Epidemiology of Adolescent Marijuana Use and Its Impact on Cognition and Education

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Executive Summary

Our review of research data finds (a) that youth are uniquely vulnerable to marijuana’s negative cognitive effects, (b) that lifetime statistics exaggerate the true risks for sustained addiction, because there is an age-related “maturing out” phenomenon of reduced or eliminated use during one's 20’s and 30’s, but (c) that heavy marijuana use is closely associated with lowered academic performance and school leaving (although the causal mechanisms are still uncertain).

We recommend an expansion of focus from addiction risks to education risks. The negative cognitive impact in regular and heavy users is associated with significant academic risks, lowered school performance and poor school retention. This negative impact on learning during one’s prime school years may have long-lasting consequences in life. We argue that focusing tax revenues on academic remediation and on school retention should be highest priority for investment of marijuana tax revenues.

Drug Use Surveys: Results from the 2013 National Survey on Drug Use and Health (NSDUH) [1] found that marijuana was the most commonly used illicit drug, with 19.8 million current users aged 12 or older (7.5%). There were 2.2 million adolescents aged 12 to 17 who were current illicit drug users (8.8% of adolescents); and, 7.1% of adolescents were current users of marijuana. Nationally, about half (48.6%) of youths aged 12 to 17 reported that it would be "fairly easy" or "very easy" for them to obtain marijuana. The 2011-2013 California Healthy Kids Survey [2] found that 73% of California’s 11th graders say marijuana is "fairly" or "very easy" to obtain.

Two other large national studies provide data on adolescent marijuana use: Monitoring the Future (MTF) and the Youth Risk Behavior Survey (YRBS). Their data from 1971-2013 is compared in the graphic at right.

Daily use is often considered a proxy for drug dependence and past month use a proxy for regular use. In debates about cannabis regulation, youth risks of marijuana use are generally expressed as lifetime risks for dependence, a metric that unfortunately takes no account of a change in use pattern or remission of the diagnosis.
Since 1975, the Monitoring the Future Study (MTF) has measured drug, alcohol, and cigarette use and related attitudes among adolescent students nationwide [4]. Overall, 41,675 students from 389 public and private schools participated in the 2014 study. The survey is funded by the NIDA, a component of the National Institutes of Health (NIH), and conducted by the University of Michigan.

**Teen Patterns of Drug Use:** Monitoring the Future has found that >80% of 12th graders say marijuana is "fairly" or "very easy" to obtain. Marijuana is now, by far, the most prevalent abusable drug used by teens.

Decades of anti-smoking campaigns have dramatically reduced cigarette consumption in America; and, since 2009 more high school seniors smoke marijuana (21.2%) than smoke cigarettes (13.6%). This is surely related to their growing perception that marijuana is the safer drug.
Hard vs. Soft Drugs: Unlike Europe, America’s War on Drugs has made no meaningful distinctions between hard and soft drugs, nor carefully parsed the harms of diverse drugs to self versus harms to society. This lumping of harms is one reason why harm reduction strategies have faced great political and regulatory opposition in the U.S.

Drug abuse expert panels in the U.K., the Netherlands, and Scotland have published opinions about relative harms of commonly abused drugs [5-8], and, their ratings placed marijuana/cannabis in the mid to low ranges of both kinds of harms, generally falling below opiates, stimulants, alcohol, and tobacco. The Dutch and other Europeans explicitly consider cannabis to be a “soft” drug, and state regulatory controls seek to separate the soft and hard drug markets from each other.

Lachenmeier & Rehm [9] recently reviewed fatal toxicology data of illicit drugs in order to seek less subjective data than expert reports. Their analysis emphasizes a new “Margin of Exposure” (MOE) approach to assessments of relative risk. “Despite these early efforts for toxicology-based risk assessments, the most common methods are still based on expert panel rankings on harm indicators such as acute and chronic toxicity, addictive potency and social harm, e.g. the approaches of Nutt et al. [5] in the UK and of van Amsterdam et al. [7] in the Netherlands [9].”

Our MOE results confirm previous drug rankings based on other approaches. Specifically, the results confirm that the risk of cannabis may have been overestimated in the past. At least for the endpoint of mortality, the MOE for THC/cannabis in both individual and population-based assessments would be above safety thresholds for data based on animal experiments. In contrast, the risk of alcohol may have been commonly underestimated.

A main finding of our study is the qualitative validation of previous expert-based approaches on drug-ranking (e.g. Nutt et al. [5]), especially in regard to the positions of alcohol (highest) and cannabis (lowest). Currently, the MOE results must be treated as preliminary due to the high uncertainty in data. The analyses may be refined when better dose-response data and exposure estimates become available. The high MOE values of cannabis, which are in a low-risk range, suggest a strict legal regulatory approach rather than the current prohibition approach. [9]
**Lifetime vs. Current Dependence:** In the U.S. the most commonly quoted figure for the percentage of individuals who have used marijuana and have developed dependence at some point in time is 9%. It is based on data from the National Comorbidity Study conducted in the early 1990s [10-12]. The National Institute on Drug Abuse (NIDA) states that 1 in 6 (about 17%) of those who start in early teen years become dependent at some time [13, 14].

However, marijuana dependence is not invariably a lifelong illness. Lifetime rates can be misleading and often contribute to exaggeration of harms. Lifetime rates do not reflect actual prevalence in the population at a particular time, the age of greatest risk, the rapidity of dependence, the duration, or pathways out of regular use. Lifetime dependence rates do not reflect the number of users for whom dependence was only a passing phase. For example, among those who begin use at age 13, 28% have been dependent at some point by age 18; 33% by age 21; and 43% by age 30. However, only 14% of those who started use at 13 are still dependent at age 30 (Horwood, personal communication July 2014, based on Christchurch Health and Development Study data).

The majority of heavy marijuana users pass through a phase of problem use before becoming non-addicted periodic users or nonusers. (By analogy, a majority of adolescents may suffer from acne (high lifetime incidence), but only a minority (low point prevalence) has it through adulthood. Although this “maturing out” phenomenon is statistically reassuring, it does not diminish the repeatedly established fact that onset of use in adolescence produces greater risks for an early episode of cannabis dependence. In addition, the often overlooked risks are age-sensitive for academic impairment [15], criminal justice entanglement (see separate Blue Ribbon Commission briefing on legal harms), and school dropout [16] during key education years.

**Early Onset Increases Risks:** It is clear that the earlier an individual begins using marijuana the more likely dependence will occur quickly [17]. Individuals who delay onset of marijuana use after age 21 show a remarkably low rate (0.5%) of dependence within the first two years of their use.

<table>
<thead>
<tr>
<th>Onset of Marijuana Use [17]</th>
<th>Age 11-13</th>
<th>Age 14-15</th>
<th>Age 16-17</th>
<th>Age 18-20</th>
<th>Age 21 &amp; Older</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent Active Users</td>
<td>21.3%</td>
<td>27.1%</td>
<td>23.8%</td>
<td>16.0%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Dependent within 2 years</td>
<td>5.4%</td>
<td>6.0%</td>
<td>4.4%</td>
<td>1.9%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Although dependence rates start to drop at 16-17 years of age, the Monitoring the Future Study and California Healthy Kids Survey find higher rates of use (not necessarily dependence) in 12th graders than in younger grades. This suggests gradually increasing levels of recreational use in high school.

**Marijuana Cessation:** Unlike hard drugs and alcohol, dependence on marijuana does not appear to be a lifelong condition for the majority of users. Cessation of marijuana use is actually the norm. Seventy-four percent of those who have used marijuana at least ten times have stopped use by age 32 [17-19]. Those who started using early, who use illicit drugs other than marijuana and who use marijuana to cope or change their mood are more likely
to continue their use. Those who become parents, have a non-using partner or use marijuana for social reasons stop earlier [18, 19]. The 1972 Commission on Marijuana and Drug Abuse in the USA [20] reported that 61% of those who had stopped using marijuana cited a simple loss of interest in the drug.

The best studies for assessing marijuana risks over time are prospective cohort studies beginning in youth and continuing through adulthood [21-32]. A particularly well-studied cohort is enrolled in the Christchurch Health and Development Study (CHDS). CHDS follows 691 New Zealand youth from birth to age 38. Those who start marijuana use at 18 have a cumulative 5% lifetime prevalence by age 21 and 10% by age 30. However, only 3-5% of those who started at 18 are still dependent at 30 [Horwood, personal communication, July 2014]. Lifetime prevalence rates generally peak around age 25, and range from around 43% for those with an age of onset of 13 years down to around 5-10% for those with an onset after age 18.
Twelve-month prevalence rates are a more clinically meaningful metric of long-term outcomes. In Horwood’s cohort, those with an earlier age onset of cannabis use had higher lifetime rates of cannabis dependence at any subsequent assessment age, and were more likely to show current cannabis dependence (as reflected in the past 12 month prevalence rates). Again, there is increased risk with earlier age of onset.

Farmer et al. (2015) recently published a prospective study from the Oregon Depression Project in which teens were given four assessments between ages 16 and 30 [32]. The initial cohort was 1,709 adolescents, and 816 had a prior history of substance abuse or a psychiatric diagnosis. Cannabis abuse and dependence were combined and analyzed as cannabis use disorder (CUD). The lifetime prevalence was 19.1%, with an average age of onset of 18.6 years. Among those diagnosed as showing CUD, 81.8% had achieved at least a year of recovery by age 30. The mean duration of the initial CUD episode was three years (35.6 months). Recurrence occurred in 27.7%. Among those with a second episode of CUD, the mean time to recurrence was 46.1 months. The authors conclude that, “About 30% of those with a CUD exhibit a generally persistent pattern of problematic use extending 7 years or longer,” and it is apparent that a majority of individuals, especially women, who develop CUDs during the developmental periods studied recovered by the age of 30 years. Rather than a chronic and relapsing condition, CUDs for many appear to be developmentally limited (see also Flory et al. 2004; Windle & Wiesner, 2004; Lynskey et al. 2006). [32]

Transitions to Dependence: Two studies of adults 18 and older by Lopez-Quintero used the extensive data of the National Epidemiological Survey on Alcohol and Related Conditions (NESARC) conducted by the National Institute of Alcohol Abuse and Alcoholism (43,000 interviews in 2001-2002) and resurveyed in 2004-2005). After the first year of cannabis use onset, the probability of transition to dependence was under 2.0%. The probability estimates of transition to dependence a decade after use onset was 5.9%. Lifetime cumulative probability estimates indicated that 8.9% of cannabis users would become dependent on those substances at some time in their life [33].

The figure at right illustrates the cumulative probability of transitioning to dependence on nicotine, alcohol, cannabis and cocaine among users of these substances. The risks are manifestly higher for nicotine (the highest of all), alcohol, and cocaine. Among those who met criteria for cannabis dependence at some point in their life (n=530), the cumulative probability of remission within the first year of dependence onset was 4.7%. The cumulative probability of remission a decade after onset of dependence was 66.2%. Lifetime cumulative probability estimates of dependence remission were 97.2% for cannabis, proving that dependence on marijuana is
not an inevitably progressive life-long condition [34]. Psychiatric comorbidity predicted a higher rate of transition to dependence and a lower rate of remission.

A more useful concept than lifetime dependence is “heavy use”, 20 or more days per month. National Household Survey Data in 2000 estimated that 1.6% of lifetime marijuana users qualified as heavy users. Heavy use was concentrated among younger users: 3% of those 12-17 years old, 4% for ages 18-25 and down to 1% for 26+ [SAMHSA 2001]. This closely approximates Horwood’s data showing that meeting criteria for cannabis dependence is often a transient state that coincides with a period of heavy/regular/chronic cannabis use. However, there remains a small minority (3-5% of our cohort) who adopt chronic cannabis use as a lifestyle choice and who will remain heavy users throughout their lives. [Horwood, personal communication, July 2014]

California Schools Data: The biennial California Healthy Kids Survey (CHKS) asks school kids many questions about drug use and perceived risks. It can be seen in the table at right that in 2011-2013, slightly more students abstained from marijuana (76%) than alcohol (67%).

However, it was notable that 8% of 11th graders use marijuana 20 or more days each month—thus qualifying as heavy users [2].

During the past 30 days, on how many days did you use alcohol...marijuana?

<table>
<thead>
<tr>
<th>CHKS 2011-13</th>
<th>Grade 7</th>
<th>Grade 9</th>
<th>Grade 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>93%</td>
<td>85%</td>
<td>76%</td>
</tr>
<tr>
<td>1-2 Days</td>
<td>3%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>3-9 Days</td>
<td>1%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>10-19 Days</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>20 or more</td>
<td>1%</td>
<td>4%</td>
<td>8%</td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>89%</td>
<td>80%</td>
<td>67%</td>
</tr>
<tr>
<td>1-2 Days</td>
<td>8%</td>
<td>12%</td>
<td>17%</td>
</tr>
<tr>
<td>3-9 Days</td>
<td>2%</td>
<td>4%</td>
<td>10%</td>
</tr>
<tr>
<td>10-19 Days</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>20 or more</td>
<td>1%</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

From Table A4.4, 14th Biennial California Healthy Kids Survey (CHKS), 2011-13

If we conservatively extrapolate frequency of use from the California Healthy Kids Survey 2011-13 to the expected high school enrollment for 2015-2016, we create the table on the following page to estimate the numbers of California students who are likely to be regular marijuana users (10-19 days each month) and heavy users (20 or more days each month) in the coming year. These numbers are quite substantial already.

We estimate that 131,000 California high school students are already heavy users and an additional 49,000 are regular users before any new legalization or regulation initiative has been implemented.
California school data make it clear that high school students already find marijuana easy to obtain and that a substantial number of them are already regular or heavy users. Although it seems intuitively likely that legalization will increase access simply through increased supply, it is not clear whether this will significantly increase the numbers of youthful regular and heavy users in California. Arguably, it may be more likely to increase the numbers of occasional users, and increase the proportion of adolescents with some experimental exposure to marijuana.

We estimate that approximately 180,000 students would be considered regular users (10-19 days per month) or heavy users (20 or more days per month). Heavy use in 8% of upper level students is particularly likely to be associated with significant academic impact—irrespective of whether criteria for cannabis dependence have been met. It is to this costly social/educational impact that we now turn our attention.

Special attention needs to be paid to high-risk youth who leave the educational system before completing high school. Continuation schools in California designed to re-engage out-of-school youth serve about 4% of the state’s high school students, disproportionately serving low-income and minority youth. The California Healthy Kids Survey (CHKS) in 2007 found a “sharply higher prevalence of high-risk behaviors” among the 25,600 11th graders in alternative continuation than in regular high school juniors [35]. Their daily marijuana use was about five times higher in 11th graders.

### Estimated Monthly Marijuana Use in California High Schools (2015-16)

<table>
<thead>
<tr>
<th>California High School Marijuana Use</th>
<th>Grade 9</th>
<th>Grade 10</th>
<th>Grade 11</th>
<th>Grade 12</th>
<th>Graduates</th>
<th>Total Gr. 9-12:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Enrollment 2015-16</td>
<td>496,021</td>
<td>489,532</td>
<td>470,944</td>
<td>489,939</td>
<td>416,058</td>
<td>1,946,436</td>
</tr>
<tr>
<td>Marijuana Use per month</td>
<td>CHKS</td>
<td>Estimate</td>
<td>CHKS</td>
<td>Estimate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent 3-9 Days</td>
<td>4%</td>
<td>4%</td>
<td>5%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number 3-9 Days</td>
<td>19,841</td>
<td>19,581</td>
<td>23,547</td>
<td>24,497</td>
<td></td>
<td>87,466</td>
</tr>
<tr>
<td>Percent 10-19 days</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
<td>3%</td>
<td></td>
<td>48,538</td>
</tr>
<tr>
<td>Number 10-19 days</td>
<td>9,920</td>
<td>9,791</td>
<td>14,128</td>
<td>14,698</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent 20 or more days</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
<td>9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number 20 or more days</td>
<td>19,841</td>
<td>29,372</td>
<td>37,676</td>
<td>44,095</td>
<td></td>
<td>130,983</td>
</tr>
</tbody>
</table>

Students using >3 days/mo. 266,987
Students using >10 days/mo. 179,520
Students using >20 days/mo. 130,983

Marijuana Use in Traditional and Non-Traditional California Schools (CHKS 2007)

<table>
<thead>
<tr>
<th></th>
<th>7th Grade</th>
<th>9th Grade</th>
<th>11th Grade</th>
<th>11th Non-Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifetime Use</td>
<td>07%</td>
<td>28%</td>
<td>49%</td>
<td>80%</td>
</tr>
<tr>
<td>Prior 30 Days</td>
<td>04%</td>
<td>16%</td>
<td>29%</td>
<td>57%</td>
</tr>
<tr>
<td>Daily Use</td>
<td>-</td>
<td>-</td>
<td>03%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Marijuana’s Impact on Cognition, Learning, and Education: [15, 16, 21, 26, 27, 36-48]

Youth often refer to chronic users as “potheads: or “dopers,” thus tacitly recognizing behavioral consequences of regular use. The maturation of the brain’s wiring system is not complete until one’s mid-twenties; and, cannabinoids interact in many poorly understood ways in the developing brain. The neuropsychological literature has established many kinds of measurable cognitive impairments in regular users and continued impairments for a month or more into abstinence. What remains unclear and in dispute is whether long-term impairments (such as IQ deficits) can be definitively attributed to heavy marijuana use.

The National Institute of Health (NIH) has begun a 10 year prospective Adolescent Brain and Cognitive Development (ABCD) study to answer many questions about adolescent neurodevelopment under the impact of marijuana and other drug use.

The research literature is clear that marijuana use is closely associated with poorer school performance and higher rates of school leaving, as illustrated by the California continuation school data presented above. However, because marijuana use, particularly in young people, is so subculture-bound, it is unclear whether youth who are doing poorly in school gravitate to smoking pot, or whether smoking pot helps to derail the attention, memory, and calculating abilities that are needed for school progress. (Briefing #3 explores research on the cognitive effects of marijuana in more detail.)

Brain Development: The brain undergoes rapid development throughout adolescence [49-51], permitting qualitatively higher levels of abstraction and learning. Excessive marijuana use during this critical phase of brain development has both physical [52-54] and cognitive impacts [40, 42-44, 46, 55].

Cognition: For young marijuana users a negative impact on memory, cognition and judgment [56] is likely to interfere with school learning and academic achievement. Heavy marijuana use during early adolescence affects important cognitive functions such as memory [37, 57, 58], calculation speed, and other executive functions [40, 47, 59, 60]. While adolescent marijuana users may score as well as nonusers on many cognitive tests, brain imaging suggests that they recruit more areas of the brain to accomplish the task, a sign of inefficient brain function [61]. These cognitive deficits can persist in adolescents for a month following abstinence [41, 62].

The IQ Controversy: Meier et al.’s frequently quoted longitudinal study (2012) undertaken in Dunedin, New Zealand followed over one thousand individuals born in 1972 for the next 38 years [44, 46]. Cognitive testing compared IQs at ages 13 and 38. Teen marijuana use lowered IQ by as much as 8 points for the earliest onset users. Scores on five subtests of executive functions were all diminished. Marijuana users who started after 18 showed no such decrements. These conclusions created spirited debate in the pages of Proceedings of the National Academy of Sciences (2013, vol 110) with some arguing that the effects could be better explained by social class factors [46, 63].

In 2014, a large U.K. study (The Avon Longitudinal Study of Parents and Children, based on data from 2,235 children born in the Bristol area in 1991 or 1992) tested IQ at age 8 and again at age 15 [64]. The researchers found that there was no relationship between cannabis use and lower IQ at age 15, but that heavier cannabis users (50 times or more by
age 15) showed marginally impaired educational abilities as manifested by 3% lower school exam results at age 16. Mokrysz, the lead researcher, commented that,

"People often believe that using cannabis can be very damaging to intellectual ability in the long-term, but it is extremely difficult to separate the direct effects of cannabis from other potential explanations. Adolescent cannabis use often goes hand in hand with other drug use, such as alcohol and cigarette smoking, as well as other risky lifestyle choices. It's hard to know what causes what--do kids do badly at school because they are smoking weed, or do they smoke weed because they’re doing badly? This study suggests it is not as simple as saying cannabis is the problem. This is a potentially important public health message--the belief that cannabis is particularly harmful may detract focus from and awareness of other potentially harmful behaviours. However the finding that heavier cannabis use is linked to marginally worse educational performance is important to note, warranting further investigation." [64]

Unfortunately, the *Avon Longitudinal Study* is not comparable to the Dunedin Study. Meier et al.’s finding was that adults with long-term dependence on cannabis starting during adolescence and continuing 4 or more times per week during the 20 years after adolescence had lost IQ points by age 38. Those who lost the most IQ points were those who had started their cannabis use youngest. There is no reason to expect that teens who have used cannabis only 50 times would already show a loss of IQ points by age 15. The ALSPAC study would need at least 20 more years of follow up, and data on cannabis dependence, before it could be compared to the Dunedin Study [personal communication with Madeline Meier, Feb 2015].

**Academic Performance:** Although it is well established that heavy marijuana use is associated with diverse cognitive deficits and inefficiencies, it is not yet firmly established whether cognitive effects, peer group effects, or other factors account for most of the diminished academic performance [65]. There is a current debate among researchers about whether poorer school performance and lowered academic achievement is caused by marijuana’s effects on brain functions, or by an affiliation effect from joining a drug using cohort that often disdains academics and normative culture, or by even earlier social class effects.

Lynskey and Hall (2000) reviewed the literature on cannabis effects on educational attainment [15]. Cannabis use was associated with lower grade point average, less satisfaction with school, negative attitudes to school, increased rates of absenteeism, and poor school performance. However they caution that, “results of cross-sectional studies cannot be used to determine whether cannabis use causes poor educational performance, poor educational performance is a cause of cannabis use or whether both outcomes are a reflection of common risk factors.” They favor the theory that the linkage between cannabis and poor performance is due to the social context in which cannabis is used.

Silins et al. (2014), writing in *Lancet Psychiatry*, combined individual-level data from three large, long-running longitudinal studies in Australia and New Zealand on up to 3,765 participants who used cannabis [66]. They wanted to learn more about frequency of cannabis use before age 17 and seven developmental outcomes (completing high school, obtaining a university degree, cannabis dependence, use of other illicit drugs, suicide attempt, depression, and welfare dependence) up to the age of 30 years. Daily users of cannabis before age 17 were over 60% less likely to complete high school or obtain a degree.
compared to those who have never used the drug. Daily users of cannabis during adolescence were seven times more likely to attempt suicide, have an 18 times greater chance of cannabis dependence, and were eight times more likely to use other illicit drugs in later life.

**School Retention:** Bray et al. (2000) found that marijuana initiation is positively related to dropping out of high school, calculating that marijuana users’ odds of dropping out were about 2.3 times that of non-users [67]. However, there are many factors at play in school dropout [65]. Poor academic performance may precede regular marijuana use, peer and affiliation factors may lead to dropout, as well as poverty and family factors. And there may be common third variables linking marijuana use and dropping out of school. We are sure of the association between marijuana use and school dropout; however, we cannot be sure that marijuana use is the causal factor.

Linskey et al. (2003) studied 1,601 students, ages 15-21, in Melbourne, Australia. Weekly cannabis use was associated with a significantly increased risk of leaving school [15, 16]. The effect was strongest in the young and diminished at older ages. They thought that cannabis use was one proxy for social context.

Fergusson et al. (2003) reported on a 25-year longitudinal study of a birth cohort of 1,265 New Zealand children. They found that,

> Young people who had used cannabis on more than 100 occasions had rates of leaving school without qualifications that were 5.8 times higher than those who had never used cannabis. Similarly, those who had never used cannabis were 3.3 times more likely to enter university and 4.5 times more likely to attain a university degree than those who had used cannabis on at least 100 occasion. [39]

Fergusson et al. concluded that, “The weight of the evidence from this study suggests a possible causal linkage between the early use of cannabis and increased risks of high school dropout among young people. Several lines of evidence support this conclusion. First, there is evidence of a consistent dose-response relationship between cannabis use and risks of leaving school without qualifications. Secondly, this association persists even following control for a wide range of prospectively assessed confounding factors [39].” They further concluded that these effects were more likely to be due to the social context of use rather than from a direct effect on cognitive ability or motivation.

Horwood et al. (2010) analyzed data from three Australian cohorts of over 6,000 participants [26]. They looked at high school completion, university enrollment, and degree attainment. Rates of attainment were highest for those who had not used cannabis by age 18, and lowest for those who had used before age 15. They calculated that early cannabis use may contribute up to 17% of the rate of failure to achieve academic milestones.

**Employment:** Hara et al. (2013) explored the relationship of marijuana use to employment in 7,661 individuals over a 17 year period [25]. They concluded that marijuana use was associated with lower workforce productivity at age 23. Heavy users) minimum of 5,000 times) are twice as likely as their families of origin to have a household income below $30,000 [68].
Preventive Resilience Factors: There is an emerging literature on risk factors and preventive (“resilience”) factors in adolescent development [21, 69]. Eassey et al. [70] found that “School attachment, parental disapproval of substance use, associating with non-using peers, and experiencing less peer pressure demonstrated protective effects on the frequency of marijuana use;” but that school attachment had a protective effect only on chronic users. Promotion of such resilience factors generally requires organized school collaborations and an emphasis on what has come to be known as school “climate [71].” Programs that seek to change school climate typically target drug use, bullying and other forms of violence, LGBT attitudes, and academic achievement. (Briefing #5 on Student Assistance Programs explores this topic in more detail.)

Conclusions:

One size does not fit all. Preventive messaging to youth will be insufficient to the challenge in an adult legalization environment. Public responses to marijuana-related risk factors in young people need to be stratified. The table below summarizes our recommendations for assessment and remediation.

<table>
<thead>
<tr>
<th>Key Findings:</th>
<th>Implications for Prevention/Mitigation</th>
</tr>
</thead>
</table>
| 1. Early onset (ages 13-16) of marijuana use is a significant risk factor. | a) Universal and selected prevention activities that seek to delay initiation of marijuana use.  
                                           b) Engagement of cohesive peer groups.  
                                           c) Family engagement for at-risk youth. |
| 2. Regular (10-19 days/mo.) and heavy users (more than 20 days/mo.) are more likely to show cognitive slippage than occasional users. | a) Indicated intervention by Student Assistance Programs (SAPs)  
                                           b) SAPs need to include cognitive and learning assessments.  
                                           c) SAP referral mechanisms for learning skills training and professional assistance for drug dependence. |
| 3. There will likely be 49,000 regular users (3%) and 130,000 heavy users (9%) in California high schools (2015-16), before any change in access or use attributable to a legalization initiative. | a) Evidence-based programs to improve school climate  
                                           b) Engagement methods for school disaffiliated kids. |
| 4. Regular and heavy users are more likely to skip school, drop out, and not proceed to further education. | a) Recovery support  
                                           b) Long-term outcome research needs to be funded by new marijuana tax revenues. |
| 5. Transitions out of marijuana use are common after high school, but are poorly studied. |                                                                                  |
Marijuana-related risks to public health are more concentrated in adolescents than in adults. While most public debate focuses on risks of addiction/dependence, the adolescent age-specific risks to cognition and educational progress are often neglected; and, we believe that these costs are more substantial and more problematic. Adolescents are best addressed at their workplace and among their peers; and, that is the school system.

It is increasingly well established that chronic marijuana use diminishes cognitive efficiency and has other measurable cognitive impacts. Negative impacts of cannabinoids on learning and educational progress are most significant during adolescence, the prime educational preparation years. Regular marijuana use is associated with impaired academic performance and school dropout. Although it is not clear whether the mechanisms are more related to cognitive slippage or to social/peer factors, it is clear that early marijuana use is a significant risk factor for slipping off the rails during one's prime education years.

Marijuana tax revenues would be well spent if a minimum of 15% were reserved for youth services, and preferentially allocated to school-based programs (such as Student Assistance Programs) that emphasize learning skills, remediation of academic performance, school climate, school retention, peer group interventions, and family engagement. Up to 1/3 of that reserve (5%) should support clinical care for disadvantaged and uninsured youth in the most severe end of the marijuana use spectrum.
Endnotes:


64. ECNP (Claire Mokrysz). No Relationship Between Moderate Adolescent Cannabis Use, Exam Results or IQ, Large Study Shows Science Daily 2014; Available from: http://www.sciencedaily.com/releases/2014/10/141020212410.htm.
ENDNOTES with Abstracts


Converging lines of evidence suggest an adverse effect of heavy cannabis use on adolescent brain development, particularly on the hippocampus. In this preliminary study, we compared hippocampal morphology in 14 "treatment-seeking" adolescents (aged 18-20) with a history of prior heavy cannabis use (5.8 joints/day) after an average of 6.7 months of drug abstinence, and 14 demographically matched normal controls. Participants underwent a high-resolution 3D MRI as well as cognitive testing including the California Verbal Learning Test (CVLT). Heavy-cannabis users showed significantly smaller volumes of the right (p < 0.04) and left (p < 0.02) hippocampus, but no significant differences in the amygdala region compared to controls. In controls, larger hippocampus volumes were observed to be significantly correlated with higher CVLT verbal learning and memory scores, but these relationships were not observed in cannabis users. In cannabis users, a smaller right hippocampus volume was correlated with a higher amount of cannabis use (r = -0.57, p < 0.03). These data support a hypothesis that heavy cannabis use may have an adverse effect on hippocampus development. These findings, after an average 6.7 month of supervised abstinence, lend support to a theory that cannabis use may impart long-term structural and functional damage. Alternatively, the observed hippocampal volumetric abnormalities may represent a risk factor for cannabis dependence. These data have potential significance for understanding the observed relationship between early cannabis exposure during adolescence and subsequent development of adult psychopathology reported in the literature for schizophrenia and related psychotic disorders.

Cannabis is the most commonly used illicit drug. Prevalence rates are particularly high among adolescents. Neuropsychological studies have identified cannabis-associated memory deficits, particularly linked to an early onset of use. However, it remains unclear, whether the age of onset accounts for altered cortical activation patterns usually observed in cannabis users. Functional magnetic resonance imaging was used to examine cortical activation during verbal working memory challenge in (1) early-onset (onset before the age of sixteen; n=26) and (2) late-onset cannabis users (age at onset at least sixteen; n=17). Early-onset users showed increased activation in the left superior parietal lobe. Correlational analyses confirmed the association between an earlier start of use and increased activity. Contrariwise neither cumulative dose, frequency nor time since last use was significantly associated with cortical activity. Our findings suggest that an early start of cannabis use is associated with increased cortical activation in adult cannabis users, possibly reflecting suboptimal cortical efficiency during cognitive challenge. The maturing brain might be more vulnerable to the harmful effects of cannabis use. However, due to a lack of a non-using control group we cannot exclude alternative interpretations.

BACKGROUND: Despite the relatively high prevalence of marijuana use among college students, little information exists regarding health outcomes associated with different use patterns or trajectories. METHODS: Seven annual personal interviews (years 1-7) were administered to 1253 individuals, beginning in their first year in college. Growth mixture modeling was used to identify trajectories of marijuana, alcohol, and tobacco use frequency during years 1-6. Logistic regression was used to evaluate the relationship between marijuana use trajectories and several year 7 health outcomes, holding constant year 1 health, demographics, and alcohol and tobacco use trajectories. RESULTS: Six marijuana use trajectories were identified: non-use (71.5% (wt) of students), low-stable (10.0% (wt)), late-increase (4.7% (wt)), early-decline (4.3% (wt)), college-peak (5.4% (wt)), and chronic (4.2% (wt)). The six marijuana trajectory groups were not significantly different on year 1 health-related variables, but differed on all ten year 7 health outcomes tested, including functional impairment
due to injury, illness, or emotional problems; general health rating; psychiatric symptoms; health-related quality of life; and service utilization for physical and mental health problems. Non-users fared significantly better than most of the marijuana-using trajectory groups on every outcome tested. Chronic and late-onset users had the worst health outcomes. CONCLUSIONS: Marijuana use patterns change considerably during college and the post-college period. Marijuana-using students appear to be at risk for adverse health outcomes, especially if they increase or sustain a frequent pattern of use.


In this paper we estimate the risk of becoming cannabis dependent within 24 months after first use of cannabis and examine subgroup variation in this risk. The study estimates are based on the National Household Survey on Drug Abuse conducted during 2000-2001, with a representative sample of U.S. residents ages 12 and older (n=114,241). A total of 3352 respondents were found to have used cannabis for the first time within a span of up to 24 months prior to assessment. An estimated 3.9% of these recent-onset users developed a cannabis dependence syndrome during the interval since first use (median interval duration approximately 12 months). Excess risk of cannabis dependence was found for those with cannabis onset before late-adolescence, those with family income less than US dollars 20,000, and those who had used three or more drugs before the first use of cannabis (i.e., tobacco, alcohol, and other drugs). While these findings generally support previous study results, this study's focus on recent-onset users more closely approximates prospective and longitudinal research on the incidence (risk) of becoming cannabis dependent soon after onset of cannabis use, removing the influence of users with long-sustained or persistent cannabis dependence developed years ago.


OBJECTIVES: This study sought to describe patterns of initiation, persistence, and cessation in drug use in individuals from their late 20s to their mid-30s, within a broad perspective that spans 19 years from adolescence to adulthood. METHODS: A fourth wave of personal interviews was conducted at ages 34-35 with a cohort of men and women (n = 1160) representative of adolescents formerly enrolled in New York State public secondary high schools. A school survey was administered at ages 15-16, and personal interviews with participants and school absentees were conducted at ages 24-25 and 28-29. Retrospective continuous histories of 12 drug classes were obtained at each follow-up. RESULTS: There was no initiation into alcohol and cigarettes and hardly any initiation into illicit drugs after age 29, the age at which most use ceased. The largest proportion of new users was observed for prescribed psychoactives. Periods of highest use since adolescence based on relative and absolute criteria were delineated. Among daily users, the proportions of heavy users declined for alcohol and marijuana but not for cigarettes. CONCLUSIONS: Cigarettes are the most persistent of any drug used. Drug-focused interventions must target adolescents and young adults.


Event history analysis was applied to monthly life and drug histories of a representative community sample of 706 marijuana users, followed from ages 15-16 to 34-35, to investigate factors associated with cessation of marijuana use from adolescence to adulthood. In addition to age and gender, the most important determinants of cessation are the phenomenology of marijuana use, social role participation, depressive symptoms and deviance. Frequent users, those who started using early and those who use illicit drugs other than marijuana are more likely to continue their marijuana use. Using marijuana for social reasons accelerates cessation, using to change one's mood reduces cessation. Becoming pregnant and a parent is the most important social role leading to marijuana cessation for women. There is also a very important experimental effect of the interview itself on the reported timing of a cessation. The effect of a social context favorable to marijuana use appears to reflect selection rather than social influence.


BACKGROUND: Regular adolescent cannabis use predicts a range of later drug use and psychosocial problems. Little is known about whether occasional cannabis use carries similar risks. AIMS: To examine associations
between occasional cannabis use during adolescence and psychosocial and drug use outcomes in young adulthood; and modification of these associations according to the trajectory of cannabis use between adolescence and age 20 years, and other potential risk factors. METHOD: A 10-year eight-wave cohort study of a representative sample of 1943 secondary school students followed from 14.9 years to 24 years. RESULTS: Occasional adolescent cannabis users who continued occasional use into early adulthood had higher risks of later alcohol and tobacco dependence and illicit drug use, as well as being less likely to complete a post-secondary qualification than non-users. Those using cannabis at least weekly either during adolescence or at age 20 were at highest risk of drug use problems in young adulthood. Adjustment for smoking in adolescence reduced the association with later educational achievement, but associations with drug use problems remained. CONCLUSIONS: Occasional adolescent cannabis use predicts later drug use and educational problems. Partial mediation by tobacco use raises a possibility that differential peer affiliation may play a role.


AIMS: Debate continues about whether the association between cannabis use in adolescence and common mental disorders is causal. Most reports have focused on associations in adolescence, with few studies extending into adulthood. We examine the association from adolescence until the age of 29 years in a representative prospective cohort of young Australians. DESIGN: Nine-wave, 15-year representative longitudinal cohort study, with six waves of data collection in adolescence (mean age 14.9-17.4 years) and three in young adulthood (mean age 20.7, 24.1 and 29.1 years). PARTICIPANTS: Participants were a cohort of 1943 recruited in secondary school and surveyed at each wave when possible from mid-teen age to their late 20s. SETTING: Victoria, Australia. MEASUREMENTS: Psychiatric morbidity was assessed with the Revised Clinical Interview Schedule (CIS-R) at each adolescent wave, and as Composite International Diagnostic Interview (CIDI)-defined ICD-10 major depressive episode and anxiety disorder at 29 years. Frequency of cannabis use was measured in the past 6 months in adolescence. Cannabis use frequency in the last year and DSM-IV cannabis dependence were assessed at 29 years. Cross-sectional and prospective associations of these outcomes with cannabis use and dependence were estimated as odds ratios (OR), using multivariable logistic regression models, with the outcomes of interest, major depressive episode (MDE) and anxiety disorder (AD) at 29 years. FINDINGS: There were no consistent associations between adolescent cannabis use and depression at age 29 years. Daily cannabis use was associated with anxiety disorder at 29 years [adjusted OR 2.5, 95% confidence interval (CI):< 1.2-5.2], as was cannabis dependence (adjusted OR 2.2, 95% CI: 1.1-4.4). Among weekly+ adolescent cannabis users, those who continued to use cannabis use daily at 29 years remained at significantly increased odds of anxiety disorder (adjusted OR 3.2, 95% CI: 1.1-9.2). CONCLUSIONS: Regular (particularly daily) adolescent cannabis use is associated consistently with anxiety, but not depressive disorder, in adolescence and late young adulthood, even among regular users who then cease using the drug. It is possible that early cannabis exposure causes enduring mental health risks in the general cannabis-using adolescent population.


Marijuana is the most widely used illegal substance in the world, and persistent and frequent use during adolescence has been associated with precarious transitions and deleterious consequences in adulthood. This study used a group-based trajectory approach to analyze panel data collected from 1,725 youth participating in the National Youth Study to describe pathways of marijuana use and to explore protective factors that may reduce the continuation of use. A trajectory approach allowed us to operationalize risk based on prior within-person patterns of self-reported marijuana use. Three trajectory groups of marijuana users were identified: chronic users (17%), rising users (40%), and abstainers (43%). Our results show that some protective factors are significantly associated with decreases in marijuana use for each trajectory group (e.g., parent disapproval and non-using peer associations), but others are significantly associated with decreases in marijuana for a particular trajectory group and not others (e.g., school attachment for chronic marijuana users). The implications of our findings are discussed for the risk and protective factor framework, as well as their importance in a society where opinions of marijuana are currently changing.

ECNP (Claire Mokrysz) [2014]. "No Relationship Between Moderate Adolescent Cannabis Use, Exam Results or IQ, Large Study Shows." *Science Daily* from http://www.sciencedaily.com/releases/2014/10/141020212410.htm.

A large UK study has found that occasional adolescent cannabis use does not lead to poorer educational and intellectual performance, but that heavy cannabis use is associated with slightly poorer exam results at age 16. The results come from the Avon Longitudinal Study of Parents and Children (ALSPAC, also known as *Children
of the 90’s”) a long-term study that follows the health of children born in the Bristol area (UK) in 1991 and 1992. The work is being presented at the annual congress of the European College of Neuropsychopharmacology (ECNP) in Berlin. The researchers analysed data from 2,612 children who had their IQ tested at the age of 8, and again at the age of 15. These children’s examination results were then factored in via the National Pupil Database. At the age of 15, each person in the study completed a survey on cannabis use. The researchers then used regression analysis to look at how cannabis use affected both intellectual and educational performance. A number of children could not be included in the final analyses (for example because they had experienced a head injury), leaving a total sample size of 2,235.

The researchers found two main points:
1. Cannabis use appeared to be associated with decreased intellectual performance. Cannabis use was, however, highly correlated with other risky behaviours such as alcohol, cigarette and other drug use. When the researchers took these other behaviours into account, they found there was no relationship between cannabis use and lower IQ at age 15.
2. Heavier cannabis users (at least 50 times by age 15) however, did show marginally impaired educational abilities. These children tended to have poorer exam results (3% lower) on compulsory school exams taken at age 16, even after adjusting for childhood educational performance, as well as alcohol, cigarette and other drug use.


BACKGROUND: Despite its importance as a public health concern, relatively little is known about the natural course of cannabis use disorders (CUDs). The primary objective of this research was to provide descriptive data on the onset, recovery and recurrence functions of CUDs during the high-risk periods of adolescence, emerging adulthood and young adulthood based on data from a large prospective community sample. METHOD: Probands (n = 816) from the Oregon Adolescent Depression Project (OADP) participated in four diagnostic assessments (T1-T4) between the ages of 16 and 30 years, during which current and past CUDs were assessed. RESULTS: The weighted lifetime prevalence of CUDs was 19.1% with an average onset age of 18.6 years. Although gender was not significantly related to the age of initial CUD onset, men were more likely to be diagnosed with a lifetime CUD. Of those diagnosed with a CUD episode, 81.8% eventually achieved recovery during the study period. Women achieved recovery significantly more quickly than men. The recurrence rate (27.7%) was relatively modest, and most likely to occur within the first 36 months following the offset of the first CUD episode. CUD recurrence was uncommon after 72 months of remission and recovery. CONCLUSIONS: CUDs are relatively common, affecting about one out of five persons in the OADP sample prior to the age of 30 years. Eventual recovery from index CUD episodes is the norm, although about 30% of those with a CUD exhibit a generally persistent pattern of problematic use extending 7 years or longer.


AIM: To examine the associations between the frequency of cannabis use and the use of other illicit drugs. DESIGN: A 25-year longitudinal study of the health, development and adjustment of a birth cohort of 1,265 New Zealand children. MEASUREMENTS: Annual assessments of the frequency of cannabis use were obtained for the period 14-25 years, together with measures of the use of other illicit drugs from the same time period. FINDINGS: The frequency of cannabis use was associated significantly with the use of other illicit drugs, other illicit drug abuse/dependence and the use of a diversity of other drugs. This association was found to be particularly strong during adolescence but declined rapidly as age increased. Statistical control for confounding by both fixed and time dynamic factors using random- and fixed-effects regression models reduced the strength of association between frequency of cannabis use and other illicit drug use, but a strong association between frequency of cannabis use and other illicit drug use remained even after control for non-observed and time-dynamic sources of confounding. CONCLUSIONS: Regular or heavy cannabis use was associated with an increased risk of using other illicit drugs, abusing or becoming dependent upon other illicit drugs, and using a wider variety of other illicit drugs. The risks of use, abuse/dependence, and use of a diversity of other drugs declined with increasing age. The findings may support a general causal model such as the cannabis gateway hypothesis, but the actual causal mechanisms underlying such a gateway, and the extent to which these causal mechanisms are direct or indirect, remain unclear.

AIMS: To examine the relationship between cannabis use in adolescence/young adulthood and levels of educational attainment. DESIGN: Data were gathered over the course of a 25-year longitudinal study of a birth cohort of 1265 New Zealand children. MEASUREMENTS: Measures analysed included (a) frequency of cannabis use in adolescence and young adulthood (15-25 years); (b) levels of educational achievement to age 25 years; and (c) social, family and individual characteristics assessed prior to age 16. FINDINGS: Increasing cannabis use was associated with increasing risks of leaving school without qualifications, failure to enter university and failure to obtain a university degree. The association between cannabis use and leaving school without qualifications persisted after control for confounding factors. When due allowance was made for pre-existing levels of cannabis use there was no evidence to suggest the presence of reverse causal pathways in which lower educational achievement led to increased cannabis use. CONCLUSIONS: Findings support the view that cannabis use may act to decrease educational achievement in young people. It is likely that this reflects the effects of the social context within which cannabis is used rather than any direct effect of cannabis on cognitive ability or motivation.


Questions surrounding the effects of chronic marijuana use on brain structure continue to increase. To date, however, findings remain inconclusive. In this comprehensive study that aimed to characterize brain alterations associated with chronic marijuana use, we measured gray matter (GM) volume via structural MRI across the whole brain by using voxel-based morphometry, synchrony among abnormal GM regions during resting state via functional connectivity MRI, and white matter integrity (i.e., structural connectivity) between the abnormal GM regions via diffusion tensor imaging in 48 marijuana users and 62 age- and sex-matched nonusing controls. The results showed that compared with controls, marijuana users had significantly less bilateral orbitofrontal gyri volume, higher functional connectivity in the orbitofrontal cortex (OFC) network, and higher structural connectivity in tracts that innervate the OFC (forceps minor) as measured by fractional anisotropy (FA). Increased OFC functional connectivity in marijuana users was associated with earlier age of onset. Lastly, a quadratic trend was observed suggesting that the FA of the forceps minor tract initially increased following regular marijuana use but decreased with protracted regular use. This pattern may indicate differential effects of initial and chronic marijuana use that may reflect complex neuroadaptive processes in response to marijuana use. Despite the observed age of onset effects, longitudinal studies are needed to determine causality of these effects.


The relationships between executive processes, associative learning and different aspects of real world memory functioning were explored in a sample of cannabis users and nonusers. Measures of executive component processes, associative learning, everyday memory, prospective memory, and cognitive failures were administered. Relative to nonusers, cannabis users were found to be impaired in several aspects of real world memory functioning. No other group differences were apparent. The absence of cannabis related deficits in those executive component processes and aspects of learning that are believed to support real world memory processes is surprising given that cannabis related deficits were obtained in real world memory. The present results are discussed within the context of neuroimaging evidence which suggests that cannabis users may exhibit different patterns of neural activation when performing executive tasks while not always exhibiting deficits on these tasks.


BACKGROUND: Many studies have suggested that adolescence is a period of particular vulnerability to neurocognitive effects associated with substance misuse. However, few large studies have measured differences in cognitive performance between chronic cannabis users who started in early adolescence (before age 15) with those who started later. AIMS: To examine the executive functioning of individuals who started chronic cannabis use before age 15 compared with those who started chronic cannabis use after 15 and controls. METHOD: We evaluated the performance of 104 chronic cannabis users (49 early-onset users and 55 late-onset users) and 44 controls who undertook neuropsychological tasks, with a focus on executive functioning. Comparisons involving neuropsychological measures were performed using generalised linear model analysis of variance (ANOVA). RESULTS: The early-onset group showed significantly poorer performance compared with the controls and the late-onset group on tasks assessing sustained attention, impulse control and executive functioning. CONCLUSIONS: Early-onset chronic cannabis users exhibited poorer cognitive performance than controls and
late-onset users in executive functioning. Chronic cannabis use, when started before age 15, may have more deleterious effects on neurocognitive functioning.


Magnetic resonance imaging (MRI) provides accurate anatomical brain images without the use of ionizing radiation, allowing longitudinal studies of brain morphometry during adolescent development. Results from an ongoing brain imaging project being conducted at the Child Psychiatry Branch of the National Institute of Mental Health indicate dynamic changes in brain anatomy throughout adolescence. White matter increases in a roughly linear pattern, with minor differences in slope in the four major lobes (frontal, parietal, temporal, occipital). Cortical gray matter follows an inverted U-shape developmental course with greater regional variation than white matter. For instance, frontal gray matter volume peaks at about age 11.0 years in girls and 12.1 years in boys, whereas temporal gray matter volume peaks at about age at 16.7 years in girls and 16.2 years in boys. The dorsal lateral prefrontal cortex, important for controlling impulses, is among the latest brain regions to mature without reaching adult dimensions until the early 20s. The details of the relationships between anatomical changes and behavioral changes, and the forces that influence brain development, have not been well established and remain a prominent goal of ongoing investigations.


Remarkable advances in technologies that enable the distribution and use of information encoded as digital sequences of 1s or 0s have dramatically changed our way of life. Adolescents, old enough to master the technologies and young enough to welcome their novelty, are at the forefront of this "digital revolution." Underlying the adolescent’s eager embrace of these sweeping changes is a neurobiology forged by the fires of evolution to be extremely adept at adaptation. The consequences of the brain’s adaptation to the demands and opportunities of the digital age have enormous implications for adolescent health professionals.


We report the dynamic anatomical sequence of human cortical gray matter development between the age of 4-21 years using quantitative four-dimensional maps and time-lapse sequences. Thirteen healthy children for whom anatomic brain MRI scans were obtained every 2 years, for 8-10 years, were studied. By using models of the cortical surface and sulcal landmarks and a statistical model for gray matter density, human cortical development could be visualized across the age range in a spatiotemporally detailed time-lapse sequence. The resulting time-lapse "movies" reveal that (i) higher-order association cortices mature only after lower-order somatosensory and visual cortices, the functions of which they integrate, are developed, and (ii) phylogenetically older brain areas mature earlier than newer ones. Direct comparison with normal cortical development may help understanding of some neurodevelopmental disorders such as childhood-onset schizophrenia or autism.


BACKGROUND: Although cannabis is the most widely used illicit drug in the United States, few recent American studies have examined the attributes of long-term heavy cannabis users. METHOD: Using a case-control design, we obtained psychological and demographic measures on 108 individuals, age 30-55, who had smoked cannabis a mean of 18000 times and a minimum of 5000 times in their lives. We compared these heavy users to 72 age-matched control subjects who had smoked at least once, but no more than 50 times in their lives. RESULTS: We found no significant differences between the two groups on reported levels of income and education in their families of origin. However, the heavy users themselves reported significantly lower educational attainment (P < 0.001) and income (P = 0.003) than the controls, even after adjustment for a large number of potentially confounding variables. When asked to rate the subjective effects of cannabis on their cognition, memory, career, social life, physical health and mental health, large majorities of heavy users (66-90%) reported a 'negative effect'. On several measures of quality of life, heavy users also reported significantly lower levels of satisfaction than controls. CONCLUSION: Both objective and self-report measures suggest numerous negative features associated with long-term heavy cannabis use. Thus, it seems important to understand why heavy users continue to smoke regularly for years, despite acknowledging these negative effects. Such an understanding may guide the development of strategies to treat cannabis dependence.

AIMS: To examine changes in the evidence on the adverse health effects of cannabis since 1993. METHODS: A comparison of the evidence in 1993 with the evidence and interpretation of the same health outcomes in 2013. RESULTS: Research in the past 20 years has shown that driving while cannabis-impaired approximately doubles crash risk and that around one in 10 regular cannabis users develop dependence. Regular cannabis use in adolescence approximately doubles the risks of early school-leaving and of cognitive impairment and psychoses in adulthood. Regular cannabis use in adolescence is also associated strongly with the use of other illicit drugs. These associations persist after controlling for plausible confounding variables in longitudinal studies. This suggests that cannabis use is a contributory cause of these outcomes but some researchers still argue that these relationships are explained by shared causes or risk factors. Cannabis smoking probably increases cardiovascular disease risk in middle-aged adults but its effects on respiratory function and respiratory cancer remain unclear, because most cannabis smokers have smoked or still smoke tobacco. CONCLUSIONS: The epidemiological literature in the past 20 years shows that cannabis use increases the risk of accidents and can produce dependence, and that there are consistent associations between regular cannabis use and poor psychosocial outcomes and mental health in adulthood.


This paper summarizes the most probable of the adverse health effects of regular cannabis use sustained over years, as indicated by epidemiological studies that have established an association between cannabis use and adverse outcomes; ruled out reverse causation; and controlled for plausible alternative explanations. We have also focused on adverse outcomes for which there is good evidence of biological plausibility. The focus is on those adverse health effects of greatest potential public health significance-those that are most likely to occur and to affect a substantial proportion of regular cannabis users. These most probable adverse effects of regular use include a dependence syndrome, impaired respiratory function, cardiovascular disease, adverse effects on adolescent psychosocial development and mental health, and residual cognitive impairment.


BACKGROUND: Cognitive deficits that persist up to a month have been detected among adult marijuana users, but decrements and their pattern of recovery are less known in adolescent users. Previously, we reported cognitive deficits among adolescent marijuana users after one month of abstinence (Medina, Hanson, Schweinsburg, Cohen-Zion, Nagel, & Tapert, 2007). In this longitudinal study, we characterized neurocognitive changes among marijuana-using adolescents across the first three weeks of abstinence. METHOD: Participants were adolescent marijuana users with limited alcohol and other drug use (n=19) and demographically similar non-using controls (n=21) ages 15-19. Participants completed a brief neuropsychological battery on three occasions, after 3 days, 2 weeks, and 3 weeks of stopping substance use. Abstinence was ascertained by decreasing tetrahydrocannabinol metabolite values on serum urine drug screens. Verbal learning, verbal working memory, attention and vigilance, and time estimation were evaluated. RESULTS: Marijuana users demonstrated poorer verbal learning (p<.01), verbal working memory (p<.05), and attention accuracy (p<.01) compared to controls. Improvements in users were seen on word list learning after 2 weeks of abstinence and on verbal working memory after 3 weeks. While attention processing speed was similar between groups, attention accuracy remained deficient in users throughout the 3-week abstinence period. CONCLUSIONS: This preliminary study detected poorer verbal learning and verbal working memory among adolescent marijuana users that improved during three weeks of abstinence, while attention deficits persisted. These results implicate possible hippocampal, subcortical, and prefrontal cortex abnormalities.


This study analyzes data on 7661 individuals who participated in the 1979 National Longitudinal Survey of Youth (NLSY79) to estimate trajectories of employment and marijuana-use over a 17-year period. Bivariate random intercept and slope modeling is applied to examine concurrently the cross-correlation between the two concurrent longitudinal trajectories from age 23 to 39. Parameter estimates indicate baseline level (at age 23) of employment to be negatively correlated with marijuana, suggesting marijuana-use is associated with lower workforce productivity at age 23. The longitudinal employment slope is positively correlated with employment intercept for both males and females, indicating that survey participants with higher levels of employment at age
23 are more likely to have a positive impact on employment trajectory over time. For males, however, the employment slope is also significantly correlated with marijuana intercept (r=0.07), indicating marijuana-use in early adulthood may uniquely lower workforce productivity over age.


The authors suggest that the most promising route to effective strategies for the prevention of adolescent alcohol and other drug problems is through a risk-focused approach. This approach requires the identification of risk factors for drug abuse, identification of methods by which risk factors have been effectively addressed, and application of these methods to appropriate high-risk and general population samples in controlled studies. The authors review risk and protective factors for drug abuse, assess a number of approaches for drug abuse prevention potential with high-risk groups, and make recommendations for research and practice.


BACKGROUND: The associations between age of onset of cannabis use and educational achievement were examined using data from three Australasian cohort studies involving over 6000 participants. The research aims were to compare findings across studies and obtain pooled estimates of association using meta-analytic methods. METHODS: Data on age of onset of cannabis use (<15, 15-17, never before age 18) and three educational outcomes (high school completion, university enrolment, degree attainment) were common to all studies. Each study also assessed a broad range of confounding factors. RESULTS: There were significant (p<.001) associations between age of onset of cannabis use and all outcomes such that rates of attainment were highest for those who had not used cannabis by age 18 and lowest for those who first used cannabis before age 15. These findings were evident for each study and for the pooled data, and persisted after control for confounding. There was no consistent trend for cannabis use to have greater effect on the academic achievement of males but there was a significant gender by age of onset interaction for university enrolment. This interaction suggested that cannabis use by males had a greater detrimental effect on university participation than for females. Pooled estimates suggested that early use of cannabis may contribute up to 17% of the rate of failure to obtain the educational milestones of high school completion, university enrolment and degree attainment. CONCLUSIONS: Findings suggest the presence of a robust association between age of onset of cannabis use and subsequent educational achievement.


OBJECTIVE: Early-onset cannabis use has been associated with later use/abuse, mental health problems (psychosis, depression), and abnormal development of cognition and brain function. During adolescence, ongoing neurodevelopmental maturation and experience shape the neural circuitry underlying complex cognitive functions such as memory and executive control. Prefrontal and temporal regions are critically involved in these functions. Maturational processes leave these brain areas prone to the potentially harmful effects of cannabis use. METHOD: We performed a two-site (United States and The Netherlands; pooled data) functional magnetic resonance imaging (MRI) study with a cross-sectional design, investigating the effects of adolescent cannabis use on working memory (WM) and associative memory (AM) brain function in 21 abstinent but frequent cannabis-using boys (13-19) years of age and compared them with 24 nonusing peers. Brain activity during WM was assessed before and after rule-based learning (automatization). AM was assessed using a pictorial hippocampal-dependent memory task. RESULTS: Cannabis users performed normally on both memory tasks. During WM assessment, cannabis users showed excessive activity in prefrontal regions when a task was novel, whereas automatization of the task reduced activity to the same level in users and controls. No effect of cannabis use on AM-related brain function was found. CONCLUSIONS: In adolescent cannabis users, the WM system was overactive during a novel task, suggesting functional compensation. Inefficient WM recruitment was not related to a failure in automatization but became evident when processing continuously changing information. The results seem to confirm the vulnerability of still developing frontal lobe functioning for early-onset cannabis use.

Over the last decade there has been a steady increase in the prevalence of frequent cannabis use among teenagers, accompanied by a decrease in age of first use. Evidence from both animal and human studies suggests that the severity of the effects of cannabis use on cognitive development is dependent on the age when cannabis use begins. One possible explanation is that those who begin cannabis use early in adolescence are more likely to become heavily dependent. It is plausible that chronic cannabis abuse will then interfere with educational and vocational training. From a more biological perspective, however, use of cannabis during critical developmental periods in the still maturing brain may induce persistent alterations in brain structure and brain function. Therefore, the effects of frequent cannabis use during adolescence could be different from and more serious than during adulthood, an issue increasingly recognized in the field of cannabis research. In this paper we review the relevant animal and human literature on long-term effects of frequent exposure to cannabis during adolescence on the development of cognition, brain structure and function, and discuss implications, methodological and conceptual issues, and future prospects.


A comparative risk assessment of drugs including alcohol and tobacco using the margin of exposure (MOE) approach was conducted. The MOE is defined as ratio between toxicological threshold (benchmark dose) and estimated human intake. Median lethal dose values from animal experiments were used to derive the benchmark dose. The human intake was calculated for individual scenarios and population-based scenarios. The MOE was calculated using probabilistic Monte Carlo simulations. The benchmark dose values ranged from 2 mg/kg bodyweight for heroin to 531 mg/kg bodyweight for alcohol (ethanol). For individual exposure the four substances alcohol, nicotine, cocaine and heroin fall into the "high risk" category with MOE < 10, the rest of the compounds except THC fall into the "risk" category with MOE < 100. On a population scale, only alcohol would fall into the "high risk" category, and cigarette smoking would fall into the "risk" category, while all other agents (opiates, cocaine, amphetamine-type stimulants, ecstasy, and benzodiazepines) had MOEs > 100, and cannabis had a MOE > 10,000. The toxicological MOE approach validates epidemiological and social science-based drug ranking approaches especially in regard to the positions of alcohol and tobacco (high risk) and cannabis (low risk).


This paper reviews research examining the link between cannabis use and educational attainment among youth. Cross-sectional studies have revealed significant associations between cannabis use and a range of measures of educational performance including lower grade point average, less satisfaction with school, negative attitudes to school, increased rates of school absenteeism and poor school performance. However, results of cross-sectional studies cannot be used to determine whether cannabis use causes poor educational performance, poor educational performance is a cause of cannabis use or whether both outcomes are a reflection of common risk factors. Nonetheless, a number of prospective longitudinal studies have indicated that early cannabis use may significantly increase risks of subsequent poor school performance and, in particular, early school leaving. This association has remained after control for a wide range of prospectively assessed covariates. Possible mechanisms underlying an association between early cannabis use and educational attainment include the possibility that cannabis use induces an 'amotivational syndrome' or that cannabis use causes cognitive impairment. However, there appears to be relatively little empirical support for these hypotheses. It is proposed that the link between early cannabis use and educational attainment arises because of the social context within which cannabis is used. In particular, early cannabis use appears to be associated with the adoption of an anti-conventional lifestyle characterized by affiliations with delinquent and substance using peers, and the precocious adoption of adult roles including early school leaving, leaving the parental home and early parenthood.


OBJECTIVE: To examine the extent to which weekly cannabis use during mid-adolescence may increase the risk of early school-leaving. SETTING: A prospective study of a general population sample of adolescents studied...
from ages 15-21 years in Melbourne, Australia. METHOD: Computer-assisted self-completion questionnaires and telephone interviews conducted in six waves at ages 15-18 and again at age 21 in a sample of 1601 male and female school students. RESULTS: Weekly cannabis use, assessed prospectively, was associated with significantly increased risk of early school-leaving. This effect remained after adjustment for a range of prospectively assessed covariates including demographic characteristics, other substance use, psychiatric morbidity and antisocial behavior. There was suggestive evidence of an interaction between weekly cannabis use and age with the effects of weekly cannabis use on early school-leaving being strongest at the youngest ages and diminishing progressively with age. CONCLUSIONS: Early regular cannabis use (weekly use at age 15) is associated with increased risk of early school-leaving. These effects of regular cannabis use may diminish with increasing age and are likely to operate through the social context within which cannabis is used and obtained.


In this study, we reconsider the relationship between heavy and persistent marijuana use and high school dropout status. Using a unique prospective panel study of over 4500 7th grade students from South Dakota who are followed through high school, we developed propensity score weights to adjust for baseline differences found to exist before marijuana initiation occurs for most students (7th grade). We then used weighted logistic regression that incorporates these propensity score weights to examine the extent to which time-varying factors, including substance use, also influence the likelihood of dropping out of school. We found a positive association between marijuana use and dropping out (OR=5.6, RR=3.8), over half of which was explained by prior differences in observational characteristics and behaviors. The remaining association (OR=2.4, RR=1.7) became statistically insignificant when measures of cigarette smoking were included in the analysis. Because cigarette smoking is unlikely to seriously impair cognition, we interpret this result as evidence that the association between marijuana use and high school dropout is unlikely to be due to its adverse effects on cognition. We then explored which constructs drive this result, determining that they are time-varying parental and peer influences.


In adults, studies examining the long-lasting cognitive effects of marijuana use demonstrate subtle deficits in attention, executive function, and memory. Because neuromaturation continues through adolescence, these results cannot necessarily generalize to adolescent marijuana users. The goal of this study was to examine neuropsychological functioning in abinent marijuana using and demographically similar control adolescents. Data were collected from 65 adolescent marijuana users (n=31, 26% females) and controls (n=34, 26% females) 16-18 years of age. Extensive exclusionary criteria included independent psychiatric, medical, and neurologic disorders. Neuropsychological assessments were conducted after 23 days of monitored abstinence. After controlling for lifetime alcohol use and depressive symptoms, adolescent marijuana users demonstrated slower psychomotor speed (p<.05), and poorer complex attention (p<.04), story memory (p<.04), and planning and sequencing ability (p<.001) compared with controls. Post hoc analysis revealed that the number of lifetime marijuana use episodes was associated with poorer cognitive function, even after controlling for lifetime alcohol use. The general pattern of results suggested that, even after a month of monitored abstinence, adolescent marijuana users demonstrate subtle neuropsychological deficits compared with nonusers. It is possible that frequent marijuana use during adolescence may negatively influence neuromaturation and cognitive development.


Recent reports show that fewer adolescents believe that regular cannabis use is harmful to health. Concomitantly, adolescents are initiating cannabis use at younger ages, and more adolescents are using cannabis on a daily basis. The purpose of the present study was to test the association between persistent cannabis use and neuropsychological decline and determine whether decline is concentrated among adolescent-onset cannabis users. Participants were members of the Dunedin Study, a prospective study of a birth cohort of 1,037 individuals followed from birth (1972/1973) to age 38 y. Cannabis use was ascertained in interviews at ages 18, 21, 26, 32, and 38 y. Neuropsychological testing was conducted at age 13 y, before initiation of cannabis use, and again at age 38 y, after a pattern of persistent cannabis use had developed. Persistent cannabis use was associated with neuropsychological decline broadly across domains of functioning, even after controlling for years of education. Informants also reported noticing more cognitive problems for persistent cannabis users.
Impairment was concentrated among adolescent-onset cannabis users, with more persistent use associated with greater decline. Further, cessation of cannabis use did not fully restore neuropsychological functioning among adolescent-onset cannabis users. Findings are suggestive of a neurotoxic effect of cannabis on the adolescent brain and highlight the importance of prevention and policy efforts targeting adolescents.


BACKGROUND: Research shows that cannabis users exhibit deficits in prospective memory (PM) and executive function, which persist beyond acute intoxication. However, many studies rely on self-reports of memory failures or use laboratory-based measures that may not mimic functional deficits in the real world. The present study aimed to assess real-world memory functioning. METHOD: Twenty cannabis-only users and 20 non-illicit drug users were recruited. Participants completed a substance use inventory and a mood scale, followed by a non-immersive virtual reality task assessing PM and executive functioning. The task involved the participant playing the role of an office worker for the day and performing routine office duties. A number of subscales were used to assess facets of executive function (planning, adaptive thinking, creative thinking, selection, prioritisation) and PM (time-based, event-based and action-based PM). RESULTS: Multivariate analysis of variance revealed cannabis users performed worse overall on the task, with poor performance on the planning, time-based PM and event-based PM subscales. In addition, indices of cannabis (length, dose, frequency, total use) were correlated with performance on these subscales. CONCLUSIONS: The present study expands on previously established research, providing support for the cannabis-related deficits in PM and executive functioning and the role of different aspects of cannabis use in these deficits.

National Commission on Marijuana and Drug Abuse (1972). "The Report of the National Commission on Marijuana and Drug Abuse - Marihuana: A Signal of Misunderstanding ". from http://www.druglibrary.org/schaffer/library/studies/nc/ncmenu.htm. This is the first of two Reports by the National Commission on and Drug Abuse. Public Law 91-513 requires that we report to the President, Congress and the public initially on marihuana and then on the broader issue of drug abuse in the United The second Report will include a review of the marihuana issue with particular attention to studies which have been conducted in the interim.

Our mandate was a broad one, covering, for example, the nature and scope of use, the effects of the drug, the relationship of marihuana use to other behavior and the efficacy of existing law. Realizing that marihuana had never before in the American experience been the subject of a concentrated, authoritative governmental study, we launched a comprehensive research and fact-finding effort. We sought.. to evaluate and supplement existing material, to fill knowledge voids, and to assess the so-called truths commonly posed in the marihuana debate.

Soon after funds became available on March 22, 1971, we commissioned more than 50 projects, ranging from a study of the effects of marihuana on man to a field survey of enforcement of the marihuana laws in six metropolitan jurisdictions. Of particular importance in our fact-finding effort were the opinions and attitudes of all groups in our society.

Through formal and informal hearings, recorded in thousands of pages of transcripts, we solicited all points of view, including those of public officials, community leaders, professional experts and students. We commissioned a nationwide survey of public beliefs, information and experience referred to in this Report as the National Survey. In addition, we conducted separate surveys of opinion among, district attorneys, judges, probation officers, clinicians, university health officials and free clinic personnel.

Further, we do not discuss the rehabilitation of the problem marihuana user since no such specialized programs exist; we found the subject is best approached from a broader perspective of rehabilitation programs for problem users of all non-narcotic drugs. An examination of federal and state organizational response to the drug issue, as well as an in-depth study of general law enforcement strategies, have both been undertaken and will continue, but will not be reported fully until the second year.


**BACKGROUND:** Proper assessment of the harms caused by the misuse of drugs can inform policy makers in health, policing, and social care. We aimed to apply multicriteria decision analysis (MCDA) modelling to a range of drug harms in the UK. **METHODS:** Members of the Independent Scientific Committee on Drugs, including two invited specialists, met in a 1-day interactive workshop to score 20 drugs on 16 criteria: nine related to the harms that a drug produces in the individual and seven to the harms to others. Drugs were scored out of 100 points, and the criteria were weighted to indicate their relative importance. **FINDINGS:** MCDA modelling showed that heroin, crack cocaine, and metamfetamine were the most harmful drugs to individuals (part scores 34, 37, and 32, respectively), whereas alcohol, heroin, and crack cocaine were the most harmful to others (46, 21, and 17, respectively). Overall, alcohol was the most harmful drug (overall harm score 72), with heroin (55) and crack cocaine (54) in second and third places. **INTERPRETATION:** These findings lend support to previous work assessing drug harms, and show how the improved scoring and weighting approach of MCDA increases the differentiation between the most and least harmful drugs. However, the findings correlate poorly with present UK drug classification, which is not based simply on considerations of harm. **FUNDING:** Centre for Crime and Justice Studies (UK).


**RATIONALE:** Cannabis is one of the most frequently used substances. Cannabis and its constituent cannabinoids are known to impair several aspects of cognitive function, with the most robust effects on short-term episodic and working memory in humans. A large body of the work in this area occurred in the 1970s before the discovery of cannabinoid receptors. Recent advances in the knowledge of cannabinoid receptors’ function have rekindled interest in examining effects of exogenous cannabinoids on memory and in understanding the mechanism of these effects. **OBJECTIVE:** The literature about the acute effects of cannabinoids on memory tasks in humans is reviewed. The limitations of the human literature including issues of dose, route of administration, small sample sizes, sample selection, effects of other drug use, tolerance and dependence to cannabinoids, and the timing and sensitivity of psychological tests are discussed. Finally, the human literature is discussed against the backdrop of preclinical findings. **RESULTS:** Acute administration of Delta-9-THC transiently impairs immediate and delayed free recall of information presented after, but not before, drug administration in a dose- and delay-dependent manner. In particular, cannabinoids increase intrusion errors. These effects are more robust with the inhaled and intravenous route and correspond to peak drug levels. **CONCLUSIONS:** This profile of effects suggests that cannabinoids impair all stages of memory including encoding, consolidation, and retrieval. Several mechanisms, including effects on long-term potentiation and long-term depression and the inhibition of neurotransmitter (GABA, glutamate, acetyl choline, dopamine) release, have been implicated in the amnesic effects of cannabinoids. Future research in humans is necessary to characterize the neuroanatomical and neurochemical basis of the memory impairing effects of cannabinoids, to dissect out their effects on the various stages of memory and to bridge the expanding gap between the humans and preclinical literature.


Does cannabis use have substantial and permanent effects on neuropsychological functioning? Renewed and intense attention to the issue has followed recent research on the Dunedin cohort, which found a positive association between, on the one hand, adolescent-onset cannabis use and dependence and, on the other hand, a decline in IQ from childhood to adulthood [Meier et al. (2012) *Proc Natl Acad Sci USA* 109(40):E2657-E2664]. The association is given a causal interpretation by the authors, but existing research suggests an alternative confounding model based on time-varying effects of socioeconomic status on IQ. A simulation of the confounding model reproduces the reported associations from the Dunedin cohort, suggesting that the causal effects estimated in Meier et al. are likely to be overestimates, and that the true effect could be zero. Further analyses of the Dunedin cohort are proposed to distinguish between the competing interpretations. Although it would be too strong to say that the results have been discredited, the methodology is flawed and the causal inference drawn from the results premature.

  In a 2010 Lancet paper Nutt et al. propose a model for evaluating and ranking drug harms, building on earlier work by incorporating multi criteria decision analysis. It is argued that problems arise in modelling drug harms using rankable single figure indices when determinants of harm reflect pharmacology translated through a complex prism of social and behavioural variables, in turn influenced by a range of policy environments. The delphic methodology used is highly vulnerable to subjective judgements and even the more robust measures, such as drug related death and dependence, can be understood as socially constructed. The failure of the model to disaggregate drug use harms from those related to the policy environment is also highlighted. Beyond these methodological challenges the utility of single figure index harm rankings is questioned, specifically their role in increasingly redundant legal frameworks utilising a harm-based hierarchy of punitive sanctions. If analysis is to include the capacity to capture the complexity relating to drug using behaviours and environments; specific personal and social risks for particular using populations; and the broader socio-cultural context to contemporary intoxication, there will need to be acceptance that analysis of the various harm vectors must remain separate - the complexity of such analysis is not something that can or should be over generalised to suit political discourse or outdated legal frameworks.


  This report presents detailed results from the 2013 National Survey on Drug Use and Health (NSDUH), an annual survey sponsored by the Substance Abuse and Mental Health Services Administration (SAMHSA). The survey is the primary source of information on the use of illicit drugs, alcohol, and tobacco in the civilian, noninstitutionalized population of the United States aged 12 years old or older. Approximately 67,500 persons are interviewed in NSDUH each year. Unless otherwise noted, all comparisons in this report that are described using terms such as “increased,” “decreased,” or “more than” are statistically significant at the .05 level.


  The current study documents the changing rates of cannabis use, misuse and cannabis-related social harms among Australian adolescents as they grow into young adulthood. It utilised data from a longitudinal study of young people at ages 15, 16, 17, and 19. The rates of cannabis use were found to increase as participants aged; past year use increased from 7.5% at age 15 to 29.8% at age 19. Further; at ages 17 and 19, cannabis use was more prevalent among males than females. Among those who reported cannabis use, the rates of cannabis-related harms were low to moderate, and did not increase with age in the same manner as rates of cannabis use. The most prevalent self-reported cannabis-related harm was anxiety/depression; affecting between 20-30% of the cannabis users at each age. These findings may assist in understanding the extent of cannabis-related problems among youth, and in planning relevant services.


  Marijuana use is common in adolescence, yet neural consequences have not been well delineated. This review seeks to ascertain whether heavy marijuana use in adolescence is associated with persistent neurocognitive abnormalities, and whether adolescents are more vulnerable to the impact of chronic marijuana use than adults. Among heavy marijuana using adults, neurocognitive deficits are apparent for several days following use, but may disappear after one month of abstinence. Studies of adolescent heavy users have identified impairments in learning and working memory up to six weeks after cessation, suggesting persisting effects, yet raise the possibility that abnormalities may remit with a longer duration of abstinence. Given ongoing neuromaturation during youth, adolescents may be more vulnerable to potential consequences of marijuana use than adults. This is supported by rodent models, which show greater memory impairments in animals exposed to cannabinoids as adolescents relative to those exposed as adults. Further, adult humans who initiated use in early adolescence show greater dysfunction than those who began use later. Together, these results suggest that adolescents are more vulnerable than adults to neurocognitive abnormalities associated with chronic heavy marijuana use;
however, the impact of preexisting risk factors is unknown. Adolescents demonstrate persisting deficits related to heavy marijuana use for at least six weeks following discontinuation, particularly in the domains of learning, memory, and working memory. Further, adolescents appear more adversely affected by heavy use than adults. Longitudinal studies will help ascertain whether preexisting differences contribute to these abnormalities.


Background Debate continues about the consequences of adolescent cannabis use. Existing data are limited in statistical power to examine rarer outcomes and less common, heavier patterns of cannabis use than those already investigated; furthermore, evidence has a piecemeal approach to reporting of young adult sequelae. We aimed to provide a broad picture of the psychosocial sequelae of adolescent cannabis use.

Methods We integrated participant-level data from three large, long-running longitudinal studies from Australia and New Zealand: the Australian Temperament Project, the Christchurch Health and Development Study, and the Victorian Adolescent Health Cohort Study. We investigated the association between the maximum frequency of cannabis use before age 17 years (never, less than monthly, monthly or more, weekly or more, or daily) and seven developmental outcomes assessed up to age 30 years (high-school completion, attainment of university degree, cannabis dependence, use of other illicit drugs, suicide attempt, depression, and welfare dependence). The number of participants varied by outcome (N=2537 to N=3765).

Findings We recorded clear and consistent associations and dose-response relations between the frequency of adolescent cannabis use and all adverse young adult outcomes. After covariate adjustment, compared with individuals who had never used cannabis, those who were daily users before age 17 years had clear reductions in the odds of highschool completion (adjusted odds ratio 0.37, 95% CI 0.20-0.66) and degree attainment (0.38, 0.22-0.66), and substantially increased odds of later cannabis dependence (17.95, 9.44-34.12), use of other illicit drugs (7.80, 4.46-13.63), and suicide attempt (6.83, 2.04-22.90).

Interpretation Adverse sequelae of adolescent cannabis use are wide ranging and extend into young adulthood. Prevention or delay of cannabis use in adolescence is likely to have broad health and social benefits. Efforts to reform cannabis legislation should be carefully assessed to ensure they reduce adolescent cannabis use and prevent potentially adverse developmental effects.

Funding Australian Government National Health and Medical Research Council.


Memory problems are frequently associated with cannabis use, in both the short- and long-term. To date, reviews on the long-term cognitive sequelae of cannabis use have examined a broad range of cognitive functions, with none specifically focused on memory. Consequently, this review sought to examine the literature specific to memory function in cannabis users in the nontoxicated state with the aim of identifying the existence and nature of memory impairment in cannabis users and appraising potentially related mediators or moderators. Literature searches were conducted to extract well-controlled studies that investigated memory function in cannabis users outside of the acute intoxication period, with a focus on reviewing studies published within the past 10 years. Most recent studies have examined working memory and verbal episodic memory and cumulatively, the evidence suggests impaired encoding, storage, manipulation and retrieval mechanisms in long-term or heavy cannabis users. These impairments are not dissimilar to those associated with acute intoxication and have been related to the duration, frequency, dose and age of onset of cannabis use. We consider the impact of not only specific parameters of cannabis use in the manifestation of memory dysfunction, but also such factors as age, neurodevelopmental stage, IQ, gender, various vulnerabilities and other substance-use interactions, in the context of neural efficiency and compensatory mechanisms. The precise nature of memory deficits in cannabis users, their neural substrates and manifestation requires much further exploration through a variety of behavioural, functional brain imaging, prospective and genetic studies.


RATIONALE: Long-term heavy cannabis use can result in memory impairment. Adolescent users may be especially vulnerable to the adverse neurocognitive effects of cannabis. OBJECTIVES AND METHODS: In a cross-sectional and prospective neuropsychological study of 181 adolescents aged 16-20 (mean 18.3 years), we compared performance indices from one of the most widely used measures of learning and memory--the Rey Auditory Verbal Learning Test--between cannabis users (n=52; mean 2.4 years of use, 14 days/month, median
abstinence 20.3 h), alcohol users (n=67) and non-user controls (n=62) matched for age, education and premorbid intellectual ability (assessed prospectively), and alcohol consumption for cannabis and alcohol users. RESULTS: Cannabis users performed significantly worse than alcohol users and non-users on all performance indices. They recalled significantly fewer words overall (p<0.001), demonstrating impaired learning (p<0.001), retention (p<0.001) and retrieval (p<0.05) (Cohen’s d 0.43-0.84). The degree of impairment was associated with the duration, quantity, frequency and age of onset of cannabis use, but was unrelated to alcohol exposure or other drug use. No gender effects were detected and the findings remained after controlling for premorbid intellectual ability. An earlier age of onset of regular cannabis use was associated with worse memory performance after controlling for extent of exposure to cannabis. CONCLUSIONS: Despite relatively brief exposure, adolescent cannabis users relative to their age-matched counterparts demonstrated similar memory deficits to those reported in adult long-term heavy users. The results indicate that cannabis adversely affects the developing brain and reinforce concerns regarding the impact of early exposure.


INTRODUCTION AND AIMS: To examine the associations between substance abuse/dependence symptoms and life satisfaction, before and after adjustment for fixed and time-dynamic sources of confounding. DESIGN AND METHODS: Data were drawn from a 30year longitudinal study of a birth cohort of 987 individuals. Associations between alcohol abuse/dependence symptoms, cannabis abuse/dependence symptoms and life satisfaction were examined using repeated measures regression models. Associations were adjusted for fixed and time-dynamic sources of confounding, including family background, personality, demographics, recent life events, current employment and recent mental illness. RESULTS: There were significant associations between alcohol abuse/dependence and life satisfaction (P<0.0001) and between cannabis abuse/dependence and life satisfaction (P<0.0001). These significant associations remained after adjustment for fixed sources of confounding. However, adjusting for time-dynamic sources of confounding substantially reduced the associations. After adjustment for time-dynamic sources of confounding there were no significant associations between alcohol abuse/dependence and life satisfaction (P>0.17) or cannabis abuse/dependence and life satisfaction (P>0.25). DISCUSSION AND CONCLUSIONS: These findings suggest that associations between life substance abuse/dependence and life satisfaction can be explained by time-dynamic factors, such as employment, life events and comorbid mental illness that are associated with reduced life satisfaction. When due allowance is made for confounding, alcohol and cannabis abuse/dependence are not associated with reduced life satisfaction.


AIMS: To examine whether moderation of cannabis use among adolescent cannabis users is associated with reductions in cannabis use frequency and risk of dependence in young adulthood. DESIGN: Ten-year representative cohort study with six surveys in adolescence (mean age 14.9-17.4 years) and two in young adulthood (mean age 20.7 and 24.1 years). PARTICIPANTS: Inception cohort of 1943 Victorian secondary school students (96% response rate), with 1520 (78% of adolescent participants) interviewed in the final wave. MEASUREMENTS: Participants were classified into six groups according to the maximum level of adolescent use and the extent of subsequent moderation in such use: non-users, occasional to abstinence, occasional persisting, weekly to abstinence, weekly to occasional and weekly persisting. Outcome measures were weekly+ cannabis use and DSM-IV cannabis dependence at 20 and 24 years. FINDINGS: Thirty-one per cent reported cannabis use during adolescence. Most adolescent users had moderated their use; from occasional to abstinence (71% of occasional users), weekly to abstinence or weekly to occasional (28% and 48% of weekly+ users, respectively). By age 24, both occasional use groups were at similar, elevated risk of regular and dependent cannabis use compared to non-users. Weekly+ adolescent users were at greatest risk of these outcomes, although the weekly to abstinence group exhibited lower risk than those in the weekly persisting and weekly to occasional groups, who were at similar risk. CONCLUSIONS: While many young people have dynamic cannabis use patterns, a pattern of moderating adolescent cannabis


AIMS: To examine the association between cannabis use by 18 years and problematic cannabis use at 24 years, considering possible mediating and confounding factors. DESIGN: Ten-year representative prospective study with data from six time-points in adolescence (mean age 14.9-17.4 years) and two in young adulthood (mean
age 20.7 and 24.1 years) SETTING: Victoria, Australia. PARTICIPANTS: Inception cohort of 1943 secondary school students (95.6% response rate), with 1520 (78% of adolescent participants) interviewed in the final wave. MEASUREMENTS: Participants reported frequency of cannabis use for the past 6 months at each time-point in adolescence (age 14-17 years). Cannabis exposure was defined as: maximum frequency of use (occasional, weekly, daily), number of waves of use (1 or 2; 3-6) and first wave of use (early use: first waves 1-3). Young adult (24 years) outcomes were: weekly+ cannabis use and DSM-IV cannabis dependence, referred to collectively as problematic use. FINDINGS: Of those interviewed at age 24 (wave 8), 34% had reported cannabis use in adolescence (waves 1-6), 12% at a level of weekly or more frequent use; 37% of these adolescent cannabis users were using at least weekly at wave 8, with 20% exhibiting dependence. Persistent adolescent cannabis and tobacco use as well as persistent mental health problems were associated strongly with problematic cannabis use at 24 years, after adjustment for potential confounding factors. CONCLUSIONS: Heavy, persistent and early-onset cannabis use were all strongly predictive of later cannabis problems. Even so, occasional use was not free of later problems. Where there was co-occurring tobacco use or persistent mental health problems, risks for later problem cannabis use was higher.


BACKGROUND: Adolescent cannabis use predicts the onset of later illicit drug use. In contrast, little is known about whether cannabis in young adulthood also predicts subsequent progression or cessation of licit or illicit drug use. METHODS: 13-year longitudinal cohort study with recruitment in secondary school students in Victoria, Australia. There were six waves of adolescent data collection (mean age 14.9-17.4 years) followed by three in young adulthood (mean age 20.7, 24.1 and 29.0 years). Discrete-time proportional hazards models were used to assess predictive associations between cannabis use frequency (occasional (<weekly), weekly to less than daily and daily) in 1756 participants in earlier young adult waves and subsequent cigarette smoking, high-risk alcohol use and amphetamine, ecstasy and cocaine use, including incident use (uptake) and cessation in later young adult waves. RESULTS: Compared with continuing occasional cannabis use: (1) never use provided the strongest protection from uptake of all drugs; (2) quitting cannabis lowered rates of illicit drug use uptake; (3) weekly+cannabis users had two to three times the rates of illicit drug use uptake, while daily users had six times the rate of uptake of cigarette smoking; and (4) never use of cannabis was associated with higher rates of cessation from licit drug use, while daily cannabis predicted lower cessation rates for all drugs except cocaine. CONCLUSIONS: This study provides compelling evidence of the continuing association between cannabis, licit and other illicit drug use well into young adulthood. Preventing cannabis use uptake and use escalation remain crucial health aims given the burden associated with cigarette, alcohol and illicit drug use.


AIM: To evaluate the relationship between change in cannabis use and changed cognitive performance over 8 years. DESIGN: We used survey methodology with a cohort design. SETTING AND PARTICIPANTS: An Australian community sample aged 20-24 years at baseline. MEASURES: We assessed cognitive performance with the California Verbal Learning Test (CVLT) (immediate and delayed), Spot-the-Word test (STW), Symbol Digit Modality test (SDMT) and Digit Backwards (DB). Groups of cannabis users were defined from self-reports across three waves as: 'never' (n= 420) 'remain light' (n= 71), 'former light' (n= 231), 'remain heavy' (n= 60), 'former heavy' (n= 60) and 'always former' (since start of study) (n= 657). Planned contrasts within mixed model repeated-measures analysis of variance was used for longitudinal analysis with an adjusted alpha of 0.01. FINDINGS: Data were obtained from 2404 participants with 1978 (B2.3%) completing wave 3. At baseline there were significant differences between cannabis groups on CVLT (immediate and delayed) and SDMT. However, after controlling for education, gender, gender x group and gender x wave, there were no significant between-group differences and only CVLT immediate recall reached adjusted statistically significant longitudinal change associated with changed cannabis use (group x wave P = 0.007). Specifically, former heavy users improved their performance relative to remaining heavy users (estimated marginal means: former heavy 6.1-7.5: remain heavy 6.4-6.6). CONCLUSIONS: Cessation of cannabis use appears to be associated with an improvement in capacity for recall of information that has just been learned. No other measures of cognitive performance were related to cannabis after controlling for confounds.

BACKGROUND: Marijuana intoxication appears to impair response inhibition, but it is unclear if impaired inhibition and associated brain abnormalities persist after prolonged abstinence among adolescent users. We hypothesized that brain activation during a go/no-go task would show persistent abnormalities in adolescent marijuana users after 28 days of abstinence. METHODS: Adolescents with (n = 16) and without (n = 17) histories of marijuana use were compared on blood oxygen level dependent (BOLD) response to a go/no-go task during functional magnetic resonance imaging (fMRI) after 28 days of monitored abstinence. Participants had no neurological problems or Axis I diagnoses other than cannabis abuse/dependence. RESULTS: Marijuana users did not differ from non-users on task performance but showed more BOLD response than non-users during inhibition trials in right dorsolateral prefrontal, bilateral medial frontal, bilateral inferior and superior parietal lobules, and right occipital gyri, as well as during "go" trials in right prefrontal, insular, and parietal cortices (p < 0.05, clusters > 943 microl). Differences remained significant even after controlling for lifetime and recent alcohol use. CONCLUSIONS: Adolescent marijuana users relative to non-users showed increased brain processing effort during an inhibition task in the presence of similar task performance, even after 28 days of abstinence. Thus, increased brain processing effort to achieve inhibition may predate the onset of regular use or result from it. Future investigations will need to determine whether increased brain processing effort is associated with risk to use.


OBJECTIVE: To produce an expert consensus hierarchy of harm to self and others from legal and illegal substance use. DESIGN: Structured questionnaire with nine scored categories of harm for 19 different commonly used substances. SETTING/PARTICIPANTS: 292 clinical experts from across Scotland. RESULTS: There was no stepped categorical distinction in harm between the different legal and illegal substances. Heroin was viewed as the most harmful, and cannabis the least harmful of the substances studied. Alcohol was ranked as the fourth most harmful substance, with alcohol, nicotine and volatile solvents being viewed as more harmful than some class A drugs. CONCLUSIONS: The harm rankings of 19 commonly used substances did not match the A, B, C classification under the Misuse of Drugs Act. The legality of a substance of misuse is not correlated with its perceived harm. These results could inform any legal review of drug misuse and help shape public health policy and practice.


For more than a century, there has been a growing interest in school climate. Recently, the U.S. Department of Education, Center for Disease Control and Prevention, Institute for Educational Sciences, a growing number of State Departments of Education, foreign educational ministries, and UNICEF have focused on school climate reform as an evidence-based school improvement strategy that supports students, parents/guardians, and school personnel learning and working together to create ever safer, more supportive and engaging K-12 schools. This work presents an integrative review on school climate research. The 206 citations used in this review include experimental studies, correlational studies, literature reviews, and other descriptive studies. The review focuses on five essential dimensions of school climate: Safety, Relationships, Teaching and Learning, Institutional Environment, and the School Improvement Process. We conclude with a critique of the field and a series of recommendations for school climate researchers and policymakers.


Drug policy makers continuously face a changing pattern of drug use, i.e. new drugs appear on the market, the popularity of certain drugs changes or drugs are used in another way or another combination. For legislative purposes, drugs have mostly been classified according to their addictive potency. Such classifications, however, lack a scientific basis. The present study describes the results of a risk assessment study where 19 recreational drugs (17 illicit drugs plus alcohol and tobacco) used in the Netherlands have been ranked by a Dutch expert panel according to their harm based on the scientific state of the art. The study applies a similar approach as recently applied by Nutt et al. [Lancet 2007;369:1047-1053], so that the results of both studies could be compared. The harm indicators scored are acute and chronic toxicity, addictive potency and social harm. The aim of this study is to evaluate whether the legal classification of drugs in the Netherlands corresponds with the ranking of the drugs according to their science-based ranking of harm. Based on the results, recommendations are formulated about the legal classification of recreational drugs at national and international level which serves a rational approach for drug control.


The focal point of this paper is the transition from drug use to drug dependence. We present new evidence on risk for starting to use marijuana, cocaine, and alcohol, as well as risks for progression from first drug use to the onset of drug dependence, separately for each of these drugs. Data from the National Comorbidity Survey (NCS) were analyzed. The NCS had a representative sample of the United States population ages 15-54 years (n = 8,098). Survival analysis techniques were used to provide age- and time-specific risk estimates of initiating use of marijuana, cocaine, and alcohol, as well as of becoming dependent on each drug. With respect to risk of initiating use, estimated peak values for alcohol and marijuana were found at age 18, about two years earlier than the later peak in risk of initiating cocaine use. With respect to risk of meeting criteria for the clinical dependence syndrome, estimated peak values for alcohol and marijuana were found at age 17-18. Peak values for cocaine dependence were found at age 23-25. Once use began, cocaine dependence emerged early and more explosively, with an estimated 5-6% of cocaine users becoming cocaine dependent in the first year of use. Most of the observed cases of cocaine dependence met criteria for dependence within three years after initial cocaine use. Whereas some 15-16% of cocaine users had developed cocaine dependence within 10 years of first cocaine use, the corresponding values were about 8% for marijuana users, and 12-13% for alcohol users. The most novel findings of this study document a noteworthy risk for quickly developing cocaine dependence after initial cocaine use, with about one in 16 to 20 cocaine users becoming dependent within the first year of cocaine use. For marijuana and alcohol, there is a more insidious onset of the drug dependence syndrome.


Chronic marijuana users (MJ Users) perform poorly on the Iowa Gambling Task (IGT), a complex decision-making task in which monetary wins and losses guide strategy development. This functional magnetic resonance imaging (fMRI) study sought to determine if the poor performance of MJ Users was related to differences in brain activity while evaluating wins and losses during the strategy development phase of the IGT. MJ Users (16) and Controls (16) performed a modified IGT in an MRI scanner. Performance was tracked and functional activity in response to early wins and losses was examined. While the MJ Users continued to perform poorly at the end of the task, there was no difference in group performance during the initial strategy development phase. During this phase, before the emergence of behavioral differences, Controls exhibited significantly greater activity in response to losses in the anterior cingulate cortex, medial frontal cortex, precuneus, superior parietal lobe, occipital lobe and cerebellum as compared to MJ Users. Furthermore, in Controls, but not MJ Users, the functional response to losses in the anterior cingulate cortex, ventral medial prefrontal cortex and rostral prefrontal cortex positively correlated with performance over time. These data suggest MJ Users are less sensitive to negative feedback during strategy development.


While precise figures are unavailable, 2007 estimates by California’s Legislative Analyst suggest that California’s nontraditional or alternative school system serves between 10% and 15% of the states 6,300,000 students yearly. In the first large-scale study of its kind, analysis of recent California Healthy Kids Survey (CHKS) data show a sharply higher prevalence of high-risk behaviors and problems among 25,600 students in alternative continuation and community day schools than among 11th graders in California’s traditional or comprehensive high schools. Nontraditional students also appear to have fewer developmental supports or protective factors in their lives.


This is the first report to provide the survey results from this representative biennial statewide sample. The data were collected between fall of 2011 and spring of 2013 from 39,165 students enrolled in the randomly-selected sample of 109 secondary schools.

AIM: We extend the literature on the association of early onset of drug use and estimated risk for developing a substance use disorder (SUD) by investigating the risk that recent onset of alcohol and cannabis use confers for developing a substance use disorder at each chronological age of adolescence and young adulthood (12-21-years-old). DESIGN: Using 2003 data from the National Survey on Drug Use and Health [Substance Abuse Mental Health Service Administration (SAMHSA), 2004. Overview of Findings from the 2003 National Survey on Drug Use and Health. Office of Applied Studies, NSDUH Series H-24, DHHS Publication No. SMA-04-3963, Rockville, MD], we computed separate risk indices for developing an alcohol and cannabis use disorder for recent (prior 2 years) alcohol and cannabis users, respectively, at each age from 12 to 21 years of age, and compared estimated risk to recent onsets users among respondents aged 22-26. FINDINGS: The results indicated that the teenage years were strongly linked to an elevated risk status. The odds ratio (OR) of having a prior year alcohol use disorder (AUD) among recent onset alcohol users was significantly elevated for youth at ages 14, 16, 17 and 18 (range of ORs=2.0-2.1) compared to the estimated risk for AUD among recent onset users aged 22-26. For cannabis, we obtained significantly elevated ORs for a cannabis use disorder (CUD) at each of teenage years (ages 12-18; range of ORs=3.9-7.2), when compared to older recent onset users (aged 22-26). CONCLUSIONS: These data provide further epidemiological support that adolescence is a particularly vulnerable period for developing a SUD.