Developing Public Health Regulations for Marijuana: Lessons From Alcohol and Tobacco

Rosalie Liccardo Pacula, PhD, Beau Kilmer, PhD, Alexander C. Wagenaar, PhD, Frank J. Chaloupka, PhD, and Jonathan P. Caulkins, PhD

Until November 2012, no modern jurisdiction had removed the prohibition on the commercial production, distribution, and sale of marijuana for nonmedical purposes—not even the Netherlands. Government agencies in Colorado and Washington are now charged with granting production and processing licenses and developing regulations for legal marijuana, and other states and countries may follow. Our goal is not to address whether marijuana legalization is a good or bad idea but, rather, to help policymakers understand the decisions they face and some lessons learned from research on public health approaches to regulating alcohol and tobacco over the past century. (*Am J Public Health.* 2014;104: 1021–1028. doi:10.2105/AJPH.2013.301766)

Marijuana legalization is no longer an abstract notion. In November 2012, voters in Colorado and Washington passed initiatives that not only made it legal to possess up to an ounce of marijuana for nonmedical purposes but also allow for-profit firms to supply the market. Colorado's initiative additionally allows home production. Although marijuana remains illegal under federal law, policymakers in these states are now developing regulatory regimes that will allow licensees to produce and sell marijuana and other cannabis products, including infused candies and other edibles, to anyone who is aged 21 years or older. ("Marijuana" is an American term, customarily applied to the dried leaves and flowers of the cannabis plant. There are other cannabis plant products, including resin, which is referred to in the United States as "hashish." The majority of cannabis consumed in the United States is in the form of marijuana, which is probably why initial state legalization statutes that have passed are specifically about "marijuana" although even these laws do not mean to be restrictive in their terms. For example, Washington speaks of "marijuana-infused" drinks and edibles, and Colorado's Amendment 64 defines "marijuana" to be all possible products of the plant except industrial hemp.) Bills to legalize marijuana are being introduced in other states, and we will likely see more ballot initiatives in future elections.

Although many jurisdictions have experimented with alternatives to strict marijuana prohibition, including decriminalization, medical marijuana, and the Dutch "coffee shops," no industrialized nation has legalized the cultivation, processing, distribution, and supply of marijuana for recreational purposes in the modern era—not even the Netherlands. In the Netherlands, de facto legalization extends only to retail sales of up to 5 grams; wholesale distribution of marijuana to coffee shops remains illegal and is actively enforced. That is not to say that it has never been legal; in fact, marijuana was a legal commodity in the United States until the early 1900s. But regulatory policy on the cultivation, processing, distribution, and sale of marijuana and its derivative products is unprecedented in the modern era.

Because there are no modern examples of marijuana regulation, policymakers are confronting many new questions about how to manage a marijuana market. Should the number of licensees be restricted, and, if so, how should those scarce licenses be allocated? Should vertical integration be allowed, or should there be separate licenses for growing, processing, and selling marijuana? What product safety requirements should be considered (in terms of specific ingredients allowed or disallowed), and who will be responsible for testing the product? How restrictive should licenses be in terms of permitted quantity and potency? Should taxes be assessed per unit weight, as a percentage of value (ad valorem), or on some other basis, such as Δ-9-tetrahydrocannabinol (THC) content? Should marijuana be sold in conventional stores alongside other products or only in specialized venues? What about within-state Internet sales? Although the questions are new for marijuana, policymakers have grappled with similar questions pertaining to alcohol and tobacco, raising the question of what lessons can be learned from these 2 substances and applied to marijuana policy.

We have summarized insights and ideas that grew out of a meeting of alcohol, tobacco, and illicit drug policy experts hosted by the RAND Drug Policy Research Center on February 11, 2013, to foster discussions about how one might regulate marijuana to promote public health objectives assuming a decision to legalize has already been made. The arguments here do not necessarily reflect the opinions of every coauthor but, instead, reflect a general consensus of ideas that grew out of those discussions. The conference was filmed by C-SPAN.[1]

WHY PUBLIC HEALTH REGULATIONS ARE NEEDED

Marijuana has been used for thousands of years. Similar to alcohol, most adults who use marijuana continue to perform their expected social roles and do not exhibit serious problems. Millions of people have derived pleasure from the plant, and there is evidence that some cannabinoids have important medical benefits.[2,3] It is for these and other reasons interested parties have pursued legalization.

Legalization does not imply a lack of regulation, however. Essentially all markets in modern societies are subject to at least some regulation. Although different perspectives and philosophies favor more or less regulation, we have presented the public health perspective

favoring certain types of regulations in light of documented harms associated with marijuana use, particularly for youths.[4,5] Although the magnitude of the various health harms is debated, there are certain acute effects and consequences of chronic use for which the evidence of adverse effects is fairly strong, including panic attacks and increased anxiety, impaired judgment and reaction time, increased probability of experiencing psychotic symptoms, and risk of dependence.[4,6–11] Moreover, the correlation between frequent marijuana use among adolescents and a wide range of adverse outcomes, such as poor educational attainment, is strong although it is difficult to disentangle the effects of use versus other unobservable third factors.[12–14]

Discussions of policy alternatives to prohibition either implicitly or explicitly involve both public health and other objectives, many of which conflict. For example, minimizing consumption by dependent users conflicts with the goal of maximizing tax revenue because the minority of very heavy users account for the majority of consumption and, hence, tax revenues. Thus, it is important to start any discussion of possible regulatory approaches with agreement on common objectives. We have assumed the following objectives, because they are frequently raised in legalization debates as areas of common ground among reformers and those opposed to legalization:

1. minimizing access, availability, and use by youths,
2. minimizing drugged driving,
3. minimizing dependence and addiction,
4. minimizing consumption of marijuana products with unwanted contaminants and uncertain potency, and
5. minimizing concurrent use of marijuana and alcohol, particularly in public settings.

The last objective is motivated by epidemiological and health services research suggesting that concurrent use of alcohol and marijuana may increase the risk of traffic crashes, acute health effects, and other harms relative to using either substance alone.[15–18] However, for some individuals concurrent use could also reduce alcohol consumption and possibly some of the consequences associated with heavy drinking (e.g., aggression). It is impossible to predict how concurrent use will influence social welfare under legalization, and we urge researchers to pay close attention to this relationship. But because of the existing evidence, it seems appropriate, at least initially, to minimize the concurrent use of marijuana and alcohol in public.

Of course, these are not the only public health or policy objectives that one could consider. Some people may want to reduce overall smoking of marijuana (out of concern about adverse effects on the respiratory system) or overall consumption of THC (to reduce impairment). Similarly, some might consider minimizing use in public to reduce perceived normative acceptance and to prevent secondhand smoke exposure, as for tobacco. However, those in favor of legalization may want to allow use in public places and not have restrictions on use or products consumed, should be on the grounds that consumption makes users feel good and such, this consumption makes them feel good, and such policies increase personal liberties. Because of the obvious contention in trying to find common ground on restrictions or limitations on adult use, we have chosen not to include it as an explicit objective, although we recognize there are public health arguments for making reduction in overall use a main goal.

This is not the first time the public health community has struggled to balance competing objectives concerning dependence-inducing products or activities. Obvious analogies include drinking and gambling.[19–23] Lessons can be learned from the repeal of alcohol prohibition. Importantly, the Twenty-First Amendment did not specify a particular form of a regulated market but, rather, left it to the states to experiment with different models, including the option to retain the prohibition. Although no US state today retains a strict prohibition, it is also true that no single regulatory model has emerged, suggesting that there may not be 1 perfect model. Although examples from numerous US states, Russia, Finland, and Sweden demonstrate that state-run monopolies with control of wholesale or retail off-premise sales, prices, locations of outlets, hours of operation, and advertising help control problems associated with excessive drinking,[24–28] such state monopoly controls have gradually decreased within the United States since Prohibition, with most alcoholic beverages in most states now distributed via licensing systems. As noted by Fosdick and Scott, a fundamental characteristic of licensing systems is that they retain the profit motive and, hence, the incentive to increase sales.[20] Evidence from privatization experiments in the United States and abroad has shown that such transitions lead to more outlets, longer hours of operation, increased promotions, and, importantly, increased sales and use.[29–33] Other regulatory strategies have emerged to try to counter the harms created by the licensing system. We have reviewed some approaches that the literature suggests can minimize the threats posed to public health by alcohol and tobacco.

INSIGHTS FROM ALCOHOL AND TOBACCO

What can be done if policymakers are interested in developing regulations that help reduce (1) access, availability, and use by youths; (2) drugged driving; (3) the risk of dependency and addiction; (4) consumption of marijuana products with unwanted contaminants and uncertain potency; and (5) concurrent use of marijuana and alcohol, particularly in public settings? Below are some key insights that can be gleaned from the alcohol and tobacco literature.

Keep Prices Artificially High

Hundreds of studies on tobacco and alcohol show that raising prices reduces consumption and a long list of related health and social harms. Many studies show that raising excise taxes on cigarettes is one of the most effective strategies for reducing early initiation and use, discouraging the transition to being a pack-a-day smoker, and increasing quit attempts even among youths.[34–37] Similarly, higher alcohol taxes and prices have been shown to reduce initiation, binge drinking, drunk driving, and traffic crash rates even among youths.[38–40] Higher alcohol prices are also associated with lower violence and deaths from chronic diseases such as cirrhosis and certain cancers.[39,41,42]

Legalization of marijuana would reduce production costs, perhaps substantially, and that would be expected to lead to lower prices to consumers.[43,44] Although one could try to raise the price of regulated marijuana all the way back to its illegal underground market

price through taxation or fees, such a strategy encourages current illegal producers and sellers to remain in the market or for gray market arbitrage between low- and high-tax jurisdictions. Underground markets have emerged across states, and even across nations, in response to much smaller economic gains per unit weight or volume when smuggling tobacco,[35,45,46] and "home growing" marijuana is easier than home growing tobacco.

Any strategy that involves keeping the price of regulated marijuana high will need to include mechanisms that reduce the incentive for tax-evading underground markets. That can be done in at least 2 ways: (1) designing the regulatory structure around tax collection (e.g., by banning home production and issuing few production licenses), and (2) having strong enforcement and sanctions for those operating outside the regulatory structure. The potential and limitations of such strategies might be inferred from the cases of tobacco and alcohol, in which the underground markets account for variable sizes of the total market in different countries despite designated agencies explicitly charged with providing oversight over, monitoring of, and enforcement in the industry. Thus, there is no guarantee that an underground market in marijuana will not continue to exist, particularly if the legal market imposes significant taxes or restricts the types of marijuana goods that can be sold.

Adopt a State Monopoly

One way to keep price artificially high and reduce underground market competition is a state-run monopoly on production, distribution, and sale. (Note that this model could still allow privatized production and, in the case of marijuana, cultivation and processing if the state monopoly focused entirely on distribution and retail sales.) Research on state alcohol monopolies, and monopolies more generally, have shown that monopolies help keep the price of a good higher through reduced competition, reduce access to alcohol by youths, and reduce overall levels of use.[19,28–30,47,48] State monopolies would be impossible to implement currently in the United States because of continuing federal prohibition. However, it is worth discussing the public health advantages of a tightly controlled state monopoly in case the federal legal landscape changes, either through repeal or amendment of the Controlled Substances Act or with some sort of waivers system.[49]

State stores often sell only the commodity in question—marijuana in this case. That is not unique to a state store model; private stores could also be similarly restricted. And it is not without drawbacks, notably a smaller number of outlets reducing customer convenience. Inconvenience is a cost that helps constrain consumption, and single-purpose stores discourage using the intoxicating substance as a loss leader, effectively cross-subsidizing its consumption with profits from the sale of other substances. The problem of using intoxicants as loss leaders is evident in the case of alcohol, generating considerable policy debate in the United Kingdom and elsewhere, with some movement toward imposing minimum per dose pricing in addition to conventional product taxes to maintain higher prices.[50,51]

As the sole distributor and retailer of marijuana, the state government could more aggressively pursue violators who pretend to be legitimate distributors or retailers because they could be more easily identified as nongovernment employees. With aggressive deterrence against underground market suppliers, the government can set prices at levels higher than otherwise possible. Competition would not push prices lower, as there would be a single supplier. Moreover, having monopoly control of marijuana distribution would facilitate messaging concerning the quality and content of the marijuana product sold, warnings about risks of use, and adherence to point-of-sale advertising restrictions. If the government store sold only unbranded "generic" forms, it would eliminate altogether the incentive for producers to promote their product. Finally, considerable evidence from both the alcohol and tobacco literature suggests that monitoring and frequent enforcement checks of sellers can reduce sales to minors.[52–54] This is easier to accomplish with state-owned stores.

Restrict and Carefully Monitor Licenses and Licensees

If a government monopoly is not possible, the next most preferred option is a strong licensing system in which licenses are required to participate in any part of the supply chain: grower, producer or processor, wholesaler or distributor, and retailer. (One could also require that individual users receive a license to consume.[55–57]) Setting up licensing systems is justified mainly because it allows the government to trace all products and ensure that they meet some minimum quality standards required by law and because the sale of the products can be monitored in terms of excess or insufficient supply. (It is important to note that licensing is necessary but not sufficient for supply to be effectively monitored.) In the case of intoxicating or addictive substances like alcohol and tobacco, however, it can also limit competition (which can keep prices high), enable effective tax collection, limit the density of retail outlets, and reduce the potential for diversion, particularly if licenses are restricted.

Currently, there is no strong evidence about the impact of licensing tobacco retailers on tobacco use, partly because tobacco outlets are so pervasive and policies in this area are just beginning to take shape. The density of tobacco outlets is positively associated with smoking rates, particularly among youths,[58–60] but causality has yet to be definitively ascertained. There is clearer evidence in the tobacco literature that strong licensing provisions that are actively enforced (through regular random compliance checks and imposition of penalties) are effective at limiting sales to minors because of the potential for license revocations or suspensions for violators.[61–63] Moreover, fees collected through the licensing systems provide steady revenues to support active oversight and enforcement by regulatory agencies.[62]

The alcohol literature demonstrates the benefits of outlet licensing more clearly; studies from various disciplines converge in showing a strong positive relationship between alcohol outlet density and alcohol misuse as well as unintentional injuries and crime.[28,64–66] The evidence is so strong that several national and regional health organizations, including the European Commission,[67] the World Health Organization,[68] and the US Department of Health and Human Services,[69] have included recommendations related to licensing restrictions in prevention plans.

Keeping the number of licenses small also helps control the cost of regulating these new businesses and enforcing compliance (because there are fewer entities to oversee). Fewer

licenses make it easier for the government to keep close records on each licensee, making it easier to discover anomalies in their books that could indicate diversion to underground markets.

Rules—even arbitrary, meddlesome, and pointless rules—can also create inefficiency in the industry, keeping costs and hence prices higher. Although normally this is viewed as a cost, not a benefit, of regulation, the welfare effects of higher prices are ambiguous when consumption of that good creates externalities. One could view the 3-tier alcohol supply system, which restricts those with a specific form of license (production, distribution, retail sale) from engaging in the business activities of the other licensees, in this light. This allows states to impose fees (or taxes) at different points in the supply chain and keep the industry from realizing efficiencies that would otherwise emerge from vertical integration.

Licensing retailers who engage in direct to consumer sales can be restricted in a variety of ways, as evidenced by existing alcohol and tobacco restrictions. For example, in the case of tobacco, licensing restricts the type of businesses that can sell tobacco, location of retailers (e.g., distance from schools, parks, and other youth venues), density of retailers (on the basis of, e.g., population and geography), and modes of sales (e.g., bans on vending machines and self-service). Similarly there are many restrictions on retailers of alcohol, including restrictions on locations, modes and hours of sale, and goods that can be sold.

Limit the Types of Products Sold

Although limiting the types of products sold are tied to licensing, regulators can easily overlook its value. An important lesson comes from tobacco policy, however. Although public health warnings have been posted on cigarette cartons since the 1960s, the government was unable to pass legislation allowing the US Federal Drug Administration to regulate the constituents of tobacco products until 2009. It has literally taken decades of scientific evidence for there to be enough political will for the government to step in, and just how the US Federal Drug Administration will use that power remains unclear.[70]

The lesson for marijuana may be to establish authorities' rights to impose regulations from the outset because of how difficult it can be to expand regulatory scope ex post. Subjects for regulation might include what is allowed to be in the product (e.g., additives, flavorings), methods of production (e.g., to reduce pesticides, mold, or other contaminants), "bundling" of marijuana with other inputs (e.g., edibles, nicotine), and limits on THC content. It might also be useful to consider whether high levels of THC can and should be allowed if accompanied by high levels of cannabinoids that are believed to offset some of the effects of THC, like cannabidiol. If governments wait to try to impose such product restrictions or leave the industry to regulate this itself, the outcome could be problematic, as profit motive will likely dominate decisions rather than consumer safety.

Both the alcohol and tobacco industry have developed products that are particularly appealing to youths. Examples include candy and gum cigarettes, alcohol pops, and wine coolers. It seems valuable to impose restrictions on marijuana products targeting youths similar to those imposed on the alcohol and tobacco industry. Although it may be impossible to think in advance of every possible product that could appeal to youths, examining current products would be a useful place to start. The medical marijuana industry already sells THC-infused chocolate bars, peanut butter cups, Rice Krispies treats, hard candies, and lollipops.

Attempt to Limit Marketing

The US doctrine of commercial free speech makes it difficult to limit advertising. However, bans on advertising, promotion, and sponsorship have been achieved in some areas (and in other countries) at times when significant harms were identified (e.g., tobacco and, to a lesser extent, hard liquor and sugary drinks). If the goal is to maintain antismoking norms and keep risk perceptions high to reduce youths' initiation and use of marijuana, comprehensive marketing restrictions can be justified. Moreover, if the federal ban on marijuana legalization remains, market restrictions may in fact be possible because of threat of sanctions from the federal government. (An August 29, 2013, memorandum from the US Department of Justice listed 8 enforcement priorities for federal prosecutors making decisions about marijuana cases in states that have legalized marijuana. One of the priorities is to target firms that not only sell marijuana to children but also market in a manner that is appealing to youths.) The alcohol and tobacco literature have demonstrated positive relationships between tobacco and alcohol advertising, promotion and sponsorship, and youths' use, including product placements in movies and on television and radio.[48,71–74] There is no reason to believe that marijuana marketing would not be equally appealing.

In light of evidence showing that partial restrictions on marketing are largely ineffective at reducing tobacco use because they just lead to a shift of expenditures to other forms of nonbanned marketing,[73] a comprehensive ban on all forms of marijuana marketing might be the ideal. Such an approach would encompass all forms of advertising (e.g., print, television, radio, transit, billboards, point-of-sale, Internet, and social media outlets), promotion (e.g., price discounting, coupons, free sample distribution), sponsorships, and other indirect forms of marketing (e.g., brand stretching, branded merchandise). Approaches for doing this are described in the World Health Organization Framework Convention on Tobacco Control Article 13 guidelines.[75] Additional restrictions recently placed on tobacco in other countries that might be considered for marijuana include complete bans on the retail display (as done in all Canadian provinces and territories, all Australian states and territories, Norway, the United Kingdom, and Iceland) and plain packaging policies (as done in Australia, effectively eliminating the use of the pack as a marketing tool). Such steps, which would arguably appear very restrictive for a relatively harmless product that had already been freely traded in the marketplace, would be minimal for a new product because of its first chance to be legally traded. Opinions differ on whether such marketing restrictions would withstand legal challenges in the United States, but it is clear that efforts to restrict marijuana marketing should be initiated before or at the time marijuana is legalized. Options may exist at that point that will no longer be possible after marijuana sales have become well established.

Restrict Public Consumption

Limiting consumption in public serves 2 purposes: it reduces secondhand exposure to smoked marijuana, and it reduces the extent to which marijuana use is seen by youths as

socially acceptable or normative. The value of reducing secondhand exposure to marijuana smoking is not something that science has clearly established in the way that reducing exposure to secondhand smoke from tobacco has been shown.[76] Nonetheless, nonusers are exposed through secondhand smoke and heavy passive exposure to marijuana can result in measurable THC concentrations in the nonusers' blood serum and urine.[77,78] However, the passive exposure is unlikely to lead to a failed urine test.[79] But for some, exposure to marijuana smoke is as offensive as exposure to tobacco smoke—regardless of the health implications of that exposure.

The second justification for limiting marijuana consumption in public places is the beneficial effect on youths' initiation. The tobacco literature shows that clean indoor air laws targeting public places that youths tend to congregate (e.g., concerts, sporting events, malls, and public transportation) are associated with reduced initiation and self-reported use of cigarettes among children and adolescents.[72,80] Even broad workplace clean indoor air laws (affecting restaurants and the like) have been shown to influence the smoking behavior of youths by influencing antismoking norms.[36] By limiting where marijuana can be consumed, regulators can reduce the exposure youths have to marijuana, perhaps making it less normative and more likely that youths delay initiation or never start at all.

Restrictions on where marijuana can be consumed could also reduce the probability that marijuana and alcohol be used concurrently. Because of the evidence on how concurrent use increases the risk of a traffic crash, restricting place of consumption could have important implications for impaired driving. For example, use could be restricted to establishments that do not allow alcohol to be consumed or to private residences. However, if concurrent use leads to a decrease in alcohol consumption for some individuals, this could also produce some benefits (e.g., reduction in aggression). We cannot predict how concurrent use will influence social welfare under legalization; researchers should pay close attention to this relationship.

Measure and Prevent Impaired Driving

Driving under the influence of marijuana can be dangerous. Even the National Organization for the Reform of Marijuana Laws includes "no driving" in its *Principles of Responsible Cannabis Use*.[81] In their review of research, Room et al. argue that the

> better controlled epidemiological studies have recently provided credible evidence that cannabis users who drive while intoxicated are at increased risk of motor-vehicle crashes.[82(p18)]

More recent literature reviews and meta-analyses reached the same conclusion.[10,83]

Although driving under the influence of marijuana can adversely affect psychomotor performance, the effect is much greater for those driving under the influence of alcohol.[16,84] Research has found that those under the influence of both marijuana and alcohol are at a much greater risk of a crash than are those under the influence of either by itself.[85] Some have argued that THC-impaired drivers compensate by driving more cautiously, but it is also true that it is very difficult to ascertain true impairment because impairment can be affected by a number of individual specific factors, including tolerance, amount of THC consumed, and mode of consumption.[11,86]

Part of the problem of measuring impairment relates to the substance itself and how it is metabolized in the body. The main psychoactive constituent in marijuana is THC, and although its acute psychoactive effects often last only a few hours, it remains detectable in blood for several hours and, for some chronic users, up to 7 days after use.[87] Furthermore, metabolites typically included in specific tests of urine are detectable for even longer.[85,87] Therefore, detection of use can occur well outside the window of impairment.

Although measurement of THC in blood concentration is broadly viewed as the gold standard because it correlates more closely with impairment,[87–89] obtaining blood is invasive and requires transporting the individual to a place where blood can be safely drawn. Urine samples are easier to collect but also a bit invasive, and they correlate less well with true impairment, particularly for cannabis. Oral fluid testing is the least invasive, but until recently these tests have not generated estimates that are as reliable when done in the field as when done in the lab.[90] Tool development continues, but it is a developing field.[88–89]

There is also the problem of determining what level of THC concentration in the blood is a reasonable level at which to say that someone is likely to be impaired. In the only study of its kind, an international team of scientists conducted a meta-analysis of the experimental and epidemiological research to develop a per se limit for THC in blood that would indicate comparable impairment to a blood alcohol concentration of 0.05%.[11] They concluded that a THC concentration in blood serum of 7 to 10 nanograms per milliliter (equivalent to a range of 3.5–5.0 ng/ml in whole blood) is comparable. Both Washington and Colorado set legal limits of THC for driving impairment to 5 nanograms per milliliter as measured in whole blood. Some toxicologists argue attempting to set legal limits for THC that approximate alcohol limits is a mistake.[11] The policy question is whether the allowable level should permit significant impairment for drivers (as the current case for alcohol, allowing driving at modest impairment levels below 0.08) or whether the legally allowable level for THC should be set at a very low level approximating zero impairment (currently in place for alcohol in the United States for drivers younger than 21 years).

If a serious campaign to reduce marijuana-impaired driving is to be undertaken, lessons can be learned from the alcohol literature, in which a variety of strategies have been tried, evaluated, and modified on the basis of prior experience, including alcohol-specific controls (e.g., per se laws, higher prices, higher minimum legal drinking age), enforcement (mandatory fines and jail times for offenders, sobriety check points), transportation (graduated licensing and safety belt laws), and media campaigns. Reviews have been conducted identifying successful and cost-effective strategies, such as raising beer prices and driving under the influence per se laws.[91–92] Reviews have also identified core elements of specific approaches that increase the likelihood of success, such as the meta-analysis by Elder et al.[93] that identified the following: careful planning, solid execution, significant audience exposure, concurrent ongoing prevention activities, and active and visible enforcement of drunk driving laws.

KEY INSIGHTS AND AREAS FOR FUTURE RESEARCH

Reasonable people can disagree about the merits of legalizing marijuana. There is

tremendous uncertainty about its consequences, and individuals hold different beliefs about the value of tangible outcomes (e.g., dependence and psychotic symptoms) and other outcomes such as greater intoxication and personal freedom. We have not taken a position about whether marijuana legalization is a good or bad idea or whether a particular perspective is more or less relevant. Rather, we have provided a starting point for the public health community to start thinking about how specific public and safety goals might be approached under a legal regime and the range of policy options that could be considered in light of them. We have focused on 5 objectives that we hear frequently discussed in legalization debates, and we discussed various regulatory approaches that have been shown to contribute to achieving similar objectives for tobacco and alcohol.

Table 1 summarizes the discussion in "Insights From Alcohol and Tobacco," linking specific regulatory approaches (in terms of evidence of effectiveness) to each of the 5 public health goals. The approaches are not necessarily mutually exclusive. Furthermore, not all of these approaches influence specific goals in the same way or to the same magnitude. Some regulations target a particular behavior directly (e.g., higher prices to decrease youths' use and dependence and impaired driving regulations to reduce drugged driving), whereas others do so indirectly (limits on products sold to reduce the appeal of products to children and, hence, youths' use and future dependence). It is expected that larger effects will be observed when the links are direct or coupled with strong monitoring of compliance and enforcement.

The alcohol and tobacco literature are germane to other issues raised by legalization, such as the design of an overall prevention strategy and strategies for minimizing the criminalization of youths. In some cases, lessons may translate easily because of similarities in the nature of the behaviors or substances (e.g., the continuum of lower risk to higher risk behavior with alcohol consumption or specific alcohol products). However, in other cases the parallels are imperfect. For example, the strategy of reaching a cooperative agreement with the industry self-restricting advertising is greatly complicated because the marijuana industry is highly fragmented, with many small firms instead of a few dominant players. So, although it is valuable to look to the tobacco and alcohol control models, one must be mindful of how the substances' markets differ in terms of the behavior of users and the behavior of suppliers. Society has cycled through different policy approaches with alcohol and tobacco, with times of unregulated free markets, prohibition on production and sales (in the case of alcohol), and proactive regulation; so much can be learned from the experiences of regulating these substances.

However, researchers and agencies must exert greater effort to help evaluate alternative strategies. In particular, more research is needed—and soon—on the relationship between alcohol and marijuana. Notably, one can find studies that support the conclusion that the goods are economic substitutes or that they are complements; the fact is that scientists are still grappling with this question and have not reached a consensus. Furthermore, past research simply does not address the current circumstance, as legalization of commercial marijuana production is unprecedented and could bring many changes (e.g., a substantial decline in marijuana price) that has not been part of the equation when evaluating previous policy changes.

Greater effort needs to be given to data collection in states adopting legalization to assess the impact of regulations and how they are enforced on the use of intoxicating substances. Data tracking marijuana prices, marijuana potency, other cannabinoid constituents, methods of consumption (e.g., smoking a marijuana cigarette vs using e-cigarette–like devices with hash oil), youths' exposure to advertising, commerce among youths, and the like, can provide valuable information for understanding the effects of these policies. Nevertheless, another lesson from the tobacco and alcohol experience is that the full implications of policy changes may not manifest within the first 10 years—let alone the first few years. There can be important consequences that accumulate slowly over time, through generational replacement and industry adaptation.

Finally, even though the current science does not suggest marijuana is as harmful as alcohol or tobacco, there is general agreement among us that if a jurisdiction is going to experiment with something other than prohibition, a restrictive regulatory approach is preferred. (Note that it is possible to regulate while only allowing nonprofit producers and sellers. Jurisdictions have a choice about whether they want to allow for-profit companies to supply the market.) On the basis of the US experience with alcohol and tobacco, in which products were directly marketed and promoted to children, new products were developed to entice young users, and high outlet density led to normalized beliefs and increased use, it seems more prudent from a public health perspective to open up the marijuana market slowly, with tight controls to test the waters and prevent

TABLE 1—Linking Regulatory Approaches to Public Health Objectives

	Public Health Objective to Minimize				
Regulatory Choices	Youths' Access and Use	Drugged Driving	Dependence and Addiction	Unwanted Contaminants and Uncertain Potency	Concurrent Use of Marijuana and Alcohol[a]
Increase prices	X	X	X		?
Create state monopoly	X	X	X	X	X
Restrict and monitor licenses and licensees	X	X	X	X	X
Limit products sold	X	X	X	X	
Limit marketing	X	X	X		X
Restrict public consumption	X	X	X		X
Measure and prevent impaired driving		X			X

[a]It is impossible to predict how concurrent use will influence social welfare under legalization, but because of the existing evidence it seems appropriate, at least initially, to minimize the concurrent use of marijuana and alcohol in public.

gross commercialization of the good too soon. If history is any guide, a laissez-faire approach could generate a large increase in misuse and consequent health and social problems. ■

About the Authors

At the time this work was conducted, Rosalie Liccardo Pacula and Beau Kilmer were with the Drug Policy Research Center, RAND Corporation, Santa Monica, CA. Alexander C. Wagenaar was with the Department of Health Outcomes and Policy, University of Florida College of Medicine, Gainesville. Frank J. Chaloupka was with the Institute for Health Research and Policy, University of Illinois, Chicago. Jonathan P. Caulkins was with the Heinz School of Public Policy, Carnegie Mellon University, Pittsburgh, PA.

Correspondence should be sent to Rosalie Liccardo Pacula, PhD, Co-Director Drug Policy Research Center, RAND Corporation, 1776 Main St, Santa Monica, CA 90407-2138 (e-mail: pacula@rand.org). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted October 13, 2013.

Contributors

R. L. Pacula coordinated and managed this project. All authors contributed significant intellectual content and were involved in conceptualizing, drafting, and revising the article.

Acknowledgments

This article was supported through an honorarium from the Robert Wood Johnson Foundation's Public Health Law Research Program and by internal funds from the RAND Corporation.

Note. Opinions expressed herein are those of the authors and do not necessarily reflect the opinions of either of the funding organizations.

Human Participant Protection

Institutional review board approval was not needed because this research did not involve human participants.

References

1. C-SPAN. Public health effects of state marijuana laws. Available at: http://www.c-span.org/Events/RAND-Corp-Holds-Discussion-on-Public-Health-Effects-of-Marijuana/10737437957-1. Accessed March 11, 2014.

2. Leung L. Cannabis and its derivatives: review of medical use. *J Am Board Fam Med.* 2011;24(4):452–462.

3. Watson SJ, Benson JA, Joy JE. Marijuana and medicine: assessing the science base. a summary of the 1999 Institute of Medicine report. *Arch Gen Psychiatry.* 2000;57(6):547–552.

4. Hall W, Degenhardt L. Adverse health effects of non-medical cannabis use. *Lancet.* 2009;374(9698): 1383–1392.

5. Hall W, Pacula RL. *Cannabis Use and Dependence: Public Health and Public Policy.* Melbourne, Australia: Cambridge University Press; 2003.

6. Moore TH, Zammit S, Lingford-Hughes A, et al. Cannabis use and risk of psychotic or affective mental health outcomes: a systematic review. *Lancet.* 2007; 370(9584):319–328.

7. D'Souza DC, Perry E, MacDougall L, et al. The psychotomimetic effects of intravenous delta-9-tetrahydrocannabinol in healthy individuals: implications for psychosis. *Neuropsychopharmacology.* 2004;29(8): 1558–1572.

8. Anthony JC. The epidemiology of cannabis dependence. In: Roffman RA, Stephens RS, eds. *Cannabis Dependence: Its Nature, Consequences and Treatment.* Cambridge, UK: Cambridge University Press; 2006:58–105.

9. Lynskey MT, Agrawal A, Henders A, Nelson EC, Madden PAF, Martin NG. An Australian twin study of cannabis and other illicit drug use and misuse, and other psychopathology. *Twin Res Hum Genet.* 2012;15 (5):631–641.

10. Armentano P. Cannabis and psychomotor performance: a rational review of the evidence and implications for public policy. *Drug Test Anal.* 2013;5(1):52–56.

11. Grotenhermen F, Leson G, Berghaus G, et al. Developing limits for driving under cannabis. *Addiction.* 2007;102(12):1910–1917.

12. Lynskey M, Hall W. The effects of adolescent cannabis use on educational attainment: a review. *Addiction.* 2000;95(11):1621–1630.

13. McCaffrey DF, Pacula RL, Han B, Ellickson P. Marijuana use and high school dropout: the influence of unobservables. *Health Econ.* 2010;19(11):1281–1299.

14. Ranganathan M, D'Souza DC. The acute effects of cannabinoids on memory in humans: a review. *Psychopharmacology (Berl).* 2006;188(4):425–444.

15. Bramness JG, Khiabani HZ, Morland J. Impairment due to cannabis and ethanol: clinical signs and additive effects. *Addiction.* 2010;105(6):1080–1087.

16. Soderstrom CA, Trifillis AL, Shankar BS, Clark WE, Cowley RA. Marijuana and alcohol use among 1,023 trauma patients: a prospective study. *Arch Surg.* 1988; 123(6):733–737.

17. Polen MR, Sidney S, Tekawa IS, Sadler M, Friedman GD. Health care use by frequent marijuana smokers who do not smoke tobacco. *West J Med.* 1993;158(6):596–601.

18. Pacula RL, Ringel J, Dobkins C, Truong K. The incremental health services cost associated with marijuana use. *Drug Alcohol Depend.* 2008;92(1):248–257.

19. Cook PJ. *Paying the Tab: The Economics of Alcohol Policy.* Princeton, NJ: Princeton University Press; 2007.

20. Fosdick RB, Scott AL. *Toward Liquor Control.* New York: Harper; 1933.

21. Aaron P, Musto D. Temperance and prohibition in America: a historical overview. In: Moore MH and Gerstein DR, eds. *Alcohol and Public Policy: Beyond the Shadow of Prohibition.* Washington, DC: National Academies Press; 1981:127–181.

22. Clotfelter CT, Cook PJ. *Selling Hope: State Lotteries in America.* Cambridge, MA: Harvard University Press; 1991.

23. Thompson WN. *Gambling in America: An Encyclopedia of History, Issues, and Society.* Santa Barbara, CA: ABC-CLIO; 2001.

24. Men T, Brennen P, Boffetta P, Zaridze D. Russian mortality trends for 1991–2001: analysis by cause and region. *BMJ.* 2003;327(7421):964–969.

25. Shkolnikov V, McKee M, Leon DA. Changes in life expectancy in Russia in the mid-1990s. *Lancet.* 2001; 357(9260):917–921.

26. Johansson E, Bockerman P, Prattala R, Uutela A. Alcohol-related mortality, drinking behavior, and business cycles: are slumps really dry seasons? *Eur J Health Econ.* 2006;7(3):215–220.

27. Luoto R, Poikolainen K, Uutela A. Unemployment, sociodemographic background and consumption of alcohol before and during the economic recession of the 1990s in Finland. *Int J Epidemiol.* 1998;27(4): 623–629.

28. Wagenaar AC, Holder HD. Changes in alcohol consumption resulting from the elimination of retail wine monopolies: results from five U.S. states. *J Stud Alcohol.* 1995;56(5):566–572.

29. Wagenaar AC, Holder HD. A change from public to private sale of wine: results from natural experiments in Iowa and West Virginia. *J Stud Alcohol.* 1991;52(2): 162–173.

30. Her M, Giesbrecht N, Room R, Rehm J. Privatizing alcohol sales and alcohol consumption: evidence and implications. *Addiction.* 1999;94(8):1125–1139.

31. Macdonald S. The impact of increased availability of wine in grocery stores on consumption: four case histories. *Br J Addict.* 1986;81(3):381–387.

32. Edwards G. *World Health Organization. Alcohol Policy and the Public Good.* Oxford, UK: Oxford University Press; 1994.

33. Holder H, Agardh E, Högberg P, et al. *If Retail Alcohol Sales in Sweden Were Privatized, What Would Be the Potential Consequences?* Stockholm: Swedish Institute for Public Health; 2007.

34. Lillard DR, Malloy E, Sfekas A. Smoking initiation and the iron law of demand. *J Health Econ.* 2013;32(1): 114–127.

35. Chaloupka FJ, Yurekli A, Fong GT. Tobacco taxes as a tobacco control strategy. *Tob Control.* 2012;21(2): 172–180.

36. International Agency for Research on Cancer. *IARC Handbooks of Cancer Prevention, Tobacco Control, Volume 13: Evaluating the Effectiveness of Smoke-Free Policies.* Lyon, France: International Agency for Research on Cancer; 2009.

37. Chaloupka FJ, Warner KE. The economics of smoking. In: Culyer AJ and Newhouse JP, eds. *Handbook of Health Economics.* Oxford, UK: Elsevier; 2000:1539–1627.

38. Grossman M, Chaloupka FJ, Saffer H, Laixuthai A. Effects of alcohol price policy on youth: a summary of economic research. *J Res Adolesc.* 1994;4(2):347–364.

39. Xu X, Chaloupka FJ. The effects of prices on alcohol use and its consequences. *Alcohol Res Health.* 2011; 34(2):236–245.

40. Ruhm CJ. Alcohol policies and highway vehicle fatalities. *J Health Econ.* 1996;15(4):435–454.

41. Cook PJ, Tauchen G. The effect of liquor taxes on heavy drinking. *Bell J Econ.* 1982;13(2):379–390.

42. Wagenaar AC, Tobler AL, Komro KA. Effects of alcohol tax and price policies on morbidity and mortality: a systematic review. *Am J Public Health.* 2010;100(11): 2270–2278.

43. Kilmer B, Caulkins JP, Pacula RL, MacCoun R, Reuter PH. *Altered State? Assessing How Marijuana Legalization in California Could Influence Marijuana Consumption and Public Budgets* Santa Monica, CA: RAND Corporation; 2010. No. OP-315-RC.

44. Caulkins J, Hawken A, Kilmer B, Kleiman M. *Marijuana Legalization: What Everyone Needs to Know.* New York, NY: Oxford University Press; 2012.

45. Joossens L, Chaloupka FJ, Merriman D, Yurekli A. Issues in the smuggling of tobacco products. In: Jha P, Chaloupka FJ, eds. *Tobacco Control in Developing Countries.* Oxford, UK: Oxford University Press; 2000:393–406.

46. Joossens L, Raw M. Smuggling and cross border shopping of tobacco in Europe. *BMJ.* 1995;310 (6991):1393–1397.

47. Miller T, Snowden C, Birckmayer J, Hendrie D. Retail alcohol monopolies, underage drinking, and youth impaired driving deaths. *Accid Anal Prev.* 2006;38(6): 1162–1167.

48. Babor TF, Caetano R, Casswell S, et al. *Alcohol: No Ordinary Commodity: Research and Public Policy.* New York, NY: Oxford University Press; 2003.

49. Kleiman MAR. Cooperative enforcement agreements and policy waivers: new options for federal accommodation to state-level cannabis legalization. *J Drug Policy Anal.* 2013;6(1):1941–2851.

50. Stockwell T, Zhao J, Giesbrecht N, Macdonald S, Thomas G, Wettlaufer A. The raising of minimum alcohol prices in Saskatchewan, Canada: impacts on consumption and implications for public health. *Am J Public Health.* 2012;102(12):e103–e110.

51. Rice P, Drummond C. The price of a drink: the potential of alcohol minimum unit pricing as a public health measure in the UK. *Br J Psychiatry.* 2012;201 (3):169–171.

52. DiFranza JR, Dussault GF. The federal initiative to halt the sale of tobacco to children—the Synar Amendment, 1992–2000: lessons learned. *Tob Control.* 2005;14(2):93–98.

53. Sloan FA, Stout EM, Whetten-Goldstein K, Liang L. *Drinkers, Drivers, and Bartenders: Balancing Private Choices and Public Accountability.* Chicago, IL: University of Chicago Press; 2000.

54. Stead LF, Lancaster T. A systematic review of interventions for preventing tobacco sales to minors. *Tob Control.* 2000;9(2):169–176.

55. Kleiman MAR. *Against Excess: Drug Policy for Results.* New York, NY: BasicBooks; 1992.

56. Room R. Individualized control of drinkers: back to the future? *Contemp Drug Probl.* 2012;39(2):311–343.

57. Kilmer B, Humphreys K. Losing your 'license to drink': The radical South Dakota approach to heavy drinkers who threaten public safety. *Brown J World Aff.* In press.

58. Henriksen L, Feighery EC, Schleicher NC, Cowling DW, Kline RS, Fortmann SP. Is adolescent smoking related to the density and proximity of tobacco outlets and retail cigarette advertising near schools? *Prev Med.* 2008;47(2):210–214.

59. Novak SP, Reardon SF, Raudenbush SW, Buka SL. Retail tobacco outlet density and youth cigarette smoking: a propensity-modeling approach. *Am J Public Health.* 2006;96(4):670–676.

60. Schneider JE, Reid RJ, Peterson NA, Lowe JB, Hughey J. Tobacco outlet density and demographics at the tract level of analysis in Iowa: implications for environmentally based prevention initiatives. *Prev Sci.* 2005;6(4):319–325.

61. Ma GX, Shive S, Tracy M. The effects of licensing and inspection enforcement to reduce tobacco sales to minors in Greater Philadelphia, 1994–1998. *Addict Behav.* 2001;26(5):677–687.

62. American Lung Association. Tobacco retailer licensing is effective. 2012. Available at: http://center4tobaccopolicy.org/documents/tobacco-retailer-licensing-is-effective-august-2012. Accessed March 11, 2014.

63. DiFranza JR. Which interventions against the sale of tobacco to minors can be expected to reduce smoking? *Tob Control.* 2012;21(4):436–442.

64. Task Force on Community Preventive Services. Recommendations for reducing excessive alcohol consumption and alcohol-related harms by limiting alcohol outlet density. *Am J Prev Med.* 2009;37(6):570–571.

65. Campbell CA, Hahn RA, Elder R, et al. The effectiveness of limiting alcohol outlet density as a means of reducing excessive alcohol consumption and alcohol-related harms. *Am J Prev Med.* 2009;37(6):556–569.

66. Popova S, Giesbrecht N, Bekmuradov D, Patra J. Hours and days of sale and density of alcohol outlets: impacts on alcohol consumption and damage: a systematic review. *Alcohol Alcohol.* 2009;44(5):500–516.

67. World Health Organization. European alcohol action plan 2000–2005. Available at: http://www.euro.who.int/en/health-topics/disease-prevention/alcohol-use/publications/pre-2009/european-alcohol-action-plan-20002005. Accessed March 11, 2014.

68. World Health Organization. Global strategy to reduce the harmful use of alcohol. 2010. Available at: http://www.who.int/substance_abuse/activities/gsrhua/en. Accessed October 8, 2013.

69. Grover P, ed. *Preventing Problems Related to Alcohol Availability: Environmental Approaches.* Rockville, MD: US Department of Health and Human Services; 1999. DHHS Publication No. SMA 99-3298.

70. Husten CG, Deyton LR. Understanding the Tobacco Control Act: efforts by the US Food and Drug Administration to make tobacco-related morbidity and mortality part of the USA's past, not its future. *Lancet.* 2013; 381(9877):1570–1580.

71. US Department of Health and Human Services. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General.* Rockville, MD: Public Health Service, Office of the Surgeon General; 2012.

72. National Cancer Institute. *The Role of the Media in Promoting and Reducing Tobacco Use.* Bethesda, MD: US Department of Health and Human Services, National Institutes of Health; 2008. Tobacco Control Monograph No. 19.

73. Saffer H, Chaloupka FJ. The effect of tobacco advertising bans on tobacco consumption. *J Health Econ.* 2001;19(6):1117–1137.

74. Anderson P, Bruijn A, Angus K, Gordon R, Hastings G. Impact of alcohol advertising and media exposure on adolescent alcohol use: a systematic review of longitudinal studies. *Alcohol Alcohol.* 2009;44(3):229–243.

75. World Health Organization. Guidelines for implementation of Article 13 of the WHO framework convention on tobacco control. Available at: http://www.who.int/fctc/guidelines/article_13.pdf. Accessed March 11, 2014.

76. US Department of Health and Human Services. *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General.* Washington, DC: 2006.

77. Cone EJ, Johnson RE. Contact highs and urinary cannabinoid excretion after passive exposure to marijuana smoke. *Clin Pharmacol Ther.* 1986;40(3):247–256.

78. Mørland J, Bugge A, Skuterud B, Steen A, Wethe GH, Kjeldsen T. Cannabinoids in blood and urine after passive inhalation of cannabis smoke. *J Forensic Sci.* 1985;30(4):997–1002.

79. Niedbala RS, Kardos KW, Fritch DF, et al. Passive cannabis smoke exposure and oral fluid testing. II. Two studies of extreme cannabis smoke exposure in a motor vehicle. *J Anal Toxicol.* 2005;29(7):607–615.

80. Levy DT, Friend KB. The effects of clean indoor air laws: what do we know and what do we need to know? *Health Educ Res.* 2003;18(5):592–609.

81. National Organization for the Reform of Marijuana Laws. Principles of responsible cannabis use. 1996. Available at: http://norml.org/about/intro/item/principles-of-responsible-cannabis-use-3. Accessed March 11, 2014.

82. Room R, Fischer B, Hall W, Lenton S, Reuter P. *Cannabis Policy: Moving Beyond Stalemate.* Oxford, UK: Oxford University Press; 2010.

83. Li MC, Brady JE, DiMaggio CJ, Lusardi AR, Tzong KY, Li G. Marijuana use and motor vehicle crashes. *Epidemiol Rev.* 2012;34(1):65–72.

84. Smiley A. On road and driving simulator studies. In: Kalant H, Corrigal W, Hall W, Smart R, eds. *The Health Effects of Cannabis.* Toronto, Canada: Addiction Research Foundation; 1999.

85. Ramaekers JG, Berghaus G, van Laar M, Drummer OH. Dose related risk of motor vehicle crashes after cannabis use. *Drug Alcohol Depend.* 2004;73(2):109–119.

86. Jones AW, Holmgren A, Kugelberg FC. Driving under the influence of cannabis: a 10-year study of age and gender differences in the concentrations of tetrahydrocannabinol in blood. *Addiction.* 2008;103(3):452–461.

87. Lee D, Milman G, Barnes AJ, Goodwin RS, Hirvonen J, Huestis MJ. Oral fluid cannabinoids in chronic, daily cannabis smokers during sustained, monitored abstinence. *Clin Chem.* 2011;57(8):1127–1136.

88. Verstraete AG. More reliable on-site detection of cannabis in oral fluid. *Clin Chem.* 2012;58(10):1389–1391.

89. Desrosiers NA, Lee D, Schwope DM, et al. On-site test for cannabinoids in oral fluid. *Clin Chem.* 2012;58 (10):1418–1425.

90. DuPont RL, Voas RB, Walsh JM, Shea C, Talpins SK, Neil MM. The need for drugged driving per se laws: a commentary. *Traffic Inj Prev.* 2012;13(1):31–42.

91. Wagenaar AC, Maldonado-Molina MM, Ma L, Tobler AL, Komro KA. Effects of BAC limits on fatal crash involvement: analyses of 28 states from 1976 through 2002. *J Safety Res.* 2007;38(5):493–499.

92. Kenkel DS. Do drunk drivers pay their way? A note on optimal penalties for drunk driving. *J Health Econ.* 1993;12(2):137–149.

93. Elder RW, Shults RA, Sleet DA, Nichols JL, Thompson RS, Rajab W. Effectiveness of mass media campaigns for reducing drinking and driving and alcohol-involved crashes: a systemic review. *Am J Prev Med.* 2004;7(1):57–65.