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IJDP journal Article Highlights

- We examine Colorado's regulatory process of legalised cannabis for adults
- Sourced from peer reviewed academic papers, grey literature, mass and niche media
- Public health, industry investment, methods of consumption and testing are relevant
- The scheme includes features to mitigate adverse impacts but faces major challenges

Issues in the implementation and evolution of the commercial recreational marijuana market in Colorado

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Abstract

For almost a century, the cultivation, sale and use of recreational cannabis has been prohibited by law in most countries. Recently, however, under ballot initiatives four states in the US have legalised commercial, non-medical (recreational) marijuana markets. Several other states will initiate similar ballot measures attached to the 2016 election that will also appoint a new President. As the first state to implement the legislation in 2014, Colorado is an important example to begin investigating early consequences of specific policy choices while other jurisdictions consider their own legislation although the empirical evidence base is only beginning to accrue. To this end the paper brings together material sourced from peer reviewed academic papers, grey literature publications, reports in mass media and niche media outlets. and government publications to outline the regulatory model and process in Colorado and to describe some of the issues that have emerged in the first 20 months of its operation. These issues include tension between public health and profit, industry and investment, new methods of consumption, the black market and product testing. The paper concludes that, while it is too early to determine the impact of the scheme, and noting that it includes some features designed to mitigate adverse impacts, it faces major challenges. Not least of these are the lack of an effective overarching federal regulatory structure, as a consequence of the federal prohibition on cannabis, combined with a rapidly growing cannabis industry which, like other industries, will seek to exploit loopholes to maximise profit.

Keywords: cannabis, regulation, Colorado, marijuana, testing, edibles, dabbing

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In 2012, Colorado legalised a commercial, non-medical (recreational) marijuana market for adults via amendment 64 by ballot initiative. The State legislature set up a task force with 30 stakeholders including lawyers, public health representatives, consumers, legislators, cannabis industry insiders and others who produced 58 recommendations for the development of initial regulations (Brohl & Finlaw, 2013; Colorado Department of Revenue and Marijuana Enforcement Division, 2013). The taskforce was guided by nine principles set out in the amendment most notably: ensuring the safety of Colorado youth; efficient regulation that is not overly burdensome; the ability to respond to consumer needs; and a predictable funding mechanism under the new law (Hickenlooper, 2014). As noted by Governor Hickenlooper (2014, p.1), "We are working as a convener for all interested parties and experts to shape public policy that utilizes the decades of public health lessons gained from regulating alcohol and tobacco". As of September 2015, recreational marijuana licenses have been granted in Colorado to 385 retail stores (dispensaries), 496 cultivators and 141 infused product manufacturers (Colorado Department of Revenue, 2015b). This paper addresses issues stemming from the resulting regulation as described below.

Background

Existing literature has necessarily been limited to speculation and modelling the implementation and potential implications of a commercial marijuana market (CMJM) (Caulkins et al., 2015; MacCoun & Reuter, 2001; Rolles & Murkin, 2013; Room, Fisher, Hall, Lenton, & Reuter, 2010). A major concern for public health commentators has been that given the widespread use of cannabis (Kilmer &

Pacula, 2009; United Nations Office on Drugs and Crime (UNODC), 2014), small increases in consumption could result in large-scale increases in harm (Lenton, 2013). This is primarily because even if the proportional increases in harm are small, the sheer number of users may result in large net increases in numbers of people experiencing harm (dependence, motor vehicle accidents, mental health problems, respiratory problems etc.) and seeking services. It has been proposed that regular and heavy cannabis users and the young will be particularly susceptible to any increases in cannabis availability occurring as a result of the Colorado scheme (e.g. Hall & Degenhardt, 2015). Such risks may be amplified via profit-focused models of recreational marijuana markets (Caulkins, 2014). The implementation of the Colorado model provides an opportunity to go beyond speculation to gather evidence on the real world application of a recreational cannabis policy, thereby potentially informing policymakers and researchers about what not to do as well as being a blueprint for other schemes. While respected scholar Kleiman has reportedly described it as the second worse outcome behind prohibition (Lopez, 2014, December 17), implementation of the Colorado model has received a self-assessed "A" grade from Colorado's director of marijuana coordination, Andrew Freedman. He explained that they started with no template to guide new legislation and emphasised that from the state's perspective, legislation was driven by public health concerns as opposed to tax revenues (The Cannabist, 2015a, March 27). Unfortunately, given data lag and other factors, it may take years or even decades for the full extent of the scheme's impact on consumption patterns and user initiation rates to become clear (Pacula & Sevigny, 2014). As a consequence, the majority of early insights are likely to focus on regulations and implementation as opposed to outcomes (Caulkins et al., 2015).

As the academic literature on the implementation of the Colorado scheme is only now beginning to emerge, this paper brings together material sourced from peer reviewed academic papers, grey literature publications, along with reports in mass and niche media outlets and government publications. It addresses tension between public health representatives and profit focused firms, the influence of industry and investment, the relevance of the cannabis market as a cash-based economy, politics and public opinion, changes in methods of consumption, testing (in relation to both products and consumers), the definition of the black market, school funding, drug education programs and staff training and other issues. The remainder of this paper will address each of these in turn after describing the Colorado regulatory process.

Regulatory Process

The legal status of the Colorado CMJM is complex. Labelled "quasi-legal" by Hawken, Caulkins, Kilmer, and Kleiman (2013), there is variance in and crossover between international, federal, state, local and tribal jurisdictions. Federally, botanical cannabis remains a prohibited schedule I substance that according to the Drug Enforcement Administration (2015) legally has "... no currently accepted medical use and a high potential for abuse". On the other hand a number of states have approved the consumption of medicines (such as Marinol ® and Satvex®) comprising extracted cannabinoids (individually or in combination) (see Rodgers, 2014, July 29). In addition, the US Government appears to own a patent for using extracted or synthesised cannabinoids to treat a variety of diseases (Leaf Science, 2014, July 25). These contrasting frameworks impact directly on the Colorado market in several important ways.

The new regulations regarding marijuana policy are important from a public health perspective, with the intention to regulate the availability, supply and promotion of marijuana in order to protect the most vulnerable. The process that governs the recreational marijuana market in Colorado has been described as a "work group" model" by Christian Sederberg, an attorney from the cannabis industry who was an integral member of the Amendment 64 campaign (Garcia & Manning, 2015, August 25). General legislation must first pass through the House and Senate, usually with a deadline for final implementation. Once passed, a work group is formed consisting of stakeholders representing industry (including cultivators, product manufacturers, testing facility operators and marketing professionals), public health (including representatives from Children's Hospital, a School Resource Officer and the Department of Health and Environment), law enforcement (including County Sheriff of Colorado and Association of Chiefs of Police), regulators, and so on, who collaborate via work group meetings and public hearings to fine tune the detail (House Bill 14-1366 Edibles Work Group, 2014a). The process in theory leads to a comprehensive regulation when agreement is reached, although in practise it can and has resulted in regulatory paralysis due to lack of consensus (see for example Ingold, 2014b, October 20; Ingold, 2014d, November 17; The Denver Post Editorial Board, 2014, November 22). Opposition groups contend "...promised regulation has been met by an industry that fights tooth and nail any restriction that limit its profitability" (The Gazette, 2015, March 22).

Nor is the law uniformly implemented across the state, with local areas empowered to a considerable extent and only 67 of 321 jurisdictions opting to allow medical and recreational dispensaries (Brohl, Kammerzell, & Koski, 2015). Cannabis businesses are subject to regulations from the Colorado Department of Revenue Marijuana

Enforcement Division (2015) which stipulate comprehensive licensing criteria, inventory tracking procedures (see Metrc, 2015), a framework for testing compliance, expensive security measures such as 24 hour video on every cannabis plant, restrictions on proximity to schools, and limitations on most forms of advertising such as targeting minors (Endejan, 2015). Initial rules, which have since expired, outlined vertical integration whereby retailers were obliged to cultivate at least 70% of their own product, which strongly hindered wholesale distribution (Schroyer, 2014, October 1). Since October, 2014, Colorado residents could apply for licenses as stand alone wholesale growers or retail only stores with specific regulations for each market segment (Ingold, 2014c, June 30). In addition, requirements of the Colorado Department of Revenue, Department of Public Health & Environment, Fire & Safety and compliance with standard classification of child resistant packages as outlined by American Society for Testing and Materials (ASTM) must be met.

However, federal prohibition means there exist no standards for testing under frameworks established by the Food and Drug Administration (Allen, 2015, April 28). Moreover, there are currently no pesticides registered for cannabis in the U.S. (Stone, 2014) (product testing is discussed further below). Zoning and building codes contribute additional layers of compliance. For the consumer public there are (i) age restrictions, (ii) regulations preventing public consumption and (iii) differences in quantities allowed to be purchased by locals and those from out of town. The regulatory environment, it should also be noted, is extremely dynamic and constantly evolving at state and local levels.

Predictably, the industry has protested that the regulations are too onerous. Thus the term 'regulatory tsunami' has been used by some firms to describe the processes that they claim to restrict cottage growers because of the financial burden

that only larger businesses can afford (Johnson, 2015, April 23). One industry insider commented, "This industry has been regulated into absurdity, it's like you're handling nuclear material" (Gilboy, 2014, October 23). Others contend that over-regulation contributes to a larger black market (discussed below).

Commercialism and Public Health Tension

The commercialised regulatory model of the Colorado cannabis market crystallises tension between industry profit and public health. Researchers have identified high frequency users and youth as most vulnerable to the negative consequences of legal cannabis (Caulkins, Hawken, Kilmer, & Kleiman, 2012). A public health approach would aim to reduce cannabis consumption and as far as possible prevent youth from early initiation to cannabis user careers. This is at odds with a profit centric model of distribution that exists to increase sales (Caulkins, 2014). Tobacco and alcohol companies have been drawn on as examples of how "big cannabis" could potentially market products to the detriment of consumers (Barry, Hiilamo, & Glantz, 2014; Lenton, 2014; Room, 2014). According to Ben Cort of the Center for Addiction Recovery and Rehabilitation at the University of Colorado: "Just like Big Tobacco before it, the marijuana industry derives profits from addiction ... and its survival depends on turning a percentage of kids into lifelong customers" (The Gazette, 2015, March 22).

Commercial entities and public health researchers square off on two main fronts: marketing and lobbying. First, marketing is a critical activity for commercial enterprises and is a key feature of this debate. Research has shown correlations between levels of cannabis consumption and both advertising (D'Amico, Miles, & Tucker, 2015; Room et al., 2010) and number of outlets (Freisthler & Gruenewald,

2014; Room, 2014). A recent study in California showed greater exposure to medical marijuana advertising was associated with higher probability of use among youth (D'Amico et al., 2015). Traditional techniques of advertising are strictly limited in Colorado's recreational marijuana regulations including outright bans on advertisements that target children and may proceed only when evidence is provided documenting that less than 30% of the potential audience is under the age of 21. In addition internet pop-up advertisements are prohibited. (Ghosh et al.,2015). However there are exceptions. These include shop front signage and websites limited to those over 21, and marketers have a tendency to find loopholes and engage in guerrilla strategies such as viral internet campaigns or ambush marketing at public events. Moreover, containing the implementation of modern internet strategies is extremely problematic as discussed below.

Several uncertainties pertain to this issue as demonstrated by recent television advertisements that were subsequently prevented from airing due to legal concerns (Labak, 2015, July 22). For example, do product reviews of different cannabis strains such as those published in The Cannabist (2015c) constitute advertisements? A recent study involving Youtube demonstrated that 34% of captured videos relating to marijuana concentrates included product reviews, promotion, and/or product recommendations (Krauss et al., 2015, p.3). The study further found that only 20% of the videos under investigation were limited to viewers aged 18 years and over. Questions also remain as to: whether and how cannabis regulations should deal with product placement in movies or interviews; how laws will keep pace with modern technologies such as social media, website advertising, and online sales; and whether celebrity branding should be regulated more explicitly as performers such as Snoop Dog and Willie Nelson take steps to enter the industry (Kedmey, 2015, April

21). Another important question concerns how the right to commercial free speech in the US constitution will impact such matters (e.g. Edwards, 2014; Endejan, *2015*).

Second, given the unique regulatory process in Colorado, industry representatives have the ability to exert influence at the work group level before regulations are finalised. In addition, lobbying power has increased within the National Cannabis Industry Association (NCIA), or "big pot" (Kleiman, 2014) since implementation (Bentsen & Gunton, 2014, July; Caulkins, 2014; National Cannabis Industry Association, 2014). As of August 2015, the NCIA consisted of nearly 1000 member legal cannabis businesses (Dowell, 2015, August 4). Although in dollar terms it remains well behind established lobbying groups such as those representing the alcohol industry, growth of lobbies is a concern for public health researchers (Kleiman, 2014).

Industry and Investment

Cannabis is a profitable commodity, with estimates setting expenditure at €40 − 120 billion globally per annum (Kilmer & Pacula, 2009). The legal U.S. marijuana market, including medical and recreational, was estimated at \$2.7 billion in 2014 (Marijuana Index, 2015). Media sources reported that close to US\$700 million was spent in the licensed medicinal and recreational markets in Colorado in 2014 (Wyatt, 2015d, February 10), and official statistics showed it brought in almost \$70 million in state taxes and licensing fees that year (Brohl et al., 2015). According to the Colorado Department of Revenue (2015a), taxes on recreational cannabis include a standard sales tax of 2.9%, a 10% special marijuana sales tax and 15% excise tax on wholesale marijuana transfers. While Colorado Cannabis Chamber of Commerce (CCCC) (2015) claims 18,000 newly legalised jobs have been created, hard data on

these numbers is limited. In addition it remains unclear to what extent jobs may simply have been transferred from the black market to the legal marijuana economy. In 2015, a venture capital firm with Bob Marley branding rights among its assets raised a record \$75 million in a funding round (Shontell, 2014, December 16). Since the Securities and Exchange Commission (SEC) recently approved share registration of a marijuana dealer (Millman, 2015, January 28), Silicon Valley and Wall Street investors appear to have been increasingly active.

Many companies selling marijuana are thriving, with Medicine Man Denver (2015) estimating \$12 million in revenues for 2014 (MSNBC, 2014) and Incredibles (2015) producing 40,000 infused candy bars per month (CNBC, 2015, February 26). Moreover, demand for supplementary services, such as cartridges for smokeless cigarette devices (vapourisers), appear to be growing quickly, with CNBC (2015, February 26) describing the "vast profitibility" of O.penVAPE (2015), for example, reported to be distributing 270,000 cartridges in one month and growing "exponentially". Solid data pertaining to start up profitability, however, is not yet available. While future estimates of growth provided by industry trade publications may not be reliable, it is interesting to note that cannabis testing has been identified as "the most attractive subsector of the industry", with loose projections indicating a billion dollar industry testing over 5000 pounds of marijuana by 2020 (Marijuana Stock News, 2015, July 16). Consulting firms have developed training and education programs that are increasingly delivered through marijuana-focused conferences and other events (e.g. International Conferences Group, 2015). In addition, new technologies such as software for tracking and tracing of marijuana plants and products have been developed to meet the new regulatory environment (see Metrc, 2015). A social media company, MassRoots (2015), has developed a self-styled

Instagram for cannabis app and recently applied for a Nasdaq listing. With a growing base of 500,000 users currently, the app has been described as a mobilising force for the 2016 elections (CNN Money, 2015a, August 31). Moreover, a host of other industries have emerged around the Colorado CMJM including data mining, security, electrical lighting, law firms, specialist transportation and delivery services such as the recently launched "Uber for weed" as detailed by Mann (2015, April 6). It was claimed that a minimum of \$1 million is required to establish a competitive retail marijuana dispensary in Colorado (MSNBC, 2014).

While some have compiled fortunes in quick time, others have lost their investments. Fifty-five marijuana focused companies were publicly traded in the U.S. (Bloomberg, 2015, April 15), and it has been claimed that \$23 billion was lost by naive investors in cannabis penny stock "pump and dump" schemes (Pearson, 2015, February 26). Cautious regulating that requires 24 hour surveillance on every cannabis plant also appears to benefit larger businesses due to considerable set-up costs (Johnson, 2015, April 23). Indeed, long-term advocates such as NORML have pointed out that marijuana legalisation movements appear to be 'losing their innocence' as enterprises focus on profit maximisation (Stroup, 2015, March 16).

A Cash Business

Marijuana transactions have traditionally taken place on a cash-only basis and this aspect is yet to evolve in legalised markets. Banking is an issue that illustrates the operational difficulties of the contradictions between federal and state law in the US. Federally licensed banks are unable to take on clients in the cannabis industry. Industry press reported that in 2014, 1292 relationships were terminated by banks who apparently feared federal charges of money laundering (Olson, 2015, April 27).

Colorado state senators have called for legislation that ensures access for legal marijuana businesses to basic banking services (Mendoza, 2015, July 9), although as recently as August, 2015, an application from a Colorado credit union for a master account with the Federal Reserve was denied (Popper, 2015, July 30). In response, a lawsuit has been filed against the Federal Reserve stating the ruling is "anticompetitive [and] ... detrimental to public safety" (Smith, 2015, July 31). Hughes (2015b, July 31) has observed that, as a result, most marijuana-related businesses in Colorado must operate on a cash only basis and bear the high cost of handling and safeguarding this cash themselves with "the public at risk in having hundreds of millions of dollars of cash flowing about the streets of Colorado". In addition it has been noted that armed guards are required to "escort marijuana business owners when they arrive to pay ... taxes" at the Colorado Department of Revenue (Hughes, 2015b, July 31). Governor Hickenlooper has reportedly vowed to continue pushing the federal Government for a resolution (CNN Money, 2015b, July 31)

As such, the cannabis lobby, NCIA, is attempting to address the issue by expanding efforts federally. NCIA Deputy Director West reportedly stated: "Now is a good time for us to step up to yet another level by expanding that lobbying team..." (Dowell, 2015, August 4). Additionally, Section 280E of the federal tax law prevents cannabis producers, processors and retailers (officially drug traffickers) from deducting business expenses from gross profit (Bentsen & Gunton, 2014, July; Canna Law Blog, 2015, January 30), which is problematic for anyone running a cannabis business. Thus there is a higher likelihood of undeclared transactions in this sector and an accompanying loss of tax revenues for the state (see discussion on black market below).

Politics and Public Opinion

For at least 2 years, surveys have shown that the majority of people in the US favour the legalisation of cannabis use (Galston & Dionne, 2013; Motel, 2015, April 14). Public opinion plays a crucial role in the political process (Lenton, 2004), and politicians and law makers now see cannabis as an issue that must be addressed in election campaigns. Most notably the issue has a clear role in the 2016 presidential election (Hudak, 2015, March 22). For example, it is claimed that potential Presidential Candidate Chris Christie, who calls state revenue from cannabis "blood money", would clamp down on states operating CMJM (Wood, 2015, March 27). Conversely, Hillary Clinton announced a 'wait and see approach', while "I wasn't a choir boy" Republican Rand Paul is a co-sponsor of a federal CARERS bill aimed at legitimising medical marijuana (Associated Press, 2014, December 6; Kroll, 2015, March 11). Paul recently became the first presidential candidate of a major party to accept campaign funds from the legal marijuana industry, with a \$5000 contribution from NCIA's Political Action Committee being one of several donations made at a private fundraiser in Denver. In line with traditional Republican philosophy, Paul has been reported as believing the federal government should stay out of state matters (The Cannabist, 2015b, July 1). Moreover, other candidates such as Jeb Bush and Donald Trump have been forced to state a position publicly on the issue. In contrast, Kleiman (2014) has observed that "letting legalisation unfold state by state, with the federal government a mostly helpless bystander, risks creating a monstrosity."

Although some polls indicate marijuana legalisation is popular among voters, other data indicate that marijuana *consumers* are viewed less than favourably (e.g.Hatalsky, Trumble, & Diggles, 2014, December 8; Stroup, 2015, March 16) suggesting stigma remains towards this group. Industry representatives are taking

steps to reduce this stigma. For example, the replacement of industry icon Tommy Chong (of "Cheech and Chong" fame) by the NCIA seems to be an attempt to strengthen legitimacy via "dehippification" (the authors' term) as "the cannabis industry wants to move past the stoner stereotypes ... to remake itself as a ... respectable segment of the economy" (Burges, 2015, March 31).

Methods of Consumption

The way cannabis is consumed is evolving. The traditional method of smoking via joints, pipes or bongs is being replaced by eating, using a vapouriser for smokeless inhalation or "dabbing" a concentrated form of the flower material. Outcomes including levels of intoxication and long-term health issues such as lung disease and dependency can vary according to how marijuana is consumed.

Edibles

The surprising popularity of marijuana infused products (MIPs), commonly known as edibles, is an issue that has underpinned the regulatory evolution of medical and recreational cannabis in Colorado. Official data indicates approximately 5 million units of edible products were sold in Colorado in 2014, with just over half in the recreational market (Brohl et al., 2015). MacCoun and Mello (2015) note that the packaging of edibles that appears similar to that of non-infused snacks, has the potential to confuse children. Kleiman has reportedly stated that once regulated correctly, edibles may be the healthiest method to imbibe marijuana (Lopez, 2014, December 17), although the variably delayed impact and level of intoxication after ingestion has the potential for harmful, or at least unpredictable, outcomes. Dr Alan Shackelford, a Denver medical marijuana doctor, stated in an interview: "When marijuana is ingested, the absorption rate is much slower and subject to many

variables. The onset of effect is slower, the peak is achieved much more slowly and the effect typically lasts much longer" (Baca, 2015g, December 4). This variability is not helped by the manufacturing process that can involve traditional baking techniques or simply spraying concentrated extracts of marijuana onto normal non-intoxicating candy.

Since the implementation of recreational marijuana reform, there have been reports in the Colorado media of two suicides and one murder claimed to be related directly or indirectly to edibles (Gorski, 2014, July 1). According to statistics reportedly presented by Children's Hospital Colorado, unintentional ingestions of marijuana remain low in comparison to presentations for consumption of other toxic items (McDonough, 2015, March 30) However, Michael DiStefano, medical director of the hospital, was reported to have said hospital admissions doubled for accidental ingestion of cannabis to nine cases in the first six months of 2014 (Ingold, 2014a, May 21). The issue received further attention after an influential New York Times article detailed an uncomfortable experience with a marijuana-infused chocolate bar based on a personal account (Dowd, 2014, June 3).

A response to the potential dangers of consumption has been relatively swift from both advocacy groups and regulators. Public education programs were launched by advocacy groups (Council on Responsible Cannabis Regulation, 2014; First Time 5, 2014; Marijuana Policy Project, 2014).

On the regulatory side, the stated aim of the Marijuana Enforcement Division (MED) is to enact processes and regulatory procedures to provide full transparency in its regulation. In regards to edible marijuana products, two separate bills passed the House and Senate in 2014 (House Bill 14-1366 Edibles Work Group, 2014b;

Marijuana Enforcement Division, 2014b). Stakeholder work groups with representatives from industry, enforcement, Smart Colorado, and public health were established (Brohl et al., 2015). The result has been changes to compliance laws regarding packaging, labelling and potency restrictions that require edibles to be either wrapped individually or clearly marked increments containing a maximum of 10 milligrams of THC (Baca, 2015e, January 29). Governor Hickenlooper reportedly stated that the bills "are critical to our ongoing goal of making Colorado the healthiest state in the nation and our constant goal of protecting children" (Ingold, 2014a, May 21).

An additional issue is the disparity identified between product labelling and actual THC content that has been blamed on the quality of both manufacturing techniques and testing procedures (Baca, 2014, March 9). There is, however, apparent evidence of improvement in product compliance with follow up tests by Steep Hill Labs in 2015 reporting a higher degree of reliability between reported and actual THC levels in marijuana edibles, although there remains room to improve (Baca, 2015c, April 12). Similarly, there appears to be room for improvement in the regulatory landscape of Colorado's CMJM generally. In 2015, draft regulations were tabled by regulators recommending edible marijuana be marked with a stop sign shape while use of the word "candy" was also under review (Wyatt, 2015b, August 11). However, it was argued by representatives of manufacturing firms that using a stop sign symbol is akin to putting "a skull and cross bones on items". A new THC symbol is due for consideration before a public hearing (The Denver Post Editorial Board, 2015, August 22). The new rules must be finalised and implemented in early 2016.

Dabbing

More advanced methods of extraction, a wider selection of concentrates (Chambers, 2013, October 28) and the lessened risk of enforcement in an environment where cannabis is legal, have likely increased the popularity of dabbing. "Dabbing is the inhalation of a concentrated THC product [commonly] created through butane extraction" (Stogner & Miller, 2015). More precisely, concentrated forms of cannabis are inhaled through an "oil rig", a type of specialised pipe, that vapourises the product on a hot surface known as the "nail", which is usually made of titanium, quartz or ceramic (Kleiman, 2015; Prichard, 2015a, June 19). The user heats the concentrate with a blow torch, although the correct temperature is contested among aficionados, with debate generally centering on flavour maximisation and the reduction of toxin intake: This process has been described in detail by Coffey (2015, August 3).

While sales percentages and market share of concentrates are not publicly available in Colorado (as the authors were informed via email by the Marijuana Enforcement & Taxation Department of Revenue), it appears they account for a substantial though smaller segment of the market behind traditional flower and edible options. In an attempt to map consumer activity, one study drew on a sample frame of 125,000 tweets with available geolocation data. After adjusting for general Twitter use, Daniulaityte et al. (2015) showed that "dab"-related terms were significantly more prominent in Oregon, Colorado and Washington where recreational and medical marijuana have been legalised. Another study looking at Youtube as a potential learning resource for dabbing found high rates of representation (8%) from Colorado channels publishing related videos (Krauss et al., 2015).

In terms of extraction, there is a range of procedures which vary in complexity. To extract Butane Hash Oil (BHO), referred to variously as nectar, moon rock, honeycomb, wax, shatter, crumble, oil or errl, butane is pressurised in a vessel and the plant material is washed over. Additional forms of concentrated THC derive from extraction procedures known as Kief, Water hash, CO2 oil and Rosin (Prichard, 2015b, June 19). The process of BHO extraction, or "blasting", is extremely volatile due to the flammable nature of butane and has been identified as the cause of a number of high profile home explosions. In Colorado, where more than 30 butane explosions were linked to amateur concentrate manufacturing in 2014, new regulations went into effect on July 1, 2015 outlawing home extraction by nonlicensed manufacturers (Moreno, 2015, June 30). It is now a requirement that licensed manufacturers in Colorado purchase specialised equipment such as vacuum ovens and comply with normal fire and safety conventions around dangerous goods (see House Bill 15-1305 Unlawful Manufacture Marijuana Concentrate (CO), 2015). However, given the higher cost of concentrated marijuana in Colorado dispensaries, estimated at \$700 per ounce compared to \$200 per ounce for standard flower material, and the apparent ease of extraction, home manufacture of concentrates is predicted to remain popular (Bell et al., 2015).

While media reports suggest dabbing is riskier than smoking marijuana (see for example Montemayor, 2015, March 26), a recent study involving 357 participants found that using 'dabs' was no more problematic than using herbal cannabis, however participants self-reported a higher tolerance and withdrawal, suggesting a higher dependence potential for dabbing (Loflin & Earleywine, 2014). The same study noted informal claims of THC percentages between 70 – 90%. This potency is specifically linked to BHO extraction, which produces the strongest concentrate on

the market today. As a counterpoint, kief extraction, for example, produces a concentrate with THC in the 20 – 60% range (Prichard, 2015b, June 19). Kleiman (2015) has noted the risk of products with higher THC percentages is dependent on a number of variables, not least of which is the ability of the user to titrate the dosage. Discomfort can be experienced from "dabbing" too much too quickly (Prichard, 2015c, June 19). Evidence remains limited regarding potential health benefits of consuming lower quantities of more potent forms of cannabis (Hall & Fischer, 2010). Conversely, a recent study has suggested links between daily use of higher potency cannabis with low CBD ratios and schizophrenia (Di Forti et al., 2015). Furthermore, imagery of blow torches and media headlines that present dabbing as the "crack of cannabis" (Dunt, 2015, September 1) have some industry insiders concerned about the image being presented at a time when public support for the scheme is extremely vulnerable to any indication of increasing harm. Whether out of concern or interest, mass media stories certainly provide exposure given that Google searches for the term "dabbing" spiked immediately after the above mentioned article, although searches on the topic have been generally increasing sharply since 2013 (Google Trends, 2015). The issue of dabbing remains an important consideration for future research. While various claims abound, it may be some time before evidence regarding the relative risks of dabbing concentrates, compared to smoking herbal cannabis, are clarified. Caulkins et al. (2015) contend that tax models may be an area where the question of concentrates could be addressed, perhaps in a manner similar to the comparative taxes applied to beer versus whiskey.

Vapourisation

This is a process where cannabis is heated to allow transmission of cannabinoids without combustion (Gieringer, 2001). As noted above, the manufacturing of vapourisers as a cannabis delivery mechanism appears to be a growing industry in Colorado and nationally, providing consumers with the ability to consume both flower material and concentrates in a more discrete odourless form (Drug Enforcement Administration (DEA), 2014). This is an important consideration in Colorado where public consumption of cannabis remains outlawed as mentioned previously.

Recently popularised by the e-cigarette movement, another perceived advantage of 'vaping' is the potential for harm reduction as the method creates substantially fewer carcinogens and toxicants in inhaled THC content (Hall & Fischer, 2010). Many carcinogens present in smoke are related to toxic by-products of the combustion process rather than cannabinoids inherent in the plant. Hall and Fischer (2010) identified a number of studies that indicated a reduced health risk when utilising vapourisers as a cannabis delivery system. Temperature, again, has been mentioned as an important consideration in reducing negative health impacts because different cannabinoids have different boiling points. Insufficient heat does not boil off the pharmacologically active cannabis terpenoids, while extreme temperatures cause combustion and associated carcinogens (Quora, 2013). In contrast, a link has been identified between residual nitrogen and unsafe levels of ammonia in marijuana vapour, so it is recommended to ensure a "clean" plant product that has been "flushed" of residues, something that is done in the final growing stage, before harvest to further reduce respiratory risk (Quora, 2013). Quality testing that aims to identify pathogenic microbes and moulds in cannabis in

the Colorado scheme (such as outlined by Daley, Lampach, and Sguerra (2013)) may reduce some, but not all, harmful outcomes associated with vapourised marijuana consumption (see below for a more detailed discussion regarding testing protocols in Colorado).

Testing

Marijuana testing is a complicated process both in terms of scientific methodology and within complex and confusing intersecting frameworks of federal and state laws. In essence, there are two broad areas of relevance to testing: product quality and consumer testing.

Product testing

Firstly, a central component of a legalised marijuana market is the ability to provide customers with a safe, consistent and pure product (Kilmer, 2014). Quality product testing should ensure safety in regards to (i) purity, for example identification of harmful pesticides, moulds and other residuals, and (ii) potency relating to both THC percentages and THC to CBD ratios (Kilmer, 2014). Under the Colorado scheme, mandatory testing for potency began in May 2014, followed by testing for consistency in July 2014 (Marijuana Enforcement Division, 2014a; Rappold, 2015, March 24). However, it has been claimed that the Colorado testing landscape remains immature and displays a number of limitations including: non standardised lab testing, which has led to a wide disparity of results (Allen, 2015, April 28; Green, 2015, March 28; Wyatt, 2015a, March 26); lack of access to testing, particularly from medical caregivers (Kammerzell, 2015); and insufficient testers to deal with the volume of requests (Kammerzell, 2015). As such, the presence of fungus and residues remains problematic in Colorado marijuana (Rappold, 2015, March 24). To

date, 16 facilities have been granted general testing licenses in Colorado for recreational marijuana, several of which have achieved further provisional certifications to test for some or all of (i) potency/ homogeneity, (ii) residual solvents contamination and (iii) microbial contamination (Colorado Department of Revenue, 2015b).

Further, as Stone (2014) has noted, an emerging concern is how to address pesticide use and abuse in CMJMs. Federal prohibition excludes cannabis specific pesticides from registration within the existing robust regulatory framework of the Environmental Protection Association (EPA) that approves hundreds of agricultural commodities as safe for human consumption and offers guidelines for maximum residue level (MRL) (Daley et al., 2013). Although no pesticides or fungicides have been approved for use on cannabis federally, the Colorado Department of Agriculture (CDA) (2015) lists several criteria and guidelines for compliance that must be followed according to state law. Media reports suggest such concerns led to over 60,000 cannabis plants being guarantined at 11 grow facilities (Hughes, 2015a, April 30). Colorado is slowly beginning to enforce the regulatory requirements for pesticide testing of recreational and medical marijuana. In September 2015, Denver officials expanded pesticide inspections to ensure only pesticides allowed by the CDA are used on products (Baca, 2015f, September 7). However, as of September 2015, Gobi Analytical (2015) remained the only lab certified to test for pesticides (Migoya & Baca, 2015, September 7). In November, Governor Hickenlooper issued an edict that declared tainted marijuana a public safety threat (Migoya & Baca, 2015, November 13). The issue remains complex with two consumers recently suing the

largest grow facility in Colorado over the inappropriate use of Eagle 20, a potentially dangerous product for human consumption (Migoya & Baca, 2015, October 5).

Testing consumers for intoxication

Second is the issue of drug testing consumers, which relates specifically to driving under influence (DUI) and employment law. Current methods of testing impaired drivers involve blood or saliva testing and have been noted to lack accuracy in measuring real time levels of intoxication. Traces of fat soluble THC can remain in the body for days to weeks after consumption, which is problematic for DUI testing because a positive test can be triggered despite no current impairment (Wood, Brooks-Russell, & Drum, 2015). In an extreme case in July 2015, a driver with THC levels in the blood 4 times the legal limit was found not guilty (Roberts, 2015, July 22). Studies have shown breath testing for cannabis may offer a viable alternative (e.g. Himes et al., 2013). As such, a number of companies are trying to develop new reliable technology for testing levels on intoxication (see for example Caba, 2014; Cannabix Technologies Inc., 2015; Emerging Growth LLC, 2014; Equities Canada, 2014).

The principal concerns with employment law and marijuana involve testing and contract termination (Klein, 2015). A recent high profile case in the Colorado Supreme Court demonstrated the sensitive nature of this complex matter after ruling a quadraplegic person with a medical marijuana card who consumed off duty to control leg spasms was fired legally after cannabis was identified during a random drug test (Millican, 2015, June 17; Wallace, 2015, June 15). In Colorado, employers have the ability to craft their own policies where surveys indicate that employment levels are having an impact on the rigour of implemented workplace drug testing

policy. For example, in early 2014 many firms increased drug testing while a year later, as unemployment rates dropped below 5% and competition increased for identifying skilled labour, a number of companies began omitting THC from a preemployment drug screen, particularly in the hospitality industry (Wallace, 2015, June 15). An important consideration of good drug testing regimes includes situational clarity, such as determining whether tests will be administered pre-employment, randomly or upon reasonable suspicion of impairment. In addition, employers need to outline types of tests, provide notice, assure confidentiality and uniformity of enforcement and so on (Klein, 2015; Phillips et al., 2015). As the legal marijuana market in Colorado matures, of interest will be the extent to which, if at all, the synthetic cannabis market develops as a potential mechanism to bypass workplace testing.

Defining the Black Market

In an excellent summation of possibilities associated with legalised cannabis markets, Caulkins et al. (2015) described how specific choices by policy makers may determine the extent to which legal marijuana replaces the black market. Under this framework, price is seen as a major factor contributing to black market activity encouraged by excessively high taxation, expensive regulatory compliance, variation between medical and recreational costs and lack of ability to deduct legitimate business expenses as outlined above.

Cross-border transactions, such as a recent attempt to fly out 200 pounds of marijuana flower to Kansas (Rizzo, 2015, July 22) or \$12 million of medical grade product to Minnesota (Turtinen, 2015, March 26) are clearly black market activities. However, it is becoming apparent in Colorado that as the regulatory framework

evolves, there are definitional challenges regarding what constitutes a black market, particularly regarding caregiver quotas that until recently were legal although unregulated. For example, do the black market merchants now consist simply of unlicensed or unregulated growers and distributors selling a no longer illicit product that is untaxed? In Colorado it is legal for anyone over 21 to grow up to 6 plants each in any normal household (Colorado Department of Revenue and Marijuana Enforcement Division, 2013), although regulations are being considered by many jurisdictions at the local level to reduce this limit (Phillips, 2015, July 25).

The matter is further complicated by rules specific to the medical market that were implemented before the legalisation of recreational cannabis. These rules provided a loophole for unregulated cultivators to grow significant sized crops for the sake of medical marijuana patients without obtaining a license (Schrader, 2015, April 14). The establishment of "grow ops" meant thousands of plants were often cultivated legally in single locations creating safety concerns such as overloaded electrical systems, hazardous lighting and chemical use (Watts, 2015, March 10). The recreational marijuana industry complained that such grow operations invited back black market elements as caregivers were not obliged to comply with residential requirements, background checks or "seed to sale" tracking. To address this, new regulations were passed into law in May 2015 that limited licensed caregivers to 99 plants. According to a sponsor of the bill, the regulation aimed to ensure that caregivers were included within the regulatory system (Wyatt, 2015c, May 18). This has been modified further at the level of local councils, with Denver, for example, imposing limits of 36 plants in one location (Watts, 2015, March 10). Presumably it is also in the industry's interest to limit the capacity for users to grow their own marijuana.

Additionally, long-time marijuana dealers harbour some resentment to being shut out of the legal industry. As one grower/dealer has been quoted as saying: "It's kind of like we made all the sacrifices and they packed it up and are making all the money" (Griego, 2014, July 30). From this perspective, taxation is seen as a blunt instrument forcing the most socioeconomically vulnerable back to the black market. Yet another consideration is to what extent black market dealers can translate their skills into the modern industry. "There's no denying that if you've surreptitiously evaded the cops, maintained customer loyalty and kept your business afloat ...you know...something about growing and selling pot effectively" (Hesse, 2015, February 11). In late 2014, it was estimated that 40% of all marijuana transactions in Colorado were undertaken among black and grey segments of the marijuana economy (Bard, 2014, September 3). It remains unclear to what extent black market dealers have an opportunity to be registered as licensed industry professionals.

School Funding, Drug Education Programs and Staff Training

In specific regard to schools, under the Colorado model a 15% excise tax is earmarked for "Public School Capital Construction Assistance Fund Transfer" (Cannabis Public Media, 2015, August 18) for new school buildings. In the first 5 months of 2015, \$13.6 million was reported to have been collected via this tax (Baca, 2015b, July 13). As of August 2015, 26 projects were funded across Colorado, and competition among schools for construction funding is said to be fierce (Kelley, 2015, August 31).

How drug education is handled is another important component of the Colorado legalization reform. Tax revenue is being allocated not only to upgrade schools generally, but also towards specific drug education and treatment programs. In

Colorado Springs, for example, \$2.28 million was allocated to three school districts in 2015 for behavioural health counselling and drug prevention education (Kelley, 2015, August 31). To date, the Colorado Department of Public Health and Environment (2015) has released three public awareness campaigns, including one for the general public and the others aimed at youth education (see also Don't Be a Lab Rat, 2015; Protect What's Next, 2015). It has been noted that health industry workers such as nurses may require more training (Scriber, 2014), and a range stakeholders from law enforcement to accounting firms will be hoping for increased funding in future for additional training relating the marijuana industry.

Additional Issues

A number of other issues are relevant and require more research. Firstly, price is seen as a critical element and has been described in detail elsewhere (e.g. Caulkins et al., 2012). If prices are too high, black market activity may expand, while extremely low-cost marijuana is predicted to increase consumption rates among the most vulnerable (i.e. youth and dependent users) (Kleiman, 2015). Secondly, the relationship between medical and recreational markets is complex and evolving. Medical marijuana has long been viewed as a "Trojan horse" for full recreational markets (Hall & Weier, 2015; PBS Frontline, 1997-1998). However, powerful narratives used by advocates such as Gupta (2013, August 9) contribute significantly to the discussion, and the issue remains vigorously contested with emotion and anecdotes often substituting for lack of evidence. While an increasing amount of research into medical benefits of marijuana is being funded (e.g. D'Souza & Ranganathan, 2015), there remain significant hurdles to this research, including variation in state and federal laws and possibly the difficulty of patenting components that are already in use.

Further issues include but are not limited to: "cannabis migration" by high frequency recreational users (e.g. CannabisRehab.org, 2015) and parents accessing marijuana as a medicine for their children (Pickert, 2015, July 30); environmental concerns relating to large scale cultivation (Warren, 2014); tourism, in particular revenue spikes in the Colorado high seasons (Baca, 2015a, August 13); how the public consumption of marijuana is regulated (e.g. Baca, 2015d, June 17; Murray, 2015, August 10); and gender in terms of both equal representation in the industry (Mitchell, 2015, March 3; The Cannabist, 2015d, June 9) and consumption patterns (Ingold, 2011, March 13). Furthermore, unexpected consequences such as increases in Colorado house prices require further research attention (CNN Money, 2015c, June 4). While many of these issues are fascinating there is not the opportunity to deal with their complexity in this paper.

Conclusions

Colorado implemented legislation that legalises marijuana for recreational purposes for those over the age of 21 almost two years ago. It would seem an appropriate time to attempt to describe some of the issues that have emerged during its operation. In a general sense the intention of the legislation was to establish a legal scheme for the production and distribution of cannabis for non-medical use in a way that mitigated certain problems. From the perspectives of both regulators and public health representatives, the legislation is intended to create an environment that minimises harm, in the broadest sense, to individuals and the community generally. At this early stage, the model appears functional and seems to be evolving slowly in response to issues that have arisen. The regulatory process is reasonably transparent, has the ability to respond to issues as they arise, and there is equal access for a range of stakeholders including industry representatives and public

health professionals to contribute to the final make up of regulations. Whether profit motivated companies should be granted full accessibility to the regulatory process before laws are even passed remains contentious. As yet, no drastic increases in harm have been noted as a consequence of the scheme. A funding mechanism has been implemented that provides funds for school construction projects, drug education and treatment programs and the creation and development of product testing infrastructure.

However, the scheme faces major challenges, of which the most notable appear to be federal prohibition which limits access to relevant national infrastructure, the growing influence of the cannabis industry that may seek to exploit loopholes in advertising restrictions, and immature testing regimes which can not yet cope with demand, thereby limiting the effectiveness of the regulation to provide a safe product for consumers.

One of the core principles guiding the new legislation was the protection of youth. This has been attempted with regulations that impose restrictions on the age of consumption and advertising of products. Further emphasis has been placed on youth education programs. To date, two public education programs aimed at teens, "Don't be a lab rat" and "Protect the future", have been released by the state. However, the uncertainty surrounding advertising loopholes that may permit youth targeting continues to be a cause for significant concern. How successful the regulations will be in terms of limiting user uptake in this important group remains unknown.

Beyond protecting youth, the harm-reduction approach of ensuring product is safe for human consumption is hindered by federal prohibition that prevents access to

national testing frameworks and guidelines such as those provided by the FDA and EPA. This, in turn, has an impact on the stated aim of being able to respond to consumer needs in a timely fashion. The purity of Colorado marijuana has yet to reach levels promoted in the legislation, with a number of reports detailing unsafe levels of moulds, non-approved pesticides and other contaminants in products. While regulations have been passed that outline compliance requirements for testing of potency and purity, it has taken more than a year to start seeing some levels of enforcement to support that implementation. It is notable that testing facilities appear unable to cope with demand, creating significant delays. However, progress is being made in this area, despite only one lab currently being certified to test for pesticide residues in marijuana products.

A further aim of the regulations was legislation that was not unduly burdensome. The achievement of this appears questionable at this early stage. Furthermore the speed of regulatory evolution in response to changing consumer patterns such as dabbing appears to be hindered by lack of agreement between numerous stakeholders, although some progress has been made as the edibles legislation shows. How this regulation deals with a landscape that is changing the dynamic of the black market will be fascinating to see.

To ensure product safety from the outset, policy makers need to be mindful of limitations of infrastructure before implementing policy that legalises marijuana. Furthermore, the proliferation and popularity of edibles and vapourisers may be an unintended consequence of bans on public consumption in the Colorado model or it may simply be an industry providing a market product for THC extracted from material which was simply treated as waste in the illegal market. Either way it is a consequence of the Colorado model worthy of further investigation. Finally, the

model would look quite different without federal prohibition and this component remains problematic in assessing the Colorado model. Federal alignment does not appear to be a priority to 2016 Presidential candidates.

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