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Lessons from Tobacco For Developing Marijuana Legalization Policy

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EXECUTIVE SUMMARY

- The state of the marijuana market is similar to where tobacco was at the turn of the 20th century, before cigarettes were mass-produced using mechanization, heavily engineered to maximize addictive potential, and marketed using national brands and modern mass media.
- Tobacco products are designed to maximize use through use of flavours and the physical construction of the products.
- While in part because of relatively low use (compared to tobacco) and the fact that marijuana and tobacco are often used together, the specific health dangers of marijuana are not yet fully defined.
- Predominately, both substances are smoked/inhaled, which makes the onset of effects rapid and the potential for abuse high.
- The similarities between tobacco and marijuana) are that both substances affect similar areas of the brain involved in regulating pleasure, reward, and dependence. Co-use reinforces the effects of both drugs and contributes to the addiction potential of marijuana
- Co-use also highlights the potential for a tobacco-style marijuana industry emerging but also the likelihood that policies that have been successful at reducing and preventing tobacco use would probably also be appropriate for minimizing marijuana use if it is legalized.
- Marijuana smoke has a similar toxicity profile as tobacco smoke, and has been linked to cancer, heart and other diseases.
- Other forms, such as edibles, oils and vaporised marijuana have other risk profiles that are not yet well defined.
- The four US states that have legalized retail marijuana to date have implemented regulatory regimes that are largely modeled on alcohol policy.
- Business interests in the United States consider marijuana as potential for significant market growth.
- Legalizing marijuana opens the market to major corporations, including tobacco companies, which have the financial resources, product design technology, marketing power, and political clout to quickly transform the marijuana market.
- While there has not yet been major corporate entry into the market, it is likely that this will change once corporations, including the tobacco companies, consider the political environment favorable.
- Experience from tobacco control shows that it is very difficult to prevent youth smoking without addressing adult smoking.
- Prohibitions on tobacco marketing, strong graphic warning labels, aggressive media campaigns, smokefree environments and taxation are effective policies that have reduced tobacco use and could be applied to minimize use and health impacts of legalized marijuana.
- There are enough similarities between tobacco and marijuana products that the evidence and experience from successful tobacco control programs could form the basis for a public health approach to legalizing marijuana.
- The principles defined in the WHO Framework Convention on Tobacco Control could form the basis for a public health approach to legalizing marijuana, which would seek to minimize industry influence in the policy process and to minimize consumption of marijuana products and the associated health risks of a new legal marijuana market.

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INTRODUCTION

Although marijuana is predominately illegal worldwide, its estimated use is increasing around the world.[1, 2] In contrast, tobacco is legal, but its use is declining. The challenge facing policymakers is to develop appropriate regulatory frameworks that avoid population level harms that are associated with increased consumption of marijuana products.[3-5] One approach would be to implement policies to create a social and legal environment in which people are no longer prosecuted for using marijuana but, like tobacco, its use is socially not acceptable.[6]

Popular support for marijuana legalization has shifted in recent years to somewhere between decriminalization to full legalization.

This report provides information to inform development of marijuana legalization policies by providing the following information:

- High level review of the existing evidence on the effectiveness of tobacco control legislation and policies in relation to restrictions in marketing and advertising, product packaging and labelling, public education and product engineering (eg. product types and delivery methods, flavouring) in reducing risks to public health.
- An analysis of jurisdictions that are on the lower and higher end of the spectrum of tobacco control policies, and how these policies impact risk perceptions, social norms, tobacco use rates, and prevalence of tobacco-related disease in these jurisdictions.

Issues Raised by a Commercialized Marijuana Market

A commercialized marijuana market has not been open anywhere in the world long enough to reliably evaluate the effectiveness of programs designed to minimize use or evaluate the health consequences of the kind of increased use expected to follow legalization. Using the precautionary principle, governments could learn from past and present regulatory successes and failures in tobacco control,[6] and use this knowledge to inform the policy making process for retail marijuana.

Legalizing medical and retail marijuana markets, without adequate evidence supporting marijuana's therapeutic benefit,[7] opens the door to multinational corporations—including the tobacco companies—that could market retail marijuana products as medicinal and safe.[8] Indeed, the tobacco companies seriously considered entering the marijuana market in the late 1960s when legalization for medical use seemed a real possibility.[9] The history of tobacco[10-13] and alcohol[14-16] control shows that these companies use aggressive marketing strategies and political tactics to increase and sustain tobacco and alcohol use, including wielding their economic and political power to fight effective public health regulations. A key impediment to the development and implementation of effective public health policies is the existence of a wealthy, sophisticated, and politically powerful industry that recognizes the threats to their profitability that effective government regulation to minimize use and sales represents. This history illustrates the risks of corporate capture of the marijuana market.

As of 2016, the legal marijuana industry in the United States was already considering ways to maximize profit by targeting daily users.[17] A 2016 report by *Marijuana Business Daily* states:

> Another strong positive indicator for the industry is that the majority of people who use cannabis, both on the medical and recreational sides of the industry, consume marijuana every single day. These individuals form the backbone of the industry.[18]

Whether or not widespread daily use will materialize with marijuana will depend on how policymakers and society structures and regulates the production, distribution, marketing, and sale of the newly legalized marijuana market, and how the new legal marijuana industry operates.

From a public health perspective, two characteristics of the tobacco market that have not yet fully materialized for the new marijuana market are important when thinking about proactive policy development for marijuana:

- Marijuana has not yet been subject to advent of branding, mass marketing, and advertising
- Marijuana businesses have not had the capacity to develop heavily engineered products designed to increase and maximize consumption

A key policy decision that government is faced with is whether to minimize regulation or employ the precautionary principle concurrently with legalization.[19, 20] There is a risk that minimizing regulation could allow for the growth of a politically powerful marijuana industry that uses modern marketing and product engineering to maximize use and profits, with the associated public health costs. In contrast, the precautionary principle could help to avoid some of the social and health costs of marijuana commercialization through implementation of policies to minimize consumption based on the available evidence.[6]

In addition, strict product regulations that would prohibit the kind of sophisticated product engineering used to maximize use that the tobacco industry developed for cigarettes[21, p. 151-186, 22-31] and that the food industry developed for soft drinks and manufactured foods high in sugar, fat, and salt[32] could help restrain use. One approach would be to implement a government monopoly over the production and distribution of cannabis which would, by policy, not advertise or engineer products to maximize use. Another would be to restrict access to cannabis cooperatives where marijuana users grow marijuana for personal use and where distribution for remuneration is strictly prohibited, modelled on those implemented in Uruguay,[33] Spain,[34] and Belgium.[35]

ADDICTION: TOBACCO AND MARIJUANA

While the psychoactive agents in tobacco and marijuana are chemically different (i.e. nicotine in tobacco and THC in marijuana), both agents have similar effects on the regulation of dopamine levels in the brain[36] and research has shown that dopamine plays an important role in regulating pleasure, motivation, reward and addiction/dependence.[37-40]Furthermore, both tobacco and cannabis are mostly consumed by inhalation (e.g., smoking, vaping), and this mode of administration leads to rapid increases in levels of nicotine or THC in the brain closely followed

in time by varying psychoactive effects. Inhalation is also the form of administration most likely to lead to abuse, tolerance and addiction (second to intravenous administration) as the speed of onset of psychoactive effects from drugs of abuse is strongly associated with drug abuse potential addiction/dependence.[41]

The US Surgeon General concluded that nicotine was an addictive drug in 1988.[42] The tobacco industry, however, recognized that nicotine was an addictive drug in the 1960s and used its sophisticated understanding of nicotine pharmacology to design cigarettes to maximize addictive potential and, so, cigarette consumption and industry sales and profits.[22, Chapter 3]

The US National Institute on Drug Abuse described marijuana addiction as follows:[43]

> Marijuana use can lead to the development of problem use, known as a marijuana use disorder, which in severe cases takes the form of addiction. Recent data suggest that 30 percent of marijuana users may have some degree of marijuana use disorder.[44] People who begin using marijuana before the age of 18 are 4 to 7 times more likely to develop a marijuana use disorder than adults.[45]
>
> Marijuana use disorders are often associated with *dependence*—in which a user feels withdrawal symptoms when not taking the drug. Frequent marijuana users often report irritability, mood and sleep difficulties, decreased appetite, cravings, restlessness, and/or various forms of physical discomfort that peak within the first week after quitting and last up to 2 weeks.[46, 47] Marijuana dependence occurs when the brain adapts to large amounts of the drug by reducing production of and sensitivity to its own *endocannabinoid* neurotransmitters. [48, 49]
>
> Marijuana use disorder becomes addiction when the person cannot stop using the drug even though it interferes with many aspects of his or her life. Estimates of the number of people addicted to marijuana are controversial, in part because epidemiological studies of substance use often use dependence as a proxy for addiction even though it is possible to be dependent without being addicted. Those studies suggest that 9 percent of people who use marijuana will become dependent on it,[50, 51] rising to about 17 percent in those who start using young (in their teens).[52, 53]
>
> In 2014, 4.176 million people in the U.S. abused or were dependent on marijuana;[54] 138,000 voluntarily sought treatment for their marijuana use.[55] [citations transferred from NIDA website to reference list for this report[43]]

The adolescent brain, particularly the prefrontal cortex areas controlling judgment and decision-making, is not fully developed until the mid-20s, which creates the possibility that exposure of the developing brain to marijuana could have long-term effects,.[56] including increased risk of addiction/dependence. Similarly, with tobacco, the younger an adolescent is when she or he begins using tobacco, the more likely they are to develop addiction/dependence.[57, p. 184] The fact that the brain is not fully developed until the mid-20s also raises concern about the adequacy of marijuana prevention programs that are limited to or focused on youth.

There are several similarities between tobacco and marijuana: both substances are for the most part smoked/inhaled, the onset of effects is rapid and therefore the potential for abuse is high, both substances affect similar areas of the brain involved in regulating pleasure, reward and addiction/dependence,[36] both substances are often used together, and co-use reinforces the effects of both drugs and contributes to the addiction potential of marijuana,[58, 59] all highlight the potential for a tobacco-style marijuana industry emerging and the likelihood that policies that have been successful at reducing and preventing tobacco use may also be appropriate for minimizing marijuana use if it is legalized.

In addition marijuana and tobacco use behaviors are closely linked in youth and young adults. Marijuana use among adolescents and young adults increases their chance of becoming a smoker anywhere from two to twelve fold.[60] Similarly, adolescents and young adults who use tobacco are two to fifty-two times more likely to use marijuana.[60] These linkages highlight the need to consider both substances and also highlights the attractiveness to join marketing and branding of marijuana and tobacco products for businesses seeking to maximize consumption and profits.

MARIJUANA RISKS AND HARMS

The harms of marijuana do not currently approach those of tobacco or alcohol, likely as a result of the fact that marijuana is illegal in most places, with the result that widespread regular heavy marijuana use is uncommon, and few users become lifetime marijuana smokers.[61, 62] It is also likely that the individual-level risks of cannabis use are underestimated.[63] The specific levels of both population and individual risks will depend on how use patterns change in the new legalized market. It is, for example, possible that marijuana could turn out to be as harmful as tobacco if marijuana use patterns eventually resemble current tobacco use.

Marijuana is used by tobacco smokers separately or in combination with tobacco in various forms including “spliffs,” cigarettes that contain a combination of marijuana and tobacco. Dual users may also smoke blunts or marijuana flower wrapped inside tobacco leaves, cigars or cigarillos, or “blunt chase”—the act of following marijuana smoking with (menthol) cigarette smoking. This pattern in particularly common among African American in the United States (74% black females; 83% black males).[64] Electronic cigarettes (e-cigarettes) establish another link between marijuana and tobacco, as open-system e-cigarettes may be used equally for delivering tetrahydrocannabinol (THC) and/or nicotine.[65] Co-use of marijuana and tobacco presents undesirable effects, such as difficulty in quitting both substances.[60] Nonsmoking youth and young adults who use marijuana are more likely to start using tobacco and suffer nicotine addiction.[66, 67]

The fact that co-use of marijuana with tobacco[60, 67] and alcohol[68] is common makes it difficult to quantify the health effects of marijuana alone or the possible synergistic effects with these other substances. This situation may change as marijuana use increases and tobacco use declines. The technical difficulties of precisely quantifying the magnitudes of particular health effects of marijuana use in isolation should not be interpreted as affirmative evidence for benign or safe effects of marijuana use.

Regardless of whether marijuana is more or less harmful than tobacco or alcohol, it is not harmless.[69] Marijuana smoke has a similar toxicity profile as tobacco smoke,[70, 71] and the California Environmental Protection Agency has identified marijuana as a cause of cancer.[72] One minute exposure to secondhand marijuana smoke significantly impairs vascular function in ways that increase the risk for cardiovascular disease.[73] Case-control studies conducted in Europe have found associations between smoking highly potent marijuana flower with an increased risk of cardiovascular disease, heart attack, and stroke in young adults.[68]

Acute risks associated with marijuana and marijuana product (i.e., concentrates, edibles) use can include anxiety, panic attacks, and paranoia. Generally, adolescents with a personal or family history of schizophrenia are the most at risk for psychotic symptoms.[69, 74] There is strong evidence to support preventing marijuana use in adolescence. Compared to those who began use in adulthood, adolescents were more likely to develop psychosis.[75] Developing psychosis and psychotic symptoms may be made worse through regular and frequent use.[63] Heavy marijuana consumption during adolescence is associated with an earlier onset of schizophrenia. The direction of causality is not clear; it is possible that teens use marijuana to deal with the onset of schizophrenia and its associated health problems.[76]

Other health risks associated with frequent and chronic use in youth and vulnerable populations can include long-lasting detrimental changes in cognitive function in the developing brain.[74, 77] poor educational outcomes, lower IQ scores,[77] anxiety disorders and depression.[63] Lubman et al reviewed the evidence on cannabis and adolescent brain development and concluded:

> Heavy cannabis use has been frequently associated with increased rates of mental illness and cognitive impairment, particularly amongst adolescent users. … cumulating evidence from both animal and human studies suggests that regular heavy use during this period is associated with more severe and persistent negative outcomes than use during adulthood, suggesting that the adolescent brain may be particularly vulnerable to the effects of cannabis exposure. As the endocannabinoid system plays an important role in brain development, it is plausible that prolonged use during adolescence results in a disruption in the normative neuromaturational processes that occur during this period. There is evidence for synaptic pruning and white matter development as two processes that may be adversely impacted by cannabis exposure during adolescence. Potentially, alterations in these processes may underlie the cognitive and emotional deficits that have been associated with regular use commencing during adolescence.[78]

While human studies are limited in their ability to show causal relationships between marijuana use and adverse health outcomes, animal models can help fill in important research gaps. In a rat model, exposure to Delta9-Tetrahydrocannabinol (THC), the psychoactive compound in marijuana, during adolescence altered neurochemical, cognitive and behavioral brain functions similar to those observed in schizophrenics.[79, 80] Exposure to THC also resulted in developmental delays in rat brains, leading to alterations in both short and long-term memory impairments.[81-84] Studies show that there are comparative detrimental changes to spatial working

memory in adolescent rhesus monkeys exposed to THC [85] as there are for adolescent human users.[86]

The impact of secondhand marijuana smoke and health among children and adults is less clear, but the experience with secondhand tobacco smoke provides reason for concern. Secondhand marijuana smoke contains fine particulate matter that is known to be harmful when inhaled, in addition to other toxic and carcinogenic chemicals such as polycyclic aromatic hydrocarbon and nitrosamines.[70] Studies in adults have demonstrated that it is possible to get a "contact high" from intense secondhand marijuana smoke exposure, which demonstrates that it is possible, under certain circumstances, for bystanders to absorb enough marijuana smoke by secondhand exposure to exert biological effects.[87] As noted above, one minute exposure to secondhand marijuana smoke significantly impairs vascular function and this effect persists for longer than exposure to secondhand tobacco smoke.[73]

Intrauterine exposure to marijuana (i.e., exposure during pregnancy) has been associated with problems with executive function that persist through young adulthood,[88, 89] suggesting the potential for pre-natal exposure to impact, on a longer term basis, behavior or cognitive development in offspring. A recent study on a cohort of young children hospitalized with bronchiolitis in Colorado demonstrated a marijuana smoke exposure prevalence of 16%. This prevalence was markedly higher in children who were also exposed to tobacco smoke (50%).[90]

EVIDENCE-BASED TOBACCO CONTROL POLICIES

Marketing and Advertising

Youth are regularly exposed to protobacco messaging through a wide variety of media channels, including static tobacco advertising on newspapers and magazines, retail outlets, the Internet,[91] and on television or in the movies.[92] Marketing activities of tobacco industry are a key factor in leading young people to take up tobacco, keeping some users from quitting, and achieving greater consumption among users.[93] The 2012[57] and 2014[21] US Surgeon General reports concluded that tobacco industry promotional activities, including branding, imagery, event sponsorship, and marketing campaigns, cause the onset and progression to smoking among young people. NCI's smoking and health monograph, *The Role of the Media in Promoting and Reducing Tobacco Use*, had earlier found a causal relationship between tobacco marketing exposure and youth smoking. Even minimal exposure to tobacco advertising positively influenced youth attitudes and perceptions on smoking, as well as smoking intentions among youth.[93, p. 16] Causal effects of tobacco marketing on smoking may be stronger among youth than adults as youth are also more likely to be brand loyal.[57, p. 522] and are more susceptible to tobacco industry marketing.[94]

Youth susceptibility to smoking, experimentation, and current use varies by the source of pro-tobacco media. Current tobacco use is associated with exposure to static advertising and to on-screen smoking depicted in TV and in movies, both directly and through perception of peer use among youth[92] and young adults.[95]

Tobacco advertising influences youth smoking behavior at multiple levels.[57, p. 599] Tobacco advertising and promotion affect awareness of smoking, recognition of specific brands, attitudes about smoking, intentions to smoke, and actual smoking behavior among youth[57, p. 508, 96, 97] and contribute to reduced risk perceptions around tobacco use.[93, p.170, 94, 98] Even with prohibitions on youth-targeted marketing, tobacco industry marketing directed at young adults, encourages use and increased consumption within the young adult population,[99] and indirectly impacts youth smoking because youth consider young adults as aspirational role models.[57, p.508] (There is substantial evidence of similar effects, including binge drinking,[100] for alcohol industry promotions.[101-103]) The WHO Framework Convention on Tobacco Control recognizes that the most effective strategy to protect public health would be to prohibit tobacco marketing entirely.[104]

Tobacco companies use advertising as a marketing technique to create positive imagery and associations with tobacco products, and to attach desirable characteristics, activities, and outcomes with tobacco product use.[57, p. 600] Branded merchandise helps to establish brand identity and brand loyalty among novice users, which is an integral part of the tobacco industry's long-term economic strategy. Indeed, the tobacco industry specifically targets young adults in clubs using branded promotions and merchandise.[105]

For youth, there is evidence that owning cigarette-branded[106] or alcohol-branded[102] items leads to progression to being an established smoker and initiation of drinking. Among adults, young adults (defined in this study as 18-30 years old) are significantly more likely that older adults (31-65) to own cigarette-branded items and to be attracted to the advertising of a cigarette brand .[107] In short, promoting products through branded merchandise is a particularly important strategy for companies and they seem to be heavily targeting youth and young adults, who appear to be more susceptible to it than older adults and are the demographic that is susceptible to initiation or escalation of product use.

Brand sharing and brand stretching grant another access point for tobacco companies to subliminally advertise and market their products.[108, p. 5] In addition to using the cigarette package, tobacco companies place brand names and use other design techniques on the actual stick, which is rated by smokers as more attractive than cigarettes without these characteristics.[109]

Despite some restrictions in the USA, tobacco companies continue to advertise in magazines with significant youth audiences, and are more likely to advertise youth preferred brands in these magazines.[110] Tobacco companies circumvent partial advertising restrictions by concentrating advertisements in magazines where youth audience composition is near or at the minimum threshold level, thereby still exposing a sizeable number of youth to tobacco ads.[111, 112] For example, in the United States even a 15% threshold, which was the FDA-proposed rule in 1996 for advertising in print media, would have exposed at least two million youth to tobacco industry advertising.[112]

Cigarette companies consolidate marketing expenditures for magazine advertisements to brands that are popular among youth, African Americans, and LGBTQ populations (i.e., mentholated cigarette brands: Camel, Kool, and Newport).[111] In the 1990s most of the US state attorneys general sued the major cigarette companies alleging, among other things, that the

companies were advertising to children.[113] The litigation (for all but 4 states, who had already settled) was resolved with the "Master Settlement Agreement," in which the companies agreed to some restrictions on marketing to children. After the agreements was signed, the percent of total magazine advertisement spending for mentholated brands increased from 13% in 1998 to 76% in 2006, with an associated increase in youth mentholated cigarette smoking (8 percent per year between 2002-2006).[111]

The tobacco industry's claims that marketing is only used for brand switching and increasing marketing share[12] does not make economic sense.[114] For such claim to be economically viable, the number of people switching brands between companies would have to exceed individual tobacco company marketing expenditures, which is unlikely because several brands are sold by a few cigarette companies.

Despite claims made by RJ Reynolds in the US in the late 1980s that it did not directly target children, youth were more likely than adults to report previous exposure to RJ Reynolds' Joe the Camel cartoon character advertising campaign (97.7% vs 72.2%; P <.0001) and accurately associated such image with Camel cigarette brand name (93.6% vs 57.7%; P <.0001). Children also found cigarette advertisements that used Joe the Camel as more appealing than adults.[115] The market share for youth use of Camel had also increased from 0.5% in 1988 to 33% in 1991 during the Joe the Camel campaign.

In addition to several scientific reviews, the tobacco industry's own internal documents and courtroom testimony provide strong evidence for a causal relationship between tobacco marketing and smoking. Indeed, the 2012 US Surgeon General's Report, *Preventing Tobacco Use Among Youth and Young Adults,* firmly concluded*:*

> Taking together the epidemiology of adolescent tobacco use, internal tobacco company documents describing the importance of new smokers, analysis of the design of marketing campaigns, the actual imagery communicated in the $10-billion-a-year marketing effort, the conclusions of official government reports, and the weight of the scientific evidence, it is concluded that advertising and promotion has caused youth to start smoking and continue to smoke.[57, p. 522]

Youth receptivity to tobacco marketing is a strong predictor for smoking initiation and consumption patterns independent of other important predictors of smoking behavior (i.e., parental or peer smoking behavior).[57, 92] The odds of initiating smoking among youth receptive to tobacco marketing are twice that compared to unreceptive peers (OR=1.9%; 95% CI=1.3-2.9).[57, p. 515] Longitudinal studies show increased odds of progression from initiation of smoking to established smoking among adolescents who both owned cigarette promotional items and had a favorite cigarette advertisement.[116]

In the United States, there are few regulations on tobacco industry marketing of other tobacco products (smokeless tobacco, hookah, cigarillo, and e-cigarettes), despite rising use among young adult populations. Among young adult bar patrons (18-26), marketing receptivity is associated with other tobacco product (OTP) use, including smokeless tobacco, hookah, cigarillos, and e-cigarettes. Moreover, current smokers receptive to tobacco marketing are also

more likely to be poly-tobacco users (i.e., report use of cigarettes, smokeless tobacco, cigarillos, or a combination of three or more tobacco products.[117]

In the United States, unlike conventional cigarettes, e-cigarettes are allowed to be advertised on television. Between 2011 and 2013 exposure to television e-cigarette advertisements increased by 256% for youth and 321%, for young adults, driven primarily by a large advertising campaign on national cable networks. [118] Among never e-cigarette users, youth exposure to e-cigarette advertising was associated with reduced risk perceptions on use (i.e., that e-cigarettes are cool, healthy, and enjoyable) than among youth not exposed to similar ads.[119] Youth who thought the ads were more effective (in terms of leading to cognitive and behavioral changes) were more likely to have a positive attitude toward e-cigarettes and greater intentions for future e-cigarette use. The increased e-cigarette advertising was paralleled by increases in youth e-cigarette use.[120] Adults in the United States are also influenced by e-cigarette advertising, with adults reporting greater intention to initiate e-cigarette use after exposure to e-cigarette advertising.[121]

Similar observations on the effects of alcohol marketing on youth substance use behavior are noted in the literature. Exposure to alcohol advertising is independently associated with initiating drinking, drinking dependence, and binge drinking among young adults (18-24).[122, 123] Middle and high school students that own alcohol branded merchandise are more likely to report ever alcohol use. Ownership of alcohol branded merchandise is positively associated with youth perceptions on peer use and peer acceptance of alcohol.[123]

Cigarette companies recognize the importance of promoting co-use of tobacco and alcohol among young adults.[124] Nicotine cravings are enhanced by alcohol use and alcohol cravings are enhanced by nicotine use.[125] Indeed, cigarette companies use imagery of alcohol use in their cigarette advertisements in print media, which disproportionately impacts young adults, particularly college students.[124, 126]

Likewise, exposure to television food commercials is an important predictor for unhealthy food choice, brand preference, and high caloric food consumption.[127-129] Receptivity to television fast food marketing is associated with youth obesity, with a one point increase in marketing receptivity being associated with a 19% increased odds of being obese.[130]

Internet

Electronic commerce such as internet, mail order, text messaging, and social media sales are difficult to regulate, leading to increased youth sales, tax evasion, and illicit trade compared to traditional tobacco sales.[108, p. 5, 131] Although tobacco companies advertise on the internet, a substantial amount of tobacco promotion occurs through social media and user-generated promotional media, and the content is predominantly positive.[132, 133] These messages reach both adults (with adults recalling ever seeing internet ads for tobacco increasing from 6.9& in 2001to 17.8% in 2005[134]) and adolescents.[135] In addition, internet sales have provided new avenues for tobacco companies to market their products to youth.[57, p. 551, 91, 108, p. 5]

A 2002 study that examined cigarette advertising on the Internet in the USA found that nearly 20% of cigarette-selling websites did not include warnings that sales to minors are illegal

or prohibited. Among those websites that required some form of age-verification, more than half required that a buyer confirm legal purchase age (e.g., by clicking a button that says "I am over age 18"), 15% required that buyers manually type in their date of birth, and 7% required buyers manually enter information from a driver's license.[136]

At least fifteen US attorneys general have conducted Internet stings and found that children as young as 9 years old were able to purchase cigarettes. For example, a New York sting operation found that 93% of websites observed had sold to children under 18 (24 websites sold to minors out of the 26 sampled).[137] A 2004 study found that more than 96% of minors aged 15-16 were able to find an Internet cigarette vendor and place an order in less than 25 minutes, with most completing the order in seven minutes.[138] A study in California found that 101 websites selling tobacco failed to comply with California laws regarding age and ID verification to prevent youth sales.[139]

A detailed 22-page summary of the scientific evidence through 2011 on tobacco sales through the Internet submitted to the US Food and Drug Administration to conclude that youth access to tobacco cannot be prevented by existing rules and procedures in the US, including those by which sellers conduct age verification were ineffective at preventing youth access to tobacco products.[140]

A 2013 report by the World Health Organization shows that 96 countries banned internet tobacco advertising,[141] but enforcing such bans has proven difficult. For example, while the sale of snus is illegal in all European Union countries except Sweden, online vendors in Sweden target online marketing activities toward EU citizens outside of Sweden, including sales promotions, price discounts, and gifts with purchase. A study that made (illegal) test purchases in ten EU member states reported a 96% success rate (of the total purchases made, only two failed).[142] Age-verification relied on self-reports from buyer, and the majority of these sales applied Swedish taxes only, contrary to EU requirements.[142]

Point of Sale

Tobacco companies also heavily invest in marketing their products at the point-of-sale, which encourages use among both youth and adults. Longitudinal studies demonstrate that exposure to point-of-sale tobacco displays is associated with increased susceptibility to smoking, as well as smoking initiation and progression to smoking among youth,[143-145] particularly when stores are located near schools.[57, p. 543-544] Point-of-sale advertising also encourages impulse buys,[57] and increased consumption, and discourages quit attempts among smokers.[146]

Smoking in Movies

Youth are regularly exposed to onscreen smoking in youth-rated films. In 2012 the US Surgeon General concluded "The evidence is sufficient to conclude that there is a causal relationship between depictions of smoking in the movies and the initiation of smoking among young people."[57, p. 602] The US National Cancer Institute[93, p. 413] and World Health Organization [147, p. 5] also concluded that onscreen smoking causes youth to smoke.

Industry Voluntary Advertising Codes

A longstanding tobacco industry strategy to prevent adoption of more stringent government regulation to either severely restrict or prohibit tobacco advertising is for tobacco companies to offer voluntary advertising codes[148, 149] in which the industry agrees to limit advertising placement to media outlets with a larger fraction of youth viewers than the fraction of youth in the population. These voluntary codes, however, do not effectively prevent youth exposure to tobacco advertising. Indeed, a 2001 report prepared for the World Health Organization, *Fatal Deception: The tobacco industry's "new" global standards for tobacco marketing*, states:

> Industry-inspired voluntary marketing restrictions create the appearance of concern and responsibility, but only include measures known to be ineffective. Their overarching aim is to protect the tobacco business. The agreements are formulated without regard to established research on youth smoking and without any intention to evaluate the results.[150]

The same situation exists for the lack of practical effect of the alcohol industry's voluntary advertising code on alcohol advertising on television. The US alcohol companies voluntarily restriction on advertising in media outlets with no more than 30% of the viewership under the legal purchase age (21 years old) still permits them to advertise and market their products in media outlets where youth are more likely to be exposed.[15] Despite high levels of compliance with this voluntary code, the alcohol industry effectively reaches 18-20 year olds.[122] For example, a 2000 study found that *Sports Illustrated* and *Rolling Stone* had the highest number of alcohol advertisements of all publications examined.[151] (For comparison, *Rolling Stone's* audience under age 18 is twice that of *Time* magazine.[151]) Similarly, researchers at the Center on Alcohol Marketing and Youth at Georgetown University found that youth (12-20 years old) were exposed to 45% more beer and 27% more spirits advertisements than legal drinking-aged adults.[152]

Corporate Social Responsibility

The World Health Organization identifies corporate social responsibility (CSR) campaigns as direct and indirect forms of advertising and marketing of tobacco products.[141, p. 6] Tobacco companies strategically use CSR campaigns to boost public credibility and curry favor with policymakers. As a result, the Framework Convention on Tobacco Control advises that government signatories to the convention include CSR in national laws and prohibit this form of marketing of tobacco products.[141]

In addition to its political dimension, CSR programs are an important element of the tobacco industry's marketing program. CSR is a way for tobacco companies to legitimize themselves because research shows that delegitimizing tobacco industry leads to less smoking. Young adults who support action against the tobacco industry are less likely to be smokers and

smokers who support action against the tobacco industry are more likely to quit.[153, 154] Promoting understanding of the industry's behavior has been a central theme of the California Tobacco Control Program since it started in 1989[155] ("countering pro-tobacco influences" or "industry denormalization") and has been documented to contribute to its effectiveness.[156] The American Legacy Foundation (now Truth Initiative) "truth" campaign, which has a strong industry denormalization message, has been associated with lower youth smoking.[157-159] The success of the anti-industry strategy is indicated by repeated attempts by the cigarette companies to sue (unsuccessfully) to block such messaging by California and the American Legacy Foundation (now Truth Initiative).[160]

Industry-sponsored "youth smoking prevention" programs

Industry-sponsored "youth smoking prevention programs" are part of industry's larger public relations strategy to show that tobacco companies are socially responsible corporations willing to work with policymakers on overlapping issues.[148] As a result of increased public scrutiny of tobacco industry deception and youth targeted marketing campaigns,[148] US tobacco companies began developing their own "youth smoking prevention" campaigns in the 1980s to displace effective state-run campaigns.[161-163] Tobacco company investment in these programs often outweighs spending on government-run campaigns, resulting in potentially harmful effects for youth. Between 1999 and 2003, US exposure to tobacco company youth/parent advertisements were almost identical to state/national anti-tobacco advertisements on television (average exposure per month: 4.56 versus 4.97 for households; 3.05 versus 3.38 for adolescents).[164]

Industry-sponsored youth prevention programs are counterproductive[159, 165] (from a health perspective) because they frame youth use as a societal or parental issue,[162, 166, 167] and reinforce smoking as an adult choice (i.e., a way to look and be "grown up").[161, 167] The tobacco industry has invested heavily in developing such ineffective frames to displace more effective tobacco control messages.[148] Youth (15-17 years old) exposed to tobacco industry "youth smoking prevention" messaging were more likely to report reduced risk perceptions, increased approval of smoking, greater intentions to smoke, and past 30-day smoking than youth not exposed to these messages.[165]

PRODUCT LABELLING AND PACKAGE DESIGN

Warning labels and pictorial warnings

According to smokers in Western countries, aside from television, the most common source of health information regarding the risks of smoking comes from tobacco product packaging.[57, p. 715, 168] Indeed, evidence from the Global Adult Tobacco Survey shows that among 12 countries surveyed between 2008 and 2010, more than 90% of men had reported seeing the health warning label on cigarette packages.[169] Large graphic warnings (pioneered in Canada) and plain packaging (pioneered in Australia) reduce tobacco use, discourage nonsmokers from initiating, and encourage smokers to quit.[170-172] Large warnings specified in the WHO Framework Convention on Tobacco Control[173] have spread across the world as countries have

implemented the FCTC,[174, 175] with slower adoption of effective warning labels in countries that had previously entered into voluntary agreements with the tobacco industry.[174]

The extent to which health warning labels on tobacco packages impact risk perceptions and smoking behavior largely depends upon the size, prominence, position, and design of these messages.[57, 173] Warning labels that cover up to at least 50% or more of principal display areas, and not just limited to the sides of the tobacco package,[169] are associated with increases in health knowledge and motivation to quit.[57, 173] Experimental studies in Canada demonstrate that increasing the warning label from 50% to 75%, 90%, or 100% increased its effectiveness among youth.[176]

Studies evaluating graphic, pictorial warning labels in Canada and Australia have shown high levels of cognitive processing and an association between cognitive processing, intentions to quit, and quit attempts.[170] In Brazil and Thailand, countries with strong pictorial depictions on the health impacts of smoking, had the strongest impact on thinking about quitting among current smokers.[169] Nationally representative data from Canada demonstrate that 80% of youth reported pictorial health warning messages decreased the attractiveness of smoking.[177]

Compared to small, text-only warning labels, large warning labels that include images in addition to text are more effective at communicating health risks associated with use, evoking an emotional response, provoking thoughts about quitting, increasing motivations and quit attempts among smokers.[57, 173, 178, 179] National data from Canada show that 95% of youth rated pictorial health warnings as more effective at communicating health risks than text-only versions.[180] Large pictorial warnings have longer lasting effects on increasing risk perceptions, encouraging quitting and quit attempts among smokers,[178] and are more likely to be seen by low-literacy adults and children.[173]

In contrast, small, text-only warning labels, such as those used for tobacco in the United States, have low impact on youth tobacco use.[181-184] In addition, these warning labels do not effectively communicate health messages on the specific health risks of tobacco consumption to the public.[185] Young people are less likely to recall seeing text-only warning labels.[183, 184] Among participants that report text-only warning label recall, only one-third were able to accurately recall message content.[183]

Additional requirements for effective warning labels include positioning health messages on front and back, and on the top of all principal display areas. Warning labels on tobacco packages are more effective when novel health warnings and messages are used, and the content, layout, and design of the warning label are rotated periodically to avoid “burn out” of stale messages.[173, 178] While youth perceive health messages on US warning labels for tobacco products to be believable,[186] few reported that these messages were informative or relevant, and that these messages were “vague”, “stale”, and “worn-out”.[187]

Warning labels that include messaging with cessation information and a toll-free quitline number are associated with an increase in calls to the quitline,[188, 189] particularly among male smokers and those from low socioeconomic groups,[190] and help to address tobacco-related health disparities.

Implementation of comprehensive warning labels for tobacco packaging has been actively opposed by tobacco industry interference in the policy process.[10] Between 1984 and 2003, countries without mandated HWL on tobacco packages transitioned to having either some form of HWL or a voluntary industry HWL passed by the tobacco companies. Countries with voluntary industry HWLs were less likely to adopt comprehensive HWLs, which were compliant with FCTC guidelines than countries with previously enacted mandated HWLs.[174] These findings also point to the importance of implementing at the time of legalization a comprehensive set of demand reduction policies for marijuana before a large marijuana industry develops and works to weaken or defeat public health strategies to control use.

Tobacco package design and plain packaging

Cigarette pack design is a key component to tobacco company marketing techniques.[57, p. 534] Package design establishes brand identity and promotes brand appeal, particularly among youth.[57, 94, 98, 141]

Tobacco companies design products that are attractive to children while being marketed toward young adult peers. A longitudinal study on youth attitudes toward cigarette brands found a ten-point increase (34% to 44%) in the proportion of teenage girls reporting a favorite cigarette brand between 2007 and 2008. The study coincided with the launch of RJ Reynold's campaign for Camel No. 9, a brand that appears to be specifically designed to attract teenage girls, and which accounted for the majority of the increase in brand preference.[116] Similar impacts on brand preference were found among young people in Mexico[191] that had reported a greater exposure to tobacco marketing and advertising.

Tobacco companies use package design techniques to mislead consumers into perceiving their products as less harmful or safer than other tobacco products. Tobacco product packaging with descriptors such as "natural", "light", "mild", and "organic" are associated with false beliefs of the health risks of smoking,[192, 193] and are perceived as less harmful or healthier than tobacco products without these descriptors,[173, 193, 194] likely because the tobacco companies target concerned[195] and older smokers[196] at risk of quitting. Indeed, the cigarette companies consider the color of the package as an "ingredient" of the cigarettes that can be used to manipulate users' perception of the taste of the product in ways interchangeable with changes in the physical product itself.[197]

The effectiveness of health warnings may be enhanced through the use of standardized packaging (i.e., plain packaging),[173] a strategy used to reduce attractiveness and appeal of tobacco, to increase the prominence of health warnings,[198, 199] and to correct misperceptions on the health risks of smoking. Plain packaging enhances the effectiveness of health warnings by increasing their noticeability, and has been shown to make smoking less appealing and has the potential to reduce the level of false beliefs about the risks of different brands.[57, 200, 201]

Compared to branded packages, tobacco products in standardized packaging are associated with reduced brand awareness and identification,[198] and reduced brand appeal,[202] particularly among young women.[203] Consistent with previous research in high-income

countries, plain packaging in low and middle-income countries have similar impacts on reducing tobacco product appeal.[204]

Consistent with adopting a comprehensive tobacco control approach, plain packaging may be useful even if nations have adequately funded mass media campaigns (discussed in the following section). Unlike media campaigns, packaging changes have almost universal reach and ongoing frequency of exposure. Packaging changes cost little to governments, unlike media campaigns that constantly have to justify their funding allocations against ongoing efforts by tobacco companies to defund media campaigns.[160, 205] As discussed in detail in the next section, plain packs with larger graphic health warning labels complement media campaign messages, amplifying their impact.[206]

PUBLIC EDUCATION AND MASS MEDIA CAMPAIGNS

There is broad scientific consensus that mass media campaigns aimed at the general population are an important element of a comprehensive program to prevent youth initiation of tobacco use and reduce its prevalence.[57, 93, 207] The 2012 US Surgeon General Report concludes that there is sufficient evidence to infer a causal relationship between the level of funding for antismoking media campaigns and reduced smoking prevalence among youth.[57, p. 691]

The effectiveness of well-done anti-tobacco media campaigns is not an argument against other elements of a comprehensive tobacco control policy. Indeed, media campaigns can amplify the effects of other policies, such as plain packaging, advertising restrictions, graphic warning labels and smokefree laws, as well as the other way around, since marketing prohibitions reduce the salience of pro-smoking cues, and increase and reinforce anti-smoking norms.[208] In particular, in Australia, introduction of pictorial health warnings on cigarette packets was supported by a televised media campaign highlighting illnesses featured in two of the warning labels (gangrene and mouth cancer).[206] Between 2005 and 2006, the proportion of smokers aware that gangrene is caused by smoking increased by 11.2 percentage points (OR 23.47, $p<.001$), and awareness of the link between smoking and mouth cancer increased by 6.6 percentage points (OR 2.00, $p<0.006$). In contrast, awareness of throat cancer decreased by 4.3 percentage points, and this illness was mentioned in the pack warnings but not the advertisements. Smokers who had prior exposure to the warnings were significantly more likely to report positive responses to the advertisements and stronger post-exposure quitting intentions. Thus, anti-smoking television advertisements and pictorial health warnings on cigarette packets reinforced each other to positively influence awareness of the health consequences of smoking and motivation to quit.

Analysis of the impact of tobacco control policies and mass media campaigns on smoking prevalence in Australian adults found that stronger smokefree laws, tobacco price increases and greater exposure to mass media campaigns combined to independently explain 76% of the decrease in smoking prevalence from February 2002 to June 2011.[209]

For example, youth exposure to anti-tobacco media campaigns reduced the odds of current cigarette use by 15% and smokeless use by 30% compared to students with zero media exposure.[210] Greater exposure reduced the odds of current cigarette use and smokeless use by 30% and 45%, respectively. Antismoking media campaigns help to shape social norms and

institutional policies around smoking, which in turn change smoking behavior at the population level,[211] including adult quit attempts.[212] Several studies have found that youth are equally likely to report favorable responses to adult-targeted ads as to youth targeted ads,[213, 214] Studies from California,[215] Massachusetts,[216] and Australia[217] demonstrate that exposure to adult-targeted mass media campaigns is associated with reduced smoking initiation and smoking behavior among youth. Even in countries where comprehensive tobacco control policies have been in effect for decades (i.e., Norway), intensive mass media campaigns have a positive additional influence on smoking behavior outcomes.[218]

Tobacco taxes are used to provide an annual revenue stream to support implementation of government media campaigns that consist of paid radio, television, billboard, internet and social media, and print advertising. Media campaigns with greater impact also include public relations campaigns for general market and population-specific communities, including various ethnic populations, young adult, and lesbian, gay, bisexual, transgender, and queer (LGBTQ) communities.[219, 220]

Social norm change

Social norm change has been one of the most effective tobacco control strategies in the United States.[221] The most successful application of the social norm change strategy took place in California, where in 1989 a statewide tobacco control program was implemented to transform the social environment where tobacco use is not socially desirable or acceptable.[93] The key to the success of the California Tobacco Control Program has been its design as a broad-based campaign focused on reinforcing the nonsmoking norm aimed at the population as a whole – not just smokers or youth,[222] for each element of the program, including the statewide hard hitting, evidence-based media campaign.[222-224] Indeed, by focusing on adults through its comprehensive tobacco control program, California has achieved one of the lowest youth smoking rates (10%) in the United States.[223, 225, 226]

Advertising bans are another important policy to denormalize tobacco use. Like large graphic warning labels and plain packaging, they are inexpensive for governments to implement, and generally apply to all products Point of sale tobacco display bans in Ireland[227] and Australia[228] were both followed by reduction in perceived smoking prevalence among youth and young adults, which reflects lower normalization of tobacco use. In contrast to media campaigns, which require regular appropriations and create ongoing opportunities for the tobacco industry to weaken, block, or eliminate funding,[160, 205] advertising bans, once enacted, are legally binding.

Industry denormalization messaging

Promoting understanding of the industry's predatory behavior has been a central theme of the California Tobacco Control Program since it started in 1989[155] ("countering pro-tobacco influences" or "industry denormalization") and the Truth Initiative (formerly American Legacy Foundation) "truth" campaign. The messaging frame on industry behavior is an important reason for these campaigns' success at preventing smoking initiation and promoting quit attempts,[153, 154, 156-159] likely because they reduce the attractiveness of affiliating with the tobacco companies' brand images. In contrast, programs that focus solely on individual, peer and family influences[163] on youth smoking prevention and understate or ignore the effects of tobacco

industry advertising are less effective than campaigns that highlight the role of the tobacco industry. [57, 163] Indeed, when Florida – where the "truth" campaign first originated in 1999– shifted its media messaging away from confronting the tobacco industry to a softer "kids shouldn't smoke" message, it lost its effectiveness.[229]

PRODUCT ENGINEERING, PRODUCT CHARACTERISTICS, AND DELIVERY METHODS

Tobacco companies use product engineering to maximize consumption and profits.[22] Large corporations have the scientific and technical capacity to undertake research and development programs that aim to identify which characteristics of a product to manipulate, and use sophisticated manufacturing processes to accentuate product features that maximize addictive potential. The cigarette companies invested heavily in their secret internal R&D departments to understand the addiction process, and modified their products to increase their addictiveness.[22] Reviews of internal industry documents show that cigarette companies manipulate nicotine levels, cigarette length, chemical additives[23] (including menthol,[24-26] sugar, which becomes acetaldehyde when burned,[230] and other flavors like cocoa,[27]) to alter nicotine absorption, improve the flavour of the smoke, reduce harshness,[28] and increase puff intensity.[29] They also use ventilated filters, manipulation of nicotine levels,[30] and other product modifications to attract novice smokers[21, 31] and to increase addictive potential by optimizing nicotine delivery and dosing.[23]

Cigarette companies also designed their brands to meet psychological and psychosocial needs of consumers.[231, 232] In addition to attracting youth,[195, 233] product design technology was used to recruit and socially normalize smoking among women,[232, 234] African Americans,[235] Latinos,[236] Asians,[237, 238] LGBTQ,[239] low income groups,[240] and veterans.[241]

Cigarette companies have also taken advantage of weak cigarette testing protocols around the world to conceal the actual toxicity of their products to consumers and regulators.[242, 243]

In the process of manufacturing cigarettes to enhance nicotine delivery, and so the addictiveness and sales of cigarettes, tobacco companies have reduced particle size and made many other design changes which , while good for the cigarette business, resulted in a more dangerous cigarette in 2014 than in 50 years earlier in 1964.[21, p. 8, 151-186] Changes in tobacco blends and curing of tobacco has caused US cigarettes to have higher levels of tobacco specific nitrosamines (TSNAs), a group of carcinogens found in tobacco and nicotine products.[244, p. 4] The 2014 Surgeon General Report observed that "[f]or Kentucky reference cigarettes, mutagenicity per mg of total particulate matter was 30–40% lower for unfiltered cigarettes than for the same cigarette with a filter added."[21, p. 184, 245]

These design changes have not only made cigarettes become more dangerous in terms of rising lung cancer rates,[21, p. 8, 151-186] but also contributed to an increase in overall mortality, chronic obstructive pulmonary disease (COPD) and heart disease.[246] The rising risks correspond to changes in cigarette design – unfiltered to filtered, higher tar to lower tar, introduction of filter vents, among other changes to cigarette design. Deeper inhalation of more dilute smoke increases exposure of the lung parenchyma. These and other design changes in cigarettes may

also have contributed to the shift, beginning in the 1970s, in the histologic and topographic features of lung cancers in male smokers, with an increase in the incidence of peripheral adenocarcinomas that largely offset the decrease in squamous-cell and small cell cancers of the central airways.[246]

Filters

Filters are part of modern cigarette design, including the presence of microscopic "ventilation" holes designed to dilute smoke when it is being tested in a smoking machine to trick tests into rating the cigarettes as having lower tar and nicotine deliveries than they actually do. Filters represent the kind of technology that a corporatized marijuana industry could develop to mislead the public into thinking that products were less dangerous than they are and to engineer products to increase use.

The resulting lower tar and nicotine readings were used to mislead smokers into thinking that the cigarettes were safer to keep health-concerned smokers smoking. (This behavior was a central element of the conspiracy to defraud the public that led a federal court to rule that the US cigarette companies and their trade organizations violated the Racketeer Influenced Corrupt Organization Act.[247]) Filter technology is also an important element of the design of a modern cigarette to lower particle size and make the smoke go deeper into the lung to increase nicotine absorption, with the effect that it causes more disease.[21, p. 151-186] In addition, the filters themselves break down and deposit tiny pieces of the filter material in smokers' lungs, which may contribute to the diseases smoking causes.[248] Filter material found in smokers' lungs includes toxin-containing charcoal granules[249] and plant and plastic fibers.[250] Cigarette filter fibers have been observed in lung tissue from patients with lung cancer and who were known to be habitual smokers.[251]

In short, a cigarette filter functions much as the way Volkswagen manipulated the pollution controls on its diesel engines: They create the illusion of being less polluting while making the disease burden worse. Internal industry documents demonstrate that the cigarette companies designed cigarettes with filters knowing from the beginning that filters did not actually reduce risk. Filters were part of an overall public relations strategy and marketing tool to manipulate smokers into continuing to use hazardous tobacco products.[252] A 1976 internal memo from Ernest Pepples, vice president and general counsel of Brown and Williamson Tobacco Company, provides a clear example of such deceptive cigarette company practices:

> In most cases, however, the smoker of a filter cigarette was getting as much or more nicotine and tar as he would have gotten from a regular cigarette.[22, p. 27, 253]

Judge Gladys Kessler's landmark 2006 ruling[247] that the cigarette companies had created an "illegal enterprise" to defraud the public in violation of the Racketeer Corrupt and Influenced Organizations (RICO) Act mentions filters 424 times' including:

> The Public Health Service believes that the following statements are justified by studies to date… No method of treating tobacco or filtering the smoke has been demonstrated to be effective in materially reducing or eliminating the hazard of lung cancer.

> A May 1967 report on 'Project 6900' (a Philip Morris research project) described further tests with mice, pigs, monkeys and cats, concluding that filtered smoke was 'no less tumorigenic than nonfiltered smoke.'
>
> As established by the Findings of Fact set forth in this Section, cigarette company Defendants researched, developed, and implemented many different methods and processes to control the delivery and absorption of the optimum amount of nicotine which would create and sustain smokers' addiction. These methods and processes included, but were not limited to: altering the physical and chemical make-up of tobacco leaf blends and filler; maintaining or *increasing the nicotine to tar ratio by changing filter design, ventilation and air dilution processes, and the porosity and composition of filter paper*; altering smoke pH by adding ammonia to speed nicotine absorption by the central nervous system; and using other additives to increase the potency of nicotine. [emphasis added]

Menthol and Flavour Additives

The tobacco companies use menthol and other flavour additives including fruit and candy flavouring as marketing tools to attract young smokers.[13, 57, 167, 254, 255] National survey findings from the United States[57] and Japan[26] confirm that menthol cigarette use is disproportionately common among younger and newer adolescent smokers. [13, 57, 167, 254, 255] Tobacco products that disguise the taste of tobacco through flavouring agents and palatability enhancers create products that largely appeal to youth and young adults.[256]

Menthol is the most popular characterizing flavour of cigarettes in the US, with more than 90% of all cigarettes containing menthol.[257] Tobacco companies use menthol's analgesic effects to mask acute effects of smoking (i.e., throat burn, pain, and cough). Such harsh effects, if experienced by the smoker, could encourage quit attempts and cessation among menthol users.[258] Women perceive the minty aroma of menthol cigarettes to be more socially acceptable than non-menthol cigarettes,[258] which complicates public health efforts to denormalize tobacco use.

In the US, the tobacco companies intensely market menthol cigarettes in predominately black communities through price discounts, signage, and through associations of menthol use with hip hop lifestyle and culture.[235, 259-261] Family and social factors that prevented smoking among African American teens do not seem to carry over into young adulthood likely due to tobacco company targeted marketing.[260] In 2012, teenage smoking prevalence among whites was twice as high as black smoking prevalence (8% compared to 4%).[21]

While use rates among young adults remains higher for whites (37%) than blacks (26%),[21] compared to white smokers, menthol cigarettes are disproportionately used among black smokers. National data from the United States show that around 80% of African American smokers use menthol cigarettes compared to around 30% of whites.[262-264] Tobacco-caused morbidity and mortality rates are disproportionately higher among African Americans compared to whites,[235, 260] and menthol cigarette smoking is disproportionately high among African Americans, which may help to partly explain the disproportionate tobacco-related disease burdens.[262, 265-267]

Newer products, including as e-cigarettes, also use flavouring agents in liquid nicotine that are attracting youth and young adults to these products.[268, 269] The US Food and Drug Administration (FDA) included a detailed and scientifically accurate summary of the evidence that menthol, candy, and fruit-flavoured tobacco products attracted youth to tobacco use and deterred quitting in its final version of the "deeming rule" in which the FDA asserted jurisdiction over e-cigarettes, cigars, and other tobacco products, including placing restrictions on the use of menthol and other flavours in the newly deemed tobacco products.[270]

Without explanation, the White House Office of Management and Budget deleted this material from the final rule.[270] (The official in the Office of Management and Budget in charge of the review of the deeming rule had previously worked for an e-cigarette company and returned to work there after completing work on the FDA deeming rule.[271]) Despite this policy decision by the Office of Management and Budget, the FDA's analysis still provides a strong and concise summary of the scientific evidence that menthol and other flavours are harmful to public health:

> Existing data also show that youth and young and adults are using menthol flavored products, along with other flavored products. For example, in one survey of 953 middle school and high school students who had used e-cigarettes during their lifetime, 71 percent reported having tried sweet flavors and 22.1 percent reported having tried menthol-flavored e-cigarettes (Ref. 23, Krishnan). Moreover, cigarette data also confirms the appeal of menthol to youth. Younger populations have the highest rate of smoking menthol cigarettes, and studies looking at the differences in prevalence rates, age of first cigarette, and progression to regular smoking show a greater use of menthol in younger smokers and declines in use with age from adolescent to young adults to adults (Ref. 23E, Report citing, e.g., Ref. 23F, Fernander; Ref. 23G, Hersey 2006). In fact, data analyzed from the 2006 National Youth Tobacco Survey revealed that among youth smokers who reported a usual brand, 51.7 percent of middle school smokers and 43.1 percent of high school smokers consistently reported that their usual brand was menthol (Ref. 23E, Report, citing Ref. 23H, Hersey 2010). Menthol in cigarettes also is likely associated with increased dependence, with consistent findings showing that menthol smokers are more likely to smoke their first cigarette within five minutes of waking (a well-established measure of dependence), and are less likely to successfully quit smoking (id.; citing, e.g., Ref. 23I, Nonnemaker 2013).
>
> Focus group data also has suggested that removing flavors from tobacco products may reduce young adults' intentions to try these products and subsequently use them (Ref. 13, Choi). For example, researchers have found that among cigar smokers (in middle and high school), those who use flavored little cigars generally have a lower intent to quit than users of non-flavored tobacco products, which is consistent with evidence showing increased tobacco dependence among menthol smokers (Ref. 19, King). Similarly, a study of youth and young adults found that flavored tobacco use facilitates nicotine

dependence among young smokers, despite low smoking frequency (Ref. 15A, Huh). [270, p. 175-176]

….

Recent data, as well as studies included with comments, illustrate that youth are particularly attracted to flavored ENDS [electronic nicotine delivery systems, another name for e-cigarettes and related products] products. As a result, one tobacco company's website acknowledges that youth like flavors when it states, "kids may be particularly vulnerable to trying e-cigarettes due to an abundance of fun flavors such as cherry, vanilla, piña colada and berry" (Ref. 16D, Lorillard). According to 2014 NYTS data, 5.9 percent of U.S. middle and high school students reported using flavored e-cigarettes in the past 30 days (citation pending). Preliminary data from the national Population Assessment of Tobacco and Health (PATH) Study also demonstrate the popularity of flavored e-cigarettes among youth. Researchers found that 85.3 percent of youth aged 12 to 17 who used e-cigarettes in the past 30 days reported using flavored e-cigarettes (e.g., menthol, mint, clove, spice, candy, fruit, chocolate, wine, cognac, or other flavors) (Ref. 16E, Ambrose). Moreover, of those youth reporting having ever used an e-cigarette, 81 percent reported that their first e-cigarette was flavored (id.). This data also shows that 81.5 percent of current e-cigarette users (defined as those who used an e-cigarette in the past 30 days) stated that they used e-cigarettes because it “comes in flavors I like” (id.).

Results from small cross-sectional studies also suggest that flavored e-cigarette use is popular among youth. Several comments included a study that was under review for a peer-reviewed publication and has since published. In this survey conducted in four high schools and three middle schools in Connecticut in 2013, 25.2 percent of high school students reported trying e-cigarettes in their lifetime and 12 percent reported using e-cigarettes in the past 30 days, while among middle school students, 3.5 percent reported trying e-cigarettes in their lifetime and 1.5 percent reported using e-cigarettes in the past 30 days (Ref. 23, Krishnan). Among the 953 lifetime e-cigarette users interviewed, 71 percent reported having tried sweet flavors, and 22.1 percent reported having tried menthol-flavored e-cigarettes. In terms of preferred flavors, 56.8 percent reported preferring sweet flavors, while 8.7 percent preferred menthol e-cigarettes (Ref. 23, Krishnan). [270, p. 179-180] [Reference numbers refer to references in the FDA document, which is publicly available online. [270]]

In sum, flavours, like other aspects of product engineering, have important implications for health in terms of creating new products designed to increase use and maximize addictive potential, which has serious implications for public health.

Without adequate controls in place, all the types of product engineering manipulations that have been developed for cigarettes could easily be applied to marijuana products.

ANALYSIS OF JURISDICTIONS ON THE LOWER AND HIGHER END OF THE SPECTRUM OF TOBACCO CONTROL POLICIES

Comprehensive strategies to reduce demand for tobacco

Comprehensive tobacco control policies, including the implementation of prohibitions on advertising,[141, 272-274] health warning labels, mass media campaigns that use anti-tobacco denormalization messaging,[157, 275-278] and comprehensive smokefree laws.[279] reduce smoking. The overall effectiveness of these policies can be maximized if implemented as part of a comprehensive approach to controlling tobacco.[21, 215, 222, 224, 280-283] Indeed, the 2014 US Surgeon General Report concluded:

> Several factors were particularly crucial in altering social norms around cigarette smoking in the United States, making it increasingly less acceptable: (1) the emergence of a nonsmokers' rights movement and evidence linking exposure to secondhand smoke to disease; (2) an understanding of regular cigarette smoking as an addictive behavior and one that begins in adolescence; and (3) a focus on the tobacco industry itself as a key influence on smoking behavior and the importance of countering its actions.[21]

California has the United States' longest-running comprehensive tobacco control program, which includes an ongoing and aggressive mass media campaign aimed at the general public combined with strong smokefree laws. (US states do not have authority to mandate strong warning labels on tobacco products.) Since its launch in 1989, adult smoking rates have dropped from 23.7% in 1988 to 11.65% in 2014, while cigarette consumption has fallen by over 70%, with estimates that 1,000,000 saved lives and $134 billion healthcare savings for taxpayers.[284]

The more that governments spend on comprehensive tobacco control programs, the more rapid the decline in tobacco sales and smoking prevalence. In US states where investment in comprehensive tobacco control programs was larger and sustained over longer periods of time, cigarette sales and smoking prevalence, even among youth, declined more rapidly than the nation as a whole.[21, p. 804]

Reductions in smoking are rapidly followed (i.e., the next year) by reductions in medical costs. In the US, the short-run (one year) elasticity between changes in smoking (measured as prevalence and per smoker consumption) is 0.22, meaning that a 10% relative drop in smoking is followed the following year by a 2.2% drop in medical costs.[285] There is also a similar short-term relationship between changes in cumulative funding for tobacco control programs,[286] with California's general market campaign, which includes messaging on social norm change and tobacco industry denormalization,[225, 287] having a larger effect than Arizona's campaign, which is focused on youth and avoids confronting the tobacco industry.[288] In particular, between 1989 and 2008 the California Tobacco Program cost US$2.4 billion and led to cumulative healthcare expenditure savings of $134 billion. These findings are consistent with earlier studies that show that the characteristics of campaign messaging have a large influence on youth attitudes and smoking behavior outcomes.[57, pp. 686-688]

These rapid changes in medical costs are due to the fact that risks of cardiac events,[289-292] non-cancer lung disease, complications of pregnancy,[293] and effects on children[294-299] begin to appear almost immediately when people stop smoking or being exposed to secondhand smoke. Cancer is also affected, albeit more slowly over time.[300, 301] Hospitalizations for heart attacks, other cardiovascular conditions, stroke, and pulmonary conditions drop immediately following implementation of smokefree laws,[21, p. 435-443, 302] as do need for treatment of respiratory conditions,[303] and complications of pregnancy and hospitalizations for childhood illnesses.[294-299, 304, 305] The fact that marijuana smoke exposure has similar – indeed larger – effects on vascular function[73] suggests that there may be similar adverse consequences and medical costs if marijuana use increases following legalization and expansion of the market.

Tobacco control policy change in Australia between 2001 and 2011 played a substantial role in reducing smoking prevalence among Australian adults between 2001 and 2011.[209] During that time, the Australian government increased tobacco taxes, adopted more comprehensive smokefree laws, and increased investment in mass media campaigns, which can explain 76% of the decrease in smoking prevalence from 23.6% (in January 2001) to 17.3% (in June 2011).[209]

Comprehensive tobacco control policies may have an even greater impact on cigarette consumption and demand reduction in low and middle income countries compared to high income countries.[306] For example, there has been a 50% reduction in male and female smoking prevalence in Brazil between 1989 and 2010, which represents a 46% relative reduction compared to the 2010 prevalence under the counterfactual scenario of policies held to 1989 levels.[307] Combined these policies had averted 420,000 deaths by 2010, with estimates of an almost 7 million (4.5 million–10.3 million) deaths averted projected by 2050.[307]

Uruguay, an international leader in tobacco control, became one of the first countries to fully implement the Framework Convention on Tobacco Control. In 2006, Uruguay implemented its national smokefree law, and in 2009 the government implemented the largest graphic warning label, covering 80% (up from 50%) of the package. In that same year Uruguay prohibited use of false or misleading statements on tobacco packages (i.e., light or mild descriptors). There were three tobacco tax increases in June 2007, June 2009, and February 2010, which made tobacco products in Uruguay the highest in the region. In 2012, the Ministry of Health launched an aggressive mass media campaign[308] and in 2014 the government prohibited all forms of tobacco marketing including advertising, promotion and sponsorship, product promotion, and point-of-sale displays.

Since implementation of its comprehensive tobacco control program, tobacco consumption, risk perceptions, and social acceptability of use and the tobacco industry have shifted dramatically. From 2003 to 2011, adult smoking dropped by 3.3 percent each year while youth smoking dropped by 8 percent, from 39% to 31% for males and from 28% to 20% for females.[308] In 2012, 75% of Uruguayans favored a total ban on all tobacco products within 10 years and 60% of the population believed the tobacco companies were unethical. Support for comprehensive smokefree laws among smokers increased from 54% in 2006 to 90% in 2012.[308] After Uruguay implemented its smokefree law, hospital admissions for heart attacks dropped 20%[309] and non-hospital emergency visits for bronchospasm dropped by 15%.[303]

Canada,[283] Iceland,[310] Mexico,[311] and Norway[218] have implemented comprehensive tobacco control programs, and have achieved reductions of greater than 50% in both male and female smoking prevalence.[312]

Comprehensive versus partial advertising bans

There is a large body of evidence on the impact of comprehensive bans on tobacco company marketing, advertising, and promotional activity on reducing tobacco product use.[57, 93, 141] It has been estimated that if comprehensive prohibitions on protobacco marketing were in place in jurisdictions such as the United States, school programs and anti-tobacco media campaigns would have an even larger effect on reducing youth smoking behavior.[210] To be effective, comprehensive bans on advertising, marketing, and promotional activity must be broad in scope, including television, radio, billboards, public transit, print and digital communications (e.g., internet, social media, text, and other new-age advertising platforms), the use of cartoon characters, event sponsorship, product placement in popular media, and branded merchandise, giveaways, free samples, and distributing ads or coupons.[108, 313]

While laws that partially restrict advertising and marketing activity are associated with reduced tobacco consumption, the effect is not nearly as large as comprehensive laws. The National Cancer Institute concluded:

> The studies of tobacco advertising bans in various countries show that comprehensive bans reduce tobacco consumption. Noncomprehensive restrictions generally induce an increase in expenditures for advertising in 'nonbanned' media and for other marketing activities, which offset the effect of the partial ban so that any net change in consumption is minimal or undetectable.[93]

A 2000 study on marketing restrictions in OECD countries found that the effects of marketing bans are cumulative (i.e., the more places where tobacco advertising is prohibited the greater the effect on reducing tobacco use) and that partial bans (defined as a dichotomous variable which is equal to one if cumulative ban is 3, or 4, and is equal to zero otherwise[314]) were not associated with reductions in tobacco use. Overall, comprehensive bans (defined as a dichotomous variable which is equal to one if cumulative ban is 5, 6, or 7, and is equal to zero otherwise) on advertising and promotions were associated with a significant (6.3%) reduction in tobacco consumption since implementation, with larger effects for more comprehensive (in terms of number of media covered) bans.[314]

Market segmentation is an important aspect of tobacco industry marketing.[115, 235-237, 239, 241, 260, 261, 313, 315-317] Tobacco companies use market research to understand smoking behaviour among different segments of the population,[31, 318] and, in turn, use such research in future marketing campaign messages.[195, 315, 319] This information can be used to design advertising campaigns that circumvent partial advertising restrictions by shifting expenditures toward other media outlets (i.e., point of sale advertising or product placement in popular media).[57, 141] For example, after the 1998 Master Settlement Agreement in the United States, in which the tobacco companies agreed to some limitations on their advertising and promotional activities, the tobacco industry shifted marketing expenditures to direct mailings and online marketing.[57] Partial advertising restrictions permit cigarette companies to target young adults through lifestyle

magazines created by the industry,[318] event sponsorships,[315] and low income and less educated women through distribution of coupons with food stamps, direct mail, and bundle offers at the point-of-sale.[320]

Following implementation of a 2012 law that prohibited point-of-sale tobacco displays in New Zealand the odds dropped significantly for experimentation with smoking (0.73, 95% CI 0.69 to 0.78), smoking initiation (0.91, CI 0.84 to 0.98), and smoking prevalence (0.71, CI 0.64 to 0.79), among adolescents,[321] consistent with similar studies from Ireland,[227] Norway,[322] and Australia.[228] There was a marginal decrease in perceived peer smoking among New Zealand smokers, which may have been greater if all forms of tobacco marketing had been prohibited simultaneously.[321]

Because the tobacco industry continuously seeks to evade any advertising restrictions, the World Health Organization recommends that governments license tobacco manufacturers and retailers, with penalties and sanctions for noncompliance, including license suspension and revocation for repeat violations commensurate on the nature and seriousness of the offence(s), to assist with enforcement efforts to control tobacco advertising.[141] It is also recommended by the World Health Organization that governments dedicate funding for comprehensive enforcement programs provides legal protection and an ongoing revenue stream for government efforts to monitor and enforce regulatory compliance with marketing bans.

Limitations of Youth-Oriented Prevention Programs

As discussed earlier, tobacco control programs that focus on youth and avoid the tobacco industry denormalization strategy are less effective at reducing tobacco use and the associated medical costs than general market campaigns that include denormalization of the tobacco industry.[21, 225, 229, 287, 288, 323] In particular, the California model has never focused on youth, but rather treated them as part of a larger society, led by adults, in which social norms are changed to reject tobacco use.[155, 222, 223] The themes of secondhand smoke (which engages the nonsmoking majority) and increasing distrust of the tobacco industry have been important elements in achieving low levels of smoking among both youth and adults.[156, 324, p. 13]

These effective tobacco control campaigns are based on the fact that one way that the tobacco companies recruit youth to smoke is by presenting smoking as an initiation into the adult world. Indeed, a marketing plan prepared for Brown and Williamson Tobacco Company in 1975 had recommended:

> For the young starter, the cigarette is not yet an integral part of life, of day-to-day life in spite of the fact that they try to project the image of a regular run-of-the-mill smoker. For them, the cigarette and the whole smoking process is part of the illicit pleasure category… In the young smoker's mind the cigarette falls into the same category with wine, beer, shaving, wearing a bra (or purposefully not wearing one) declaration of independence and striving for self-identity. For the young starter, a cigarette is associated with introduction to sex life, with courtship, with smoking 'pot' and keeping late study hours.[325]

The marketing plan then went on to explain how to use these behavioral insights to develop advertising messages to sell cigarettes:

> Thus, an attempt to reach young smokers and starters, should be based on the following major parameters:
>
> - Present the cigarette as one-of a few initiations into-the adult world.
> - Present the cigarette as part of the illicit pleasure category of product and activities.
> - In your ads create a situation taken from the day-to-day life of the young smoker, but in an elegant manner have this situation touch on the basic symbols of the growing-up, maturity process.
> - To the best of your ability (considering some legal restraints) relate the cigarette to "pot", wine, beer, sex, etc.
> - Don't communicate health or health-related points.[325]

This research, conducted for the Brown and Williamson Tobacco Company over 40 years ago illustrates the close linage between adult behavior and youth tobacco use. It helps understand why it is so difficult to narrowly target youth for tobacco use prevention and, by implication, to prevent youth marijuana use while accepting adult use. Appreciating the close linkage between adult and youth behavior explains why programs, such as the California Tobacco Control Program, which do not focus on youth,[223] have resulted in low levels of youth smoking.

As indicated above, the tobacco companies understand this point[99] and have worked to displace effective programs that blame the tobacco industry for youth smoking[163] with messages limited to youth (and sometimes parents) that focus on "responsible decision making" and delaying use until adulthood.[161, 163] These messages reinforce industry marketing messages, and as discussed above, youth (15-17 years old) exposed to tobacco industry "youth smoking prevention" messaging were more likely to report reduced risk perceptions, increased approval of smoking, greater intentions to smoke, and past 30-day smoking than youth not exposed to these messages.[165]

Because school-based programs are usually disconnected from broader social norm change strategies, they are generally ineffective at preventing smoking.[326-328]

Smokefree laws

In 2006 the U.S. Surgeon General affirmed that there is no risk-free level of exposure to tobacco smoke.[329] Secondhand smoke causes cardiovascular disease, lung cancer, stroke, respiratory disease, and premature death in adults. Infants and children exposed to secondhand smoke are at risk for sudden infant death (SIDS), asthma attacks, ear infections, and respiratory infections.[330] Smokefree laws are designed to protect the health and safety of the public from secondhand smoke. They also have the beneficial side effect of denormalizing tobacco use, and supporting smoking cessation.[21, p. 26-29, 210, 331-333] In addition, comprehensive smokefree laws stimulate adoption of voluntary smokefree home policies,[334-336] which also help to denormalize

smoking, discourage initiation[337], and supports quit attempts and smoking cessation among current smokers.[337, 338]

Comprehensive smokefree laws are associated with larger drops in hospitalizations for heart attacks, other cardiovascular conditions, stroke, and pulmonary conditions,[21, p. 435-443, 302] as well as complications of pregnancy, hospitalizations for childhood illnesses, and perinatal complications.[294-299, 304]

Exemptions in smokefree laws negatively impact lower socioeconomic groups and contribute to health disparities. Lower socioeconomic status individuals are more likely to work in establishments that do not have 100% smokefree coverage or circumvent the law through exemptions (i.e. workplaces that employ five or fewer employees).[339] In addition, women are disproportionately impacted by exemptions in smokefree laws because women are overrepresented in the hospitality industry.[340] In California, for example, exemptions in the statewide smokefree law had disproportionately exposed low income workers, Latinos, and young adults to secondhand tobacco smoke in the workplace,[324] thereby contributing to health disparities.[341, 342] In 2016 California passed a law that eliminated these exemptions.[343]

While most states in the US now have comprehensive smokefree laws which cover workplaces and restaurants, there are few similar policies on tobacco smoking in multiunit housing, despite the fact that exposure differentially impacts children, the elderly, and disabled,[70, 344, 345] particularly in publically funded multiunit housing.[344] Residents of multiunit housing who do not smoke have evidence of significant exposure to tobacco smoke.[346] A recent study in California of tobacco smoke exposure among Hispanic residents also identified respondents who were concerned about marijuana smoke incursions.[347]

OVERVIEW OF TOBACCO-TYPE RESTRICTIONS IN JURISDICTIONS WITH LEGALIZED CANNABIS

There are two broad approaches from the tobacco control experience in creating a regulatory framework for marijuana sales, one in which marijuana is legal but actively discouraged (the public health model, Table 1) and one in which marijuana is legal and promoted for adults (the business model).[6] Both approaches remove marijuana from the criminal justice system and legalize a commercial market, but have very different implications for how future consumption – and associated negative health effects – develop over time. Indeed, a 1933 report that strongly recommended a government monopoly over the alcohol market following repeal of alcohol prohibition in the United States instead of administrative regulation concludes:

> Under the license system, the will to survive permeates every department of the trade, and the means to press a tenacious fight for survival are abundant. As proposals to dismember any part of the liquor selling business become more threatening the entire trade combines more solidly to protect itself. In brief, a licensed liquor trade, once established, cannot easily be dislodged.[348, p. 61]

Table 1: Public Health Framework* Versus States Marijuana Regulations[6, 349]	*Public Health Standard*	*Colorado*	*Washington*	*Alaska*	*Oregon*	*California*
Lead Agency						
Department of Health	✓	X	X	X	X	X
Advisory Committees						
Membership solely of public health experts	✓	✓	--	X	✓	X
No decision-making authority for marijuana industry or vested interests	✓	X	--	X	X	X
Regulatory Complexity						
Creates a single system of retail marijuana	✓	X	✓	X	X	X
Tax Revenue						
Tax covers full costs	✓	X	X	--	X	X
Dedicated revenue to marijuana prevention and control and research	✓	X	✓	--	X	X
Prevention and Control Programs						
Media campaign						
Aimed at general population (not just youth)	✓	X	X	--	X	X
Modeled on social norm change	✓	X	X	--	X	X
Smokefree Laws						
Prohibit any public use of marijuana	✓	✓	✓	✓	✓	X
Prohibit marijuana use wherever tobacco smoking is prohibited	✓	✓	✓	X	✓	✓
Protect local control	✓	✓	✓	✓	✓	✓
Prohibit indoor use in marijuana retail stores or marijuana clubs	✓	X	✓	X	✓	--
Marketing and Advertising						
Prohibit free or discounted samples	✓	X	✓	✓	✓	X
Prohibit cartoon characters	✓	✓	✓	✓	✓	✓
Prohibit sport and cultural event sponsorship	✓	X	X	X	X	X
Prohibit product placement in popular media and co-branded merchandise	✓	X	X	X	X	X
Prohibit therapeutic claims	✓	✓	✓	✓	✓	✓
Prohibit outdoor advertising on billboards	✓	✓	X	X	X	--
Prohibit advertising on television, radio	✓	X	✓	X	X	X
Restrict advertising in print and digital communications with 15% threshold	✓	X	X	X	X	X
Licensing Rules						
Impose serious penalties on retailers underage sales	✓	✓	✓	--	✓	X
Prohibit sale of tobacco or alcohol in marijuana retail stores	✓	✓	✓	✓	✓	✓
Prohibit tobacco and alcohol retailers from holding marijuana license	✓	X	X	X	X	X
Retail Sales						
Require retailer use age verification system (ID scanners) at point of sale	✓	X	X	X	X	X
Prohibit retailers within 1,000 feet of underage-sensitive areas	✓	X	✓	X	X	X
Prohibit electronic commerce (internet, mail order, text messaging, social media)	✓	✓	✓	✓	✓	X
Product Standards						
Require strong potency limits and product quality testing	✓	X	X	X	✓	X
Prohibit products containing additives (nicotine, alcohol, caffeine, or toxic chemicals)	✓	✓	X	✓	✓	X
Prohibits flavored products appealing to underage persons	✓	X	✓	X	X	X
Warning Labels						
Require warning labels modeled on state of the art tobacco labels	✓	X	X	X	X	X

Key: ✓ Required by law or regulation; X Not required by law or regulation; -- Pending legislative approval or rulemaking process

***** Public health framework developed by the authors based on best practices from tobacco control. [6, 349]

An important lesson from tobacco control is that if commercial interests are heavily involved in the early marijuana regulatory process then it is likely that as negative public health impacts of increased use develop, it will become ever more difficult to implement public health policies that have, over many years and with great difficulty, been applied to tobacco because there will be a rich and politically powerful industry working against implementation of effective policies to reduce consumption.[13]

Commercial sales of medical marijuana in the United States through for-profit dispensaries began in the 2000s.[6, 350] In 2012 and 2014, drug reform groups in Colorado, Washington, Alaska, and Oregon, and the District of Colombia used the initiative process to legalize sales, possession, and use of non-medical marijuana for adults age 21 and over.[351] (The District of Colombia legalized personal possession and cultivation in small amounts for no remuneration without legalizing commercial sales.[352]) The four US states that legalized retail sales have implemented tax and regulatory structures for the marijuana market, based on the 2014 US Department of Justice Cole Memorandum,[353] which stated that the federal government would only intervene in states that failed to prevent diversion to other states, criminal involvement, and access to minors.[351] The four states that have legalized retail marijuana are using US alcohol policies as a model for regulating retail marijuana, which prioritizes business interests over public health.[6]

Large and immediate increases in cannabis use and cannabis-related harms should not be expected in jurisdictions that have legalized use and sales for adults because it will take time for population shifts in perceived risks and social acceptability of its use that will likely lead to increased use.[352 275] Alcohol use and alcohol-caused harm did not increase substantially in the immediate post-Prohibition era of alcohol in the United States. Alcohol producers were slow to develop and expand the market, possibly due in part to alcohol use not being socially acceptable. An additional factor was implementation among several states of the "Rockefeller Model" alcohol policy framework, which recommended tight control over the legal market through either a government monopoly or a comprehensive licensing system which divided the industry into three tiers (production, distribution, and sales), limited hours of operation for retail outlets, prohibited price reductions or other strategies to increase consumption, including rigid restrictions on alcohol promotions. This model was based on a 1933 report, *Toward Liquor Control*, commissioned by John D. Rockefeller that concluded:

> The private profit motive by which sales are artificially stimulated is the greatest single contributing cause of the evils of excess.[348]

For several years, alcohol control employed in the US states through state-owned and operated stores was more effective than pre-prohibition policies, and at least as effective as prohibition, in maintaining low levels of alcohol per capita consumption.[354]

Alcohol consumption in the US did not reach pre-prohibition levels until 35 years after its repeal in 1970. In part, this rise in alcohol consumption can be attributed to privatization of alcohol monopolies or partial privatization of alcohol sales,[354] where private companies take control over a portion of the market (i.e., wine industry).[355] (Partial privatization is more likely to occur than total privatization of alcohol monopolies). There is a positive relationship between

privatization and alcohol sales, a well-established proxy for excessive alcohol consumption, due to several intermediate outcomes including increased alcohol density, increased availability (days and hours/day), increased advertising, and reduced prices..[356] These intermediate outcomes increase access and artificially stimulate demand for privatized alcohol, which leads excessive consumption and the associated health, social, and economic adverse outcomes. Confirming previous research in Iowa and West Virginia,[357] privatization of wine sales was associated with significant increases in sales in five US states. An interrupted time-series analysis found that after privatization, wine sales increased by 42% in Alabama, 150% in Idaho, 137% in Maine, 75% in Montana and 15% in New Hampshire,[358] while beer and spirit sales, under public monopolies, remained stable.

Eliminating government control over alcohol sales is associated with increases in retail density of alcohol outlets. Ten years following privatization of liquor sales in Alberta, Canada the number of retail outlets increased three fold from 310 in 1993 to 938 in 2003, with an associated increase in absolute alcohol consumption.[359] In contrast, re-monopolization of alcohol sales in Sweden resulted in significant declines in the number of outlets from 11,550 to 300 after implementation in 1977. Government control over the market in Sweden also led to declines in hospital admissions for alcohol intoxication, suicides and falls, as well as declines in alcohol-related traffic accidents.[360]

The experience with alcohol suggests that governments should consider alternative frameworks for marijuana regulation over the commercially-focussed model implemented in the four US states.[3, 6, 17, 361] Avoiding a privatized marijuana market, as well as an industry that will aggressively oppose any public health effort to increase consumption in order to maximize profits, would likely lead to lower consumer demand, consumption and prevalence, even among youth, and may reduce the associated public health harm.[6, 11, 350, 355, 359, 362]

As discussed below, one model for doing so would be to create an agency, similar to Uruguay's Regulation and Cannabis Control Institute (IRCCA), to control the production and distribution of marijuana and cannabis products.[363] Alterative or a variation of existing frameworks that might avoid corporatization or other forms of excessive commercialization could also be considered, including the European models of the Dutch *coffeeshops* or the Spanish *cannabis clubs*.[364]

De facto legalization in the Netherlands allows coffee shop owners to distribute cannabis to Dutch residents as long as certain guidelines are followed: sales limited to 5 grams per person/day at the same store, prohibition of advertising, and sales and shop access restricted to adults 18 and above. Failure to comply with these guidelines will result in shop closure. Between 1997 and 2007, the number of shops decreased by 40% from 1,179 to 702 due to non-compliance with Dutch cannabis policy.[365]

Cannabis social clubs (CSCs) or cannabis collectives, are quasi-legal, largely unregulated distribution systems for cannabis. In jurisdictions where cannabis consumption is legal but production remains illegal, cannabis users form informal networks to maximize production and avoid purchase through the illegal market. Governments tolerate this form of cannabis

distribution on the basis that private members cultivate cannabis for personal use and do not profit from production.[33, 35]

Proponents of CSCs argue that cannabis collectives can control product quality and reduce risky consumption.[366] In both regulated and unregulated markets, cannabis collectives can help to reduce the harms of consumption in the illegal market by providing potency education to consumers as well as on the effects of cannabis varieties on individual users.[33] Whether or not such claims are valid remains to be seen, particularly if cannabis clubs have to compete with other access points (i.e., retail stores or pharmacies in Uruguay).[367] For example, in a 2016 survey conducted in Uruguay, CSCs were the least favored cannabis source (13%) compared to pharmacies (56%) and home cultivation (30%).[368] These findings suggest that consumers would need incentives to access cannabis clubs over other access points or these other access points would need to be prohibited entirely. Moreover, in contrast to the cannabis collectives in Spain where product quality is not monitored by the government, policymakers or societies could implement strict product testing requirements for cooperatives to follow under existing product safety protocols.

Lead Regulatory Agency

The architecture of the marijuana regulatory regime will depend upon the regulatory agencies charged with developing and implementing new regulations and the charge to that agency. In particular, making the health department the lead agency with a clear mandate to minimize consumption (as with tobacco control programs) will lead to a different regulatory environment than an agency that views its primary mission as promoting business or tax revenue, albeit in a regulated market.[3, 5] As of October 2016 the four US states have opted for government agencies that prioritize a regulated business environment over implementation of public health programs that seek to minimize use through demand reduction programs based on social norms change.[6, 369] California, which legalized recreational marijuana in November 2016, also followed the business framework.[349]

As of November 2016, none of the US retail marijuana legalization states had designated the public health department the lead regulatory agency. Designating the revenue department or agriculture department as the lead regulatory agency has not benefited public health because the interest of revenue generation is considered equal to or at times more important than that of public health. From the tobacco control experience, granting substantial authority to business-oriented agencies, such as the Department of Food and Agriculture,[370, 371] that would support the interests of marijuana growers and retailers, will likely result in these agencies issuing regulations that would help to increase market size, rather than institute strong controls to protect public health. In US tobacco growing states, commissioners of agriculture have been important allies to the tobacco industry and have blocked tobacco control policies (e.g., smokefree laws, tobacco taxes) to support the financial interests of tobacco growers.[370] Analogous problems with regulatory agencies for alcohol and food regulation provide additional examples of the problems of regulatory capture.[372-374]

Public health departments in Colorado and Oregon were involved in developing policy recommendations for new regulatory frameworks,[375, 376] but were not the lead agencies. In Washington the health department was in control of developing the public education and

research programs[377] which led to the implementation of some public health policies (i.e., age restriction, age verification for face to face sales, smokefree laws, local control) but a comprehensive approach to reduce population level harm was not undertaken in any of the states[6] (Table 1).

Industry participation in regulatory process

Because public health regulations are often in direct conflict with the interests of profit-driven corporations [378], a public health framework would protect the policy process from industry influence. In contrast to what states that have legalized retail marijuana have done to date, a public health framework would require that expert advisory committees involved in regulatory oversight and public education policymaking processes consist solely of public health officials and experts, and limit the marijuana industry's role in decision-making to participation as a member of the "public." Including the tobacco industry on advisory committees when developing tobacco regulations blocks, delays, and weakens public health policies [104]. The World Health Organization Framework Convention on Tobacco Control, the global public health treaty ratified by 180 parties (not including the United States) as of April 2016, recognizes the need to protect the policymaking process from industry interference:

> [Governments] should not allow any person employed by the tobacco industry or any entity working to further its interests to be a member of any government body, committee or advisory group that sets or implements tobacco control or public health policy.[104, Article 5.3]

For example, the marijuana industry in Colorado has already worked to minimize public health protections on packaging and THC limits per serving size by working through a member of the advisory committee that set up the initial rules and in Alaska industry participation on the regulatory board led to adoption of cannabis smoking clubs. Recognizing that there may be some areas where regulators and public health experts need third party expertise on regulatory issues, one option could be to hold public hearings where members of the public, including the marijuana industry, provide testimony to government authorities on complex regulatory issues. Public health advocates and researchers have increasingly been calling for similar treatment for other unhealthy commodity industries in the regulatory process.[379, 380] A marijuana regulatory framework that prioritizes public health would have similar provisions.

Colorado and Oregon allowed multiple stakeholders, including members of the marijuana industry, public health, and law enforcement, on advisory committees that made recommendations to legislatures and state agencies during the rulemaking process.[381, 382] In Alaska, the legislature created the Marijuana Control Board to consist of five voting members, with requirements for at least one member to be from the marijuana industry and one either from the general public or actively engaged in the marijuana industry.[383] Rather than electing a member of the general public, in 2016, the governor appointed two members from the marijuana industry, including the president of the Alaska Marijuana Industry Association as chairman, and the executive director of a the Coalition for Responsible Cannabis Legislation, a marijuana legalization advocacy organization developed in Alaska in 2013.[384]

Industry participation on regulatory boards or advisory committees poses a significant risk to public health.[17] As noted above, the World Health Organization Framework Convention on Tobacco Control commits parties to not include the tobacco industry or other vested interests as members of any government body, committee or advisory group that sets or implements public health policy. In contrast, all four states relied on industry participation in the development of rules and regulations because of the lack in regulatory models for the novel industry,[375] which led to inadequate adoption of policies to protect public health.

For example, in Colorado, industry members of the 2014 working group on pesticide regulation delayed action on a 2013 Colorado Department of Agriculture draft list of allowable pesticides that would have required growers use only nontoxic forms, arguing that the proposed list was too restrictive,[369] resulting in regulatory paralysis. Between 2014 and 2016, pesticide use in Colorado was unregulated during which time producers were reportedly using inappropriate or unsafe chemicals,[369] including Eagle 20, a fungicide used to kill mites, mildew and assorted pests.[385] Eagle 20, which was not among the list of approved pesticides as of 2016, contains myclobutanil, which when burned produces the poisonous gas hydrogen cyanide.[386] In 2016, marijuana industry participation on the rulemaking board in Alaska led to the adoption of marijuana smoking clubs, despite the risks of exposure to secondhand marijuana smoke on cardiovascular function.[73]

Dual marijuana markets with inconsistent rules

A single market, in which all sales are regulated as retail -- without a separate medical market -- simplifies regulatory efforts, including licensing enforcement, implementation of underage access laws, prevention education programs, and taxation.[6] The existence of a licensing system for medical marijuana in Colorado and Oregon before retail legalization led to regulators developing dual licensing systems for medical and retail; in Colorado marijuana businesses could apply for both.[375] As of October 2016, Alaska had not developed regulations for its medical marijuana licensing system through for profit dispensaries, though medical marijuana has been legal since 1998. All four US states that had legalized recreational use as of October 2016 maintained dual markets with medical marijuana subject to different rules than retail, including higher possession and cultivation limits, and lower age limits (18 for medical vs 21 for retail). In 2015, Washington legislators eliminated separate medical marijuana dispensaries. Retail marijuana stores that applied for and received a medical marijuana endorsement from the Department of Health could legally sell both medical and retail marijuana products. Otherwise, the same regulatory inconsistencies still existed in all four states. Medical marijuana is exempt from state and local taxes, which created price differences between the two markets, and likely has contributed to the continued growth of the medical marijuana market.[375]

The experience from tobacco is that regulatory complexity ultimately favors corporate interests with the financial resources to manipulate and weaken public health policies to reduce use.[378, 387] The tobacco companies use their extensive legal resources and more detailed information about market structure to take advantage of complexity in regulations to make enforcement more difficult for government regulators, which general move slowly and are subject to political constraints. It is unknown what effect these complex legal environments that often favor large corporate interests, and that complicate implementation of effective public health policies, will have on marijuana prevalence at the population level.

State Control over Cannabis Sales in Uruguay

While the Netherlands *de facto* legalized possession and use of marijuana in 1976,[352] in 2014 Uruguay became the first country to legalize the cultivation, processing, distribution, and supply of marijuana for recreational purposes. Uruguay's law mandates that the government control the manufacture, distribution, and sale of cannabis under the authority of the Regulation and Cannabis Control Institute (IRCCA) a new agency created to oversee cultivation licensees and pharmacies, cannabis clubs, and at-home cultivation.[364] The agency would produce generic, unbranded cannabis, eliminating the incentive to market and advertise competitive products.[6] The state would use its licensing power to grant licenses to qualified professional farmers (as well as for home cultivation for personal use) and limit the number of licenses, depending on demand, to avoid an illegal market.

As of November 2016 Uruguay was still developing a government monopoly over marijuana production and distribution system.[388] It had implemented regulations for personal cultivation and the operation of cannabis co-operatives, where Uruguayans pay membership fees to be part of collectives that grow marijuana,[368] but was still in the process of drafting the rules for cultivation licenses for private companies and distribution through pharmacies.[368]

Marketing and Advertising Restrictions

Because the four US states (plus California, Maine, Massachusetts, and Nevada) elected to adopt commercially-focused marijuana regulatory schemes, it is unlikely that these state governments will legally be able to prohibit all forms of marketing and advertising, particularly if marijuana is legalized at the federal level. While it is theoretically possible for government to limit advertising and promotion in the United States, it is extremely difficult to craft such restrictions in light of how the courts have interpreted the US First Amendment protections of free speech. Other governments have successfully restricted tobacco advertising much more extensively than was possible in the United States. Uruguay in 2013 prohibited all forms of marijuana marketing, advertising, and promotions, modeled on its provisions for tobacco products.[389]

As discussed above, the alcohol industry has voluntarily committed not to advertise in mass media outlets (i.e., print, television, radio, and the internet) where more than 30% (roughly the proportion of the population between 2-20 years old) of the audience is "reasonably" expected to be under age 21.[390] Also as discussed above, the 30% threshold is high enough to allow the alcohol industry to reach youth with their marketing.[390] Colorado and Oregon codified that alcohol industry voluntary standard into their marijuana advertising restrictions. In Colorado, event sponsorship, including sporting events and concerts, were permitted as long as less than 30% of the audience is under age twenty-one, whereas in Washington these events were subject to the same location restrictions as traditional mass media advertising (i.e., cannot be located 1,000 feet from K-12 schools, public parks, public transit, and game arcades).

None of the states prohibit online advertising or the use of social media. Colorado prohibits the use of unsolicited pop-up advertisements on the Internet; otherwise in Colorado and Oregon internet advertising is subject to the same 30% threshold for underage exposure. Neither state has specific rules on how the age restriction on internet advertising will be defined or

enforced. Washington included an unenforceable guideline suggesting that businesses "use social media with caution and be mindful not to appeal to, or solicit, viewers under the age of 21. If possible, please restrict views to adults age 21 and older."[391]

Indeed, in 2015, within two years of implementation of legalization laws in Colorado and Washington, the marijuana industry was already taking advantage of the weak advertising restrictions. Online advertising is widely used by the marijuana industry. Eighty-five percent in Colorado and 65% in Washington of marijuana companies advertise online through company websites. A little less than half of marijuana companies that had operational websites used age-verification systems in Colorado (41%) or Washington (35%). Among those with age-verification systems, more than half in Colorado (54%) and in Washington (59%) require viewers hit "yes" to gain access to the website, while only 5% in both states require information on the viewer's birthdate.[8]

Advertising restrictions could be designed to protect consumers and vulnerable populations. However, state laws in Colorado and Washington were unable to prevent marijuana companies from using false or misleading health claims to advertise their products online. Among websites of marijuana companies, 61% in Colorado and 44% in Washington made health claims about their products.[392] The most common health claim was on treatment for anxiety (80% and 100% respectively) and depression (35% and 44%), insomnia (57% and 68%), and pain management (96% and 52%),[8] even though the scientific literature is either mixed or has low evidence of these therapeutic effects.[392]

None of the states prohibit marijuana companies from using directories or store locator websites (i.e., WeedMaps, https://weedmaps.com/earth/us) which often are *de facto* advertising.[8] Seventy-five percent in Colorado and 56% in Washington of marijuana companies were listed on WeedMaps. In addition to not requiring age-verification to create an online account, WeedMaps allows marijuana companies to circumvent advertising restrictions by listing product descriptions, prices, price promotions and coupons, and post images of their products without warning statements (Figure 1). In addition, WeedMaps provides a platform for publication of online testimonials in which users make health claims on the therapeutic benefits of marijuana use. Online testimonials undermine enforcement of truth-in-advertising laws that prohibit marijuana companies from making false or misleading claims on their products.

The same issues that make age-verification systems for tobacco advertising ineffective[136, 140] have already occurred with online marijuana advertising.[8] Uruguay acted to protect public health by prohibiting marketing and advertising entirely, which would likely prevent the issue of directories and store locator websites,[6, 364]

Warning Labels and Package Design

Based on the experience with tobacco discussed above, regulatory frameworks for marijuana could reduce product appeal by prohibiting attractive packaging, including the use of cartoon characters and descriptors that give the impression that a product is reduced harm.

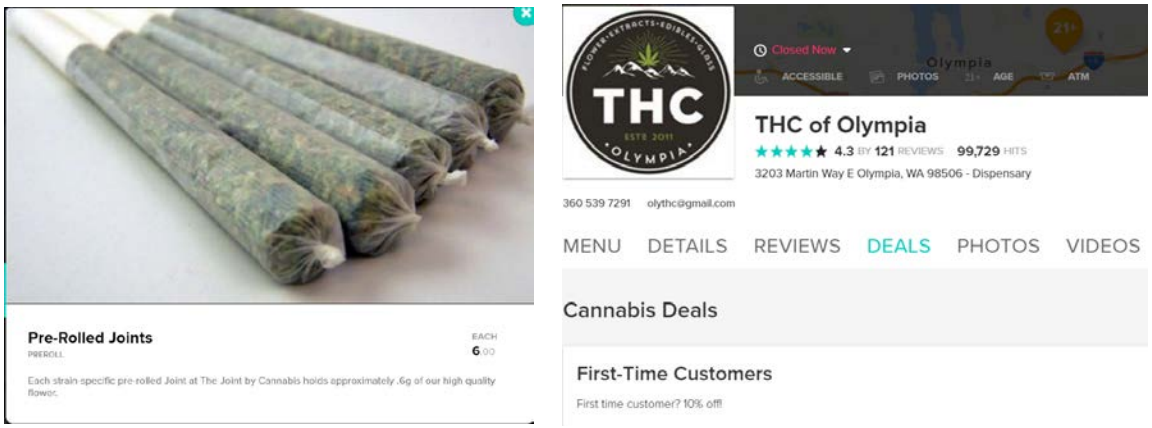


Figure 1. Example of WeedMap online profiles of marijuana Companies in Colorado and Washington. (left) Colorado operational website for the Joint Denver, a retail marijuana store in Denver that advertises its products and pricing on WeedMaps and includes price promotions. Available at: https://weedmaps.com/dispensaries/cannabis-recreational#/menu/pre-rolled-joints[393] (right) Washington State operational website for THC of Olympia, a retail marijuana store in Olympia that offers 10% off for new customers.[394] Available at: https://weedmaps.com/dispensaries/the-healing-center-2-2#/menu

Labels provide information to the consumer on its content, including product potency and serving size. As such, it is important that marijuana labels are accurate so as to avoid marijuana intoxication and accidental use. Poor production and premarketing testing procedures to accurately measure THC concentration contained in a marijuana product had led to inconsistent concentration levels in marijuana edibles.[369] A 2015 study of the accuracy of labels in San Francisco and Los Angeles, California. and Seattle, Washington found that marijuana products were unlikely to be accurately labeled in terms of THC content.[395] While 17% of the sample was accurately labeled, 23% reported THC levels 10% higher than indicated on the label, and 45% reported THC levels 10% below its labeling content.[395]

Although not yet in place as of November 2016, Uruguayan authorities had indicated that the IRCCA will develop requirements for generic, non-appealing packaging.[364] None of the four US states require plain packaging, although under the Oregon Liquor Control Commission's rules, marijuana companies that use generic labels without graphics, pictures, or logos are not required to submit their packages to the OLCC for pre-approval.[396]

Colorado prohibits the words "candy" or "candies" on marijuana packaging and Oregon prohibits product packaging that contains "cartoons, including use of comically exaggerated features, attribution of human characteristics to animals, plants or other objects, or the similar use of anthropomorphic technique, or attribution of unnatural or extra-human abilities, such as imperviousness to pain or injury, X-ray vision, tunneling at very high speeds or transformation."[397]

While the four US states prohibit false or misleading health claims on marijuana labeling,[6, 364] the regulations do not specify what would invalidate such claim or how the liquor control boards in charge of overseeing packaging regulations would enforce these laws. State

laws do not prohibit the use of "natural," "pure," "clean," "additive-free," "fair trade," "omega 3, 6, and 9," or any other descriptor that would increase product appeal or reduce risk perceptions on packaging, labeling, or advertising, which permit marijuana companies to use package design and ingredient lists to circumvent restrictions on health claims.

For example, in 2016 the Colorado marijuana company Dixie Elixirs sold an orange zest flavored product labeled as "awakening" and a peppermint flavored product labeled as "relaxing," and included an ingredient list with supplements including "Siberian ginseng" and "ashwagandha," an herb promoted as reducing stress and promoting wellbeing, despite the fact that no clinical trials have verified these claims.[398] Another Colorado company that produced Ebbu Raw, used its labeling and package design to "[build] trust with customers.[399] Evergreen Herbal's 4.20 Bars were labeled with descriptors "fair trade," "With Omega 3, 6, 9," and "cacao," which may signal users that these products are environmentally safe or may produce health benefits. Washington packaging requirements allowed marijuana companies to design marijuana packages with brand names such as Mirth "Relax. It's Legal" in Rainier Cherry Soda flavor,[400] or Evergreen Herbal's 4.20 Bars in milk or dark chocolate, and flavored with sea salt, toffee, hazelnut or hemp crunch.[401]

One way to prevent marijuana companies from taking advantage of weak language for restrictions on health-related messaging would be to require that all advertising and marketing statements and claims be evidence-based and approved by the health authority, including claims about the product improving sex, energy, sleep, weight reduction, vitamin supplements, among other health-related claims that would increase product appeal.

Edibles that lack accurate product labeling pose a serious public health risk to adult consumers as well as children.[395] It appears that the regulations on potency limits, labelling and standardization of dose, and packaging in Colorado and Washington were not strong enough to prevent cannabis-related harm. Adults that have used highly potent products have been increasingly reporting unpleasant psychological experiences such as psychosis, anxiety (i.e., panic attacks),[68] and depression symptoms.[402] There is cause for concern that marijuana edibles in the US states have high THC content, which may responsible for many of these observed effects.[402]

In 2015, product regulation laws in Colorado were updated to require clear demarcation or individually wrapped servings (i.e., individually package each 10 mg of THC serving in a cookie with 100 mg of THC).[369, 375] There were no changes to the THC limits per serving size or per package, which could have helped reduce marijuana intoxication in both children and adults. After reviewing the evidence from Colorado and Washington that edibles were causing harm in children and inexperienced users, Oregon reduced its maximum THC limit to 5 mg per serving, and 50 mg per package.[403, 404] This experience illustrates the importance of health authorities having the power to adjust maximum serving size and related packaging as scientific evidence on the harms associated with different doses accumulates.

An additional issue related to product regulation of marijuana edibles is the high THC potency per package without adequate requirements that these products clearly be demarcated to explicitly communicate the actual size of an individual serving to the consumer.[402] In Colorado

and Washington, product regulations allow for each package to contain up to ten 10 mg servings of THC or 100 mg of THC. Poor product labeling in Colorado and Washington contributed to an increase in calls to poison control centers[405] and self-reports of adult intoxication.[402, 405] In Colorado, marijuana-related calls to the poison control center increased from 44 in 2006 to 227 in 2015,[406] while in Washington calls increased by 79% from 111 in 2010 to 199 in 2014.[407] Since commercialization, calls increased by 55% from 129 in 2012 to 199 in 2014.[407]

The tobacco companies and consulting firms hired by the tobacco companies have released a series of studies arguing that plain packaging in Australia was followed by substantial increases in smuggling and counterfeit cigarettes.[408] Detailed analysis of data from a variety of sources has not supported these claims.[409] In contrast to industry claims, the February 2016, the Australian Government released its "Post-Implementation Review on Tobacco Plain Packaging" concluded:

> While the full effect of the tobacco plain packaging measure is expected to be realised over time, the evidence examined in this [post-implementation review] suggests that the measure is achieving its aims. This evidence shows that tobacco plain packaging is having a positive impact on its specific mechanisms as envisaged in the [Tobacco Plain Packaging] Act. All of the major datasets examined also showed on-going drops in national smoking prevalence in Australia. These decreases cannot be entirely attributed to plain packaging given the range of tobacco control measures in place in Australia, including media campaigns and Australia's tobacco excise regime. However, analysis of Roy Morgan Single Source Survey Data shows that the 2012 packaging changes (plain packaging combined with enhanced graphic health warnings) have contributed to declines in smoking prevalence, even at this early time after implementation. The analysis estimated that the 2012 packaging changes resulted in a "statistically significant decline in smoking prevalence [among Australians aged 14 years and over] of 0.55 percentage points over the post-implementation period, relative to what the prevalence would have been without the packaging changes". This decline accounts for approximately one quarter of the total decline in average prevalence rates observed between the 34 months prior to implementation of the measure and the 34 months following the implementation of the measure (the total decline between the two periods was estimated as being 2.2 percentage points, with average prevalence falling from 19.4% to 17.2%).[410] [citations eliminated]

Scollo et al[411] specifically examined the veracity of industry claims that pain packaging would lead to an increase in the amount of counterfeit cigarettes using data from national cross-sectional telephone surveys conducted in Australia from April 2012 (6 months before implementation of plain packaging to March 2014 (15 months after). There was no change in use of "cheap whites" (<0.1%; p=0.134), international brands purchased for 20% or more below the recommended retail price (0.2%, p=0.140), or packs purchased from informal sellers (<0.1%, p=0.124). The prevalence of any use of unbranded illicit tobacco remained stable at about 3% (p=0.141). In short, they found no evidence in Australia of increased use of two categories of manufactured cigarettes likely to be contraband, no increase in purchase from informal sellers and no increased use of unbranded illicit 'chop-chop' tobacco.

Product Characteristics and Flavors

Liquor control boards in charge of approving products prior to market release allowed fruit and candy flavored marijuana products to enter the legal markets in Washington and Colorado. Despite a rule that the Washington State Liquor and Cannabis Control Board not approve any marijuana-infused edible products "especially appealing to children" such as, but not limited to, "gummy candies, lollipops, cotton candy, or brightly colored products" did not block approval of fruit flavored sodas and candy, chocolate and peanut butter flavored cookies and brownies, and chocolate truffles,[412] including Mirth Provisions' Legal Sparkling Rainier Cherry Soda[400] and Nana's Secret Soda in Orange Cream and Peach Flavors.[413] Colorado does not have even such nominal restrictions and similar products have entered the market, including Dixie Elixir's Crispy Cracken and Chocolate Cherry Pretzel.[414]

Marijuana edibles may be a safer alternative for adult consumers than marijuana cigarettes because they avoid combustion. However, because edibles are being produced in a wide array of flavors and variations that often are appealing to children, it is questionable whether these products contribute to less harm.[369, 415] Avoiding these harms could be achieved through tight regulation, including low limits on potency, large warning labels, accurate labeling, standardization of dosing, and standardization of packaging to avoid accidental ingestion by children and adults. There is concern that the high potency of these products as well as their appeal to children may result in adverse health consequences.[4]

Indeed, it is likely that such youth appealing products[416] are a major contributor to an increase in accidental childhood ingestion since legalization in Colorado[402] and Washington.[417] Prior to legalization in Colorado and Washington there were few cases involving marijuana-related accidental poisonings in children. Children admitted to the emergency room for accidental marijuana ingestion increased from 0 to 14 two years following liberalization of medical marijuana laws in Colorado.[418] Following implementation of retail marijuana laws in Colorado in 2013, an additional 14 children were admitted to the hospital for ingestion of edibles,[402] with the first 9 occurring in the first 6 months of legalization.[369]

Washington, which modeled its product labeling and potency rules on Colorado's,[419] experienced a similar increase in adverse outcomes. In 2014, 45% (90 out of 199) of calls to poison control center were related to marijuana intoxication for those under age twenty – since legalization in 2012, these calls have increased from 50 in 2012 to 90 in 2014. Significantly, the highest number of calls in 2015 (64%) were regarding children under the age of five.[407] Of the calls reported for the first nine months of 2015, 51% were in the marijuana/cannabis category, 42% were associated with infused-products, and 7% were related to marijuana oil. Youth accounted for 43% of the statewide calls during this nine-month period in 2015.

National data from the United States show similar trends for accidental childhood ingestion. Between 2005-2011 there was an annual 30% increase in marijuana exposure in medical marijuana states while non-medical marijuana states showed no increase.[392]

To address the issue of accidental consumption of marijuana edibles, Colorado and Oregon enacted legislation requiring marijuana producers to place a THC warning symbol on their products (Figure 2).

Public Education and Mass Media

Colorado, Washington, and Oregon developed mass media campaigns aimed at preventing youth marijuana use (Figure 3), not general market campaigns designed to minimize overall population use as is done for tobacco. These campaigns were targeted at youth with messages on health risks of impaired memory, developmental delays, increased risk for addiction, depression, anxiety, psychosis, or other mental illnesses. Messages related to the consequences of marijuana use include ineligibility for receiving financial aid and how marijuana-related charges may lead to school suspensions and expulsions. State health departments public awareness messages in Colorado[420] and Washington[421] directed to adults only cautioned adults, particularly new users, to "be safe and sensible" when using newly legal marijuana (Figure 4) rather than discouraging use altogether.

Figure 2. (top) Oregon Health Authority's universal symbol required on marijuana packaging(0.48 inches wide by 0.35 inches high). (bottom) Colorado Department of Revenue THC Warning Symbol required on all retail (red) and medical (white) marijuana products (0.5 inches wide by 0.5 inches high). Both effective 1 October 2016.

Colorado contracted with the University of Colorado to evaluate the impact of its mass media campaign on change risk perceptions and use behaviors as well as increasing knowledge of marijuana laws, health impacts of use, safe storage practices, and prevention.[375] Adult exposure to the 2015 "Good to Know Campaign" was associated with an increased likelihood of accurately identifying retail marijuana laws compared to adults with zero exposure, with the proportion adult acute awareness increasing from 62% to 73% at follow up. There were moderate effects on knowledge of harms associated with use and perceptions of risk related to underage use (4.5% change at follow up), use around children (8.2%), and high risk use (8.6%). The survey did not question respondents whether or not the campaign impacted use behavior or thoughts on quitting, intentions to quit, or quit attempts[422] (Figure 5).

Figure 3. (top) Oregon Health Authority Youth Prevention Campaign 2016 (bottom) Colorado Department of Public Health and Environment Youth Prevention Campaign 2015

Taxation

Taxation can both be used to raise marijuana prices artificially in order to discourage consumption,[361] and to prevent taxpayers from subsidizing the regulatory, public education, and

Figure 4. (left) Oregon Health Authority Adult Education Campaign 2016 (right) Colorado Department of Public Health and Environment Adult Education Campaign 2015

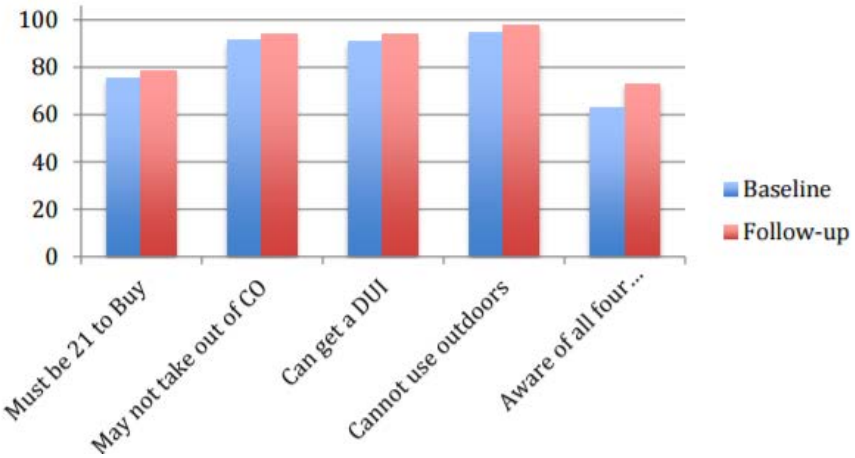


Figure 5. Awareness of Media Campaign of Retail Marijuana Law, Baseline to Follow Up[422]

health costs associated with increased marijuana use and secondhand exposure. A marijuana tax based on these principles could be set at a level that is at least budget neutral so as to cover (together with annual licensing fees) the costs of administration, enforcement, the marijuana

prevention and control program, and the marijuana education and research program and adjusted periodically for inflation. Additional tax increases could be used as a way to raise the price to reduce marijuana initiation and promote cessation.

While all four US states that had legalized recreational marijuana as of October 2016 and Uruguay tax marijuana, these tax rates were not set at levels designed to cover regulatory, public health education, and medical costs associated with marijuana legalization.[68] In Colorado,[423] Washington,[424] and Oregon,[425] state legislators were directed by the ballot initiatives voters enacted to adjust the retail sales tax to make retail marijuana competitive with black market prices. Washington and Oregon ballot initiatives also include criteria for adjusting marijuana taxes to discourage use, and an additional requirement in Oregon to maximize net revenue from the marijuana tax. In Uruguay, officials of the IRRCA have determined that marijuana will be taxed at $1 per gram to compete with black market prices, despite national legislation requiring that government officials develop and fund an enforcement system and education and prevention programs.[364]

Shortly after legal sales went into effect, state legislators in Colorado,[426, 427] Washington,[428] and Oregon[429] reduced marijuana taxes to compete with the black market. Colorado reduced the retail sales tax from 10% in 2014 to 8% in 2015, while Washington consolidated the state's three-tier tax system to a single ad valorem excise tax of 37% at the retail sales level to reduce the marijuana industry's federal income tax liability[428] because consumers would pay the tax and so would technically not be considered part of the retailers' gross income. (According to Internal Revenue Code Section 280E, marijuana businesses cannot deduct from gross income business expenses that are associated with trafficking illicit substances, which in effect increase the amount an individual in the marijuana business would pay on their federal income tax, and Washington legislators were concerned that marijuana taxes were not deductible under 280E.) Oregon also modified its wholesale tax in 2015 to a price-based excise tax of 17% of the retail sale, with up to an additional 3% tax levied at the local level, to increase state revenue through increased sales stimulated by lower prices.[429] In the three states where marijuana taxes were reduced, state legislators were more concerned with short-term gains of competing with the black market and maximizing state revenue than long-term public health impact and costs associated with reduced use through higher taxes.

There are no requirements for marijuana to be taxed based on a percentage of tetrahydrocannabinol (THC) content, which may in effect provide incentive for manufacturers to increase the THC content of cannabis.[68] Indeed, US marijuana producers have been increasing product potency over the last 20 years.[430] Between 1995 and 2014, marijuana potency increased from 5% to 12%, with a corresponding decline in cannabinol. The result was a THC/CBD ratio increase from a factor of 14 in 1995 to a factor of 80 in 2014.[431] In jurisdictions with legal marijuana sales, edibles and cannabis concentrates, where THC concentration can be as high as 70%, has increased in recent years. A weight-based tax, or a tax based on the unit of THC per weight or volume could be a solution to this problem.

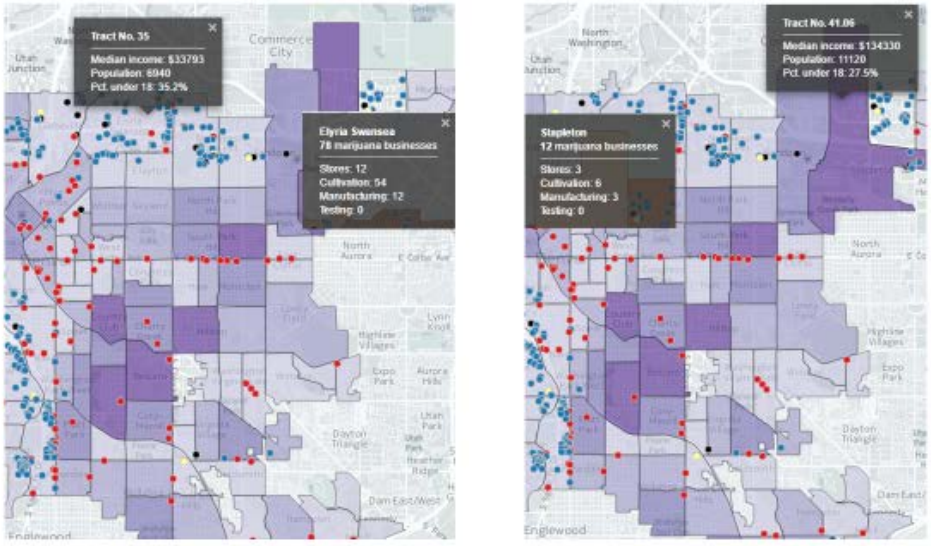
Another policy worth considering from the alcohol control literature is implementation of minimum unit pricing (MUP).[361] Evidence from Canada show that MUP for alcohol is associated with reduced consumption and alcohol-related harms.[432] Longitudinal estimates from British

Colombia suggest that a 10% increase in MUP for a given alcohol product would result in a 16.1% drop in consumption.[433] As is the case with most parts of the new regulatory framework for marijuana, implementation of MUP for marijuana should be considered at the same time as legalization in order to avoid potential legal battles with a professionalized marijuana industry. In 2012, Scotland was the first country to pass national legislation requiring MUP for all alcohol products.[434] However, implementation of MUP in Scotland has been met with fierce opposition from the drinks industry, with claims of MUP as a violation of European Union trade law.[435]

Location requirements

The US states took varied approaches to regulating restrictions on marijuana business locations, none of which protect those most likely to regularly use marijuana (18-24 year olds[436]) In Colorado, local governments were prohibited by state law from granting a license to a business within 1,000 feet of a school defined as "public or private preschool or a public or private elementary, middle, junior high, or high school or institution of higher education", alcohol or drug treatment facility, principal campus of college, university or seminary, or a residential child care facility.[56] Although Washington lawmakers prohibited marijuana businesses within 1,000 feet of K-12 schools, recreational center or facility, child care center, public park, public transit center, library, or any game arcade, it allowed local governments to pass rules to reduce the distance requirement to a minimum of 100 feet from areas where children and adolescents are likely to congregate.[50] As of September 2016, four Washington cities (Shelton, Seattle, Olympia, and Tacoma) reduced the buffer zone for marijuana businesses to 500 feet, and one city (George) reduced its buffer zone to 100 feet for parks, recreational/community centers, libraries, childcare centers, game arcades, and public transit centers.[437] Oregon lawmakers did not prohibit retail store locations within 1,000 feet of colleges or universities despite the fact that many college students are under 21. Retail stores in Alaska were prohibited under the legalization initiative within 500 feet of child-sensitive areas, defined as facilities that provide services for persons under 21, a building in which religious services are regularly conducted, or a correctional facility. Colleges and universities are not explicitly included.

Retail outlet density is positively associated with youth and young adult smoking,[438-440] heavy alcohol consumption,[441-443] and marijuana use.[365, 444-446] Despite the fact that use is higher in areas where there are more retail outlets, marijuana regulatory regimes in the four US states have failed to implement licensing systems to control retail density in ways that would protect vulnerable populations (Figure 6). Similar to tobacco[440, 447] and alcohol outlets[442, 445] marijuana businesses appear to be concentrated in low-income, minority communities. By 2016, Colorado marijuana businesses were more likely to be located in census tracts with higher proportions of racial/ethnic minorities (35% versus 28%), lower proportion of young people, lower median household incomes ($51,800 compared to $65,000), higher crime rates, and higher concentrations of alcohol outlets (13 versus 3 per square mile).[448] Similar findings were observed in California neighborhoods with medical marijuana dispensaries.[449, 450]



Source: The Denver Post (http://extras.denverpost.com/maps/news/marijuana/licensed-facilities/)

Figure 6. Overconcentration of Marijuana Licensees in Low Income Communities in Denver Metropolitan Area in 2016.[451] Despite the fact that retail density is associated with higher rates of use and use-related harm for tobacco and alcohol outlets, regulators in Colorado failed to use the licensing system to prevent excessive concentration of retail marijuana stores and cultivation facilities in low income communities.[451]

EFFECT OF EXISTING MARIJUANA REGULATORY REGIMES

Research on US state implementation of retail marijuana laws has focused on potential impacts of these laws on risk perceptions,[452] use,[417, 452, 453] health harms[402] and stakeholder participation in the regulatory process.[369] There is only a limited literature on the impact of marijuana policies on use and associated harms from the experiences in the Netherlands,[365, 454] Uruguay,[368] and the United States.[364] However, variability in US state medical marijuana laws makes it difficult to make strong generalizations, which likely explains why there is no scientific consensus on how legalization will impact risk perceptions or use patterns.[368, 369, 392, 455, 456] Studies of the impacts of *de facto* legalization in the Netherlands on young people are mixed and inconclusive.[352, 365, 454] There is limited evidence on the complexities of how a policy is implemented and when it is implemented having a dramatic effect on health-related outcomes.[457]

Effects of Changes in the Legal Environment on Marijuana Risk Perceptions

It is important to consider perceptions of risk when assessing the public health impacts of marijuana legalization laws. Several social behavioral theories have placed perceived risks as a precursor to risky behavior,[458-462] with lower risk perceptions leading to increased substance use.[392, 463-465] For example, young people who perceive long-term tobacco use as low risk are nearly four times more likely to start smoking than peers with high risk perceptions.[464]

Perception of harm for marijuana use has been decreasing in the United States, even among young people (12-17).[466, 467] The proportion of high school seniors reporting that regular marijuana use poses little to no health risks more than doubled between 2004 and 2014, from

20% to 45%.[468] Youth at low risk for drug use report greater intentions to use marijuana if full legalization of medical and/or retail marijuana occurred.[469] Data from Colorado show that risk perceptions among 18-25 year olds decreased from 2006 to 2014, with 18.5% of young adults perceiving "great risk" from once-per-month marijuana used in 2006 to 8.4% in 2014; among 26 years and above from 32.8% in 2006 to 19.8% in 2014 (Figure 7).[406]

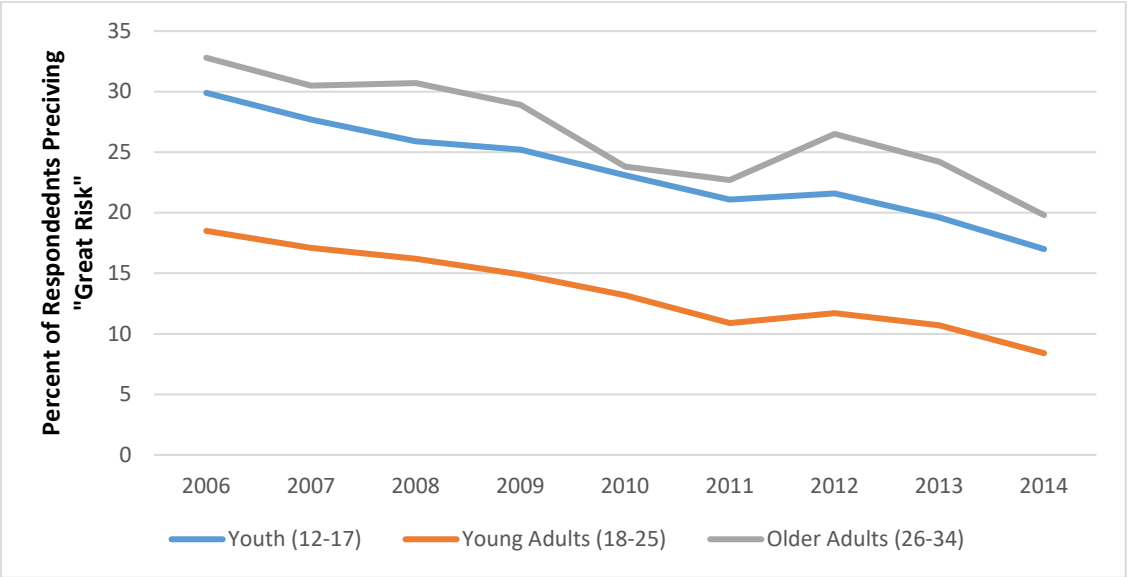


Figure 7. Perception of "great risk" for using marijuana once per month in Colorado by age.[406]

While use among youth has not increased since legalization of recreational use in 2013, perception of "great risk" from monthly marijuana use declined from 30% in 2006 to 17% in 2014, and past 30-day use was 12.6%, well above the national average of 7.2% (Figure 7). Risk perceptions among teens in Washington showed little differences between age groups. By 2014, almost 100% of the 10th and 12th grade current users reported no perceived harm. The 10th grade students reported no risk at 95%, 8th grade students reported no risk at 90%, and 6th graders reported no risk at 75%.[407] Given the association between reduced risk perceptions and substance use, it is likely that as social norms on marijuana use increase and access becomes more widespread, use among youth will also increase in Colorado and Washington.

US youth perceive marijuana to be either harmless or less risky than tobacco or alcohol.[392, 470, 471] Data from California, which legalized medical use in 1996 show that teens perceive marijuana and blunts (tobacco cigars hollowed out and filled with marijuana) as more socially acceptable and less risky than cigarettes. Exposure to positive messages on therapeutic benefits of marijuana use was associated with a 6% greater odds of marijuana use while peer use was associated with 27% greater odds of use.[472] Similarly young adults in Colorado acknowledged the harmful effects of tobacco use, including secondhand exposure, while exposure to marijuana smoke was perceived as benign.[65]

The trend in marijuana legalization may contribute to shifts toward reduces risk perceptions and more permissive norms among young people in the US.[352, 416, 473] Indeed, a 2014 Canadian study with adults found that social normalization of cannabis is driven and reinforced by its perceived widespread use, low incidence of harm from use, and positive social norms

surrounding medical use. Canadians were also skeptical of the media's "exaggerated" portrayal of the harms and risks of cannabis use, although some users did acknowledge health risks, particularly for smoked marijuana. Health risks commonly cited in the public discourse, including respiratory problems, mental health problems, cognitive and memory deficits, were not salient to cannabis users who perceived use was associated with a low incidence of cannabis-related harm. Some participants in the study perceived risks of cannabis to be modest compared to tobacco and alcohol.[2]

Effects of Changes in the Legal Environment on Marijuana Use

Marijuana use in the United States has been rising since 2002 in both young and older adult populations, while days of use among past year users has also increased. Hall and Pacula's initial comparisons of young adults in the United States found few differences between use in decriminalization versus prohibition states.[53] Williams and Bretteville-Jensen used the 2001 National Drug Strategy Household Survey to assess the impact of marijuana decriminalization policy on marijuana smoking prevalence in Australia and found that decriminalization is associated with earlier youth marijuana use,[474] and short-term increases in the population prevalence of use.[475] Living in a medical marijuana state was associated with an increased likelihood of initiating marijuana use among young adults, although states with medical marijuana laws had higher rates of use before legalization.[476] No clear increases have been found since legalization of medical marijuana, especially in youth.[476]

Marijuana prevalence among young adults (18-25) in Colorado went from 21% in 2006 to 31% in 2014 and among adults (26 and above) from 5% in 2006 to 12% in 2014.[406] In 2014, 14% of adults were regular marijuana users (past 30 day use), with 33% reporting daily use.[406] In Washington young adult use (18-25) went from 11% in 2011 to 15% in 2013, and older adult use (45-64) from 4% in 2011 to 8% in 2013.[477] Eighteen percent of young adults in Oregon[478] and 21% in Alaska[479] reported past 30-day marijuana use in 2014, prior to state implementation of retail marijuana laws. In Uruguay, marijuana use has been increasing since 2001, with 23% reporting ever use, 9.3% reporting past year use, and 6.5% reporting current use in 2014 (Figure 8).[367] Of note, since Oregon, Alaska, and Uruguay had not fully implemented marijuana

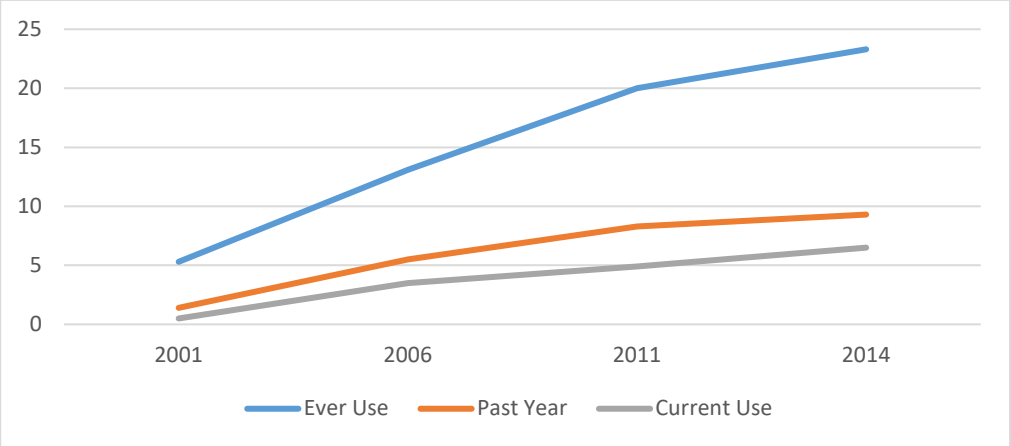


Figure 8. Marijuana Use in Uruguay (2001-2014) Source: National Household Survey on Drug Use in Uruguay[367]

regulatory frameworks these data provide very little information about the direct impact of legalization laws on risk perceptions and use.

While previous research argued that marijuana prevalence is unrelated to legalization because higher use rates were generally found prior to legalization,[392] data from Denver and Seattle suggest that youth perceptions of risk have decreased and adult use has increased since implementation of retail marijuana laws.[480] Moreover, while prevalence was indeed higher than the national average in the four US states that legalized recreational marijuana, liberalizing marijuana laws in 2013 and 2014 has led to dramatic increases in young adult prevalence in Colorado and Washington after the retail market opened. Notably, in Oregon, marijuana use among those 26 years and older nearly doubled between 2006–2007 and 2012-2013 (6% to 10%), while national use has increased only slightly (4% to 5%) (Figure 9).

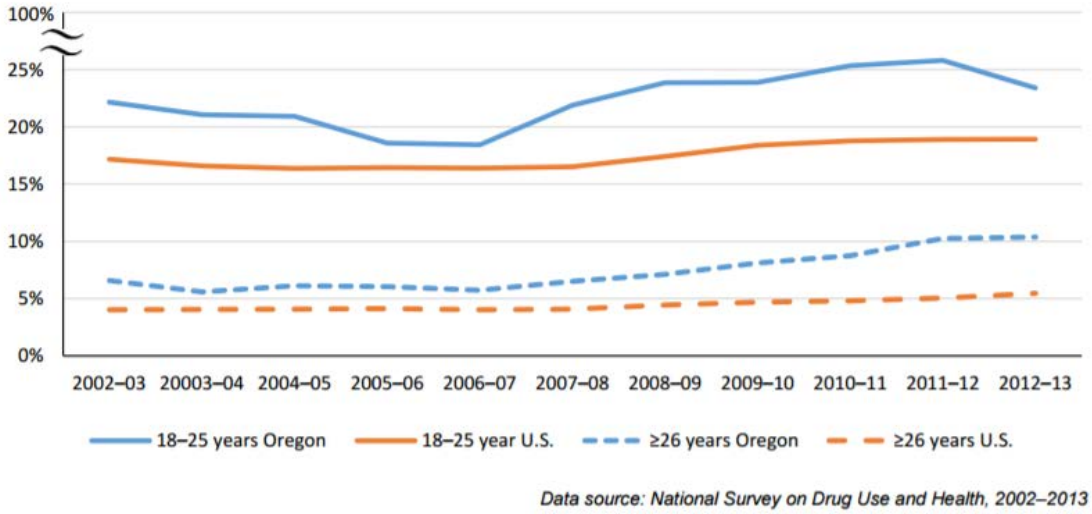


Figure 9. Marijuana Use Prevalence in Oregon Compared to National Average for Young and Older Adults (2003-2013) In 2015, the Oregon Health Authority collected baseline data on population level risk perceptions and use of marijuana. These data show that between 2003 and 2013 marijuana prevalence in Oregon (blue line) was higher than the national average (orange line) for young and older adults. Notably, marijuana use among older adults nearly doubled between 2007 and 2013, while national use increased only slightly (4% to 5%).[481]

A longitudinal cohort study in Washington found that as risk perceptions declined social approval of marijuana use for adults increased between 1985 and 2014. The highest approval rating for marijuana use was 52% in 2012 compared to 1% in 1985, when the ballot initiative to legalize retail marijuana was approved, while 65% of the cohort perceived marijuana as harmful in 2012 compared to 80% in 1985. Marijuana use had been slowly increasing since 1984 and remained relatively stable until 2014 up until legalization. In 2015, among current past-month users, rates of monthly use nearly doubled from four to six times per month to over 10 times per month.[452] Regular marijuana users in Washington were also more likely to report marijuana use disorders, which increased from 13%-18% between 2005 and 2009, to 26% in 2014. Parents were also more likely to accept underage marijuana use by their children than previous generations, up from 6% in 1991 to 19% in 2014.

In the United States, 34% of frequent users reported using marijuana on 20 days per month in 2012-2013, an increase from 11% in 2002-2003,[482] In Washington, high-frequency users of marijuana, those who consume more than twenty-one times a month, account for 80% of total consumption, consuming between 1.3 to 2 grams/day.[407] In Oregon, nearly one-third of current users were daily users compared to 11% who report use once per month, 24% for 2-3 days, 10% for 4-9 days, 15% for 10-19 days, and 11% for 20-29 days per month.[481]

In Uruguay, frequent users (i.e., 4 days/week) were more likely to have higher daily consumption rates of cannabis compared to less frequent users (i.e., 3 days/week).[368] On average, daily users reported consuming 3 grams of marijuana per day whereas once per week users consumed 1 gram per day. These data suggest that the 40 gram per month limit in Uruguay is far higher than what the average user consumes and may contribute to sales in the illegal grey market where heavy or unregistered users, or tourists can access cannabis.[368]

Effects of Legalization on Mode of Cannabis Administration

Noncombustible forms of marijuana (i.e., edibles and vaporized products) are increasing in popularity.[4] Even though the use of noncombustible products might be increasing, their overall share is still very low among youth and adults compared to combustible product use in the four US states and Uruguay.

Among current marijuana users in Colorado, young adults were more likely to report smoking marijuana (91%) than vaporizing (5%) and consuming edibles (4%).[483] Cross-sectional data [407, 479]show similar findings among high school seniors with 74% in Washington (2014)[407] and 88% in Alaska (2015)[479] reporting combustible product use as the preferred mode of consumption. Similar findings were noted in Oregon in 2015, with nearly 90% of adults and youth reporting combustible marijuana use (Figure 10).[481]

In Washington, in 2014 high school seniors were less likely to report oral ingestion (12%), vaporization (7%), or other modes of administration (4%) than combustible product use.[407] In Oregon, adults were less likely to report edible use (27%), vaporization (14%), while 25% reported using multiple routes of administration.[481] Multiple administrative routes was most frequent among heavy marijuana users (20+ days of use in the past month) than less frequent users. Among frequent cannabis users in Montevideo, use of joints (92.5%) and pipes (40%) were two of the most widely reported modes of administration in the past 12-months. Other modes of administration that were less popular include: edibles (26.4%), vaporization (15.7%), drinks (9.4%), tinctures (7%), and creams (2.2%).[368]

Thus, while consuming edibles and vaporizing marijuana may be less dangerous in terms of cancer, heart disease, and lung disease than using smoked products, smoking remains the dominate mode for consuming marijuana. In addition, it is unknown what the health impacts of these forms of administration are on cardiovascular health or brain function.

Observed health changes after legalization

Marijuana commercialization was associated with a significant increase in annual hospitalizations from 803 (2001-2009) to 2,413 (2013-2014) in Colorado following the opening of the commercial retail market in 2013. In addition, emergency room visits increased from 739

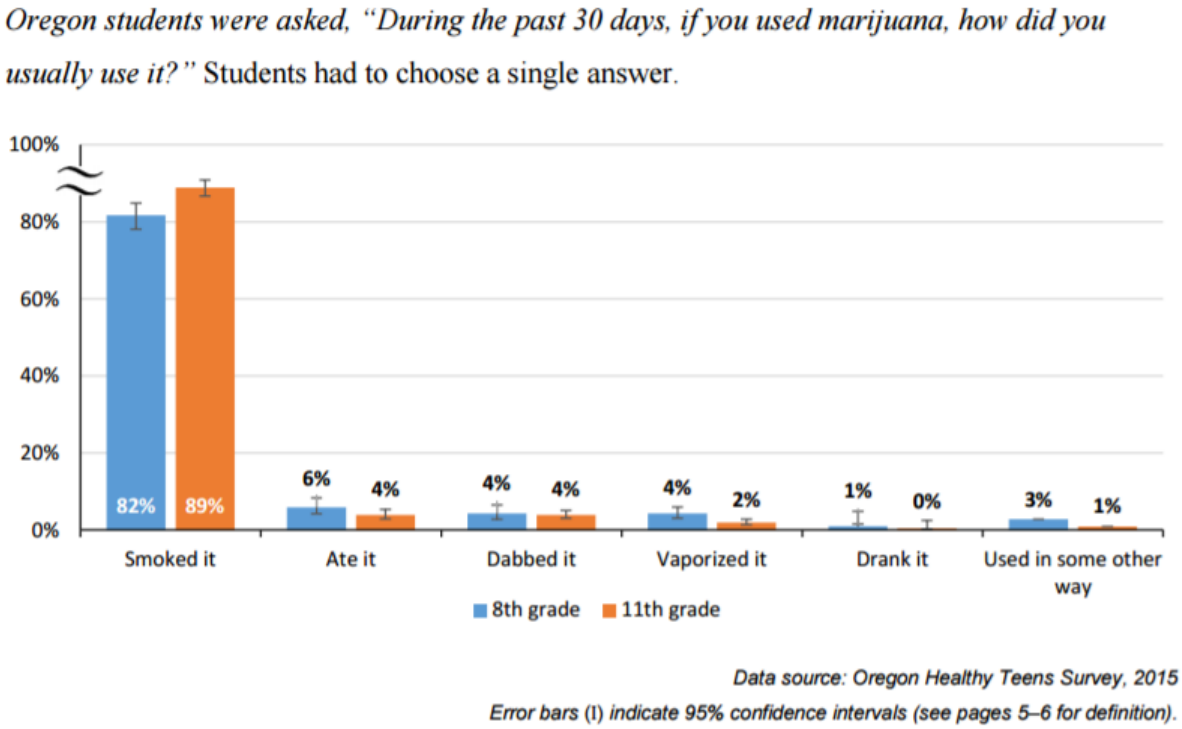


Figure 10. In 2015 in Oregon, smoked marijuana remained the dominate form of use among students.[481]

per 100,000 (2010–2013) to 956 per 100,000 ED visits (2014–June 2015).[406] There was also an increase in emergency room visits for burns, cyclic vomiting syndrome, and marijuana intoxication. At the University of Denver's burn center, 31 people were treated for marijuana-related burns as a result of unexperienced users experimenting with chemical extraction using butane.[402] Some of the increase in hospital utilization could be explained by an increase in new users experimenting with alternative ways to use and produce marijuana.[1, 402]

The prevalence of cyclic vomiting syndrome increased after legalization of for-profit medical dispensaries in Colorado in 2010.[484] Since 2012, when retail marijuana laws were implemented, cyclic vomiting syndrome has doubled from 41 per 113, 262 ED visits in to 87 per 125, 095 after medical marijuana was legalized.[402]

Legalization of retail marijuana in Colorado was associated with a 44% increase in marijuana-related auto fatalities,[485] from 55 in 2013 to 79 in 2014.[406] In Washington, auto fatalities that involved drivers with active THC in their blood increased by 122.2% from 2010 (16) to 2014 (23).[407] The interpretation of marijuana-related traffic fatalities is difficult because, unlike alcohol, there is no scientific consensus on what defines "THC impairment," and THC can be found in the blood or urine several days after use.[76] Legalization may also have resulted in

ascertainment bias in that police in Colorado were testing more frequently for THC levels in drivers than prior to legalization. Rather an increase in drivers who tested positive for THC may better explain an increase in marijuana use generally rather than marijuana-impaired drivers specifically.

The available epidemiological data on risk perceptions and use patterns from the four US states are limited in their ability to provide a comprehensive overview of the effects of state implementation of marijuana laws because legalization has only been in place for a relatively short period of time. The best that public health authorities can do is provide evidence from the tobacco control experience to have at least an understanding of what potentially the impact of these laws could be on marijuana risk perceptions, use, social norms, and harms associated with use.

These shortcomings in the available literature indicate the importance of collecting adequate baseline data before enacting policy change (i.e., risk perceptions, social norms, prevalence data, frequency of use, consumption patterns, types of products, mode of administration).Identifing proximal measures of harm (and benefit) with which to measure impacts of legalization (i.e., emergency room data, use by pregnant women, school performance, driving accidents, workplace accidents, other drug use (including opiates, tobacco and alcohol) would also facilitate evaluating the effects of marijuana policy change.

CONCLUSIONS

In many ways the state of the marijuana market is similar to where tobacco was at the turn of the 20th Century, before corporatization of the market, with industrialized product design and production and mass marketing.[13] The result was the rise of a sophisticated and politically powerful tobacco industry that led to the death and suffering of hundreds of millions of people worldwide. It took nearly a century to begin to bring the tobacco industry under control as a result of the combined forces of national and international public health advocacy and policymaking, as exemplified by the WHO Framework Convention on Tobacco Control.[486]

The four US states that have legalized retail marijuana to date have used regulatory regimes largely modeled on alcohol policy regimes. There has not yet been a legalized nationwide market available for entry of major corporations. It is likely that large corporations, including the tobacco industry,[9] with the product engineering and marketing power to quickly transform the market, could capitalize on the opportunities that such a market represents.

In part because of relatively low use (compared to tobacco) and the fact that marijuana and tobacco are often used together, the specific health dangers of marijuana are not yet fully defined. We do know that marijuana smoke is toxicologically similar to tobacco smoke and had been identified as a human carcinogen by the California Environmental Protection Agency[72] since 2009. There is also evidence of risk of heart and lung disease as well as psychological issues. Other forms, such as edibles, oils, and vaporized marijuana have other risk profiles that are not yet well defined. The question from a policymaking perspective is whether to apply the precautionary principle and develop policies to minimize use based on the existing evidence base

or wait, likely 20 to 30 years, until the specific risks of marijuana and secondhand exposure have been quantified as precisely as they have been for tobacco today.

There is evidence to support the conclusion that without adequate public health controls a newly legalized marijuana market will transform into one modelled on the tobacco market. There are enough similarities between tobacco and marijuana products that the evidence and experience from successful tobacco control programs could form the basis for a public health approach to legalizing marijuana. principles defined in the WHO Framework Convention on Tobacco Control[486] could form the basis for a public health approach to legalizing marijuana, which would seek to minimize industry influence in the policy process and to minimize consumption of marijuana products and the associated health risks of a new legal marijuana market.

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