Evaluation of the imapct of legalizing marijuana on society in the state of Colorado, USA

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EVALUATION OF THE IMPACT OF LEGALIZING MARIJUANA ON SOCIETY IN THE STATE OF COLORADO, USA

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LIST OF ABBREVIATIONS

11-OH-THC	11-hydroxy-Tetrahydrocannabinol
BHO	Butane Hash Oil
BrAC	Breath Alcohol Level
CBD	Cannabinoid
CBG	Cannabigerol
CHS	Cannabinoid Hyperemesis Syndrome
CI	Confidence Interval
COOH-THC	Carboxy-Tetrahydrocannabinol
CS	Cannabinoid Screen
CDPHE	Colorado Department of Public Health and Environment
DEA	Drug Enforcement Agency

DUI	Driving Under the Influence
ED	Emergency Department
HKCS	Healthy Kids Colorado Survey
5HT1A	5-hydroxytryptophan-1A
IQ	Intelligence Quotient
MG	Milligram
MML	Medical Marijuana Law
MTF	Monitoring the Future
NMMS	Non-Medical Marijuana States
NHTSA	National Highway Traffic Safety Association
NG	Nanogram
OR	Odds Ratio
UCR	Uniform Crime Reporting
UDHQ	Universal Donor Health Questionnaire
USBP	United States Border Patrol
TBSA	Total Body Surface Area
THC	Tetrahydrocannabinol

SUMMARY

Background and Aims: The legalization of marijuana in Colorado and its effect on health issues such as pediatric intoxications, BHO burns, teen use and CHS is evaluated. Social issues such as criminality and traffic concerns are covered as well. As of January 2014, Colorado has opened commercial dispensaries after having legalized recreational use in 2012. This means that there has been a limited amount of time in which to fully appreciate the consequences of recreational legalization.

Methods: PubMed and Google Scholar were used to find pertinent material. Search terms included but not limited to: public health, Colorado, marijuana, cannabis, teen use, legalization, etc. The search was primarily focused on Colorado. Included, however, were government studies and reports from such agencies as the NHTSA, CDPHE and USBP. Such studies were given particular weight since they were designed for use by policymakers, have epidemiological importance and are broad based. Longitudinal studies with data pre-legalization and post legalization were especially selected for their value in gauging the impact with regard to the issues and concerns described above. Evidence-based research and quality of study design were the primary criteria for study selection.

Findings: Marijuana legalization does not seem to increase teen use, but a low perception of risk does predispose toward use. Pediatric intoxication calls, visits to the emergency room and hospitalizations are increasing dramatically albeit in limited numbers. Butane hash oil burns are increasing, but is a very minor contributor to the proportion of burn patients overall. Traffic has been affected in terms of increasing DUIs involving cannabis with more screens being conducted by law enforcement. However, these DUIs do not necessarily translate into traffic accidents. Criminality has not increased, aside from property crime such as robberies involving commercial dispensaries operating on a cash basis.

Key Words: Marijuana, Legalization, Colorado.

1. Introduction

1.1 Time Line of Legal Status

Marijuana is a psychoactive substance which has been used historically both medicinally and recreationally. From 1914 onward, the United States criminalized the use of marijuana. In 1970, Congress placed the substance into Schedule I, thus defining the substance as having no recognized medicinal use.

Efforts toward decriminalization began in 1977 (Stephen Stiff 2014). Colorado decriminalized marijuana in 1975. This meant that possession resulted in a fine instead of a criminal penalty (Emily Scott 2010). Medical marijuana was legalized November 2000. It was approved for use in cancer, glaucoma, HIV/AIDs, seizures, severe pain, muscle spasms and cachexia. Patients were permitted to grow six plants for themselves (Colorado Constitution 2000).

The Colorado Department of Public Health and Environment is tasked with medical marijuana card distribution. In the first seven years following medicinal legalization, there were around 6,000 card holders overall. In 2009, an expansion of medical marijuana occurred with the opening of dispensaries. Prior to this, “caregivers” grew plants for patients. Dispensaries were not specifically prohibited according to Colorado Amendment 20 (Medical Use of Marijuana 2000). It did not specify how many patients a “caregiver” was limited to serve, so dispensaries began to operate.

In 2009, applications for medical marijuana licenses grew to 41,000. In November 2012, Colorado Amendment 64 was passed, thus allowing those over 21 to grow up to six plants, possess up to one ounce and be able to buy marijuana (Jeffrey Miron 2014).

2. Traffic Safety Concerns

2.1 Crash and Injury Risk While Driving Under the Influence

With marijuana legalized for recreational use, an increase of DUIs and collisions were anticipated. The relationship between driving and substance use is quite well

investigated as far as alcohol is concerned but less so with other intoxicants. There are several factors worth examining: the number of crash fatalities, the number of DUIs and the extent to which marijuana affects driving ability. Likewise, it is important to identify risk reduction factors that could be associated with driving and marijuana use.

As for a raw increase in fatal accidents, there is no apparent evidence from Colorado Department of Transportation data. From 2002 to 2015, fatal accidents among drivers under the age of 65 has steadily decreased. Fatalities of drivers, passengers, pedestrians and bicycles combined have decreased from year to year since 2002. Most notably, during the initial year of recreational legalization (2014-2015), there was no increase in fatalities.

Marijuana has been shown to affect driving related behavior such as road tracking, psychomotor function and divided attention (Sarah Urfer et al. 2014). It is unclear, however, whether this translates into an increased amount of collisions. There have been many studies regarding impairment while driving under the influence of marijuana. The results have varied with estimates of no risk to quite elevated risk.

Investigations of the relationship between use and crash risk have been conducted using simulation, case-control and culpability analysis. Limitations of such studies include the self-reporting of drug use, which is subject to respondent bias. It is more reliable to confirm by laboratory analysis either through oral fluid, blood or urine sample. Creating a standardized level to define marijuana intoxication from blood sample level, however, is problematic. The concentration may not indicate the intoxication level which an individual is experiencing. Chronic versus occasional users could have the same level of blood concentration but different levels of intoxication. The correlation between concentration and intoxication is not as directly correlated as with alcohol. The resultant measurements from positive CS screens indicate that there has been use but not that this was necessarily prior to driving.

Given these issues, the best study design seems to be case-control with laboratory confirmation (Richard Compton & Amy Berning 2015). In the case-control design, subjects are matched for driving conditions, severity of injury and time of day driving

occurred. The case-control design with laboratory analysis seems to be the best methodology to elucidate the risk of accidents while DUI.

For the purpose of determining the impact on crash risk for those driving under the influence with alcohol and drugs, the National Highway and Traffic Association implemented the largest case-control study of its kind. Some 3,000 cases involving crashes were compared to 6,000 non-crash control cases. Participation in the study was anonymized and voluntary with a high participation rate. Efforts were made to compare the location, time of day, direction of driving and day of the week in each case versus control cases.

Only individuals with confirmed psychoactive metabolites were included in the study. There were 10,221 breath alcohol measurements, 9,285 oral fluid and 1,764 blood samples collected. The most commonly orally confirmed intoxicant aside from alcohol was marijuana followed by: stimulants, narcotic-analgesics, sedatives and antidepressants. Marijuana was positive in 7, 6% of crash-involved drivers and 6,1% of controls. Overall, 16% of individuals tested positive for an illegal or legal drug or pharmaceutical. While blood alcohol level and the dose-relation response were evaluated in this study, the dose-response with marijuana was not followed. Any concentration of active metabolites found, however, was included.

The unadjusted OR was 1.25. However, this result did not account for age, gender, ethnicity or alcohol use. Men are more involved in collisions than women and younger individuals, who are presumably willing to engage in riskier driving behavior than older individuals. Once these factors were accounted for, the adjusted OR was 1, that is, there were even odds of a crash occurring with a driver under the influence of marijuana or otherwise. The study confirmed what others have noted with regard to alcohol. As a point of comparison, even at the legal BrAC of 0.08, the OR was 4, a dramatically higher risk, and increased in a dose-dependent manner (Richard Compton & Amy Berning 2015).

The OR may be reduced by compensatory driving behaviors such as driving much more slowly, as some have suggested. Likewise, marijuana users presumably consume more at home as opposed to public spaces such as bars, so smokers are less likely to drive.

Allowing for smoking in public places might increase the OR. The Colorado regulation to prevent smoking in public places may, in fact, limit the OR with regard to marijuana DUIs.

The Institute of Transport Economics in Norway made a systematic review and meta-analysis of 66 studies that evaluated drug use and its association with crash risk. Of the 264 estimates that were gathered with regard to risk estimation of drug use, 44 of them were for cannabis. This study did not evaluate alcohol. The study designs identified in the estimates for cannabis included cohort, culpability, case-control and sample surveys. Study quality was evaluated on methods used: self-report, blood sample, oral fluid or urine sampling. Quality was also assessed on whether the study included a dose-response relationship, the severity of accidents as well as how well confounding variables were controlled for. Publication bias was also examined. The meta-analysis controlled for 24 confounding variables including, gender, age, driving experience, etc.

A study with less than 5 estimates was considered to be of questionable value. There were 10 estimates for fatal crashes, 15 for crashes involving injury and 17 including property damage. After adjusting for publication bias, the OR was 1.26 with regard to accidents resulting in property damage and was found to be statistically significant. Fatal accidents and accidents involving injury were statistically insignificant and found to be 1.26 and 1.10 respectively.

The estimates were performed without regard to sampling methodology, be it self-report or laboratory confirmed. When accidents involving injuries based on laboratory confirmed values were evaluated, the OR for the chance of an accident was 1.16. More rigorously controlled studies tended to have lower estimations of risk in comparison to less well controlled studies, according to the researcher. Moreover, it was noted that increased rigor in future research with regard to control of confounding factors and the use of laboratory confirmation provide for a more reliable OR (Rune Elvik-2013).

A study was performed by the Denver Colorado Emergency Department to evaluate crash responsibility of injured motorists. All levels of injury severity were surveyed along with any vehicular type and all individuals over the age of 18 until the study reached some 400 cases. Urine samples were taken within one hour of being admitted to the

emergency department. The level of detection applied was 5 ng/ml for THC and 11-OH-THC, the psychoactive metabolite of THC indicating use within 30 hours of a test. COOH-THC was also tested to indicate remote use.

A case-control approach with a culpability component was chosen. Cases judged responsible for a crash were compared to control cases judged not to be responsible for a crash. A traffic crash analyst was blinded to toxicological results and previous citations for DUI. Of the total cases, about 32% of the samples contained impairing substances with marijuana accounting for 17% and alcohol accounting for 14% of those samples.

The crash analyst took into account pre-crash variables such as: direction of travel, the number of vehicles on the road, speed, improper driving acts and previous traffic violations. The analyst took into consideration exacerbating conditions such as weather, adverse road conditions, etc. Drivers not using an intoxicant or alcohol were found to be responsible for crashes in 47% of all cases. Seventy samples of the total 414 cases were positive for marijuana, but not enough urine was left to check for acute, recent or remote use. Fifty seven samples were tested and then compared.

Marijuana use by itself was not linked to any increase in crash risk in acute, recent or remote use (OR = 1,1, CI = 0, 5-2,4). When age, gender and seat belt use were accounted for, only alcohol use resulted in a higher crash risk (OR = 3,2). However, marijuana and alcohol used together resulted in higher crash risk. The researchers speculate that drug use in itself may not be the most significant factor in driving impairment, rather individuals using these substances tend to have traits such as risk taking, impulsiveness and aggressive driving behaviors which make them more prone to accidents (Steven Lowenstein & Jane Koziol-McClain 2001).

2.2 Legalization and Relationship to DUI

A study specific to Colorado (Sarah Urfer et al. 2014) contained an analysis of blood samples from DUI cases over the period of 2011 to February 2014. Colorado has set the range of acceptable blood concentration levels at <5 ng/ml. Impairment presumably becomes more noticeable above this level. Of 12,082 cases of suspected DUIs, 4,235 Cannabinoid Screens were requested by law enforcement officers. An individual testing

positive for alcohol was not scrutinized further for other intoxicants. Of those screens, 2,621 tested positive. These were then retested for THC and its metabolites. Screens below 2 ng/ml were not included. Of those retested, 1,598 were positive. The percentage of law enforcement requests for CSs increased from 28% in 2011 to 35% in 2014. The rate of CSs remained consistently around 62% positive while the screens with a concentration above 2 ng/ml for THC increased from 28% to 68%. The median concentration of THC found was 6,3 ng/ml.

This study also contained a frequency of distribution of cases by THC concentration. A large proportion of the cases 890/1848 fell below the state regulated level of 5 ng/ml. The next largest group was 760/1848 which was in the 5-14 ng/ml range (Sarah Urfer et al. 2014).

Given the pharmacokinetics of marijuana, it may be assumed that the majority of individuals testing positive had not smoked immediately prior to driving but had probably done so three or more hours before. Peak plasma concentration is anywhere from 100-200 ng/ml and falls to 5 ng/ml in the course of three hours. A single "hit" from a marijuana cigarette can cause a blood concentration level of 7-18 ng/ml (NHSTA Drugs and Human Performance 2016).

An increase in Colorado DUIs was confirmed in this study. Furthermore, the cohort responsible for this increase was identified as males with an average age of 24 since 87% of the samples collected were from this group. Since the study used lab confirmed results at the time of driving, it is probably a study deserving more weight than studies that do not. These findings do provide some evidence Denver can use for determining future emergency response in light of new marijuana laws.

Still, it is possible that the increase found may be an artefact due to law enforcement officers being more likely to request a CS following recreational legalization or being better at recognizing DUIs or even being more suspicious of young male drivers. Further study may be needed to confirm the results of this study.

3. Marijuana Legalization and Its Effect on Crime

3.1 Marijuana and Crime Introduction

There have been concerns that an increase in violent and non-violent crime occurring post-legalization is possible. Violent crimes include murder, rape, robbery and aggravated assault. Non-violent crimes or “property crimes” include burglary, larceny and vehicle theft. All of these crimes are “Part I offenses.”

The federal government has classified marijuana as a Schedule I drug, which means it is not identified for any medicinal use and is the tightly regulated. Individual states, however, have passed legalization laws. The federal government has the power to shut down dispensaries and grow factories, but has chosen not to intervene and to let state law stand.

However, due to marijuana being illegal federally, marijuana businesses such as dispensaries do not have access to the banking system. As a result, it is entirely a cash business. This could lead to an increase in property related crime (Catherine Alford 2014). On the other hand, it has been conjectured that a legal way to satisfy marijuana demand might shrink the “black market” supply (Jeffrey Miron 2014). By extension, people may be less exposed to violence by not having to acquire it through illegal sources.

3.2 Uniform Crime Reporting System Data Conclusions

Violent and non-violent crimes are reported through the “Uniform Crime Reporting System.” From January 2009-July 2014, there was no significant increase of robberies, burglaries, aggravated assaults or murders in Denver, Colorado. UCR data was aggregated from 1960-2012 for Colorado with regard to these same crimes. There was also no increase in these crimes after decriminalization, medical marijuana legalization, etc. (Jeffrey Miron 2014). The post-legalization period of medical marijuana after 2009 is covered by this data (few people with medical marijuana cards existed prior to this time) and the statistics from Denver are especially significant because it is the city with highest concentration of dispensaries within the state.

The effect of medical marijuana laws on Part I offenses from UCR data from 1990-2006 was evaluated. States passing medical marijuana laws were compared to those that did

not. The study contained an assessment as to whether states adopting MML were subject to a change in their crime trend. Sociodemographic variables were controlled for: unemployment rate, per-capita income, those living below the poverty line, proportions of residents in the age groups of 15-24, 25-34 and 35-44, number of prison inmates, etc. The conclusion was that all states, regardless of MML, were subject to a decrease of Part I offenses, but those that passed MMLs had a more drastic reduction. The study's conclusion was that there was no positive association between crime increase with MML legalization (Robert Morris et al. 2014).

A different approach was taken in another study with the same UCR data. Effective legalization was taken into consideration. This means the time period when marijuana was not just made legal, but was also accessible to buy. These changes were examined across states to analyze MML in relation to crime rates (Catherine Alford 2014). It is too early to fully assess the effect of recreational legalization on crime rates since legalization has only occurred in the recent past.

Pre-existing differences found in the crime trends of those states that legalized were compared to those that did not. The paper included these state-specific crime trends affecting MML. In particular, the legalization of dispensaries versus home cultivation was examined with regard to their separate effects on crime rates. The introduction of dispensaries was found to be associated with an increased robbery rate of 10,98% and a property crime of 8,12%. Home cultivation was not significantly associated with an increase in property crime whereas and it was negatively associated with a robbery rate of 10,03% (Catherine Alford 2014).

3.3 U.S Border Marijuana Seizures

According to a White House report compiled from NSDUH, Americans are spending about 40 billion dollars a year on marijuana (Beau Kilmer et al. 2014). Much of the supply to satisfy this demand comes from Mexico. The U.S. border patrol releases annual statistics on marijuana, cocaine, heroin and methamphetamine seizures. They monitor activity at the border with Canada, the coasts of the U.S. and the southwest

border. During 2011-2015, over 99% of marijuana seized came from Mexico through ports of entry such as California, Texas, etc.

Table 1: Drug seizures from the southwestern border of the United States by Border Patrol 2011-2015. Adapted from: Data from U.S. Border Patrol sector profiles for each fiscal year (2011-2015), p 4.

	Marijuana (Million Pounds)	Cocaine (pounds)	Heroin (ounces)	Methamphetamine (pounds)
2011:	2,52	8,763	6,191	1,888
2012:	2,29	5,992	6,383	3,430
2013:	2,43	3,910	8,937	3,446
2014:	1,92	4,443	9,205	3,771
2015:	1,54	4,294	8,237	6,429

Seizures of marijuana on the southwestern border have noticeably declined as demand is gradually being replaced by a supply of domestically produced marijuana. As demonstrably shown in Table 1 above, Drug Enforcement Agency data include more reports of cases involving domestic marijuana versus marijuana entering from outside the U.S. In its National Drug Assessment Report, the DEA attributes this change due to lower quality marijuana being produced in Mexico compared to domestic sources (Drug Enforcement Agency 2015). In contrast, heroin and methamphetamine seizures have increased substantially as marijuana seizures decrease. As the price of marijuana decreases and quality of domestic suppliers improve, the demand for marijuana from outside the US will most likely continue to drop, thereby forcing cartels to continue expanding operations in cocaine, heroin and methamphetamines.

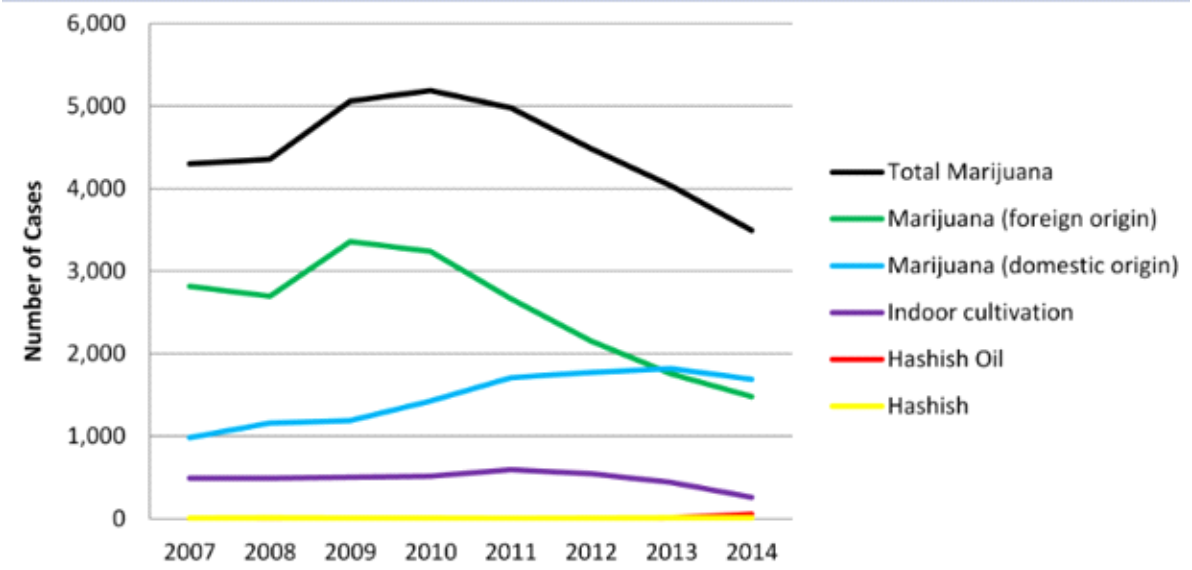

Figure 1: Domestic marijuana cases year 2007-2014. According to: Drug Enforcement Agency: national drug assessment summary (2015). p. 66.

Figure 1 above shows how 2013 was the first time in recent history that the number of cases involving marijuana of domestic origin is higher than marijuana of foreign origin. The number of domestic origin cases has been steadily increasing while the number of cases of foreign origin have steadily been decreasing post commercialization in Colorado.

4. Health Consequences of Legalization

4.1 Effect on the Blood Supply

An article in the Transfusion Journal added a potential implication for the general blood supply after legalization. "Overall, we are concerned that these events may create a perception of social and medical approval of marijuana and use among blood donors, which may lead to blood donor confidence that is it safe to donate blood, even after recent marijuana use." (Garret Booth & Eric Gehrie 2014)

The Transfusion Journal article published a study about prevalence of illicit drugs in the plasmapheresis supply. It discovered that out of 75 paid plasmapheresis donors, 20% of

those had marijuana metabolites present. Eleven of the samples were found to have cocaine metabolites and three samples contained both cocaine and marijuana (Peter Hellstern et. al 2003). This could indicate lack of public awareness of risk associated with drug use and donation. A wider study is necessary to see to what extent this problem may exist, especially in Colorado and Washington. Specific recommendations for donor screening may result from further findings and any risks identified by the study should be made known to the public.

As of yet, there has not been any conclusive verification whether presence of marijuana metabolites in the supply is safe or not. For this reason, the author suggested it might be wise to remove this group of people from the donor pool. The authors of the article suggested adding a question to the UDHQ asking about marijuana use during the pre-selection process of donors.

Due to blood being exchanged between states, it is possible that tainted blood could show up elsewhere in greater proportions apart from Colorado and Washington where marijuana has been legalized. This could have a potentially harmful effect on populations requiring transfusions such as premature infants. (Garrett Booth & Eric Gehrie 2014) Likewise, in a case where a pregnant woman is receiving a transfusion, there could be potential effects to the fetus in utero from marijuana metabolites.

4.2 Cyclical Vomiting Syndrome

Cannabis hyperemesis is seen in heavy daily users of cannabis. The phases of the clinical course include a prodromal, hyperemetic and recovery period. (Jonathan Galli et. al 2011) The emetic period leads to persistent vomiting and nausea for 24-48 hours leading to dehydration and subsequent emergency department visits. Patients who ultimately quit using cannabis had symptom relief. Patients also had a learned behavior of hot showering in order to achieve symptom relief. There were associated autonomic disturbances with diaphoresis, flushing and body temperature changes as well. (J Allen et. al 2004) Treatment focuses on supportive care for dehydration with intravenous fluids. Generally, the vomiting is resistant to treatment with anti-emetics. (Jonathan Galli et. al 2011)

Some case reports characterized the abdominal pain as “colicky,” but the largest case report performed by the Mayo Clinic (n = 98) found that pain type was not uniform. The pain was generally in the epigastric or periumbilical areas of the abdomen. They found that symptom timing was usually in the morning. The greatest proportion of patients was under 50 years of age, which is in line with the national demographic of those using marijuana recreationally (Douglas Simonetto et. al 2012). The lack of standardization of clinical criteria for CHS (Cannabis Hyperemesis Syndrome) may delay CHS diagnosis in some cases for many years. The wide range of differential diagnoses may also lead to many unnecessary clinical tests being performed. Moreover, the confusion of cyclical vomiting with cannabis hyperemesis (Jonathan Galli et. al 2011) adds to the difficulty of a proper diagnosis.

Paradoxically, marijuana is generally viewed as an anti-emetic. However, there have been case reports of intravenous marijuana use causing gastrointestinal distress similar to that seen in cyclical vomiting syndrome. (Nosratola Vaziri et. al 1981) (Daniel Brandenbeurg & Richard Wernick 1983)

The reason for these emetic effects could be due to cannabinoids, non-psychotropic compounds found in marijuana. CBD acts on CB1, CB2 and 5-HT1A receptors and seems to have anti-emetic effects at low doses while at high doses have an emetic effect. CBG is antagonistic at the CB1 and 5-HT1A receptors which could explain the pro-emetic effect. Furthermore, it has been suggested that genetic polymorphisms of liver enzymes could be responsible for some people metabolizing more pro-emetic metabolites. Another explanation is that the effects of THC’s anti-emetic properties are interfered with by the gut response to CB1 receptor stimulation, which causes altered intestinal mobility and lower esophageal sphincter relaxation. (Jonathan Galli et al 2011)

Since mostly case studies and anecdotal reports have been available up to now, the legalization in Colorado has created an environment in which to evaluate CHS on a large scale. In a retrospective cross-sectional study from Colorado, ED visits were

reviewed from pre-legalization (November 1, 2009-October 31, 2009) and post-liberalization (June 31, 2010-May 31, 2010). Causes of vomiting and nausea were excluded if they were due to infectious or cancerous etiologies, etc. The prevalence of CHS was found to be 41 per 113,262 pre-liberalization to 87 per 125,095 post-liberalization. (Howard Kim et. al 2015) Further epidemiologic studies may help to clarify the extent of this problem and aid in evaluating the problem as well as to identify the underlying mechanism of CHS.

4.3 Pediatric Exposure

One of the public health effects of marijuana legalization is the potential for pediatric intoxication and the consequences of this. Pediatric health consequences can include CNS symptoms such as lethargy, dizziness, coma, somnolence and ataxia. A particularly disturbing clinical effect can also be respiratory insufficiency, which could necessitate intubation. Wang retrospectively compared 1378 patients under the age of 12 who visited the emergency department for accidental ingestions and found that 14 had marijuana intoxication.

The Rocky Mountain Poison and Drug Center data confirms Wang's suspicion of an increased trend in pediatric intoxications, as does Colorado Hospital Association data from 2000-2014. Data below in Figure 2 shows a steady increase of emergency calls to the Poison and Drug Center follow commercialization of marijuana over the 2009-2014 period—an increase of 276% for persons 24 and younger. Calls increased by 450% during the same period for children eight or younger. Calls increased by 927% for adults 25 or older.

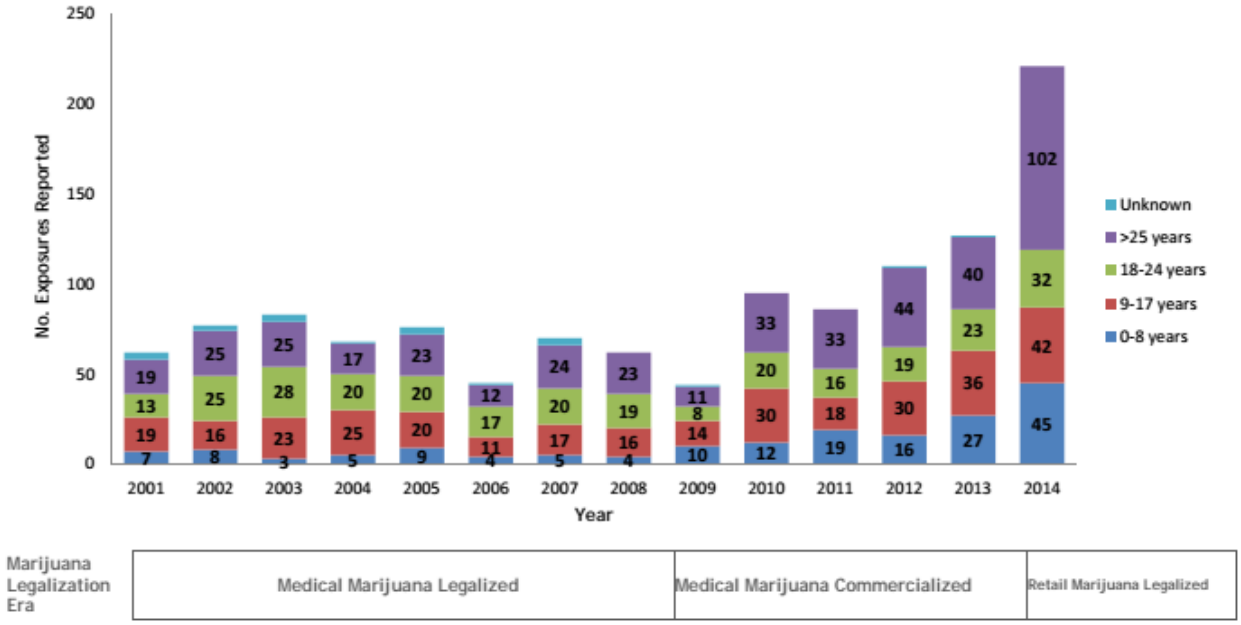

Figure 2: Rocky Mountain Poison and Drug Center Marijuana Exposure Calls through December 31, 2014 by Age Group of Case. According to: Barker L, Hall K et al. (2015a), p. 163.

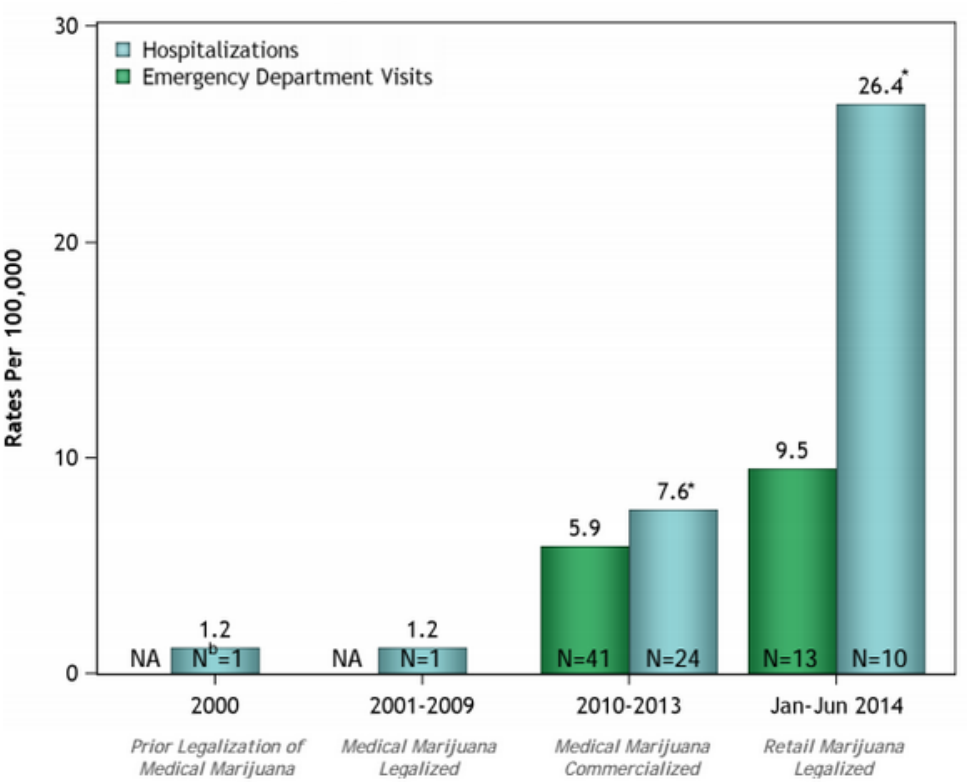

Figure 3: Colorado hospital Association data 200-2014. Rates of hospitalizations (HD) and emergency department (ED) visits with possible marijuana exposures in children up to 9 years per 100,000 HD and ED visits in children under 9 year old by time period in Colorado. According to: Barker L, Hall K et al. (2015), p. 11.

Wang compared patients pre-liberalization of marijuana before 2009 to intoxications after October 1, 2009. Intoxications had increased from zero cases pre-liberalization to 14 cases post-liberalization. (George Wang et. al 2013) While these results are not negligible, the scope of the problem is much smaller in comparison to the most common intoxications he found in the Emergency Department. The majority of intoxications were from other pharmaceuticals, most commonly acetaminophen, antihistamines and antidepressants. It is worth noting that none of the 14 patients identified in Wang's study suffered any lasting morbidity.

The most common route of pediatric intoxication found in Wang's study was through edibles. Edibles come in variety of forms such as candies, baked goods and drinks. These are often packaged in ways that might resemble children's foods, thus making them more appealing to children. There is no consistency of dosing in edible products. These factors increase the potential for such cases and untoward consequences. Children are particularly at risk for serious acute side effects in comparison to adults. Adults can withstand much higher concentrations of THC. For example, 100 mg in adults could cause delirium and anxiety, however, this same dose in children could cause respiratory issues (Andrew Monte et. al 2015).

Edibles are the most likely route of intoxication for children as other methods of consumption such as smoking, which is less feasible or attractive in this age range. In order to combat intoxications, moves to regulate packaging as marijuana edibles indistinguishable from normal food product appear to be reasonable precautions. Colorado, after passing Amendment 64, has responded to such potential problems by requiring child-resistant packaging and a warning label. Colorado has also created regulations by limiting the concentration of marijuana in edibles to 10 mg (Robert MacCoun & Michelle Mello 2015).

According to a systematic review done by the Colorado Department of Public Health and Environment in regards to Unintentional Marijuana Exposures in Children, they found evidence that child-resistant packaging could be moderately effective given that legalization of marijuana is moderately correlated with an increase in Emergency Department visits for intoxications (Daniel Vigil-2015). Wang found that the intoxicated children were in the age range of two years old (George Wang et. al 2013). With this age group, it is plausible that child-resistant packaging could be effective, but older children and adolescents would have much less problem overcoming the obstacles presented by child-proof packaging.

4.4 Butane Hash Oil Burns and Explosions

Butane hash oil, colloquially known as "dabs," is a waxy extraction from marijuana. It is 90% pure THC. The extraction process utilizes butane which is a highly flammable substance. Individuals who get burned tend to have done this process in an environment that is not well ventilated. Butane is quite dense and accumulates in the lower portion of a room. Static can cause it to spark and ignite. When it ignites, it can cause home explosions and burns. These tend to be flash fires which ignite an individual's clothes, but they do not tend to be blast injuries involving shrapnel.

In a cross-sectional study from the periods of January 1, 2008 to August 31, 2014, the incidence of hash oil burns was evaluated. Data was gathered from the National Burn Repository. There were 29 unique patients, mostly men with a median age of 26. There were zero cases pre-liberalization, 19 cases from the period of October 2009 to December 2013 and 12 during 2014. On average, TBSA involvement was 10% and an average hospital stay was10 days. Many patients needed ventilator support and/or skin grafting. (Cameron Bell et. al 2015)

The numbers of burns increasing post-liberalization may be due to responder bias. People appear to be more open to reporting marijuana extraction as the cause of the explosion because their activity at the time was not inherently illegal. A supporting study from New Zealand to this effect contains a case series of burn patients involved in

illegal drug manufacturing. Adult burn admissions over a period of 18 months were reviewed and individuals suspected of having been involved in a hash oil related explosion were contacted. Of 64 contacts, nine said hash oil extraction was the cause of the burns. Of these nine, only two were truthful in their admission histories. This may be relevant as it could change the burn management protocol (Porter C-Armstrong J 2004)

In order to combat this issue, Colorado has made the home production of this oil illegal as of July 1, 2015. Law enforcement and first responders are being trained for such eventualities. While there is potential for additional explosions in home manufacture, a switch to solvents other than butane is occurring. These solvents, however, are more expensive and might lead to a smaller proportion of producers to continue using butane. Public health messaging to increase awareness of potential hazards of extraction may need to be introduced along with regulations for worker safety in legal commercial extraction businesses.

5. Teen and Adolescent Use

5.1 Introduction

Opponents of legalization often mention the potential for increased marijuana use among adolescents. This population is at risk for negative cognitive consequences such as loss of IQ which was found in at least one study to be concentrated in adolescent-onset as opposed to adult-onset users (Madeline Meier et al. 2013). A systematic review found that chronic marijuana use was associated with bronchitic symptoms such as coughing, phlegm and wheezing (Jeanette Tetrault et al. 2007). Memory, attention span, motivation and problem solving issues associated with acute use may affect learning (Alain Joffe-Samuel Yancy 2004). Given such risks, factors involving teen use should be evaluated for the purpose of preventing adolescent onset.

Using the example of tobacco restrictions introduced in the 1990s, due to public health concerns, the State of Colorado has sought to limit potential consequences of teen use by regulating advertising to minors (John Hickenlooper 2014). While there is limited reporting on how some small grants have been awarded to schools applying for a health

education employee, scant information is currently available on what other measures the State of Colorado is contemplating with regard to protecting minors within this new context.

5.2 Medical Marijuana Laws/Decriminalization and Increased Use

Researchers reviewed data from the National Survey on Drug Use and Health, finding that prevalence of marijuana use among 12-17 year olds was 8.7% higher than in states that have not legalized medical marijuana (Melanie Wall et al. 2011). They found that lower teen use numbers were associated with perception of less risk in using marijuana. Legalization of medical marijuana may indicate that the community at large has a lesser perceived risk in using marijuana and this socially accepted usage increases adolescent use likelihood (Melanie Wall et. al 2011).

Another study containing an evaluation of NSDUH data also indicated that medical marijuana laws have limited effects on marijuana use (Sam Harper et al. 2012). Marijuana's decriminalization effect on high school student attitudes was conducted in another study over the 1975-1980 time period. It was revealed in the study that attitudes were not affected by decriminalization. It was suggested that marijuana use was viewed as socially acceptable prior to its decriminalization (Alain Joffe-Samuel Yancy 2004).

A research team evaluated data accumulated from the “Monitoring the Future” survey over the 1991 -2014 time frame. This survey is performed at 400 randomly selected schools each year and includes data from 1,098,270 adolescents. Upon evaluation, it was found that medical marijuana laws did not increase adolescent use of marijuana, but that adolescent use was higher in states with such laws. States with such laws already had a higher prevalence of last 30 day marijuana use in adolescents than in non-medical marijuana states (Magdalena Cerda et al. 2015). Additional research on factors other than legalization might shed light on usage differences and aid in preventing adolescent use.

Other data from NSDUH from 2002-2003 adds further weight to the argument that the new environment created by legalization is not the precipitant of increased use. Just after the medical marijuana legalization in Colorado in 2002, marijuana and medical

licenses still were not widely available. The state still had the highest use in nearly every category for nearly every age group including: illicit use in the past month, illicit use in the last year, lowest perception of risk from smoking marijuana, high use of any illicit drugs and high use of cocaine. Alaska, Oregon, Washington and other states sharing these characteristics with Colorado passed medical marijuana laws earlier in comparison to states that had higher risk perception and lower substance use (Douglas Wright-Neeraja Sathe 2005). Figure 4 shows Colorado, Washington, Alaska and Oregon as higher use states prior to legalization. Additional research on factor other than legalization might shed light on usage differences and aid in preventing adolescent use.

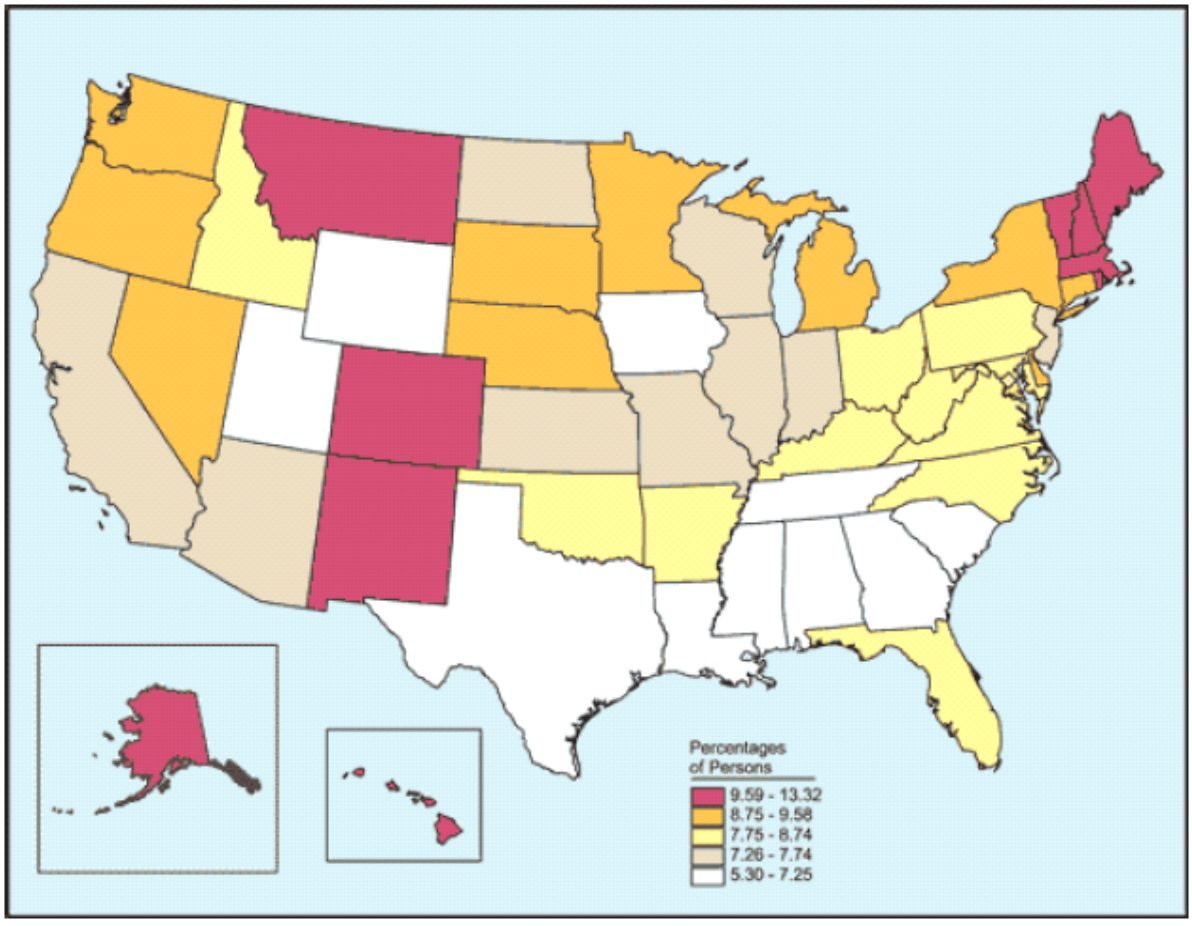

Figure 4: Marijuana use in past month among youths aged 12 to 17, by state: percentages, annual averages based on 2002 and 2003 NSDUHs. According to: Wright D, Sathe N. (2005), p. 25.

5.3 Perception of Risk

According to some researchers, perception of risk associated with marijuana use may play a larger role than legalization or subsequent availability. Temporal trends in marijuana attitudes in Colorado versus 34 Non-medical Marijuana States (NMMS) were examined in one study in which adolescents 12-17 years old had significantly diminished perception of risk in comparison to NMMS. All age groups investigated had lower risk perception in comparison to NMMS (Joseph Schuermeyer et. al 2014).

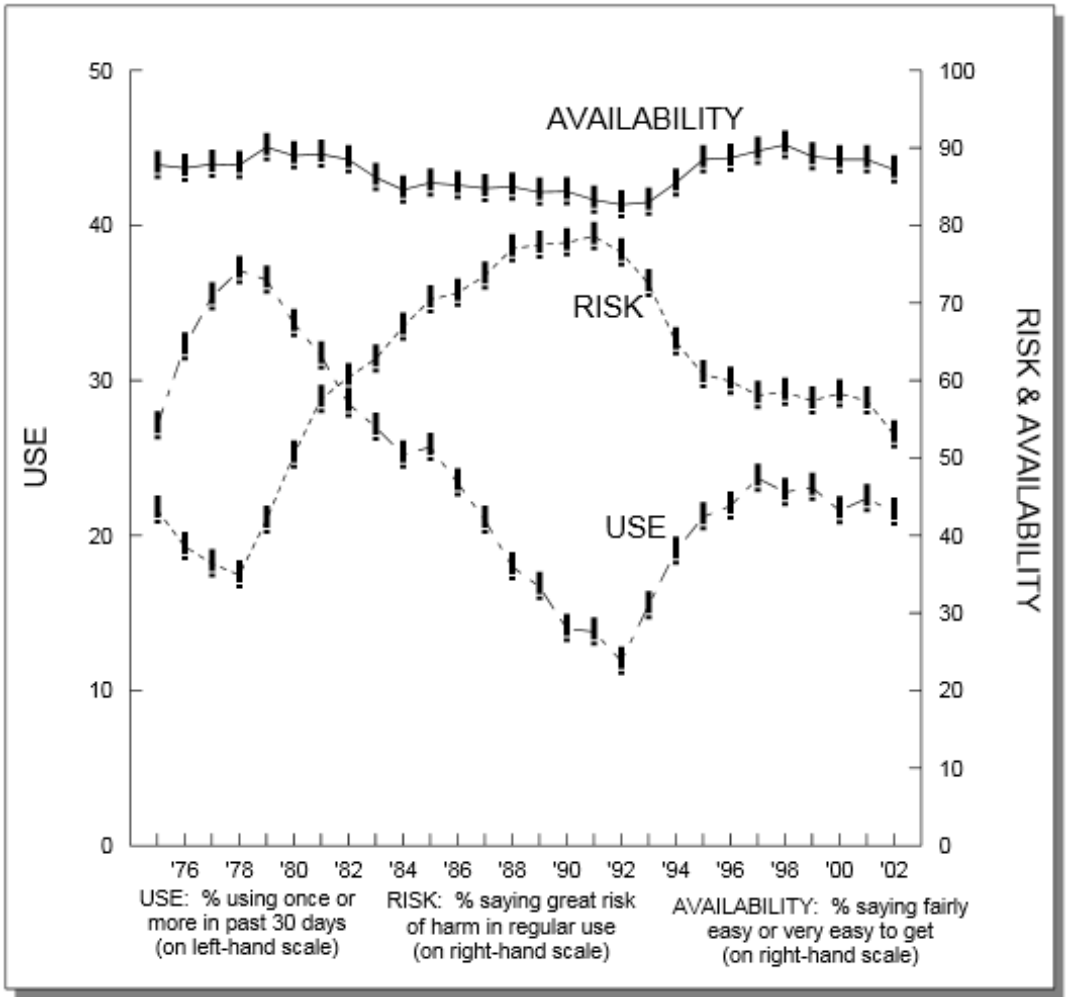

Figure 5: Marijuana: trends in perceived availability, perceived risk of regular use and prevalence of use in past 30 Days for twelfth graders. According to: Johnston LD, O'Malley PM, Bachman JG (2003), p. 318.

Figure 5 above summarizes the Monitoring the Future Survey. Twelfth graders from 1975 onward have consistently reported in high percentages they perceive their access to marijuana is high. If availability is linked to use, then one would expect to have consistently higher percentages of use, however this is not the case. Availability was relatively constant over time (x-axis is the timeline from 1975-2002), so the interaction between perception of risk and use could be independently analyzed as variables. As the table clearly illustrates, use varied by perception of risk, and this was independent of time as well.

The Healthy Kid Colorado Survey only began in 2013 with intention to be taken every alternating year, so trends may become more apparent with time. In 2013, which was just prior to commercial legalization of marijuana in Colorado, 40,000 students were surveyed on their patterns of substance use including marijuana, tobacco, and alcohol. With regard to teen marijuana use, Colorado was in line with national trends of “ever having used marijuana” and “past 30 day use.” Trends of use have remained stable through 2005-2013 (Amy Anderson et al. 2015). Data accumulated from the Youth Risk Behavior Survey substantiate this trend. Marijuana use in students from 1995-2005 steadily declined and from 2005 the use rate has remained stable (Jeffrey Miron 2014).

While there was an anticipated increase in teen use when recreational use was legalized in 2012, more time is needed post legalization for complete interpretation of the data being accumulated from the HKCS. The key factor identified with increased teen marijuana use in the HKCS was grade level whereas habitual use and onset of use varied on factors such as ethnicity, sex and sexual orientation. Preliminary data such as these could help devise a targeted approach to dealing with the teen use issue. Likewise, efforts targeted to specific socioeconomic regions may be beneficial since use appears to be more concentrated in the southwestern part of the state and the Denver region, areas that are differentiated by their social and economic characteristics. Polysubstance use is also the most prevalent in the southern and specifically southwestern part of Colorado (Ashley Brooks-Russel et. al 2013)

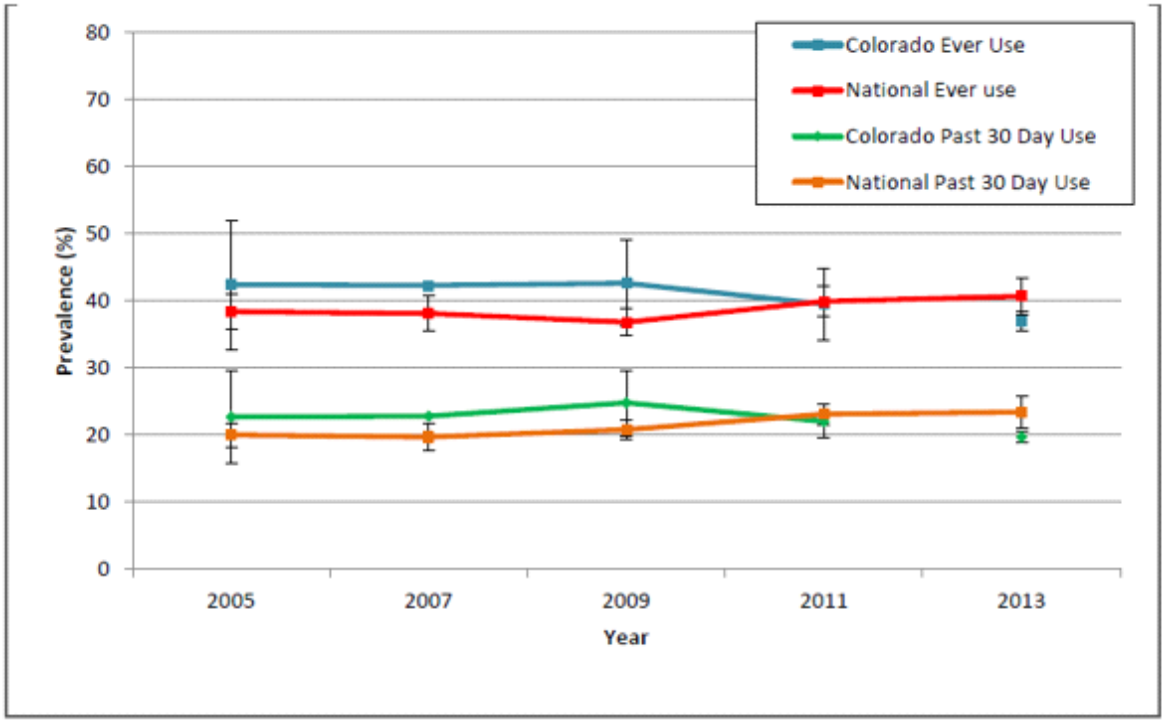

Figure 6: Marijuana use among high school students in U.S. and Colorado 2005-2013 from HKCS. According to: Gruber K, Anderson A, Calanan R, VanDyke M, Barker L, Burris D, Tolliver R (2015), p. 3.

Figure 6 shows trends from 2005 to 2013 for the prevalence in percentages of marijuana use for Colorado teens and national teens. The number of Colorado teens who have ever tried marijuana is higher than the national percentages reported, then decline until 2011 when the percentages actually are much the same. Likewise, the numbers of Colorado teens reporting use in the last 30 days was at a higher threshold than national percentages and climbing until 2009 when percentages began trending below the national percentages.

Ease of access in Figure 6 seems to differ from what the "Monitoring the Future" survey implied. However, the MTF table was only based on the perception of 12th graders and not inclusive of other grade levels. The HCKS did not define what “regular marijuana use” entailed. It could be more useful to evaluate this in a fashion similar to how HCKS

evaluated alcohol, in terms of 1-2 a week being seen as risky, 1-2 a month etc. Also, individuals' perceptions of what constitutes "regular use" varies widely.

At first glance, increased use with increased age seems to be a trivial finding. Nevertheless, why should it not be the opposite case? One might expect the older and wiser individual would perceive more risk and refrain from risky behavior. One explanation proposed is that young adolescents in their development are deterred by law in order to stay out of trouble, presumably because they understand the law in concrete terms. You break the law and you are punished. Once adolescents develop abstraction, though, they are less likely to be persuaded by simple black and white legal arguments (Alain Joffe-Samuel Yancy 2004). If this is the case, Public Health education or appeals to students on the basis of law may not prove very fruitful.

Parental use also appears as a risk factor in adolescent use (Alain Joffe-Samuel Yancy 2004). On the other hand, it appears that perception of parental disapproval is correlated inversely with use. "Don't do as I do, but do as I say," seems to resonate in this context, and in the way you might expect--it has the opposite effect. Again, while parents are in the best position to be role models and advocate for the health of their children, what they do and say may make a difference in the behavior of their children in regard to increased use. Public Health messaging might address parents and how they might best talk to children on the issue to produce the desired effect.

6. Conclusion

First, the increase in pediatric intoxications in Colorado is of special concern due to the potential for respiratory depression. Nevertheless, the scope of the problem is relatively small in comparison to intoxication with other available pharmaceuticals. As such, adults should keep their edibles out of the reach of children. Packaging should be easily identifiable with warning labels informing adults of known issues. Intoxication of adults is not life threatening. With adults, mostly supportive therapy is employed with intravenous hydration and an anxiolytic.

Likewise, Cannabinoid Hyperemesis Syndrome, while increasing, seems still to be an uncommon manifestation of chronic cannabis use. However, a large delay in diagnosis is not uncommon. For this reason, more hyperemesis cases may be cannabis related. As the stigma associated with cannabis use diminishes over time, more of these cases may be properly identified and resolved.

As for the number of butane hash oil extraction burns, while increasing after legalization are still uncommon. Colorado has made home extractions illegal, but as there may be more industrial production of butane hash oil with flammable solvents, an increase in accidents may occur. On the other hand, making home extraction illegal may diminish an individual's willingness to admit to how burns occurred, thus affecting treatment plans.

In regard to teen use, it seems that Colorado has been a high drug use state for adults and adolescents over many years even prior to legalization. Nevertheless, teens perceiving high risk report low use in spite of constant high perceived availability. Education focused on informing teens of the risks related to cannabis use seems to be the logical approach to helping them make informed decisions. The State of Colorado and schools appear to be gradually working together in this direction.

As far as can be determined at this point, the likelihood of an increase in traffic fatalities involving marijuana is low and is will probably remain low. Individuals who smoke marijuana tend to consume at home instead of in public as compared to alcohol. According to studies cited in the thesis, the majority of people do not have a peak marijuana concentration when pulled over. The majority have blood levels indicating use 2 or more hours prior. Also, people who smoke and drive tend to have compensatory behaviors.

At this time, the effect of legalization in Colorado on increased criminality seems to be mostly related to property crime with cash-related robberies of dispensaries. Such criminality may subside once dispensaries have access to a banking system, something which Colorado is now contemplating.

Indications are that marijuana legalization in Colorado as well as other states is showing a positive effect on reducing drug trafficking from Mexico. While methamphetamines and heroin are replacing much of the marijuana trafficking, there is smaller market for those drugs than for marijuana.

In summary, the case of Colorado legalization offers the earliest view as to what others may face when and if they chose to follow this same path. Marijuana legalization in Colorado has resulted in mixed health and safety outcomes. Significant effects of legalization on either one is limited and manageable. Furthermore, the issue of increased criminality appears to be limited and manageable as well. Finally, illegal drug trafficking in marijuana and criminality associated with it originating from outside of the country appears to be decreasing as a result of legalization in Colorado and elsewhere. While the link between legalization in Colorado and elsewhere has not been definitively established, new approaches to the drug problem on a state level may provide solutions for the nation even as health and safety risks remain in check.

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9. Biography

Marina Vosika is a 6th year medical student at the University of Zagreb Medical English Faculty in Zagreb, Croatia. As part of her studies, he has completed a surgery rotation in Glasgow, Scotland at the Royal Glasgow Infirmary and has completed Public Health courses with the University of Amsterdam and the University of Lund. At this time, she is planning a Masters in Public Health following medical rotations in England and Germany. She was born in the U.S. and is both a U.S. and a Croatian citizen.