outlets. Delivery services may promote more at-home than in-community use and target a higher-income, more tech-savvy consumer. However, underage cannabis purchases may increase with home delivery because age verification is not done in the store. The public health impacts of home delivery have yet to be well studied, primarily because of the lack of data on home delivery transactions within a geographic area (Matthay et al., 2023).

Limits (caps) on the amount of cannabis a retail operator can sell to a consumer in a single transaction are standard practice across the states. The limits vary from 1 oz to 2 oz of dried flower and 3.5 g to 15 g of concentrate (Pacula et al., 2021). Research has shown that imposing weight-based limits rather than limits on total THC purchased has important implications. Assuming that individuals purchased average-concentration products in the marketplace in 2019, Pacula and colleagues (2021) show that consumers in all states with legal cannabis could purchase more than 500 10-mg doses of

THC in a single transaction within state-specific sales limits (Pacula et al., 2021). In six states, the amount that could be purchased, assuming average concentration, was greater than 1,000 10-mg doses of THC and in two states was greater than 1,500 10-mg doses (Pacula et al., 2021).

As with alcohol, some states require retail employees to receive server training as part of regular operating requirements and licensure. The training can vary in content and orientation. Some training focuses on administrative rules and penalties related to the law and what procedures retailers must follow (e.g., in Oregon, no underage sales or exportation out of state). Other programs (e.g., in New Mexico) provide more content that brings awareness of the risks to those who use cannabis in the event of excess consumption or use with other substances. Understanding of the extent to which such training programs and their specific content influence server behavior is just beginning to emerge and represents an important area for further work (Buller et al., 2019, 2021).

All states that have legalized cannabis thus far have set up retail license systems so that only licensed cannabis stores can sell cannabis products. Restaurants, convenience stores, and grocery stores are not currently allowed to sell cannabis products, thereby restricting its general availability. Since passage of the 2018 Farm Bill, however, cannabis products are found everywhere unless the states have instituted additional policies to restrict their sale and are being sold even in states that have not legalized cannabis, confusing many consumers.

Product Design

Unlike provinces in Canada or Uruguay (see below), most adult-use states impose few restrictions on the types of cannabis products that can be sold and purchased. States allow a wide array of smokable, vaporable, edible, infused, and concentrated products to be sold in legal adult-use cannabis retail stores (Schauer, 2021). Requirements regarding shelf-life stability and perishability, meant to minimize food safety risks, are mandated in at least three states: California, Michigan, and Washington. As of January 2021, all states have serving-size limits on the amount of THC permitted in edibles and other consumable cannabis products that can be contained within a single package. These limits differ considerably from limits imposed on the total amount sold in a single transaction. Four states (Alaska, Oregon, Massachusetts, and Vermont) have a limit of 5 mg of THC per serving and up to 50 mg per package. Most other states have limits of 10 mg of THC per serving and up to 100 mg per package. Nonedible THC-infused cannabis products are not regulated in most states, leaving many highly concentrated THC products available for purchase. Vermont alone has placed a cap on the THC concentration in products other than edibles,

limiting cannabis flower to no more than 30 percent THC and cannabis oils to 60 percent THC, and prohibiting all oils and concentrates other than cartridges for vape pens (Schauer, 2021).

As a result of the recent uptick in health issues associated with cannabis products, many states have instituted policies that limit certain ingredients in retail cannabis products (Schauer, 2021; see also Chapter 3). These include excipients (media for delivering a drug), diluents, terpene flavoring blends, and other compounds added to vape cartridges. Many states have banned or tested for vitamin E acetate, often found in cannabis vape cartridges, since it causes e-cigarette, or vaping, product use–associated lung injury, commonly referred to as EVALI. Certain states, such as Colorado and Oregon, have placed restrictions on specific ingredients proven to be unsafe for aerosolization, such as polyethylene glycol; squalane; propylene glycol; and triglycerides, including medium-chain triglycerides. Only a few states have placed limitations on flavors allowed in cannabis products, such as nonnatural artificial flavoring, or prohibiting their use altogether.

Policies Limiting Youth Access and Exposure to Promotions

A central premise of state legalization was that adopting these policies would make it easier to keep the products away from youth. All states impose a minimum legal purchase age of 21. However, states vary in the extent to which these rules are enforced through unannounced compliance checks of retailers. While most states conduct random retailer inspections, they do so under the auspices of checking as to whether the retail premises are ready to open or (if they are newly opened) generally following state rules. Random retailer inspections involve an employee of the supervising agency visiting without prior notice and serving as a source of information and assistance for retailers, answering retailers' questions, offering training, discussing issues, and ensuring proper signage or use of the seed-to-sale system in the store. Compliance checks, on the other hand, tend to be more punitive. These typically involve a minor who appears to be 21 attempting to purchase products illegally, with law enforcement witnessing a sale to a minor and penalizing the retailer (through fines) for violating the law. All states with adult-use laws have established retail compliance inspection programs, but most have not (as yet) established a mechanism for conducting compliance checks. Early-adopting states (e.g., Washington, Colorado, Oregon) have done both. The specifics of these programs differ across states in terms of frequency and severity of penalties imposed and under what conditions, and the process for determining which outlets to check.

In the case of tobacco, early studies showed no changes in adolescent tobacco use following the introduction of the federal minimum legal purchase age (MLPA) until Congress enacted the Synar Amendment in 1992,

requiring states to enforce MLPA laws by conducting random inspections of tobacco retailers. Early evidence showed that states adopting comprehensive and aggressive tobacco retailer inspection programs experienced reductions in adolescent smoking relative to states that did not (Chaloupka and Pacula, 1998; DiFranza and Dussault, 2005; Sloan, 2000; Stead and Lancaster, 2000). In the case of alcohol, similar studies have examined the impact of inspections of retailers' checks of adolescent IDs on underage drinking. This research has shown that these inspections, too, have been effective at reducing access to alcohol, heavy drinking, and alcohol-related traffic fatalities among adolescents (George et al., 2021; Grube et al., 2018; Holmila et al., 2010; Schelleman-Offermans et al., 2012; Schweitzer et al., 2017; Scribner and Cohen, 2001).

While advertising cannabis is legal in most states with legalized adult use, states vary as to the amount, type, and location of legal advertisements, which can influence how frequently youth encounter them. Delaware and Montana are the only two adult-use states that prohibit advertising cannabis and cannabis products entirely (Allard et al., 2023). All states but New Jersey and Virginia restrict targeting or appealing to those under age 21 in advertising. The same states, excluding Arizona, also prohibit advertising false or misleading claims (Allard et al., 2023). Many states have adopted limitations on advertising based on the age of the viewership audience (most states mandate that more than 71.6 percent of the intended audience be age 21 and over in cannabis-related advertising, using the standard set for the alcohol industry) instead of completely restricting advertising to individuals over age 21. Yet millions of children could still be exposed to cannabis advertising if offered via a popular media channel, such as online. Since cannabis advertising can be placed on billboards, buildings, or storefronts, exposure of adolescents to proindustry messaging can occur readily in neighborhoods and areas with retail outlets (Allard et al., 2023; Firth et al., 2022; Shi and Pacula, 2021; Swinburne, 2022).

More than half of states with legal adult use place restrictions on the physical location of advertising. In California, for example, cannabis advertisements cannot be placed within 1,000 feet of a school, daycare center, or youth center where children are present. However, these restrictions will not eliminate children's exposure to cannabis advertising because they can still be exposed where they live. Other policies found commonly across states include restrictions on retail building signage, guidelines specific to internet-based advertising, prohibitions on depicting product consumption, and requirements to include warning statements (Allard et al., 2023; Schauer, 2021).

In compliance with the standards of the U.S. Poison Prevention and Packaging Act, all states with legal adult use require cannabis and cannabis-infused products to be dispensed in child-resistant packaging (Schauer,

2021). Furthermore, most states mandate that package visuals cannot appeal to or directly target underage people with cartoons, toys, shapes, or designs. Some jurisdictions explicitly state that packaging cannot resemble any product that does not contain cannabis or cannabis concentrates, namely items typically marketed to children, such as food. Several states prohibit the use of the word "candy" or "candies" on labeling, and others prohibit using specific fonts that may appeal to underage people. Additionally, at least three states (Washington, Massachusetts, and Maine) require a visual symbol on the product package indicating that the product is not safe for children (Schauer, 2021).

Policies for Reducing Cannabis-Impaired Driving

Every state, whether it has adopted an adult-use law or not, has rules regarding cannabis-impaired driving, but state standards vary considerably. Three states with adult-use laws (Arizona, Michigan, and Rhode Island) have adopted zero-tolerance laws, prohibiting drivers from having any amount of THC or its metabolites in the body when driving (APIS, 2023b). Three adult-use states (Illinois, Montana, and Washington) have adopted specific "per se laws," which prohibit drivers from driving with a detectable amount of THC—from 2 nanograms per milliliter (ng/mL) to 5 ng/mL—in their blood, regardless of evidence indicating whether that amount would impair the average driver. Colorado similarly specifies that drivers with more than 5 ng/mL of THC in their blood can reasonably be presumed to be impaired. Still, that state allows a defendant an affirmative defense, meaning that even if the defendant tests above 5 ng/mL, they can provide other evidence to demonstrate they were not impaired. Most adult-use states, however, specify that it is necessary to determine whether the driver was under the influence (i.e., impaired) by THC identified in the body, even if the amount exceeds a specified threshold. The public health value of these different approaches is difficult to ascertain.

The variability in state laws for blood THC limits stems at least partially from the lack of correlation between the level of delta-9-THC in the blood and the degree of impairment. This lack of correlation is due to the ability to develop tolerance; individual differences; and other factors, such as mode of use. With more frequent use, such as daily, and use at multiple times during the day, individuals have higher levels of blood THC reflecting accumulation that do not correspond with recent use or impairment. In a meta-analysis of 28 studies, McCartney and colleagues (2022) found a weak association between THC biomarkers and impairment for individuals who use cannabis occasionally and no association with impairment among individuals who use cannabis regularly. They therefore concluded that blood THC level is a poor indicator of impairment. Other studies using

driving simulators have similarly found that blood THC levels are not well correlated with impairment or recent use. Given the ability to develop tolerance to some of the cognitive and psychomotor effects of cannabis, it is unclear whether recent use necessarily leads to driving impairment among those who use it regularly (Colizzi and Bhattacharyya, 2018). In a study of individuals using cannabis for medical reasons, for example, recent use did not significantly affect cognition or performance on neuropsychological assessments or simulated driving, despite measurable levels of THC in the blood (Arkell et al., 2023; Manning et al., 2024), highlighting the challenges of using blood THC–based assessments to determine impairment (Arkell et al., 2021; Brooks-Russell et al., 2021; Marcotte et al., 2022).

Furthermore, blood THC levels differ importantly based on the route of administration. With edibles and other forms of oral ingestion, blood levels achieved are substantially lower than they are with inhaled cannabis because THC goes through first-pass metabolism and is converted to an active metabolite (see Figure 1-6 in Chapter 1). Here too, then, considering THC level alone will not indicate recent use or impairment (Newmeyer et al., 2016; Spindle et al., 2021).

Finally, the detection of cannabis-impaired driving is further hindered by the limitations of current roadside detection technology and approaches. For example, studies with placebo-controlled designs have found that field sobriety testing, which was initially developed to detect alcohol impairment, has relatively low sensitivity and specificity for detecting cannabis impairment (Bosker et al., 2012; Downey et al., 2012; Marcotte et al., 2023).

Additional Aspects of Regulations Relevant to Impacting Supply, Product Sold, and Possession/Use

Restrictions on Cultivation

"Home cultivation," also referred to as home growing or self-cultivation, refers to growing cannabis plants at home. States have different quantity limits, prerequisites for plant maturity, and licensing requirements. Currently, two states—Illinois and Washington—fully prohibit home cultivation (Wadsworth et al., 2022b). All other states allow home cultivation to some degree, although the number of plants allowed, particularly plants in a flowering state, varies. Most states limit cultivation to 6 plants, with up to 3 in a flowering state. However, some permit only 2–4 plants (Oregon, Maryland, Virginia, Washington, and the District of Columbia), and two states permit the cultivation of more than 6 plants (Minnesota and Maine—up to 8 and 18 plants, respectively—if 50 percent are flowering) (Wadsworth et al.,

2022b). Home growing is not subject to mandatory testing requirements, so there are no controls on possible contaminants in homegrown cannabis.

Commercial cultivation of cannabis is defined as growing cannabis from seedlings or immature plants to maturity with the intent to distribute or sell, or any cultivation larger than the state limits for home cultivation (Schauer, 2021). States regulate commercial cultivation of cannabis predominantly through preapproved cultivation licenses. Distinctions among state regulations arise in the type and range of licenses offered. Licenses are often categorized into tiers based on permissible canopy size and location (e.g., indoor, outdoor, mixed). Vertical integration (the ability of the same party or entity to grow, process, and sell cannabis) is legal in all states except Washington. In Washington, neither the cannabis producer nor the processor may have a vested financial interest in any cannabis retailer.

Restrictions and Requirements on Packaging and Labeling

Food and beverage products regulated by the FDA are subject to clear guidelines on labeling and packaging, as these are critical to consumer safety. Similarly, uniform standards for packaging and labeling of cannabis products allow consumers to make decisions about product safety and risks associated with use. While packaging and labeling restrictions are mandated by every state that has legalized adult cannabis use, the regulations vary widely across states (Schauer, 2021). Only three states require plain packaging, and they all define it differently, from requiring that the package be only one color with no information but the required labeling to requiring that it be plain without bright colors; nine states require opaque packaging for cannabis products (Swinburne, 2022).

At least eight states require a "universal symbol" providing a visible notation that the product contains cannabis to help prevent accidental ingestion of products that may look like noncannabis products. The universal symbol used varies from state to state (except for Massachusetts and Maine, which share the same symbol) in terms of color, design, and the content of the warning (Schauer, 2021). At least four states (Colorado, Massachusetts, Maine, and Nevada) require that their "universal symbol" be printed onto each serving of multiple-serving edible cannabis products (Schauer, 2021).

States almost universally require that THC and CBD content be listed on the label, although little uniformity exists regarding requirements on how this content is to be presented. More than 80 percent of states require inclusion of the batch number, product tracking, and manufacturer contact information. Many states also require that packaging include a warning label. However, the specifics of this warning again differ among states,

and the information is presented as a long legal disclaimer in small font, limiting its effectiveness in communicating potential risks. Some states require the inclusion of warnings regarding pregnancy or breastfeeding, delayed intoxication, driving, and operation of heavy machinery, while few mandate the inclusion of general health and dependence risks. Various items, ranging from usage instructions, nutritional panels, potency statements, and food allergens, are required by only a few states (Kruger et al., 2022).

Restrictions on Possession and Use

Limits on the amounts of cannabis possessed typically coincide with the quantity of cannabis that can be sold in a single transaction. While there is a moderate amount of variability across states in the specific amounts that consumers can possess or carry without threat of penalty, the penalties for possession of amounts above these limits can be significant. Many states also impose restrictions on where people can possess or use cannabis. Eleven states prohibit the use of cannabis in public, and another eight states have restrictions on use in public. Only Missouri, Rhode Island, and Virginia have no explicit public-use rules. Consumption on any federally regulated land is prohibited at the state level. Only a few states, such as California, allow individual municipalities to decide on appropriate public uses of cannabis with no state intervention. A few states authorize social uses of cannabis, such as in cannabis consumption sites (APIS, 2023b).

Cannabis Regulation in the United States: Findings

The lack of data documenting the systematic enforcement of the public health–oriented regulations, and flagrant evidence of violations of them, leads to tremendous skepticism and uncertainty as to the real public health benefit of the existing state laws. In many states there are clear violations of laws on sales of youth-oriented products (Luc et al., 2020) and on promotion of cannabis products to youth (Cui et al., 2023; Krauss et al., 2017), as well as violations on marketing rules, including posting health claims (Berg et al., 2023; Shi and Pacula, 2021). Retailer trainings are not targeting safety of products to consumers, as evidenced by research showing sales to pregnant women (Barbosa-Leiker et al., 2022; Dickson et al., 2018). This patchwork of federal, state, and local regulations—coupled with a lack of information on actual enforcement of existing regulations—makes it challenging to study the effectiveness of different approaches within the states. Additional data are needed before careful evaluations can be conducted.

CANNABIS LEGALIZATION IN CANADA AND URUGUAY

Both Canada and Uruguay have legalized cannabis for adult use. A review of their approaches and the public health impacts observed can be compared with U.S. cannabis policy.

Canada

The passage of the Cannabis Act in June 2018 made Canada the first large, high-income country in the world to legalize and regulate cannabis for adult use. The act was passed with public health and public safety objectives in mind, and a series of federal, provincial, and territorial authorities were established to manage the supply, distribution, sale, and use of cannabis throughout the country.

The federal government was responsible for licensing all aspects of production, including for industrial hemp, from cultivation to processing and testing. It set no limits on the number of producers or the amount each licensee could produce. It also did not place any restrictions on the types of companies participating in production. Indeed, several multinational alcohol and tobacco companies that have stayed out of the U.S. cannabis market (primarily because of the federal prohibition) have invested in or partnered with organizations in the Canadian cannabis market (Lindenberger, 2022; Marlboro maker Altria buys big stake in Canadian marijuana company, 2018).

Canada's federal health authority, Health Canada, was tasked with developing the requirements for cannabis product testing, packaging, and labeling, ensuring that a consistent product and information were available regardless of where the product was purchased. While the act permits promotion under specific conditions, such as to help adults make informed decisions about which cannabis products to use, it explicitly prohibits promotions that (1) might be deemed as appealing to youth; (2) depict a person, celebrity, character, or animal; (3) include false, misleading, or deceptive messages; or (4) could give an erroneous impression about the health effects of cannabis (Health Canada, 2024).

The provinces and territories (henceforth "provinces") have authority to determine regulations regarding the distribution and sale of cannabis within their jurisdictions, the availability of certain types of cannabis products, home cultivation, and the circumstances of legal use. In most provinces, the provincial government serves as the sole wholesaler (i.e., the retailers can purchase cannabis products from the provincial government only) (Pardal et al., 2023). The provincial governments determine what products can be sold and, through the wholesale monopolies, directly influence the prices at which they are sold. Initially, all provinces were also

allowed to operate online stores where those above the legal purchase age could order products to be delivered by mail. Today, only seven provinces allow private retailers to make online sales; such sales in the other provinces are run exclusively by the government (CCSA, 2024).

The provinces' retail markets vary considerably. Only government-owned retail stores are allowed to sell cannabis in four provinces (New Brunswick, Nova Scotia, Prince Edwards Island, and Quebec), while five provinces (Alberta, Manitoba, Nunavut, Saskatchewan, and Yukon) have strictly private retail licensees operating retail stores (CCSA, 2024). The remaining provinces have a mix of government-run and private outlets. There is important variation among the provinces in the number of retail outlets, with some provinces, such as Alberta and Saskatchewan, having more than 15 outlets per 100,000 people, and others, such as Quebec and Prince Edward Island, having fewer than 2.5 per 100,000 (Rosenberg et al., 2023). All provinces but Quebec and Manitoba allow for home production (CCSA, 2024), but variation exists in the number of plants allowed (Pardal and Wadsworth, 2023).

Finally, while the Cannabis Act specifies a minimum age for possessing and purchasing cannabis (18 years), provinces can choose to raise the minimum legal purchase age above this level. Today, only Alberta has a minimum age of 18; the rest of the provinces have set it at 19 except for Quebec, which in January 2020 raised its minimum age from 18 to 21 (CCSA, 2024).

When retail sales began in Canada in October 2018, very few products were allowed to be sold. Initially, only dried flower and some oral oils were allowed. Nationally, these products were taxed at a rate of 10 percent, or $1 Canadian per gram. When vape cartridges, concentrates, and edible products started being sold for nonmedical purposes in early 2020, they were taxed as a function of their delta-9-THC content ($0.01 per mg of THC).

The variation over time within and among provinces in the number and type of retail outlets, minimum legal purchase ages, and types of products sold over time has been used to investigate the role of cannabis policy in various health outcomes. First, the introduction of edibles, vape oils, and other products into the adult-use retail market in January 2020 led to a rise in the prevalence of consumption of these higher-THC-concentration products (Hammond, 2023). The introduction of these products occurred at the same time as a rapid expansion of the commercial availability of cannabis retail outlets in a few territories, particularly Ontario. A series of studies shows that the combination of these two factors led to significant increases in the total number of emergency department (ED) visits involving cannabis (Myran et al., 2022); the number of ED visits attributable to cannabinoid hyperemesis syndrome (Myran et al., 2022), the number of

ED visits for cannabis-involved traffic and motor vehicle injuries (Myran et al., 2023a), and the number of ED visits for cannabis-involved psychosis (Myran et al., 2023b). Notably, these studies did not show similar increases in ED visits following the simple legalization of the retail sale of flower products and home cultivation. Other studies have found additional evidence of public health harms associated with the introduction of higher-THC-concentration products in other provinces or across Canada, including a dramatic rise in the rate of ED visits for cannabis-involved poisoning, particularly among children (Myran et al., 2023c; Varin et al., 2023; Yeung et al., 2021).

Studies examining either self-reported impaired driving, administrative data on traffic crashes, or ED visits associated with motor vehicle crashes in Canada have shown no statistically significant relationship with the opening of adult-use markets in the first phase of legalization, when only dried flower could be sold (Callaghan et al., 2021; Imtiaz et al., 2024; Nazif-Munoz et al., 2023; Walker et al., 2023). These findings provide an interesting contrast to studies finding a rise in crashes when products containing higher THC concentration were allowed (Myran et al., 2023a).

Cannabis legalization in Canada is also associated with a reported rise in easy access to cannabis between 2018 and 2019 (Wadsworth et al., 2022a) and other impacts on health. Callaghan and colleagues (2023) evaluated weekly counts of ED visits associated with cannabis-related disorder and poisoning among underage youth in Ontario (<19 years of age) and Alberta (<18 years of age) from April 2015 through December 2019. Using a time series model, they found a 20 percent increase in underage cannabis-related ED visits associated with legalization. Yeung and colleagues (2020) examined monthly cannabis-related ED visits (2013–2019) and poison center calls (2016–2019) in Calgary and Edmonton, Alberta, using a pre–post time series design. They found a small but statistically significant increase in cannabis-related ED visits and a more considerable increase in poison center calls. Alberta was one of the provinces that experienced an immediate rapid expansion of retail stores with legalization.

A comprehensive review of the public health impacts of legalization in Canada by Hall and colleagues (2023) found that legalization resulted in a substantial decline in cannabis-related arrests, decreases in the legal price of cannabis, and a substantial increase in the THC concentration of cannabis products, but only a modest increase in past-month use by adults and mixed findings on impacts on use by youth. The authors note that the rise in acute ED visits involving cannabis among adults occurred in areas with rapid expansion of retail outlets and that the greatest increases in adolescent poisonings occurred after the introduction of edibles in the adult-use market.

Uruguay

Uruguay has adopted a highly regulated approach to the legalization of adult use of cannabis (Cerdá and Kilmer, 2017). Cannabis was legalized through a law enacted in December 2012; home cultivation was allowed in August 2014; cannabis clubs were allowed in October 2014; and pharmacy sales started in mid-2017, although it took a while for pharmacy sales to become an appreciable market. The Institute for the Regulation and Control of Cannabis (IRCCA, n.d.b) regulates the cultivation, production, retail sales, and possession/use of cannabis, with the express intent of protecting public health (IRCCA, n.d.b).

Cultivation includes home cultivation, cannabis clubs, and commercial cultivation. Six plants are allowed for home cultivation, with a limit of 480 g in yield per year. Cannabis clubs can cultivate up to 99 plants, with the same limit of 480 g in yield per person per year. Clubs must register with IRCCA and provide lengthy documentation of club infrastructure, security, and operations. Commercial cultivation is allowed only through three licensed producers, and IRCCA implements a strict quality control system for each commercial lot and seed-to-sale tracking. Strict controls are also placed on production for commercial cultivation. Only pharmacies can sell cannabis flower, and the government sets product strength limits. Currently, three strains are offered: Alpha, an indica-dominant strain with up to 9 percent THC and at least 3 percent CBD; Beta, with the same THC and CBD composition but a sativa-dominant hybrid; and Gamma, which is indica-dominant but with less than 1 percent CBD and up to 15 percent THC. Cannabis is sold in plain, unbranded packaging, with clear information about the product content and health risks associated with consumption (IRCCA, n.d.a).

Retail sales are allowed only in pharmacies; currently, 38 pharmacies sell cannabis in the country (1.3 percent of all pharmacies, or roughly 0.67 per 100,000 adult population[2]) (Isorna et al., 2023). No advertising is allowed. Only citizens or permanent residents age 18 years or older can buy cannabis; per person retail transactions are limited to 10 g per week, 40 g per month. The government sets the price to fall just below that of the illegal market. Cannabis is not taxed. While cannabis possession and use have been decriminalized in Uruguay since 1974, access to legal cannabis is possible only through registration in a national system. Interested consumers must register in the system to purchase their cannabis from pharmacies, grow it at home, or join a social cannabis club.

The Uruguayan model has seen both challenges and successes. Data show that following legalization, Uruguayans abandoned *prensado*, a poor-quality illegal form of cannabis, and shifted to flower, and they reduced

[2] Calculated assuming an adult population of 3,423,108.

contact with illegal dealers (Queirolo, 2020). At the same time, constraints such as a production shortfall and lack of retail sites may have prevented the system from being implemented fully (Isorna et al., 2023). Furthermore, concerns exist that the highly regulated approach may have discouraged cannabis purchasers from using the legal market. While registration among those who use cannabis has grown since it was first legalized, it is estimated to reach just 51 percent of those who use cannabis in Uruguay, including 34 percent who obtain cannabis directly from the legal market and 17 percent who obtain it from others who obtained it through the legal market.

Limited data exist on the effects of Uruguay's cannabis legalization on health. To date, research has shown no impact on cannabis use or perceived risk of use among adolescents (Laqueur et al., 2020). While a transitory increase in risky and frequent cannabis use was observed in 2014 immediately after cannabis legalization among 18- to 21-year-olds enrolled in school this increase was not sustained over time (Rivera-Aguirre et al., 2022). No analyses have been published on the effects of cannabis legalization in Uruguay on cannabis consumption among the general adult population. A study of pregnant persons in a public hospital in Montevideo did find a rise in the use of alcohol and cannabis before and during pregnancy in 2016 compared with 2013 (Pinto et al., 2020). However, the study's cross-sectional design with no comparison group limits the ability to draw inferences about the extent to which this change was due to cannabis legalization.

Two peer-reviewed studies examine the relationship between legalization and traffic outcomes in Uruguay. Using an interrupted time-series approach with weekly data on fatal automobile crashes from 2012 to 2017, Nazif-Munoz and colleagues (2020) concluded that the enactment of legalization in December 2013 may have been associated with an increase in fatal motor vehicle crashes, particularly among car drivers and in urban settings. Kilmer and colleagues (2022) used department-level variation in registrations for legal cannabis over time to examine the association with traffic crashes involving injuries. While they found no evidence that total registrations were associated with these crashes, they did find a consistent, positive, and statistically significant association between the number of individuals registered as self-cultivators and the number of traffic crashes with injuries. This finding is generally consistent with that of Nazif-Munoz and colleagues (2020), which focused mainly on the period before pharmacies began selling cannabis.

Alternative Regulatory Models: Findings

Canada and Uruguay legalized cannabis federally and have more consistent policies nationwide compared with the United States. Canada has mandated minimum-age limits and national restrictions on advertising, and some provinces have a state monopoly. At least initially, there has been no

increase in impaired driving after legalization, but a rise in ED visits has been associated with higher-THC products and rapid retail expansion. Uruguay has a highly regulated model with limited retail outlets and product types. Studies thus far show a shift from illegal cannabis to legal options but may not have fully captured the market because of limitations on access. Data on public health impacts in Uruguay are limited but suggest no increase in adolescent use other than a possible rise in risky use among young adults shortly after legalization. There is conflicting evidence on traffic crashes.

CONCLUSIONS AND RECOMMENDATIONS

With federal cannabis prohibition in the United States creating a patchwork of state laws, the legal cannabis industry operates in a complex and often contradictory environment. The market for hemp products resulting from the 2018 Farm Bill is a prime example of the confusion resulting from limited federal involvement. The ambiguous definition of hemp in that legislation has led to a largely unregulated market for semisynthetic cannabinoids. These products raise significant concerns about safety, accurate dosing, and potential misuse, especially among young adults who may have easier access.

Conclusion 2-1: The redefinition of the federal meaning of "hemp" in the Agricultural Improvement Act of 2018 (2018 Farm Bill) has created considerable uncertainty and confusion as to what cannabis products are legal and has led to a massive new market in semisynthetic cannabinoids with little regulatory or public health oversight.

Recommendation 2-1: Congress should refine the definition of "hemp" to state clearly that no form of tetrahydrocannabinol or semisynthetic cannabinoid derived from hemp is exempt from the Controlled Substances Act.

State-to-state variations in regulations leave public health guidance unclear and limit efforts to prevent harmful use. The lack of federal oversight has fostered a fragmented industry with inconsistent regulations, oversight, and enforcement standards. In contrast, some countries have adopted a more measured approach with stricter government control over cannabis legalization. Such a stricter regulatory framework may better protect public health.

Conclusion 2-2: The federal government has not provided adequate guidance on public health policies that might minimize the adverse consequences of cannabis legalization. States that have legalized cannabis have created regulatory frameworks that have prioritized commerce

over public health. The significant state-to-state variation in regulations on products, retail sales, and use has resulted in inconsistent applications of public health safeguards. A better understanding of the influence of this variation on public health is needed.

Conclusion 2-3: Other countries have taken a centralized, government-regulated approach to protecting public health by placing stricter controls on the access to, availability of, and safety of cannabis products.

The committee's evaluation of policies that limit youth exposure to cannabis found significant variation among the states. While all states require those who use cannabis to be age 21 and older, enforcement through random checks is limited. Advertising restrictions are also inconsistent among the states. Most states allow cannabis advertising with some limitations on who sees it (not necessarily age-restricted) and where it is placed (e.g., not near schools), with the result that millions of children are exposed to procannabis messages. Loopholes further weaken these restrictions. Unlike stricter countries, some U.S. states permit advertising with enticements such as coupons, health claims, and even depictions of product use. Additionally, few limitations exist on targeting people outside the state or using public platforms such as billboards. Although product packaging is regulated to prevent child appeal, the lack of enforcement and weak advertising restrictions create a situation in which young people in the United States are still subject to cannabis promotion. It is important to note that if cannabis is legalized for sale in the United States at the federal level, advertising restrictions will become more difficult because of First Amendment protections for the advertising of legal products. Advertising for tobacco and alcohol is restricted because other policies gave states the authority to do so (the 21st Amendment in the case of alcohol and the Master Settlement Agreement for Tobacco) (Lange et al., 2015). Additionally, best practices for limiting advertising to youth need to consider where youth are receiving the information; restrictions on advertising on social media thus are likely more critical than restrictions on traditional media outlets.

State-level cannabis legalization is illegal under federal law unless cannabis, like tobacco or alcohol, is removed from the Controlled Substances Act. Still, given that the federal government has been allowing the states to create commercial markets for cannabis under federalism, federal agencies could assist the states that have chosen to legalize. The Council on State and Territorial Epidemiologists, a nonprofit organization of member states and territories representing public health epidemiologists, which includes the CDC, has guidance and resources on public health surveillance. Similar guidance could be created for other public health functions.

The National Conference of State Legislators (NCSL) and the National Governors Association (NGA) may be able to provide leadership on how

jurisdictions can protect youth access and exposure to cannabis products. The NCSL provides bipartisan policy research, training resources, and technical assistance to every state legislator and staffer. The NGA is a nonpartisan political organization founded in 1908, representing 55 states, territories, and commonwealth governors. The two organizations often work together to provide examples of legislation.

Recommendation 2-2: In conjunction with other federal agencies, the Centers for Disease Control and Prevention should conduct research on and develop best practices for protecting public health for states that have legalized cannabis, drawing from tobacco and alcohol policies. These best practices should encompass marketing restrictions (e.g., on advertising and packing), age restrictions, physical retail and retail operating restrictions, taxation, price restrictions, product design, and measures to limit youth access. Other strategies for protecting public health that warrant identification of best practices include reducing cannabis-impaired driving, promoting state retail monopoly, and encouraging cultivation practices that limit contamination of both products and the environment. The best practices should be reconsidered and updated periodically as new research emerges.

Recommendation 2-3: The National Governors Association, the National Council of State Legislatures, and other public health stakeholders should develop model legislation concerning best practices related to marketing restrictions (e.g., on advertising and packaging), age restrictions, physical retail and retail operating restrictions, taxation, price restrictions, product design, and measures to limit youth access, as well as strategies for reducing cannabis-impaired driving, promoting state retail monopoly, and encouraging cultivation practices that limit contamination of both products and the environment. Once the Centers for Disease Control and Prevention's best practices have been developed, they should be incorporated into the model legislation.

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3

Cannabis Consumption and Markets in the United States

The public health impacts of consuming cannabis depend on many factors, such as the type of product and amount consumed, who is using it, and the legal environment in which they are using. Understanding the product is complicated: there are many cannabinoids, product types, and administration methods. It is also critical to understand the characteristics of who is using cannabis: youth? adults? those who have experience using it? people with health conditions? Finally, the legal environment in which cannabis is used is critical for many reasons. For example, it influences the size of the illegal market, where public health policies have less influence, although there is also less advertising, promotion, and product choice. This chapter provides an overview of the national trends in the perceived availability of cannabis, patterns of use, the types of products available, and who is using them. Some insights about cannabis markets follow. The discussion is based on information from two key data sources: the National Survey on Drug Use and Health (NSDUH) and the International Cannabis Policy Study (ICPS).

The NSDUH,[1] administered by the Substance Abuse and Mental Health Services Administration (SAMHSA), is a nationally representative cross-sectional survey of the civilian, noninstitutionalized U.S. population aged 12 and older. State-specific estimates are available, but only from analyses of the restricted-use datasets. The committee sought to evaluate changes in use patterns over time, comparing states that have legalized cannabis with those that have not; however, the committee could not access the restricted-use data necessary for this purpose. The survey collects data on recency of use,

[1] Prior to 2002, the NSDUH was called the National Survey on Drug Abuse.

frequency of use, age of first use, and perceived risk and approval, as well as criteria in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*) on abuse and dependence and in the *DSM-5* on cannabis use disorder. Respondents are also asked whether a doctor or other health professional recommended any or all of their use. NSDUH also captures many population characteristics. The committee evaluated changes in availability and use by race and ethnicity, age, sex, poverty status, veteran status, education level, and pregnancy status, to determine the impact of cannabis use patterns on marginalized or vulnerable groups. While the NSDUH remains a critical resource for understanding shifts in cannabis use geographically and over time, it has undergone important changes since 2014 that need to be considered when making comparisons over time:

- In 2014, SAMSHA changed the sampling design to improve the precision of national estimates and estimates in older adults. The changes included modifying the distribution of the sample across the 50 states and the District of Columbia and reducing the oversampling of youth and young adults (CBHSQ, 2015).
- In 2015, SAMHSA changed the survey administration methods. Changes were made to the data collection equipment, respondent materials, and the survey questionnaire (e.g., revised questions on prescription drugs, methamphetamine, hallucinogens, inhalants, and binge alcohol), and new questions were added (e.g., sexual orientation and attraction, disability status, identification of active-duty family members). The 2015 changes were aimed at improving the quality of data and addressing SAMHSA's substance use and mental health policy and research needs (CBHSQ, 2015). The 2015 changes impact the following variables: co-use with alcohol and perception of the risk or availability of cannabis.
- In 2020, changes were made to the survey to address the methodological limitations of data collection posed by the COVID-19 pandemic. The primary methodological changes were (1) limited data collection from mid-March through September 2020; (2) the introduction of web data collection in October 2020, with limited in-person data collection; and (3) questionnaire changes beginning in October 2020. These changes affected the data collection mode effects and potentially had other effects on the estimates. Because these changes in data collection coincided with the COVID-19 pandemic, the effects of the methodological changes cannot be separated from actual changes in outcomes (SAMHSA, n.d.-a).
- In 2021, SAMHSA began using web-based interviewing, limiting comparisons between the 2021 data and data from previous years (SAMHSA, n.d.-b).

Throughout this chapter, series breaks in the trend data indicate changes in the NSDUH trend data.

One main limitation of the NSDUH is that information on the types of cannabis products consumed does not reflect the diversity of cannabis products available in the marketplace. The ICPS, an annual survey that began in 2018 in Canada and the United States, was explicitly designed to identify changes in cannabis use, particularly in the specific types and amounts of different products consumed, as well as the impact of different policy approaches to regulating cannabis in these countries (Hammond et al., 2020, 2022). The ICPS has expanded to include nationally representative samples of household members aged 18 years and older in Australia and New Zealand (2021) and in the United Kingdom and Germany (2022). Data from this survey provide some interesting details on the specific products consumed and mode of administration, and how these have changed in a relatively short period (Hammond et al., 2020, 2022).

TRENDS IN PERCEIVED AVAILABILITY OF CANNABIS AND CANNABIS USE PATTERNS

This section provides an overview of what is known about trends in the perceived availability of cannabis and use (e.g., prevalence of use, frequency of use, quantity consumed, and cannabis use disorder), as well as types of products used in the United States, based on data from the NSDUH and ICPS.

Perceived Availability

Studies have found that the perceived availability of cannabis is associated with its use. For example, a recent study found that individuals who perceived cannabis as being both low risk and available were 22 times more likely to have used it in the past year compared with those who perceived it to be both high risk and unavailable (Levy et al., 2021). Understanding individuals' perceptions of cannabis availability is especially important among vulnerable populations as more states legalize the drug. A California study, for example, found that pregnant people perceived cannabis legalization as reducing barriers to prenatal cannabis use—that is, enabling access, increasing acceptance, and enhancing trust in cannabis retailers (Young-Wolff et al., 2022).

According to data from the NSDUH, the overall trend in the perceived availability of cannabis remained relatively flat from 2002 through 2014. Since 2014, however, there has been a detectable increase. The percentage of persons aged 12 or older who perceived cannabis to be "fairly easy" or "very easy" to obtain was 60.3 percent in 2014; by 2022, this percentage had

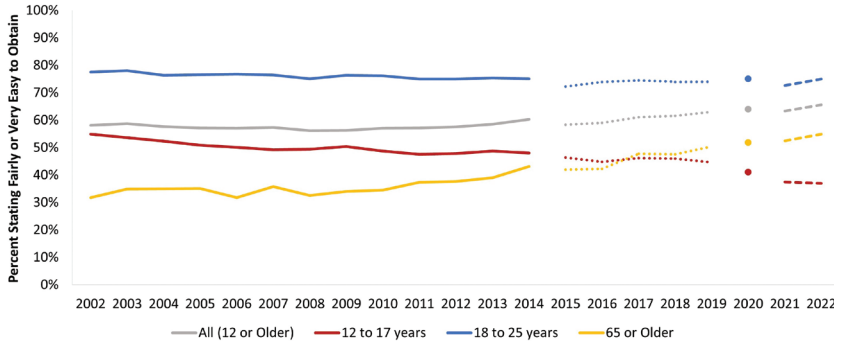

FIGURE 3-1 Perception of availability of cannabis by age group, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes to the NSDUH made in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

grown to 65.6 percent (Figure 3-1). An increase in perceived availability is particularly pronounced among older adults—those 65 or older. In this age group, the perception that cannabis is "fairly easy" or "very easy" to obtain nearly doubled, increasing from 31.8 percent in 2002 to 54.9 percent in 2022. Notably, while the perception of cannabis availability among 18- to 25-year-olds decreased slightly over time—declining from 77.5 percent in 2002 to 75.0 percent in 2022—this age group consistently ranks highest in perceived availability. For those aged 12–17, there also appears to be a larger decrease in perceived cannabis availability relative to the other age groups.

Looking at perceived availability by race and ethnicity, a lower percentage of non-Hispanic Asian American, Native Hawaiian/Other Pacific Islander, and multiracial individuals reported perceiving cannabis as being "fairly easy" or "very easy" to obtain as compared with other racial subgroups; however, this percentage grew from 38.8 percent in 2002 to 51.2 percent in 2022 (Figure 3-2).[2]

Finally, while the availability of cannabis was perceived to be highest among respondents with some college, the most significant increase was seen among those with *at least a college education*—increasing from 56.8 percent in 2002 to 71.7 percent in 2022 (Figure 3-3).

[2] For these NSDUH trend analyses, non-Hispanic Asian American, Native Hawaiian/Other Pacific Islander, and multiracial individuals are placed in the same category. The committee recognizes that these are very different populations and acknowledges that the trends across and within these groups may vary. The committee urges that future epidemiological studies and policy analysis separate these groups if the data allow for such subgroup analyses.

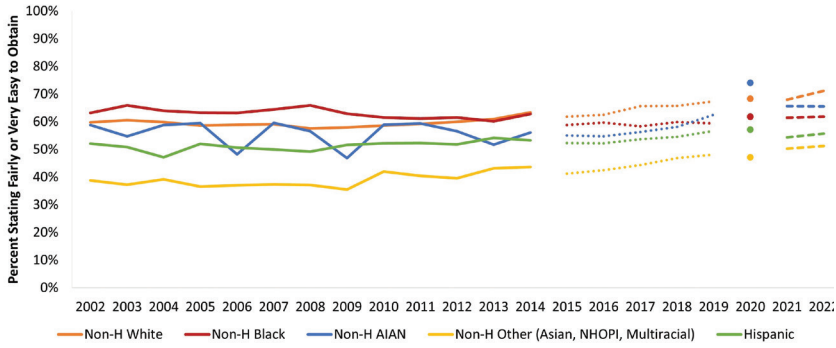

FIGURE 3-2 Perception of availability of cannabis by race or ethnicity, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

Prevalence

Overall, past-year cannabis use has nearly doubled over the last two decades. In 2002, according to the NSDUH, 11.0 percent of the noninstitutionalized U.S. population aged 12 or older reported past-year cannabis use. By 2022, this figure had grown to 21.9 percent.

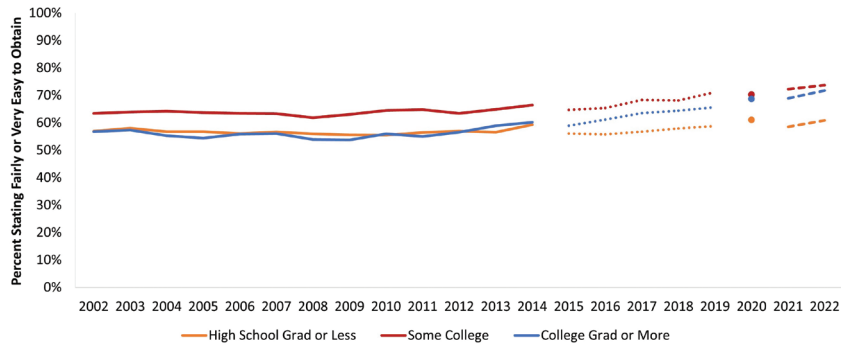

FIGURE 3-3 Perception of availability of cannabis by education level (ages 18 years and older), NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

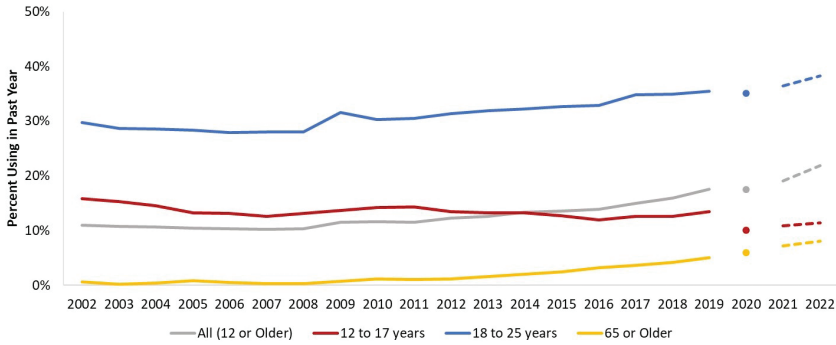

FIGURE 3-4 Past-year cannabis use by age group, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

While overall prevalence has increased, differences are evident by age, sex, race or ethnicity, and other sociodemographic factors. For example, Figure 3-4 shows that the percentage of teenagers (aged 12–17) who reported past-year prevalence fell from 15.8 percent in 2002 to 11.4 percent in 2022. However, past-year prevalence among young adults—those aged 18–25—was consistently the highest among all age cohorts. In 2002, 29.7 percent of young adults reported past-year use; by 2022, this percentage had grown to 38.3 percent. The trendline was also positive for adults aged 65 and older, in whom past-year cannabis prevalence increased from 0.6 percent to 8.0 percent, more than a 12-fold increase.

Notable differences in past-year cannabis use are also evident by race or ethnicity (Figure 3-5). In 2022, past-year use was highest among non-Hispanic American Indian/Alaska Native people, 28.4 percent of whom reported past-year use, compared with non-Hispanic White people (22.9 percent); non-Hispanic Black people (22.9 percent); non-Hispanic Native Hawaiian people, Other Pacific Islanders, and multiracial individuals (16.3 percent); and Hispanic people (20.3 percent). Note that the precision of the estimates among the racial groups varies, and prevalence estimates for the non-Hispanic American Indian/Alaska Native population are less precise than those for other races.

While self-reported past-year cannabis use was consistently higher among men than among women—24.3 percent versus 19.6 percent, respectively, in 2022—women experienced a more significant 20-year increase

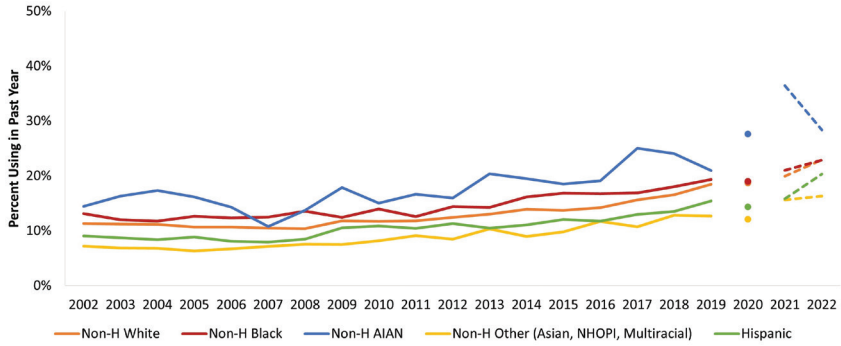

FIGURE 3-5 Past-year cannabis use by race or ethnicity, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

compared with men (Figure 3-6). Specifically, in 2002, 8.5 percent of women reported past-year cannabis use, while in 2022, that percentage was 19.6 percent.

As illustrated in Figure 3-7, the percentage of pregnant persons who reported past-year cannabis use—which ranged from 12.6 percent in 2002 to 21.9 percent in 2022—was similar to that for the overall population of persons aged 12 or older.

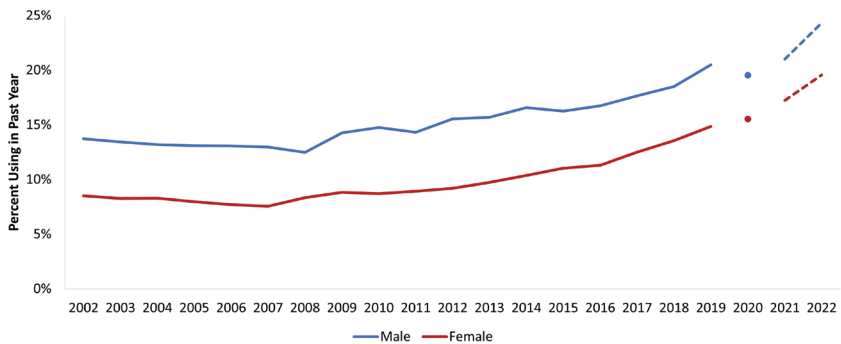

FIGURE 3-6 Past-year cannabis use by sex, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

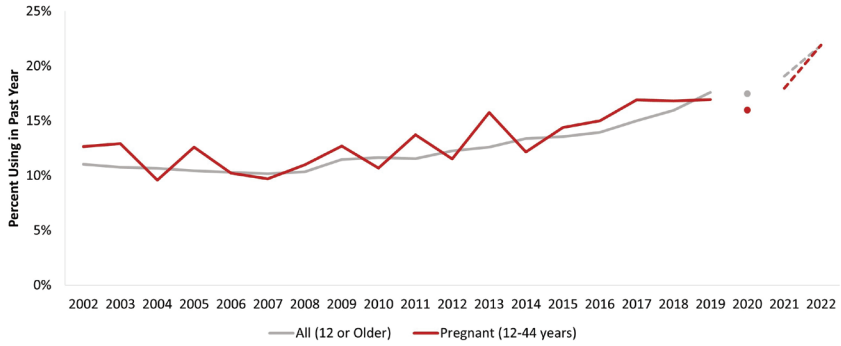

FIGURE 3-7 Past-year cannabis use among pregnant persons, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

While 6.1 percent of veterans reported past-year cannabis use in 2002—a percentage nearly half of that reported by the population aged 12 and older—that rate had more than tripled by 2022, reaching 18.4 percent (Figure 3-8).

Small and much more subtle differences in past-year cannabis use were seen by poverty status. A higher percentage of those living in poverty (at or below the federal poverty level) consistently reported more past-year use (15.3% in 2002; 24.9% in 2022), and the gap between those in poverty and

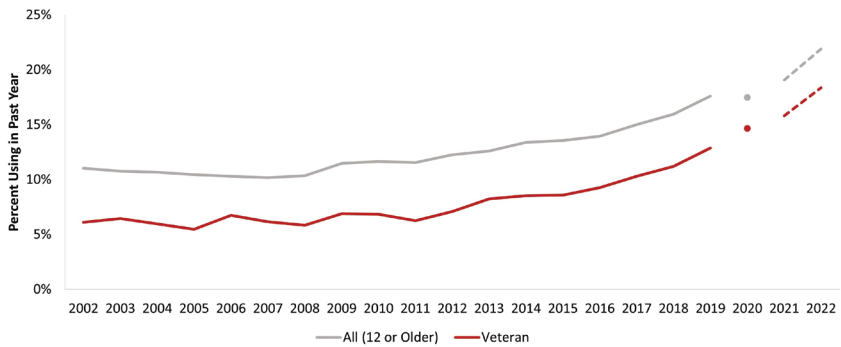

FIGURE 3-8 Past-year cannabis use among veterans, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

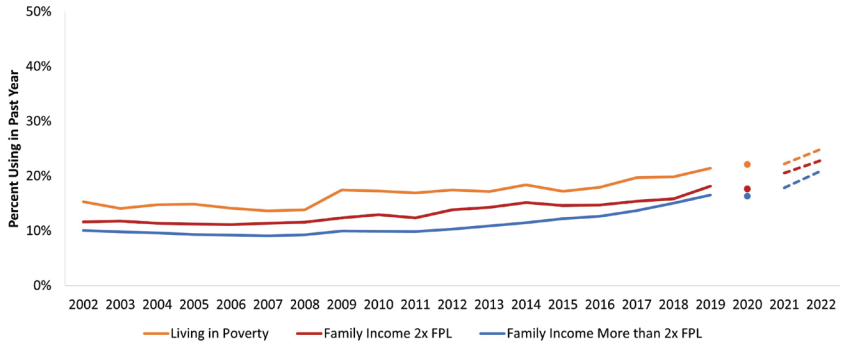

FIGURE 3-9 Past-year cannabis use by family poverty status, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. Living in poverty = family income below the federal poverty level (FPL); family income 2x the FPL = income less than 2x the FPL but above the FPL; more than 2x the FPL = 2x the FPL or greater.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

those with family incomes of more than twice the federal poverty level has remained somewhat stable over time. There was a difference of 5.2 percentage points in 2002 and 4.0 percentage points by 2022 (Figure 3-9).

The percentage of respondents reporting past-year use was lowest among the most educated—that is, among those with at least a college degree (Figure 3-10). In 2022, 27.0 percent of those with some college

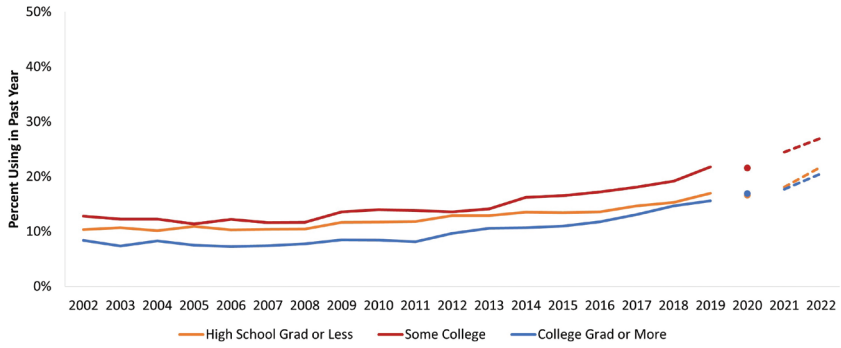

FIGURE 3-10 Past-year cannabis use by education level (ages 18 and older), NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

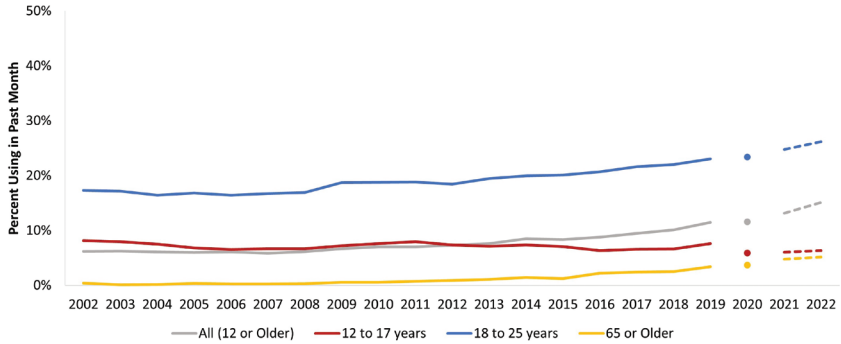

FIGURE 3-11 Past-month cannabis use by age group, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent the methodological changes made to the NSDUH in 2014, 2015, 2020, and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

reported past-year use, compared with 21.8 percent among those with a high school degree or less and 20.6 percent among those with a college degree or higher. In all cases, past-year prevalence rates more than doubled from 2002 to 2022.

Past-month cannabis use by age is presented in Figure 3-11. Overall, 6.2 percent of the population aged 12 or older reported past-month cannabis use in 2002. This percentage more than doubled and rose to 15.1 percent in 2022—a greater increase than was seen in past-year cannabis use over the same period. Other trends and differences by race or ethnicity, sex, pregnancy status, veteran status, poverty status, and education closely mirror those previously described. Even so, graphs depicting trends in past-month prevalence rates from 2002 to 2022 are reported in the online Appendix E.[3]

Frequency of Use

Focusing on prevalence helps in understanding how the population of people who use cannabis is changing, but from a health and market perspective, it is important to also assess how frequently cannabis is being used (e.g., in terms of total use days). Indeed, the trends in these measures can be quite different. As displayed in Figure 3-12, Caulkins (2024) shows that while there has been a notable increase in the past-year and past-month prevalence of cannabis since the early 1990s, the increase was much larger for two other measures focused on frequency of use: total cannabis use days

[3]Appendix E can be found online at https://nap.nationalacademies.org/27766.

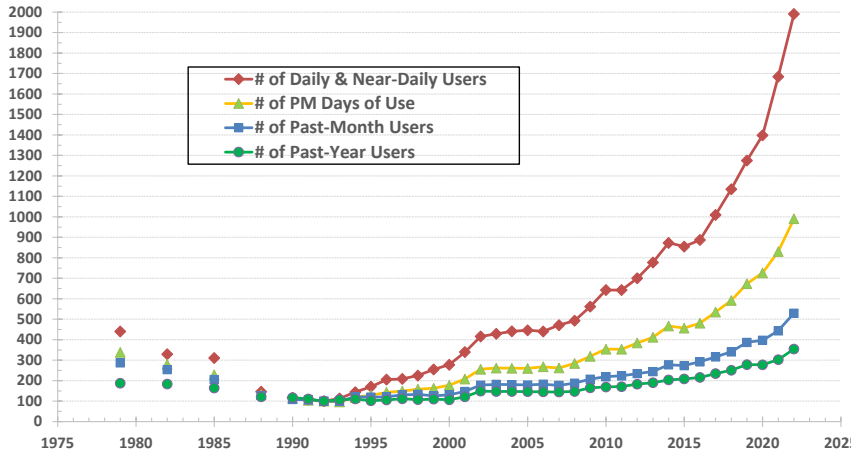

FIGURE 3-12 Growth in cannabis prevalence and frequency of use reported in the NSDUH and its predecessors since 1979 (indexed: level = 100 in 1992).
NOTES: NSDUH = National Survey on Drug Use and Health; PM = past month.
SOURCE: Reproduced from Caulkins, 2024.

in the past month and number of people who reported using cannabis daily or near-daily (DND; 21+ days in the past month).[4] In fact, Caulkins (2024) also shows that as of 2022, more people in the United States reported using cannabis than alcohol on a DND basis (see Figure 3-13) (Caulkins, 2024).

The next two figures in this section focus on total use days in the past year for specific demographic groups. Figure 3-14 examines total use days by sex, showing that males use cannabis more frequently than females.[5] In 2002, males reported 1.42 billion use days in the past year, while females reported 0.69 billion use days. By 2022, both males and females reported more use days: 4.8 billion for males and 3.3 billion for females. Thus, while females accounted for slightly less than one-third of total use days in 2002, this proportion increased to slightly more than 40 percent in 2022. DND use was consistently higher among males than females. In 2022, with 7.8 percent of males reporting DND use compared with 5.0 percent of females (based on NSDUH data analyzed Seema Hemant Choksy Pessar, consultant to the committee; figure not shown).

[3] Of course, one must be mindful that even among very frequent users, there can be important variation in the quantity of cannabis consumed per use day, as discussed later in this chapter.

[4] The sex-specific figures in this chapter and the online Appendix E are based on the NSDUH question: "Are you male or female?" Starting in 2015, questions were added to the NSDUH about sexual orientation and identity for those aged 18 and older (CMS, n.d.). Sexual minorities are an important subpopulation when one is considering cannabis use patterns and reasons for use.

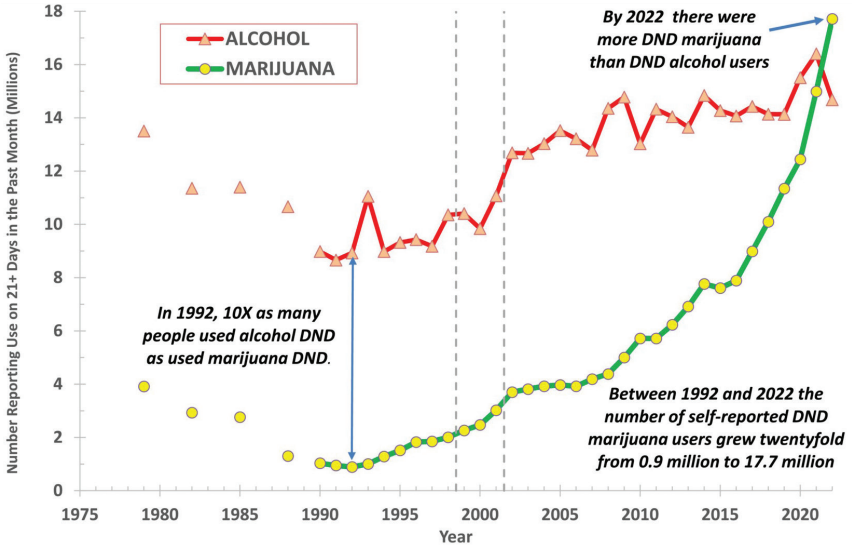

FIGURE 3-13 In 2022, more people reported using cannabis than alcohol on a daily or near-daily (DND) basis.
NOTES: Data presented are based on the NSDUH, which underwent methodological changes in 2020 and 2021. NSDUH = National Survey on Drug Use and Health.
SOURCE: Reproduced from Caulkins, 2024.

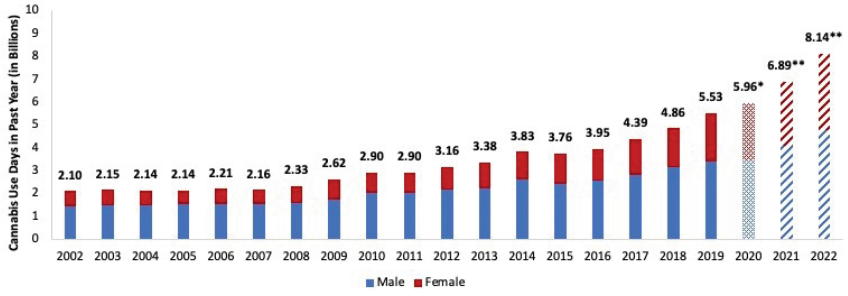

FIGURE 3-14 Estimated cannabis use days in the past year as a share of total days by sex (in billions), NSDUH, 2002–2022.
NOTES: Asterisks and changes from solid, to dotted, to dashed shading represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

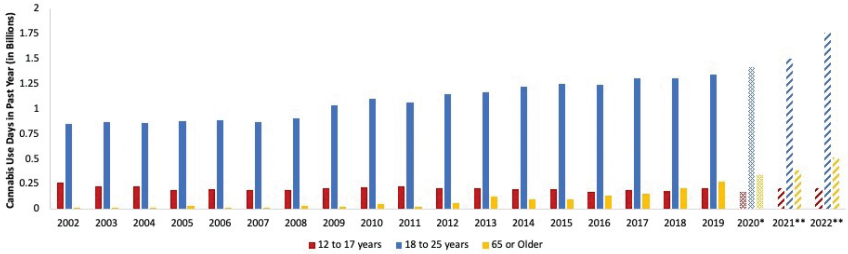

FIGURE 3-15 Estimated cannabis use days in the past year by age group (in billions), NSDUH, 2002–2022.
NOTES: Asterisks and changes from solid, to dotted, to dashed shading represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

Figure 3-15 shows total use days for three age groups of interest: those under age 18, those aged 18–25, and those aged 65 and older. Whereas total use days for those under age 18 remained fairly stable over the 2002–2022 time period, there were notable increases for young adults (aged 18–25) starting in 2009 and for those aged 65 and older starting in 2012.

It is commonly asserted that the prevalence of cannabis use is similar across racial and ethnic groups, although Black people are four times more likely than White people to be arrested for cannabis-related reasons (Resing, 2019).[6] However, it may be more important to account for frequency of use (Burns et al., 2013). As seen in Figure 3-16, the highest prevalence of DND cannabis use are reported by American Indian and Alaska Native people, followed by non-Hispanic Black people. Non-Hispanic White people have a lower rate of DND use than Black people, while Hispanic people have an even lower rate of use than White people. Each trend has been rising over time, but unlike simple 30-day prevalence, the prevalence estimates for DND do not have a clear pattern of differences among racial and ethnic groups. The American Indian and Alaska Native estimates are the least precise of the racial ethnic groups, so the differences (particularly prior to 2021) are unlikely to be statistically significant.

The frequency of cannabis use is also socially stratified. Whereas cannabis use was often associated with college campuses in the 1960s (see, e.g., Goldstein, 1966), college grads today have the lowest rates of DND use.

[5] Insights about racial disparities in cannabis arrests are described in Chapter 5.

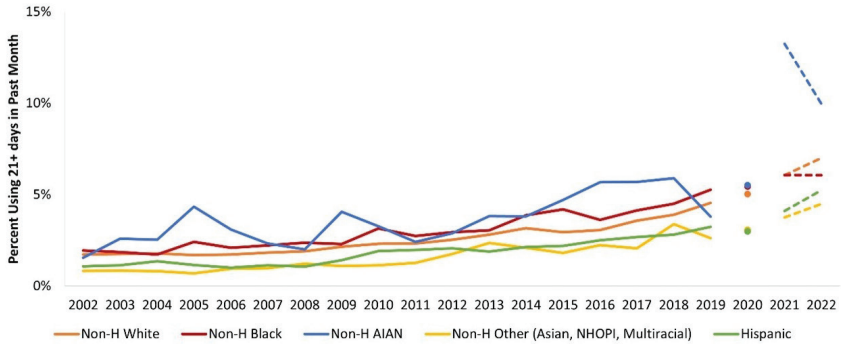

FIGURE 3-16 Daily/near-daily cannabis use by race or ethnicity, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent methodological changes to the NSDUH. NHOPI = Native Hawaiian or Other Pacific Islander; non-H = non-Hispanic; NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

As seen in Figure 3-17, the rate of DND cannabis use for college grads in 2022 is about half of that for those with some college or a high school education or less.

Another important trend observed when examining shifts in total use days is found among pregnant people. Estimated cannabis use days in

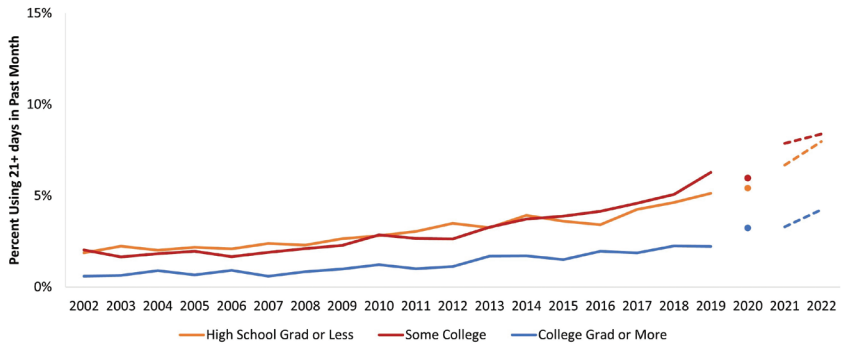

FIGURE 3-17 Daily/near-daily cannabis use by education level (ages 18 and older), NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

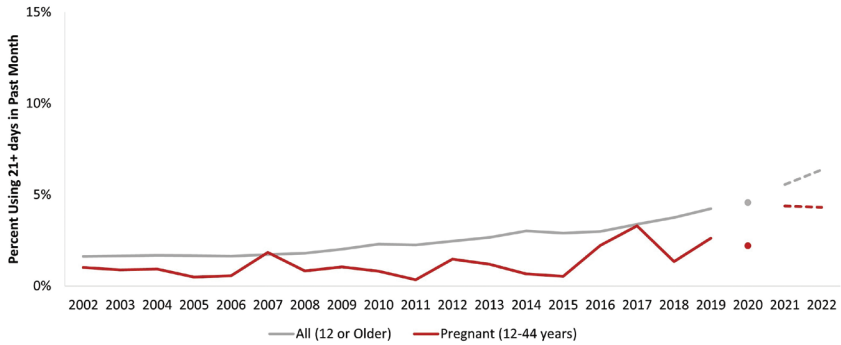

FIGURE 3-18 Daily/near-daily cannabis use among pregnant persons, NSDUH, 2002–2022.
NOTES: Changes from solid, to dotted, to dashed lines represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

the past year for this population increased from 10.2 million in 2002 to 36.5 million in 2022. Furthermore, the percentage of pregnant persons with DND use increased from 1 percent in 2002 to 4.3 percent in 2022 (Figure 3-18).

Product Types and Mode of Administration

Dried flower is still the most commonly consumed cannabis product, but over time, fewer people have reported consuming dried flower. Among people who reported using any cannabis product in the past year, the share that reported past-year use of any dried flower decreased from 80 percent in 2018 to 70 percent in 2023 (Figure 3-19). By 2023, 3 in 10 people who had used cannabis in the past year had exclusively used a product processed from cannabis, not the plant itself. The use of every other type of cannabis product has increased; the share of people that used edibles in the past year increased by more than 40 percent between 2018 and 2023, from 41 percent to 59 percent; use of vape oils increased by 27.3 percent, from 33 percent in 2018 to 42%; and use of concentrates was up 47.1 percent, from 17 percent in 2018 to 25 percent in 2023.

The ICPS can also be used to evaluate whether consumers use a single cannabis product or a variety of products (see the description of the ICPS in the introduction to this chapter). Figure 3-20 shows the share of people who reported using one, two, three, or even more products in the past month during 2023. Fewer than half (41.4 percent) reported using a single

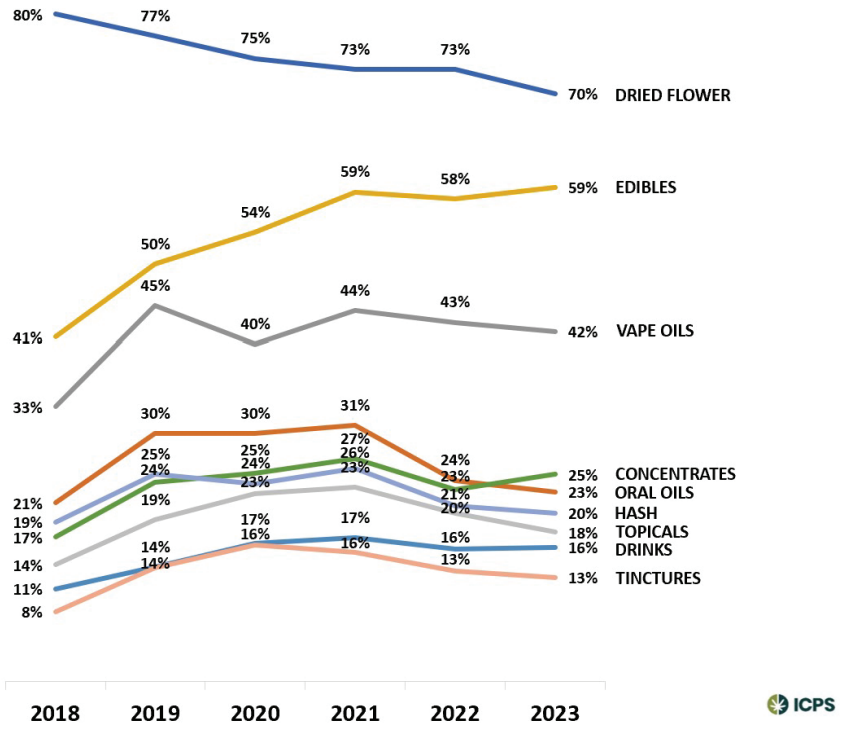

FIGURE 3-19 Types of cannabis products used among individuals reporting use of cannabis in the past year in the United States, International Cannabis Policy Study, 2018–2023 (N = 64,054).
SOURCE: Generated by David Hammond, consultant to the committee.

cannabis product, more than a quarter (28.8 percent) using two products, and just under 30 percent (29.7 percent) using three or more products.

Use of different types of products is similar regardless of the legal status of cannabis. Figure 3-21 displays state cannabis legalization status in 2023 the types of cannabis products used by people who reported past-year cannabis use. Dried herb dominates in all states, followed by edibles and vape oils; least common is use of cannabis in drop or capsule form. The use rates for each product type are similar regardless of the legal status of cannabis where people live.

The NSDUH estimates past-year rates of vaping, dabbing, smoking, and eating or drinking cannabis products in people aged 12 and older (Figure 3-22). In 2022, smoking was reported as the most common route of administration in the past month (11.8 percent), followed by eating/drinking (5.4 percent), vaping (5.2 percent), and dabbing (2.4 percent).

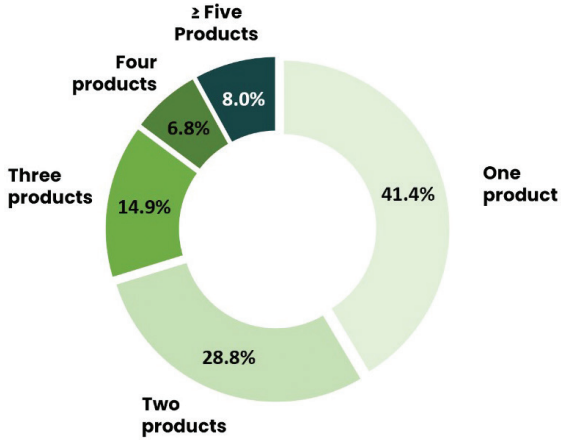

FIGURE 3-20 Number of products used "monthly" among individuals reporting use in the past 30 days, International Cannabis Policy Study, 2023 (N = 10,214).
SOURCE: Generated by David Hammond, consultant to the committee.

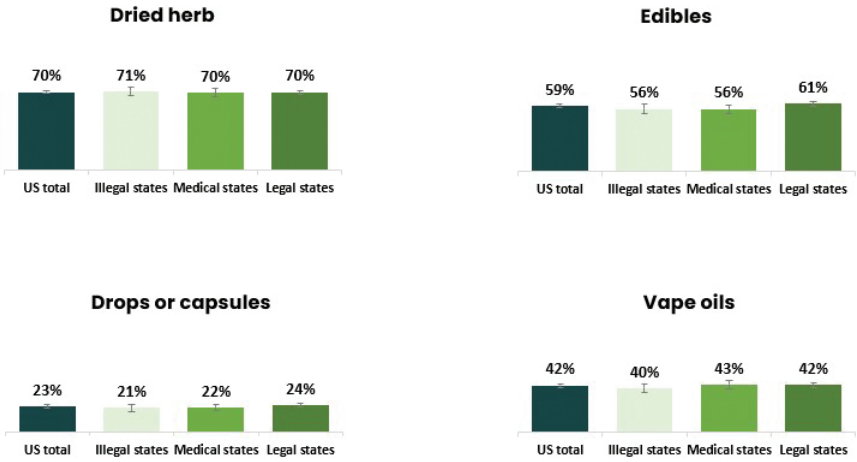

FIGURE 3-21 Types of cannabis products used among people reporting past-year use of cannabis, by state-level cannabis legalization status, International Cannabis Policy Study, 2023 (N = 10,214).
SOURCE: Generated by David Hammond, consultant to the committee.

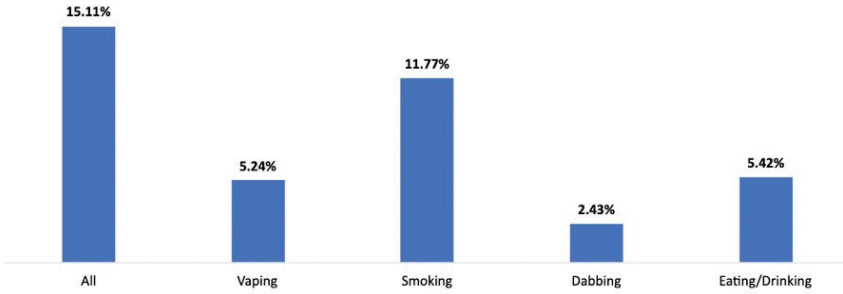

FIGURE 3-22 Past-month cannabis use by mode of administration among those aged 12 and over, NSDUH, 2022.
NOTES: Changes from solid, to dotted, to dashed lines represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

Young adults (aged 18–25) accounted for the highest proportion of past-month cannabis smokers (21.4 percent). Smoking was also common among males (14.0 percent) and females (9.7 percent), people living in poverty (15.1 percent), and those who had some college (15.1 percent) (Figure 3-23).

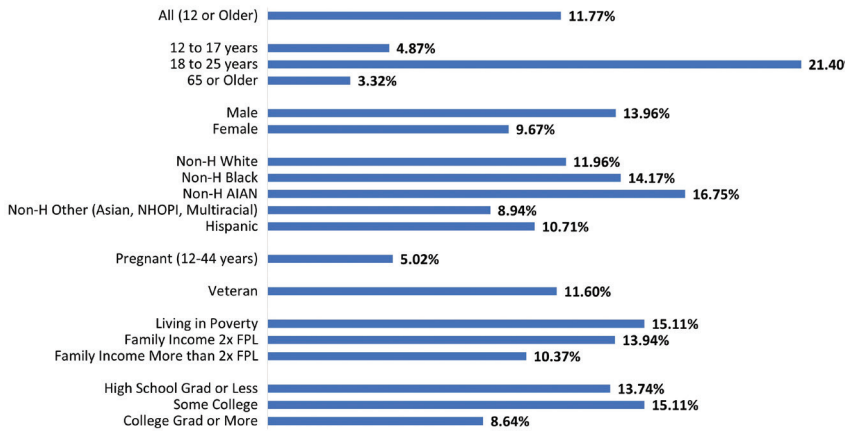

FIGURE 3-23 Past-month cannabis use: Smoking, NSDUH, 2022.
NOTES: FPL = federal poverty level; NHOPI = Native Hawaiian and Other Pacific Islander; non-H = non-Hispanic; NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

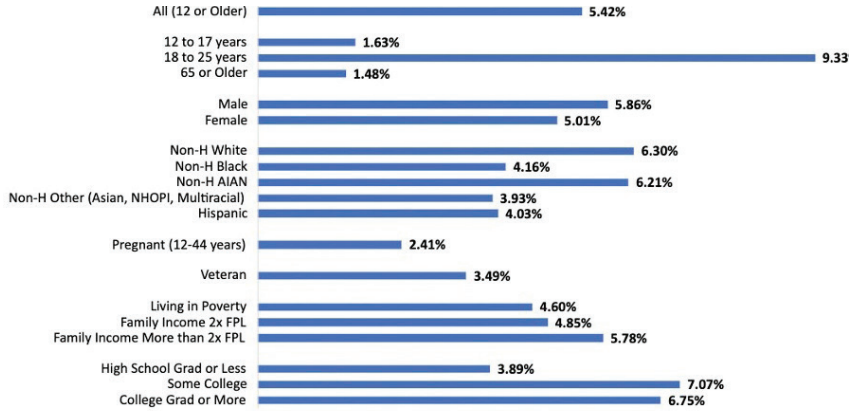

FIGURE 3-24 Past-month cannabis use: Eating/drinking, NSDUH, 2022.
NOTES: FPL = federal poverty level; NHOPI = Native Hawaiian and Other Pacific Islander; non-H = non-Hispanic; NSDUH = National Survey on Drug Use and Health.
SOURCES: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

Eating and drinking of cannabis was also most prevalent among young adults (aged 18–25) (9.3 percent), with modest rates among males (5.9 percent), females (5.0 percent), non-Hispanic Whites (6.3 percent), American Indians/Alaska Natives (6.2 percent), more affluent populations (5.8 percent), and those with some college (7.1 percent) or a college degree (6.75 percent) (Figure 3-24).

Vaping (12.6 percent) and was dabbing (7.1 percent) were also most prevalent among those aged 18–25 (Figures 3-25 and 3-26).

Among pregnant persons, the most prevalent modes of administration for the past 30 days were smoking (5.0 percent), vaping (3.5 percent), eating/drinking (2.4 percent), and dabbing (2.0 percent). Among veterans, those rates were smoking (11.6 percent), vaping (3.6 percent), eating/drinking (3.5 percent), and dabbing (1.4 percent).

Quantity Consumed

When examining the health consequences of using cannabis, knowing the frequency of use, types of products used, and how they are used is necessary but insufficient. One must also know how much of each product is consumed and, ideally, the THC concentration of the product, so a dose could be estimated. As noted earlier, one would expect the consequences of daily use to differ for those who smoke cannabis multiple times per day versus those who have a puff or two from a cannabis vape pen every night

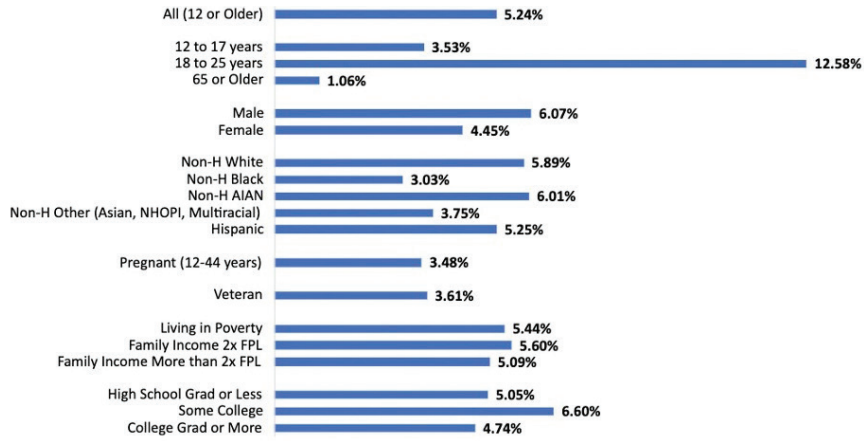

FIGURE 3-25 Past-month cannabis use: Vaping, NSDUH, 2022.
NOTES: FPL = federal poverty level; NHOPI = Native Hawaiian and Other Pacific Islander; non-H = non-Hispanic; NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

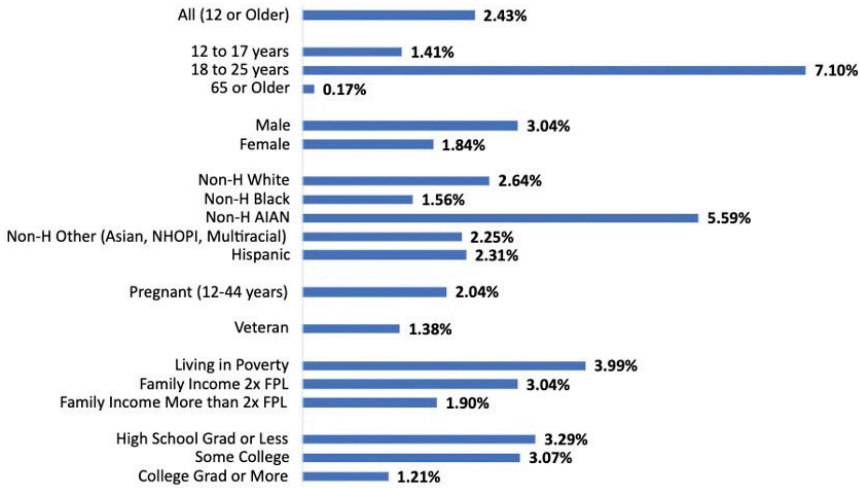

FIGURE 3-26 Past-month cannabis use: Dabbing, NSDUH, 2022.
NOTES: FPL = federal poverty level; NHOPI = Native Hawaiian and Other Pacific Islander; non-H = non-Hispanic; NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

before going to sleep. While the NSDUH does not ask about the quantity consumed for any cannabis products, other surveys have attempted to collect this information; however, this is still very much an emerging field of study.

Early research on the quantity of cannabis consumed focused primarily on flower (which dominated consumption at that time), and on estimating the total amount of cannabis consumed in a jurisdiction. These estimates were based mainly on internet convenience samples from the 2010s and were used mainly for generating reasonable ranges for heavy cannabis users, who account for most consumption and expenditure (Kilmer et al., 2014). For these samples, it was common for the median amount of flower used by daily users per use day to be approximately 1.5 g; those using fewer days per month generally consumed less per use day (Caulkins et al., 2020; Kilmer et al., 2013).

More recent surveys have focused on collecting information on quantity consumed for multiple types of cannabis products, not just flower—especially in Canada (Callaghan et al., 2019; Hammond and Goodman, 2020). Within the United States, the ICPS does collect this information, and Wadsworth and colleagues (2023) reported the mean (with standard deviation) and median amounts used during a use day by product, frequency of use, and state legal status. For people living in states that had enacted legalization in 2020 and used dried flower, evidence shows that frequency of use is positively correlated with amount used (Table 3-1). Table 3-2 presents similar data for some other cannabis products, but only for two groups: all past-year users who used the product and those who used it on a DND basis.

While converting these quantity estimates into the amount of delta-9-tetrahydrocannabinol (THC) consumed would be useful, there are important challenges to doing so. First, research from Hammond and Goodman (2020) finds that consumer knowledge of THC levels is low, and that there were only modest differences between consumers living in jurisdictions that had and had not legalized nonmedical cannabis. Second, even if consumers

TABLE 3-1 Mean (standard deviation [SD]) and Median Grams of Dried Flower Used Per Use Day for People Living in States That Legalized Cannabis, 2020 (N = 4,126)

	Used Less Than Monthly in the Past Year	Used Monthly in the Past Year	Used Weekly in the Past Year	Used Daily or Near Daily in the Past Year
Mean (SD)	0.64 (1.04)	0.97 (1.24)	1.13 (1.34)	2.05 (1.94)
Median	0.25	0.5	0.6	1.2

SOURCE: Hammond et al., 2022.

TABLE 3-2 Mean (standard deviation [SD]) and Median Amount of Nonflower Cannabis Products Used Per Use Day for People Living in States That Legalized Cannabis, 2020

Product	Unit of Measure	All Past 12-Month Consumers	Used Daily or Near Daily in the Past Year
Mean (SD) Dried flower	Grams	1.35 (1.64)	2.05 (1.94)
Median		0.75	1.20
		(N = 4,126)	(N = 1,508)
Mean (SD) Cannabis oil—vaped	Times per day	3.66 (3.05)	5.02 (3.59)
Median		3.00	4.00
		(N = 1,862)	(N = 377)
Mean (SD) Edibles/foods	Number per day	1.49 (1.39)	1.92 (1.56)
Median		1.00	1.00
		(N = 3,595)	(N = 248)
Mean (SD) Concentrates	Grams	1.18 (1.60)	1.26 (1.59)
Median		0.50	0.50
		(N = 987)	(N = 233)

SOURCE: Hammond et al., 2022.

remember what was on the label of the product they consumed, serious questions exist about the accuracy of THC levels reported on labels in the United States (Geweda, 2024, further discussed later in this chapter; Schwabe, 2023). Third, the amount of THC that reaches the bloodstream varies with the product consumed (e.g., smoking leads to THC loss in sidestream smoke, and not all THC is destroyed by pyrolysis [Perez-Reyes, 1990]). Furthermore, some products can be consumed in multiple ways (e.g., flower can be smoked or vaped). Fortunately, important research is focused on improving and standardizing measures of THC consumption (Borodovsky et al., 2022; Freeman and Lorenzetti, 2020, 2023; Wood et al., 2024).

Cannabis Use Disorder

In addition to general cannabis use patterns, cannabis use is evaluated with respect to clinical *DSM* criteria of abuse, dependence, or cannabis use disorder. Use of the terms "cannabis abuse" and "cannabis dependence" in *DSM-IV* was based on seven criteria related to symptoms, duration, and impact on daily functioning. A diagnosis of cannabis abuse required meeting one or more of four criteria; a diagnosis of cannabis dependence required meeting three or more of the seven total criteria. *DSM-V*, which replaced *DSM-IV* in 2013, includes 11 criteria that incorporate six of the seven former *DSM-IV* abuse and dependence criteria (with the legal

problem criterion removed), as well as new craving and withdrawal criteria. Moreover, *DSM-V* combines elements of abuse and dependence into a single category of "cannabis use disorder" with varying degrees of severity—mild (presence of two or three criteria), moderate (four or five criteria), and severe (six or more criteria). Changes in the *DSM* diagnostic criteria would be expected to affect the classification and prevalence of cannabis use disorders, but studies examining the concordance between *DSM-IV* and *DSM-V* have generally found high levels of agreement (Compton et al., 2013; Hasin et al., 2016). There are nevertheless some nuances, including slight variations in prevalence rates of cannabis use disorder when *DSM-V* rather than *DSM-IV* criteria are applied. For example, *DSM-V* criteria appear to yield slightly higher prevalence rates because of the integration of abuse and dependence into a single disorder, and the prevalence of moderate to severe *DSM-V* cannabis use disorder is higher than that of *DSM-IV* cannabis dependence that may also be attributed to the cannabis withdrawal criterion (Compton et al., 2013; Goldstein et al., 2015; Hasin et al., 2016).

Based on NSDUH estimates, rates of cannabis abuse and dependence remained relatively stable from 2002 to 2019, with the highest rates of abuse and dependence among young adults (aged 18–25) (Figure 3-27). For 2020, except for youth (aged 12–17), for whom the data suggest a slight decline in rates of cannabis abuse and dependence, the data are generally consistent with the longer-term trends for the other age groups. In 2021, the NSDUH introduced the diagnostic category of cannabis use disorder to better accord with *DSM-V* criteria for classifying substance use disorders. The

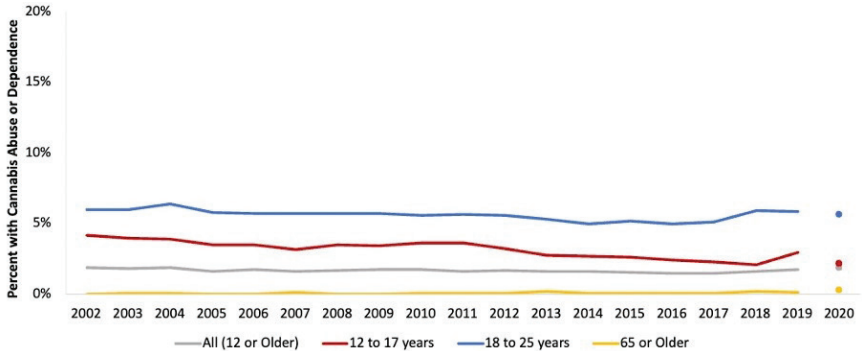

FIGURE 3-27 Past-year cannabis abuse or dependence by age group, NSDUH, 2002–2020.
NOTE: Changes from solid, to dotted, to dashed lines represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

frequency of the disorder is higher than previous estimates of cannabis use and dependence (online Appendix E). Given that cannabis use disorder has only been measured for two years using the new *DSM-V* criteria, it is challenging to determine how this has changed over the full 20-year time period. It follows a similar pattern as that of cannabis use and dependence, with the highest rates of the disorder among young adults (aged 18–25), males, non-Hispanic American Indians/Alaska Natives, people living in poverty, and people with some college education. In 2022, cannabis use disorder was less common in pregnant persons than in the general population but was increasing in both populations (Figure 3-28, online Appendix E).

Perceived Availability and Cannabis Use: Findings

The overall trend in the perceived availability of cannabis remained relatively flat from 2002 through 2014 but then began to increase, consistent with the opening of adult-use retail markets in a few U.S. states. There was a large increase in perceived availability among those 65 or older, but a noteworthy decrease for those aged 12–17.

Over the past 20 years, the number of people who use cannabis in the United States has seen a large increase. More important, however, the share of people using cannabis on a DND basis has risen even faster—in fact, much faster; 2022 was the first year when the number of Americans

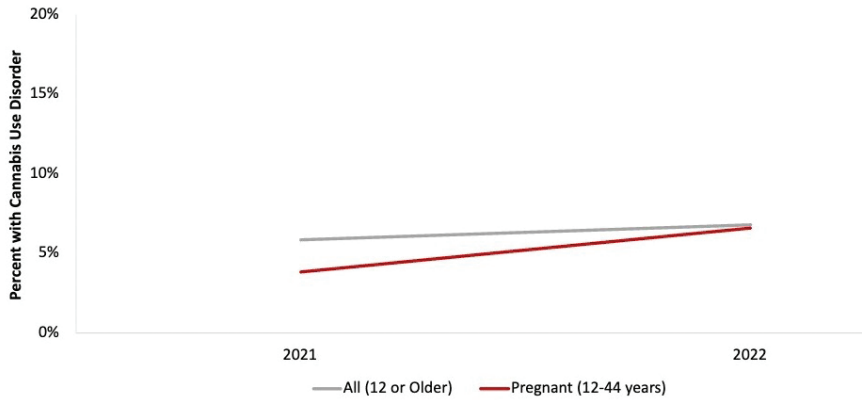

FIGURE 3-28 Past-year cannabis use disorder among pregnant persons, NSDUH, 2021–2022.
NOTE: Changes from solid, to dotted, to dashed lines represent methodological changes to the NSDUH. NSDUH = National Survey on Drug Use and Health.
SOURCE: Generated by Seema Hemant Choksy Pessar, consultant to the committee.

using cannabis on a DND basis was larger than the number of Americans using alcohol on a DND basis. Perhaps of even greater significance from a public health perspective is the enormous rise in frequent use among those aged 65 and older as well as pregnant persons, two particularly vulnerable populations.

The number of cannabis products consumed has also grown, with a greater number of Americans reporting use of concentrates, edibles, and vape oils, while dried flower (still the most commonly used product) has declined. Smoking is the most common route of administration, followed by eating and drinking, vaping, and dabbing.

NSDUH estimates for cannabis use disorder has only been measured for 2 years using the new *DSM-V* definition, making it challenging to determine whether there have been changes over time. Still, the demographic characteristics for the disorder follow patterns similar to those for cannabis use, with the highest rates among young adults (aged 18–25), males, non-Hispanic American Indians/Alaska Natives, people living in poverty, and with those with some college education.

TRENDS IN CANNABIS CONCENTRATION AND PRICES

Consumption patterns alone form an incomplete picture of the cannabis landscape, in part because the core intoxicant contained in cannabis has changed dramatically during this time and differentially across different product forms. Examining the trends in delta-9-THC concentration and prices over time therefore provides important additional insights as to whether the cannabis marketplace is evolving in a manner that supports public health. This section describes current trends in these two areas, recognizing the limitations of the available data sources.

Concentration of THC in Products

As reported earlier, the concentration of delta-9-THC and other active ingredients in cannabis products has been increasing. However, data do not exist on the delta-9 THC levels consumed over time. The increase in the average THC levels over time can be seen in data from seized cannabis flower in the United States (Figure 3-29). In the late 1990s, the average THC level for seized cannabis flower was less than 5 percent; by 2010, this figure had increased to roughly 10 percent, and by 2019, it was closer to 14 percent (El Sohly et al., 2021). Seized products do not represent what is available in state-legal markets or is being consumed (e.g., enforcement could have prioritized trafficking of higher-concentration products). Of interest, ElSohly and colleagues (2021) observed that cannabidiol (CBD) concentrations do not follow the same trends as those for delta-9-THC, having declined from

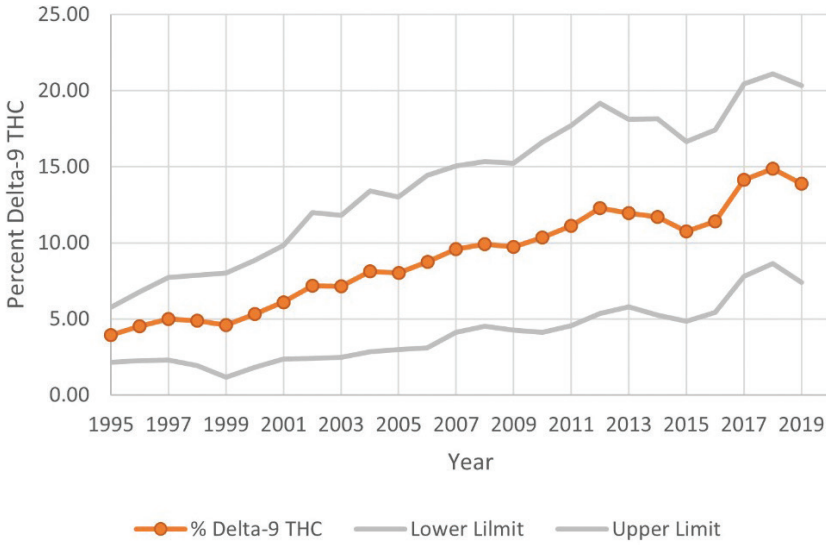

FIGURE 3-29 Mean delta-9 THC concentration for cannabis flower seized and submitted to the Drug Enforcement Administration for testing, 1995–2019.
NOTE: THC = tetrahydrocannabinol.
SOURCE: Generated by the committee based on ElSohly and colleagues, 2016, 2021.

0.4 percent in 2009 to 0.14 percent in 2017 and climbed to approximately 0.6 percent in 2019 (see also ElSohly et al., 1984).

State-level "track-and-trace" data systems can also be used to assess the concentration levels of products purchased in the state-legal market. While these data do not elucidate the concentration of products obtained from the illegal market, they become more representative of total consumption as legal sales displace illegal sales over time.

Generally, trend data from track-and-trace data systems show increases in the labeled delta-9-THC content of products sold, but these content figures are not always accurate. A study in Washington state found that the average THC levels of the flower sold increased from 16.5 percent in 2014 to 21.4 percent in 2017 (Kilmer et al., 2019). The study also found that the THC levels of the extracts sold increased from roughly 40 percent to 70 percent over the same period. In Colorado, the average THC levels for the flower sold increased from roughly 14 percent in 2014 to 19 percent in 2020; for concentrates, the THC level was in the 40–50 percent range in 2014, increasing to close to 70 percent over time (MPG Consulting and Leeds School of Business, 2021).

As noted, however, questions arise about the accuracy of THC levels on the labels of products sold in state-legal markets. Indeed, multiple media

investigations have focused on the prevalence of THC-level inflation by testing labs (Roberts et al., 2023; Schoenberg, 2023). These issues have also been documented in the scientific literature. For example, Zoorob (2021) examined the THC test results for flower products in Nevada and Washington, finding:

> There is a statistically unusual spike in the frequency of products reporting just higher than 20% THC in both states consistent with economic incentives for products to contain at least 20% THC. This "bunching" of reported THC levels exists among some, but not all, cannabis testing labs, suggesting that laboratory differences (rather than precise manipulation by growers) drive this potential manipulation in reported THC content. (p. 1)

A more recent analysis tested 23 packages of cannabis flower from 10 dispensaries in Colorado. The THC concentrations reported on the package labels were lower than those in recent reports by retail outlets. Overall, about 70 percent of the samples contained more than 15 percent less THC than reported on the label (Schwabe et al., 2023). This finding is especially noteworthy since Colorado has the longest-running nonmedical market in the United States. Geweda and colleagues (2024) conducted a similar exercise, focused on 107 flower samples collected by law enforcement from state-legal adult-use commercial dispensaries in California, Colorado, and Oregon (Geweda et al., 2024). Of the 107 products, only 32 (30 percent) had a delta-9-THC content within +/–20 percent of the labeled content.

These studies, which focused on three different states and various media reports, suggest caution when using the THC data on labels or what is available in seed-to-sale tracking systems.[7] While there are ways to address some discrepancies statistically, these findings highlight the need to improve accuracy and reduce fraud in the cannabis testing industry (see Chapter 4 for discussion of product testing). Findings on the inconsistency of product labeling of THC content within a given product category (e.g., flower, oil, tincture) are important for understanding trends in THC concentration within a product category but do not negate the point that, overall, total THC available in products in the marketplace is rising as products with a much higher THC concentration (vape pens, edibles, oils) displace products with lower concentration (flower products).

Prices

The price of cannabis has implications for many of the outcomes discussed in cannabis policy debates—consumption of cannabis, consumption

[6] This is not just an issue for delta-9-THC. Spindle and colleagues (2022) analyzed 105 topical cannabinoid products and found that 18 percent were overlabeled for CBD (>10 percent less CBD than advertised), and 58 percent were underlabeled (>10 percent CBD than advertised).

of other substances, size of the illegal market, tax revenues, and the profitability of licensed cannabis businesses—implications that can affect the viability of cannabis-related social equity programs (see Chapter 5) (Kilmer et al., 2014, 2019). This section reviews the theoretical reasons why legalization could decrease prices and then presents evidence of these price declines.

There are multiple reasons why the legalization of cannabis supply may reduce the production and distribution costs dramatically. First is the reduction in risk compensation (Reuter and Mark, 1986). When people buy drugs from the illegal market, they are typically compensating the seller and everyone along the supply chain for their risk of arrest, incarceration, and sometimes violence. This risk is reduced, if not eliminated, with legalization. Second, production in the illegal market can be very inefficient, a phenomenon that Reuter (1983) refers to as *structural consequences of product illegality*. Once an industry no longer hides its activities, transactions become less costly. It becomes easier to acquire and use cost-saving technologies (e.g., trimming machines, extraction materials, packaging technologies). This increase in efficiency should reduce costs. Third, if large producers can supply the market, they can take advantage of economies of scale, reducing the price per unit produced.

In the early 2000s, it was typical for sinsemilla (cannabis grown without seeds) in the wholesale illegal market to be sold for more than $3,000 per pound (Caulkins and Kilmer, 2016; Kilmer et al., 2010). As theory would predict, these wholesale prices have dropped dramatically post legalization. Here, the committee focuses on two of the first four states to legalize—Colorado and Oregon, which have regularly published wholesale price information. Figure 3-30 presents the median market price for a pound of cannabis in Colorado from January 2014 to April 2024.[8] When this series started, the median price per pound was slightly less than $2,000; as of early 2024, it was $750 (unadjusted for inflation) (CDOR, 2023). This decrease has not been consistent; there has been fluctuation. In April 2023, the price was as low as $649 per pound.

Oregon observed a similar decrease (Figure 3-31). Based on wholesale prices obtained from the state's seed-to-sale tracking data, the price per pound at the wholesale level went from roughly $1,800 in early 2016 to roughly $750 in late 2023, with the price as low as $550 in late 2022 (unadjusted for inflation) (OLCC, 2023).

[7] Each quarter, Colorado's Department of Revenue reports the "average market rates" for cannabis, which are defined as "the median market prices per pound or count of each category of unprocessed retail marijuana that is sold or transferred from retail marijuana cultivation facilities to retail marijuana product manufacturing facilities or retail marijuana stores" (CDOR, 2024, para. 1).

FIGURE 3-30 Median market price for a pound of "bud" in Colorado's state-legal market.
SOURCE: Generated by the committee based on CDOR, 2023.

However, just because there is a massive price drop at the wholesale level does not necessarily mean there will be a similar decrease in retail prices. In principle, governments can set minimum prices or can set prices directly in government-run stores (see Chapters 2 and 4) to discourage purchases, but these approaches have not been implemented in state-legal markets in

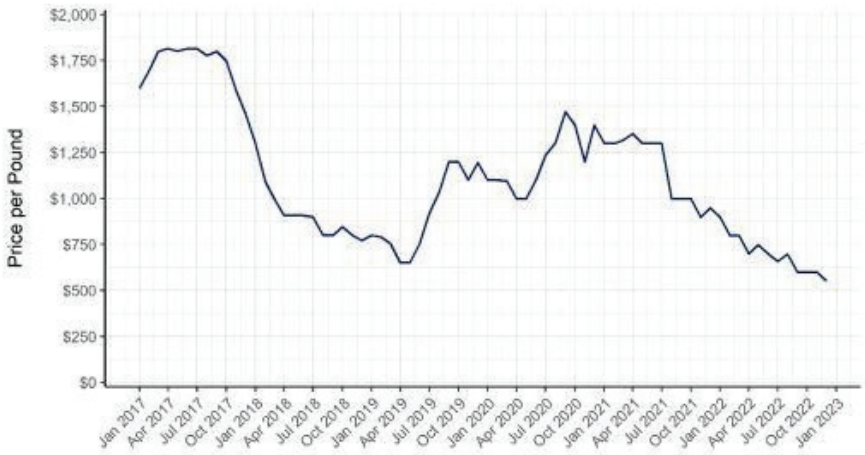

FIGURE 3-31 Median wholesale price per pound for "usable marijuana" in Oregon's state-legal market.
SOURCE: OLCC, 2023.

the United States. States that have legalized marijuana have allowed profit-maximizing companies to sell cannabis, and this competition has resulted in reductions in the legal retail prices. In Washington, the median price per gram of flower was close to $25 when the stores opened in July 2014 but had fallen below $10 nearly 2 years later (Smart et al., 2017). The price per gram of flower sold at the retail level in Colorado fell from approximately $14 in January 2014 to roughly $5 in September 2020 (MPG Consulting and Leeds School of Business, 2021). In Oregon, the median price per gram of flower was more than $10 in late 2016 and had decreased to under $4 by the end of 2023. Even in one of the more recent legalization states—Michigan—it was reported that the price per ounce of flower dropped 40 percent, from roughly $9 per gram in early 2021 to $5 per gram in early 2022 (Semmler, 2022). Of course, the size of these price drops depends on the regulatory decisions made by the states (e.g., the number of cannabis business licenses issued), and they take time to go into effect (Hunt and Pacula, 2017).

When making these price comparisons over time and across markets, it is critical to compare similar products. The increase in the average THC concentration of flower products over time would suggest that the price per unit of THC is falling even faster than the declines described above. Furthermore, most of these price series do not adjust for inflation, which would show an even larger decrease. However, very few analyses incorporate THC concentration into their price analyses (Davenport, 2020; Hansen et al., 2020; Smart et al., 2017). One notable exception is Davenport's (2020) analysis of Washington state's seed-to-sale data, which generates model-based estimates of the price per 10-mg dose of THC for various products over time (Figure 3-32). Not only is a general decline observed over the 3 years examined, but there is also a variation in the price per unit of THC by product. Flower was the cheapest, which was unsurprising since it requires less processing than the other products (Davenport, 2020). The extent to which these price differentials have continued since 2018 and whether they are similar in other states is unclear.

Thus far, this section has focused on trends in administrative price data from the early adoption of legalization states. There have also been analyses of self-reported prices via surveys, not focused exclusively on legalization states. For example, a cross-sectional study using ICPS data found that respondents living in U.S. states with operating adult-use stores paid less per gram of flower than those living in states where cannabis is illegal entirely or is allowed only for medical purposes, or in states that had legalized but where retail stores had not yet opened (Wadsworth et al., 2023). Another ICPS analysis of Canadian data found that self-reported prices per gram of flower fell in both the legal and illegal markets from 2018 to 2022 (Hammond, 2023). However, it is vital to ensure that similar products are being compared in surveys and other data sources.

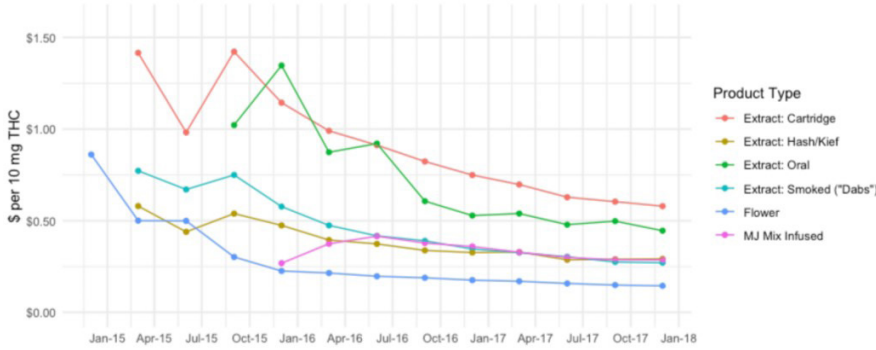

FIGURE 3-32 Retail price per 10-mg THC in Washington state's legal market through 2017, by type of product.
NOTE: MJ = marijuana; THC = tetrahydrocannabinol.
SOURCE: Davenport, 2020.

Notably, price declines are occurring while cannabis supply and possession are still prohibited under federal law. If federal law changed and it was no longer illegal to move cannabis across state lines, production could concentrate in a few places in the United States.[9] According to one estimate, all the cannabis consumed nationwide could be produced on a few dozen average-sized (450-acre) farms (Kilmer et al., 2022; USDA, 2020). If a change in federal policy allowed large corporations (e.g., tobacco, alcohol, or food companies) to participate in the cannabis market and cannabis were sold in grocery stores or by national online retailers, retail prices would likely be depressed even more (Caulkins and Kilmer, 2016). Some presenters at the committee's public meetings argued that a federal change in cannabis policy should prioritize smaller companies over large corporations; a related question is the sustainability of a policy prioritizing small businesses.

Concentration and Price: Findings

The concentration of delta-9-THC in cannabis flower has been increasing, while prices have been declining. Changes in federal cannabis laws could further reduce prices by allowing interstate commerce and potentially

[8] It has also been argued that state-level restrictions on interstate commerce could be challenged even without federal legalization. For example, Mikos (2021) asserts "that the restrictions legalization states now impose on interstate commerce in cannabis likely violate the Dormant Commerce Clause" (p. 857).

attracting larger corporations to the cannabis industry (Caulkins and Kilmer, 2016; Kilmer et al., 2021). The potential impact of increased corporate involvement on market dynamics and social equity goals requires further consideration.

WHAT IS HAPPENING WITH THE ILLEGAL CANNABIS MARKET?

Understanding of the illegal cannabis market in the United States is complicated by poor data and the sizable unregulated market resulting from the 2018 Farm Bill (discussed in Chapter 2). The source for cannabis has shifted from Mexico, which was the dominant source for the United States through the year 2000 (Kilmer et al., 2010). As state-legal production ramped up and sinsemilla came to dominate the U.S. flower market, there was less demand for Mexican-grown cannabis, as it tended to have a lower THC concentration. The amount of cannabis seized at the U.S. southwest border has declined more than 97 percent[10]—from 2.4 million pounds in 2013 to 61,000 pounds in 2023 (based on data from U.S. Customs and Border Protection; Figure 3-33) (Grillo, 2024). Some cannabis in the U.S. market likely comes from Mexico, but the Drug Enforcement Administration's 2020 National Threat Assessment also supports the finding of an increase in domestic production.

The size of the illegal market could be estimated by taking the total delta-9-THC consumed[11] in the United States and subtracting the total amount sold in state-legal stores, with adjustments for cannabis derived from home cultivation. However, credible, peer-reviewed estimates of the national cannabis market do not exist. The Office of National Drug Control Policy used to include such estimates in its *What America's Users Spend on Illegal Drugs* series. However, the most recent data from this report are from 2016 (Midgette et al., 2019).

Another challenge is that different components of the illegal market have different harms and require different policy responses. For example, cannabis grown in another country and imported to the United States requires a different policy response than does an adult's legally purchasing cannabis and then selling it to someone under age 21. There could also be unlicensed production in the United States, as well as movement of legally produced or purchased cannabis products to other states (Hansen et al.,

[9] There are limits to drawing inferences from seizure data (Reuter and MacCoun, 1995), and there was an increased focus on seizing fentanyl and methamphetamine from Mexico during this period. Still, the size of the drop is consistent with the massive increase in production throughout the United States.

[10] It is important to note that data from state traceability systems capture the amount of delta-9-THC obtained from legal sources, not necessarily consumed.

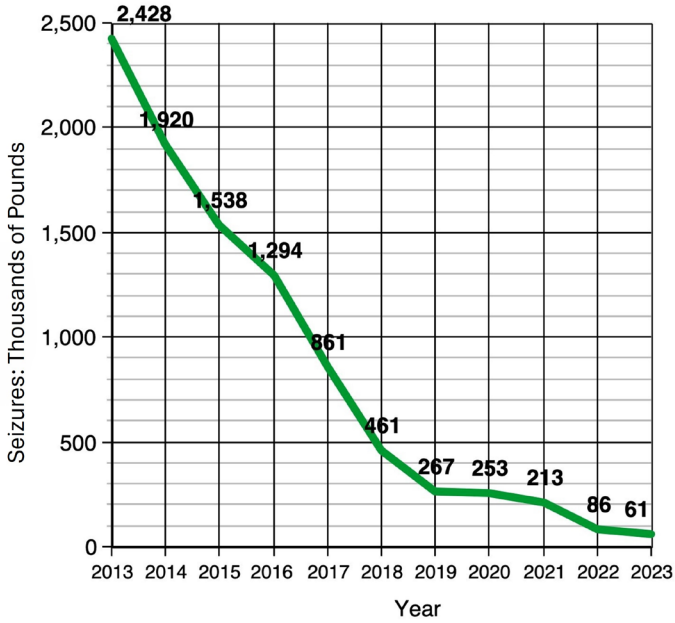

FIGURE 3-33 Marijuana seizures at the U.S. southwest border, 2013–2023.
SOURCE: Reproduced from Grillo, 2024.

2020). Analyzing all the different types of illegal markets is infeasible. Instead, the committee examined how much cannabis comes from licensed markets in states where it is legal and the extent to which legalization displaced or reduced illegal cannabis cultivation within the United States.

How Much Cannabis Comes from Licensed Markets in States Where It Is Legal?

While some information is available on this question, it varies across states, time periods, measures, and the quality of the methodology used. In the first 3 years of retail cannabis sales in Washington (Kilmer, 2019), an estimated 40–60 percent of the THC obtained by state residents came from the state-licensed cannabis market. A study by the Oregon Liquor and Cannabis Commission (OLCC, 2019) estimated that circa 2018, "an estimated 55% of total statewide marijuana consumption among Oregonians aged 21 or older is procured from OLCC Recreational Retailers" (p. 1). More recent figures from industry sources suggest that the vast majority of cannabis consumed by state residents in Colorado and Oregon comes from the legal market, but there is very little information about the methodologies used to generate these industry estimates (e.g., see Barcott, 2022).

In addition to variation across states and over time, there is within-state variation in the share of cannabis consumed that comes from the legal market. Some states allow localities to opt out of allowing licensed cannabis retail stores and sometimes deliveries (Chapter 2). Indeed, allowing jurisdictions to choose whether to license stores has been offered as one explanation for why the illegal market remains so robust in California. Still, other arguments exist, such as lax enforcement and minimal penalties for participating in the illegal market (see, e.g., Kaste, 2024).[12]

Other measures of illegal market activity have been published, but the extent to which they provide insights about the size of the illegal market varies. For example, reporting the share of people who used cannabis obtained from illegal and legal sources in the past year is not the same as knowing what share of total expenditures or total consumption came from the illegal market, although these surveys collect rich demographic information that could provide helpful information about the people participating in illegal and legal markets.

Some surveys collect information about where cannabis was purchased, which provides some insight into whether individuals are purchasing from legal or illegal sources. Since 2018, for example, the ICPS has been asking respondents who report past-year use of cannabis to identify all the sources for each type of cannabis they used. Responses include home grown or from a family or friend, dealer, internet delivery service or mail order, retailer, or other. Figure 3-34 reports trends in the sources of all cannabis obtained in the past 12 months for respondents answering this question in the ICPS. As more states have liberalized their policies and allowed either medical dispensaries or retail stores to open, a growing share of people who used cannabis in the past year have reported purchasing it from a store (from 26 percent in 2018 to 56 percent in 2023, a doubling in just 6 years). This finding is consistent with an insight from Figure 3-34 that the shares of those reporting purchasing from a dealer and a friend have both declined.

Figure 3-35 shows the same results broken down by whether the respondent lived in a state that has legalized adult-use cannabis, medical cannabis,

[11] This point about enforcement—which is discussed further in Chapter 5—is especially important for understanding the struggles New York has experienced with cannabis legalization. Indeed, the governor has referred to the transition as "a disaster" (Kaste, 2024). When an increasing number of bodegas and other outlets started selling cannabis illegally after legalization passed but before legal stores had been licensed, authorities did not prioritize stopping these illegal sales. The number of illegal outlets exploded because sellers believed there was little legal risk; some estimated that New York City alone had roughly 1,500 illegal cannabis outlets operating circa November 2023 (Bisram, 2023). There are reports of increased enforcement activity against these unlicensed sellers (often civil instead of criminal; see Hart, 2024), but this creates massive challenges for the initial licensed retailers who were equity licensees and nonprofit organizations.

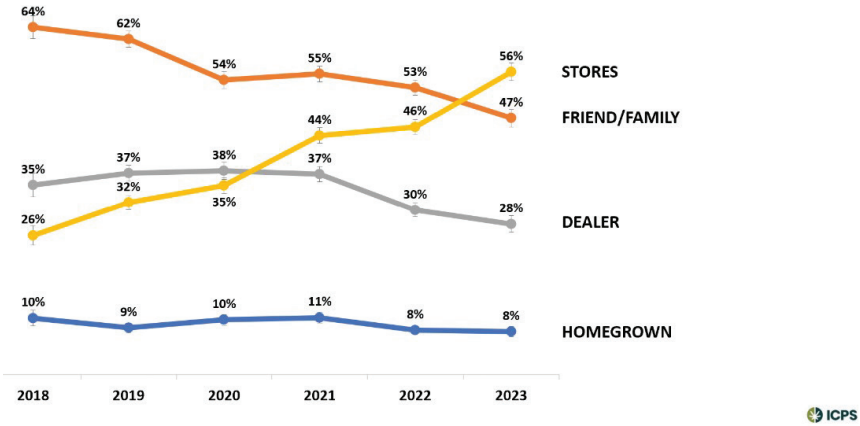

FIGURE 3-34 Self-reported cannabis sources in the past 12 months among people who used cannabis in the past year, ICPS 2018–2023.
SOURCE: Generated by David Hammond, consultant to the committee.

or neither. Importantly, it shows that the share of respondents reporting that they purchased their cannabis at a store is significantly higher (64 percent) among people living in an adult-use state than among those who reported living in a state where cannabis is illegal (39 percent). In comparison, the share of people living in a legalization state who reported purchasing from a dealer (23 percent) is considerably lower than that of individuals living in a state where cannabis is illegal (38 percent). Individuals living in

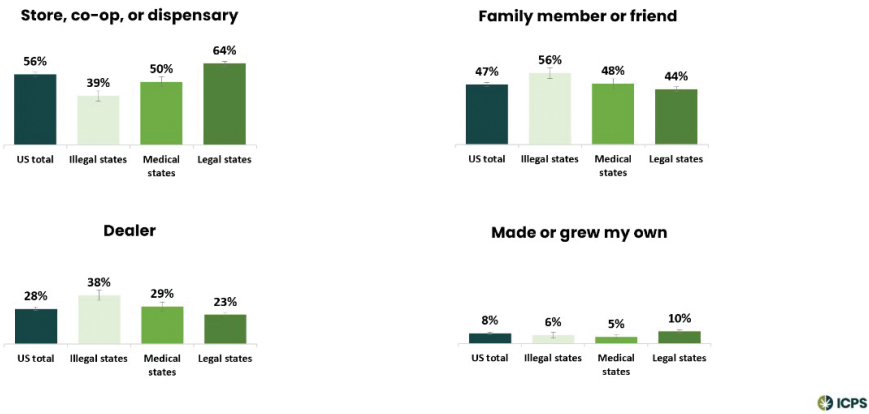

FIGURE 3-35 International Cannabis Policy Study, data on cannabis sources in the past 12 months by state-level cannabis legalization status, 2023 (N = 15,162).
SOURCE: Generated by David Hammond, consultant to the committee.

legalization states are also less likely to report obtaining cannabis from a friend or family member (44 percent) compared with those living in states without legalization (56 percent). Still, the differences are smaller than those from other sources.

To What Extent Has Legalization Displaced or Reduced Illegal Cannabis Cultivation within the United States?

Given the patchwork of cannabis laws, variation in enforcement, and the fact that cross-state shipping has always been a staple of the U.S. cannabis market, it is entirely possible that (1) overall illegal production has decreased, and (2) illegal production has increased in some states that have legalized. Some early-adopting legalization states had robust illegal markets before legalization that helped supply other parts of the country. If legalization made it easier for these illegal producers to operate (e.g., cheaper and easier to access production materials) and more difficult to identify while also decreasing enforcement risk, it is entirely plausible that illegal production could have increased in these states.[13]

However, empirically assessing this relationship is complex. A census of illegal cultivation operations over time does not exist, and simply focusing on seizures or reported cultivation can be problematic. As Reuter (1995) notes, seizure figures are a function of three phenomena: (1) the amount of illegal activity occurring, (2) efforts made to hide these illegal activities, and (3) detection and enforcement efforts by law enforcement officials. There have been attempts to use satellite imaging and thermal cameras to detect outdoor and indoor cannabis cultivation, but the committee is unaware of efforts to do this systematically over time to measure the impact of legalization. St. John's (2022) exposé in the *Los Angeles Times* about illegal cultivation in California does include satellite photos of one area in 2014 and 2021, documenting the proliferation of illegal cannabis greenhouses in Mount Shasta Vista and reporting that in nearby Juniper Flat.greenhouses covered more than 10 million square feet, a 4,200% increase since 2018 (St. John, 2022). The piece, which also includes several interviews with law enforcement officials and community members, concludes that illegal cultivation in California has proliferated since legalization. However, the article

[13] There may also be concern about where illegal growing is occurring given its potential damage to the environment. For example, a study by Prestemon and colleagues (2019) examines reports of illegal growing on U.S. national forests from 2004 to 2016, reporting that nonmedical legalization was associated with a decrease in reports of illegal growing operations. However, since the study is based on reports rather than a more objective measures, such as satellite images of cannabis grows, legalization could have affected the probability that someone reported what was believed to be illegal growing (one could imagine bias in both directions). The study also does not control for time-invariant characteristics of each state (i.e., state-level fixed effects), which could affect the estimates.

includes a quote about illegal cultivation from the director of the California Department of Cannabis Control: "Do I think it's worse? I honestly couldn't say one way or another" (St. John, 2022, toward the end of article).

CONCLUSIONS

Since 2002, the number of people using cannabis has increased. The frequency of use has increased at a much faster rate, with more people reporting daily or near-daily use of cannabis than of alcohol in 2022. While dried flower remains the most common product, concentrates, edibles, and vape oils are gaining popularity, with people who use cannabis often employing multiple routes of administration. Measures of delta-9-THC concentrations suggest an increase since 2002, and the prices for cannabis products in many legalization states have declined.

Conclusion 3-1: The price per unit of delta-9-THC is declining, with implications for many outcomes discussed in cannabis legalization debates, such as consumption, the size of the illegal market, tax revenues, and the profitability of businesses (which can affect social equity efforts). These declines would likely be accelerated with federal legalization.

Understanding the dynamics of the legal versus illegal cannabis market is complicated by the lack of data on total cannabis (and delta-9 THC) consumption in the United States and the confusion created by the 2018 Farm Bill. There is evidence that in states that have legalized cannabis, an increasing number of state residents are getting their cannabis from state-legal sources; however, this evolution can take time.

Conclusion 3-2: Reduction in the size of the illegal cannabis market is shaped by multiple factors, ranging from the regulatory environment to enforcement activities.

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4

Applying the Core Public Health Functions to Cannabis Policy

Changes in cannabis policy impact public health. The core public health functions—assessment, policy development, and assurance—serve as a framework for leveraging ten essential public health services that can be used to promote public health for everyone (IOM, 1988). The essential services, introduced in 1988, further developed in 1994, and updated in 2020, are designed to promote equitable policies and address community structural barriers that may have led to health inequities (Castrucci, 2021).

The ten essential public health services are theoretical concepts and practical actions that fit within the core public health functions (Figure 4-1). Public health policy makers, cannabis regulators, and public health authorities have crucial roles in implementing these functions. Assessment involves surveillance, population health monitoring, and research to investigate root causes. Policy development includes communication, community mobilization, partnership building, public health policy and advocacy, and public health law and regulation. Assurance involves maintaining a competent workforce, robust infrastructure, continuous improvement, and equitable access to essential services for a healthy population (Castrucci, 2021).

The committee's public health approach to cannabis policy, as outlined in Chapter 1, is not just a theoretical framework but is firmly rooted in the core public health functions and essential public health services (as detailed in Box 4-1, repeated here from Chapter 1). In this context, the core public health functions apply to cannabis policy directly, demonstrating their practical relevance and importance.

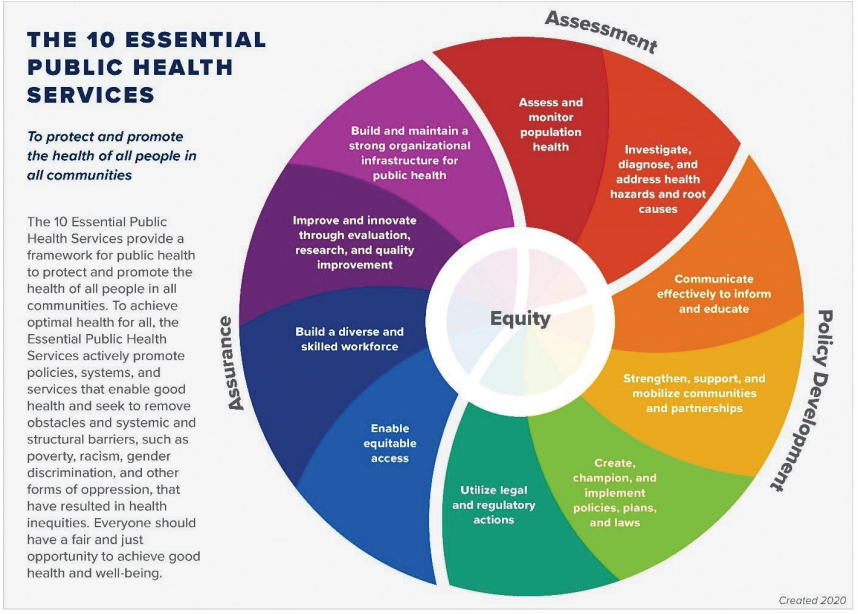

FIGURE 4-1 The ten essential public health services and their relationship with the core public health functions of assessment, policy development, and assurance. SOURCE: CDC, 2020.

ASSESSMENT

The core function of public health assessment necessitates a robust and adaptable surveillance system to monitor the public health effects of cannabis legalization. Assessment is crucial for understanding the potential effects of cannabis on the population and informing evidence-based policies. It triggers the need for additional investigation and can serve as a basis for evaluating changes in programs and policies.

State of Practice: Surveillance or Assessment and Monitoring of Population Health

Public health surveillance or assessment and monitoring of population health is the systematic collection, analysis, and interpretation of health-related data (German et al., 2001). Public health surveillance is used to plan, implement, and evaluate public health (Teutsch, 2010). Surveillance is sometimes confused with and misunderstood as solely related to data collection and public health research, but it is more complex. Surveillance

BOX 4-1
Public Health Approach to Cannabis Policy

Assessment

- Conduct surveillance of or assess and monitor the health impacts of cannabis.
- Investigate the causes of any identified harms from cannabis use.

Policy Development

- Build and mobilize partnerships between cannabis regulators and public health authorities.
- Inform, educate, and empower communities to develop cannabis-related public health campaigns.
- Develop cannabis policies centered on protecting public health that are not influenced by the regulated industry.
- Equitably enforce cannabis policies designed to ensure compliance.

Assurance

- Protect the public from the potential harms of cannabis (e.g., accidental ingestion or poisoning, crashes from impaired driving, secondhand smoke, and environmental impacts).
- Protect those who use cannabis from potential harm and ensure access to treatment.
- Build and support a diverse and skilled cannabis public health workforce.
- Improve and innovate cannabis public health functions through ongoing evaluation, research, and continuous quality improvement.
- Build and maintain a strong organizational infrastructure for cannabis and public health.

SOURCE: Adapted from Ghosh et al., 2016.

is an ongoing system that aims to inform the decisions or actions of a public health authority (Otto et al., 2014). Surveillance should start with a plan. Crafting a surveillance plan requires careful consideration of the system's goals, essentially answering the question, "What do you want to know?" Those goals in public health surveillance include understanding the incidence or prevalence of a specific behavior, disease, or health outcome; establishing public health priorities; conducting program evaluation; and allocating resources (Teutsch, 2010).

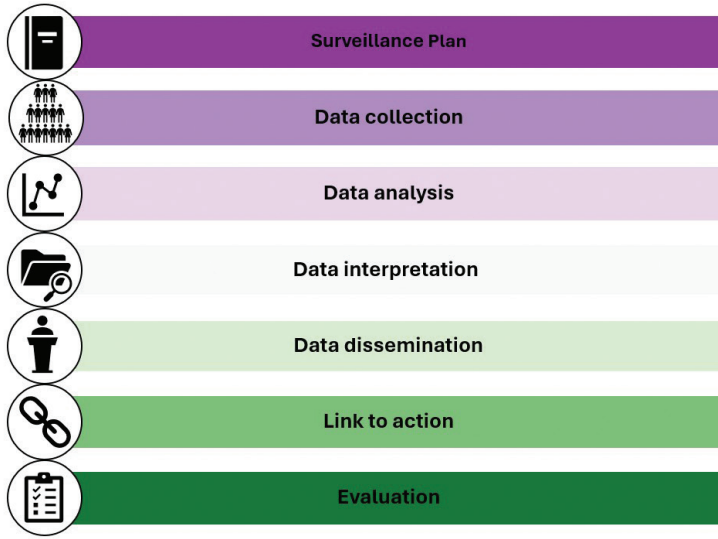

FIGURE 4-2 The phases of public health surveillance.

The surveillance system includes the surveillance plan; data collection, analysis, interpretation, and dissemination; a link to action; and evaluation (Figure 4-2) (CDC, 2018). Data collection can leverage existing data, such as surveys and administrative data. Data analysis plans are an important part of a surveillance plan; essential analytic elements need to be calculated often to ensure that the system is working and work best when they are automated. Data dissemination involves presenting analysis results so that decision makers and those who use cannabis can understand their significance. The findings from surveillance can guide actions such as treatment, prevention, policy development, and outbreak control at the local, regional, and national levels. Regular evaluation is undertaken to ensure that the system continues to serve the purposes for which it was designed and adapts to new needs.

There are many types of public health surveillance systems. The details of how a surveillance system operates depend on the specific questions to be answered, the available data infrastructure, the available budget, and the precision needed in the ultimate results (CDC, 2018; German et al., 2001; Teutsch, 2010).

Status of Surveillance or Assessment and Monitoring of Population Health

Cannabis surveillance in the United States is conducted by individual state governments; the Centers for Disease Control and Prevention (CDC); the Food and Drug Administration (FDA); and other state, federal, and territorial agencies.

Cannabis Surveillance by the State Governments

In 2015, the Council of State and Territorial Epidemiologists (CSTE), a nonprofit U.S. organization that focuses on public health issues through epidemiology, formed a cannabis subcommittee. The subcommittee was designed to provide a platform for state public health agencies and collaborators to share knowledge and resources, thereby fostering a national approach to systematically monitoring, characterizing, and mitigating the public health consequences of cannabis use (CSTE, n.d.). The subcommittee authored a position statement that identified critical gaps in surveillance of the public health impacts of cannabis. These gaps included a lack of funding, standard methods for or coordination of data collection, uniform guidance for data analysis and reporting, and research on cannabis-related health outcomes (CSTE, 2016).

In 2018, CSTE conducted an environmental scan of public health surveillance in the first eight legalizing states: Colorado, Washington, Alaska, Oregon, California, Maine, Massachusetts, and Nevada. The survey found that six of the eight states had a legislative requirement for surveillance, but two of those six provided no funding to support it. The CSTE scan also found some gaps in the components of a surveillance system (Binkin et al., 2018). Prelegalization planning for dedicated marijuana surveillance systems was limited. Most states relied on existing resources. Further research was needed to fill gaps in knowledge about the health effects of cannabis use and the data and metrics needed for surveillance. Only six states had published reports on cannabis. Several states reported that data were being actively used to shape and modify state or local policies and inform program planning.

In 2021, the CDC and the American Public Health Association convened a learning collaborative of cannabis experts and stakeholders to discuss public health surveillance of cannabis. The collaborative identified successful partnerships among states; open communication; publicly available data that can be used to generate reports; and dashboards that allow for data sharing and coordinated, comprehensive analyses (APHA, 2021).

The collaborative also identified several challenges in cannabis surveillance (APHA, 2021). Staffing limitations, including vacancies and unfamiliarity with data systems, hamper analysis capabilities. Confidentiality concerns and the need to navigate consumer protections create barriers to data collection. Access to necessary agency data is often restricted or delayed, and establishing data-sharing agreements has proven difficult. Incomplete data, including underreporting and missing entries, further complicates the analysis. Statutory limitations and budget constraints restrict data use and impede research efforts (APHA, 2021).

Furthermore, the collaborative found that limited policy evaluation hinders understanding of the effectiveness of policies and limits informed adjustments. Fragmented coordination across agencies and inconsistencies among states and major cities create additional obstacles (APHA, 2021).

To determine whether the gaps identified in surveillance systems in 2018 and 2021 remain, the committee reviewed surveillance plans on state public health websites for a selected group of states—California, Colorado, Connecticut—using the province of Manitoba in Canada as a comparison (Bilandzic and Bozat-Emre, 2020; CCSS, 2021; CDPHE, 2022; King et al., 2022). It noted the processes for each surveillance system component (Table 4-1). Apart from data analysis and interpretation, it appeared that the cannabis surveillance systems within the states did contain necessary components of a surveillance system.

TABLE 4-1 Surveillance System Components in Select States and Manitoba, CA

Surveillance system component	California	Colorado	Connecticut	Manitoba
Surveillance plan	Established with clear objectives	Established with clear objectives	Established with clear objectives	Established with clear objectives
Data collection	Surveys (CA Healthy Kids, BRFSS, NSDUH etc.), administrative data (hospital encounters), law enforcement data, mortality data	Poison control center data, surveys (BRFSS, YRBSS, PRAMS, NSDUH), regulatory data (seed-to-sale), health care administrative data, traffic data, mortality data	Surveys (BRFSS, YRBSS, PRAMS, NSDUH), regulatory data (seed-to-sale), health care administrative data, traffic data, mortality data	Surveys (existing), product recall data, poison control data, hospital discharge data, drug analysis data, crime data
Data analysis & interpretation	Not described		Not described	Not described
Data dissemination	Reports published	Data analysis is presented on a rolling dashboard. Presented to government bodies every 2 years.	Not described	Published reports and infographics
Link to action	Informs policy changes and program development	Informs policy changes and program development	Informs policy changes and program development	Informs policy changes and program development

NOTES: BRFSS = Behavioral Risk Factor Surveillance System; NSDUH = National Survey of Drug Use and Health; PRAMS = Pregnancy Risk Assessment Monitoring System; YRBSS = Youth Risk Behavior Surveillance System.
SOURCES: Bilandzic and Bozat-Emre, 2020; CCSS, 2021; CDPHE, 2022; King et al., 2022.

Cannabis Surveillance in the Federal Government

The CDC and FDA perform complementary roles in cannabis surveillance in the United States. At the CDC, the Division of Overdose Prevention in the National Center for Injury Prevention and Control has issued a 5-year plan (2020–2025) with the overall goal of monitoring and addressing the use of and exposure to cannabis and its associated health and social effects (CDC, 2020). In pursuit of this goal, the CDC has developed a cannabis surveillance strategy by articulating priority outcomes and populations to guide the state, tribal, local, and territorial governments in building capacity.

The strategic pillars of the CDC's plan are to monitor trends; advance research; build state, tribal, local, and territorial capacity; support health systems and health care providers; partner with public safety, schools, and community coalitions; and improve public knowledge and awareness. Priority outcomes include initiation and use, substance use disorder, poisonings, occupational injury, motor vehicle crash injury, employment, cardiopulmonary conditions, environmental exposure, developmental outcomes, and prenatal and pregnancy complications. Specific populations prioritized for monitoring include adolescents and young adults, older adults, infants and young children, pregnant or postpartum persons, workers, minority groups, and people in poor health or with chronic conditions (CDC, 2020). Some examples of actions the CDC is taking to implement its cannabis strategy are listed in Figure 4-3. The plan does not include data analysis, interpretation, dissemination, and links to action.

The FDA (2024b) has a limited role in monitoring cannabis-derived products through passive pharmacovigilance systems. Although not always considered in the context of public health surveillance, pharmacovigilance systems—also known as adverse drug reaction monitoring, drug safety surveillance, side effect monitoring, unsolicited reporting, and postmarketing surveillance—exist to identify problems related to medicines, vaccines, and other medical products, as well as nonmedical products, such as dietary supplements.

Pharmacovigilance comprises the science and activities of detecting, assessing, understanding, and preventing adverse effects or any other medicine- or vaccine-related problem (Nour and Plourde, 2019). In the 1960s, in response to the thalidomide disaster, national pharmacovigilance systems were established to enable earlier identification of severe adverse drug events (Fornasier et al., 2018). The central feature of historical and current pharmacovigilance systems is databases of spontaneously reported adverse events suspected to have been caused by a medical product, such as a drug, biological product, or medical device (Fornasier et al., 2018). These anecdotal reports are submitted by health care professionals, consumers, and other sources directly to national regulatory agencies or medical product

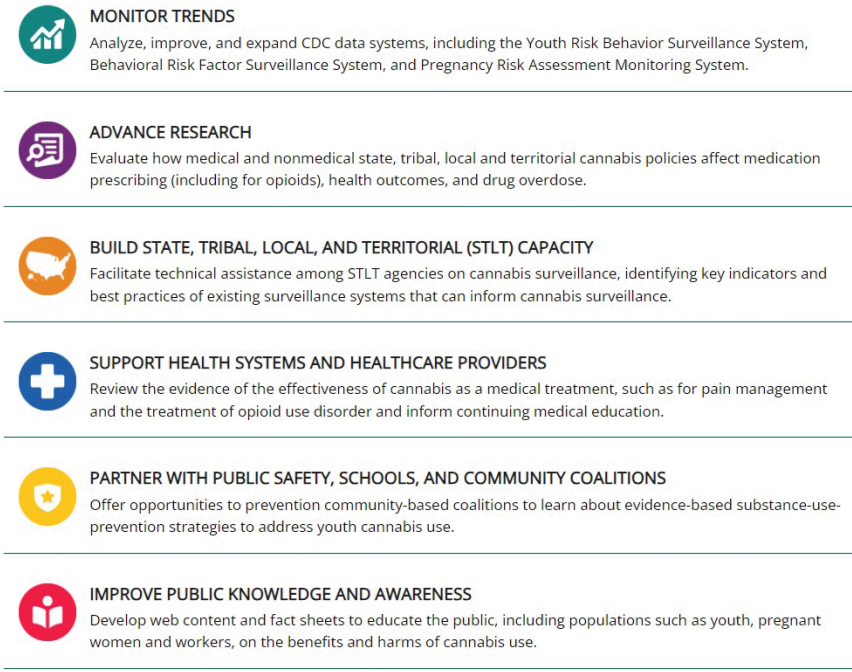

FIGURE 4-3 Examples of Centers for Disease Control and Prevention (CDC) activities to implement its cannabis strategy.
SOURCE: CDC, 2021.

manufacturers, which submit the reports to regulators. Because of the large volume of reports received, manufacturers and regulators identify signals of potential product–outcome relationships by calculating disproportionality metrics of product–outcome pairs that are observed more frequently among the anecdotal reports than would be expected by chance (Fornasier et al., 2018; Nour and Plourde, 2019).

While spontaneous reporting systems are still widely used for pharmacovigilance, their use has been supplemented by screening studies of health care data aimed at identifying potential novel associations between medical products and adverse outcomes in recent years. Signals of potential medical product–outcome associations identified through spontaneous reporting systems or screening analyses of health care data are often strengthened and confirmed (or weakened and refuted) through subsequent epidemiologic studies using health care data or systematic investigation (Bate et al., 2019).

The FDA has approved a few cannabinoid drugs—Cesamet™ (nabilone), Marinol® (dronabinol), and Epidiolex. These drugs are monitored for safety

in existing pharmacovigilance systems. While cannabis and cannabis-derived products are not currently FDA-approved medications, the agency leverages two electronic databases—the FDA Adverse Event Reporting System (FAERS) and the Center for Food Safety and Applied Nutrition's Adverse Event Reporting System (CAERS)—to monitor their safety profile (FDA, 2023, 2024a).

FAERS and CAERS are passive surveillance systems that rely on voluntary reporting of adverse events and product quality concerns. These reports can originate from diverse stakeholders, including health care professionals, consumers, and law enforcement officials. The FDA facilitates reporting through established channels such as the MedWatch Program, the Safety Reporting Portal, and the Consumer Complaints process. This broad accessibility allows for the collection of data from a wide range of populations, potentially uncovering safety signals that might otherwise be missed (FDA, 2023, 2024a).

The FDA could use FAERS and CAERS data regarding cannabis products to inform regulatory decisions and guide public health education. If concerning trends were identified within the data, the FDA could take appropriate regulatory actions, such as product recalls or safety warnings, to safeguard public health. The FDA could also develop targeted public health communications highlighting specific safety concerns associated with cannabis use. For example, the FDA has warned consumers about children's accidental ingestion of cannabis edibles that were mistaken for commonly consumed foods such as breakfast cereal, candy, and cookies (FDA, 2022).

The anecdotal nature of FAERS and CAERS data introduces inherent limitations. Passive systems such as these substantially underreport events. Reported events may not be entirely representative of the entire cannabis-consuming population, and definitively establishing causality between a product and a reported event can be challenging. Another limitation is that passive reporting systems require that people know of their existence to capture adverse events. However, increasing public awareness of the reporting system can increase the reporting of cases, making it difficult to interpret whether an increase in cases indicates increasing problems (Thacker and Berkelman, 1988).

Research

Public health assessment includes research aimed at determining the root causes of any problems identified in the surveillance system or identifying new problems or issues that should be tracked in the system. Research and surveillance have many commodities and can use the same datasets. A critical difference between research and surveillance is that research is not

an ongoing system directed toward public health action. It may uncover previously unknown risk factors, shed light on structural factors influencing health, or evaluate the effectiveness of existing prevention strategies. Unlike surveillance, which prioritizes standardized and readily deployable methods, research can embrace a broader range of methodologies, including qualitative studies, in-depth analyses, and pilot interventions. While research findings might or might not be immediately actionable, this exploratory phase is vital in advancing public health knowledge. Validated research methods may improve surveillance systems, allowing for more comprehensive data collection and analysis in the future. CDC policies define "research" as a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge (45 CFR § 46.102[d]). This definition underscores the emphasis on knowledge creation and discovery that distinguishes research from the more action-oriented nature of surveillance.

California, Colorado, and Connecticut are all conducting or supporting research to investigate public health challenges related to cannabis use. California funds cannabis research, including that focused on public health impacts, environmental effects, economic factors, and social justice issues. Studies are examining everything from the effects of cannabis on brain development to the impact of marketing on youth use. The research is designed to inform policy and improve understanding of the complex issues surrounding cannabis legalization (DCC, 2024). In Colorado, the Cannabis Research and Policy Project, a collaboration between the Colorado School of Public Health and the University of Colorado Anschutz Medical Campus, is leading this research. It conducts systematic reviews of existing research, recommends evidence-based policy changes, and develops public education campaigns (Colorado School of Public Health, 2024). In Connecticut, cannabis research is focused primarily on therapeutic uses (King et al., 2022).

Cannabis Assessment: Findings

The committee found that among the states, cannabis surveillance does not include all the essential components of a public health surveillance system: a surveillance plan; data collection, analysis, interpretation, and dissemination; a link to action; and regular evaluation. While most states are implementing some or most components of such a system, most state surveillance systems are underfunded, limiting the frequency of analyses and data dissemination, which in turn limits the link to action. Only Colorado has a complete system with regular analyses, research, and plans for reporting to policy makers, an important activity that may lead to public health action.

POLICY DEVELOPMENT

Policy encompasses laws, regulations, policy procedures, administrative actions, incentives, and voluntary practices of governments and other institutions. Not all public policies are legally enforceable; some are guidance developed by administrative agencies with the expectation that they will be adhered to (Pollack Porter et al., 2018). Policy development is critical for primary prevention of potential harms from cannabis use. All major public health achievements involve policy development (CDC, 1999, 2011). The development of public health policy requires strong partnerships, policy implementation, compliance, and enforcement (Castrucci, 2021). Effective cannabis policy hinges on collaboration among regulators, public health experts, and empowered communities to prioritize public health through informed regulations and equitable enforcement (Pollack Porter et al., 2018).

State of Practice: Public Health Policy Development

The CDC's (2022) policy development process consists of problem identification, policy analysis, strategy and policy development, and policy enactment. It centers on stakeholder engagement, education, and evaluation. Problem identification requires clarifying and framing a problem or issue with respect to the effect on public health. Public health practitioners and policy developers use data to define the issue and its characteristics (frequency, scope, budgetary impacts) and any gaps in the data. Policy analysis involves researching potential solutions; evaluating their health impact, cost-effectiveness, and feasibility; and ultimately selecting the most effective option. The process of strategy and policy development translates the selected solution into an actionable plan, outlining implementation steps and stakeholder engagement and potentially drafting the policy. "Policy enactment" refers to following internal or external procedures for getting policy enacted or passed. Policy implementation bridges the gap between policy and practice by translating policy into actionable steps, monitoring its adoption, and ensuring its ongoing effectiveness. Stakeholder engagement and evaluation are continuous threads throughout the policy process, ensuring informed decision making and measuring the policy's effectiveness (CDC, 2022).

The CDC also advocates for a collaborative approach to public policy development, termed "Health in All Policies," because policies in such areas as education, zoning, labor, and working conditions—often formulated by nonhealth professionals—impact public health. Health in All Policies approaches are also intended to improve health equity but need to reflect recognition of political opportunities, understanding

that institutionalization can be helpful but should not delay acting, and awareness that promoting equity through such policies requires dedicated resources (Hall and Jacobson, 2018).

Civic Engagement and Belonging

Systems of civic engagement and belonging are critical in public health policy development and can serve as an avenue for combating health inequities. Cultivating belonging demonstrates an understanding of the value of personal and community culture and knowledge systems and an awareness that valuing these differences is essential to achieving equity. Accordingly, policy developers must work with community members to strengthen communities' established and self-determined assets, means of connection, and values. The Federal Plan for Equitable Long-Term Recovery and Resilience (ELTRR) articulates a whole-of-government approach established by more than 35 U.S. agencies, including the departments of Health and Human Services, Education, Transportation, and Justice. The goal is to improve health and well-being for everyone in the country, with a focus on achieving equity. The ELTRR identifies seven key factors necessary for health and well-being and places "belonging and civic muscle" as the foundation of the approach, defined by the ability to have healthy, fulfilling relationships and strong social supports, along with the ability to participate in civic life. Communities with strong civic muscle can design their pathways to resilience, gather assets so they can respond effectively and equitably in a crisis, persistently expand vital conditions while alleviating urgent needs, and use their power to ensure mutual accountability (ODPHP, 2022). The working group that created the plan formulated recommendations emphasizing the importance of involving community members in policy making (NASEM, 2023a).

Prevention of Industry Influence

Industry may disproportionately influence public health policies. It can influence specific policies in many ways, such as by participating in rulemaking or assembling scientific studies or reviews that support its desired policy decisions. Industry participation in rulemaking is often called regulatory or agency capture, denoting situations in which the regulated industry strongly influences the agency or people responsible for creating or implementing the regulations. Selectively supporting and assembling science to confuse decision makers and the public is effective because if the decision makers and the public believe the science is unclear, public support for action is undermined. Some of the many examples of industry influence on policy include the tobacco industry's downplaying the harms of tobacco use and

the health impact of secondhand smoking, the fossil fuel industry's denying and devaluing of its impacts on climate change, and chemical companies' efforts to deflect concerns about the safety of chemicals (Michaels, 2020; Oreskes and Conway, 2011). Industry-developed information campaigns endanger public health by delaying regulations on harmful products and pollution of the air and water. They also erode trust in science by making it difficult to distinguish genuine uncertainty from manufactured doubt (NASEM, 2023b).

State, Tribal, Territorial, and Local Public Health Policy Development

State, tribal, territorial, and local public health officials have a substantial role in public health policy development. The 10th Amendment of the U.S. Constitution, which reserves unspecified powers to the states, creates a decentralized environment for public health policy development. As a result, a significant portion of public health policy decisions is made at the state, territorial, tribal, and local levels. The CDC and other agencies guide states on many issues, and several other collaboratives provide resources for policy development. Examples of these organizations are the Association of State and Territorial Health Officials (ASTHO), the National Association of County and City Health Officials (NACCHO), the American Public Health Association (APHA), the National Conference of State Legislatures, and the National Governors Association.

Another resource available to guide public health policy decisions at any level is the Community Guide developed by the Community Preventive Services Task Force (2023), the product of an independent panel that issues evidence-based recommendations and findings on public health interventions designed to improve health and safety. The Community Guide includes recommendations for the primary prevention of potential harms on many topics, including excessive alcohol use, mental health, alcohol-impaired driving, tobacco use, and substance use (CPSTF, 2023).

Compliance and Enforcement

Compliance refers to the "extent to which an individual, organization, group or population acts in accordance with a specific public policy" (APIS, n.d., para 4). It requires determining who is responsible for enforcement and the processes used to ensure that regulations are followed. The responsible agencies need the requisite skills and experience to enforce policies fairly and successfully. Another important consideration is how regulatory compliance will be determined, such as specifying how much industry self-regulation is allowed or whether compliance is assured through inspections or more passive reporting mechanisms (APIS, n.d.). While protecting against

regulatory capture when developing policies is vital, it is also essential to consider that a regulated industry may try to influence compliance and enforcement strategies. Enforcement does not mean just law enforcement or policing but encompasses the "sum total of actions taken by public entities to increase compliance with specific public policies" (APIS, n.d., para.4). Enforcement relies on many tools beyond policing and criminal penalties, including inspections, compliance checks, fines, recall of products, and revocation of licenses. Ideally, policy enforcement creates a system that encourages compliance across the board, from licensed businesses to consumers, with penalties graduating in severity and consequences depending on the nature of the noncompliance (APIS, n.d.).

Tobacco provides an excellent example of the complexity of regulation and enforcement. The U.S. Department of Agriculture oversees cultivation standards for tobacco (7 USC 511, 511s), while the FDA regulates manufacturing, product testing, and labeling to ensure safety and limit youth appeal (PL-102-321; PL-116-94). The Bureau of Alcohol, Tobacco, Firearms, and Explosives tackles illegal tobacco suppliers (PL-111-154 [2009]). State and local governments are crucial for enforcing minimum age for purchase and use and marketing regulations at retail locations. The FDA takes the lead with warnings and penalties for violations (21 CFR 1140). Smoke-free environments are regulated primarily by state and local authorities, with the Environmental Protection Agency (EPA) providing educational resources and the federal government enforcing a ban on smoking in its buildings (Executive Order 13058).

Compliance with alcohol policy is similarly ensured through federal, state, and local authorities. The Alcohol and Tobacco Tax and Trade Bureau oversees the production, import, distribution, labeling, and advertising of alcohol. It issues permits and enforces regulations to ensure product safety and prevent illicit sales. The Federal Alcohol Administration Act (27 U.S.C., Chapter 8, §§ 201–212) mandates permits for producers, importers, and wholesalers, while the FDA regulates ingredient labeling. Advertising is mainly self-regulated by the alcohol industry, with federal agencies such as the Federal Trade Commission encouraging responsible practices to limit youth exposure (Mart, 2012).

Policies on alcohol retail sales and consumption are set by states and some local jurisdictions, and compliance is ensured through local enforcement. For example, each state has a licensing system for retailers, and some jurisdictions require training for servers or bartenders. States also determine where alcohol can be consumed publicly and enforce laws against underage drinking. Some federal highway funding can be withheld from states, most notably to ensure adherence to a blood alcohol (BAC) limit for driving of 0.08 percent (23 USC 163); one state (Utah) has a lower BAC limit (Utah HB155) to further reduce alcohol-related crashes.

Status of Cannabis Policy Development

State, tribal, territorial, and local public health officials can follow best practices for developing public health policies when creating policies for legalized cannabis. These practices include following the CDC's policy development steps; using a Health in All Policies approach; empowering communities; promoting civic engagement and belonging; limiting industry influence; and encouraging collaboration among federal, state, tribal, and local governments in the development and implementation of cannabis policies. Chapter 2 provides a detailed summary of cannabis policies across the states; here, the committee describes some findings on the overall application of these best practices for policy development.

State cannabis policies vary widely, and a thorough evaluation of whether the development of those policies followed the best practices for public health policy development is difficult. A review of cannabis policies across the United States highlights the patchwork of state regulations around cannabis, including taxation rates, revenue allocation, product restrictions (e.g., forms, additives, flavors, concentration), packaging and labeling requirements, consumption locations, advertising limitations, and social equity programs aimed at fostering minority participation in the industry (Schauer, 2021).

States with legalized adult-use cannabis did not generally follow a Health in All Policies approach in developing their policies. At least initially, the policy development began with prioritizing market outcomes (such as enabling sales and consumption), which can be misaligned with public health goals (such as reducing dependence and preventing underage consumption) (Hall et al., 2019; Kilmer, 2019; Schauer, 2021). Consumer awareness about cannabis products and health and safety considerations has also not been prioritized (Schauer, 2021). For example, early adopters of legal cannabis for adult use, such as Colorado and Washington, relied on established agencies such as alcohol and beverage control or departments of revenue to oversee adult-use cannabis, which gave less control to public health authorities. Indeed, public health agencies, typically responsible for medical cannabis, are generally excluded from overseeing adult use. Over time, states have created stand-alone cannabis control commissions, evidence of the growing recognition of their complexities specific to cannabis regulation. Local jurisdictions regulate licensing, zoning, and business operations, but their authority thus far has varied (Schauer, 2021). Some states have enabled local authorities to apply taxes and numerous specific policies (e.g., California), whereas others have largely preempted local authority beyond a full ban on sales or the application of time–place–manner restrictions (e.g., Washington).

Civic Engagement and Belonging in Cannabis Policy

The extent to which cannabis policy development has occurred within a civic engagement and belonging system is unclear. All states followed required and discretionary methods for engaging with stakeholders when promulgating rules regarding cannabis policy, and there are examples of proposed rules around cannabis policy that were not adopted because of public input, such as the proposal in California to allow police officers to become cannabis business owners (Bowling and Glantz, 2019a). The lack of social equity considerations in the initial policy development process demonstrates that those with less civic muscle may not have participated. Even in states where cannabis legalization was motivated by social justice concerns, social equity was usually not considered in the initial policy development (Firth et al., 2019; Schauer, 2021). States did not initially institute the cannabis social equity programs that many in the public desired (Gerber, 2022; Schauer, 2021).

Industry Influence on Cannabis Policy

Industry influence on cannabis policy development has been difficult to limit. The cannabis industry had a seat at the table in the development of initial regulations in several states, including Colorado and California. And like tobacco and alcohol companies before them, the cannabis industry uses political donations and lobbying to influence regulations (Carlini et al., 2022; Subritzky et al., 2016). Large corporations such as those in the tobacco and alcohol industries are also investing in cannabis businesses (primarily in countries where cannabis is federally legal), suggesting confidence in the cannabis industry's future profitability, and are leveraging public support for medical cannabis to push for broader legalization (Adams et al., 2021). The cannabis industry may downplay the risks and overstate the benefits of cannabis to influence policy. This is evident from the close ties among cannabis businesses, patient groups, and researchers, making it difficult to separate genuine medical cannabis research from industry promotion (Adams et al., 2021; Subritzky et al., 2016; Wagoner et al., 2021).

There are many examples of industry influencing rulemaking on cannabis policy (Carlini et al., 2022; Subritzky et al., 2016). The cannabis industry has also influenced the development of flavoring limits and environmental regulations. Several attempts to remove flavoring from cannabis products in California have failed despite successful efforts to do so for nicotine vaping and e-cigarette products. And while the Colorado Department of Agriculture proposed prohibiting the use of pesticides that require federal registration in legal cannabis cultivation, it changed the regulations following industry pushback (Carlini et al., 2022; Subritzky et al., 2016).

At least five states have attempted to place limits on the tetrahydrocannabinol (THC) concentration in cannabis products following legalization,

and all five have failed (Pacula et al., 2022). In Washington state, the cannabis industry attempted to impede four different bills (HB 2546, 2020; HB 1463, 2021; HB 1641, 2023; and HB 1642, 2023) that would have placed THC concentration limits on cannabis products, adopted concentration-based taxation, and instituted age-based concentration sales (Carlini et al., 2024). Three rhetorical messages were effective at defeating additional regulation of cannabis products: (1) arguing that such regulations would threaten economic benefits and public health and go against the will of the people, (2) discrediting the science that supported the regulation of cannabis products with high THC concentration or the individuals that were advocating for these policies, and (3) distracting from the bill's focus using tangential topics that would derail the discussion (Carlini et al., 2024). Similarly, in Vermont, the industry has pushed back on limits of 30 percent THC in flower and 60 percent THC in solid extracts (Hawks, 2023; Levine, 2024).

Conflicts of interest have been observed among cannabis regulators. In Colorado, a cannabis regulator left a government job and immediately started working for a cannabis cultivator (Harmony & Green) to advise them on following the rules despite a state law requiring a 6-month waiting period after such a switch. In Washington state, a government official who approves cannabis business licenses rented out a large piece of land (25 acres) to someone who wanted to start a cannabis business. In Massachusetts, an employee responsible for issuing medical cannabis licenses applied for one of those licenses while still employed by the agency. In Ohio, six companies that lost their bids for cannabis business licenses sued the state, claiming that the reviewers who scored the applications did so unfairly and hired biased consultants with conflicts of interest. In Arkansas, a court order stopped the state from issuing licenses to grow cannabis because of a lawsuit alleging issues similar to those found in Ohio (Bowling and Glantz, 2019b).

Issues with conflicts of interest may be more commonly associated with medical than with adult-use cannabis programs. Surveys found that only 20 percent (6 out of 30) of the states that legalized medical cannabis had conflict-of-interest provisions in their medical cannabis codes, and the remaining 80 percent relied on general provisions relating to all areas of regulation. In contrast, 88 percent (seven out of eight) of the first states to legalize adult cannabis use included conflict-of-interest provisions directly in their cannabis codes or regulations (Bowling and Glantz, 2019b).

Guidance for Cannabis Policy Development

Neither the CDC nor the White House Office of National Drug Control Policy (ONDCP) has crafted guidance for cannabis policy development. In fact, under 21 USC 1703, ONDCP is prohibited from using federal funds

to study anything related to the medical or nonmedical legalization of cannabis and other Schedule I drugs.[1] However, other organizations, such as ASTHO, NACCHO, and APHA, provide resources for policy development (Jernigan et al., 2021). The Community Guide includes no recommendations for cannabis policy development, but the recommendations related to tobacco and alcohol can be applied (Ghosh, 2016). Chapter 2 describes how these public health levers have been implemented in various ways across the states with legal cannabis for adult use.

Compliance with and Enforcement of Cannabis Policy

Cannabis regulatory compliance can be burdensome to implement. Currently, each state with a legal cannabis market must bear the administrative burdens associated with establishing and maintaining systems to ensure compliance with state policies on cannabis cultivation, product development, packaging restrictions, marketing restrictions, sales, and youth access.

An audit of 700 California outlets during summer 2019 found that while nearly all retail outlets were compliant with age identification checks before any purchase, the vast majority (85.1 percent) did so after entry into the building, where child-appealing marketing and materials promoting the health benefits of cannabis were visible to anyone allowed in the waiting room. The audit found that violations of rules regarding free samples (21.6 percent), on-site consumption (16.1 percent), and materials promoting health benefits (38.9 percent) were all common (Shi and Pacula, 2021).

Another audit of the retail sales of 30 randomly selected cannabis retailers in each of five U.S. cities (Denver, Colorado; Seattle, Washington; Portland, Oregon; Las Vegas, Nevada; and Los Angeles, California) in summer 2022 likewise found that age verification rates were high (>90 percent) (Berg et al., 2023). Most retailers also complied with regulations on signage, such as restricted access for those under the legal age (87.3 percent), no on-site consumption (73.3 percent), and no distribution to people below the legal age (53.3 percent). Retailers were likely to post warnings regarding use during pregnancy or breastfeeding

[1] The law states: "no Federal funds appropriated to the Office of National Drug Control Policy shall be expended for any study or contract relating to the legalization (for medical use or any other use) of a substance listed in schedule 1 of section 812 of this title and take such actions as necessary to oppose any attempt to legalize the use of a substance (in any form) that –

- is listed in schedule I of section 812 of this title; and
- has not been approved for medical purposes by the Food and Drug Administration" (21 USC 1703 § (b)12).

(72.0 percent), followed by health risks (38.0 percent), impacts on youth (18.7 percent), and driving under the influence (14.0 percent). However, there were other signs of noncompliance with policies, as 28.7 percent of these stores posted health claims, 20.7 percent posted signage appealing to youth, and 18.0 percent sold products with youth-oriented packaging (Berg et al., 2023).

Retail audit studies provide evidence of the states' challenges in encouraging compliance and enforcement. A study conducted in summer 2017 sought to understand the extent to which retail employees at either medical or adult-use cannabis outlets would recommend cannabis to pregnant women (Dickson et al., 2018). Female researchers from the study team made calls to 400 retailers throughout Colorado, claiming to be 8 weeks pregnant and experiencing severe nausea and inquiring whether the person working at the retailer could recommend any products for them. The study found that most retailers (67 percent) recommended cannabis products for "morning sickness," with medical stores doing so more frequently than adult-use-only stores (83.1 percent versus 60.4 percent). A more recent study that in 2022 conducted a mystery shoppers audit of 140 licensed cannabis stores in five cities with well-established state markets (Denver, Colorado; Portland, Oregon; Las Vegas, Nevada; Los Angeles, California; and Seattle, Washington) also found that it was common for retail employees to recommend cannabis for therapeutic uses (90 percent), regardless of whether state laws existed to prohibit the practice (Romm et al., 2023). While retailers endorsed cannabis primarily for common conditions such as anxiety, insomnia, and pain, endorsements for pregnancy-related nausea and warnings against use during pregnancy and driving varied by city (Romm et al., 2023).

Monitoring of online marketing is highly challenging for states. One study conducted in 2022 collected and analyzed data regarding retailer characteristics, age verification, and marketing strategies (e.g., product availability, health-related content, promotions, website imagery) among 195 cannabis retail websites in five U.S. cities (Denver, Colorado; Seattle, Washington; Portland, Oregon; Las Vegas, Nevada; and Los Angeles, California). The analysis reveals concerning trends, such as the prevalence of unsubstantiated health claims despite regulations prohibiting them in some states (59 percent). Discounts, samples, or promotions were on 90.8 percent of websites, and 63.6 percent had subscription/membership programs. Subpopulations represented in website content included 27.2 percent teens/young adults, 26.2 percent veterans, 7.2 percent sexual/gender minorities, and 5.6 percent racial/ethnic minorities. Imagery also targeted young people (e.g., 29.7 percent party/cool/popularity; 18.5 percent celebrity/influencer endorsement) (Duan et al., 2023).

Cannabis Policy Development: Findings

Comparing cannabis policy development against best practices for policy development yields several findings. First, early policy efforts were more favorable to market outcomes such as increased sales, tax revenue, and removal of an illicit market than to public health outcomes such as reducing dependence and underage use. Nor was consumer awareness of health risks prioritized. Since those early efforts, regulatory structures have been evolving, and dedicated cannabis control commissions have been emerging. Although public health agencies are often excluded from overseeing adult-use cannabis, they are increasingly included in policy development. Public engagement has been mixed: stakeholder involvement has occurred, but a lack of social equity considerations in initial policy development suggests limited participation from marginalized groups. The legal cannabis industry exerts influence through lobbying and donations, potentially downplaying risks and overstating benefits. Furthermore, only a minority of medical cannabis states have specific conflict-of-interest provisions.

ASSURANCE

Public health assurance refers to how the public health system consistently safeguards the health and well-being of the entire population. It is a comprehensive approach to guaranteeing a robust public health system. It encompasses five public health services: ensuring that everyone can access necessary health care, fostering a diverse and qualified workforce, providing health education and primary prevention programs, conducting continuous evaluation and improvement, and establishing a solid public health infrastructure. Cannabis policy assurance exemplifies these principles in action.

State of Practice: Public Health Assurance

Best practices of public health assurance extend beyond traditional public health interventions such as vaccination campaigns. Given the complex nature of public health and the government's responsibility to protect all citizens, assurance often necessitates collaboration with various partners outside the public health sector (Knight, 2014; Perry, 2024). These partners may include private companies, community organizations, and nonprofit groups (Braveman and Gottlieb, 2014; Perry, 2024).

Strengthening assurance requires well-equipped state and local health departments with the resources to deliver essential public health services that are accessible and culturally sensitive, which includes considering factors such factors as language, social background, and ethnicity (NASEM, 2017; Perry, 2024). In this context, assurance encompasses a broader range

of services and actions than just health care. Assurance processes address factors that create barriers to public health interventions or directly improve health outcomes for the population. Examples include ensuring fair housing policies; protecting voting rights; and promoting equitable access to education, particularly within the public health workforce itself (Churchwell et al., 2020; Jain et al., 2022; NASEM, 2017; Perry, 2024).

Ensuring occupational health and safety is also important in cannabis policy. Certain safety and security professions in the United States require employee drug testing, with the goal of deterring drug use among these critical roles, identifying potentially impaired workers, and minimizing health and safety risks associated with compromised performance. The U.S. Department of Transportation requires testing for employees in transportation sectors such as aviation and trucking. The Department of Defense enforces similar regulations for contractors accessing classified information. And the Nuclear Regulatory Commission mandates "fitness-for-duty" programs at certain nuclear facilities, which include drug testing to ensure that workers' impairment from the use of cannabis does not compromise safety (SAMHSA, 2023).

Ensuring occupational health for those who work in the cannabis industry requires establishing occupational health and safety standards and procedures that ensure compliance with and enforcement of those standards. The Occupational Safety and Health Administration is responsible for setting occupational standards in the United States. The National Institute for Occupational Safety and Health (NIOSH) focuses on research, recommendations, and education, offering free health hazard evaluations, investigating potential health risks in workplaces, promoting research, and safeguarding worker well-being. The Health Hazard Evaluation program helps employees, unions, and employers learn whether health hazards exist at their workplace and recommends ways to reduce hazards and prevent work-related illness (Lybrand and Coughanour, 2021).

Status of Cannabis Policy Assurance

Public health assurance completes the cycle of ten essential public health services. Assurance leverages existing organizational structures to safeguard public health in the context of cannabis legalization, seeking to advance four key priorities. First, assurance prioritizes harm reduction by minimizing the potential risks associated with cannabis production and use. At the same time, it ensures access to appropriate treatment for individuals who may require interventions. Second, assurance recognizes the vital role of a skilled and diverse public health workforce equipped specifically to address the complexities of cannabis legalization. Third, it fosters a culture of continuous improvement in cannabis public health functions through ongoing evaluation, research, and a commitment

to evidence-based practice. Finally, assurance emphasizes the need for a robust organizational infrastructure that effectively supports cannabis-specific and broader public health initiatives.

Protecting Those Who Use Cannabis from Potential Harm

States with legal adult use of cannabis are using several strategies to mitigate the risks of consuming cannabis products and limiting certain types of products that might be deemed unsafe, limiting serving sizes, banning certain harmful ingredients, and testing products to ensure that they do not contain harmful contaminants (Schauer, 2021).

A review of cannabis policies in 2021 found that all adult-use states allow a broad array of products (e.g., flower, vape, concentrates). Three states (California, Michigan, and Washington) limit edibles to shelf-stable forms to minimize food safety risks. Most states prohibit adulterated prepackaged products with added THC. Colorado implements a unique level of oversight by requiring specific audits for products designed to mimic existing noncannabis medications (e.g., inhalers, suppositories) (Schauer, 2021).

As of 2021, all adult-use cannabis states had implemented THC serving-size limits for edibles and other consumable products (Schauer, 2021). While these limits were developed in response to high-profile incidents of edible overconsumption (Barrus et al., 2016; Nicks, 2014; Schauer, 2021), they differ among states. Most states allow a 10-mg THC serving, generally capped at 100 mg per package. Washington requires individual wrapping for edible and infused product servings within a package. However, highly concentrated THC products exceeding these serving sizes remain widely available. Vermont planned to implement limits on THC concentration in flower (30 percent) and oils (60 percent) and to restrict oils and concentrates to vape pen cartridges (Schauer, 2021).

The 2021 review of cannabis policy found that states also have limits on ingredients that can be contained in cannabis products. Many states have banned or are testing for vitamin E acetate because of the 2019 outbreak of e-cigarette or vaping product–associated lung injury (EVALI) (Schauer, 2021). Colorado has banned medium-chain triglycerides oil and polyethylene glycol oil entirely. Similarly, Oregon has prohibited squalane, propylene glycol, and all triglycerides, substances that lack established safety data for aerosols. Nevada limits the added terpene content in vape oils to 10 percent, which aligns with the upper range of naturally occurring terpenes in the cannabis plant. Vermont takes the strictest approach, permitting only natural cannabis-derived flavors in its upcoming adult-use market. States that regulate cannabis and cannabis-derived products do not have uniform testing procedures or regulatory approaches to ensure product integrity, safety, and labeling (Schauer, 2021).

Product testing is another crucial strategy for mitigating the risks of consuming cannabis. Federal Schedule I classification restricts the involvement of state-based laboratories in cannabis testing. Establishing state reference laboratories, which could validate third-party results, remains challenging for most states (Schauer, 2021). As a result, testing standards vary widely across the states with respect to the timing of testing within the production process (pre- or postproduction); the sampling and process validation protocols; and the testing methods, thresholds, and protocols by contaminant type and product category (Schauer, 2021). The adult-use states mandate cannabis product testing by licensed in-state third-party laboratories accredited to international standards (ISO 17025) (Schauer, 2021). All states test for cannabinoid concentration and residual solvents. There have been cases of "lab shopping," whereby product manufacturers search for laboratories that provide favorable THC concentration results (Jikomes, 2022; Roberts, 2023; Schauer, 2021).

Testing for contaminants such as pesticides and inorganic metals (cannabis is a hyperaccumulator of metals [Bengyella et al., 2022]) is standard in most states (Gourdet et al., 2017; Pinkhasova et al., 2021). About two-thirds of states test for mycotoxins, moisture content, and microbials (Schauer, 2021). The number of contaminants tested for (Figure 4-4) and the action levels (pass or fail exposure limits) used to assess the contamination results vary widely. Most action levels are based on the EPA tolerance values for animal products (milk, eggs), which may be overly protective as cannabis may be consumed less frequently than milk or eggs (Jameson et al., 2022).

A study evaluating cannabis testing standards compared test results for nearly 10,000 samples previously analyzed by CannaSafe (a testing laboratory licensed in California) with the jurisdictions' range of action levels. The study found that the range of contaminant concentrations varied widely, as did the action levels (Figure 4-5). The regulatory responses would vary accordingly.

Risk Mitigation Education Campaigns

The committee found limited but emerging risk mitigation education campaigns in use across states. Such programs exist in Colorado and Canada (Brooks-Russell et al., 2017; Fischer et al., 2017). Initial campaigns in 2014, which took more of a prohibitionist approach across all ages, did not produce the same impact, paving the way for future public education campaigns to branch out to focus on risk mitigation for those who use cannabis, focused especially on impaired driving and parents with young children, who face an accidental ingestion risk.

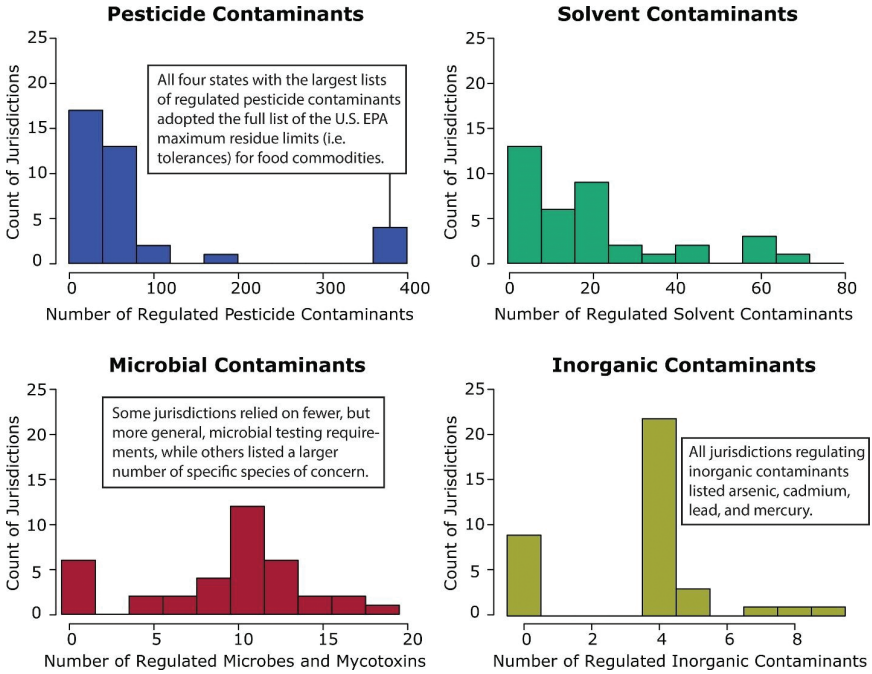

FIGURE 4-4 Histograms showing the number of listed cannabis contaminants regulated by states as of May 18, 2022.
NOTE: EPA = Environmental Protection Agency.
SOURCE: Jameson et al., 2022.

After the initial launch of the health department's "Good to Know" campaign, Colorado adults familiar with the campaign were 2.5 times more likely to know fundamental cannabis laws, with those who used cannabis being more knowledgeable than those who did not. Adult perceptions of the risks and health effects of cannabis use also increased significantly after the campaign. The number of those who knew the risks of driving after using cannabis increased by 23 percent, and those who realized that daily use could impair memory increased by 26 percent (Brooks-Russell et al., 2017).

The health department's evaluation showed that the number of adults prepared to talk to their children about the risks of using cannabis had increased by 12 percent since the campaign began. Following an additional campaign developed for youth ("Protect What's Next"), youth were more likely to agree that cannabis made it more difficult to think clearly and complete tasks.

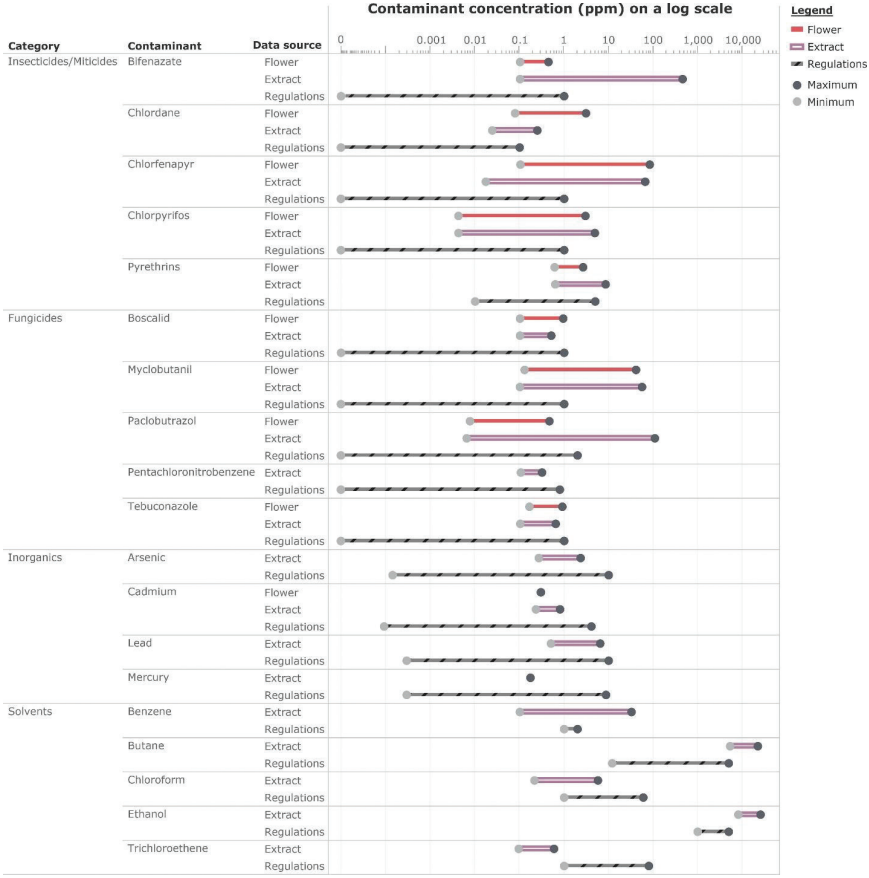

FIGURE 4-5 Range plot comparing the concentrations of the top five most frequently detected contaminants by category with the range of regulatory action levels identified in 30 states and Washington, DC.
NOTES: Action levels were not found in six jurisdictions with legalization. The concentration levels are based on 141 flower and 423 extract samples that had detected contamination in the compliance testing of 5,654 cured cannabis flowers and 3,760 cannabis extracts in California between June 2020 and May 2021. The chemical analysis was conducted using methodologies that comply with California state regulations. Only four inorganics were analyzed in the samples. No arsenic, lead, or mercury was detected in the flower samples, and solvents were not tested. PPM = parts per million.
SOURCE: Jameson et al., 2022.

Because cannabis had been shown to have adverse health effects during pregnancy and breastfeeding, part of the education campaign focused on women of reproductive age. Ninety percent of these women agreed that using cannabis during pregnancy posed some risks.

Future campaign and educational outreach efforts launched in Colorado and other states continue to expand engagement with those who use cannabis. Colorado's recent campaign, "Responsibility Grows Here" (CDPHE, n.d.), has gone further by utilizing "Meg the Budtender" as the primary educator and spokesperson on responsible use.

Canada has developed *Lower-Risk Cannabis Use Guidelines* to provide science-based recommendations on how those who choose to use cannabis can reduce their risks. The guidelines, listed below, are based on a review of the literature on potential levers for lowering risk (Fischer et al., 2017):

1. The most effective way to avoid the risks of cannabis use is to abstain from use.
2. Delaying cannabis use, at least until after adolescence, will reduce the likelihood or severity of adverse health outcomes.
3. Use products with low THC content and high CBD: THC ratios.
4. Synthetic cannabis products, such as K2 and Spice, should be avoided.
5. Avoid smoking burnt cannabis and choose safer inhalation methods, including vaporizers, e-cigarette devices, and edibles.
6. If cannabis is smoked, avoid harmful practices such as inhaling deeply or breath-holding.
7. Avoid frequent or intensive use, and limit consumption to occasional use, such as only one day a week on weekends or less.
8. Do not drive or operate other machinery for at least 6 hours after using cannabis. Combining alcohol and cannabis increases impairment and should be avoided.
9. People with a personal or family history of psychosis or substance use disorders, as well as pregnant women, should not use cannabis at all.
10. Avoid combining any of the risk factors related to cannabis use. Multiple high-risk behaviors will amplify the likelihood or severity of adverse outcomes. (p.4)

Although the guidelines were based on a literature review, their effectiveness has not yet been evaluated in an empirical study.

Primary Prevention Education to Discourage Cannabis Use

Primary prevention programs have been initiated in many communities, although the committee found no catalog of campaigns related to legal cannabis across states and jurisdictions. Several common approaches

to primary prevention are peer association, family involvement, community-based programs, and media campaigns. These interventions target individuals (through skills development), families (through communication), schools (through educational programs), and communities (through environmental changes and policy). By addressing cannabis use at its roots, primary prevention strategies aim to prevent initiation and promote healthy choices.

Although many different programs can be implemented across jurisdictions to discourage cannabis use, the effectiveness of such programs is mixed. A systematic review found low to moderate evidence for the effectiveness of primary prevention programs in deterring substance use among adolescents. Results indicated that adolescents who received a brief intervention generally reduced their alcohol and cannabis use more compared with adolescents who received no intervention at all. However, adolescents who received a brief intervention did not reduce their alcohol and cannabis use more than adolescents who received information-only interventions (Carney et al., 2016).

A systematic review found the most robust evidence for universal school-based interventions that target multiple risk behaviors, demonstrating that such programs may be effective in preventing engagement in tobacco use, alcohol use, illicit drug use (which included cannabis), and antisocial behavior and in improving physical activity among young people, but not in preventing other risk behaviors. The results of this review do not provide strong evidence of benefit for family- or individual-level interventions across the risk behaviors studied (MacArthur et al., 2018).

Another systematic review of primary prevention programs for substance use among children and youth found the most substantial evidence of effectiveness for the Life Skills Training Program (LST). LST targets elementary to high school settings and is delivered by teachers or trained moderators, addressing such topics as misunderstandings about drugs, decision making, problem solving, and stress and anxiety management. Across the 17 LST evaluations reviewed, 10 found a reduction in use of substances, including alcohol and drugs, among adolescents (Tremblay et al., 2020). However, poor reporting and concerns about variation in the quality of evidence highlight the need for greater investment in rigorous evaluations of universal primary prevention interventions directed at children and adolescents (MacArthur et al., 2018). Blueprints for Healthy Youth Development provides information on primary prevention programs for children and adolescents with a demonstrated effectiveness for substance use prevention (Mihalic and Elliott, 2015).

Community-level prevention programs, such as the Drug-Free Communities (DFC) Support Program, may be effective. Participants in this program had lower cannabis use relative to participants in the Youth Risk Behavior Survey, which was used for comparison purposes (ONDCP,

2023). The DFC Support Program is a national initiative funded by the federal government and led by ONDCP in collaboration with the CDC; the program is aimed at preventing and reducing youth substance use by empowering local communities. DFC grants are awarded to coalitions comprising representatives from various sectors, such as schools, parents, law enforcement, and youth organizations. These coalitions develop and implement evidence-based strategies for addressing local substance use risk factors and promoting protective factors that encourage healthy choices among youth (CDC, 2023).

Mass media campaigns to prevent illicit use of drugs, including as cannabis, are widespread. A systematic review of media campaigns to prevent illicit drug use identified 23 studies of designs involving 188,934 young people conducted in the United States, Canada, and Australia. The studies tested very different interventions and used several questionnaires to interview the young people about the effects of the interventions. Because of the variability in interventions studied and methods used, the authors could not reach substantive conclusions (Ferri et al., 2013).

Building a Strong Cannabis Workforce

Building a strong cannabis workforce will require collaborations among public health authorities within each state and across states and among cannabis regulators, clinical providers, and the cannabis industry. Colorado has established a network with a point of contact for cannabis in each county or city health department. The state health department also learns about emerging issues from the local public health officials. The health department, in conjunction with the Colorado Department of Revenue's Marijuana Enforcement Division, holds science policy forums and educational conferences for local and state public health officials to learn about and discuss cannabis-related public health topics. The health department is creating educational materials for health care providers to inform them about cannabis-related topics (Ghosh, 2016).

Several states and Canada require or encourage responsible vendor training of cannabis retail sales staff. The Massachusetts program, for example, teaches compliance with regulations; licensing requirements; product labeling; acceptable payment methods; tracking systems; methods for verifying customer age, identifying valid ID, and determining whether a sale is legal based on the customer's age; and techniques for handling a suspected underage purchase. The training also covers the physiological and cognitive effects of cannabis, including its effects as a stimulant, depressant, and hallucinogen, as well as ways to discuss the legal and safety aspects of cannabis use, such as how cannabis impairs driving and the legal limitations on consumption locations (CCCM, n.d.).

A few studies have reviewed the effectiveness of responsible vendor training (Buller et al., 2019, 2020, 2021). One study used a randomized pre–posttest controlled design to evaluate the impact of online training in responsible cannabis vendor practices on compliance with ID checking regulations. The training was provided to a random sample of state-licensed adult-use cannabis stores (N = 175) in Colorado and Washington in 2016–2017. The study found that the training increased refusal to serve buyers who appeared young and failed to provide a state-approved ID. However, it did not improve refusal rates overall, although stores with lower refusal rates at baseline and those that used the training may have benefited (Buller et al., 2021). A similar study found that training alone did not deter sales to customers who appeared to be alcohol impaired (Buller et al., 2020).

Cannabis legalization is changing clinical practice. Clinicians need to understand the new laws, health risks, and safety factors associated with cannabis use. Clinical providers may need to modify clinical procedures (e.g., patient–provider communication, increase in substance use screenings) and undergo additional training so they know how to talk to patients about cannabis use. A survey of 114 clinical providers in Colorado found that clinicians were knowledgeable about cannabis laws. However, surveys of students in the health professions (medicine, nursing, pharmacy, social work) indicate that these students lack knowledge of and receive no education on the topic. Surveys of clinicians show they are uncomfortable counseling patients about the specific health risks of cannabis use and lack confidence in their knowledge. Clinicians expressed caution with regard to legalization and perceived potential risks, especially for youth and those who are pregnant or breastfeeding (Brooks et al., 2017).

NIOSH has conducted several Health Hazard Evaluations of the hazards faced by cannabis workers. Cannabis cultivation workers face hazards similar to those in other agricultural workforces, including exposure to respiratory irritants and ergonomic injuries. Indoor cultivation poses some unique hazards—greenhouses and tents can harbor high levels of fungal spores, bacteria, pesticides, and endotoxins, posing potential allergic and respiratory concerns (Beckman et al., 2023; Couch et al., 2019; Sack et al., 2023). Additionally, the cannabis plant exhibits allergenic properties (Beckman, 2024; Decuyper et al., 2020).

In July 2021, the Western Center for Agricultural Health and Safety at the University of California, Davis, hosted a virtual meeting titled "Cannabis Industry: Setting Priorities for Occupational Health." This meeting aimed to identify the most pressing research, policy, and training needs to safeguard cannabis workers from occupational illness and injury. The meeting identified the need for occupational safety standards

and best practices for trimming machines, pesticide management, allergen control, wildfire preparedness, and psychosocial support (Schenker and Beckman, 2023).

Improving and Innovating with Ongoing Cannabis Evaluation

Evaluation is essential to ensuring effective cannabis policy. It can determine whether the right questions are being asked of the cannabis surveillance system, whether the cannabis policies are appropriate, and whether the prevention education and workforce campaigns are working. Policies have changed when problems have been identified, as in the example previously described of vitamin E acetate being banned from cannabis inhalation products following the 2019 EVALI outbreak. Several states partner with universities to support continuous evaluation and research aimed at monitoring essential outcomes (Ghosh, 2016).

Cannabis Assurance: Findings

The committee found that states have adopted many measures for public health assurance related to cannabis policy. The efforts at consumer protection regarding product safety testing are commendable, but there are inconsistencies across the state programs and issues with laboratory quality. Guidelines related to lowering the risk of use have been implemented in some localities, as have primary prevention media campaigns, which appear to improve consumer knowledge of the risks of cannabis. The Drug-Free Communities Support Program, the Life Skills Training Program, and other programs identified by Blueprints for Healthy Youth Development can all be leveraged to inform primary prevention for substance use. Encouraging a robust public health workforce for cannabis is critical, as are communication and information sharing within and between states with legalized cannabis. Training of retail sales staff is also needed, as they are routinely asked for advice on cannabis use, and audits have found that best practices for public health protection are not followed consistently. Clinician training is important as well because providers are not confident in discussing cannabis use with patients.

CONCLUSIONS AND RECOMMENDATIONS

This analysis of the application of the core public health functions to cannabis policy underscores the need for a more comprehensive public health approach to cannabis in the United States. Prioritizing public health alongside economic considerations, ensuring balanced stakeholder involvement, implementing consistent consumer protection measures, and fostering a well-trained workforce are critical steps in promoting responsible

cannabis use. The policy landscape is complex, marked by an initial focus on economic outcomes in early legalization efforts. Public health considerations, such as reducing dependence and underage use, were often lower priorities. Similarly, consumer awareness of cannabis-related health risks received minimal attention.

Conclusion 4-1: Cannabis policy discussions need to consider impacts on public health. Inadequate inclusion of public health in cannabis policy decisions has limited the application of the core public health functions in states that have legalized cannabis for adult or medical use. Further development of the core public health functions as related to cannabis is therefore needed.

Currently, cannabis surveillance data are collected and analyzed by various entities with limited coordination. While most states are completing some components of a surveillance system, many systems are incomplete. State surveillance systems are underfunded, limiting the frequency of analyses and data dissemination, which in turn limits their link to action. Only Colorado has a complete system with regular analyses, research, and plans for reporting to policy makers, an important activity that may lead to public health action. Despite their limitations, diverse data sources, such as surveys, health records, and mortality statistics, are available, related mainly to the products used. Consistent use and application of the essential components of a public health surveillance system—data collection, analysis, and dissemination—would create a more comprehensive picture of cannabis use and its health impacts, ultimately informing practical public health actions. The CDC has a cannabis surveillance plan that is missing such elements as approaches to data dissemination, a link to action, and regular evaluation. Collaboration with federal partners, such as the departments of Agriculture and Commerce, is also needed to gain an understanding of cannabis production. The FDA has passive reporting systems to monitor product safety (FAERS and CAERS). However, it is difficult to interpret the data from these systems because increased reporting may be a function of increased knowledge that the system exists.

Recommendation 4-1: The Centers for Disease Control and Prevention, in conjunction with its federal, state, tribal, and territorial partners, should create an adaptable public health surveillance system for cannabis. This surveillance system should include, at a minimum, cannabis cultivation and product sales, use patterns, and health impacts. It should also include all the essential components of a public health surveillance system: a surveillance plan, data collection, data analysis, data interpretation, data dissemination, a link to action, and regular evaluation.

The regulatory structure for cannabis is evolving, with dedicated cannabis control commissions emerging. While public health agencies are increasingly involved in policy development, their role in overseeing adult-use cannabis remains uneven. Public engagement efforts, while present, lack inclusivity, potentially overlooking the perspectives of marginalized communities.

The legal cannabis industry exerts influence through lobbying and donations, raising concerns about potential bias in policy development. Furthermore, the limited adoption of conflict-of-interest provisions in medical cannabis states is a cause for concern. Industry influence on policy development is not new to the cannabis industry. The regulated industry can provide valuable input in the initial scoping and problem formulation phases of the policy development process. However, best practices would be for policy-making organizations to have conflict-of-interest policies that bar those with financial ties to the regulated industry from being involved in writing the policies. Policy decisions are typically posted for 30 days before they become final rules, which allows for input from the regulated industry and other relevant interested parties.

Conclusion 4-2: Cannabis policies have been developed without adequate protection against undue industry influence. Industry lobbying and conflicts of interest have interfered with the policy development. As the industry has expanded, it has stymied regulations intended to protect public health by downplaying the risks and overstating the benefits of cannabis.

Consumer protection strategies implemented by states with legal cannabis sales include product restrictions (e.g., limiting the dose of THC in edibles), THC serving size limits, and bans on harmful ingredients. However, significant inconsistencies in cannabis product testing standards exist across states, creating potential consumer safety risks. Cannabis is a source of exposure to harmful environmental chemicals, emphasizing the need for adequate product safety standards. A recent cross-sectional study found that those who use cannabis have higher exposure to cadmium and lead in both blood and urine compared with those who do not use cannabis or tobacco (McGraw et al., 2023).

The U.S. Pharmacopeia (USP), an independent, scientific nonprofit organization, sets standards for the quality, safety, and purity of various products, including medicines, food ingredients, and dietary supplements. USP is actively involved in establishing quality standards for cannabis and cannabis-derived products to protect public health. It has established procedures for testing of identity and composition, detection of contaminants, and validation of analytical methods. The laboratory testing methods encompass several cannabinoid compounds, including delta-8-THC. USP

has also developed reference standards to ensure accurate identification and measurement of constituents and sampling considerations to improve representative analysis, labeling, and packaging resources. And it is developing a cannabis inflorescence (flower) monograph for the *Herbal Medicines Compendium*, scientifically valid methods, information on physical reference standards, and acceptance criteria for establishing the identity of cannabis chemotypes, content of cannabinoids and terpenes, and limits on contaminants (Sarma et al., 2020). Although the standards are in development for primarily medical cannabis products, the reference materials and laboratory methods could be used to improve the quality of laboratory safety for cannabis products consumed for any reason.

Recommendation 4-2: The U.S. Pharmacopeia has established product quality and analytical standards for cannabis inflorescence (flower) and is developing standards for cannabis extracts incorporated into pills and edibles. As these standards are completed, state cannabis regulators should adopt and enforce them to ensure the safety and quality of all legal cannabis products.

As the cannabis industry expands, fostering a well-trained workforce across both the industry and public health sectors is critical. Colorado's collaborative approach, whereby public health authorities, regulators, and the cannabis industry share resources, facilitates communication and knowledge exchange. However, a significant gap exists. Clinicians often report discomfort with discussing cannabis use with patients, highlighting the need for improved training and resources. Providing this training is especially important considering the potential interactions between cannabis and prescription medications, as well as the link between cannabis use and chronic disease risk factors. As recommended by the U.S. Preventive Services Task Force, conducting routine screening for substance use by asking questions would allow for early identification of cannabis use and potential interventions.

Conclusion 4-3: The U.S. Preventive Services Task Force has guidelines for screening adult patients for substance use. Education and training of clinicians related to the effects of cannabis use, as well as the management of patients using cannabis, could improve clinical care.

Several states require training for retail cannabis sales staff on regulations, product knowledge, and responsible sales practices. Despite limited evidence in the literature for the effectiveness of this training in preventing underage sales, training for retail staff on many different aspects of cannabis and its implications for public health remains vital. Since many people who use cannabis trust cannabis retail staff (Young-Wolff et al., 2022), staff

need to be trained on the health effects and harms associated with cannabis use. The CDC or another public health authority could create an online training model that could be updated regularly.

Recommendation 4-3: State cannabis regulators should require training and certification for all staff at cannabis retail outlets who interact with customers. The training should address the effects of cannabis on humans, prevention of sales to minors, warnings about cannabis-impaired driving, cannabis use in pregnancy, high-concentration or high-potency products, and how to identify signs of impairment. The effectiveness of the training should be assessed and the content updated as new scientific information about the positive and negative impacts of cannabis emerges.

Colorado and other states have developed targeted public health campaigns, which are essential for improving knowledge about cannabis and its potential harms. Developing and evaluating education campaigns is time- and resource-intensive. Leadership from the CDC could help guide the states toward developing campaigns that are more likely to improve knowledge.

Recommendation 4-4: The Centers for Disease Control and Prevention (CDC), in coordination with other relevant agencies, should develop and evaluate targeted public health campaigns directed mainly toward parents and vulnerable populations (e.g., youth, those who are or are likely to become pregnant, adults over age 65) about the potential risks of cannabis; how to identify risky behavior, such as the use of cannabis in combination with alcohol or prescription drugs; and risk mitigation strategies, such as lower-risk use guidelines and safe storage. These public health campaigns should include discouraging unhealthy use, such as the use of cannabis in combination with other substances (alcohol, tobacco, or drugs), and the increased risk associated with the use of high-concentration or high-potency products.

Continued evaluation of the public health and societal impacts of changes in cannabis policy is critical as the policy landscape rapidly evolves. Currently, the Office of National Drug Control Policy is prohibited from studying the impacts of cannabis legalization because as of July 2024, cannabis is classified as a Schedule I substance under the Controlled Substance Act, and botanical cannabis has no FDA-approved medical use.

Recommendation 4-5. Congress should remove restrictions on the Office of National Drug Control Policy (ONDCP) from studying the impacts of cannabis legalization. The ONDCP should be allowed to support research on the impacts of changes in cannabis policy.

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5

How Cannabis Policy Influences Social and Health Equity

Health equity, through which "everyone has the opportunity to attain their full health potential, and no one is disadvantaged from achieving this potential because of social position or any other socially defined circumstance" (NASEM, 2017, p. 32), is central to a public health approach to cannabis policy. Factors that benefit or harm health are unequally distributed across populations. Race, ethnicity, poverty, age, life stage, gender identity, sexuality, and social factors can place people at disproportionately high risk for many acute and chronic diseases compared with the general population (NASEM, 2017).

While some distinctions are made between social equity, which often focuses on addressing racism and other forms of discrimination, and health equity, the two concepts are deeply intertwined. Addressing social equity by dismantling structural racism, for instance, directly impacts health equity by disrupting the mechanisms through which health inequities persist. Accordingly, combatting the influence of systemic or structural racism[1] in the United States through public health practice has become an increasingly high priority among many public health leaders (Bassett and Graves, 2018). In 2018, New York State Health Commissioner Mary Bassett called for

[1] "Structural racism" is the totality of ways in which a society fosters racial and ethnic inequity and subjugation through mutually reinforcing systems, including housing, education, employment, earnings, benefits, credit, media, health care, and the criminal legal system. These structural factors organize the distribution of power and resources (i.e., the social determinants of health) differentially among racial, ethnic, and socioeconomic groups, perpetuating racial and ethnic health inequities. The key difference between institutional and structural racism is that structural racism happens across institutions, while institutional racism happens within institutions. "Systemic racism" is another term used to describe this (NASEM, 2023a, p. xxv).

recognizing that racist ideas have shaped public health practice and stressed that health equity could not be achieved without addressing systemic racism (Bassett and Graves, 2018).

Some have posited that cannabis legalization could reduce social inequities by mitigating the adverse consequences of the criminalization of cannabis use, possession, and sales, which has targeted minoritized groups (Golub et al., 2007; Resing, 2019). However, legalization does not eliminate cannabis policing, and increased policing in minoritized neighborhoods can happen for reasons unrelated to cannabis (Hinton and Cook, 2021). Moreover, even in states with legal cannabis markets, there are laws to be enforced, such as the prohibition of sales to those less than 21 years of age, laws banning smoking in public or near certain buildings, and bans on cannabis-impaired driving, all of which could be unequally enforced (Kilmer, 2019).

There are many reasons to be concerned about how the legal cannabis industry contributes to health inequities. Disproportionate marketing toward minoritized groups and concentration of retail stores in the neighborhoods in which they live, for example, could lead to unequal distribution of the health impacts of cannabis use. This chapter evaluates the impacts of cannabis policy on health equity by considering the criminal justice consequences of cannabis prohibition, assessing social equity programs adopted in some states, and evaluating the effects of cannabis policies on social determinants of health.

IMPACTS ON HEALTH EQUITY RELATED TO CRIMINAL JUSTICE

Entanglements with the criminal justice system can contribute to health inequities when increased policing or racism contributes to disparities in arrests and incarceration. Following incarceration, individuals are at increased risk of morbidity and mortality compared with the general U.S. population (Wang and Shavit, 2023; Wildeman and Wang, 2017). The stigma of a criminal record impacts not only those who committed the offense, but also the health of family members (Wildeman and Wang, 2017). Incarceration is associated with higher rates of chronic health conditions among both adults and children in the family (Wildeman and Wang, 2017; Wildman et al., 2019). There are stark differences by race in this regard; nearly 25 percent of Black Americans have three or more immediate family members who have been incarcerated for any reason, compared with just over 5 percent of White Americans (Sundaresh et al., 2021).

Impacts of Cannabis Arrests

Cannabis arrests have varying impacts on people's lives. From 2010 to 2019, there was an average of 692,115 cannabis arrests a year (Chapter 1), very few of which resulted in incarceration (Kachnowski et al., 2023).

In some cases, arrest may cause people to make changes that positively impact their lives. However, others are negatively affected, and some are incarcerated, which impacts their health and well-being. To learn more about those experiences, the committee invited speakers affiliated with the Last Prisoner Project[2] (Jason Ortiz, Donte West, Stephanie Shepherd, and Kyle Page) to describe how the criminal justice system has impacted their lives. All four speakers shared stories of the devastating impact of cannabis-related criminal justice entanglements; none had faced charges of violent crime.

Jason Ortiz described his arrest for cannabis use as a teen, the fear when he was arrested at school, how he almost did not graduate high school, and how he benefited from a change in Connecticut's Higher Education Act that removed the federal aid elimination penalty from his arrest.

Donte West described the emotional toll and the fight to overturn his conviction for possessing a pound of cannabis. West emphasized that his conviction impacted his life in ways that cannot be quantified and said, "When you get incarcerated, not only your freedom gets taken away, but also you don't get to make memories with your loved ones."

Kyle Page highlighted the dehumanization during sentencing and the struggle to rebuild a life after prison, especially with regard to employment and family relationships. Kyle shared his experience of being sentenced for cannabis possession. His lawyer explained they needed to "humanize" him for the judge. Page said:

> That was extremely frightening to me to think that the person in charge of the rest of my life, in charge of my daughter's father's life, needed me to be humanized. Think of the gravity—you could do 20 years in prison or 6, depending on whether someone judged me to be a human. That's a frightening thought.

Stephanie Shepherd emphasized the long-term consequences of arrest and incarceration, including limitations on housing, credit, and professional opportunities. She was age 30 when she began using cannabis, 41 when she was convicted of conspiracy to distribute cannabis, and 50 when she was released. Now, at age 54, she still struggles to get her life back together. Shepherd described the shameful feeling she had when she first tried to find employment after release. She said,

> When I got out, and I had to go to a job interview with an ankle monitor on, I cried in that job interview because I had never had to explain to someone why I couldn't stay late, where I just came from, why there's a 10-year gap in my work experience, and this was just a coffee shop [job].

[2] Video recordings of the committee's public meetings can be found on the project page: https://www.nationalacademies.org/our-work/public-health-consequences-of-changes-in-the-cannabis-landscape.

The session showed how incarceration disrupts lives, separates families, and creates lasting hardships. Reintegration into society is a challenge, especially given the difficulties of finding housing and employment with a criminal record for cannabis offenses.

Impacts of Changes in Cannabis Policy on Inequities in Arrests

With changes in laws, enforcement practices, and norms for cannabis has come a noteworthy reduction in arrests for cannabis possession. While historical data on the number of such arrests do not exist,[3] the best national data source on these arrests suggests that they decreased from 613,986 in 2002 to 500,395 in 2019, an 18.5 percent reduction.[4] Given how much cannabis use increased over this period (Chapter 3), this reduction means that the risk of arrest conditional on use has decreased even more. Based on data on the total number of cannabis use days from the National Survey on Drug Use and Health for 2002 and 2019 (Chapter 3), cannabis possession arrests per million days of cannabis use decreased by roughly 69 percent over this period.[5]

To assess some of the potential racial disparities in cannabis arrests, the committee received data from two research teams that published race-specific analyses using Federal Bureau of Investigation (FBI) cannabis possession arrests (Gunadi and Shi, 2022a; Sheehan et al., 2021). Both papers use subsets of states (Gunadi and Shi use 36 states,[6] while Sheehan and

[3] The national data reported before 2021 were found in the Federal Bureau of Investigation's (FBI's) annual *Crime in the United States* report. These data underestimate the total number of cannabis possession arrests because of a recording procedure known as the "hierarchy rule," which means that if someone is arrested for multiple offenses at the same time, only the most serious one is reported to the FBI (e.g., if someone were arrested for robbery and cannabis possession, the law enforcement agency would record only the robbery arrest since it was more serious). In 2021, the FBI began requiring all states to comply with the National Incident-Based Reporting System, which allows multiple offenses to be linked to a particular arrest. However, not all localities are yet compliant, and compliance varies by jurisdiction (NASEM, 2023b).

[4] The FBI reported that in 2002, there were 1,538,813 arrests for drug abuse violations, and 39.9 percent of these were for cannabis possession, meaning there were 613,986 cannabis possession arrests (Tables 28 and 29, FBI UCR, 2003). The comparable figure for 2019 was 500,395 cannabis possession arrests (1,558,862 * 32.1%). The 2019 data are the most up-to-date and reliable information because data for other years may have been impacted by missingness due to the COVID-19 pandemic (FBI CJISD, 2019).

[5] In analyses presented in Chapter 3, the committee found that there were approximately 2.1 billion days of cannabis use in 2002. By 2019, that figure had increased to 5.5 billion days. Using the arrest data from the FBI, this means that arrests per million use days decreased from roughly 292 in 2002 to 91 in 2019, or 69%.

[6] Some analyses in Gunadi and Shi (2022b) include Florida, and thus reflect data from 37 states.

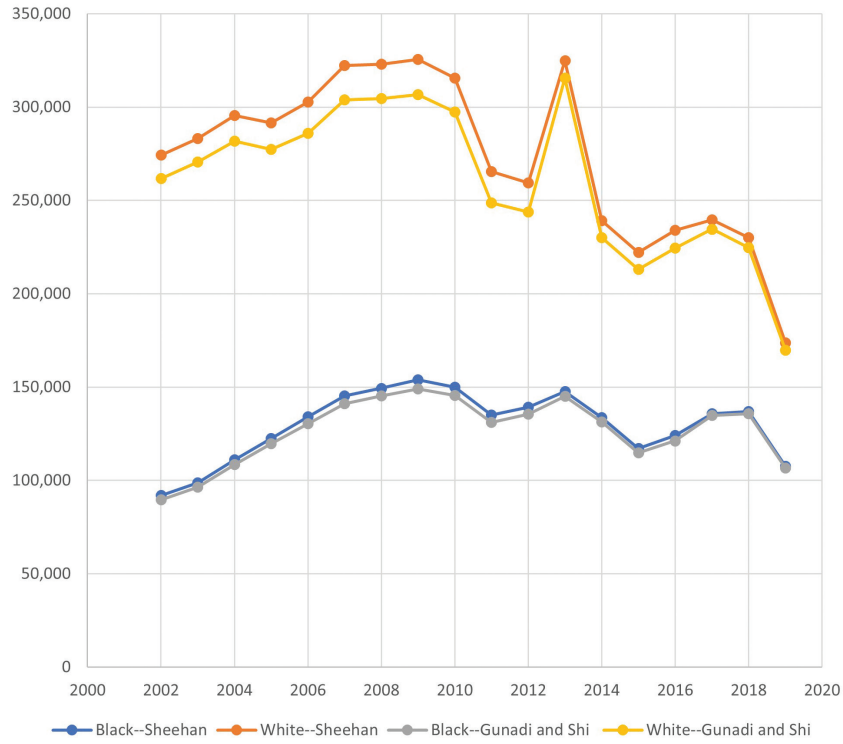

FIGURE 5-1 Cannabis arrests over time, stratified by race, from two articles. SOURCE: Generated by the committee from Gunadi and Shi, 2022a; Sheehan et al., 2021.

colleagues use 43 states) and focus on arrests of both Black and White people.[7] The levels and trends are similar across both datasets; the correlation coefficient for cannabis possession arrests of Black people for the two datasets was 0.998, while that for cannabis possession arrests of White people was 0.997 (Figure 5-1). Comparing total cannabis possession arrests for 2002–2004 and 2017–2019 (3-year periods used to mitigate single-year anomalies), data from both papers show large reductions in arrests for White people over both periods (Gunadi and Shi: –22.7 percent; Sheehan

[7] As noted by Gunadi and Shi (2022b): "Finally, the UCR data has limited information on arrests by race. Other than arrest data for Blacks and Whites, data are only available for American Indians and Asians. Ethnicity information, such as Hispanic origins, is unavailable for most of the years" (p. 2).

et al.: –24.6 percent). For Black people, however, the data show nearly the opposite, with both data sources documenting substantial increases (Gunadi and Shi: 28.1 percent; Sheehan et al.: 26 percent). While these data have limitations and do not cover the entire country, they emphasize continued inequity in arrests for cannabis possession and deserve additional analysis (Gunadi and Shi, 2022a; Sheehan et al., 2021).

Collateral Consequences

The health and economic impacts of arrests and incarceration extend far beyond the initial punishment. Laws, regulations, and the policies of private organizations, including businesses and educational institutions, as well as social stigma, all contribute to the harms people experience after entanglement in the criminal justice system. Examples include job loss, housing insecurity, and limitations on educational and business opportunities. Collateral consequences for families and communities are discussed below (Maurer, 2017).

Impacts of Incarceration on Economic Security

Incarceration of youth is associated with limited educational opportunities, with subsequent adverse impacts on economic security and wage growth (Western, 2002). Criminal arrests during adolescence are associated with greater criminal activity in young adulthood and midlife, further limiting educational and employment opportunities (Green et al., 2019). Formerly incarcerated people are twice as likely as the general public to fail to complete high school or obtain a general equivalency diploma, and eight times less likely to complete college. And formerly incarcerated people of color are at the greatest educational disadvantage (Couloute, 2018).

Providing educational opportunities in carceral settings has the potential to improve public safety, reduce recidivism, and improve social integration following release (Royer et al., 2021). More than two-thirds of currently incarcerated individuals express a desire to enroll in academic courses or programs while incarcerated (Rampey et al., 2016). One study estimates that recidivism is reduced by 43 percent among those who participate in such educational programs, yet numerous barriers exist to providing them (Davis et al., 2014). For example, some prisons require drug testing for those wishing to participate in higher education programming provided by community-based academic institutions (Royer et al., 2021). Additionally, most incarcerated individuals are eligible for postsecondary education, but access is hampered because incarcerated people are banned from accessing funding for education, such as Pell grants (Oakford et al., 2019).

STATE- AND LOCAL-LEVEL CANNABIS EQUITY PROGRAMS

Many state and municipal governments have instituted policies and programs to address the harms of cannabis prohibition (Wakefield et al., 2023). State-level cannabis social equity efforts include record relief and resentencing, assistance for industry participation (technical and financial), and community reinvestment. Policies in states that were early to adopt cannabis legalization did not include social equity provisions, at least initially, whereas more recently, equity provisions have been included in tandem with cannabis legalization reforms (Love et al., 2022; Schlussel, 2021). In 2023, the policies of 22 of the 24 states with legal adult use had social equity provisions (Table 5-1). Record relief and resentencing are the most common social equity provisions, and all legal adult-use states with social equity provisions have some level of criminal justice reforms. Twenty states where cannabis is legal for adult use are considering industry participation assistance, and 18 states are considering community reinvestment provisions (Hrdinova and Ridgway, 2024).

Record Relief and Resentencing

Record relief expunges (clears) or seals the records of cannabis offenses, while resentencing involves changing the sentences for those currently incarcerated for a cannabis-related offense. All states with a social equity program have some record relief, but only eight include resentencing provisions in their policies (Hrdinova and Ridgway, 2024).

The way record relief programs operate varies (Hrdinova and Ridgway, 2024; Love et al., 2022; Schlussel, 2021; Wakefield et al., 2023). One of the most important variations is in whether the relief is automatic or government initiated, or whether it requires the person with a record to petition for the relief. In 2024, 16 states had government-initiated record relief, and 6 had solely petition-based programs, meaning that those with a criminal record must initiate the process to relieve their records (Hrdinova and Ridgway, 2024). Record relief programs also differ as to the types of offenses that can be relieved and whether the records are cleared or sealed (Hrdinova and Ridgway, 2024; Wakefield et al., 2023).

Petition-based record relief has many barriers to widespread use, limiting the number of people who benefit. Petition-based expungements require filing a formal petition with the court and may involve public hearings, fees, and other formalities. The court costs alone may deter eligible people from filing a petition. Public defenders or other free or reduced-cost legal services are often unavailable, and hiring a lawyer may not be financially feasible (Berman, 2018). Additionally, resource constraints may pose a challenge for court systems. High volumes of requests can create bottlenecks in

TABLE 5-1 Overview of Major Social Equity Policy Areas by State

State	Record Relief and Resentencing	Community Reinvestment	Industry Participation Assistance
Alaska (2014 by ballot)	No	No	No
Arizona (2020 by ballot)	Yes (enacted during and post legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
California (2016 by ballot)	Yes (enacted during legalization)	Yes (enacted during legalization)	Yes (enacted post legalization)
Colorado (2012 by ballot)	Yes (enacted during legalization)	Yes (enacted post legalization)	Yes (enacted post legalization)
Connecticut (2021 legislation)	Yes (enacted post legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Delaware (2023 legislation)	Yes (enacted pre-legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Illinois (2019 legislation)	Yes (enacted during legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Maine (2016 by ballot)	No	No	No
Maryland (2022 legislation)	Yes (enacted pre-legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Massachusetts (2016 by ballot)	Yes (enacted post legalization)	Yes (enacted post legalization)	Yes (enacted post legalization)
Michigan (2018 by ballot)	Yes (enacted post legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Minnesota (2023 legislation)	Yes (enacted post legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Missouri (2022 legislation)	Yes (enacted during legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Montana (2020 by ballot)	Yes (enacted during legalization)	No	No
Nevada (2016 by ballot)	Yes (enacted post legalization)	No	Yes (enacted post legalization)
New Jersey (2020 by ballot)	Yes (enacted pre/post legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
New Mexico (2021 legislation)	Yes (enacted pre-legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
New York (2021 legislation)	Yes (enacted during and post legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Ohio (2023 by ballot)	Yes (enacted pre-legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Oregon (2014 by ballot)	Yes (enacted post legalization)	No	No
Rhode Island (2022 legislation)	Yes (enacted pre-legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Vermont (2018 legislation)	Yes (enacted post legalization)	Yes (enacted post legalization)	Yes (enacted post legalization)
Virginia (2021 legislation)	Yes (enacted pre-legalization)	Yes (enacted during legalization)	Yes (enacted during legalization)
Washington (2012 by ballot)	Yes (enacted post legalization)	Yes (enacted post legalization)	Yes (enacted post legalization)

SOURCE: Hrdinova and Ridgway, 2024.

processing applications due to administrative limitations and wait periods (Wakefield et al., 2023). Not surprisingly, then, data suggest that petition-based record relief has a serious uptake gap. One study evaluating record expungement, not specifically with respect to cannabis, estimated that among people legally eligible for expungement of criminal convictions, only 6.5 percent obtain it within 5 years of eligibility, but those who do obtain it experience higher wages and have a low subsequent crime rate (Prescott and Starr, 2019).

To address the barriers to petition-based record relief, many states and jurisdictions have committed to automatically clearing eligible records for people who have completed their sentences and remained crime free and to expanding the criteria for eligibility for clearance. Since 2018, 12 states (California, Colorado, Connecticut, Delaware, Michigan, Minnesota, New York, New Jersey, Oklahoma, Pennsylvania, Utah, and Virginia) have passed laws that align with the laws and policies[8] of the Clean Slate Initiative.[9]

Social Equity Business Assistance

A fundamental goal of many state cannabis social equity programs is to help those harmed by cannabis criminalization to benefit financially from the legal market. The criteria for receiving support can include having prior involvement with the criminal justice system; being economically disadvantaged; living in or having resided in an economically disadvantaged area; and other considerations, such as veteran status, race, or ethnicity. The business assistance can include preferential licensing, financial support, and assistance (Hrdinova and Ridgway, 2024). Most cannabis social equity programs include industry support. Alaska, Maine, Montana, and Oregon are the only legal adult-use states without some social equity business assistance.

In 12 states, laws require that a particular portion of cannabis business licenses be allocated to individuals from communities that have been targeted unfairly by past cannabis enforcement. State regulators may also establish additional applicant criteria (Hrdinova and Ridgway, 2024). For example, Connecticut and New York reserve 50 percent of licenses for social equity applicants. New Jersey allocates 25 percent of licenses to applicants from selected impact zones. Other states—including Arizona, Delaware, Nevada, Ohio, Rhode Island, and Washington—specify the

[8] https://www.cleanslateinitiative.org/states (accessed March 28, 2024)

[9] The Clean Slate Initiative is an organization that "passes and implements laws that automatically clear eligible records for people who have completed their sentence and remained crime-free and expands who is eligible for clearance" (para. 1) (https://www.cleanslateinitiative.org [accessed March 28, 2024]).

number of equity licenses awarded, often dividing the numbers into cultivation, manufacturing, retail, and testing licenses. Nevada also has a license for cannabis consumption lounges, half of which are awarded to equity applicants (Hrdinova and Ridgway, 2024).

Twenty states have programs that provide license or business assistance (Hrdinova and Ridgway, 2024). Although each state's program is different, some examples of license assistance include priority application review, reduced application fees, financial assistance programs to help launch a cannabis business, and education and training programs (Hrdinova and Ridgway, 2024).

Priority application review ensures that specific applications are processed more quickly. For example, the New Jersey Cannabis Regulatory Commission ranks priority groups based on diversity status, owner's economic and criminal background, and physical location.[10] Applications from higher-ranking groups are reviewed first (Hrdinova and Ridgway, 2024).

Reduced application fees are used in 11 of the 24 adult-use states (Hrdinova and Ridgway, 2024). The programs typically reduce or waive fees related to the initial application. Vermont uses a fee reduction schedule that begins with a full waiver and gradually increases over time, allowing social equity owners to achieve financial sustainability (Vermont CCB, n.d.). Delaware offers special microbusiness licenses with lower fees and less frequent renewals, catering to smaller-scale operations for those without the capital to start a large business (Hrdinova and Ridgway, 2024).

Financial assistance programs that can help launch a cannabis business are part of social equity programs in several states, including California, Colorado, Connecticut, Delaware, Illinois, Massachusetts, and New York. These programs offer funding assistance through grants, microloans, and no- or low-interest loans. How the funds can be used to support the business varies by state, and the loan repayment structures differ based on the loan terms (Hrdinova and Ridgway, 2024).

Technical assistance programs provide support and resources to cannabis business owners. These programs offer training on regulatory compliance, business planning, marketing strategies, and cultivation techniques. Some programs also include access to funding and mentorship opportunities. Colorado's Accelerator License program helps cannabis business owners from communities impacted by cannabis prohibition by partnering those with social equity licenses with an established cannabis business. The established business can then advise the social equity licensee on how to run a successful business.[11]

[10] https://www.nj.gov/cannabis/businesses/priority-applications/ end of page (accessed March 22, 2024).

[11] https://sbg.colorado.gov/accelerator-program (accessed March 22, 2024)

Business assistance programs have several problems. While business assistance may benefit minoritized groups that want to participate in the cannabis industry, the industry has been in a constant state of change, making it difficult for businesses to profit. In addition to the investment risks of running a new business, the risks could grow if federal legalization allows (1) cannabis to cross state lines legally and (2) large corporations to become involved in the trade (Kilmer et al., 2021). Moreover, some early analyses have shown that social equity business programs have been abused and largely benefited wealthy people with political connections and sizable commercial cannabis companies. Some companies have canvassed lower-income areas to identify someone to apply for a license backed by the larger company (Lawrence and Minton, 2023). Business license programs could also contribute to health inequities. Entrepreneurs often start businesses near where they live, so social equity licenses could contribute to an overconcentration of retail outlets in communities that have experienced disadvantage and have been unfairly targeted by cannabis enforcement.

Community Reinvestment

Community reinvestment programs use a portion of the tax revenue generated by the sale of legal cannabis to address social and economic needs in communities that have been negatively impacted by cannabis prohibition (Hrdinova and Ridgway, 2024; Yang et al., 2023). The programs' goals vary, but the funding structures typically include directed grant programs. The funds are used for education, mental health services, substance use treatment, economic development, violence prevention, and legal aid (Yang et al., 2023). The tax dollars generated by cannabis sales can be substantial. California's community reinvestment grants, for example, total $50 million per year.[12] It is estimated that if states designated just 25 percent of annual cannabis excise tax revenues to support mental health services, the result could be increased availability of psychiatric crisis units, coordinated specialty care, and suicide prevention services (Berg et al., 2023; Purtle et al., 2022). A 2023 report from the Tax Foundation estimates that if cannabis legalization were nationwide, it could generate $8.5 billion annually (Hoffer, 2023).

Community reinvestment programs have many challenges. Tax revenue is a function of sales; Colorado, for example, saw tax revenues begin to decline in 2021 (CDR, 2024). Maintaining a grant program is also costly, and the grantee's ability to deliver the intended results limits the grant program's benefits. In addition, cannabis taxes could replace traditional

[12] https://business.ca.gov/california-community-reinvestment-grants-program (accessed March 22, 2024).

funding for social programs. There are also social equity considerations regarding cannabis taxation (Yang et al., 2023). Those who have lower incomes and use cannabis may spend a higher proportion of their income on cannabis and thus are more impacted if taxes increase the price of cannabis. So those who are intended to benefit from the program may be paying an increased proportion of the cost (Jernigan et al., 2021).

State Social Equity Programs: Findings

State and local cannabis equity programs are a recent development aimed at addressing the social and economic harms caused by cannabis prohibition, which has disproportionately impacted communities of color. Cannabis legalization has spurred a range of social equity efforts in the United States that encompass criminal justice reform, assistance with industry participation, and community reinvestment programs. While these initiatives hold promise for mitigating the harms of cannabis prohibition, challenges remain in implementation and effectiveness. Addressing these challenges will ensure that social equity is a central feature of the legal cannabis industry. Start-ups may need help staying afloat in competitive markets to contend with predatory rent prices and loan repayments (Gerber, 2022). As these programs continue to develop, monitoring their effectiveness and adjusting as needed will be essential (Title, 2021).

SOCIAL DETERMINANTS OF HEALTH

For decades, research and scholarship have illustrated that social and structural factors—such as race, ethnicity, zip code, education level, employment, and income—impact health outcomes and thereby create significant health inequities (NASEM, 2023a). Systems of power, individual factors, and physiological pathways influence health equity. Systems of power are policies, processes, and practices that determine who gets resources and better opportunities for health. These systems can promote health equity or perpetuate inequities (access to basic needs, humane housing, meaningful work, and reliable transportation). Individual factors concern people's responses to social, economic, and environmental conditions through their attitudes, skills, and behaviors and their interaction with biological predisposition. Physiological pathways refer to people's biological, physical, cognitive, and psychological abilities (Peterson et al., 2021).

To understand how cannabis policy contributes to health equity, it is essential to consider the social and structural factors that impact the well-being of individuals and communities. These structural factors affect

local, state, and federal government; industry; and health care systems. The social determinants of health framework acknowledges the social and structural factors that must be addressed to improve health equity. Many different social-ecological models, describe how social and structural factors influence health. Healthy People 2030 and a recent National Academies report categorize the social determinants of health as economic stability, education access and quality, health care access and quality, neighborhood and built environment, and social and community context (HHS, n.d.; NASEM, 2023a). The committee considered how changes in cannabis policy can influence these social and structural determinants of health (Figure 5-2).

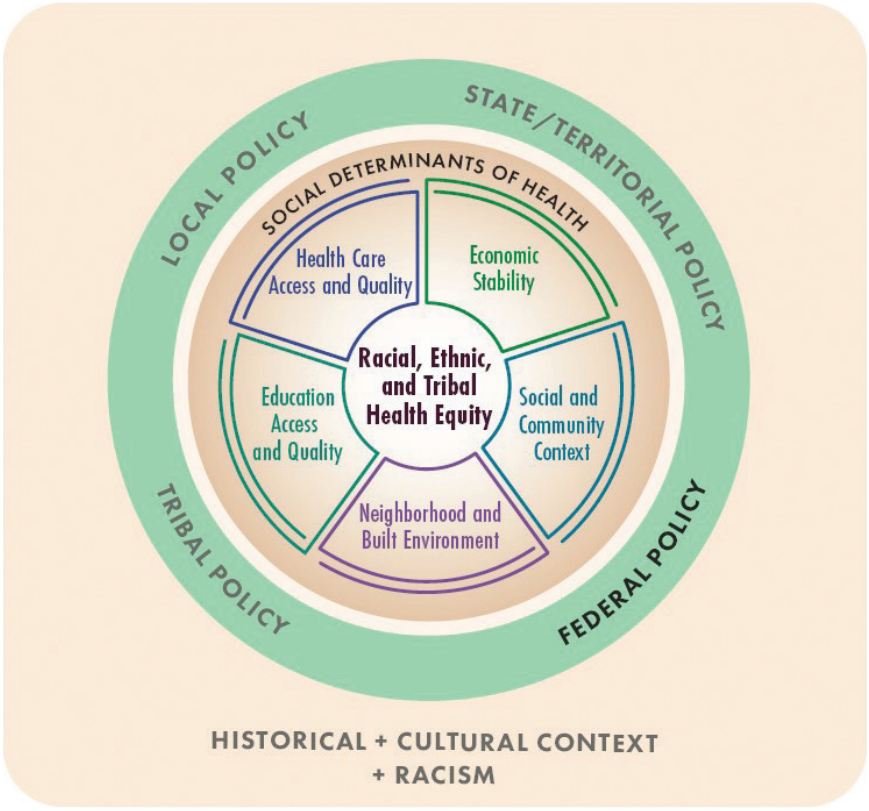

FIGURE 5-2 Conceptual model for how policies impact the social determinants of health and health equity.
Source: NASEM, 2023a.

Economic Stability

The economic impact of cannabis legalization on communities is nuanced and still unfolding. Touted economic benefits of cannabis legalization include tax revenue, job creation, increased investment, reduced law enforcement costs, and increased tourism (Brown et al., 2023). There are also documented societal costs of cannabis legalization, which may impact economic stability (Chapter 6). While the economic impact of cannabis legalization is complex, valuable lessons can be learned from the current landscape, as well as from examples with other substances (e.g., retail availability and regulation of alcohol).

Taxation transfers income from people to the government. The state tax revenue from legalized adult-use cannabis exceeded initial estimates in 2021; states collected a combined $3 billion (Hoffer, 2023). However, it is important to note that cannabis tax revenues in Colorado (the longest-running legal market) began to decline in 2021 (CDR, 2024). Tax revenue can be used for various purposes, including education, infrastructure, social programs, and expansion of both prevention and treatment services for cannabis use. Given that estimates from the National Survey on Drug Use and Health (NSDUH) for past-month cannabis use are slightly higher among those living in poverty compared with those in other income brackets (see Figure 3-9 in Chapter 3), cannabis taxes are regressive.

The legal cannabis industry does create legal jobs in cultivation, processing, retail, and testing (Levin, 2023). Job creation is complicated to assess because, ideally, the legal industry is slowly replacing the illegal industry, and there may be a transfer from illegal to legal jobs. Estimates suggest that hundreds of thousands of jobs have been created across the United States as a result of cannabis legalization (Cooper and Martinez Hickey, 2021). However, it is unclear if those are replacing those lost in the illegal industry.

There are tremendous inequities in the development of the cannabis industry, however, as it is skewed mainly toward White male entrepreneurs and employees. About 75–80 percent of retail outlets are owned by White people, and about 70 percent of those employees are White. Fewer than 6 percent of owners or employees are Black (Doonan et al., 2022; Harris and Martin, 2021; Swinburne and Hoke, 2019). There are many reasons for these employment inequities, such as the collateral consequences of arrests (Maurer, 2017) and lower access to the capital needed to start a business (Harris and Martin, 2021).

Legalization and the increased prevalence of use that follows affect employment in other sectors as well. Many industries use pre- or postemployment drug testing. The practice is controversial, particularly where

safety and security concerns are not paramount (Cohen et al., 2022; Hoffman, 1999; Price, 2014; Treglia et al., 2022). Following the passage of the Drug-Free Workplace Act of 1988 (41 USC 81), which requires federal grant recipients or contractors to establish and maintain a drug-free workplace policy, 40–45 percent of U.S. workers reported the use of drug testing in their workplaces (Carpenter, 2007; Oh et al., 2023). Black workers are tested more frequently than White workers, even controlling for occupation (Becker et al., 2014; Carpenter, 2007). Since employer drug testing can prevent people from acquiring or maintaining a job, these disparities likely impact health equity.

At the committee's second public meeting, Ryjean Reid described how employer drug testing impacted him personally. He was employed as a first-line manager at an airline and lost his position after testing positive for cannabis last year. Based on his experience with cannabis testing, he said he thinks that "cannabis prohibition creates a second class of citizenship in the United States, and these inequities in enforcement are overall damaging in terms of public health."

As cannabis policies have shifted, employers have changed drug testing practices. Many cannabis legalization laws have included explicit language protecting employee rights concerning cannabis use outside of regular work hours. According to data from the National Conference of State Legislatures, as of January 22, 2024, 8 of the 24 states with adult-use cannabis legislation (California, Connecticut, Montana, Nevada, New Jersey, New York, Rhode Island, and Washington) had statutes protecting employees' rights to use cannabis while off duty.[13] These states have either statutory or constitutional language requiring employers not to discriminate at the time of hiring or against off-duty use of cannabis by employees. However, some of these laws exempt employers in particular occupations (e.g., construction in California). None of these laws prevent employers from testing after an accident or for cause.

The economic impacts of cannabis legalization are complex, with potential benefits and drawbacks for communities. To date, cannabis legalization may not be improving economic inequities. The cannabis industry, while generating tax revenue for a state's government, may not be benefiting those harmed by cannabis policing, and employer drug testing practices may impact employment status among Black people because the practice is applied inequitably.

[13] Data from the National Conference of State Legislatures, last updated January 22, 2024. (https://www.ncsl.org/health/cannabis-and-employment-medical-and-recreational-policies-in-the-states [accessed August 14, 2024]).

Educational Access and Quality

Cannabis policy has complex impacts on educational access and quality. In the United States, public school funding for kindergarten through 12th grade (K–12) comes primarily from state and local revenues, such as local property taxes, personal and corporate income taxes, and excise taxes. These revenues are then distributed to school districts based on formulas that consider a variety of factors, including local property tax revenue, area needs, and school attendance (ECS, 2024; Peter G. Peterson Foundation, 2023; Skinner and Riddle, 2019). This means that resources allocated to any neighborhood public school are tied to the value of local property in the area and how many students are present. Some states use revenue from cannabis taxation to support schools; as of September 6, 2022, Alaska, Colorado, Michigan, Nevada, New York, and Oregon used at least a portion of the tax revenue to support educational programs (Lozier, 2022).

Cannabis policy can impact educational access and quality within a community through at least two channels. First, cannabis policies that influence the availability of, access to, and marketing of kid-friendly products might impact either the prevalence or frequency of cannabis use by youth. Youth use of cannabis can negatively impact cognitive function, such as attention and working memory, especially during critical developmental stages in adolescence (Volkow et al., 2016). These impacts can lead to poorer performance in school and reduced motivation to attend classes, impacting absenteeism or enrollment status. Second, policies that focus on enforcement against cannabis use and possession, particularly enforcement targeting vulnerable youth populations, can lead to differential attendance and enrollment in schools, thereby impacting school resources available for education for everyone in the neighborhood.

Observational data suggest a direct relationship between cannabis misuse and lower educational achievement among adolescents and young adults (Thompson et al., 2019). The biological plausibility of the link is well supported by evidence that cannabinoids directly affect the areas of the brain involved in working memory, attention, and learning (Bhattacharyya et al., 2015; Bloomfield et al., 2019; Bossong et al., 2012; Ramaekers et al., 2021), and is further supported by experimental evidence showing a deleterious dose–response relationship between delta-9 tetrahydrocannabinol (THC) and working memory and learning (Curran et al., 2002; Ranganathan and D'Souza, 2006). Additional preclinical and experimental evidence shows a strong biologically based dose–response relationship between delta-9 THC and motivation (Pacheco-Colón et al., 2018; Paule et al., 1992; Volkow et al., 2016), as well as cognition and decision-making behavior (Ferland et al., 2023). Well-designed longitudinal studies have found an association between early onset or frequency of cannabis use during adolescence and decreased academic performance (Horwood et al., 2010). This finding is

further supported by quasi-experimental evidence comparing academic achievement before and after cannabis prohibition, which supports the connection between cannabis use and poorer school performance (Marie and Zölitz, 2017). Moreover, the 2015–2019 NSDUH revealed that not only youth with cannabis use disorder but also those with subclinical nondisordered cannabis use had more difficulty concentrating and worse academic performance (Sultan et al., 2023). The above research does not conclusively support a causal connection between cannabis use and dropping out of school, as the findings may be subject to potential confounding caused by mental health disorders and other factors (Esch et al., 2014; Lorenzetti et al., 2020). Nonetheless, it supports a plausible connection between cannabis use and dropping out of school, which is why substantial research attention has been paid to the impact of changing cannabis policies on youth substance use.

Enforcement of existing cannabis laws can also impact school attendance and enrollment in at least two ways. First, schools' zero-tolerance policies mandating suspension or expulsion for simple drug possession directly increase suspensions and expulsions from those schools while also contributing to school alienation, academic deterioration, and delinquency among the affected students (AAP and Committee on School Health, 2003; APA Zero Tolerance Task Force, 2008; Wald and Losen, 2003). A recent survey of 1,080 public schools in 2021 found that 62 percent still retained zero-tolerance policies and that the policies of 85 percent of these schools extended to possession of illegal drugs, which would include cannabis for anyone under age 21 (Perera and Diliberti, 2023).

A second way enforcement might impact school attendance is through additional policing that occurs in low-income and ethnically diverse neighborhoods (Gaston, 2019; Lum, 2010), which can increase the chances that youth in those neighborhoods will be arrested for simple possession or use (Nguyen and Reuter, 2012). These arrests lead to an immediate absence from school due to criminal justice engagements and increase the likelihood of dropping out of school (Kirk, 2009; Kirk and Sampson, 2013), affecting the resources available to the broader school environment (since absenteeism reduces school funding).

Cannabis liberalization policies also have potential effects on school access and quality that warrant further study. To the extent that cannabis legalization policies do not address the criminality of youth possession and use or lead to changes in school zero-tolerance policies, they are likely to have only negative impacts on school access and education quality because they increase the potential for youth cannabis access and use. If, however, legalization policies are coupled with decriminalization statutes, which eliminate the criminal status of simple possession or use of small amounts of cannabis for both adults and people under 21, they may bring some benefit to disadvantaged neighborhoods and schools at risk of differential enforcement of criminalization policies (Tran et al., 2020; Wald and Losen, 2003).

Health Care Access

Cannabis policies intersect with access to health care through employment, health insurance benefit coverage, and willingness to seek treatment for health conditions. Cannabis prohibition has negatively impacted all three areas; thus, revision of these policies with legalization should improve health care access. Cannabis policies could even improve health care quality if, for example, the justice system mandated treatment for substance use, particularly as part of the juvenile justice system, should that treatment in fact be effective.

Employment impacts health care because the primary source of health insurance in the United States is through employers (Keisler-Starkey et al., 2023), where coverage is highly subsidized by preferential tax treatment and employer contributions (Gruber, 2011). Given that the prices for health care in the United States are much higher they are in other developed countries (Dieleman et al., 2017; Papanicolas et al., 2018), Americans rely on health insurance to finance their use of health care services. The collateral consequences of an arrest restrict access to employment and some access to health insurance, although coverage through Medicaid is often allowed after release.

Even individuals without a criminal record can experience limitations in their health insurance coverage due to the use of cannabis. This is the case because following a model law developed in 1947 by the National Association of Insurance Commissioners, several U.S. states allow insurance companies to deny benefits for emergency care if the injury or condition prompting the emergency visit is due to intoxication or being under the influence of any drug that a provider did not prescribe (Azagba et al., 2024). Since medical cannabis policies in the United States are technically outside of the health care system because of federal cannabis prohibition, medical use recommended by a medical provider is not necessarily protected. As of 2023, nearly half of all U.S. states (N = 23) retained denials for intoxication (APIS, 2023).

Punitive legal responses to prenatal drug use have negative health implications. Punitive policies on prenatal drug use exist in nearly half of U.S. states. As of 2022, three states had criminalized prenatal drug use (Alabama, South Carolina, and Tennessee). The most common approach to enforcement of punitive practices involves using child protective services to remove children from mothers who used drugs during pregnancy. Twenty-three states have child removal laws, and six states (Florida, Illinois, Kentucky, Missouri, North Dakota, and Texas) clearly consider prenatal drug use sufficient grounds for child abuse substantiation or termination of parental rights (Bruzelius et al., 2024). These policies can be triggered by evidence of drug use or even by a newborn having symptoms of withdrawal.

Overall, punitive prenatal drug policies create a harsh legal landscape for pregnant people struggling with substance misuse. Punitive prenatal drug use policies are counterproductive, contributing to underreporting of prenatal cannabis use, avoidance of prenatal care, and missed opportunities for education and intervention (Bruzelius et al., 2024; Pack et al., 2022). Chronic stress can worsen health conditions and make it more difficult to manage substance use. If pregnant people fear being reported to the authorities, they may be less likely to seek treatment for substance use. The lack of treatment can lead in turn to continued substance use, which does not decrease exposure to the developing fetus (Atkins and Durrance, 2020; Carroll et al., 2021; Chang et al., 2019; Faherty et al., 2019; Meinhofer et al., 2022). In addition, these punitive policies have the potential to exacerbate existing inequities. For example, studies have shown that relative to White pregnant individuals, Black pregnant individuals are more likely to be administered a urine test for substance use at delivery and more likely to be reported to child protective services for prenatal substance use despite rates of use similar to those of White people (Jarlenski et al., 2023; Rubin et al., 2022). Additionally, studies have shown that child protective services are more likely to be called for a Black than for a White baby (Harp and Bunting, 2020; Roberts and Nuru-Jeter, 2012). Institutional policy changes can mitigate such racial inequities seen with pregnant patients and provide clinicians with unbiased, standardized screening tools (Habersham et al., 2023; Peterson et al., 2023). The American College of Obstetricians and Gynecologists (ACOG, 2011) recommends that clinicians work with policy makers to repeal punitive policies on prenatal substance use.

Another consideration is the legally mandated treatment for people who use substances, although not everyone who is arrested for cannabis offenses needs substance use treatment. Mandated treatment is a common feature of juvenile criminal justice diversion programs in the United States, particularly for nonviolent drug offenses. Criminal justice referrals to treatment involving cannabis use disorder have been declining for juveniles, just as for adults, over the past 20 years, even before states legalized cannabis for adult use, presumably as a result of changes in enforcement related to other cannabis policies on medical use and decriminalization (Harris and Kulesza, 2023). Historically, people of color have had less access to treatment through the criminal justice system despite their higher arrest rates, leading to disparities in access to treatment even within the criminal justice system (MacDonald et al., 2014; McElrath et al., 2016; Nicosia et al., 2013). However, a recent study examining the impact of legalization on criminal justice referrals to treatment for cannabis use disorder suggests that access to treatment for juveniles remains high and that previous Black–White disparities may be declining in legalization states. Admission rates for juvenile criminal justice referrals involving cannabis use disorder increased

for Black juveniles 2 and 6 years after a policy change in legalizing states compared with control states (Harris and Kulesza, 2023).

The National Institutes of Health previously funded a large-scale, multisite study—the Juvenile Justice-Translational Research on Interventions for Adolescents in the Legal System (JJ-TRIALS)—which aimed to improve access to services for substance use disorder for justice-involved youth. Although not explicitly focused on cannabis, the JJ-TRIALS framework offers valuable insights for addressing cannabis use among this population (Becan et al., 2020). Previous studies exploring opportunities for engagement with adolescents in the juvenile justice system highlight the potential for diversionary pathways that steer youth away from the criminal justice system and toward treatment and supportive services (Belenko et al., 2017). The Behavioral Health Services Cascade emphasizes the potential transitions youth can navigate across service systems, such as moving from the criminal justice system to the substance use disorder treatment system. It offers a promising framework for addressing cannabis use among justice-involved youth (Belenko et al., 2017).

The impacts of cannabis policy on the quality of health care received, particularly substance use treatment, have received little attention in the literature beyond the issue of how to identify those in need of treatment for cannabis use disorder. The U.S. Preventive Services Task Force (USPSTF et al., 2020) concluded that among adults, screening by asking questions about unhealthy drug use has a moderate net benefit when services for accurate diagnosis of unhealthy drug use or drug use disorders, effective treatment, and appropriate care can be offered or referred; in adolescents, the benefits and harms of screening for unhealthy drug use are uncertain.

The USPSTF has not completed a review specific to interventions for cannabis use disorder. While there is an expansive literature identifying psychotherapeutic treatments for cannabis use disorder, including motivational interviewing, cognitive-behavioral therapy, and contingency management, the literature has consistently found these therapies to be only moderately efficacious in reducing use (frequency and amount) and limited in their ability to achieve abstinence (Babor, 2004; Dutra et al., 2008; Sherman and McRae-Clark, 2016). Furthermore, cannabis use disorder may have inequitable treatment outcomes, as inequities in outcomes related to substance use disorder treatment have persisted for decades for many substances (Dogan et al., 2021). However, only a few randomized controlled trials have specifically examined such outcomes among people of color (Jordan et al., 2022), demonstrating a need to evaluate the treatment this population receives. This issue is particularly concerning given the documented associations between racial discrimination and cannabis use, which may also impact treatment initiation as well as treatment-related outcomes.

Legalization has brought opportunities to address issues regarding access to health care for those who use cannabis. Still, the health care system has not fully embraced or changed to accommodate the new health challenges associated with a legal environment. To the extent that the prohibition against cannabis use and the related health and social policies targeting people who use cannabis within the health care system continue to be enforced, the changing cannabis environment may not lead to better health access, particularly for communities of color.

Neighborhood and the Built Environment

The current patchwork of state legalization creates a complex environment for understanding how cannabis policy impacts neighborhoods. Two concepts commonly used to evaluate the impacts of neighborhoods on health and a neighborhood's health are neighborhood disorder and disadvantage. "Neighborhood disorder" refers to observed or perceived physical and social features of neighborhoods that may signal the breakdown of order and social control and can undermine the quality of life (Sampson and Raudenbush, 1999). In contrast, "neighborhood disadvantage" is described by the socioeconomic conditions within a neighborhood, coupled with the limitations of its connections to external resources and the residents' social networks (Levy et al., 2020). Studying the impact of cannabis policy on neighborhoods requires a racial lens. Socioeconomic disparities in communities of color were, in large part, created by policies that encouraged segregation (Turner and Greene, 2021). Thus, when interpreting research on neighborhoods and cannabis policy, racism and the resulting economic disadvantage also need to be considered. In many states, for example, local jurisdictions can opt out of retail cannabis sales, which contributes to disparities because the communities with more power and economic stability may be more likely to opt out (Matthay et al., 2023).

Features of the neighborhood context including disadvantage, disorder, crime are positively correlated with cannabis use and cannabis use disorder (Cao et al., 2020; Furr-Holden et al., 2011; Rhew et al., 2022). Density of cannabis retail outlets may contribute to neighborhood-level crime and disorder, or it may be that outlets are more likely to be located in neighborhoods with more disadvantages, as the communities within them have less power or ability to oppose them (Matthay, 2021; Moiseeva, 2023). The research investigating these relationships has been inconclusive.

There is some evidence that neighborhoods with higher concentrations of poverty, crime, and minoritized populations may contribute to increased rates of cannabis use (Cao et al., 2022; Floyd, 2020). A recent study conducted in Washington state looked at annual cross-sectional surveys on cannabis

use among young adults (aged 18–25) from 2015 to 2019. The study found that, after controlling for individual factors and census tract–level metrics on availability of cannabis in retail outlets, neighborhood disadvantage was statistically significantly associated with increased weekly and near-daily use of cannabis (Rhew et al., 2022). Another study, in California, examined trends in rates of hospital emergency department visits and discharges involving cannabis use disorder at the community level from 2010 to 2019 and found greater increases in both outcomes in communities of color (Cao et al., 2022).

Evidence on cannabis policies contributing to neighborhood crime is mixed, which may be due to differences in the measurement of neighborhoods and in the types of crimes examined. A study in Denver, Colorado, found that the opening of a cannabis retail outlet was associated with higher rates of all types of crime, except for murder and car theft, in surrounding neighborhoods (Hughes et al., 2020). Another study, in Seattle, Bellevue, and Tacoma (all in Washington state), found modest but statistically significant increases in property crime in census block groups containing new cannabis retail outlets (Thacker et al., 2021). However, other studies have found a decrease in violent crime, including rapes and property crime, in Washington and Oregon with the opening of retail outlets (Dragone et al., 2019). Even when cannabis retail outlets are associated with crime (whether positively or negatively), it is unclear to what extent these associations are due to the current rules placed on cannabis outlets because of federal prohibition. Specifically, cannabis retail stores are mainly cash businesses, which are often the target of crime. This is why retail stores often have tight security systems with cameras, which may lead to lower crime in their vicinity (Chang and Jacobson, 2017).

Because of zoning laws or by choice, cannabis retailers may be concentrated in neighborhoods with historical disadvantages, which raises questions about whether the presence of an outlet creates a disadvantage, or these outlets are more likely to exist in disadvantaged neighborhoods. For example, one study examining neighborhood characteristics associated with density of cannabis retailers in Oklahoma documented a disproportionate concentration of retailers in census tracts with a larger proportion of individuals lacking health insurance and living below the federal poverty level (Cohn et al., 2023). Importantly, this same study found that a large proportion of census tracts classified as rural had at least one retailer, which may have implications for geographic differences in access to cannabis. A similar study in Washington State indicated that cannabis retailers are disproportionately located in communities with more significant disadvantages, as defined by American Community Survey composite scores (Williams et al., 2023). A study of both licensed and unlicensed cannabis retailers in California in 2018 found that not only were legally licensed retailers more likely to be found in neighborhoods

with higher poverty and in communities of color, but so, too, were unlicensed stores (Unger et al., 2020).

Retail availability of cannabis has been associated with greater cannabis use and cannabis-related health outcomes, although more research in this area is needed. Greater retail availability of cannabis has been associated with lower odds of perceiving cannabis smoking as harmful. A study in California found that having an adult-use cannabis retailer within 2 miles of a person's home and signs promoting the health benefits of cannabis were associated with both increased use and lower perceived risk among adults (Han and Shi, 2023). Another study, in rural Oklahoma, found that the presence of cannabis retailers increased exposure to cannabis-related advertising among adolescents (Livingston et al., 2023). Retail availability of cannabis has also been associated with greater odds of prenatal cannabis use among pregnant individuals in California (Young-Wolff et al., 2021).

A recent systematic review of the density of cannabis retailers (Cantor et al., 2024) found consistent positive associations between greater access to cannabis retailers across several outcomes. Greater use of health care services and increased poison control calls directly due to cannabis were observed in 10 of 12 included studies (83 percent). Increased cannabis use and cannabis-related hospitalizations during pregnancy were observed in 4 of 4 included studies (100 percent). Frequent cannabis use in adults and young adults was observed in 7 of 11 included studies (64 percent). There are no consistent associations between greater cannabis retail density and increased frequent cannabis use in adolescents (25 percent of included studies), use of health care services potentially related to cannabis (33 percent of included studies), or increased adverse neonatal birth outcomes (26.8 percent of included studies) (Cantor et al., 2024).

Social and Community Context

Cannabis policy may play a role in weaving the fabric of a community. This social fabric is built on strong social networks, a sense of collective efficacy (the ability to work together), and a focus on neighborhood safety (Barnett and Casper, 2001; Halliday et al., 2020). However, unequal enforcement of cannabis prohibition may have eroded trust, particularly within minoritized communities. Cannabis legalization may change that, but the committee's analysis of arrest data shows that disparities in arrest rates persist.

Beyond policy changes, social factors within communities also significantly influence substance use patterns. Concepts such as collective efficacy and social cohesion, which measure the strength of relationships and community bonds, are crucial for understanding this dynamic. Communities with low collective efficacy, often facing economic hardship, may struggle to enforce social norms (Kawachi and Berkman, 2000; Sampson, 2017).

Low collective efficacy could lead to less intervention in risky adolescent behavior, potentially increasing youth substance use. Studies support this link, showing a correlation between lower parental oversight and higher youth cannabis use (Handley et al., 2015). However, the relationship between social factors and substance use is complex. Strong communities with high adult involvement can also lead to lower youth substance use (Kawachi and Berkman, 2000). There is, however, a potential downside: strong social ties may normalize substance use if adults themselves partake (Fagan et al., 2015; Mayberry et al., 2009). Additionally, parents in neighborhoods with high collective efficacy may feel less pressure to supervise their children directly, assuming that the community shares that responsibility. This assumption can have unintended consequences.

The impact of changes in cannabis policy on these social processes remains unclear. While research on other substances, such as alcohol, offers some insights, the specific effects of cannabis policy within the context of a community's social fabric require further exploration.

CONCLUSIONS AND RECOMMENDATIONS

Cannabis policy has considerable impacts on health equity. Cannabis arrests and incarceration have contributed to substantial social and economic inequities due to the arrest, fines, loss of income, and collateral consequences. Those arrested face restrictions in voting, employment, housing, public assistance, immigration, family integration, and education.

Conclusion 5-1: Cannabis prohibition and traditional law enforcement tools (arrest and prosecution) have disproportionately impacted communities of color, leading to adverse collateral consequences that negatively affect people's lives in such areas as education, employment, and health care access. While policy reforms have decreased arrest rates, evidence suggests that racial inequities may persist, highlighting the need for further action to address these inequities.

The data needed to evaluate whether changes in cannabis policy have reduced inequities associated with criminal justice entanglement are lacking. To evaluate the impact of cannabis policy changes on social and health equity, it is crucial to understand who is being arrested, for what, and with what consequences. National crime data do not adequately capture demographic characteristics (e.g., race, ethnicity, income). Prior reports of the National Academies have documented problems with crime statistics and the data infrastructure supporting those systems (Box 5-1). The recommendations from those reports highlight the need for better and more accurate data, which would allow for improved monitoring of how changes in cannabis policies are affecting inequities in criminal justice.

BOX 5-1
Selected Conclusions and Recommendations from Prior National Academies Reports on Crime Statistics

Toward a 21st Century National Data Infrastructure: Enhancing Survey Programs by Using Multiple Data Sources, 2023

Conclusion 7-1: The National Incident-Based Reporting System (NIBRS) provides details about each crime incident that were not available in the previous Summary Reporting System of the Uniform Crime Reports. NIBRS represents an important step in producing detailed and accurate crime statistics. However, the transition to NIBRS is still underway, and variations in measurement and data reporting across jurisdictions need further study (NASEM, 2023b, p. 151).

Modernizing Crime Statistics: Report 2—New Systems for Measuring Crime, 2018

Conclusion 2-1: The aim of modern crime statistics is the effective measurement and estimation of crime. Accurate counting of offenses and incidents is important, but the nation's crime statistics will remain inadequate unless they expand to include more than just simple tallies with no associated measure of uncertainty or capacity for disaggregation. Through the collection of associated attribute data, the suggested crime statistics should—at minimum—enable the analysis of data in proper geographic, demographic, sociological, and economic context, and provide the raw material for important measures related to an offense (such as the harm it causes) in addition to its count (NASEM, 2018, p. 32).

Conclusion 3-1: A stronger federal coordination role is needed in the production of the nation's crime statistics: providing resources for information systems development, working with software providers to implement standards, and shifting some burden of data standardization from respondents to the state and federal levels. The goal of this stronger role is to make crime data collection a product of routine operations (NASEM, 2018, p. 53).

Recommendation 3.1: The U.S. Office of Management and Budget should explore the range of coordination and governance processes for the complete U.S. crime statistics enterprise—including the "new" crime categories—and then establish such a structure. The structure must ensure that all of the component functions of generating crime statistics are conducted in concordance with the sensibilities, principles, and practices of a statistical agency. It should provide for user and stakeholder involvement in the process of refining and updating the underlying classification of crime. The new governance process also needs to take responsibility for the dissemination of data products, including the production of a new form of Crime in the United States that includes the "new" crime categories (NASEM, 2018, p. 61).

The Uniform Crime Reporting (UCR) program tracks reported crimes and interactions with law enforcement, such as arrests. Law enforcement jurisdictions across the United States voluntarily submit data to the UCR through a summary reporting system, which is then forwarded to the FBI. In 2021, the UCR began requiring jurisdictions to switch to the National Incident-Based Reporting System, which improved standardization in the data submitted to the UCR, although problems remain. The UCR's voluntary nature leads to inconsistent data collection and reporting. For example, some locations require every law enforcement agency to submit data, while in others, fewer than 3 percent of agencies submit data voluntarily (NASEM, 2023b). Ensuring the quality and accuracy of the data is also challenging, as year-to-year changes could be due to improved data collection or changes in reporting. As of October 2022, evaluating the quality of the national estimates was impossible, as only some of the estimation procedures had been made public (NASEM, 2023b).

In addition to the lack of data on sentencing, data on crime are lacking through the other stages of the criminal justice system. There is relatively little state-by-state data and no national data providing a detailed accounting of how many persons are convicted of cannabis-related offenses or showing just who is sentenced to imprisonment and community supervision or for how long. Moreover, individuals on probation and parole often are subject to drug testing regardless of conviction offenses, and a positive test for cannabis can lead to probation sanctions, technical violations, and revocations, which may result in a period of incarceration. Data are also scarce on how past cannabis arrests or convictions may impact future criminal justice involvement. However, the U.S. Sentencing Commission recently determined that nearly 10 percent of offenders sentenced in federal courts in a year were subject to an aggravated sentencing range based on prior cannabis possession convictions (Kachnowski et al., 2023). The improved data could be used to evaluate the impact of cannabis policies on criminal justice inequities and could be used to inform improved cannabis policy enforcement.

Recommendation 5-1: Jurisdictions responsible for the enforcement of cannabis laws should endeavor to regularly gather and report detailed data concerning the use of criminal enforcement tools to enforce cannabis policies. These tools include:

- **arrests,**
- **sentences,**
- **incarceration (pre- and postadjudication), and**
- **diversion programs (e.g., drug courts, law enforcement–assisted diversion, treatment programs).**

These data should be available to the public and should include details about the specific cannabis violation (e.g., impaired driving, illicit trafficking, distribution to minors, possession, possession with intent to distribute, probation or parole violation) and the demographics of those in contact with law enforcement (e.g., race, sex, age, criminal history).

Many states that have legalized cannabis have developed state social equity programs that focus on three key areas: criminal justice reform, support for industry participation, and reinvestment in disproportionately affected communities. While these initiatives have the potential to heal the wounds of prohibition, challenges persist in implementing them and ensuring their success. As these programs evolve, continuous monitoring and adjustments are essential to maximize their effectiveness (Title, 2021). It is also essential that the impacted communities be consulted on the policy decisions that impact them. Community engagement, belonging, and civic engagement are vital for individual and community health, especially with respect to racial and ethnic equity, highlighting the need to create space for everyone and build the ability to work together. Robust institutions, participation opportunities, and freedom from discrimination are key. Feeling connected and contributing actively are essential for belonging. These elements create a foundation for a healthy and thriving society (NASEM, 2023a).

Recommendation 5-2: State cannabis regulators should systematically evaluate and, if necessary, revise their cannabis social equity policies to ensure that they meet their stated goals and minimize any unintended consequences. Policy makers should meaningfully engage affected community members when developing or revising these policies.

Record clearing is a critical social equity provision for people with criminal records. Clearing records can improve both employment and social outcomes (Wakefield et al., 2023). Government-initiated or automatic record relief is much more effective than petition-based relief. Additionally, record expungement has not harmed the community (Berman, 2018).

Conclusion 5-2: In states that have implemented record relief provisions for cannabis offenses, automatic or government-initiated relief is more effective than petition-based relief.

Recommendation 5-3: Where states have legalized or decriminalized adult use and sales of cannabis, criminal justice reforms should be implemented, and records automatically expunged or sealed for low-level cannabis-related offenses.

Despite recent attempts to protect employee rights within the context of the changing legal cannabis policy landscape, only about one-third of states with legalized adult-use cannabis have included any consideration of employee protections at the point of hire or for off-duty activities in their state cannabis statutes. Cannabis-related statutes that outline employee protections regarding cannabis use while off duty and include language clearly citing specific industry exceptions (e.g., health care, construction) and defining intoxication and impairment could lend clarity to employee drug testing. Under the Drug-Free Workplace Act (41 USC 81, 1988), employees must undergo drug testing in specific circumstances, if, for example, they work in the safety and security professions, although the testing is not always applied equitably (Hoffman, 1999; Oh et al., 2023). Until better THC detection tools are developed that can determine current intoxication or impairment, inequities could be reinforced by employer drug testing. Notably, a positive THC test result does not necessarily indicate current or even recent (within the past 24-48 hours) intoxication or impairment (Vandrey et al., 2017).

Conclusion 5-3: Employer drug testing has been applied inequitably and could impair access to employment, particularly in communities of color. Many employers are required to test employees for drug use under the Drug-Free Workplace Act, but many are not. Two-thirds of states where cannabis is legal for adult use have laws protecting employees' right to use cannabis while off duty.

The committee's analysis of the impact of cannabis policy on social determinants of health revealed important findings related to neighborhoods and health care. While some concerns exist regarding a potential link between cannabis retail outlets and increased neighborhood disorder or crime, particularly in disadvantaged communities, disentangling these effects from preexisting neighborhood characteristics remains challenging. This complexity is further highlighted by the observation that cannabis retailers are more likely to be concentrated in areas with higher poverty rates and/or higher proportions of people of color. Studies in Oklahoma, Washington, and California show that cannabis retailers are more concentrated in disadvantaged neighborhoods, raising concerns about equitable access and potential negative impacts on these communities (Cohn et al., 2023; Unger et al., 2020; Williams et al., 2023). This spatial clustering also raises concerns about potential health inequities, as research suggests that increased retail access to cannabis is associated with adverse health outcomes (Cantor et al., 2024). These findings highlight the need for further investigation into the social and health consequences of retail access to cannabis, particularly within disadvantaged communities.

Conclusion 5-4: Retail access to cannabis is often concentrated in neighborhoods with historical disadvantages. Increased retail access to cannabis is associated with increases in (1) demand for health care services, (2) poison control calls directly due to cannabis, (3) cannabis use and cannabis-related hospitalization during pregnancy, and (4) cannabis use in adults and young adults.

Assessing health care access also proved challenging for the committee. Cannabis legalization could have a positive impact on health care access by reducing the stigma associated with use. However, draconian policies that associate cannabis use during pregnancy with child abuse still exist even though medical societies such as ACOG do not support them. State-level policies that treat prenatal substance use as child abuse have health implications. The fear of punishment or losing custody of their child can cause significant stress for pregnant people struggling with substance use, leading to continued use and related harms to the developing baby (Atkins and Durrance, 2020; Carroll et al., 2021; Chang et al., 2019; Faherty et al., 2019; Meinhofer et al., 2022).

Conclusion 5-5: Drug testing in pregnancy is applied inequitably, particularly to people of color, and may deter those who use cannabis from seeking prenatal care. People who are pregnant and are using cannabis will benefit from clinical and social support; education about fetal risk; and referral to nonjudgmental, evidence-based interventions or specialty treatment, as needed, rather than being arrested or reported to child protective services.

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6

Available and Needed Research on Cannabis Policy

Evaluation, a cornerstone of public health practice, is essential for ensuring the effectiveness of public health interventions. Evaluating cannabis policy is particularly important because these policies may have significant and sometimes opposing public health consequences. Decriminalization or legalization of cannabis may reduce the harms associated with criminal justice encounters, for example, which negatively impacts the health of individuals and their families and contributes to health inequities. On the other hand, more liberal cannabis policies may lead to social acceptance of cannabis use, lower prices, and greater product diversity, all leading in turn to increased use. Additionally, allowing medical use of cannabis may provide therapeutic benefits to some with specific conditions, but also may lead people to believe cannabis use is healthy. Thus, changes in cannabis policy may have unintended public health consequences, such as increased traffic collisions, dependence or use disorders among people who use cannabis, and adverse mental health outcomes. Understanding the health effects of cannabis use is therefore crucial for evaluating the public health impacts of cannabis policy changes. This chapter explores current research on this topic.

Previous chapters evaluated cannabis policy in the United States conceptually and provided recommended actions for limiting the harms of cannabis policy or improving research and evaluation of policy changes. In this chapter, the committee proposes a research agenda that would address the many data gaps that need to be filled to improve a public health approach to cannabis policy. The chapter highlights health effects of utmost priority to the interested parties who spoke at the committee's open meetings,

reviews datasets available for evaluating cannabis policy, and summarizes the results of systematic reviews that evaluate the public health impacts of changes in cannabis policy. The discussion in these areas informs a research agenda for the next 5 years.

HEALTH EFFECTS OF CANNABIS: RESEARCH NEEDS

Numerous research needs were identified at the committee's public meetings, which included presentations from a broad range of interested parties related to cannabis and health—clinicians, parents, and educators who raised concerns about the health impacts of cannabis use. Every public meeting had an open sign-up, allowing anyone to provide input on the committee's task. The committee heard from more than 20 people, all of whom expressed concerns about the increased cannabis use that follows policy changes and the health impacts of this increased use. The most common conditions discussed were mental health disorders, substance use disorders, anxiety, depression, paranoia, psychosis, schizophrenia, suicidal ideation, and suicide. Others related to mental and behavioral health, violence, impaired learning, memory, and ability to hold a job. Still others related to impaired driving and deaths resulting from motor vehicle crashes; secondhand exposure to cannabis; exacerbation of other health conditions; and cannabinoid hyperemesis syndrome, a condition whereby a patient experiences cyclical nausea, vomiting, and abdominal pain (sometimes intense) after using cannabis (Chu and Cascella, 2023). The committee also heard about the changing product landscape and the need for ongoing evaluation of the health effects of cannabis, specifically of high-concentration tetrahydrocannabinol (THC) products.

Laura Stack, founder and CEO of Johnny's Ambassadors, shared her story of losing her son to suicide due to psychosis following cannabis use. She said her organization's parents of children with cannabis-induced psychosis "currently [has] 1,598 parents whose children are in mental institutions across the United States with cannabis-induced psychosis." She highlighted the alarming ease with which teens can access high-potency cannabis, using medical marijuana cards obtained without legitimate medical conditions. Stack emphasized the correlation between cannabis use and rising rates of mental health issues among youth, urging stronger regulations and education to protect young people.

Aubree Adams of Every Brain Matters described witnessing her son struggle with severe mental health issues, such as psychosis, violence, and suicide attempts, following heavy cannabis use, and the challenges of finding appropriate treatment. After she found a recovery community in Texas, her son was sober for more than 3 years. He relapsed, however, and her family did not see or hear from him for more than 2 years until he reached out for help. She said, "I did not recognize him when I saw him. He was

skin and bones, he couldn't eat, he was very weak. And he was only testing positive for THC." She believed he was using delta-8-THC vapes available at gas stations and smoke shops in Texas as a result of the 2018 Farm Bill, which allowed the sale of hemp-derived products.

Gabriel Mondragon described his personal experience with schizophrenia following cannabis use. He believes his cannabis use, which began around age 10, may have activated his predisposition to schizophrenia, which he has in part as a result of his family history, and which led to homelessness and drug use for much of his life. Following a psychotic event, he experienced electrocution, which caused the loss of three limbs. In his opinion, it is not just the high-concentration cannabis products that are causing severe psychotic effects but also lower-concentration products and even exposure to secondhand cannabis smoke. Mondragon also noted the negative consequences of cannabis legalization on employment, health care, and overall societal well-being. Mondragon said, "The whole point of cannabis is self-induced psychosis. The high is psychosis."

As noted in Chapter 3, the concentration of delta-9-THC in cannabis flower has been increasing over time. In addition, concentrates such as dabs, wax, and shatter contain very high concentrations of delta-9-THC, usually in the range of 60 percent but sometimes more than 90 percent. The high concentration allows the administration of a high dose in a short amount of time. Many public health professionals are concerned about the potential additional harm related to these higher concentrations. The committee identified two reviews that evaluate the impacts of delta-9-THC concentration on health (Bero et al., 2023; Petrilli et al., 2022).

Petrilli and colleagues (2022) evaluated the health impacts of high-concentration delta-9-THC products by conducting a systematic review of the association of delta-9-THC concentration with mental health and addiction. The review included observational studies of humans that compared the association of products with a higher concentration of delta-9-THC with those with a lower concentration, and evaluated mental health impacts such as depression, anxiety, psychosis, and cannabis use disorder. Of 4,171 articles screened, 20 met the review's eligibility criteria: 8 studies focused on psychosis, 8 on anxiety, 7 on depression, and 6 on cannabis use disorder. The identified studies had fair to poor quality, as assessed with the Newcastle Ottawa Scale, and used different definitions of higher and lower concentration. Yet despite the fair to poor quality of the evidence, the authors determined that the use of products with a higher concentration of delta-9-THC relative to those with a lower concentration was associated with an increased risk of psychosis and cannabis use disorder. The evidence varied for depression and anxiety (Petrilli et al., 2022).

More recently, Colorado HB 21-1317 charged the Colorado School of Public Health with conducting a scoping review of the evidence for the health effects of high-THC-concentration cannabis. A scoping review completed in

2023 identified 452 studies meeting the inclusion criteria (human studies of any epidemiological design with no restrictions by age, sex, health status, country, or outcome measured that reported THC concentration or included a known high-concentration cannabis product). The characteristics of these studies and key findings were summarized and made available to the public via a dashboard and publication (Bero et al., 2021, 2023; Cannabis Research and Policy Project Team, 2023). This scoping review found significant limitations in the quality of studies and an absence of conclusive evidence for the health effects of high-concentration cannabis products. Problems with the literature were severe, including deficiencies in study methods and minimal coverage of products relevant to today's marketplace.

The associated report from the scoping review used a scale for the amount of available evidence based on the number of statistically significant studies. The numbers of studies are classified as none, limited (1–4), moderate (5–9), and substantial (10+). There was moderate evidence for only two policy questions; all others had no or limited evidence. The two policy questions with moderate evidence were (1) whether high-concentration THC cannabis products have been associated with beneficial outcomes in those with preexisting mental health conditions (6 statistically significant studies of 15 total studies) and (2) whether high-concentration products pose a greater risk for mental and behavioral health outcomes (8 statistically significant studies of 19 total studies) (Cannabis Research and Policy Project Team, 2023).

Schlienz and colleagues (2020) found harms associated with increasing doses of THC. They administered oral THC brownie edibles that contained 0, 10, 25, and 50 mg of THC to 17 healthy adults. Peak effects were noted at 1.5–3.0 hours postingestion. The study findings indicated a dose-dependent association of increasing questionnaire subscales relating to adverse mental health effects. In the 50 mg THC group, there were statistically significant associations with paranoia, restlessness, and anxiousness or nervousness (Schlienz et al., 2020).

Another example of evidence supporting harms of increasing dose is the crossover trial conducted by Sainz-Cort and colleagues (2021). It included four exposure groups: THC extract (65 mg), CBD extract (130 mg), THC (65 mg) + CBD (130 mg) extract, and placebo (<0.05 mg THC, <0.05 CBD). The THC-only condition scores were higher than those for the THC + CBD condition for all subscales on the Psychotomimetic States Inventory. Subjective effects subscales (hearing voices and having suspicious ideas or beliefs) were also highest with the high-THC group. The outcomes for the high-THC group were the most elevated at all time points up to 75 minutes (Sainz-Cort et al., 2021).

While the research on the health effects of high-concentration THC products is in its early stages, there is reason for concern. The increasing

availability of products with THC concentrations exceeding 60 percent is coupled with evidence, albeit of fair to poor quality, suggesting a link between higher doses and a higher risk of psychosis and cannabis use disorder (Petrilli et al., 2022). The Colorado scoping review identified some evidence for both potential benefits and risks associated with high-THC products; it also found moderate evidence for a dose-dependent association between high-THC products and adverse mental health effects, with studies showing increased paranoia, anxiety, and even psychotic symptoms following THC administration (Bero et al., 2023). The THC concentration is less of a concern if the dose administered is low. The prescription drug dronabinol is more than 90 percent THC but is prescribed in small doses (2.5 mg). Some people may titrate their use of high-concentration products and limit the dose they receive; the research on titration behavior is mixed and limited. Future epidemiologic research on titrating behavior may inform harm reduction policies related to high-THC cannabis products (Leung et al., 2021).

LITERATURE REVIEW ON PUBLIC HEALTH IMPACTS OF CANNABIS POLICY

To evaluate whether health outcomes have changed as a result of changes in cannabis policy, the committee conducted a review of systematic reviews. Unlike traditional reviews that synthesize primary research, overviews of systematic reviews employ rigorous methods to identify and analyze existing systematic reviews on a specific topic. Rather than summarizing individual studies, overviews assemble evidence and compare results across multiple reviews to paint a broader picture of the evidence landscape (Becker and Oxman, 2019). The committee's review consisted of the following steps: a literature search, screening of abstracts, a full-text review of studies identified in the abstract screening, and evaluation of a final set of 14 relevant systematic reviews (Appendix D).

The committee used the Risk Of Bias In Systematic Reviews (ROBIS) tool to evaluate the systematic reviews (Whiting et al., 2016). It has been shown to have adequate internal consistency and strong evidence for measuring the intended construct (Bühn et al., 2017). The ROBIS tool helps identify potential biases within the systematic review process. Its use consists of three phases: phase 1 assesses relevance; phase 2 identifies concerns with the review process; and phase 3 judges the risk of bias in the review. Concerns with the systematic review process are captured by considering four key domains: study eligibility criteria, identification and selection of studies, data collection and study appraisal, and synthesis and findings. Signaling questions are used to guide the judgments in each domain, and they are each answered "Yes," "Probably Yes," "Probably No," "No," and

"No Information." "Yes" indicated low concerns about the domain's contributing to the risk of bias. The subsequent level of concern about bias associated with each domain is then judged as "low," "high," or "unclear" (Whiting et al., n.d.).

This approach has its limitations. Primary among these is that many harms associated with changes in cannabis policy will be difficult to observe at the population level. Most outcomes of concern associated with cannabis have many potential component causes, meaning there are many factors that would influence the prevalence of these outcomes at the population level. Another common issue is that relative to experimental designs, observational studies typically have lower internal validity, which refers to the confidence that the observed association is, in fact, true (Rosenbaum, 2017). Another flaw of the review-of-reviews approach is that some review papers include overlapping studies. To avoid double-counting studies, the committee judged the most recently published review to be the most up-to-date assessment of the evidence and relied less on the older reviews (Appendix D).

The identified systematic reviews evaluated cannabis policies with respect to decriminalization (7 reviews), medical use (8 reviews), and adult use (4 reviews). Outcomes covered include those related to perceptions and attitudes (3 reviews), use (10 reviews), other substance use (5 reviews), traffic safety (7 reviews), health care (2 reviews), and mental health (3 reviews). Annex Table 6-1 provides a high-level overview of the systematic reviews included in the committee's review.

Figure 6-1 presents the committee's assessment of the quality of the systematic reviews using ROBIS. Almost half of the identified systematic reviews had an overall low risk of bias. Study appraisal and synthesis were common domains likely to be judged as having a high risk of bias. Formal risk-of-bias tools and evidence-to-decision frameworks such as GRADE (Grading of Recommendations, Assessment, Development, and Evaluations) are applied only sometimes in policy analysis and likely need to be adapted to the types of study designs included in these systematic reviews; this is an area for methodology development for systematic reviews. The findings of the committee's review are summarized below.

Attitudes and Risk

Research on the impact of changes in cannabis policy changes on attitudes and risk perceptions presents a complex picture. Some systematic reviews, such as French et al. (2022), suggest decreased perceived harmfulness, particularly among youth and young adults. This finding aligns with the conclusion in Smart and Pacula (2019) that broader access through retail stores can influence perceptions. Sarvet et al. (2018) presents mixed results, with some

Reference	Study Eligibility Criteria	Study Identification	Study Appraisal	Synthesis	Overall
Athanassiou et al., 2023	Low	High	High	Low	High
Chihuri and Li, 2019	Low	High	Unclear	High	High
French et al., 2022	Low	Low	High	High	High
González-Sala et al., 2023	Low	High	Low	High	Low
Lachance et al., 2022	Low	High	High	Unclear	High
Melchior et al., 2019	Low	Low	Low	Low	Low
O'Grady et al., 2022	Low	Low	Low	Low	Low
Sarvet et al., 2018	High	Low	High	High	High
Scheim et al., 2020	Low	Low	Low	Low	Low
Smart and Pacula, 2019	High	Unclear	Unclear	High	High
Sznitman and Zolotov, 2015	Low	Low	High	High	High
Vingilis et al., 2021	Low	High	Low	Low	Low
Wilson and Rhee, 2022	Low	High	Low	High	High
Windle et al., 2022	Low	Low	Low	Low	Low

FIGURE 6-1 Risk-of-bias heat map for the identified systematic reviews.

studies reporting a moderate- to high-risk perception for occasional use, and others showing no significant perception of harm. All the systematic reviews evaluating the impact of cannabis policy changes on attitudes and risk perceptions had a high risk of bias. However, French et al. (2022) includes the most updated information, which shows decreasing risk perceptions with changes in legalization. This finding was corroborated by the committee's analysis of the National Survey on Drug Use and Health Data (NSDUH). Thus, the committee determined that there is *limited or suggestive evidence* that cannabis legalization leads to decreased risk perception of cannabis use.

Use-Related Outcomes

Systematic reviews investigating the link between cannabis policy changes and consumption patterns reveal mixed findings across age groups. Multiple reviews suggest an increase in adult cannabis use following legalization (Athanassiou et al., 2023; Blanchette et al., 2022; French et al.,

2022; Lachance et al., 2022), but one found no significant changes after legalization of medical cannabis (Sarvet et al., 2018). Data on young adults were similarly inconclusive, with two systematic reviews finding an increase in cannabis use (Athanassiou et al., 2023; French et al., 2022) and others highlighting a mixed picture, with studies showing increases, decreases, and no change (O'Grady et al., 2022). All the systematic reviews identified a high risk of bias in evaluations of changes in adult use. Athanassiou et al. (2023) includes the most updated information, which is corroborated by the committee's analysis data from the National Survey on Drug Use and Health (NSDUH), which shows increasing use among adults (online Appendix E). The committee determined that there is *limited or suggestive evidence* that cannabis legalization leads to increased use among adults.

Adolescent use (ages 12–17 in most systematic reviews) presents the most inconsistent results. While some systematic reviews suggest potential increases after legalization (French et al., 2022; Melchior et al., 2019), others present a mix of findings (O'Grady et al., 2022) or report no changes with legalization (Sarvet et al., 2018; Smart and Pacula, 2019). Melchior et al. (2019) is the only review with a low risk of bias, but it is more than 5 years old. French et al. (2022) and O'Grady et al. (2022) contain many of the same studies yet arrive at different conclusions. Given that the NSDUH also shows that adolescent use has been stable as cannabis policies have changed, the committee judges the evidence as *insufficient* to determine an association between cannabis policy changes and adolescent use.

Other Substance Use

Some systematic reviews evaluated the impact of cannabis policy changes on changes in the use of other substances, such as opioids, alcohol, tobacco, and other illicit substances (Athanassiou et al., 2023; Chihuri and Li, 2019; French et al., 2022; Scheim et al., 2020; Smart and Pacula, 2019). Of these, the impact of cannabis legalization on opioid use was the most well studied in the systematic reviews. Specific opioid-related outcomes include opioid prescriptions, hospitalizations, mortality, nonmedical opioid use, and opioid misuse. While some evidence suggests a decrease in opioid prescriptions and hospitalizations, with cannabis legalization, the impact on mortality and nonmedical use remains inconclusive. Two systematic reviews suggest a decrease in opioid prescriptions and hospitalizations for opioid-related issues following cannabis legalization for medical use (Athanassiou et al., 2023; Chihuri and Li, 2019). However, the literature basis for this conclusion is somewhat old. The evidence for opioid mortality was mixed among the reviews that evaluated it (Athanassiou et al., 2023; Chihuri and Li, 2019; French et al., 2022). The evidence for nonmedical opioid use and opioid misuse was also mixed, with two reviews finding mixed results

among the included studies (Chihuri and Li, 2019; French et al., 2022). Given the mixed evidence and high risk of bias of the systematic reviews, the committee determined there was *insufficient* evidence for an association between cannabis legalization and opioid use.

The effects of cannabis legalization on alcohol consumption are complex. Athanassiou et al. (2023) suggests an increase in adult alcohol consumption following legalization, while French et al. (2022), which reviews some of the same studies, reports no changes. Findings were mixed as well for the impacts of cannabis legalization on adolescent alcohol use. French et al. (2022) includes two studies suggesting that medical legalization might be associated with decreased binge drinking and past-month alcohol use among 8th and 9th–12th graders. In three studies, legalization was not found to be associated with a change in underage drinking among those aged 12–20, 10th- and 12th-grade students, or high school seniors. Overall, the committee judged the evidence for the impact of cannabis legalization on alcohol consumption–related outcomes to be *insufficient* for an association.

Evidence regarding the association between cannabis legalization and tobacco use is similarly mixed. One systematic review found that some studies suggest a higher prevalence of co-use of cannabis and tobacco in states with legalized cannabis (French et al., 2022). However, other systematic reviews found no significant changes in cigarette sales following legalization, making the overall impact on tobacco use unclear (Smart and Pacula, 2019). Overall, the committee judged the evidence for the impact of cannabis legalization on tobacco consumption–related outcomes to be *insufficient* for an association.

Findings of systematic reviews evaluating the impact of cannabis legalization on the use of other illicit drugs are also mixed and likely highly context dependent (French et al., 2022). Studies on adult illicit drug use following cannabis legalization show mixed results, and the literature on adolescent illicit drug use post legalization is similarly inconclusive. Overall, the committee judged the evidence for the impact of cannabis legalization on the consumption of illicit drugs to be *insufficient* for an association.

Traffic-Related Outcomes

Some systematic reviews evaluated the impact of cannabis policy changes on traffic-related outcomes, such as impaired driving and traffic collisions (Athanassiou et al., 2023; Chihuri and Li, 2019; French et al., 2021; González-Sala et al., 2023; Scheim et al., 2020; Vingilis et al., 2021; Windle et al., 2022). One systematic review found the literature on cannabis use and impaired driving performance to be inconclusive (French et al., 2021). Another identified a study with a higher prevalence of cannabis-impaired drivers in countries with

more liberal cannabis policies (González-Sala et al., 2023), although this study was limited by recall bias (Wadsworth and Hammond, 2019).

Evidence regarding the impact of cannabis policy changes on traffic collisions was mixed (Athanassiou et al., 2023; Chihuri and Li, 2019; French et al., 2021; González-Sala et al., 2023; Scheim et al., 2020; Vingilis et al., 2021; Windle et al., 2022). The committee noted that studies evaluating the opening of retail outlets, not just legalization, were more likely to observe an association (Scheim et al., 2020). Three systematic reviews that evaluated traffic-related outcomes had a low risk of bias (González-Sala et al., 2023; Scheim et al., 2020; Vingilis et al., 2021; Windle et al., 2022). González-Sala et al. (2023) includes the most up-to-date literature and identifies 15 studies showing a relationship between cannabis legalization and increased traffic collisions; 5 studies did not show this relationship. Thus, the committee believes there is *limited or suggestive evidence* of an association between cannabis legalization and traffic collisions.

Health Care–Related Outcomes

Two systematic reviews evaluated the impact of changes in cannabis policy on health care–related measures, such as cannabis-related hospitalizations and emergency department visits. Athanassiou et al. (2023) identifies four studies that assessed the impact of cannabis legalization on cannabis-related hospitalizations and emergency department visits. Three of the four studies noted an increase in hospital-related outcomes following cannabis legalization. Scheim et al. (2020) found that nine studies evaluating health-related outcomes related to cannabis policy changes identified increased cannabis-related hospitalizations and emergency department visits. One of those two systematic reviews (Scheim et al., 2020) had a low risk of bias; that review was somewhat old but updated by Athanassiou et al. (2023), which includes the same findings. Thus, the committee believes there is *limited or suggestive evidence* of an association between cannabis legalization and hospital visits related to cannabis use.

Mental and Behavioral Health

Few of the systematic reviews evaluated mental and behavioral health outcomes. Smart and Pacula (2019) evaluates the impact of cannabis legalization on cannabis use disorder and finds mixed evidence of an association between medical cannabis legalization and cannabis use disorder. French et al. (2022) identifies one study on the association between medical cannabis policies and suicide, which had no significant findings. One review (Scheim et al., 2020) notes that 5 percent of the identified studies included mental health outcomes but drew no conclusions about the association with cannabis policy changes. Given the null findings, the committee determined

there is *insufficient evidence* of an association between cannabis policy changes and mental and behavioral health.

CONCLUSIONS AND RECOMMENDATION

The committee's review of systematic reviews underscores the complexities of evaluating the public health impacts of changes in cannabis policy. Evaluation is a cornerstone of public health practice and is even more crucial when policies may have both positive and negative consequences. The committee found 14 systematic reviews that evaluate the public health impacts of cannabis policy. The differences in how policies are implemented among the states are not well captured, making interpretation difficult. Improvements in policy analysis databases and surveillance systems are needed to allow assessments of policy changes. The committee found *limited or suggestive evidence* that the perceived risk of cannabis declines after legalization, use among adults increases, traffic collisions increase, and hospital visits related to cannabis use increase. For all other outcomes, the committee judged the evidence to be *insufficient*.

One of the most prominent public health concerns related to cannabis policy is the rise of high-concentration THC products. The committee reviewed a systematic review and a scoping review that aimed to evaluate this question. Both reviews found that studies comparing high- and low-concentration THC products often have methodological issues and may not reflect the types of high-THC products available today. However, associations have been found between high-concentration THC products and a higher risk of psychosis and cannabis use disorder.

> *Conclusion 6-1: The risks associated with THC consumption (including psychosis, suicidal ideation, and cannabis use disorder) increase as the dose increases. Legalizing products with a high concentration of THC allows users to administer high doses in a short time and may increase cannabis-related harms. Research is urgently needed to describe the relationship between high-concentration THC products and adverse effects to better inform public policy.*

During the committee's public meetings concerns were raised about many outcomes not evaluated in the systematic reviews, including mental health outcomes; cognitive function; and physical health outcomes, such as cannabinoid hyperemesis syndrome. Further research is critically needed to explore the impacts of changes in cannabis policy on these outcomes and improve public health practices. The committee developed a research agenda (Box 6-1) designed to improve the ongoing evaluation of the public health impacts of cannabis policy.

BOX 6-1
Cannabis Policy Research Agenda

Public health outcomes of different approaches to cannabis regulation: It is critical to examine how state and local cannabis regulations—including those related to licensing, zoning, product types, product additives, advertising, and pricing—influence public health outcomes and health equity. Aspects of this needed research include investigating how these regulations affect cannabis use patterns (age of initiation, frequency, intensity, product type, concentration, and administration method), rates of heavy cannabis use, cannabis use disorder diagnoses, cannabis-related emergency department visits and hospitalizations, cannabis-related comorbid physical health and mental health outcomes, and traffic-related injuries and deaths associated with cannabis use. Studying how THC caps influence use patterns and health outcomes could improve guidelines and inform effective regulations.

Efficacy of tests used to detect cannabis impairment: Blood tests for THC, which are commonly used in law enforcement and employment screening, do not distinguish between recent and past use. Additionally, validation of field sobriety tests and objective, unbiased, and practical methods for discriminating between drivers who are or are not impaired by cannabis is critical in ensuring equitable enforcement of laws on driving under the influence.

Health effects of cannabis use by specific populations: It is critical to understand the specific health risks and benefits of cannabis use across different populations. Examples of populations critical to monitor include:

- pregnant persons, considering both potential risks to the fetus and potential benefits for managing pregnancy ailments;
- youth and young adults because of the impacts of cannabis on the developing brain;
- veterans, including how cannabis use may interact with posttraumatic stress disorder symptoms and overall mental health; and
- older adults and adults with chronic conditions, including the use of cannabis and cannabinoids for managing chronic conditions and the potential risks of drug interactions.

Health effects of emerging cannabis products: There is a great need to understand the health risks of emerging synthetic and semisynthetic cannabinoids and high-concentration products. In particular, research into dose–response relationships for different cannabis products is needed.

Mitigation of the risks of cannabis use: Evaluating risk-mitigation strategies for cannabis use and their effectiveness is crucial so that public health can understand which educational and other strategies are most effective at reducing problematic use and minimizing harm.

Recommendation 6-1: The National Institutes of Health; the Centers for Disease Control and Prevention; state, local, and tribal health authorities; and private entities should support a research agenda focused on:

- **public health outcomes of different approaches to cannabis regulation,**
- **efficacy of tests used to determine cannabis impairment,**
- **health effects of cannabis use (by product, amount, and frequency) by specific populations,**
- **health effects of emerging cannabis products, and**
- **mitigation of the risks of cannabis use.**

CONCLUSION

The rapidly evolving landscape of cannabis legalization presents a formidable public health challenge. State-by-state variations, potential federal policy shifts, and high-concentration products raise concerns about potential health risks (e.g., mental health disorders, impaired driving, cognitive decline). This complexity is compounded by the legacy of discrimination from the war on drugs and limited research on the long-term health effects of these new products, especially for vulnerable populations.

This report offers a roadmap to a more comprehensive public health approach to cannabis policy. Implementation of the committee's recommendations to increase federal involvement, revise the unclear definition of hemp in the 2018 Farm Bill, improve cannabis product quality and safety standards, and evaluate the impacts of cannabis policies on health and social equity would address public health concerns. It is the committee's view, based on the evidence presented in this report, that federal leadership in cannabis policy, the promotion of research on the health effects of cannabis, and assurance of equitable access to safer cannabis products would improve the public health response to cannabis policy in the United States.

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ANNEX TABLE 6-1 Systematic Reviews of Cannabis Policy Identified by the Committee

Reference	Setting	Policy Changes Evaluated	Types of Outcomes Considered	Risk-of-Bias Method	Study Designs Identified	No. Included Studies
Athanassiou et al., 2023	U.S.; January 1, 2012–February 1, 2022	Adult-use legalization; decriminalization	Use-related, other substance use, and health care–related outcomes	Newcastle-Ottawa Quality Assessment Scale	Longitudinal studies	32
Chihuri and Li, 2019	U.S.; various specified states, between March 10–15, 2019	Adult-use legalization; medical-use legalization	Other substance use, traffic collisions,	Newcastle-Ottawa Quality Assessment Scale	Retrospective cohort, ecological, time-series	16
French et al., 2022	U.S.; through September 2021	Adult-use legalization; decriminalization; medical-use legalization	Perceptions and attitudes, use-related outcomes, other substance use, traffic collisions	Not reported	Quasi-experimental (e.g., difference in differences), cross-sectional, longitudinal, economic crime model, comparative interrupted time-series	113
González-Sala et al., 2023	U.S., Canada, England, and Uruguay; through August 4, 2022	Decriminalization; medical-use legalization	Traffic-related outcomes	Used a quality assessment tool	Ecological, retrospective longitudinal cohort study	29
Lachance et al., 2022	U.S., Canada, and Uruguay; through October 21, 2021	Adult-use legalization	Use-related	Used a quality assessment tool	Repeated cross-sectional, longitudinal, quasi-experimental, nonexperimental, randomized control trials	32

Melchior et al., 2019	U.S., Australia, UK, Netherlands, Czech Republic; through March 1, 2018	Decriminalization; medical-use legalization	Use-related	Quality assessment tool for observational cohort and cross-sectional studies	Cross-sectional surveys, repeated cross-sectional surveys, cohort studies, cohort studies with follow-up	41
O'Grady et al., 2022	U.S.; through March 2022	Medical-use legalization	Use-related	Not reported	Quasi-experimental, randomized controlled trials, ongoing longitudinal studies, longitudinal cohort study, repeated cross-sectional, pre–post cross-sectional, cohort comparison	33
Sarvet et al., 2018	U.S.; through December 2016	Medical-use legalization	Use-related	Not reported	Longitudinal, retrospective, and prospective cohort studies	11
Scheim et al., 2020	U.S., Australia, China, Czech Republic, Mexico, Portugal; January 1970–October 4, 2018	Decriminalization	Use-related, other substance use, health care–related	Modified version of the Downs and Black checklist	Observational studies, cohort, controlled before-and-after, uncontrolled before-and-after, repeated cross-sectional	114
Smart and Pacula, 2019	U.S.; January 2005–February 2019	Adult-use legalization; decriminalization; medical-use legalization	Use-related, other substance use	Not reported	Quasi-experimental studies	42

(*continued*)

ANNEX TABLE 6-1 Continued

Reference	Setting	Policy Changes Evaluated	Types of Outcomes Considered	Risk-of-Bias Method	Study Designs Identified	No. Included Studies
Sznitman and Zolotov, 2015	U.S.; through June 2014	Medical-use legalization	Perceptions and attitudes, use-related, traffic-related	Conducted a quality assessment; no formal tool was noted	Cross-sectional observations, pre–post designs	28
Vingilis et al., 2021	U.S.; through August 31, 2020	Medical-use legalization	Traffic-related	Used a quality assessment tool	Quasi-experimental, case-control	9
Wilson and Rhee, 2022	U.S.; through May 2021	Adult use legalization; medical-use legalization	Perceptions and attitudes, use-related, other substance use	Risk of Bias in Nonrandomized Studies of Interventions (ROBINS-I) tool	Pre- and postlegalization with and without state comparison; postlegalization only with and without state comparison	41
Windle et al., 2022	U.S. and Canada (not a study limitation); through June 16, 2021	Adult-use legalization; decriminalization; medical-use legalization	Traffic-related	ROBINS-I	Quasi-experimental (e.g., difference-in-difference, interrupted time series), cross-sectional survey, cohort	65

Appendix A

Committee Member and Staff Biosketches

Steven M. Teutsch, M.D., M.P.H., (Chair), is senior fellow at the Leonard D. Schaeffer Center for Health Policy and Economics at the University of Southern California and was formerly adjunct professor at the University of California, Los Angeles Fielding School of Public Health. Until 2014, he was chief science officer at the Los Angeles County Department of Public Health, where he continued his work on evidence-based public health and policy. Previously, Dr. Teutsch worked at Merck, where he was responsible for scientific leadership in developing evidence-based clinical management programs, conducting outcomes research studies, and improving outcomes measurement to enhance quality of care. Prior to joining Merck, he was director of the Division of Prevention Research and Analytic Methods at the Centers for Disease Control and Prevention (CDC), where he was responsible for assessing the effectiveness, safety, and the cost-effectiveness of disease and injury prevention strategies. Dr. Teutsch has served as a member of the Community Preventive Services Task Force, the U.S. Preventive Services Task Force, American Health Information Community Personalized Health Care Workgroup, and the Evaluation of Genomic Applications in Prevention and Practice Working Group. He chaired the Secretary's Advisory Committee on Genetics, Health, and Society, and he has served on and chaired several National Academies of Sciences, Engineering, and Medicine panels; Medicare's Evidence Development and Coverage Advisory Committee; and several subcommittees of the Secretary's Advisory Committee on Healthy People 2020 and 2030. Dr. Teutsch has published more than 200 articles and 8 books in a broad range of fields in epidemiology, including parasitic diseases, diabetes, technology assessment, health services research,

and surveillance. He was certified by the American Board of Internal Medicine in 1977 and the American Board of Preventive Medicine in 1995, and he is a fellow of the American College of Physicians and American College of Preventive Medicine. Dr. Teutsch received his undergraduate degree in biochemical sciences from Harvard University, an M.P.H. in epidemiology from the University of North Carolina School of Public Health, and his M.D. from Duke University School of Medicine.

Yasmin L. Hurd, Ph.D., is currently the Ward-Coleman Chair of Translational Neuroscience and the director of the Addiction Institute at Icahn School of Medicine at Mount Sinai. She also serves as a professor in the departments of Psychiatry, Neuroscience, and Pharmacology and Systems Therapeutics. Dr. Hurd's research focuses on the neurobiological mechanisms underlying substance use disorders with a focus on opioids and cannabis. Her recent research has centered on developmental cannabis exposure in humans and animal models where epigenetic mechanisms associated with the drug's protracted effects on behaviors into adulthood and even across generations have been identified. Dr. Hurd aims to be a critical scientific voice to the public regarding addiction and its health impact in interest of advancing policy. A member of the National Academy of Medicine and National Academy of Sciences, she has also attained membership to the Scientific Council, American Society for Neuroscience, and the New York Academy of Sciences. She currently serves on the National Academies of Sciences, Engineering, and Medicine's committee on Neuroscience and Nervous System Disorders, and she formerly served as a member of the committee on Medication-Assisted Treatment for Opioid Use Disorder. Dr. Hurd earned her B.A. in biochemistry and human behavior from the State University of New York at Binghamton and her Ph.D. in neuropsychopharmacology from the Karolinska Institute in Solna, Sweden. She has received cannabinoids for use in her research studies from cannabis companies, including Ananda Scientific, Brains Bioceuticals, GW Pharmaceuticals, and New Age Ventures, and her studies were conducted in compliance with federal laws on drug research. Dr. Hurd also received funding from Brains Bioceuticals for the conduct of phase 1 pharmacokinetic studies on their cannabidiol-based product.

Douglas A. Berman, J.D., is Newton D. Baker-Baker & Hostetler chair in law and executive director of the Drug Enforcement and Policy Center, housed in the Moritz College of Law at the Ohio State University. Professor Berman's principal teaching and research focus is in criminal sentencing and drug policy, though he also has teaching and practice experience in the fields of legislation and intellectual property. Professor Berman is the co-author of two casebooks. One of these, *Sentencing Law and Policy: Cases, Statutes*

and Guidelines, published by Aspen Publishers, is now in its fifth edition; the other, *Marijuana Law and Policy,* was released by Carolina Academic Press in 2020. In addition to authoring numerous publications on topics ranging from marijuana reform to sentencing guidelines, Professor Berman has served as an editor of the *Federal Sentencing Reporter* for more than 25 years and as co-managing editor of the *Ohio State Journal of Criminal Law*. After graduation from law school in 1993, Professor Berman served as a law clerk for Judge Jon O. Newman and Judge Guido Calabresi, both on the United States Court of Appeals for the Second Circuit. After clerking, he was a litigation associate at the law firm of Paul, Weiss, Rifkind, Wharton, and Garrison in New York City. Professor Berman's Drug Enforcement and Policy Center receives partial funding from the Charles Koch Foundation, though the foundation does not review or oversee the center's research. He holds an undergraduate degree from Princeton University and a J.D. from Harvard Law School.

Ashley Brooks-Russell, Ph.D., M.P.H., is an associate professor and director of the Injury and Violence Prevention Center at the Colorado School of Public Health. She also serves as director of the Healthy Kids Colorado and Smart Source Surveys. Along with adolescent health, her research addresses injury prevention and traffic safety issues including the impacts of cannabis impaired driving. Dr. Brooks-Russell has supported the state of Colorado on evaluation of the public health impacts of cannabis, but she is not directly involved with developing cannabis policies for Colorado. She earned her B.A. in anthropology and a M.P.H. from Case Western Reserve University. She received her Ph.D. in health behavior from the University of North Carolina, Chapel Hill followed by a post-doctoral fellowship through the National Institutes of Health. To support her research on cannabis impaired driving, Dr. Brooks-Russell has commercial relationships with companies that conduct oral fluid and breath testing (LifeLoc and Inspect IR). She has paid a cannabis company (Bud and Mary's) to pick up samples of cannabis from study participants and deliver the samples to an independent lab for analysis.

Magdalena Cerdá, Ph.D., is professor and director of the Division of Epidemiology, as well as director of the Center for Opioid Epidemiology and Policy at the Department of Population Health at New York University (NYU) Langone Health. Her work integrates approaches from social and psychiatric epidemiology to examine how social contexts and drug and health policies shape substance use, violent behavior, and common forms of mental illness. Dr. Cerdá's current research focuses on the impact that cannabis laws, opioid prescribing policies, and harm reduction laws and services have on cannabis and opioid-related harms in the United States.

She has published more than 260 peer-reviewed journal articles as well as chapters in major textbooks in her field. Dr. Cerdá is president of the Interdisciplinary Association of Population Health Sciences. She served on the planning committee for the National Academies of Sciences, Engineering, and Medicine Workshop on Methadone Treatment for Opioid Use Disorder and served as chair of the National Academy of Medicine's Expert Group on Integrating Social Determinants of Health in Opioid Prevention, Treatment, and Recovery. She received a Ph.D. in public health from Harvard University and was a Robert Wood Johnson Foundation Health and Society Scholar at the University of Michigan. Dr. Cerdá has made several social media posts about her research findings about cannabis policy and has provided expert testimony for opioid litigation trials.

Ziva D. Cooper, Ph.D., is the director of the University of California, Los Angeles (UCLA) Center for Cannabis and Cannabinoids of the Semel Institute for Neuroscience and Human Behavior and professor in the departments of Psychiatry and Anesthesiology in the David Geffen School of Medicine at UCLA. Dr. Cooper's research, funded by the National Institutes of Health and state of California, focuses on controlled human drug administration studies of cannabis, cannabis constituents, and emerging cannabinoid products to understand variables that impact their adverse and potential therapeutic effects. Her funded studies also investigate the impact of cannabis regulation on behavior and health outcomes. Dr. Cooper is president of the International Cannabinoid Research Society and an associate editor of *Neuropsychopharmacology*, and she was previously board director for the College on Problems of Drug Dependence. Dr. Cooper served on the National Academies of Sciences, Engineering, and Medicine Committee on the Health Effects of Cannabis. She has a Ph.D. in biopsychology from the University of Michigan. Dr. Cooper has received cannabinoids for use in her research studies from cannabis companies, and these studies are conducted in compliance with federal laws on drug research. She has also reviewed research and development protocols for pharmaceutical companies developing cannabis-based drug products, including Canopy Growth Corporation and FSD Pharma.

Dustin T. Duncan, Sc.D., is professor of epidemiology and associate dean for Health Equity Research at Columbia University Mailman School of Public Health, where they direct Columbia's Spatial Epidemiology Lab and co-directs the department's Social and Spatial Epidemiology Unit. Dr. Duncan's research broadly seeks to understand how social and contextual factors, especially neighborhood characteristics, influence population health. Their intersectional and health equity-based research focuses on Black cisgender gay, bisexual, and other sexual minority men and

transgender women of color across the African diaspora, including in the United States, the Caribbean, and Africa. Dr. Duncan was formerly a fellow of the National Academy of Medicine emerging leaders program. They received a B.A. from Morehouse College and Sc.D. and Sc.M. degrees from the Harvard T.H. Chan School of Public Health.

Debra M. Furr-Holden, Ph.D., is dean and professor of epidemiology at New York University (NYU) School of Global Public Health. Previously, she held the positions of associate dean for Public Health Integration; director, Division of Public Health; C.S. Mott Endowed Professor of Public Health and director at the National Institutes of Health-funded Flint Center for Health Equity Solutions at the Michigan State University College of Human Medicine from 2016 to 2022. From 2011 to 2016, she was associate professor in the Department of Mental Health at the Johns Hopkins Bloomberg School of Public Health. Dr. Furr-Holden's research expertise includes health disparities and health equity, policy-level interventions, drug and alcohol epidemiology, and prevention science. She is a member of the National Academy of Medicine. Dr. Furr-Holden received her B.A. from Johns Hopkins University and her Ph.D. from Johns Hopkins Bloomberg School of Public Health.

Sean Hennessy, Pharm.D, Ph.D., is professor of epidemiology and of systems pharmacology and translational therapeutics at the University of Pennsylvania, where he leads the Division of Epidemiology and the Center for Real-World Effectiveness and Safety of Therapeutics. In these leadership roles, he has sought to improve the quality, impact, and visibility of his organizations' research and educational programs and to help fellow members of his organizations articulate and achieve their professional and life goals and feel that they are part of something larger than themselves. Dr. Hennessy's research evaluates the real-world effectiveness and safety of prescription drugs using healthcare data with a focus on the health effects of drug–drug interactions. He has served on the National Academies of Sciences, Engineering, and Medicine Committee on the Health Effects of Cannabis and is a member of the National Academy of Medicine. Dr. Hennessy holds a B.S. and Pharm.D. from the Philadelphia College of Pharmacy and Science and a Ph.D. from the University of Pennsylvania. In 2018, he consulted for Greenwich Pharmaceutical, a sister company for GW Pharmaceuticals, a manufacturer of cannabis drugs.

Beau G. Kilmer, Ph.D., M.P.P., is the codirector of the RAND Drug Policy Research Center and a senior policy researcher at RAND. He also serves as the vice president of the International Society for the Study of Drug Policy and is professor of Policy Analysis at the Pardee RAND Graduate School.

Since 2010, he has conducted extensive research on the topic of cannabis legalization, with a special focus on supply options, design considerations, public health implications, and social equity. Dr. Kilmer's publications on these issues have appeared in top journals (e.g., *New England Journal of Medicine, JAMA Psychiatry, American Journal of Public Health*) and media outlets (e.g., *Los Angeles Times, New York Times, Wall Street Journal*), and two editions of his coauthored book on cannabis legalization were published by Oxford University Press. He received the National Highway Traffic Safety Administration Public Service Award for his "leadership and innovation in the areas of alcohol and drug-impaired driving program and policy research," and he was selected to serve as a member of the Council on Criminal Justice in 2020. Dr. Kilmer received a B.A. from Michigan State University, an M.P.P. from University of California, Berkeley, and a Ph.D. in public policy from Harvard University.

Ellen Kurtzman, Ph.D., M.P.H., R.N., F.A.A.N., is professor of health administration in the Edward J. Bloustein School of Planning and Public Policy at Rutgers University. She also holds a courtesy appointment in the division of nursing science at Rutgers School of Nursing. Before arriving at Rutgers, Dr. Kurtzman was on faculty at the George Washington University School of Nursing. Her investigator-initiated research explores the impact of federal, state, and institutional policies on health care delivery including states' cannabis policies. From 2018 to 2019, Dr. Kurtzman served as a Robert Wood Johnson Foundation Health Policy Fellow and worked in the Office of the Speaker of the House and the Office of the Surgeon General. From 2014 to 2016, she served as the National Center for Health Statistics (NCHS)/AcademyHealth Health Policy Fellow, and in 2009 she was inducted as a fellow of the American Academy of Nursing. Dr. Kurtzman received her B.S.N. from the University of Pennsylvania, her M.P.H. from Johns Hopkins Bloomberg School of Public Health, and her Ph.D. in public policy and administration from the Trachtenberg School at the George Washington University.

Rosalie L. Pacula, Ph.D., holds the Elizabeth Garrett Chair in Health Policy, Economics & Law at the University of Southern California (USC) Sol Price School of Public Policy. Previously, she spent 21 years at the RAND Corporation, serving for 15 years as co-director of RAND's Drug Policy Research Center, where she led or contributed to studies for the U.S. Office of National Drug Control Policy, U.S. Centers for Disease Control and Prevention, the European Commission, and the U.K. Home Office. Trained as an economist, Dr. Pacula has conducted evaluations of state public health and health care policies for more than twenty-five years, applying advanced statistical methods appropriate for causal inference. Her work evaluating

the supply and demand for addictive substances, including payment for and delivery of addiction treatment services, has brought her recognition. She has been invited to serve on the National Institute on Drug Abuse (NIDA)'s National Advisory Council Cannabis Policy Workgroup (2017), the World Health Organization's Technical Expert Committee on Cannabis Use and Cannabis Policy (December 2019–2020), and the CDC's National Injury Prevention's Board of Scholarly Counsellors (2021–present). Dr. Pacula also serves as a committee member for the National Academies of Sciences, Engineering, and Medicine (2021–2022), and she is co-chair of the National Academies Forum for Mental Health and Substance Use Disorders (2023–present). She recently completed a 4-year term as president of the International Society for the Study of Drug Policy. Dr. Pacula currently serves as the co-chair of the Forum on Mental Health and Substance Use Disorders and was formerly a member of the committee on the review of specific programs in the Comprehensive Addiction and Recovery Act. She received her undergraduate degree from Santa Clara University and her doctorate in economics from Duke University. As a prominent cannabis policy researcher, Dr. Pacula has made public statements about her research findings related to cannabis policy.

Joseph F. Spillane, Ph.D., M.A., is chair of the Department of History at the University of Florida, where he also served as associate dean for student affairs in the College of Liberal Arts and Sciences from 2012 to 2022. During his time at the University of Florida, Dr. Spillane has served as president of the Alcohol and Drug History Society, and he is the co-founder of the organization's *Points* blog. His primary professional and research expertise lies in drug policy history. Dr. Spillane's other ongoing research interests include the development of the addiction research field, the history of abuse liability assessment, and police practices relative to illicit markets. His notable works include the books *Cocaine: From Medical Marvel to Modern Menace in the United States* and *Coxsackie: The Life and Death of Prison Reform*, both published through Johns Hopkins University Press. Dr. Spillane earned his bachelor's degree in history from Gettysburg College and an M.A. and Ph.D. from Carnegie Mellon University.

Donald R. Vereen, M.D., M.P.H., is a director of Community-Based Public Health at the University of Michigan School of Public Health and the Michigan Institute for Clinical and Health Research. He previously served as the deputy director at the Office of National Drug Control Policy and as a special assistant to the director of the National Institute on Drug Abuse. Dr. Vereen's primary professional and research expertise lies in research strategy, health policy, violence, drug abuse, addiction, and community-based research. He has served on the District of Columbia Task Force on

Health Affairs as a representative of the National Institutes of Health, and he has collaborated with the mayor of the District of Columbia's Health Policy Council. Dr. Vereen has an A.B. in biology and M.P.H. from Harvard University, and an M.D. from Tufts University. He advised the state of Michigan on medical marijuana policies in 2013.

Larry Wolk, M.D., M.S.P.H., is the chief medical officer of The Wonderful Company. Prior to that, he served as executive director and chief medical officer of the Colorado Department of Public Health and Environment. His accomplishments include overseeing the implementation of research, education, and surveillance of the nation's first legalized marijuana program. Prior to this role, he served as the chief executive officer for Colorado's Health Information Exchange and president and chief operating officer for Correctional Healthcare Companies. Dr. Wolk started his career by directing the outpatient pediatric clinic at the Hospital for Infants and Children at Presbyterian/St. Luke's Medical Center. In 1996, he created the Rocky Mountain Youth Clinics (now known as Every Child Pediatrics), where he served as a part-time pediatrician and where he currently serves as a board director. Dr. Wolk has been honored as a Colorado Pediatrician of the Year, a Volunteer of the Year, a Healthcare Executive of the Year, a "Denver7 Everyday Hero," and he is a recipient of the University of Vermont's Award for Service to Medicine and Community. He received his B.A. from the University of Pennsylvania and his M.D. from the University of Vermont. Dr. Wolk received his training in pediatrics and adolescent medicine, including his M.S.P.H., from the University of Colorado and the Colorado Children's Hospital. In 2022, he had a consulting relationship with the Hawthorne Gardening Company.

Kelly C. Young-Wolff, Ph.D., M.P.H., is a licensed clinical psychologist and research scientist at Kaiser Permanente Northern California Division of Research. She is also an adjunct associate professor in the Department of Psychiatry at the University of California, San Francisco; an adjunct lecturer in medicine at the Stanford University School of Medicine; and an associate professor at Kaiser Permanente Bernard J. Tyson School of Medicine. Dr. Young-Wolff's program of research is focused on understanding risk and protective factors related to the onset and course of drug and alcohol use disorders among vulnerable populations, including pregnant individuals and adolescents. She currently has four National Institute on Drug Abuse-funded studies that examine the health impacts of cannabis use and cannabis legalization on adolescents and pregnant individuals. Dr. Young-Wolff received her B.A. in psychology and anthropology from the University of California, Berkeley, and her M.P.H. and doctorate in

clinical psychology from the University of Southern California. She is an active cannabis researcher and makes statements related to her research.

Nickolas Zaller, Ph.D., is senior director of research and evaluation at the Health Alliance for Violence Intervention. He was formerly a professor at the University of Arkansas for Medical Sciences Fay W. Boozman College of Public Health and founding director of the Southern Public Health and Criminal Justice Research Center. Dr. Zaller's research focus is the overlap between behavioral health disorders, including addiction and mental illness, infectious diseases and incarceration both in the United States and internationally. He earned his bachelor's degree in microbiology and East Asian Studies from Kansas University. After graduation, he lived in China for a year as a Fulbright Scholar and then earned a doctorate in public health at the Johns Hopkins Bloomberg School of Public Health. After his Ph.D. training, Dr. Zaller completed a National Institutes of Health post-doctoral fellowship in HIV and Other Infectious Consequences of Substance Use at the Miriam Hospital and the Alpert Medical School of Brown University, where he served as a faculty member for 10 years prior to moving to Arkansas. He collaborates with harm reduction organizations and has written opinion pieces about the need for cannabis policy reforms to limit health impacts associated with incarceration.

Elizabeth Barksdale Boyle, M.P.H., is a senior program officer in the Health and Medicine Division's Board on Population Health and Public Health Practice after serving for several years as a program officer with the Board on Environmental Studies and Toxicology. Formerly, she was an environmental health scientist at Westat, where she supported the Environmental Protection Agency, the National Institute of Child Health and Development, and the National Cancer Institute. Before her tenure at Westat, Ms. Boyle was a student epidemiologist at the Minnesota Department of Health and an industrial hygienist at a consulting firm in Cincinnati. She is a fellow of the Bloomberg American Health Initiative at the Johns Hopkins Bloomberg School of Public Health, where she is pursuing a Doctor of Public Health in environmental health. Ms. Boyle has an M.P.H. in environmental health from the University of Minnesota, a certificate in risk sciences and public policy from the Johns Hopkins University Bloomberg School of Public Health, and she is a Certified Industrial Hygienist.

Rose Marie Martinez, Sc.D., has been the senior board director of the Board on Population Health and Public Health Practice (BPH) at the National Academies of Sciences, Engineering, and Medicine since 1999. BPH addresses the science base for population health and public health

interventions and examines the capacity of the health system, particularly the public health infrastructure, to support disease prevention and health promotion activities, including the education and supply of health professionals necessary for carrying them out. BPH has examined topics such as the safety of childhood vaccines and other drugs, systems for evaluating and ensuring drug safety post-marketing, the health effects of cannabis and cannabinoids, the health effects of environmental exposures, population health improvement strategies, the integration of medical care and public health, women's health services, health disparities, health literacy, tobacco control strategies, and chronic disease prevention, among others. Dr. Martinez was awarded the 2010 Institute of Medicine (IOM) Research Cecil Award for significant contributions to IOM reports of exceptional quality and influence. Prior to joining the National Academies, she was a senior health researcher at Mathematica Policy Research (1995–1999), where she researched the impact of health system change on public health infrastructure, access to care for vulnerable populations, managed care, and the health care workforce. Dr. Martinez is a former assistant director for health financing and policy with the U.S. Government Accountability Office, where she directed evaluations and policy analysis on national and public health issues from 1988 to 1995. Her experience also includes 6 years directing research studies for the Regional Health Ministry of Madrid, Spain (1982–1988). Dr. Martinez is a member of the Council on Education for Public Health, the accreditation body for schools of public health and public health programs. She received a Doctor of Science from the Johns Hopkins School of Hygiene and Public Health.

Khala Hurst-Beatty, M.P.H., is an associate program officer with the Board on Population Health and Public Health Practice in the National Academies of Sciences, Engineering, and Medicine's Health and Medicine Division. Prior to this consensus study, Ms. Hurst-Beatty worked on several Substance Abuse and Mental Health Services Administration grants where she analyzed individual and program outcomes of rehabilitation and other substance abuse treatments. Her primary interests are translational research and health equity. Ms. Hurst-Beatty conducted her graduate studies at the George Washington University. She attended Hampton University in Virginia as a presidential scholar, earning her Bachelor of Science in biology with a minor in leadership studies.

Alexandra McKay, M.A., is a research associate in the National Academies of Sciences, Engineering, and Medicine's Health and Medicine Division. While at the National Academies, she has contributed to consensus studies concerning environmental health, including Guidance on PFAS Testing and Health Outcomes, the Reassessment of the Department of Veterans Affairs

Airborne Hazards and Open Burn Pit Registry, and the Review of the Department of Veterans Affairs Presumption Decision Process. Ms. McKay has also supported other convening activities, including Children's Environmental Health: A Workshop on Future Priorities for Environmental Health Sciences and several other activities across the Health and Medicine Division and the Division on Earth and Life Studies. She has also worked for the National Park Service as an interpretation ranger, concentrating on science education and public engagement. She graduated from Yale University, where she received her M.A. in archaeological studies.

Mia Saltrelli, B.S., is a senior program assistant at the National Academies of Sciences, Engineering, and Medicine. She works in the Health and Medicine Division on the Board of Population Health and Public Health Practice. Ms. Saltrelli graduated from Furman University with a Bachelor of Science in public health.

Appendix B

Public Meeting Agendas

COMMITTEE ON PUBLIC HEALTH CONSEQUENCES OF CHANGES IN THE CANNABIS POLICY LANDSCAPE

National Academy of Sciences,
2101 Constitution Ave. NW
Washington, DC 20418

MEETING 1

SEPTEMBER 15, 2023
ROOM 250

SESSION I—PUBLIC SESSION

10:00–10:20	Purpose of Open Session and Introduction of Committee Members **Steven M. Teutsch,** *Committee Chair*
10:20–10:45	Centers for Disease Control and Prevention (CDC) Perspectives on Study Scope, Background, and Objectives **Brooke Hoots,** *Cannabis Strategy Unit Lead, Division of Overdose Prevention,* CDC

10:45–11:10	National Institute on Drug Abuse (NIDA) Perspectives on Study Scope, Background, and Objectives **Susan Weiss,** *Director,* Division of Extramural Research at NIDA, National Institutes of Health
11:10–11:35	National Cancer Institute (NCI) Perspectives on Study Scope, Background, and Objectives **Joseph T. Ciccolo,** *Program Director, Tobacco Control Research Branch, Behavioral Research Program, Division of Cancer Control and Population Sciences,* NCI
11:35–11:45	National Center for Complementary and Integrative Health (NCCIH) Perspectives on Study Scope, Background, and Objectives **David Shurtleff,** *Deputy Director,* Acting Scientific Director, NCCIH
11:45–11:50	Food and Drug Administration (FDA) Perspectives on Study Scope, Background, and Objectives **Patrick Cournoyer,** *Senior Science Advisor and Food and Drug Administration Lead for Cannabis Products,* FDA
11:50–12:15	Committee Discusses the Statement of Task with the Study Sponsors
12:15–1:15	Opportunity for Public Comment on the Committee's Statement of Task
1:15	Public Session Adjourns

MEETING 2

NOVEMBER 29, 2023

SESSION I—WELCOME AND OPENING

11:00–11:10	Welcome and Opening Remarks from the Chair **Steven M. Teutsch,** *Committee Chair*

SESSION II—PUBLIC HEALTH AUTHORITIES OF STATE AND LOCAL GOVERNMENTS

11:10–11:50	Keynote Talk: The Public Health Authorities of State and Local Governments as They Pertain to Cannabis in Light of the Federal Prohibition **Anne Boustead,** University of Arizona
11:50–12:00	Discussion with Committee

SESSION III—PUBLIC HEALTH AUTHORITIES OF STATE AND LOCAL GOVERNMENTS

12:00–12:20	State Cannabis Policy Landscape: Effects on Public Health **Beth McGinty,** Weill Cornell Medicine
12:20–1:05	State Cannabis Policy Landscape **Gillian Schauer,** Cannabis Regulators Association (CANNRA)
1:05–1:50	Panel Discussion: Perspectives from State Health Regulators **Adria Berry,** Oklahoma Medical Marijuana Authority **Nicole Elliott,** California Department of Cannabis Control **Amy Moore,** Missouri Department of Health and Senior Services **Michele Nakata,** Hawaii Office of Medical Cannabis Control and Regulation **Will Tilburg,** Maryland Cannabis Administration **Beth McGinty,** Weill Cornell Medicine **Gillian Schauer,** CANNRA
1:50–2:05	Break
2:05–2:25	Local Cannabis Policy Landscape: Across California **Ellicott Matthay,** New York University
2:25–2:45	Local Cannabis Policy Landscape: Across Oregon and Washington **Julia Dilley,** State of Oregon Public Health Division

2:45–3:30 Panel Discussion: Perspectives from Local Health Regulators
Molly Duplechian, City and County of Denver
Al Romero-Gibu, City of Grand Rapids
Kim James, City of Detroit
Sarah Ross Viles, Public Health – Seattle & King County
Mathew Swinburne, The Network for Public Health Law
Ellicott Matthay, New York University
Julia Dilley, State of Oregon Public Health Division

SESSION IV—INDUSTRY APPROACH TO THE WIDE VARIATION IN CANNABIS POLICY

3:30–4:15 How does the cannabis industry approach the wide variation in cannabis policy across local, state, and federal authority?
Jonathan Caulkins, Carnegie Mellon

4:15–5:00 Panel Discussion: A Safe and Sustainable Cannabis Industry
Michael Cooper, National Cannabis Industry Association
Daniel Fabricant, Natural Products Association
Micah Sherman, Raven, National Craft Cannabis Coalition
Ross Gordon, Humboldt County Growers Alliance, National Craft Cannabis Coalition
Carrie A. Harney, US Pharmacopeia

5:00–5:15 Break

SESSION V—PUBLIC COMMENT SESSION

5:15–5:55 Public Comment Session

SESSION VI—CLOSING REMARKS

5:55–6:00 Chair's Reflection and Preview of Workshop Day 2
Steven M. Teutsch, *Committee Chair*

6:00 Meeting Day 1 Adjourns

NOVEMBER 30, 2023

SESSION VII—WELCOME AND OVERVIEW OF THE WORKSHOP SERIES

11:00–11:10 Welcome and Opening Remarks from the Vice Chair
Yasmin Hurd, *Committee Vice Chair*

SESSION VIII—OVERVIEW OF INTERNATIONAL CANNABIS POLICY

11:10–11:55 What the United States Can Learn from the Changes in Cannabis Use Across Canada
David Hammond, University of Waterloo

11:55–12:45 Panel Discussion: Perspectives from International Researchers
Hanan Abramovici, Health Canada
Arturo Alvarez Roldan, Universidad de Granada, Spain
Alvaro Castillo-Carniglia, Universidad Mayor, Chile
Wayne Hall, University of Queensland, Australia
Rosario Queirolo, Universidad Católica del Uruguay

SESSION IX—BROADER PERSPECTIVES

12:45–1:35 Protecting Public Health and Social Equity with Legal Cannabis
Kevin Sabet, Smart Approaches to Marijuana
Cat Packer, Drug Policy Alliance
Lynn Silver, Public Health Institute
Peter Grinspoon, Massachusetts General Hospital

SESSION X—CLOSING REMARKS

1:35–1:40 Reflections and Closing Remarks from the Vice Chair
Yasmin Hurd, *Committee Vice Chair*

1:40 Meeting Adjourns

MEETING 3

JANUARY 11, 2024

SESSION I—WELCOME AND OPENING

11:00–11:10 Welcome and Opening Remarks from the Committee Chair
Steven M. Teutsch, *Committee Chair*

SESSION II—CANNABIS AND CRIMINAL JUSTICE: HAVE CANNABIS POLICY REFORMS LED TO IMPROVEMENTS IN SOCIAL EQUITY?

11:10–11:15 Session Introduction
Doug Berman, *Committee Member*

11:15–11:35 Association between Cannabis Laws and Cannabis Possession Arrest Rates in the United States
Yuyan Shi, University of California, San Diego

11:35–11:55 Mandated Drug Treatment in the Aftermath of Recreational Cannabis Legalization
Katharine Harris, Rice University

11:55–12:15 The Impact of Recreational Cannabis Legalization on Racial Disparities in Cannabis Arrests
Dale Willits, Washington State University

12:15–1:00 Panel Discussion with Session Presenters
Yuyan Shi, University of California, San Diego
Katharine Harris, Rice University
Dale Willits, Washington State University

SESSION III—CANNABIS POLICY CHANGES: IMPACTS ON THE ILLICIT MARKET

1:00–1:05 Session Introduction
Beau Kilmer, *Committee Member*

1:05–1:25 An Economic Perspective on the Impact of Cannabis Legalization on the Illicit Market
Tiffanie Perrault, McGill University

SESSION IV—CONSEQUENCES OF ENTANGLEMENTS WITH THE CRIMINAL JUSTICE SYSTEM

1:25–1:30 Session Introduction
Nick Zaller, *Committee Member*

1:30–1:50 Ramifications of a Cannabis-Related Criminal Conviction
Jason Ortiz, Last Prisoner Project

1:50–2:35 Panel Discussion: Perspectives of Those Impacted by the Justice System
Donte West, Last Prisoner Project
Stephanie Shephard, Last Prisoner Project
Kyle Page, Last Prisoner Project
Jason Ortiz, Last Prisoner Project

2:35–2:55 Break

SESSION V—CULTIVATING EQUITY: EMPLOYMENT, TAXATION, AND THE ECONOMIC LANDSCAPE OF CANNABIS REGULATION

2:55–3:00 Session Introduction
Debra Furr-Holden, *Committee Member*

3:00–3:20 Tax Aspects of Cannabis Policy
Alex Brill, American Enterprise Institute

3:20–3:40 Creating Social Equity Through Cannabis Policy
Shaleen Title, Parabola Center for Law and Policy

3:40–4:25 Panel Discussion: State Government Strategies for Social Justice in Cannabis Legalization
Damian Fagon, New York Office of Cannabis Management
Eugene Hillsman, California Department of Cannabis Control

Abigail Vivas, Division of Cannabis Regulation, Missouri Department of Health, and Senior Services
Wesley McWhite, Diversity and Inclusion, New Jersey Cannabis Regulatory Commission
Erin Johnson, Illinois Cannabis Regulation Oversight Office

4:25–5:05 Panel Discussion: Municipal Government Strategies for Social Justice in Cannabis Legalization
Imani Brown, City of Los Angeles, California
Garland Doyle, National Council on Municipal Cannabis and City of Pontiac, Michigan
Al Romero-Gibu, Grand Rapids, Michigan

5:05–5:25 Break

SESSION VI—PUBLIC COMMENT SESSION

5:25–5:55 Public Comment Session
Nick Zaller, *Committee Member*

SESSION VII—CLOSING REMARKS

5:55–6:00 Chair's Reflection and Preview of Workshop Day 2
Steven Teutsch, *Committee Chair*

6:00 Meeting Day 1 Adjourns

JANUARY 12, 2024

SESSION VIII—WELCOME AND OVERVIEW OF THE WORKSHOP SERIES

11:00–11:10 Welcome and Opening Remarks from the Committee Vice Chair
Yasmin Hurd, *Committee Vice Chair*

SESSION IX—CONSEQUENCES OF ENTANGLEMENTS WITH THE CRIMINAL JUSTICE SYSTEM

11:10–11:15 Session Introduction
Donald Vereen, *Committee Member*

11:15–11:45 Panel Discussion: Perspectives of Those Impacted by the Harms of Cannabis Policy
Juli Shamash, Parent, California
Teresa Fiore, Resident, New York
Steve Glassman, Parent, New Jersey

11:45–12:00 Break

SESSION X—CONSEQUENCES OF ENTANGLEMENTS WITH THE CRIMINAL JUSTICE SYSTEM

12:00–12:05 Session Introduction
Kelly Young-Wolff, *Committee Member*

12:05–12:25 A Comprehensive Look at Cannabis Use Disorder
Deborah Hasin, Columbia University

12:25–12:45 Not Your Grandmother's Weed: Adolescent Cannabis Use & Mental Health Concerns
Maria Rahmandar, Lurie Children's Hospital of Chicago, Northwestern University

12:45–1:05 Multi-Level Associations between Changing Cannabis Laws and Cannabis Use Disorder Treatment
Pia M. Mauro, Columbia University

1:05–1:50 Panel Discussion
Deborah Hasin, Columbia University
Maria Rahmandar, Lurie Children's Hospital of Chicago, Northwestern University
Pia M. Mauro, Columbia University
Kenneth Finn, Springs Rehabilitation

SESSION XI—STRENGTHENING A HARM REDUCTION APPROACH TO PROTECT THE MOST VULNERABLE POPULATIONS

2:10–2:15	Session Introduction **Dustin T. Duncan,** *Committee Member*
2:15–2:45	Harm Reduction Considerations for Marijuana Use and Policy **Sheila P. Vakharia,** Drug Policy Alliance
2:45–3:00	Harm Reduction, Cannabis, and Adolescents **Renee Johnson,** Johns Hopkins University
3:00–3:45	Panel Discussion: How Can Harm Reduction Policies be Used to Protect Vulnerable Populations **Christopher Williams,** Purchase College **Celestina Barbosa-Leiker,** Washington State University **Renee Johnson,** Johns Hopkins University **Sheila P. Vakharia,** Drug Policy Alliance

SESSION IX—CLOSING REMARKS

3:45–4:00	Vice Chair's Reflection **Yasmin Hurd,** *Committee Vice Chair*
4:00	Meeting Adjourns

Appendix C

Data Sources Available for Cannabis Surveillance

Numerous data sources could be used to monitor cannabis's public health effects, including poisonings, exposure biomonitoring, survey data, regulatory data, administrative data, traffic data, and mortality data.

POISONING DATA

The American Association of Poison Control Centers administers the National Poison Data System (NPDS). Each of the 55 poison control centers in the U.S. submits de-identified data on exposures (which do not necessarily represent a poisoning or overdose) to NPDS. The exposures are reported by individuals or by trained health officials who make calls to one of the national poison control centers. These data were used to find, for example, that an increase in cannabis exposures reported to poison control centers follows states' legalization of adult cannabis use (Shi and Liang, 2021) and that reported childhood exposures to edible cannabis products increased between 2017 and 2019 (Whitehill, 2021).

BIOMONITORING DATA

The CDC uses biomonitoring to measure chemicals or their metabolites (breakdown products) in human tissues and fluids to determine exposure to environmental chemicals. The agency's National Health and Nutrition Examination Survey (NHANES) conducts biomonitoring on a large scale. Using a multistage probability design to sample the noninstitutionalized

civilian population in all 50 states, biological specimens from approximately 10,000 people in each two-year survey cycle were collected for laboratory testing. These specimens include blood samples, urine, and saliva. Currently, these fluids are used to monitor for the nicotine metabolite cotinine. Still, this tool could also be used for any metabolites of cannabis exposure, as CDC laboratories have measured cannabis metabolites for research purposes (Sangmo, 2021).

SURVEY DATA

Survey data (Table C-1) are used to monitor exposure to and public health effects of cannabis, including several national and state-specific health surveys. Surveys capturing nationally representative samples of the household population include the National Survey on Drug Use or Health (NSDUH), the Behavioral Risk Factor Surveillance System (BRFSS), the National Health Interview Survey (NHIS), the National Health and Nutrition Examination Survey (NHANES), Monitoring the Future (MTF), Youth Risk Behavior Surveillance System (YRBSS)/National Youth Risk Behavior Survey (YRBS), National Epidemiological Survey on Alcohol and Related Conditions (NESARC I, II and III), Population Assessment of Tobacco and Health (PATH), Pregnancy Risk Assessment Monitoring System (PRAMS), and the International Cannabis Policy Study (ICPS). Examples of state-specific surveys include the California Health Interview Survey and Washington State Healthy Youth Survey (HYS).

A central advantage of these surveys is that they capture a broad range of people who use cannabis, including those who seldom interact with the healthcare system. Moreover, national surveys such as NSDUH, and YRBSS can produce state-level estimates of the prevalence of use in the past year or month, though often only through restricted-use datasets. Not all states include the questions about cannabis use (called the marijuana module) in BRFSS, and some states do not have adequate response rates to report population estimates from YRBSS (Geissler, 2020). Moreover, these surveys don't ask about the types of cannabis products used, mode of administration, and total quantity consumed, as it is difficult to make changes to adapt to the rapidly changing marketplace.

Several data sets (e.g., MTF, PATH, ICPS) do not consistently capture state-representative samples, which means they are not ideal for evaluating state policy changes even though they provide state identifiers. Similarly, NSDUH, while it captures state representative samples, does not provide state identifiers in public-use data files.

There are several disadvantages to using household surveys for cannabis surveillance, such as potential inaccurate reporting of cannabis

use, insufficient detail on cannabis/cannabinoid use, and selection bias of the sample. Cannabis use is often underreported in surveys due to the associated stigma. The underreporting may confound the relationship between cannabis use and legalization because as states legalize cannabis, cannabis use may become more socially acceptable or less stigmatized (Le, 2022; Smart, 2019). Response or desirability bias (such as underreporting of cannabis use) may occur when the survey is not designed or administered correctly (such as if a bystander can hear the question and the answer given). Selection bias may occur because surveys often exclude populations who may have the highest use, such as those who are not in a traditional household and those living in institutions (for example, a correctional institution or a residential nursing or mental health care facility) or those on active duty in the Armed Forces. Finally, most large-scale population surveys contain insufficient detail about the frequency of cannabis use, the specific cannabis products used (and the THC or other cannabinoids contained within them), the modes of administration used, the amounts consumed, or the individual's reason for use. Such details are needed to understand which products people use that could affect public health.

HEALTH CARE DATA

Health-care data (Table C-2) for cannabis policy surveillance include health insurance claims, electronic health records, and facility-level health record data. Evaluating cannabis-related health events using health-care data presents both opportunities and challenges. While leading health care systems with systematic screening for cannabis use offer valuable insights, such data are typically limited to subsets of patients (e.g., pregnant individuals, adolescents, primary care patients; see Appendix D) and are not publicly available. Further, emerging cannabis-related health outcomes (e.g., cannabinoid hyperemesis syndrome) are not consistently coded or documented in health care settings as there currently is no universal international classification of diseases code for cannabinoid hyperemesis syndrome. Publicly accessible datasets, like aggregated claims data or outpatient records, also rely on clinician coding practices, which can be inconsistent, especially since cannabis use screening is not as widely implemented as tobacco screening, leading to under-ascertainment. Free-text notes capture cannabis consumption only if reported by the patient and recorded by the provider, both of which are likely to be inconsistent because of legal prohibitions and cultural attitudes about cannabis use, among other reasons. Pharmacy dispensing records generally do not include information for drugs obtained outside the pharmacy.

TABLE C-1 Survey Data Sources Available for Cannabis Surveillance

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Self-report surveys							
National Survey on Drug Use or Health (NSDUH) Cross-sectional, in-person survey (some online during the COVID-19 pandemic) of civilian, non-institutionalized population of U.S. individuals aged 12 and older	No	Recency of use, frequency of use, age of first use; perceived risk and approval; DSM-IV/ DSM-V CUD	Not assessed, but respondents are asked if any or all of their use was recommended by a doctor or other health professional	CUD, driving impaired, other substance use; substance use disorders; substance use risk and protective factors; availability of substance use treatment; any mental illness and serious mental illness; suicidal thoughts and behaviors; mental health treatment	Nationally and state representative samples began in 1999, but geocoded data (state, county) restricted to public	Annual periodically since 1971, annually since 1990. In 2002, name changed from National Household Survey on Drug Abuse to NSDUH.	The public use file (PUF) does not contain state or any other geographic identifiers. Changes were made to NSDUH sampling design and questionnaire in 2014 and 2015, respectively

Behavioral Risk Factor Surveillance System (BRFSS) Cross-sectional telephone survey of noninstitutionalized U.S. adults (aged 18+)	No	Frequency, route of administration	Medical and recreational	Health status, healthy days, chronic health conditions, health-related behaviors	State-/territory-based sample of noninstitutionalized U.S. adults (18+); produces national- and state-level estimates; selected states design substate samples; cannabis module introduced in 2016 but not all states opt in, so cannabis use cannot be surveyed across all 50 states	Annual 1984–current Became a nationwide surveillance system in 1993	In 2022, 24 jurisdictions opted to use the marijuana module

TABLE C-1 Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
National Health Interview Survey (NHIS) Cross-sectional, multistage, probability household interview survey of the civilian non-institutionalized population residing in the U.S.	No	No	Unspecified	Variety of acute and chronic health conditions; functioning; risk factors and health behaviors	Uses geographically clustered sampling techniques to randomly select one sample adult (18+) and one sample child (<18) in each dwelling unit so that each month's sample is nationally and regionally representative; the sampling plan is redesigned after every decennial Census	Annual 1957–present	From 1997 to 2018, the NHIS also included a family questionnaire. In 2019, a structure of annual questions (demographic, health insurance, chronic conditions, health care access, health-related behaviors, functioning/ disability) and rotating questions (mental health, service utilization, preventive services, injuries, chronic pain) was implemented

National Health and Nutrition Examination Survey (NHANES) Cross-sectional self-reported interview and examination survey; in-home personal interviews and physical examinations and laboratory tests in mobile examination centers (MEC)	No	Recency of use, frequency of use, age of first use, age of frequent use, quantity	Unspecified	Variety of acute and chronic health conditions; functioning; risk factors and health behaviors	Nationally representative multiyear, multistage, stratified, clustered sample of civilian non-institutionalized populations (adults and children); cannabis data (drug module) introduced in 2005 and collected from participants aged 12–69 years only by interview at the Mobile Examination Center; however, data files only contain data from participants aged 18–69 years	Annual From 1960–1994, a total of seven national examination surveys were conducted Beginning in 1999, the survey has been conducted continuously	Because of COVID, data collection for the NHANES 2019–2020 cycle was not completed, and the collected data are not nationally representative Therefore, data collected from 2019–March 2020 have been combined with data from the NHANES 2017–2018 cycle to form a nationally representative sample of NHANES 2017–March 2020 pre-pandemic data Starting in 2023, NHANES is undergoing a substantial survey redesign Therefore, NHANES 2021–2022 is the last cycle of a continuous survey that began in 1999 collecting data annually and publicly releasing data every 2 years

TABLE C-1 Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
International Cannabis Policy Study (ICPS) Cross-sectional web-based survey of respondents aged 16–65 collected in the fall of each year. Respondents are recruited using non-probability sampling methods through the Nielsen Consumer Insights Global Panel and their partner panels. Post stratification weights are constructed and used to generate samples more representative of either the nation or particular states.	No	Recency of use, frequency, times per day; age of first use; products used; route of administration; amount typically used	Medical and recreational use enquired separately	CUD; general health status; past year adverse/ negative health effects; past year ED visits; past year health visits	Cross-sectional data are post-weighted to generate samples more representative of national population living in states with or without medical and/or adult use laws. Post-sampling weights include sex, age, region, race, education and smoking status	Annual (1998–current), although sample size is increasing, particularly in a few states requesting state-specific estimates (e.g. WA, MA)	This sample is based off marketing panels, not stratified samples of any specific population As such, they may not capture representative behavior of cannabis users Furthermore, sample sizes in some states are very small, limiting utility for examining effects of policy changes

Monitoring the Future (MTF) Ongoing survey of 8th, 10th, and 12th graders Cross-sectional, In-school survey that is self-administered using machine readable questionnaires They then moved to tablet- based questionnaires, starting with a random half in 2019 Approximately 16,000 students in 133 public and private high schools participate annually in the 12th grade study 8th and 10th grade surveys started in 1991 Data are collected in spring of each year using a multi-stage random sampling design	No	Recency of use (lifetime, past year, past 30 days), frequency of use, age of first use; daily use in the past 30 days; vaping cannabis (as of 2017); synthetic marijuana use (as of 2011 for 12th graders, 2012 for 8th and 10th graders Perceived health risks of occasional and frequent cannabis use are also obtained	Recreational use is the focus of the survey, but starting in 2017, MTF asked if cannabis was used under a doctor's orders	Problems with use; drive with impaired driver; mental health status; use of tobacco, alcohol and other substances Survey also contains information on healthy lifestyle behaviors (nutrition, sleep, and exercise)	Nationally representative survey However, geocoded data (state, county) are not publicly available and can only be accessed through a special process Samples are not state representative	Annual) 1976–current year for 12th graders, although detailed measures of cannabis use have been expanded over time 1991–current period for 8th and 10th graders Similar expansion of measures over time

TABLE C-1 Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Youth Risk Behavior Surveillance System (YRBSS)/ National Youth Risk Behavior Survey (YRBS) YRBSS include school-based national, state, tribal, and large urban school district surveys of representative samples of high school students and, in certain sites, representative state, territorial, and large urban school district surveys of middle school students; includes YRBS	No	Lifetime frequency, age of first use, 30-day frequency, synthetic cannabis use	Unspecified	Six categories of priority health-risk behaviors: 1) behaviors that contribute to unintentional injuries and violence; 2) sexual behaviors that contribute to human immuno-deficiency virus (HIV) infection, other sexually transmitted diseases, and unintended pregnancy; 3) tobacco use; 4) alcohol and other drug use; 5) unhealthy dietary behaviors; and 6) physical inactivity	Three-stage cluster sample design producing nationally representative estimates	Biennial 1991–current	In 2021, 45 states participated in YRBS

National Longitudinal Survey of Youth 1997 (NLSY97) Ongoing nationally representative longitudinal survey of American youths between the ages of 12–16 in December 1996 The first wave of the survey, fielded in 1997 and 1998, collected information on 8,984 individuals (4,599 males and 4,385 females)	No	Age of first cannabis use, recency of use (use since last interview, use in past month), frequency of use (number of days used in past month)	Not specified	Use while pregnant, risky sexual behavior, other substance use, mental health (MHI-5), general health behaviors	Cohort representative of youth between the ages of 12–16 living in the United States in 1996	Annual survey from 1997–2011, and then biennial afterwards. Cannabis questions are not included in every survey after 2011	Data have limited utility for studying behavior of youth given the cohort ages out of youth by 2004

TABLE C-1 Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
National Epidemiological Survey on Alcohol and Related Conditions (NESARC I, II and III) Designed to assess the prevalence of alcohol use disorders and their associated disabilities in the general U.S. household population More than 43,000 were interviewed in NESARC I, with nearly 35,000 followed up in NESARC II NESARC III was a separate cross-sectional sample of 36,000 individuals	None collected	Initiation, use during the past 12 months and over lifetime, DSM-IV measures of cannabis abuse and dependence; daily or near daily cannabis use	Not specified	Self-reported receipt of treatment for CUD by treatment modality; self-reported cannabis withdrawal symptoms, DSM-IV or V mood disorders (depression, dysthymia, bipolar I and II), anxiety disorders, self-reported psychotic disorders; PTSD, and personality disorders Physical disability measured using SF-12 Other substance abuse/dependence (DSM-IV or V) also captured	NESARC I and III are a probability sample representative of the U.S. adults population 18 years and older NESARC II was a longitudinal follow up of the same respondents in NESARC I	The survey was only conducted three times: 2001–2002, 2004–2005, and then a new cross-sectional sample in 2011	

Population Assessment of Tobacco and Health (PATH) Ongoing, nationally representative, longitudinal cohort study of non-institutionalized adults and youth in the U.S., multi-stage stratified area probability design; 2-phase selection procedure used at final stage that oversampled adults who use tobacco, young adults, and Black adults Data collection in-person using audio computer-assisted self-interviewing (ACASI) instruments and a computer-assisted personal-interviewing (CAPI) parent instrument	No	Ever cannabis use; past-year cannabis use; time since last used cannabis; past-year vaping of cannabis; past-year blunt use	Not assessed	Tobacco use behaviors, including patterns of use, attitudes, beliefs, exposures, and health outcomes	The PATH study is a national longitudinal cohort study of 45,971 adults and youth 12 years of age and older; oversampling of tobacco users, Black individuals, and young adults aged 18-24 Wave 4 employed a probability replenishment sample to account for loss of cohort members during follow-up	~Annual (5 waves; 2013–2019)	The research community can request access; data are placed in the repository ~1 year following the completion of each wave Care is needed in selecting the appropriate weights and understanding the population of inference Some variables are only available in a subset of waves

TABLE C-1 Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Pregnancy Risk Assessment Monitoring System (PRAMS) State/jurisdiction-specific, mixed-mode population-based surveillance system	No	Core questions include screening of cannabis use during prenatal care, prenatal use, use during pregnancy State-specific standard questions vary	Unspecified	Variety of maternal outcomes (e.g., preeclampsia, postpartum depression) and neonatal outcomes (e.g., NICU admission, mortality, low birthweight, preterm birth)	Sample of women who have had a recent live birth drawn from the jurisdiction's birth certificate file Each participating site samples between 1,000 and 3,000 women per year Women from some groups are sampled at a higher rate to ensure adequate data are available in smaller but higher risk populations	Annual 1998–current Cannabis questions were first introduced in 2009	Forty-six states, the District of Columbia, New York City, Northern Mariana Islands, and Puerto Rico currently participate in PRAMS The births in the 50 jurisdictions that participate in PRAMS are 81% of all live births in the U.S. In 2017, the survey included the *Marijuana and Prescription Drug Use Supplement*, which was fielded by 6 states (AK, ME, NM, NY, PA, WV)

							Includes core questions (i.e., asked by all participating jurisdictions) and standard questions (i.e., chosen by jurisdictions from a pretested list of Centers for Disease Control and Prevention (CDC) questions or state-developed)	
Examples of State Specific Surveys								
California Health Interview Survey (CHIS) Mixed mode (web and telephone) survey uses address-based sampling to select one adult in each randomly sampled and participating household Adolescents are interviewed with parental permission	No	Adults: Ever use, last use, method (one, >1 method), CBD (cannabidiol) ever use, frequency of use past 30 days, method of use (CBD added in 2021) Adolescents: Ever use, past year use, frequency of past month use	Not assessed In 2001, adolescents were asked whether their doctor talked to them about marijuana use during an exam	Health status, health conditions, mental health, health behaviors, neighborhood and housing, adverse childhood experiences, access to and use of healthcare, health insurance, public program eligibility	Nation's largest state health survey Representative of the state of California	Annual (2001–current)		Public use files are available; can apply to get confidential data Questions asked change across years CHIS data can be analyzed at the county level for the 41 most populated counties and the remaining 17 counties are combined into 3 groups

TABLE C-1 Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
WA Healthy Kids Cross-sectional survey administered to students in grades 6–12 in Washington State Primarily administered in-person in public schools, but private schools may gain access upon request, as can Alternative Learning Experiences, or online learning programs, where survey can be administered remotely	No	Frequency of use, age of first use, co-use with alcohol in past 30 days, driving within 3 hours after use, mode of administration, use of vaping products	Not assessed	Use of other substances, alcohol use, violence (e.g. firearm possession, gang involvement, fighting), depression, attempt at suicide	About 200,000 students in grades 6–12 across the state of Washington take the survey every two years	Fall of even years 2002–2018 Shift to odd years beginning 2021–present	

NOTES: CUD = cannabis use disorder; DSM = Diagnostic and Statistical Manual; ED = Emergency Department; EMR = Electronic Medical Record; MHI-5 = Revised Mental Health Inventory-5; NICU = neonatal intensive care unit; PTSD = Post-traumatic stress disorder.

TABLE C-2. Healthcare Administrative Data Useful for Public Health Surveillance of Cannabis

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Health Insurance System Claims Data							
Medicare Administrative claims data are collected on all Medicare Part A (inpatient), Medicare Part B (outpatient and physician care) and Medicare Part D (prescription drug) claims for those in FFS plans Medicare Advantage (Part C) encounter data may also be available for some enrollees Enrollees are tracked with unique I.D. to view longitudinally	Pre-2015: ICD-9 and CPT codes; 2015 forward: ICD-10 and CPT codes These codes available for any cannabis or other health condition	ICD-9 diagnoses for cannabis abuse, dependence, poisonings, or cannabis-induced psychosis	Not indicated	ICD-9/ICD-10 diagnoses or health events including place of service, CPT codes and NDC codes for prescription drugs; injuries and poisonings included; total charges Information includes timing and cost of the claims, demographic, and eligibility information about the beneficiaries, prescriber and pharmacy I.D., and national drug code	Varies on user's access to the data May be full Medicare population, so all services provided to a Medicare beneficiary that are billed to Medicare, or a 5%–20% random sample of beneficiaries across all states Inclusion of Medicare Advantage (Part C) data varies by access of user	Data are released in annual increments but include dates reflecting day of services rendered	Medicare cover those eligible due to either age (65 years or older) or formal disability status (a 2-year process) Only episodes of care paid for by Medicare are included in the claims data

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Medicaid State Information System (MSIS)/Medicaid Analytic eXtract (MAX) data Person-level data files derived from eligible enrollees in each state's Medicaid program while covered by Medicaid insurance	Pre-2015: ICD-9 and CPT codes; 2015 forward: ICD-10 and CPT codes These codes available for any cannabis or other health condition	ICD-9 diagnoses for cannabis abuse, dependence, poisonings, or cannabis-induced psychosis	Not indicated	ICD-9 /ICD-10 diagnoses or health events including place of service, CPT codes and NDC codes for prescription drugs; injuries and poisonings included; total charges Information includes timing and cost of the claims, demographic, and eligibility information about the beneficiaries, prescriber and pharmacy I.D., and national drug code	Data represent the universe of enrollees receiving healthcare paid for through FFS Medicaid plans within the state, deidentified and without geocoded data about the patient for the duration they are covered by Medicaid Some states also include and release encounter data capturing service utilization without diagnoses from Medicaid enrollees in managed care plans	Annual for each calendar year, although includes service dates so utilization can be examined on a weekly, monthly, or quarterly basis	Data are only available for approved research activity under a DUA with CMS Only records services paid for by Medicaid are included Some states only provide data on FFS plan enrollees, while others include encounter data for managed care Medicaid plans Encounters lack diagnostic and procedural details, so many analyses use only FFS data

Marketscan Commercial Claims and Encounters and Medicare Supplemental Databases Initially compiled by Truven Health in 1995 and taken over by IBM in 2016, the Marketscan data is a family of fully adjudicated claims-based data aggregated across different insurers/ employers on a large number of individuals (>270 million in 2021) enabling examination in healthcare utilization, medication history and history of diseases among the commercially ensured Data include eligibility, adjudicated claims, encounters (for managed care patients), Rx claims, diagnoses, and benefit plan info	Pre-2015: ICD-9 and CPT codes; 2015 forward: ICD-10 and CPT codes These codes available for any cannabis or other health condition	ICD-9 diagnoses for cannabis abuse, dependence, poisonings, or cannabis-induced psychosis Inpatient and outpatient lab tests are also included for some enrollees starting in 2005	Not indicated	ICD-9 /ICD-10 diagnoses or health events including place of service, CPT codes and NDC codes for prescription drugs; injuries and poisonings included; total charges Information includes timing and cost of the claims, eligibility information about the beneficiaries, prescriber and pharmacy I.D., and national drug code	The data represent a very large convenience sample from more than 120 contributing employers and 40 contributing health plans, including 9–12 state Medicaid agencies who are customers of IBM Health and agreed to contribute data (numbers reflect those who contributed in 2021) Subsamples from Medicare (retirees who possess employer-sponsored Medicare-paid plans)	Data are released in annual increments but include dates reflecting day of services rendered	While these data include information on many commercially insured, the data are neither state nor nationally representative of all patients, and inclusion/ exclusion of particular plans and employers can cause shifts in results

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
IQVIA Databases This is a suite of different health databases providing different looks at utilization and cost of different healthcare system utilization either cross-sectionally and longitudinally since 2006, including IQVIA PharMetrics Plus; Medical and Institutional Claims (history and diagnosis); and Ambulatory EMR, containing various types of healthcare/ medical data	ICD-9, ICD-10, and CPT codes included in IQVIA EMR and claims data	ICD-9 diagnoses for cannabis abuse, dependence, poisonings, or cannabis-induced psychosis Inpatient and outpatient lab tests are available in EMR database	Not indicated, but pharmacy data enable identification of patients using FDA-approved cannabis-based medications using NDC codes	ICD-9 /ICD-10 diagnoses or health events including place of service, CPT codes and NDC codes for prescription drugs; injuries and poisonings included; total charges Information includes timing and cost of the claims, eligibility information about the beneficiaries, prescriber and pharmacy I.D., and national drug code	IQVIA databases are all convenience samples of large panels of patients serving different purposes PharMetrics Plus contains nearly 4 billion Rx claims per year, covering approx. 90% of the retail pharmacy channel, 60–85% of Rx mail service and 75–80% long term care providers	Data are released in annual increments but include dates reflecting day of services rendered	Same limitations as mentioned for Marketscan

Dx and Hx
data collects
unadjudicated
office and
medical
claim data on
191 million
patients
A-EMR
collects patient
vitals, health
behaviors and
risk factors
for diagnosis
and treatment
linked to
clinical
diagnoses from
71 million
patients

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Electronic Health Record Data							
Health Systems Node (HSN) of the National Institute on Drug Abuse Clinical Trials Network (CTN)	Each of the 16 HSN health systems maintain integrated electronic health records as well as highly curated virtual data warehouses Pre-2015: ICD-9 codes; 2015 forward: ICD-10 These codes available for any cannabis or other health condition	Screening for cannabis use varies across health systems (see examples from KPNC and KPWA below)	Varies (see examples from KPNC and KPWA below)	CUD; ICD-9/ICD-10 diagnoses; prescription medications; healthcare utilization; cost data	Data represent the universe of members across 16 health plans across the United States	Continuous	Programmers at each site transform EHR and claims data elements from local data systems to a virtual data warehouse standardized set of variable definitions, names, and codes This distributed data model offers an efficient means to conduct multisite studies,

while protecting the identity of patients, providers, and health systems and allowing researchers to access data from larger, more diverse populations than they would otherwise be able to access within their own institution

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Kaiser Permanente Northern California (KPNC)	Pre-2015: ICD-9 codes; 2015 forward: ICD-10 These codes available for any cannabis or other health condition	Pregnant patients: Self-reported frequency of cannabis use during the year before pregnancy and since pregnancy (assessed at the entrance to prenatal care) and urine toxicology tests done as part of standard prenatal care Self-reported mode of cannabis use assessed beginning in 2020/2021	Not assessed	CUD; ICD-9/ICD-10 diagnoses; prescription medications; health care utilization; cost data Can link mothers with their offspring and assess pregnancy, fetal, and neonatal outcomes associated with maternal prenatal use	KPNC serves >4.6 million patients with a socio-demographic profile similar to the local and statewide California population, although the extremes of the income distribution are underrepresented Patient addresses are geocoded	ICD-based diagnoses (continuous) Prenatal cannabis use (beginning in 2009, continuous) Adolescent past-year cannabis use (beginning in 2015, continuous) AMRS data (continuous)	Available in limited settings to connected researchers

Adolescents: Self-reported use of any cannabis during the past year
Patients in addiction medicine and recovery services (AMRS): Urine toxicology testing, self-reported frequency of use
Emergency department: Urine toxicology testing (targeted; not universal)

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Kaiser Permanente Washington (KPWA)	Pre-2015: ICD-9 codes; 2015 forward: ICD-10 These codes available for any cannabis or other health condition	Adults: Prevalence and frequency of self-reported past-year cannabis use in primary care patients using validated single-item screening Daily or near-daily responses trigger additional assessment for CUD, with the psychometrically validated 11-item Substance Use Symptom Checklist to help clinicians assess CUD symptoms	Not assessed	CUD; ICD-9/ICD-10 diagnoses; prescription medications; healthcare utilization; cost data	KPWA serves ~700,000 patients, with a predominantly non-Hispanic, White, insured patient population However, patients have a socio-demographic profile similar to the local and statewide Washington population	Beginning in 2015 (continuous)	Available in limited settings to connected researchers

Patients attending KPWA mental health care are also regularly screened with a behavioral health monitoring tool that includes the single item cannabis screen and prompts for the Substance Use Symptom Checklist

Adolescents: Frequency of past-year cannabis use assessed with S2BI

Urgent Care: Urine toxicology testing (targeted; not universal)

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
University of California, Los Angeles (UCLA) (Exemplar of a localized medical health system data EMR)	Pre-2015: ICD-9 codes; 2015 forward: ICD-10 These codes available for any cannabis or other health condition	Self-administered, automated, electronic health record-based screening for cannabis ever use, past-three-month prevalence and frequency of self-reported cannabis use, use for recreational reasons, medical reasons, or both, symptoms for which they used cannabis, and mode of use among adult primary care patients ASSIST is used to identify risky use among those who use	Medical and recreational (using smart text)	CUD; ICD-9/ ICD-10 diagnoses; prescription medications; healthcare utilization; cost data	The UCLA healthcare system serves a geographically diverse area with over 200 clinics and 4 hospitals and an estimated 250,000 unique patients annually	Beginning in 2021 (continuous)	Available in limited settings to connected researchers

Veterans Health Administration (VHA)	Yes	Use based on urine toxicology tests in certain settings (e.g., emergency department)	Not assessed	CUD; ICD-9/ ICD-10 diagnoses; prescription medications; healthcare utilization; cost data	Largest integrated healthcare system in the U.S., providing care to >5.5 million veterans across the U.S.	Continuous	Available through VHA Corporate Data Warehouse, a data repository for all documented care provided at a VHA facility
Health Facility-Level Administrative data							
Healthcare Cost and Utilization Project (HCUP) Longitudinal, all-payer, encounter-level administrative data; includes 5 nationwide databases (Nationwide Inpatient Sample [NIS], Kids' Inpatient Database [KID], Nationwide Readmissions Database [NRD], Nationwide Ambulatory Surgery Sample [NASS],	As many as 30 diagnoses are collected with the actual number depending on the state data source	None	Unspecified	ICD-9 /ICD-10 diagnoses or health events; injuries and poisonings; total charges	NID = nationally representative sample from the universe of inpatient visits in hospitals among all participating states KID = nationally representative sample from the universe of pediatric inpatient visits in hospitals among all participating states	Annual 1988–current	Data are submitted by hospitals to statewide data organizations; so, the number of participating states and patterns of variables collected depend on the state data source Participating states grow in number over time and range from 27 states (SASD) to 49 states (NID, KID)

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Nationwide Emergency Department Sample [NEDS]) and 3 statewide databases (State Inpatient Databases [SID], State Ambulatory Surgery and Services Databases [SASD], State Emergency Department Databases [SEDD])					SID = state-level census of inpatient visits at hospitals in each participating state NRD = nationally representative sample from the universe of readmissions in hospitals among all participating states NASS = nationally representative sample from the universe of ambulatory surgery encounters in hospitals among all participating states		

SASD = state-level census of ambulatory surgery encounters and other outpatient services in hospitals in each participating state

NEDS = nationally representative sample from the universe of ED visits in hospitals among all participating states

SEDD = state-level census of ED visits at hospitals in each participating state

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
National Ambulatory Medical Care Survey (NAMCS) Cross-sectional national, multistage, probability sample survey of patient visits to nonfederal office-based physicians	Up to 5 diagnosis codes	Medication data collected and medical and non-medical cannabis codes available	Unspecified	Patient-reported reason(s) for visit; ICD-9/10 diagnoses; indicator for injury, trauma, overdose, poisoning or adverse effect	National, multilevel probability sample survey, which can produce estimates at national- and regional-levels	Annual 1973–current	While the survey is designed to provide national and regional estimates, from 2012–2015, the NAMCS sampling design changed to allow estimates to be made for the most populous states In 2006, NAMCS added a sample of physicians and advanced practice clinicians in community health centers (CHCs) These were included in NAMCS through 2011

National Hospital Ambulatory Medical Care Survey (NHAMCS) Cross-sectional national, multistage probability sample survey of ambulatory medical care in hospital emergency and outpatient departments	Up to 5 diagnosis codes	Medication data collected and medical cannabis code available	Unspecified	Patient-reported reason(s) for visit; ICD-9/10 diagnoses; indicator for injury, trauma, overdose, poisoning or adverse effect of treatment	Approximately 500 nationally representative hospitals, which can produce estimates at national- and regional-levels	Annual 1992–2022	In 2012, CHCs became a separate component of the survey NHAMCS is made up of three components: hospital OPD, hospital ED, and hospital-based ASL Starting in 2018, the survey collected data only on ED visits After the collection and processing of the 2022 data file, NHAMCS was discontinued

TABLE C-2. Continued

Datasets	Cannabis-Related Diagnosis Codes	Cannabis Use Variable(s)	Reason for Cannabis Use	Cannabis-Related Health Effect(s)	Sample Representation	Frequency	Notes
Treatment Episode Data System (TEDS) Admissions Data (TEDS-A) and Discharge Data (TEDS-D)	ICD-9/10 codes, up to 3 substances	Primary, secondary, and tertiary substances used by the subject, and their route of administration, frequency of use, and age at first use; number of prior treatment episodes, cannabis abuse, cannabis dependence	Not assessed	CUD, number of previous treatment admissions, other substance use disorder	Represents annual admissions from treatment facilities that receive public funding (including Federal Block Grant funds) Facilities are identified from state licensing records and /or SSA agencies, and hence differences in state systems of licensure, certification, accreditation, and disbursement of public funds affect the scope of facilities included in TEDS across states over time Started in 1992	Annual data with date of service, so episodes can be constructed on a monthly basis Generally released in fall on a 2-year delay	While it is well-understood that facilities operated by private for-profit agencies, hospitals, and the state correctional system are not necessarily included in TEDS, nor are data on facilities operated by federal agencies (e.g. the Bureau of Prisons, the Department of Defense, and the VA), the uniqueness of state licensing requirements and SSA funding requirements can generate significantly different rules of inclusion across states and within a state over time

Drug Abuse Warning Network A nationally representative sample of 53 hospitals collecting data on substance-involved ED visits using trained medical record abstractors who review electronic medical records at participating E.Ds Data include information on patient age, sex, race, ethnicity, census region as well as use of alcohol, illicit drugs, prescription medications, OTC medications, dietary supplements, and non-pharmaceutical inhalants	ICD-10 and lab test results	ICD-10 diagnoses for cannabis abuse, dependence, poisonings, or cannabis-induced psychosis Laboratory test results are also used to identify cannabis use Drugs are classified based on the drug's molecular structure, action in the body, toxicity and misuse potential	Unspecified	Any event generating the medical need for an ED visit, including poisoning, accident, psychosis, heart attack, difficulty breathing or any other acute health event	Every patient visiting the ED at one of the 53 participating hospitals who saw an ED clinician and was not admitted to the hospital subsequently is included in the study Participating hospitals are selected to be geographically representative of the U.S. population	Annual from 2021 forward Data are released annually, but information is provided on a quarterly basis	Data reflect information on people willing to seek ED care from the participating hospitals; this may not be representative of the population impacts overall

NOTES: AMRS = Addiction Medicine Recovery Services; ASL = Ambulatory Surgery Locations; CMS = Centers for Medicaid & Medicare Services; CPT = Current Procedural Terminology; CUD = Cannabis Use Disorder; DSM = Diagnostic and Statistical Manual; ED = Emergency Department; EHR = Electronic Health Record; FFS = Fee-for-service; Hx = history; ICD = International Classification of Disease; NDC = National Drug Code; OPD = Outpatient Departments; OTC = Over the Counter; Rx = prescription; S2BI = Screening to Brief Intervention; SSA = State Substance Abuse.

ADMINISTRATIVE DATA

Administrative data (Table C-3) can be used to monitor several cannabis-related events. Birth records provide information on prenatal cannabis exposure and potential neonatal outcomes. The Fatal Analysis Reporting System (FARS) offers insights into cannabis-associated motor vehicle fatalities. Crime data, including Uniform Crime Reports (UCR) and National Incident-Based Reporting System (NIBRS) arrest data, can reflect potential associations between cannabis and criminal activity. Additionally, mortality data and post-mortem toxicology data (Box C-1), encompassing both drug overdose deaths and suicide statistics, can be a crucial indicator for potential cannabis-related public health concerns.

BOX C-1
Post-mortem Toxicology for Cannabis Related Deaths is Not Forensically Reliable

Postmortem Redistribution (PMR): Tetrahydrocannabidiol (THC) may move from organs to blood after death, making it challenging to use post-mortem THC levels to estimate THC levels at the time of death. Studies show that due to PMR, THC concentration may be higher in peripheral blood (like femoral blood, which is typically used for post-mortem toxicology) compared to blood in the central blood body cavity.

Analyte Stability: THC degrades over time in storage, especially at warmer temperatures. This further complicates the interpretation of postmortem blood THC levels.

Limited Interpretation in Living Subjects: Even in living people, THC concentration does not directly indicate impairment or time of last use.

No Established Lethal Concentration: There is no defined lethal dose of THC, making concentration levels not helpful for determining the cause of death. However, THC can contribute to deaths from impaired driving, etc.

SOURCE: Adapted from Kacinko, 2024.

TABLE C-3. Other Administrative Data Useful for Public Health Surveillance of Cannabis

Datasets	Cannabis Use Variable(s)	Cannabis-Related Health Effect or Other Outcome	Sample Representation	Frequency	Notes
Birth certificate data	No	Infant birthweight, length of gestation, neonatal intensive care unit admission, delivery mode and birth history; maternal tobacco use during pregnancy, maternal morbidity	All births	Continuous, state and county jurisdictions began keeping birth records at different times	Available with state IRB approval and payment Can be linked to maternal prenatal substance use information
National Poison Data System (NPDS) Network of U.S. poison control call centers who report call information from adverse or unexpected acute events involving more than 466,000 different products in near real-time to a central location	Self-reported incidences involving severe adverse reactions or toxicities associated with use of cannabis product or synthetic cannabis Information is reported on cannabis product description, route of exposure, intentional vs unintentional exposure, product dose, product manufacture source, product ownership source, initial vital signs, clinical signs and symptoms, and subject disposition	Adverse event/ unexpected reaction associated with acute use of a cannabis product	NPDS is a data warehouse of all poison center calls made to the nation's 55 poison centers The number of included poison calls has grown over time	Data are extracted by the Poison Control Association of America upon request, so data can be constructed weekly, monthly, quarterly or annually	This data system captures reported incidences, not all ED incidences, and only reflect suspected substance; actual substance generating the adverse reaction may differ from what is reported

TABLE C-3. Continued

Datasets	Cannabis Use Variable(s)	Cannabis-Related Health Effect or Other Outcome	Sample Representation	Frequency	Notes
Fatality Analysis Reporting System (FARS) is a nationwide census of all motor vehicle traffic crashes involving a fatality (whether it was a pedestrian, driver, or rider) reported to the National Highway Traffic Safety Administration (NHTSA).	Blood, urine or saliva testing depending on the state and year Different metabolites/ cannabinoids tested for over the years 1991–1992 tested for cannabinol; 1993 and later tested for cannabinoids	Crash involving a fatality	Census of all fatal injuries suffered in motor vehicle crash at state and national level Cannabis testing not done on all cases in all states	Collected and reported annually since 1975, but details of what/how cannabis was tested for change over the years	Before 2018, FARS recorded drug-involvement for up to 3 substances based on a hierarchy, with narcotics at the top, then depressants, stimulants, hallucinogens, and finally cannabinoids Starting in 2018, FARS began reporting all substances for which there was a positive indication However, not all states uniformly test for cannabinoids and the FARS coding system does not distinguish between active and inactive cannabinoid metabolites

Civil Rights Data Collection (CRDC) Biennial survey required by the U.S. Department of Education's Office for Civil Rights (OCR).	No	Discipline, referrals to law enforcement and school-related arrests, offenses, harassment/ bullying, restraint and seclusion, student enrollment	Collects data from all local public educational agencies and schools that receive federal financial assistance, including justice facilities, charter schools, and alternative schools	Biennial (1968/1969–present)	Data available to download from website
Uniform Crime Reporting (UCR) Program National and state crime estimates for violent and property crime, in addition to 20 other crime categories (including drug possession and drug sales) Data are compiled from law enforcement reports to the FBI or other centralized agency that reports to the FBI	Cannabis use is not measured UCR records instances of cannabis possession, cannabis use in public, and the sale, manufacturing or illicit distribution of cannabis	Cannabis-related misdemeanor or felony offense (possession, use in public, possession with the intent to sale, sale, manufacturing, growing, or distribution)	Voluntary reporting by over 18,000 participating law enforcement agencies of all crimes and arrests Non-reporting agencies are imputed in some months/years, but systematic non-reporters are not reported, so data are lacking for some states and years due to incomplete reporting	Data updated annually, although arrests for some jurisdictions are reported monthly	There are several problems with the UCR data, including the application of the hierarchal rule in reporting: that is, only the most serious offense charged is recorded in the instance, not all related offenses So, cannabis-involvement in other higher order crimes (possession of a concealed weapon, assault) would not be captured offense/crime, or if the crime gets adjudicated down is not recorded in the system

TABLE C-3. Continued

Datasets	Cannabis Use Variable(s)	Cannabis-Related Health Effect or Other Outcome	Sample Representation	Frequency	Notes
National Incidence Base Reporting System (NIBRS) The new FBI standard from 2021 for collecting crime/arrest data Each single incident records all offenses involved (hierarchy rule removed) in addition to information on victims, known offenders, relationship between victims and offenders, arrestees, and property involved in the crime Info on 24 offense categories and 52 offense types included	Cannabis use of only two types is captured: (1) illicit use in public (minor, public land), and (2) law enforcement perceived offender use of the drug	Cannabis-related misdemeanor or felony offense (possession, use in public, possession with the intent to sale, sale, manufacturing, growing, or distribution NIBRS documents cannabis-involved criminal offenses, similar to UCR, but also records law enforcement perception of the offender being under the influence of alcohol or drugs at the time of offense, with up to 3 different drugs being recorded NIBRS captures the types of drugs or narcotics seized during the incident, the amount present, and whether an offender was suspected of using drugs or alcohol at or near the time of the offense	As of 2023, all 50 states and District of Columbia are certified to report incident-based crime/arrest data to NIBRS 77% of the U.S. population is covered by NIBRS-reporting law enforcement agencies There are 119 NIBRS-certified agencies serving cities and counties with a population of at least 250K	Data collected from regional offices on an ongoing basis but synthesized and reported out annually Date and time of day of the incident is recorded in the data, so crimes can be evaluated on a daily, weekly, monthly, quarterly or annual basis	

National Violent Death Reporting System (NVDRS) Collects data regarding violent deaths obtained from death certificates, coroner and medical examiner records, and law enforcement reports State-based active surveillance system that collects data on the characteristics and circumstances associated with violence-related deaths among participating states, and D.C.	No	Toxicology test results for decedents tested	Deaths collected by NVDRS include suicides, homicides, legal intervention deaths (i.e., deaths caused by law enforcement acting in the line of duty and other persons with legal authority to use deadly force, excluding legal executions), unintentional firearm deaths, and deaths of undetermined intent that might have been because of violence	NVDRS data collection began in 2003 with six participating states (MD, MA, NJ, OR, SC, and VA) and has expanded incrementally over time Since 2018, CDC has provided NVDRS funding to all 50 states, the District of Columbia, and Puerto Rico

NOTES: CMS = Centers for Medicare & Medicaid Service; DUA = Data Use Agreement.

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Appendix D

Evidence Review: Methods and Approach

This appendix describes the approach and methods that the committee used to evaluate the literature on the public health consequences on changes in the cannabis policy landscape. Specifically, the task asks the committee to "Review what is known about whether these outcomes have changed in states and localities that have changed their regulatory approach to cannabis and cannabinoids."

The committee conducted an overview of systematic reviews to assemble and review the evidence to determine whether health outcomes have changed due to changes in cannabis policy. Unlike traditional reviews that synthesize primary research, overviews of systematic reviews employ rigorous methods to identify and analyze existing systematic reviews on a specific topic. Rather than summarizing individual studies, overviews assemble evidence and compare results across multiple reviews to paint a broader picture of the evidence landscape (Pollock et al., 2020).

EVIDENCE IDENTIFICATION

Evidence identification consisted of standard steps of literature searching, abstract screening, and full-text review.

Literature Search

A trained medical librarian in the National Academies of Sciences, Engineering, and Medicine Research Center conducted searches in three databases: Ovid Embase Update, Medline, and Scopus. Search terms included

cannabis, cannabis use, and public policy. The only limits on the searches were human studies, classification as review papers, and publication in the English language. The databases were searched on April 25, 2023. The committee also amended the search by including systematic reviews on cannabis policy that were identified subsequently by committee members.

Ovid Embase Update Search Terms

1	Exp Cannabinoid/	89262
2	Cannabis smoking/ OR Cannabis use/ OR Medical cannabis/	17905
3	exp cannabis smoking/ or exp "cannabis use"/	4022
4	1 OR 2 OR 3	96485
5	Drug legislation/ or Government/ or Health care policy/ or Law/ or Legal aspect/ or "Legislation and jurisprudence"/ or Pharmacovigilance/ or Public policy/	658175
6	"systematic review*".mp.	545660
7	4 AND 5 AND 6	100
8	limit 7 to English language	97

Medline Search Terms

1	Exp Cannabinoids/ OR Marijuana smoking/ OR Marijuana/ OR Medical marijuana/	32016
2	"systematic review*".mp.	318864
3	Exp government/ OR Health policy/ OR Jurisprudence/ OR Law enforcement/ OR Legislation as topic/ OR Exp Legislation, drug/ OR Pharmacovigilance/ OR Public health surveillance/ OR Public policy/	321953
4	1 AND 2 AND 3	17
5	limit 4 to English language	16

Scopus Search Terms

TITLE-ABS-KEY (((((cannabidiol OR cannabinoid* OR cannabinol OR cannabis OR dronabinol OR marijuana OR tetrahydrocannabinol OR thc) W/6 ("drug narcotic control" OR "Drug control" OR "drug legislation" OR government* OR "Government regulation*" OR "Health polic*" OR jurisprudence OR "Law enforcement" OR law OR laws OR legal* OR legislati* OR pharmacovigilance OR policy OR policies OR "public health surveillance" OR "Public polic*" OR regulat* OR statute* OR surveillance) AND ("systematic review*")))))

After the literature searches were conducted, retrieved data was imported into Endnote and then uploaded to PICO Portal (https://picoportal.net/). PICO portal is a web-based tool that helps research teams collaborate on systematic reviews. It uses machine learning and artificial intelligence (AI) to order the abstracts reviewed during abstract screening so that the abstracts most likely to be selected will be read first. The literature search identified 248 potentially relevant systematic reviews.

The review used the following population exposure comparison and outcome (PECO) statement:

Population: Review paper
Exposure/Intervention: Evaluates cannabis policy
Comparison: Any comparison group, including internal comparisons
Outcome: Any outcome

The inclusion and exclusion criteria related to the PECO statement were as follows:

Inclusion Criteria: Reviews literature related to the public health impacts of cannabis policy
Exclusion Criteria: Did not review public health impacts of cannabis policy; reviewed only animal or mechanistic studies; reviewed cannabis as medical treatment or impacts of cannabis on individuals

Abstract Screening

One National Academies staff member completed title and abstract screening, with decisions reviewed by the Study Director. Five of 248 relevant abstracts were excluded as duplicates, leaving 243 abstracts for screening. Among the abstracts screened, 183 were excluded, leaving 60 studies for full-text review (Figure D-1).

Full-Text Screening

The full-text screening was completed in PICO Portal using a method similar to the abstract stage. One National Academies staff member completed title and abstract screening, with decisions reviewed by the Study Director. Articles were excluded at the full-text stage for several reasons. Many did not evaluate cannabis policy and thus were evaluating the wrong intervention (n = 40), one was not evaluating a health outcome, and two others were commentaries or other types of papers. Several studies were not systematic reviews; thus, they did not meet population requirements (n = 3). A total of 14 studies met the final inclusion criteria (Figure D-1).

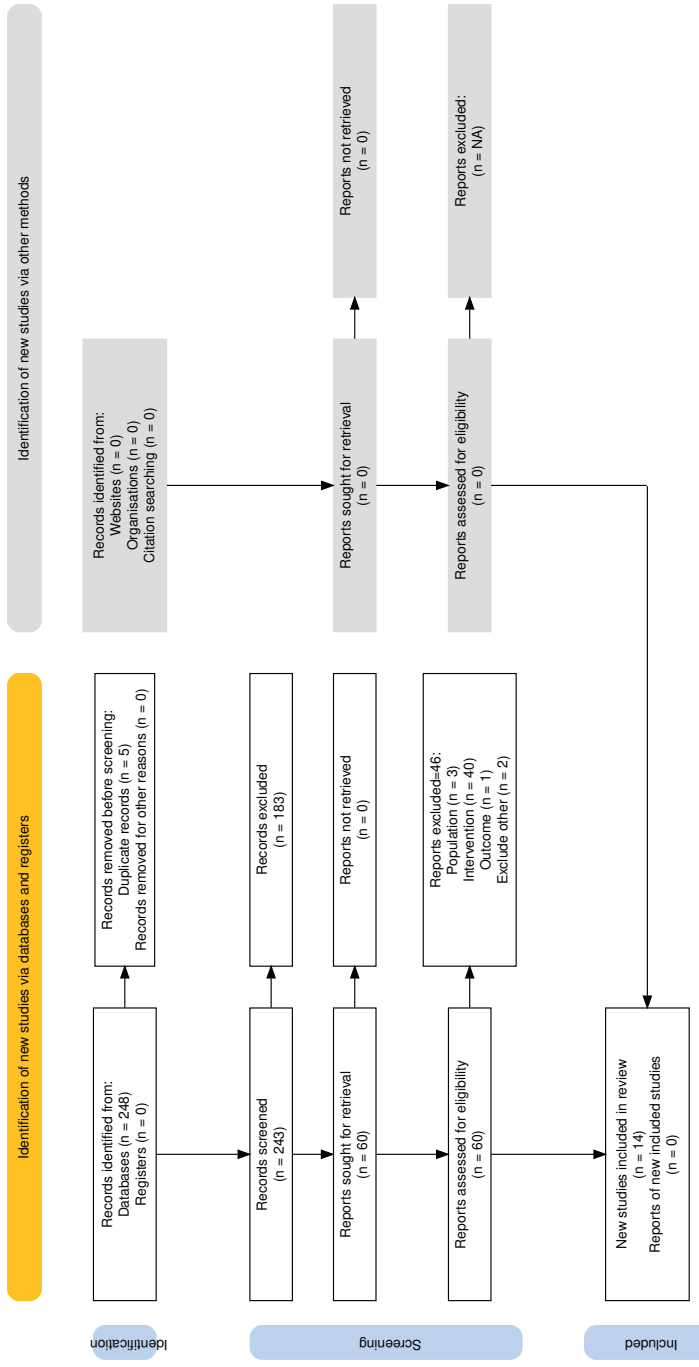

FIGURE D-1 Preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram for the committee's review of reviews on public health effects of changes to the cannabis policy landscape.
SOURCE: Committee generated using an R package and Shiny app for producing PRISMA 2020-compliant flow diagrams (Haddaway et al., 2022).

DATA EXTRACTION

We extracted data from the systematic reviews with one PICO Portal methodologist and verified the data with a second methodologist. The data tables were also reviewed by the Committee. The data abstraction form included the following:

Reference Information: Citations were migrated from PICO Portal with the addition of the two reviews identified after the database searches were completed.
Setting: The place and time for the studies included in the review.
Policy Changes Evaluated: A description of the cannabis policy changes that were reviewed in the study.
Outcomes Evaluated: Description of the outcomes evaluated.
Inclusion/Exclusion Criteria: The inclusion and exclusion criteria.
Study Quality/Risk-of-Bias Assessment Method Used: A description of the method used to assess the quality of the individual studies identified in the review.
Study Designs Identified: A description of the study designs that were found in the study.
Number of Included Studies: The number of papers included after full-text screening in the study.
Findings: A summary of the major findings of the review.
Certainty of the Evidence: A summary of how confident the authors were in the overall conclusions.

EVIDENCE EVALUATION

The 15 systematic reviews were then evaluated for risk of bias using the Risk Of Bias In Systematic Reviews (ROBIS) tool (Whiting et al., 2016). ROBIS is a specifically designed instrument for evaluating the risk of bias in systematic reviews. It has been shown to have adequate internal consistency and strong evidence for measuring the intended construct (Bühn et al., 2017). The ROBIS tool helps to identify potential biases within the systematic review process. The ROBIS tool uses three phases: 1) assesses relevance, 2) identifies concerns with the review process, and 3) judges the risk of bias in the review. Concerns with the systematic review process are captured by considering four key domains: study eligibility criteria, identification and selection of studies, data collection and study appraisal, and synthesis and findings. Signaling questions are used to guide the judgments in each domain, and they are each answered "Yes," "Probably Yes," "Probably No," "No," and "No Information," with "Yes" indicating low concerns about the domain contributing to risk of bias. The subsequent level of concern about bias associated with each domain is then judged as "low," "high," or "unclear" (Whiting et al., 2016).

The domains are then used to guide judgments on the overall risk of bias for each included systematic review, categorized as low, high, or unclear. This assessment uses a similar structure as the process used to assess bias within the key domains. Signaling questions and information are used to support the overall judgment of the risk of bias. The three signaling questions used to judge the overall risk of bias in the review relate to the interpretation of the review findings. The signaling questions cover important areas where bias can be introduced into the review. The first question asks whether interpreting the study findings addresses all the identified concerns with the systematic review process. The second is whether the studies included in the review apply to the research question's goals. The third signaling question is whether the results are balanced and avoid emphasizing only those statistically significant results (Whiting et al., 2016).

STRENGTH-OF-EVIDENCE DETERMINATION

To assess the strength of evidence regarding the association of changes in cannabis policy and impacts on public health, the committee categorized the strength of the association using categories used by other reports of the National Academies (NASEM, 2022). The strength of the evidence is based on the strength and the certainty of the overall body of evidence in the reviews (Figure D-2).

In determining the strength of the evidence, the committee considered the risk of bias in the review, the strength of the evidence as determined by the authors, and other aspects of study quality, such as reporting quality.

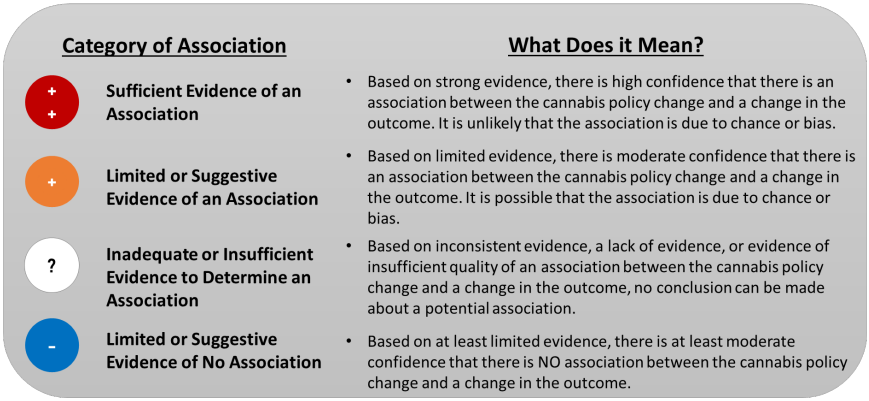

FIGURE D-2 Categories of association used in this report.
NOTES: The categories of association only describe how strong the evidence is between exposure, change in cannabis policy, and the changes in the health outcome.

Many systematic reviews covered overlapping topics; the committee judged the most recently published review to be the most up-to-date assessment of the evidence and relied less on the older reviews in making judgments.

Categories of Association

Sufficient Evidence of an Association

For effects in this category, a positive association between cannabis policy change and the outcome must be observed in studies where chance, bias, and confounding can be ruled out with reasonable confidence. For example, the committee might regard sufficient evidence of association from several small studies that are unlikely to be due to confounding or to be otherwise biased and that show an association that is consistent in magnitude and direction. Experimental data supporting biologic plausibility strengthen the evidence of an association but are not a prerequisite, nor are they sufficient to establish an association without corresponding epidemiologic findings.

Limited or Suggestive Evidence of an Association

In this category, the evidence must suggest an association between exposure to change in cannabis policy and the outcome in studies of humans. Still, the evidence can be limited by an inability to rule out chance, bias, or confounding with confidence. One high-quality study may indicate a positive association, but the results of other studies of lower quality may be inconsistent.

Inadequate or Insufficient Evidence to Determine an Association

If there was not enough reliable scientific data to categorize the potential association with an outcome as "sufficient evidence of an association," "limited or suggestive evidence of an association," or on the other end of the spectrum, "limited or suggestive evidence of no association," the outcome was placed in the category of "inadequate or insufficient evidence to determine an association" by default. In this category, the available human studies may have inconsistent findings or be of insufficient quality, validity, consistency, or statistical power to support a conclusion regarding the presence of an association. Such studies may have failed to control for confounding factors or may have had inadequate assessment of exposure.

Limited or Suggestive Evidence of No Association

A conclusion of "no association" is inevitably limited to the conditions, exposures, and observation periods covered by the available studies, and the

possibility of a small increase in risk related to the magnitude of exposure studied can never be excluded. However, a change in classification from inadequate or insufficient evidence of an association to limited or suggestive evidence of no association would require new studies that corrected for the methodologic problems of previous studies and that had samples large enough to limit the possible study results attributable to chance.

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