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Review paper

Alcohol and cannabis: Comparing their adverse health effects and regulatory regimes

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ABSTRACT

The claim that the adverse health effects of cannabis are much less serious than those of alcohol has been central to the case for cannabis legalisation. Regulators in US states that have legalised cannabis have adopted regulatory models based on alcohol. This paper critically examines the claim about adverse health effects and the wisdom of regulating cannabis like alcohol. First, it compares what we know about the adverse health effects of alcohol and cannabis. Second, it discusses the uncertainties about the long term health effects of sustained daily cannabis use. Third, it speculates about how the adverse health effects of cannabis may change after legalisation. Fourth, it questions the assumption that alcohol provides the best regulatory model for a legal cannabis market. Fifth, it outlines the major challenges in regulating cannabis under the liberal alcohol-like regulatory regimes now being introduced.

Comparisons of the adverse health effects of alcohol and cannabis have been central to the case for cannabis legalisation (BBC, 2014; Boffey, 2014; Editorial Board of the New York Times, 2014). The four US states that have so far legalised cannabis for adult use – Colorado, Washington State (2012), Alaska and Oregon (2014) – have largely adopted regulatory regimes modelled on those for alcohol (Hall & Lynske, 2016a, 2016b, 2016c; Pardo, 2014).

There are understandable reasons for the comparisons of adverse health effects and the implicit regulatory lessons from alcohol drawn by those advocating for legalisation. First, alcohol and cannabis are used in similar social contexts and for similar reasons, namely to improve mood and to enhance conviviality and the enjoyment of recreational activities (Hall & Pacula, 2010). Second, any comparison of adverse health effects favours cannabis because its adverse health effects are very modest compared with those of alcohol (Hall, Room, & Bondy, 1999; Room, Fischer, Hall, Lenton, & Reuter, 2010). Third, the comparison highlights a major form of societal hypocrisy in most developed countries, namely, that the use of a less harmful drug like cannabis is prohibited (on pain of imprisonment) while a much more dangerous drug like alcohol is freely available, heavily promoted and widely used in ways that cause substantial harm to drinkers and others. Fourth, advocates of reform may want to avoid comparing cannabis with the other widely smoked drug, tobacco, in order to avoid any argument that tobacco control provides a more suitable regulatory model for cannabis than alcohol. Given these factors it may seem a reasonable inference that the most appropriate regulatory approach to a legal cannabis market would be one based on that for alcohol, possibly with less stringent enforcement.

This paper critically examines these assumptions. First, it compares what we know now about the adverse health effects of alcohol and cannabis. Second, it discusses the major uncertainties that remain about the long term health effects of sustained regular cannabis use. Third, it speculates on how the adverse health effects of cannabis may change after the legalisation of recreational use. Fourth, it questions the assumption that alcohol is the best regulatory model for a legal cannabis market by asking how successful alcohol regulation has been in minimising the adverse health effects of alcohol. Fifth, it concludes with an outline of the major challenges in regulating cannabis under a modified alcohol regulatory regime.

The adverse health effects of alcohol

Thanks to over half a century of epidemiological research, the adverse health effects of alcohol are reasonably well understood (Babor et al., 2010; Parry, Patra, & Rehm, 2011; Rehm & Shield, 2013; Shield, Parry, & Rehm, 2013). In large doses alcohol can cause fatal overdoses from respiratory depression and alcohol intoxication, is a major cause of road accidents, and contributes to assaults and suicide (Babor et al., 2010). When consumed heavily and regularly, alcohol can cause a dependence syndrome and other mental disorders such as severe depression and psychosis (Connor,

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Haber, & Hall, 2016). Sustained heavy use increases the risks of liver cirrhosis, pancreatitis, cancers of the oral cavity, breast, and colon, some types of heart disease and stroke, and neurological diseases such as Wernicke–Korsakov syndrome and dementia (Rehm et al., 2013). For these reasons, alcohol use makes a substantial contribution to the global burden of disease (Forouzanfar et al., 2015; Lim et al., 2012; Naghavi et al., 2015; Rehm et al., 2009, 2010; Vos et al., 2015; Whiteford et al., 2013).

The adverse health effects of cannabis: the standard account

The known adverse effects of using cannabis look very modest by comparison with the manifold and protean adverse health effects of alcohol (Hall, 2015; Hall & Degenhardt, 2009; Hall, Renström, & Poznyak, 2016). As advocates of more liberal cannabis policies stress, cannabis is not known to cause fatal overdoses (Gable, 2004) because it does not have respiratory depressant effects like the opioids or alcohol (Boffey, 2014). Cannabis intoxication only modestly increases road accident risk (roughly two-fold) (Asbridge, Hayden, & Cartwright, 2012) by comparison with alcohol (6–10 fold) (Hall, 2015). There is weak evidence that cannabis use increases depression or suicide risk (Hall et al., 2016). Acutely some cannabis users have very unpleasant experiences, such as, anxiety, paranoia and hallucinations, but, it is usually argued, these symptoms resolve as the effects of intoxication dissipate. It is difficult to establish causality between cannabis use and mental illnesses because of other confounding factors, e.g. alcohol use, that also increase the risks of mental disorders (Hall, 2015).

Cannabis dependence can develop in those who engage in sustained daily or near daily use (Anthony, 2006; Anthony, Warner, & Kessler, 1994). The existence of cannabis dependence is often discounted by advocates of more liberal cannabis policies as an artefact of prohibition because, it is argued, cannabis users only seek treatment as a way of avoiding criminal penalties and that social norms will develop among users after legalisation that will discourage this pattern of use (Pacula, Powell, Heaton, & Sevigny, 2015). If the existence of cannabis dependence is conceded, then it is argued that the risk of developing dependence on cannabis is much smaller than the comparable risks for alcohol, nicotine or heroin (Anthony et al., 1994), and that the health and social consequences of cannabis dependence are much less serious than those for alcohol, nicotine and heroin dependence.

A critical analysis of the standard account

Taking cannabis dependence seriously

Cannabis dependence is not an artefact of prohibition. This is clear from the increase in the numbers of persons seeking treatment for problem cannabis use in the Netherlands (EMCDDA, 2013) where cannabis use, possession and small scale retail sales were decriminalised over 40 years ago (Room et al., 2010). The health problems reported by cannabis dependent persons – e.g. bronchitis and impaired memory – are much less serious on average than those reported by persons who are alcohol dependent (Hall, 2015) (e.g. delirium, liver disease, gastritis) but this does not mean that cannabis dependence is a minor problem (Hall, 2015).

First, cannabis dependence is a problem in itself for those who seek help. An inability to control one's cannabis use is a problem if you do not want to spend most of your days intoxicated in ways that interfere with your capacity to perform social roles. It may also require users to spend a substantial proportion of their income on cannabis. Some users simply do not like having impaired control over their drug use.

Second, the widely cited estimates of the risk of dependence among (9% of lifetime cannabis users and 15% of adolescent users) (Anthony et al., 1994) are probably under-estimates derived from population surveys done in the early 1990s. As Caulkins (2016) has pointed out, at this time the great majority of lifetime cannabis users did not use cannabis often enough to put themselves at risk of developing dependence. In US household survey data in 1998, for example, only a third of lifetime cannabis users had used cannabis more than 100 times (a criterion often used to define regular tobacco users). The dependence risk among cannabis users who had used this often was three times higher than that in lifetime users, namely, 27% (Caulkins, 2016). The relevance of these risks to contemporary cannabis users is uncertain because of the substantial increases in the THC content of cannabis over the past two decades (McLaren, Swift, Dillon, & Allsop, 2008).

Third, the outcomes for treatment of cannabis use disorders resemble those for the psychosocial treatment of alcohol dependence, in that a small proportion of treated cases achieve enduring abstinence from any episode of treatment (Martin & Rehm, 2012). In longitudinal studies cannabis dependence has a high rate of remission in the absence of treatment (Sarvet & Hasin, 2016; Heyman, 2013). However, among persons with cannabis dependence who seek treatment, cognitive behavioral treatment produces low abstinence rates six and 12 months after treatment (Gates, Sabioni, Copeland, Le Foll, & Gowing, 2016).

Correlates of cannabis dependence

Cannabis dependence in young adults is correlated with a variety of poor psychosocial outcomes (Hall, 2015; Hall et al., 2016). These include increased risks of tobacco and nicotine dependence (Ramo, Delucchi, Hall, Liu, & Prochaska, 2013; Rubinstein, Rait, & Prochaska, 2014); illicit drug use; developing schizophrenia; leaving school early, and showing poor cognitive performance in mid-adulthood (Hall, 2015). It is often argued that the relationships are not causal because these associations are better explained by a combination of factors that are correlated with regular cannabis use and these outcomes, namely, other drug use (alcohol, tobacco, and stimulants) and poor cognitive ability and greater propensity to take risks among those who are most likely to become regular cannabis users (Macleod et al., 2004). Some of these associations between heavy cannabis use and poor psychosocial outcomes in young adulthood (other illicit drug use; psychosis; poor school outcomes and cognitive impairment) may simply be correlations but it is unlikely that they all are, as the following brief summary of research suggests.

Illicit drug use

There are plausible non-causal explanations of the apparent "gateway effect" of heavy cannabis use (Hall & Lynskey, 2005; Morral, McCaffrey, & Paddock, 2002). One factor undoubtedly is the selective recruitment into regular cannabis use of young people who are at higher risk of using a variety of illicit drugs, independently of the fact that they have used cannabis (Morral et al., 2002). This includes young people who have parental history of drug use disorders, a personal history of conduct disorders in childhood and adolescence, and who have been early and regular tobacco smokers (Fergusson, Boden, & Horwood, 2006; Fergusson, Boden, & Horwood, 2008; Meier et al., 2016). Another factor is that daily cannabis users socialise with peers who are also daily cannabis users, who are more likely to approve of and use other illicit drugs. They are also more likely to be involved in illicit drug markets because they sell cannabis to peers to finance their own cannabis and other drug use (Fergusson et al., 2008). It is also possible that the heavy use of nicotine in adolescence may change brain function in ways that make users more likely to find the

effects of other drugs rewarding (Kandel & Kandel, 2015) but it is not clear in the case of cannabis whether this is a specific effect of cannabis use or an effect of early drug use more generally.

Psychoses

Daily cannabis use and cannabis dependence have been consistently associated with an increased risk of psychotic symptoms and with receiving a diagnosis of schizophrenia in a series of longitudinal studies in a number of developed countries (Hall et al., 2016; Moore et al., 2007) As argued in detail elsewhere (Hall & Degenhardt, 2006), the evidence that cannabis is a contributory cause of psychosis is arguably stronger than the evidence for the claim that heavy alcohol, amphetamine and cocaine use can cause a psychosis. First, cannabis use usually precedes the diagnosis of schizophrenia or occurrence of psychotic symptoms. Second, there is a dose response relationship between frequency and duration of cannabis and the risk of psychosis in the largest longitudinal studies. Third, these relationships persist after statistical control for plausible confounders. Fourth, a causal relationship is biologically plausible because cannabinoids act on the dopaminergic system implicated in psychosis, and in double blind studies THC produces psychotic symptoms in persons with and without psychoses (Hall, 2015).

The increased risk is only two-fold, suggesting that regular cannabis use acts in concert with a variety of other factors to increase the risk of psychosis. The modesty of the risk has limited utility from a public health perspective because additional cases of psychosis arising from regular cannabis use are difficult to avert (Hickman et al., 2009). Moreover, the contribution that cannabis use makes to the burden of disease via any causal role in psychoses is small by comparison with the contribution made by cannabis dependence (Degenhardt et al., 2009; Imtiaz et al., 2016). This is nonetheless important risk information for those young people who have a higher baseline risk of developing a psychosis (e.g. having an affected first degree relative or a history of psychotic symptoms) because psychoses can be socially disabling illnesses and their chance of developing the disorder increases from around 10% to 20% (Degenhardt & Hall, 2012).

Early school leaving and cognitive impairment

In two New Zealand birth cohort studies daily cannabis use in adolescence and young adulthood was associated with early school dropout, a failure to obtain employment, welfare dependence and a poorer quality of life in adulthood (Fergusson & Boden, 2008) and downward social mobility (Cerdá et al., 2016). In case control studies, sustained daily cannabis use is also correlated with poorer cognitive performance on psychometric tests and with changes in areas involved in memory and attention in both structural and functional neuroimaging studies (Hall & Lynskey, 2016b; Volkow et al., 2016). A small number of cohort studies have also found larger declines in cognitive ability in regular cannabis users who used daily throughout their twenties and into their thirties (Auer et al., 2016; Meier et al., 2012).

Some critics (e.g. Rogeberg, 2013) have argued that the cognitive impairment is not an effect of cannabis use but a characteristic of the type of user who becomes heavily involved in cannabis use e.g. someone with a lower socioeconomic status and poorer cognitive ability. According to this alternative hypothesis, heavy cannabis use is most attractive to the least cognitively able young adults. We do not have to choose between the drug and the user in explaining the association. It seems likely that these outcomes are due to a combination of the drug and the user in that less cognitively able young people are more likely to use cannabis regularly in ways that add to their cognitive impairment during their schooling. In young adulthood, daily cannabis use makes a dull, undemanding and unrewarding life more tolerable (Hall, 2008). In an employment market with fewer unskilled jobs for the less cognitively able, cannabis legalisation may increase the prevalence of cannabis dependence in the poorest and most disadvantaged segments of the population.

The long term health risks of regular cannabis use

The long term adverse health effects of sustained daily cannabis smoking are not as well understood as the risks of sustained heavy drinking. This is because there are many fewer daily cannabis smokers than daily drinkers, very few daily cannabis users have smoked for decades, and there have been very few studies of those who have used daily for decades.

It was a reasonable hypothesis in the 1980s that regular cannabis smoking would adversely affect the respiratory system because there were similar levels of carcinogens and tars in cannabis and tobacco smoke (see Tashkin, 1999 in Kalant, Corrigal, Hall, & Smart, 1999). Cohort and case-control studies since then have found higher rates of chronic bronchitis in regular cannabis smokers, including users who did not smoke tobacco (Tashkin, 2014). The evidence on cannabis smoking and COPD has been more mixed: a few studies have found impaired respiratory functioning in regular cannabis users (e.g. Taylor, Poulton, Moffitt, Ramankutty, & Sears, 2000) but other well designed studies, including one of the largest follow up studies, failed to do so (Hall et al., 2016).

Much the same has been true of studies of cancers of the respiratory tract in regular cannabis smokers. Case control studies have not been able to control for the confounding effects of tobacco smoking because most regular cannabis smokers who develop these cancers are either current or former tobacco smokers (Huang et al., 2015). Given what is known about the toxicology of cannabis smoke (Hall et al., 2016), it would be unwise to interpret these findings as good evidence for the absence of any respiratory cancer risks from smoking cannabis and better to conclude that there is an absence of good evidence on the question.

How may these adverse health effects change after cannabis legalisation?

Cannabis use makes a much more modest contribution to burden of disease in developed countries than alcohol (Degenhardt et al., 2009; Imtiaz et al., 2016). Those who defend cannabis prohibition can reasonably argue, however, that these comparisons are confounded by the difference in legal status between the two drugs. The small public health impact of cannabis use, they could argue, reflects the fact that cannabis use is prohibited. Lifetime cannabis use may be over 40% (and higher in younger birth cohorts) but most cannabis users have only used on a small number of occasions and there are consequently many fewer weekly cannabis users (e.g.7.5% of US persons over the age of 12 in 2013) than there are weekly drinkers (52.2% of US persons over the age of 12 in 2013 of whom 22.9% were binge users and 6.3% were heavy users) (SAMHSA, 2015). Cannabis use careers under prohibition are also much shorter than those of most drinkers, at least in part, because of the difference in legal status: most cannabis users cease use in their mid to late 20 s whereas most adults drink throughout adulthood because alcohol use is socially condoned and widely promoted unlike cannabis use (Bachman, Wadsworth, O'Malley, Johnston, & Schulenberg, 1997; Miech & Koester, 2012).

On this argument, the adverse public health effects of cannabis are likely to increase after legalisation because it will be easier to obtain and use cannabis, cannabis will be much cheaper to purchase, the criminal law will no longer act as a deterrent and, if advertising is allowed after legalisation, its use will be promoted by sellers and producers (Hall & Lynskey, 2016a). Since cannabis was

legalised in the USA the THC content of cannabis products has increased both in edible products intended for medical use and more recently in highly concentrated forms of THC, such as butane hash oils (HBO), which are smoked (Loflin & Earleywine, 2014; Stogner & Miller, 2015).

The concern that increased potency will increase the prevalence of adverse health effects is discounted by the suggestion that cannabis users will titrate their doses and so use less of the more potent cannabis products. One of the few controlled studies of titration in regular users suggests that although users do use smaller doses of more potent cannabis products they incompletely compensate and so receive larger than intended doses of THC (van der Pol et al., 2014) The increased number of hospital emergency room attendances involving cannabis also suggests that users are not good at titrating their doses of more potent cannabis products (Monte, Zane, & Heard, 2015).

How may legalisation affect the adverse health effects of cannabis?

Regular use and dependence

The most likely short term effect of cannabis legalisation will be a reduction in cannabis price, an effect which, in turn, will probably increase the frequency of use among current users (Hall & Lynskey, 2016a). This is what usually happens when alcohol availability increases or alcohol prices are reduced (Babor et al., 2010; Wagenaar, Tobler, & Komro, 2010). The effects of increased availability and reduced price will be amplified by reduced social disapproval of use, the removal of criminal sanctions (which are most likely to affect older users); and the social normalisation of cannabis use (Hall & Lynskey, 2016a, 2016b, 2016c). The use of more potent cannabis products by users who incompletely adjust for their potency may also increase dependence risk. There is suggestive evidence from the Global Drug Survey that users of more potent skunk cannabis report more symptoms of dependence than users of less potent products (Freeman & Winstock, 2015).

For these reasons, the most likely outcome of lower cannabis prices and higher potency will be an increase in cannabis dependence among current users. What is less clear is what the net effect of legalisation will be on treatment seeking. Treatment seeking could increase if legalisation destigmatises dependence and increases the capacity of the treatment system. On the other hand, treatment seeking will be reduced because adults will no longer be legally coerced into treatment. Problem users may also experience less social pressure to desist from using cannabis if regular use becomes more common and more socially acceptable.

Psychoses

Increased use of cannabis products with high levels of THC may increase the prevalence of acute psychotic syndromes in cannabis users and worsen the prognoses of young people with psychoses who use cannabis. There is suggestive evidence for these predictions from Di Forti et al's studies (e.g. Di Forti et al., 2015) of the effects of skunk cannabis on first episode psychoses and case reports of psychoses in users of highly concentrated cannabis oils (Pierre, Gandal, & Son, 2016). Prospective studies of first episode psychoses also show poorer outcomes in terms of increased hospitalisations in persons with psychoses who continue to use cannabis (Patel et al., 2016). There are also case reports of psychotic syndromes in users of synthetic cannabinoids, substances which are much more potent than THC in their effects on the CB1 receptors (van Amsterdam, Brunt, & van den Brink, 2015).

Cardiovascular effects

THC was shown to be a potent cardiovascular stimulant in the 1980s but healthy young cannabis users quickly developed tolerance to these cardiovascular effects (Sidney, 2002). There are two reasons for more concern now. First, older cannabis users among the baby boomers who continue to use (or resume use in their 60 s after legalisation) will be at much higher risk of experiencing cardiovascular disease by virtue of their age. They are also more likely to be intermittent users who will therefore be less tolerant to any cardiovascular effects and they will be using more potent cannabis products than they did as young adults. Second, cardiovascular risk may not be confined to the middle aged. There are case series and a few case-control studies of cardiac syndromes and strokes occurring in young men who were heavy cannabis smokers (Hall et al., 2016; Jouanjus, Leymarie, Tubery, & Lapeyre-Mestre, 2011; Jouanjus, Lapeyre-Mestre, & Micallef, 2014; Wolff et al., 2011, 2015).

Regulating a legal cannabis market

The foregoing analysis indicates that cannabis is a dependence producing drug but it has fewer and generally more modest adverse health effects than alcohol. It is perhaps unsurprising then that those US states that have legalised cannabis have modelled their cannabis regulations on those of alcohol, rather than tobacco, which is subject to stronger regulatory controls. Given the recent history of alcohol regulation, it is unlikely that this approach will minimise the adverse public health effects of cannabis.

Alcohol regulation has been increasingly liberalised over recent decades in most developed countries. Alcohol has been increasingly regulated as an ordinary commodity, like orange juice, rather than as an intoxicating and addictive drug (Babor et al., 2010). There have been been fewer restrictions on where and when alcohol can be sold, and alcohol taxes have not increased, effectively lowering alcohol prices. The alcohol industry has promoted the heavy use of its products to maximise profits and has sought to socialise the economic costs of alcohol use by asking tax payers to pay for the externalities of alcohol abuse (e.g. by providing more police to enforce laws against public drunkenness) (Hall & Room, 2006). The industry also encourages policy makers to blame drinkers for alcohol-related harm and self-regulates using industry-sponsored "drink responsibly" consumer education campaigns and exhortations (in the fine print of alcohol advertisements). It opposes effective public health oriented regulation that reduces access and increases alcohol taxes to reduce heavy alcohol use and alcohol-related harm (Babor et al., 2010; Hall & Room, 2006), including broad-based education and prevention campaigns aimed at the general public.

One can expect a legal for profit cannabis industry to behave in similar ways, with industry-sponsored campaigns to "consume responsibly" already emerging (Crombie 2016; Marijuana Policy Project 2014). The majority of cannabis is consumed by daily users, a substantial proportion of whom are probably problem cannabis users (Burns, Caulkins, Everingham, & Kilmer, 2013; Caulkins, 2016), as is the case for alcohol. The emerging cannabis industry therefore shares the alcohol industry's interest in maintaining, if not increasing, the number of heavy users, and recruiting new heavy users to replace those who discontinue. The regulations implemented in US states that have legalised cannabis to date have not dedicated tax revenue from marijuana sales to programs to prevent and minimise heavy use or have restricted cannabis promotions. Regulators seem to have been much more focused on eliminating the black market than on minimising public health harms. They initially set taxes at a low rate and some critics from

within the nascent cannabis industry argue that taxes will need to be reduced further to eliminate the black market (James, 2016).

If these regulatory regimes remain in place then cannabis regulators will only be able to use consumer education to minimise any public health harms from increased cannabis use. If so, the major challenge for health educators will be to provide credible health information to young people about the risks of using cannabis (Cermak & Banys, 2016; Rosenbaum, 2016). Given that cannabis is no longer illegal for adults, simple messages to "just say no" are no longer available (however ineffective they may have been under prohibition). A more complex set of messages will be required that advises adults to use "in moderation" and encourages adolescents to delay starting until they are adults and to avoid using in risky ways, if they already use (Rosenbaum, 2016). It is not clear whether we will achieve agreement on what moderate cannabis use means and it is doubtful that the cannabis industry will be any more amenable to setting "safe limits" than the alcohol industry has been. Experience from tobacco control also suggests that exhortations to avoid using cannabis until one is an adult may be counterproductive, e.g. by encouraging cannabis use in adolescents who are in a hurry to become adults in much the same way as similar approaches have done with smoking (Mandel, Bialous, & Glantz, 2006; Backinger, Fagan, Matthews, & Grana, 2003).

A worrisome prospect is post-repeal amnesia about the adverse effects of regular cannabis use. In the 1940s and 1950s, after the repeal of national alcohol prohibition in the USA, public health authorities were uncertain whether they should educate consumers about the connection between heavy drinking and liver cirrhosis, psychosis and alcoholism (Katcher, 1993). Evidence that alcohol adversely affected health was dismissed as temperance propaganda. We see signs of this today in claims that the literature on the adverse health effects of cannabis has been biased by cannabis prohibition (Retail Marijuana Public Health Advisory Committee, 2015).

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Conflict of interest

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