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The THC Content of Cannabis in Australia:

Evidence and implications

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EXECUTIVE SUMMARY

A number of commentators in the alcohol and other drugs field have recently claimed that the THC content of cannabis used in Australia has increased between 10 and 30 times over the past two decades. This has raised understandable queries about its role in a possible increase in the adverse health and psychological effects of cannabis use experienced by young people.

There is a need to distinguish two different interpretations of this claim: (i) that the average THC content of cannabis *plants* has increased, and (ii) that the average THC content of cannabis products *as consumed* by Australian users has increased by 10-30 times. We examine evidence on each claim and discuss the implications for harm.

Has the average THC content of cannabis plants increased?
The THC content of Australian cannabis products has *not* been *systematically* tested by any Australian police force over the period in which average THC content has been claimed to have increased, as there is no legislative reason for doing so. There is therefore no Australian data to support the claim that there has been a 10 to 30-fold increase in *average* THC content of cannabis in Australia.

The USA is the only country that has regularly collected data on the THC content of cannabis plants over the past several decades. Claims that this data indicated that the THC content of marijuana in the USA had increased between three to seven-fold from the early 1970s to the mid 1980s have been challenged by data from independent laboratories, and because such claims relied on the assumption that the samples from the middle 1970s were representative of cannabis consumed at that time. More recent data have failed to show a 10-30 fold increase in the THC content of seizures between 1984 and 1998. At most this series shows a small increase in THC content from 3.3% in 1980 to 4.4% in 1998.

The New Zealand government has also intermittently tested the THC content of cannabis samples over the past two decades. Samples of hydroponically grown cannabis tested in a NZ survey typically contained 6-8% THC, with an occasionally higher sample.

There are two more plausible alternative explanations for an upsurge in anecdotally reported adverse effects of cannabis use: changing cannabis markets have increased the availability of more potent forms of cannabis; and there have been changes in the patterns of cannabis use among Australian cannabis users that increase the prevalence of harmful use.

Changing Cannabis Markets
Over the past two decades a large scale illicit cannabis industry has developed in Australia to meet the demand for cannabis products among a growing number of cannabis users. It has been estimated that daily and weekly cannabis users, who prefer the more potent forms of cannabis, account for 80% of cannabis consumed. Any increase in the number of regular cannabis users that may have occurred in recent decades may have increased the demand for and availability of more potent forms of cannabis. Any such increase in the

availability of more potent forms of cannabis would have increased the amount of THC consumed by heavier cannabis users without there having been any increase in the average THC content of cannabis plants.

It is also a plausible hypothesis that the supply of more potent cannabis products has been encouraged by the success of domestic law enforcement in detecting and destroying large-scale cannabis plantations, creating an incentive for illicit suppliers of cannabis to grow small numbers of cannabis plants with a higher THC content (e.g., hydroponic cultivation).

Changing Patterns of Cannabis Use

Survey data suggest that in the 1990s young Australians have probably initiated cannabis use at an earlier age than was the case in the 1980s. The lifetime prevalence of cannabis use in Australia and the United States, particularly among adolescents, has increased, after a decline in the 1980s and early 1990s. Earlier initiation of cannabis use increases the chances that users will become daily or nearly daily cannabis users, and increases the likelihood that they will become dependent on cannabis and experience adverse personal and social consequences as a result of their use. Regular cannabis use makes users tolerant to the effects of THC, encouraging the use of more potent cannabis preparations and the use of waterpipes or "bongs" in the belief that it maximises the delivery of THC. Population based data reveal that "heads" are the most commonly used form of cannabis in Australia, while cannabis is most frequently smoked in waterpipes or "bongs".

All these changes in patterns of use – earlier initiation of cannabis use, more regular use of more potent cannabis products and greater use of waterpipes – have probably played a greater role in increasing the amount of THC consumed by regular cannabis users than any increase in the *average* THC content of cannabis plants. And it is these patterns of use that may explain apparent increases in numbers of adolescents and young adults experiencing problems with their cannabis use.

What are the health implications of any increase in THC content?

A major concern raised by the claimed increase in the THC content of cannabis has been that it will increase the adverse health and psychological risks of cannabis. Research suggests that unlike nicotine smokers, cannabis users have only a limited ability to titrate their dose. In this case, the effect of using more potent cannabis products will depend upon the type of health effect in question, and the user's experience with cannabis. Higher average doses of THC will probably increase the risk of adverse psychological effects of cannabis use, an effect likely to be most obvious among naive or first time cannabis users. This effect may discourage further experimentation with the drug among these users. Risks of increased THC exposure among regular cannabis users are less certain. They possibly include an increased risk of accidents among those who drive while intoxicated, especially if cannabis use is combined with alcohol, and an increased risk of regular cannabis users developing dependence. If the THC content of the most commonly used Australian cannabis products has increased, the net adverse effects of cannabis use may have marginally increased. Respiratory risks may be marginally decreased if cannabis smokers are able to titrate their doses of THC.

Implications

A first priority should be to collect data on the THC content of samples of cannabis consumed by regular users in Australia. A second priority should be a study of the extent to which regular cannabis users are able to titrate their dose of THC. If users perform this task poorly, then this information needs to be given to users and potential users.

A potential legislative strategy is to impose higher penalties for the cultivation and sale of cannabis products with THC content above some statutory level. This may provide incentives for illicit manufacturers to supply the less potent forms of cannabis products.

A more contentious issue is the type of health education advice that should be given to young people about the health risks of using more potent forms of cannabis. We do not need to wait until we have better data on THC content before we educate young people about: the risks of early initiation of cannabis (and other licit and illicit drug use); the greater potential for dependence if they use more potent forms of cannabis; and the respiratory risks of smoking cannabis in bongs (Hall, 1998).

Introduction

A number of commentators in the alcohol and other drugs field have recently claimed that the THC content of cannabis products used in Australia has increased between 10 and 30 times over the past two decades (Malouf, 1999; Moffit, 1998; Walters, 1993). The increased THC content has been attributed to the cultivation of hybrids of the *cannabis sativa* plant, such as, "skunk" using hydroponic growing methods. Since THC is the psychoactive substance in cannabis that is responsible for most of its effects (see Adams and Martin, 1996) these claims have raised concerns that there may be an increase in the adverse health and psychological effects of cannabis use by young people. For example, clinicians and other key informants have reported an increase in psychological and other problems among cannabis users, and a rise in demand for treatment for cannabis dependence (Davey and Davies, 1999; McKetin et al, 1999). In this report we examine evidence on these linked claims, namely, that the THC content of Australian cannabis has increased, that problems related to cannabis use have increased in recent years, and that an increase in THC content is an explanation of the perceived rise in cannabis-related problems.

There is a need to distinguish two different interpretations of the claim that THC content of cannabis has increased. These are not clearly distinguished by those who make it or in media discussions of the issue. The first interpretation is that the average THC content of cannabis *plants* has increased between 10 and 30 times. The second is that the average THC content of cannabis products *as consumed* by Australian users has increased by 10-30 times. Each of these claims will be evaluated in the light of the available data.

Has the average THC content of Australian cannabis plants increased?

The major obstacle to testing these claims is that the THC content of cannabis products has *not* been systematically tested by any Australian police force over the period in which average THC content has been claimed to have increased. Penalties under law for possession, use, cultivation or sale of cannabis products in Australian states and territories do not distinguish between cannabis products of differing potency. There is subsequently no reason for police forces to routinely test the THC content of cannabis. There are, therefore, no Australian data to support the claim that there has been a 10 to 30-fold increase in *average* THC content of cannabis plants in Australia.

Samples of seized cannabis are occasionally tested by the police and others. In NSW, for example, only one cannabis sample has been analysed by the Division of Analytical Laboratories in the past two years. This sample of compressed, hydroponically grown "heads" from South Australia had a THC content of 15% (Donkin, Division of Analytical Laboratories, NSW, personal communication, May 24). Media publicity to the THC content of single samples such as this can create a false impression that these levels are typical of the cannabis products consumed in Australia.

Other Australian data on cannabis samples tested for other purposes suggests that this NSW sample had an unusually high THC level. In 1997 the THC content of a small

number of cannabis seizures (leaf and head) was tested from a number of Australian states. This was done in the course of studying THC, tar and carbon monoxide content of smoke from cannabis cigarettes and water pipes. The analyses reported a THC content between 0.6-13% of plant material, with the majority of samples having a THC content in the range 0.6-2.5% (Gowing, Drug and Alcohol Services Council, SA, personal communication, May 24).

Data are available on THC potency of cannabis in the US and New Zealand. While these data do not provide a direct comparison to the Australian context, the three countries are broadly similar on a cultural level, and epidemiological research suggests cannabis use and dependence patterns are very similar in each (Donnelly and Hall, 1994; Hall, Johnston and Donnelly, 1999). In the absence of Australian data on THC content, data from New Zealand and the USA provide the next best indication of trends in THC content.

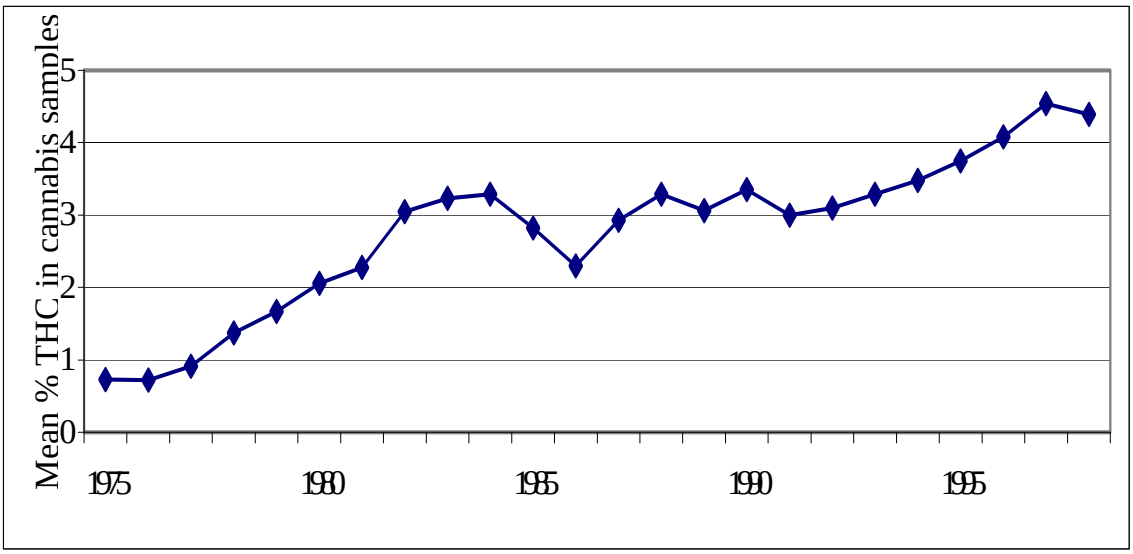
Has the THC content of cannabis plants increased in the USA?

The only country that has regularly collected data on the THC content of cannabis plants over the past several decades is the USA. The Research Institute of Pharmaceutical Sciences at the University of Mississippi has been testing THC content of cannabis seizures for the National Institute on Drug Abuse since the middle 1970s (The Potency Monitoring Project).

In the 1980s, Cohen (1986) cited the Potency Monitoring project data (subsequently reported by ElSohly and ElSohly, 1989) to support his claim that the THC content of marijuana in the USA had increased from 0.5%-1.0% in the early 1970s to 3.5% in the mid 1980s. Mikuriya and Aldrich (1988) contested the claim, arguing that samples from the middle 1970s were not representative of cannabis consumed at that time. They cited data from an analysis of cannabis samples tested at that time in California by an independent laboratory, which showed a THC content in the range of samples tested in the middle 1980s. They also argued that the Potency Monitoring Project samples from the 1970s underestimated THC potency because they were not properly stored, allowing their THC content to degrade.

More recent data from the Marijuana Potency Monitoring Project (ElSohly and Ross, 1999) have also failed to show a 10-30 fold increase in the THC content of more than 34,000 marijuana seizures analysed between 1984 and 1998. This series shows a small increase in THC content from 3.3% in 1980 to 4.4% in 1998 (see Figure 1). For all years except 1980 and 1981, greater than 82% of all confiscated samples tested consisted of leaves, flowering buds, stems and seeds, with the remainder comprising hashish and hash oil (ElSohly et al, 1998). Between 1989 and 1998, at least two thirds of all seizures had a THC content of 5% or less, with an average of only 3.9% of seizures containing more than 9% THC. While increases have occurred in the proportion of samples comprising 3%-9% THC, the bulk of seizures contain no more than 5% (ElSohly and Ross, 1999).

Figure 1: THC Content of US cannabis 1975-1998. (Source: ElSohly and Ross, 1999)



Has the THC content of cannabis plants increased in New Zealand?

The New Zealand (NZ) government has tested the THC content of cannabis samples over the past two decades. Although these have not been sampled in any systematic way they have not shown any sizeable increase in average THC content (Bedford, Environmental Science Research, Auckland, NZ, personal communication, June 1; Poulsen, Environmental Science Research, Wellington, NZ, personal communication, June 1) (see Table 1). No high THC strains of cannabis have been detected, although a network of crude hash oil laboratories has developed to extract cannabis oil from inferior quality leaf and stalk for the domestic market (Bedford, personal communication, June 1). The average potency of this hash oil has been around 13% since 1987 (Poulsen, personal communication, June 1).

There is no NZ evidence to support Australian media claims that hydroponically grown plants have a THC content of 25-30%. Samples of hydroponically grown cannabis tested in the NZ survey typically contained 6-8% THC, with an occasional sample with a higher THC content. A sample of hydroponic cannabis recently tested at the request of NZ police, for example, contained 11% THC (Poulsen, personal communication, June 1).

Table 1: Potency of Cannabis Plant seized by the Police from 1976-1996, New Zealand (Source: Poulsen, personal communication, June 1).

Year	*Number of samples*	*%THC*	
		Range	Average
Leaf			
Local			
1978-1982	18	0.3-4.2	1.6
1987-1989	72	0.3-3.9	1.1
1994-1996	59	0.2-3.8	1.0
Female Flowering Heads			
Imported			
1976-1982	21	0.5-7.5	3.8
Local			
1979-1982	11	1.3-9.7	3.6
1987-1989	68	0.7-9.2	3.3
1994-1996	110	1.0-8.8	3.4

Limitations of the Data

Data on trends in the average THC content of cannabis plants seized by police have their limitations. First, the basis for sampling cannabis seizures is rarely made explicit. It is presumably opportunistic and affected by police activities rather than being a random sample of the cannabis that is cultivated or consumed. This means that we cannot be sure how the THC content in tested samples is related to cannabis that is cultivated or consumed. If, for example, samples are selected for testing because of the suspicion that they contain unusually potent cannabis, then these data will over-estimate the typical THC content of cannabis.

Second, methods of testing THC are rarely made explicit and it is uncertain if testing of THC in Australia has been standardised between different laboratories. This is not a problem for the US Potency Testing program where the same laboratory conducted analyses of THC content over the two decades of the project.

Nonetheless, these data for all their imperfections provide a better basis for inferences about the THC content of cannabis plants than media reports of the results of individual samples tested by police. For reasons to be discussed in detail below, it would be unwise to rule out the possibility that there has been a modest increase in the average THC content of the cannabis that is consumed. Nonetheless, the available data make it very unlikely that there has been any increase in THC content of the order of 10 to 30 times, as has been claimed in the media. Any such increase would have been detected by the US Potency Monitoring Project and been apparent in the New Zealand testing data.

Why is it believed that the THC content of cannabis has increased?

A number of different factors probably explain the persistence of the belief that THC content has increased despite the absence of any supporting data.

First, defenders of the claim often point to reports of samples with unusually high THC content, usually single samples tested by the police. At best, such samples indicate the *maximum* THC content that has been achieved (assuming that there were no errors in the test results) but they do not tell us what the THC content is in the cannabis that is *typically* used by consumers. As argued above, these individual samples are likely to unrepresentative of cannabis that is consumed.

Second, any bias in the sampling of tested cannabis is amplified by the attention that the print and electronic media give to exceptional and surprising findings. If the media only report the results of samples that are suspected of being exceptionally potent, then a false impression is created that cannabis with exceptionally high THC is the norm.

Third, creeping claim inflation (like that which occurs in Chinese whispers) has amplified a possible 30% increase in THC content (as suggested by US data) to a 30-*fold* increase in some recent Australian media reports. In other media reports, the statistic has been misinterpreted to mean that cannabis now has an *average* THC content of 30%. Repetition of these assertions, without rebuttal, has established them as "facts" that "everyone knows". Sceptics who contest these claims are asked to prove that they are false rather than the (usually nameless) proponents being asked to provide evidence that they are true.

Fourth, as noted previously, an increase in average THC content seems to be a plausible explanation for an apparent increase in the number of cannabis users who experience problems as a consequence of their use (e.g. Sutherland and St George Shire Leader, 17 August 1995). However, there are two more plausible alternative explanations of this apparent trend: changing cannabis markets have increased the availability of more potent *forms* of cannabis; and there have been changes in the patterns of cannabis use among Australian cannabis users that increase the prevalence of harmful use. Each of these is discussed below.

Changing Cannabis Markets

The THC content of cannabis varies between different cannabis products. Cannabis leaf contains the least THC and the flowering "heads" or bracts contain the highest amount of THC (see Hall et al, 1994; WHO, 1997). Cannabis resin harvested from the flowering heads and compressed into hash is one of the most potent forms of cannabis (see Hall and Solowij, 1998). Leaf, heads and hash have been available in Australia for several decades (Senate Select Committee on Drug Trafficking and Drug Abuse, 1971). So too have reportedly potent strains of marijuana. For example, the Mullumbimby and the Byron Bay districts of northern NSW had a reputation for cultivating high potency cannabis products known as "Mullumbimby madness" as early as 1981 (Brouwer, 1981).

Over the past two decades a large-scale illicit cannabis industry has developed in Australia (Queensland Advisory Committee on Illicit Drugs, 1993) to meet the demand for cannabis products among a growing number of cannabis users. Regular cannabis users who smoked cannabis at least weekly were estimated to comprise 45% of those who had used cannabis in the past year in 1991 (Queensland Advisory Committee on Illicit Drugs, 1993). For each survey in the 1988-1995 National Household Survey series, one third of those who had used cannabis in the last 12 months reported doing so at least once a week. Among 14-19 year olds, this was more pronounced, with an apparent increase in regular use across the survey series (Makkai and McAllister, 1997). Studies of regular users indicate they generally prefer to use the more potent forms of cannabis, such as, the heads of the plant (Reilly et al, 1998; Swift et al, 1998), probably because they develop tolerance to the effects of less potent cannabis. Using the Queensland Advisory Committee on Illicit Drugs data, it can be estimated that daily and weekly cannabis users account for 80% of all the cannabis that is consumed.

Given the dominance of regular cannabis users in the cannabis market, it is a reasonable hypothesis that there has been an increased demand for and increased availability of products that are known to contain higher concentrations of THC (e.g., the heads as opposed to leaf). Indeed, a recent study of Western Australian cannabis users convicted of minor cannabis offences reported that they would not buy leaf, with only 4 out of 51 users who had purchased cannabis in the last 12 months having bought this form of the plant. Likewise, dealers rarely sold leaf, believed that it was virtually worthless, and gave it away or destroyed it. Most buyers (>90%) reported purchasing heads and “high potency” cannabis such as “skunk” and hydroponically grown cannabis (Lenton, Bennett and Heale, 1999). If, as seems likely, the illicit market has expanded production of these preparations, then "heads" and hash would become more readily available to all cannabis users. Any increase in the availability of these cannabis products would have increased the amount of THC consumed by heavier cannabis users without there having been any increase in the average THC content of cannabis *plants*.

It is also a plausible hypothesis that the supply of more potent cannabis products has been encouraged by the success of domestic law enforcement in detecting and destroying large-scale cannabis plantations by operations from the air and satellite surveillance. This success may have created an incentive for illicit suppliers of cannabis to grow small numbers of cannabis plants capable of supplying high THC products. This can be done in metropolitan areas by indoor hydroponic cultivation of female plants that produce the most resin (Australian Bureau of Criminal Intelligence, 1997). There are indications that domestic production is increasingly focussing on indoor hydroponic cultivation (Australian Bureau of Criminal Intelligence, 1999). In rural areas, small numbers of female plants may be grown in remote locations (e.g. state forests or in fields of corn) that are difficult for police (and others) to detect (Australian Bureau of Criminal Intelligence, 1997). However, it remains to be discovered how much the selective breeding of high THC yielding cultivars of *cannabis sativa* has contributed to any increase in the THC content of widely consumed cannabis products.

While there is no evidence that the THC content of cannabis *plants* in Australia has increased by 10-30 times, there is evidence that cannabis users currently consume the more potent *products* of the plant. In addition to the previously cited preference for the more potent cannabis preparations among regular users, 1995 and 1998 population-based National Drug Strategy household surveys report a preference for the flowering "heads" (see below). Regular Australian cannabis users (surveyed as part of the Illicit Drug Reporting System) have rated the potency of cannabis as "high", with no significant change in this rating between 1997 and 1998 (Hando et al, 1997; McKetin et al, 1999).

Changing Patterns of Cannabis Use

The media preoccupation with the THC content of cannabis has distracted attention from other causes for concern about changing patterns of cannabis use among Australian adolescents and young adults. These patterns of cannabis use, which may encourage younger users to use more potent forms of cannabis, may also increase their chances of developing problems as a consequence of their cannabis use.

Survey data suggest that in the 1990s young Australians have probably initiated cannabis use at an earlier age than was the case in the 1980s (see Lynskey and Hall, 1998). The lifetime prevalence of cannabis use in Australia and the United States, particularly among adolescents, has increased, after a decline in the 1980s and early 1990s (Johnston, O'Malley and Bachman, 1997; Lynskey and Hall, 1998; Makkai and McAllister, 1997; National Institute on Drug Abuse, 1996). This was particularly marked among female adolescents interviewed in the 1998 Australian National Drug Strategy Household Survey. While the prevalence of lifetime and recent use remained unchanged from the 1995 survey for 14-19 year old males (approximately 44% and 35% respectively), among females the lifetime prevalence increased from 24% in 1995 to 45% in 1998, and the proportion who had used in the last 12 months increased from 20% to 34% (Australian Institute of Health and Welfare, 1999).

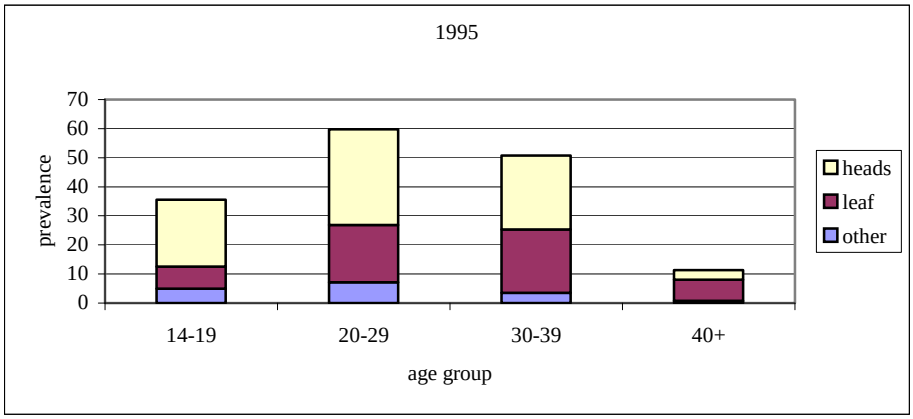
There are only limited data directly addressing age of initiation of cannabis use in Australia, as the question has only recently been incorporated into the Household Survey. An examination of "novice" users in the 1995 and 1998 National Drug Strategy Household Surveys has revealed a slight decrease in age of initiation between 1995 and 1998. Among cannabis users under 30 years of age, who had commenced cannabis use in the last 3 years, there was a slight drop in the age that use commenced, from a mean of 17.3 years in 1995 to 16.7 years in the 1998 survey (Paul Williams, Australian Institute of Health and Welfare, personal communication, June 23).

Earlier initiation of cannabis use increases the chances that these users will become daily or nearly daily cannabis users (e.g., Fergusson and Horwood, 1997; Kandel and Davies, 1992; Kaplan et al, 1986). This, in turn, makes it more likely that these young users will become dependent on cannabis and experience adverse personal and social consequences as a result of their use (Fergusson and Horwood, 1997; Hall et al, 1994; Lynskey and Hall, 1998). Levels of consumption among a minority of adolescent cannabis users can be very high. For example, 40% of a sample of NSW juvenile offenders reported smoking 40 or more "cones" of cannabis a week (Salmelainen, 1995). The risks of this

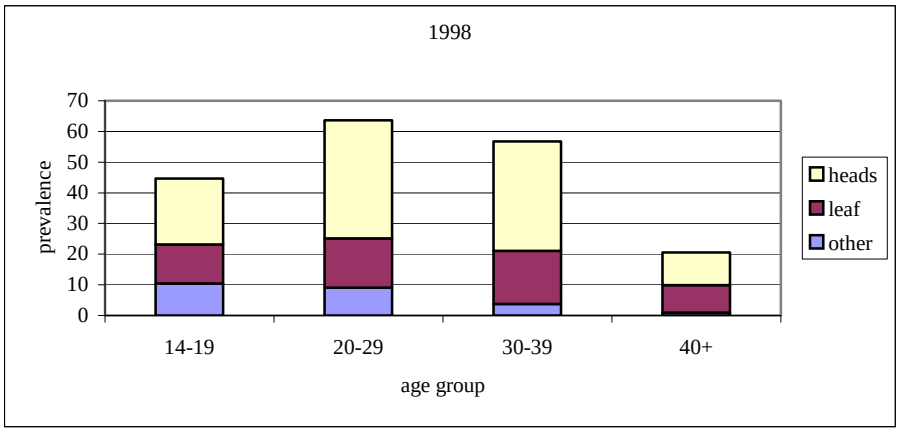
level of cannabis consumption are of a much higher order of magnitude to that of young adults in their early 20s who occasionally share a “joint” with friends in a social setting.

Regular cannabis use makes users tolerant to the effects of THC (Compton et al, 1990; Hall et al, 1994) and encourages them to use more potent cannabis preparations, such as, “heads” and hash (Swift et al, 1998). The greater expense of cannabis heads also encourages regular users to smoke them in waterpipes or "bongs" in the belief that this maximises the delivery of THC and minimises waste via sidestream smoke from joints.

Figure 1a: Type of cannabis most commonly smoked, by age, for 1995 and 1998 National Household Surveys.



Source: Makkai and McAllister (1997)

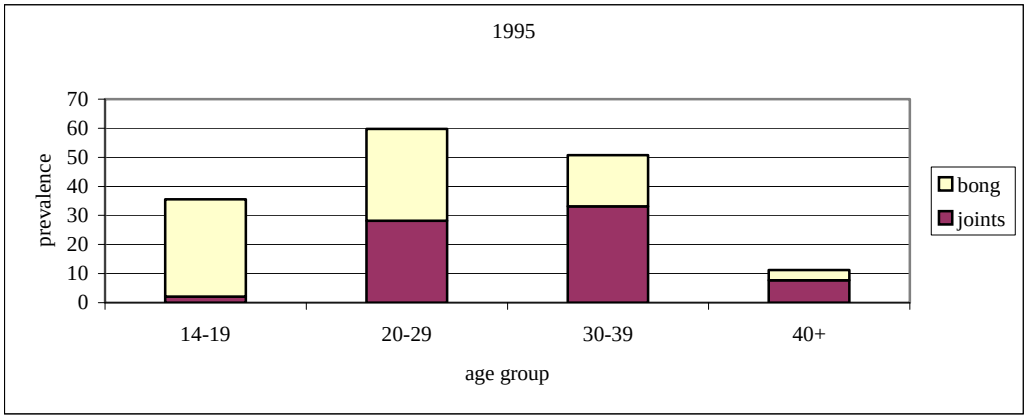


Source: Paul Williams, Australian Institute of Health and Welfare, personal communication, June 29
NB: “Other”: includes skunk, resin, oil, and other forms – almost 20% of those under 20 years reported skunk use in 1998. As it is not known how accurately users are able to identify skunk, a more conservative estimate would be to reclassify skunk (plus resin and oil) as heads – i.e., a more potent form than leaf.

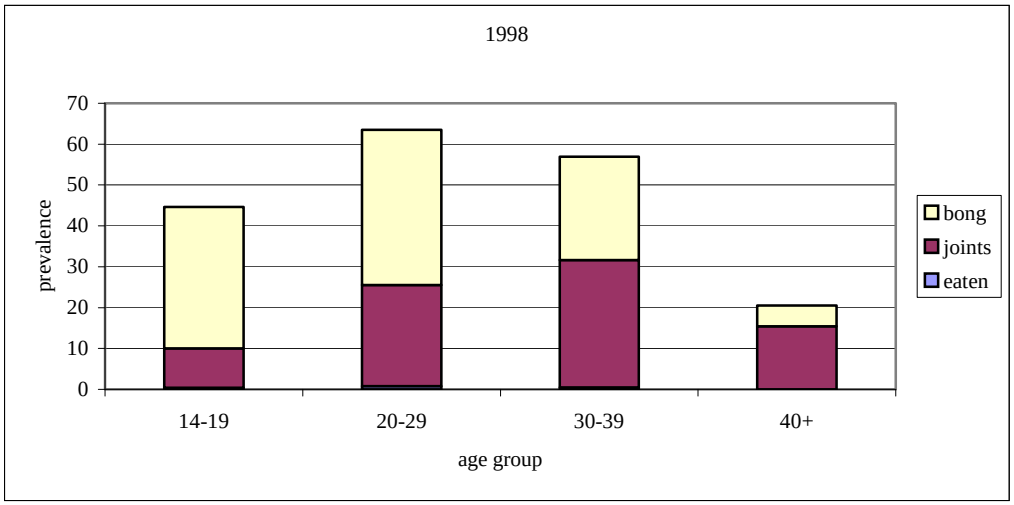
The substantial prevalence of “bong” use among younger users is shown in data from the National Drug Strategy Household Surveys in 1995 (Makkai and McAllister, 1997) and 1998 (Paul Williams, Australian Institute of Health and Welfare, personal communication, June 29). In both surveys, just over half of all users who had used in the

last year typically smoked bongs (54% in 1995 and 56% in 1998). They also preferred the more potent heads of the cannabis plant to leaf (54% in 1995 and 57% in 1998). In both surveys, younger users were more likely than older users to prefer bongs or pipes to joints (see Figures 1b). Younger users also preferred heads to leaf, with the trend reversed in older users (Figure 1a).

Figure 1b: Route of cannabis use most commonly reported, by age, for 1995 and 1998 National Household Surveys.



Source: Makkai and McAllister (1997).



Source: Paul Williams, Australian Institute of Health and Welfare, personal communication, June 29.

All these changes in patterns of use – earlier initiation of cannabis use, greater use of more potent cannabis products such as heads, and possibly the use of waterpipes – have probably played a greater role in increasing the amount of THC consumed by regular cannabis users than any increases in the *average* THC content of cannabis plants. And it is these patterns of use that may explain any increases in numbers of adolescents and young adults reportedly experiencing problems with their cannabis use.

What are the health implications of any increase in THC content?

As mentioned above, a major concern raised by those who have claimed that the THC content of cannabis has increased is that this will increase the adverse health and psychological risks of cannabis use (Malouf, 1999; Walters, 1993). These risks are summarised in Appendix 1 (see Hall and Solowij, 1998; Kalant et al, 1999; WHO, 1997 for more details).

Proponents of the claim that THC content has increased regard it as self-evident that any increase in THC content will increase the adverse health effects of cannabis use. Their critics have countered that increased THC potency may have little or no adverse effect because users are able to adjust or "titrate" their dose of THC to achieve the desired state of intoxication (e.g. Mikuyira and Aldrich, 1988; Zimmer and Morgan, 1997). If users were able to titrate their dose of THC, as tobacco smokers do with nicotine (Heming et al, 1981), then the use of more potent cannabis products would reduce the amount of cannabis material that was smoked. This would marginally reduce the risks of developing respiratory diseases, the most likely adverse health effect of regular cannabis smoking (Zimmer and Morgan, 1997).

There is very little research on whether cannabis users are able to titrate their dose of THC by modifying the amount of smoke that they inhale. Some earlier studies suggested that they could (Perez-Reyes et al, 1982) but more recent studies report that cannabis users have limited ability to titrate their dose of THC by varying their smoking technique (e.g. Wu et al, 1988; Matthias et al, 1997). These studies used a limited range of THC potency so the issue has not yet been resolved.

If users do not titrate their dose of THC, the effect of using more potent cannabis products is still uncertain. It is nonetheless a plausible hypothesis that the effects of using more potent cannabis will depend upon the type of health effect in question, and the user's experience with cannabis. Higher average doses of THC will probably increase the risk of adverse psychological effects of cannabis use (such as anxiety and panic attacks, and possibly psychotic symptoms); this would probably be most obvious among naive or first time cannabis users (Hall et al, 1994; Hall and Solowij, 1998). This experience might then discourage further experimentation with the drug among these users (Hall et al, 1994).

Among regular cannabis users, an increased average dose of THC may possibly increase the risks of accidents among those who drive while intoxicated, especially if cannabis use is combined with alcohol (Hall et al, 1994; Smiley, 1999). Research to date has not confirmed that the use of cannabis alone impairs on-road driving or increases the risks of motor vehicle accidents (Smiley, 1999) However, the use of much higher doses of THC may change this risk. In the absence of data, this is clearly a research priority. The use of more potent cannabis products may possibly increase the risk of regular cannabis users developing dependence by increasing rates of regular intoxication and use (Hall and Solowij, 1998). Regular use of higher potency cannabis products by persons with schizophrenia may also exacerbate their illness (Hall, 1998a).

Implications

All things considered, the Australian and overseas evidence does not support claims that the average potency of cannabis in Australia has increased by 10 to 30 times in recent decades. In the absence of regular testing of the THC content of cannabis products in Australia, we do not know whether it has increased, and if so, by how much. Data from the USA and New Zealand suggests that the most plausible hypothesis is that the THC content of the most widely used cannabis products may have increased modestly.

Two more important changes have probably been an increase in the availability of more potent forms of cannabis and the increased use of these more potent forms by regular cannabis users. These trends have been encouraged by a rising prevalence of cannabis use among young people, earlier initiation of use, and higher rates of regular use by adolescents and young adults. Law enforcement efforts to reduce large-scale cannabis plantations may also have played a contributory role, although this is less certain.

If the THC content of the most commonly used cannabis products has increased in Australia, the net adverse effects of cannabis use may have marginally increased. Some adverse effects may well have increased, such as adverse psychological experiences of cannabis use. More conjecturally, there may have been an increase in the risks of cannabis dependence among regular users, accidents, and exacerbation of the symptoms of schizophrenia among younger users. Respiratory risks may be marginally decreased if cannabis smokers are able to titrate their doses of THC.

Implications for Research

Given public concern about an alleged increase in the THC content of cannabis, it is desirable to have better evidence on this issue. Unsubstantiated assertions in the media are a poor basis for public policy in this, or in any other areas of public concern. The following are some priorities for research.

A first priority should be to analyse data on the THC content of samples of cannabis consumed by regular users. This could include analyses of seizures, as is done in the USA. It should also include "buy busts" that have been used in studies of heroin purity (e.g. Weatherburn and Lind, 1997) to provide better information on cannabis at street level. Some systematic method of sampling should be used to ensure that it was not only the exceptionally potent samples of cannabis that were tested. This need not be done on the scale of the US Monitoring Potency Project to be useful. Annual sampling of as few as 100 to 200 samples of cannabis products would provide useful indications of any major changes in THC content.

A second priority should be a study of the extent to which regular cannabis users are able to titrate their dose of THC. The assumed capacity of users to do so is used by some to discount concerns about any increase in the potency of cannabis (e.g. Zimmer and Morgan, 1997). If users perform this task poorly, then this information needs to be given to users and potential users.

Implications for Policy

If the public is concerned about the THC content of cannabis products, one strategy worth considering is to impose higher penalties for the cultivation and sale of cannabis products with a THC content above some statutory level. In this way, there would be incentives for illicit manufacturers to supply the less potent forms of cannabis products. The feasibility, cost and practicality of implementing this option would need to be evaluated. So too would the specification of a statutory level of THC. A simpler option may be to impose more serious penalties for dealing in specified quantities of "heads" and hash.

Implications for Health Education

A more contentious issue is the type of health education advice that should be given to young people about the health risks of using more potent forms of cannabis. There is a danger that the debate about the magnitude of any increase in the average THC content of Australian cannabis will distract attention away from the probable risks of current patterns of cannabis use in Australia. We need not wait for data on THC content to educate young people about: the risks of early initiation of cannabis (and other licit and illicit drug use); the greater potential for dependence if they use more potent forms of cannabis; and the respiratory risks of smoking cannabis in bongs (Hall, 1998b).

Conclusions

In the absence of data it is difficult to estimate how much the average THC content has increased in cannabis plants, or in the cannabis consumed by Australian users. However, there is no evidence that the THC content of cannabis has increased in the USA or New Zealand by 10-30 fold. The very limited Australian data is similar to that in the USA and New Zealand in showing a modest increase at most in the average THC content of cannabis products.

An increase in the amount of THC consumed by Australian cannabis users may have resulted from an increased availability of more potent cannabis products and their more widespread use by regular cannabis users. It is uncertain how much THC content may have increased by improved methods of cultivating high THC yielding cultivars of *cannabis sativa*. Policy responses to any increase in the THC content of cannabis would be better informed if data were collected on the THC content of Australian cannabis products.

The health consequences of any increase in THC content are less certain. Among naive users, higher THC content may increase adverse psychological effects, thereby discouraging some from continuing to use. Among persons who continue to use cannabis, a higher THC content may possibly increase the risks of dependence, accidents if driving while intoxicated, and of psychotic symptoms among persons with psychotic illnesses. If experienced users are able to titrate their dose of THC, the respiratory risks of cannabis smoking may be marginally reduced.

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APPENDIX 1: Adverse Health Effects of Cannabis Use (Hall and Solowij, 1998)

Acute Effects:

anxiety and panic, especially in naive users;

impaired attention and memory and psychomotor performance while intoxicated;

possibly an increased risk of accident if a person drives a motor vehicle while intoxicated with cannabis, especially if cannabis is used in combination with alcohol;

an increased risk of psychotic symptoms among those who are vulnerable because of personal or family history of psychosis.

Chronic Effects remain uncertain but the most ***probable*** are:

chronic bronchitis and histopathological changes that may be precursors to the development of malignancy caused by smoking cannabis;

a cannabis dependence syndrome characterised by an inability to abstain from or to control cannabis use;.

subtle impairments of attention and memory that persist while the user remains chronically intoxicated, and that may or may not be reversible after prolonged abstinence.

Among ***possible*** adverse effects that remain to be confirmed are:

an increased risk of: cancers of the oral cavity, pharynx, and oesophagus; leukemia among offspring exposed while *in utero*;

impaired educational attainment in adolescents and under-achievement in adults in occupations requiring high level cognitive skills.

Groups at higher risk of experiencing these adverse effects include:

adolescents with a history of poor school performance, who initiate cannabis use in the early teens, are at increased risk of using other illicit drugs and of becoming dependent on cannabis;

women who continue to smoke cannabis during pregnancy may increase their risk of having a low birth weight baby;

persons with asthma, bronchitis, emphysema, schizophrenia, and alcohol and other drug dependence, whose illnesses may be exacerbated by cannabis use.