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The Hidden Costs of Marijuana Use in Colorado: One Emergency Department's Experience

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Abstract

Purpose: This study aims to assess potential health care costs and adverse health effects related to cannabis use in an acute care community hospital in Colorado, comparing study findings to those medical diagnoses noted in the literature. Little information is available about specific hospital health care costs, thus this study will add to the knowledge gap and describe charges and collections from visits of these patients in one hospital's Emergency Department (ED).

Objective: Review diagnoses of cannabis users visiting a local ED and outline the potential financial and health effects of these patients on the health care system.

Design: An Institutional Review Board (IRB) approved retrospective observational study of patients seen in the ED from 2009 to 2014 with cannabis diagnoses and positive urine drug analyses (UDA) matched with hospital billing records. Randomized patient records were reviewed to determine completeness of documentation and coding related to cannabis use.

Setting: An acute care hospital in one city in Colorado. The city has nearly 100 medical marijuana dispensaries, but has not legalized recreational cannabis use. The city decided to not allow recreational stores in city limits as they were allowed to make that determination as a result of Amendment 64, which allowed municipalities to determine if they wanted recreational marijuana in their town. As of this publication, more than 70% of Colorado's municipalities have opted out of recreation marijuana sales.

Participants: Subjects seen through the ED who had both a diagnosis code listing cannabis and a positive UDA for cannabis. Exclusions were subjects with UDA for cannabis but also tested positive for other substances, subjects who had cannabis diagnosis but no UDA result or those who had no UDA but did have a cannabis diagnosis.

Conclusion: Subjects seen in the ED had similar diagnoses as those reviewed in the literature, confirming the serious side effects of marijuana use. During the study period, the study hospital incurred a true loss of twenty million dollars in uncollected charges after allowing for contractual obligations. While adverse health effects have been described in the literature, there is little data on the financial impact of marijuana use on the health care system. This study demonstrated an increasing number of patients who are seen in the ED also have used cannabis. These patients are not always able to pay their bills, resulting in a financial loss to the hospital. The authors encourage the collection of hospital financial data for analysis in the states where medicinal (MMJ) and/or recreational marijuana is legal.

Introduction

In Colorado, a medical marijuana law was passed in 2000, followed by recreational marijuana legalization in 2014 with the passage of Amendment 64. Following legalization, which led to mass commercialization of cannabis, adverse health effects have become more apparent; these include severe burns related to hash oil explosions, accidental exposures of the very young requiring hospitalization, psychoses, and driving under the influence of drugs resulting in injuries and death. While these events have been publicized, little data is available to determine what the health and financial impacts are on a single community. Here, we assess the extent to which increased cannabis usage increases financial burden on hospitals and validate published studies regarding adverse health effects of marijuana use.

Background

The use of cannabis for medicinal purposes has been increasing over the past several years, with 25 states and the District of Columbia approving its use for medical reasons.[(1)] Colorado, Washington, Oregon, Alaska, and the District of Columbia have also approved cannabis for recreational use, with varying state laws governing its use.

In the State of Colorado, medical marijuana (MMJ) users are 65% male and 35% female, with ages 21-30 comprising the largest segment of users (23%). On average, men are 41 years old and women are 45. The prescribing indication for 93% of MMJ users cite pain while 3% is for cancer.[(2)]

Colorado Springs is the second largest city in the State of Colorado with a population of nearly 440,000.[3] The study hospital is a 522-bed acute care facility in Colorado Springs. The study hospital's system have some of the busiest EDs in the state, with over 104,000 annual emergency visits.[4] Although the city has not legalized recreational cannabis, it was widely available and used prior to the legalization in 2014 because 40% of marijuana is obtained from the black market.[5] El Paso County, location of Colorado Springs and this current study, has 19,314 people with medical cannabis (MMJ) cards, 16.9% of MMJ cards in the state of Colorado.[6] As of 2014, the Department of Regulatory Agencies report there are 98 medical marijuana dispensaries in Colorado Springs[7].

Health Effects

There is data to support transmission of delta-9-tetrahydrocannabinol (THC), the principal psychoactive ingredient in cannabis, to the fetus in pregnant mothers using cannabis.[8] The American Congress of Obstetricians and Gynecologists (ACOG) published a Committee Opinion citing numerous studies to support their recommendations to discourage use of cannabis during pregnancy and lactation, including use of medical cannabis.[9] Fetal cortical growth may be affected;[10] long term effects of these children are not fully known or understood, but previous studies report findings that suggest behavioral abnormalities including hyperactivity, difficulty with executive functions into adolescence,[11] depression even if they are not using, [12] and early adolescent addiction.[13]

The number of accidental ingestions in Colorado in children under the age of 12 has increased 215% between 2010 and 2014.[14] The American Academy of Pediatrics recently released a

position statement related to cannabis use, recommending that children and adolescents should not use, or even watch adult role models use, cannabis, and that all cannabis should be in child proof containers.[15]

The effects on learning and education related to cannabis use have been documented in the literature,[16] and Colorado school expulsions for drug related reasons increased 40% between 2008 and 2014, citing marijuana as the most commonly abused substance.[17] The American Academy of Neurology recently recommended no cannabis use for children, adolescents, or adults until further study is done.[18] Cannabis has a known addictive potential, particularly in the developing brain, and has a well-described withdrawal syndrome.[19] Nationally there are 7.15% adolescents using cannabis, but in Colorado this figure is 11.16%.[20] The addiction rate is higher for adolescents (approximately 18%) than for adults (approximately 9%).[21,22,23] The relationship between cannabis use and dependency and addiction have been well described in the literature.[24,25,)]

Cannabis affects reaction time, complex thinking, hand-eye coordination, concentration and perception of time and distance, likely impacting the ability to operate a vehicle.[26] The number of Driving Under the Influence of Drugs (DUID) and percentage of driving fatalities related to cannabis in Colorado has increased. Between 2010 and 2014, cannabis related fatalities in Colorado rose 92%, although about half of drivers involved in fatal accidents were not tested for drugs.[27] The established limit for driving impaired with cannabis is a blood level of 5 ng/ml.[28] A meta-analysis of driving under the influence of cannabis indicated a statistically significant risk of motor vehicle crash risk.[29]

Cannabis has known physiologic effects that involve multiple organ systems. Recent studies have demonstrated cardiovascular and cerebrovascular effects, which include acute coronary syndromes, transient ischemic attacks, arrhythmias, and peripheral limb ischemia.[30] There are known pulmonary effects and although the link between cannabis use and lung cancer has not been proven, some early studies have correlated cannabis use to some head and neck cancers.[31,32] Smoke from cannabis has known carcinogens including ammonia at concentrations 20 times greater than tobacco, hydrogen cyanide, and heavy metals.[33]

Depression, suicidal ideation, and psychosis related to cannabis have also been well documented in the medical literature. In Colorado in 2014, when retail cannabis businesses began operating, there was a 29% increase in the number of cannabis-related emergency room visits and a 25% increase in the number of likely cannabis-related ED visits. In the three years after medical cannabis was commercialized, compared to the three years prior, there was a 46 percent increase in cannabis-related hospitalizations.[34]

Several studies have examined the use of cannabinoids, the non-psychoactive component in cannabis, for treatment of chronic pain, though these involved only a small number of patients with limited diagnoses.[35,36,37] There is emerging data that suggests other cannabis-derived compounds, primarily cannabinoids, may have analgesic properties similar to opioids. There is evidence that there may be an overlap on how opioids and endocannabinoids work in pain.[38,39,40]

Financial Implications

Health care costs related to cannabis use have not been adequately evaluated. Similar to tobacco and alcohol, which generate significant revenues for their respective industries, cannabis generates money for those states allowing its use for medical and recreational purposes. Colorado, for example, received $45,490,227 in tax revenue for 2014.[41] Some of these taxes are legally earmarked for various education endeavors and research. Using taxes from cannabis sales, the Colorado Medical Marijuana Scientific Advisory Panel funded $9 million for cannabis research involving Irritable Bowel Disease, Parkinson's tremor, pediatric palliative care, pediatric epilepsy (2) Post Traumatic Stress Disorder (2), sleep, and analgesia.[42]

Like alcohol and tobacco, cannabis may be negatively affecting health resources and may be becoming a public health concern. Alcohol costs the U.S. $222.5 billion annually with $161 billion due to productivity loss, $24.6 billion for health care expenditures and $37 billion for other costs including incarceration, motor vehicle accidents, crime, and property damages. The government bears 67% of these costs, with families, insurers, crime victims and employers sharing the remainder.[43] Smoking costs the U.S. $300 billion annually, with $156 billion in lost productivity and $170 billion in health care costs.[44] Lost productivity in the U.S. workplace due to drug abuse costs employers $81 billion.[45] Even though it is considered medicinal, cannabis may likely impact productivity as well.

A 2010 estimate by the National Highway Traffic Safety Administration claims one traffic fatality costs nearly $1.4 million in accumulated costs.[46] Thus, the 87 cannabis related motor

vehicle fatalities for 2014 (87 at $1.4 million)[47] could conceivably amount to $131.6 million. Alcohol related fatalities were 158 for the same period.[48]

The aim of the study was to discover costs and collections of patient billings for ED services and validate previous adverse health effects of marijuana as noted in the literature. We reviewed patient records to collect admission diagnoses, hospital billing and collections from the visits. We anticipated finding financial losses from uncollected bills along with admitting diagnoses similar to other publications.

Methods

Following IRB approval, laboratory results for all toxicology Urine Drug Screens (UDA) (n=45,240) were reviewed from 2009 to 2014. UDA records for subjects with cannabis with other drugs and/or alcohol were identified (n=7,078). Exclusions were subjects with UDA for cannabis but also testing positive for other substances that included methamphetamines, opioids, benzodiazepines cocaine, or alcohol >10mg/dl. These potential subjects were excluded to avoid possible confounding aspects of additional drugs on diagnoses and length of stay in the ED, thus increasing costs. The hospital laboratory used a Siemens Viva diagnostic machine for urinalysis. There were no changes over time using this device to determine the levels of detectable substances.

For the same time period, medical records were searched by Health Information Management (HIM) for billing information combined with cannabis diagnoses using coding that included:

- "long term use of drug for medicinal purposes" (V58.69),

- "recreational use of cannabis or nondependent use of drug" (305.2),
- "accidental cannabis poisoning" (969.6),
- "adverse effect of cannabis" (E939.6).

The "long term use for medicinal purposes" (V58.69), found some records (less than 0.4%) that included medications such as cardiac and pain medications, but not always cannabis. It is the practice at the study hospital to code cannabis use with this V code if cannabis use has been indicated but did not fit with the other cannabis codes. This resulted in 60,223 records. Records were then sorted to include only those listing cannabis.

Each patient record at the study hospital may contain up to 14 different diagnoses. Due to the large number of records and diagnoses, only the admitting diagnosis (usually the chief complaint) and the first four diagnoses were included in the study data, however all diagnoses in study patients included cannabis. Use of these codes may not indicate the primary reason for admission; rather it is an indication that the medical record reflected cannabis use by the subject. Some hospitals use additional codes (e.g. E854.1 accidental poisoning by pscyhodysleptics, or 304.3 cannabis dependence) with other sub-codes (e.g., in remission, continuous, intermittent, episodic). These codes were not included in the record search; therefore, additional subjects may have been missed.

Due to the large number of records found, randomly selected individual adult records were reviewed for toxicology results and, as appropriate, additional medical information to verify the consistency and accuracy of the data, including the acuity of the UDA. These included the following diagnoses along with cannabis: alcohol intoxication, alcohol abuse, poisonings,

hallucinations, giddiness and dizziness, chest pain, and vomiting. Diagnoses were grouped into broad categories: Behavioral Health, Substance Abuse, and then single categories (Table 1).

Participants were then limited to those seen through the ED who had both a diagnosis code listing cannabis and a positive UDA for cannabis. Subjects whose UDA records containing only cannabis or cannabis with alcohol levels of <10 mg/dl were then matched with subject medical records listing cannabis among the first five diagnoses groups. There were UDA results with no matching cannabis medical record diagnosis, and there were records listing cannabis among the first five diagnoses with no UDA results, indicating some records may have been missed. Records containing both cannabis diagnoses and UDA information were then matched by year and used for data abstraction (n=859, 12.1% of records found). Subject inclusion and exclusion criteria are listed in Table 2. Charges and payments collected for ED patients who were seen and sent home were provided by the HIM department based on the coding criteria listed above. The description of payors, charges and collections were reviewed by year.

Results

Mental health diagnoses comprised a majority of admission diagnoses that included suicidal ideation, psychosis, depressive disorder and altered mental status. Substance abuse was also very high and included amphetamine abuse, cannabis abuse, and alcohol abuse and withdrawal. Other diagnoses seen in the study hospital ED were convulsions, poisonings, cyclic vomiting, trauma/musculoskeletal, accidental exposure and less frequently, cardiac and respiratory. Because the first four diagnoses in any given patient were reviewed, one patient could have any or all of the above diagnoses listed.

Visits where a diagnosis related to cannabis was identified at the study hospital increased from 545 to 2,042, a 375% increase between 2009 and 2014. The percent of cannabis subjects admitted as inpatients from the ED increased from 9% to 15.3% during study period. ED charges unable to be collected increased 192%. Additionally, 15% of ED patients were admitted as inpatients. Therefore, separate charges and collections for inpatients would be in addition to the figures listed (Tables 3 and 4).

To demonstrate typical patients seen in the study hospital ED who presented with adverse health effects commonly seen with cannabis use, along with their billing information describing "lost" revenue, several case studies are included.

Case Study 1

A 30 year-old male woke up with anterior chest pain with some pleuritic quality described as an anterior sharp pain, non-radiating with some low-level pressure and tightness. He was able to snowboard without problems during the prior day and pain developed later in the evening and increased, radiating to the back and down the left arm intermittently. He had no prior symptoms, shortness of breath, paroxysmal nocturnal dyspnea, or orthopnea. He had alcohol the weekend prior and smoked marijuana the afternoon prior to presentation around the time the chest pain worsened. He did not use cocaine, methamphetamine or other drugs. He smoked less than 1/2 pack of cigarettes per day. There was no family history of cardiac disease, and he had no diabetes, hypertension, or hypercholesterolemia. Medications he took included paroxetine 40mg per day for history of depression. The physical exam was significant for elevated heart rate of

100, elevated blood pressure of 136/86. His electrocardiogram (EKG) showed the ST segment waves were elevated. The ST segment is a portion of the EKG tracing that when elevated indicates heart damage. His labs showed troponin (a protein that is released if heart muscle is damaged) of 2.26 (normally zero) and D-dimer of 0.76. A D-dimer test will show if a blood clot has been dissolved and is often ordered to help rule out conditions such as blood clot in the lung that could cause chest pain. His toxicology test was positive only for THC. A cardiac catheterization was completely normal. He was monitored overnight, troponin levels normalized and symptoms resolved. Hospital charges: $33,000 Hospital payments: $13,000 from insurance and patient.

Case Study 2

A second example was a 37 year-old female with no prior or family cardiac history presenting with intermittent chest pain of several months. She had negative heart disease history but was a 20 pack year smoker. The toxicology test was positive, but only for THC. The cardiac tests were positive, indicating a blockage in two coronary arteries supplying blood to the heart resulting in Coronary Artery Bypass Graft surgery. The hospital charges: $101,000, and the hospital collections: $0.

Case Study 3

A third example was a 27 year-old homeless male picked up by ambulance due to suicidal ideation. He had a history of mental illness including schizophrenia, depression, and bipolar disorder. He was recently discharged from mental health hospital but could not afford his prescriptions, however, was able to self-medicate with marijuana. He reported hearing voices but

had no visual hallucinations. He had no recent trauma or illness noted. His admission vitals were normal. His admission toxicology test was positive but only for THC. Hospital charges: $5700. Hospital payments: $0.

Discussion

Admitting diagnoses from the study hospital were similar to previous literature citations. Most hospitals, including the study hospital, have contracts with insurance companies for reduced reimbursement that may not be reflected in the actual collection deficits listed here. The study hospital would likely receive a percentage of billed charges that would have an impact on its bottom line. Deductibles that are the patient responsibility are included in the actual collections; however, it is not known how much of these amounts were received.

The revenue loss ($209,752,336) for cannabis patients in the study hospital in Table 4 "Uncollectible for ED Patients" is without contractual adjustments because the authors do not know the specific agreements between the study hospital and payors. Some of these agreements would decrease the uncollectible amount. What might be considered a true loss to the study hospital, according to the hospital administrators familiar with the data, would be in the 10-20% range of the total uncollectible amount.[49] This would be at least a $20 million loss over the 6-year study period. Also, only 12% of the patients who had marijuana positive UDAs were matched to billing records; indicating this loss is an underestimate and one could therefore predict a higher loss over the 6-year study period. This is due to variability in coding and inability to match diagnoses to billing records.

The financial impact of cannabis outweighs tax revenues. Hospital losses from uncollected charges have a major impact on their operating expenses. Even if the study hospital's reported loss of $37,805,507 in 2014 is adjusted for an estimated 10% true loss to account for contractual obligations and other write offs, the result would be $3,780,559 in one year. With a second acute care hospital system of around the same size in the city plus psychiatric, rehabilitation and military hospitals in the city, the community impact would be substantial.

The authors recommend that other states considering legalizing cannabis for medicinal or recreational purposes, or who already have these programs, begin collecting data to determine the financial impact on their health care systems and communities.

The authors recognize that intrinsic weaknesses of this study complicate interpretation. These include the analysis of one hospital system in one city; urine drug analyses that do not account for acuity (recent use versus prior use), although random chart review supported acuity in most cases; hospital coding did not capture all of cannabis use or abuse diagnoses; the dependency of coders on physician documentation, which may be unclear regarding cannabis use as patients are found to have conditions that may be related to cannabis but not reflected in records; billing information that may be incomplete related to coding subjectivity; and the percent of uncollected charges unlikely to reflect actual revenue impact due to contractual agreements.

Suggestions for future studies include data collection from hospitals that include reimbursement and financial losses, placing financial values on health side effects, and estimating frequency of cannabis presence in pregnant and nursing mothers and newborns.

Conclusion

Information from this study demonstrates the financial impact of cannabis. The toll of secondary effects from increased cannabis use includes physical, psychosocial, and financial to patients, families and communities.

There should be an increased public health concern for the adverse side effects and increasing utilization of health care related to cannabis use. Health care professionals should become knowledgeable of the side effects of cannabis to appropriately counsel their patients and discuss health implications with the public as well as legislators.

Prior to accepting and promoting cannabis for medicinal or recreational use, rigorous scientific research into its broad spectrum of potential risks and benefits should be completed, just as it has with other substances. Science must trump public opinion, and this begins with data collection and well controlled scientific studies related to specific medical conditions. Evidence based medicine should be considered the standard of patient care.

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Table 1 - Inclusion Exclusion Categories

Inclusion
• Subjects with positive urine drug screen for cannabis metabolites
• HIM coding for presence or use of cannabis
• HIM coding for cannabis use/intoxication/abuse
Exclusion
• Subjects without toxicology screens
• No cannabis metabolites identified
• HIM coding does not include presence or use of cannabis
• Subjects with toxicology screens that include more than cannabis metabolites

Table 2 - Diagnosis Categories Associated with Cannabis in Study Hospital ED

Behavioral
• Suicidal Ideation
• Psychosis
• Depressive Disorder
• Altered Mental Status
Substance Abuse
• Amphetamine abuse
• Cannabis abuse
• Alcohol abuse/withdrawal
Other Convulsions
Poisonings
Vomiting, cyclic vomiting, abdominal pain
Trauma/musculoskeletal
Cardiac
Respiratory
Accidental Exposure

Table 3 - Payor Percentages of Study Hospital Cannabis Related ED visits

Year	Percent of Total Cases[a]	Medicare	Medicaid (Managed, regular, pending)	Contract	Tricare	Self Pay
2009	14	21.8	15.8	28.3	14.5	5.5
2010	15.18	23.4	16.7	25.5	12.9	7.3
2011	16.17	26.3	15.5	25.5	10.9	6.3
2012	17.56	25.6	17.6	22.5	12.9	2.3
2013	17.57	23.7	21.4	23.6	11.3	2.2
2014	19.52	23.4	29.8	19.8	11.4	2.1

[a]The Percent of Total Cases indicates how many subjects had a cannabis diagnosis among the ED population. The remaining categories indicate the insurance payor and percentage of cannabis subjects.

Table 4 - Summary of Charges and Collections for all Cannabis Patients at Study Hospital.

Year	Total ED Charges	Total ED Collections	Total Percent Uncollected	Uncollected for ED Patients	Est. True Loss to Hospital (10%)
2009	$ 17,371,088	$ 4,407,960	75%	$ 12,963,128	$1,296,312
2010	$ 37,650,834	$ 4,689,971	80%	$ 19,281,866	$1,927,186
2011	$ 65,678,615	$ 6,164,878	84%	$ 31,202,264	$3,120,226
2012	$ 124,781,458	$ 9,682,466	85%	$ 53,454,607	$5,345,460
2013	$ 117,920,410	$ 9,539,458	85%	$ 55,044,875	$5,504,487
2014	$ 112,913,755	$ 6,959,978	84%	$ 37,805,597	$3,780,559
Total	$476,316,160	$41,444,711		$ 209,752,336	$20,975,233

References

1. Schatman, M.E. Medical marijuana: the state of the science. *Medscape Neurology*, Feb 6, 2015 WebMD, LLC. Retrieved Feb 10**,** 2015.

2. Wong, K, Clarke, C. The legalization of marijuana in Colorado: The impact. Percent of medical marijuana patients based on reporting conditions. 2015; (3):154 http://www.rmhidta.org/default.aspx/MenuItemID/687/MenuGroup/RMHIDTAHome.htm. P. 154. Accessed September 16, 2015

3. Colorado Springs, Colorado (CO) profile: population, maps, real estate, averages, homes, statistics, relocation, travel, jobs, hospitals, schools, crime, moving, houses, news, sex offenders. http://www.city-data.com/city/Colorado-Springs-Colorado.html, accessed May 22, 2015.

4. Facts about Penrose St. Francis Health Services https://www.penrosestfrancis.org/psf/about-us/fact-sheet/, accessed November 26, 2015

5. Lobosco K., Colorado is missing $21.5 million in pot taxes http://money.cnn.com/2014/09/02/news/economy/marijuana-taxes-colorado Accessed April 5, 2016

6. Medical marijuana registry program statistics September 30, 2015. P.2, 3 https://www.colorado.gov/pacific/sites/default/files/09_2015_MMRreport.pdf. Accessed November 27, 2015.

7. Phone conversation, Colorado Department of Regulatory Agencies, April 2, 2016

8. Learn about marijuana. Marijuana, reproduction, and pregnancy. http://adai.uw.edu/marijuana/factsheets/reproduction. Accessed May 22, 2015.

9. American College of Obstetricians and Gynecologists, 2015, Committee Opinion, Marijuana use during pregnancy and lactation. #637. http://www.acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Marijuana-Use-During-Pregnancy-and-Lactation. Accessed September 11, 15.

10. Tortoriello G, Morris C V, Alpar A, et al. Miswiring the brain: Δ9-tetrahydrocannabinol disrupts cortical development by inducing an SCG10/stathmin-2 degradation pathway. *EMBO J*. 2014; 33(7):668-685. doi:10.1002/embj.201386035.

11. Goldschmidt L, Day NL, Richardson GA. Effects of prenatal marijuana exposure on child behavior problems at age 10. *Neurotoxicol Teratol*. 2000 May-Jun; 22(3):325-36. PII: S0892-0362(00)00066-0.

12. Gray KA, Day NL, Leech S, et al. Prenatal marijuana exposure: Effect on child depressive symptoms at ten years of age. *Neurotoxicol Teratol*. 2005; 27 (3) 439-48.

13. Goldschmidt L, Richardson GA, Willford JA, Severtson SG, Day NL. School achievement in 14-year-old youths prenatally exposed to marijuana. *Neurotoxicol Teratol*. 2012; 34(1):161-167. doi:10.1016/j.ntt.2011.08.009.

14. Barker L, Bronstein AD, 2015 Rocky Mountain Poison and Drug Center (RMPDC) Data, 2000-2014. Retail Marijuana Public Health Advisory Committee. Monitoring health concerns related to marijuana in Colorado. 2014 Rocky Mountain Poison and Drug Center (RMPDC) Data, 2000-2014 p.163. https://www.colorado.gov/pacific/cdphe/monitoring-marijuana-related-health-effects. Accessed October 15, 2015

15. Ammerman S, Ryan, S, Adelman, W P. The Impact of marijuana policies on youth: Clinical, research, and legal update, The Commitee on Substance Abuse, The Committee on Adolescence. (Published online January 26, 2015) *Pediatrics.* 2015;135 (3). E769-e785. DOI: 10.1542/peds.2014-4147

16. Kuehn BM. Marijuana use starting in youth linked to IQ loss. *JAMA.* 2012; 308(12):1196. doi:10.1001/2012.jama.12205.

17. 2013 Healthy kids Colorado survey results, Colorado high school summary tables cdphe.healthstatistics@state.co.us

18. http://www.chd.dphe.state.co.us/Resources/yrbs/HS_Tables_10-21-2014.pdf Accessed September 11, 2015

19. Koppel, BS, Brust, JCM, Fife, T, et al. Systematic review: Efficacy and safety of medical marijuana in selected neurologic disorders. Report of the Guideline Development Subcommittee of the American Academy of Neurology. *Neurology*. 2014; Apr 29; 82(17):1556-63. doi: 10.1212/WNL.0000000000000363

20. Lopez-Quintero C, Pérez de los Cobos J, Hasin DS, et al. Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: results of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). *Drug Alcohol Depend*. 2011; 115(1-2):120-130.

21. Wong, K, Clarke, C. The legalization of marijuana in Colorado: The impact. Youth marijuana use. 2015; (3):35. http://www.rmhidta.org/default.aspx/MenuItemID/687/MenuGroup/RMHIDTAHome.htm. Accessed 9/16/15

22. Anthony JC. The epidemiology of cannabis dependence. In: Roffman RA, Stephens RS, eds. *Cannabis Dependence: Its Nature, Consequences and Treatment.* Cambridge, UK: Cambridge University Press; 2006:58-105.

23. Hall w, Degenhardt L. Adverse health effects of non-medical cannabis use *Lancet*. 2009; 374:1383–91 http://dx.doi.org/10.1016/S0140-6736(09)61037-0

24. Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. Treatment Episode Data Set (TEDS): 2002-2012. BHSIS Series S-71, (HHS Publication No. (SMA) 14-4850). 2014. p.19 http://www.samhsa.gov/data/2K14/TEDS2012NA/TEDS2012N_Web.pdf. Accessed April 20, 2015

25. Hurd M, Miller J-A, Trajectory of adolescent cannabis use on addiction vulnerability. *Neuropharmacology*.2014; 76 (part B):416-424. DOI: 10.1016/j.neuropharm.2013.07.

26. Kristjansson A, Lynskey C. Marijuana expectancies and relationships with adolescent and adult marijuana use. *Drug Alcohol Depend*. 2012; 126(1-2)102-10. Doi: 10:1016/j.drugalcdep.2012.04024. Epub 2012 June 8.

27. Hartman RL and Huestis MA. Cannabis effects on driving skills. (Published on line 2012 Dec 7). *Clin Chem.* 2013 Mar; 59(3):478-92. doi: 10.1373/clinchem.2012.194381.

28. Wong, K, Clarke, C. The legalization of marijuana in Colorado: The Impact. Impaired driving. 2015; (3):14. http://www.rmhidta.org/default.aspx/MenuItemID/687/MenuGroup/RMHIDTAHome.htm. Accessed 9/16/15.

29. Recreational marijuana legal, impaired driving not. https://www.codot.gov/news/2014-news-releases/01-2014/recreational-marijuana-legal-impaired-driving-not. Accessed April 14, 2015

30. Li M-C, Brady, JE, DiMaggio, CJ, Lusardi AR, Tzong KY, and Li G. Marijuana use and motor vehicle crashes. (Published online Oct 4, 2011). *Epidemiol Rev.* 2012; 34(1): 65–72. doi: 10.1093/epirev/mxr017 PMCID: PMC3276316

31. Joujanis E, Lapeyre-Mestre M, Micallef J, and The French Association of the Regional Abuse and Dependence Monitoring Centres (CEIP-A) Working Group on Cannabis Complications. Cannabis use: Signal of increasing risk of serious cardiovascular disorders. *J Am Heart Assoc* 2014; 3: e000638. doi: 10.1161/JAHA.113.000638

32. Pletcher MJ, Vittinghoff E, Kalhan R, et al. Association between marijuana exposure and pulmonary function over 20 years. *JAMA.* 2012; 307(2):173-181. doi: 10.1001/jama.2011.1961.

33. Callaghan RC, Allebeck P, Sidorchuk A. Marijuana use and risk of lung cancer: a 40-year cohort study. (Published on line July 12, 2013).*Cancer Causes Control*. 2013 24(10):1811-20. doi:10.1007/s10552-013-0259-0.

34. Moir D, Rickert WS, Levasseur G, et al. A comparison of mainstream and side stream marijuana and tobacco cigarette smoke produced under two machine smoking conditions. Published on line December 7, 2007. *Chem Res Toxicol*. 2008; 21(2):494-502.

35. Wong, K, Clarke, C. The legalization of marijuana in Colorado: The impact. Emergency room and hospital marijuana-related admissions. 2015; (3):76. http://www.rmhidta.org/default.aspx/MenuItemID/687/MenuGroup/RMHIDTAHome.htm. Accessed 9/16/15

36. Abrams DI, Jay CA, Shade SB, et al. Cannabis in painful HIV-associated sensory neuropathy: A randomized placebo-controlled trial. *Neurology* . 2007 Feb 13; 68(7):515-21. doi: http://dx.doi.org/10.1212/01.wnl.0000253187.66183.9c

37. 36. Ellis RJ, Toperoff W, Vaida F, et al. Smoked medicinal cannabis for neuropathic pain in HIV: a randomized, crossover clinical trial. *Neuropsychopharmacology*. 2009 Feb; 34(3):672-80. doi:10.1038/npp.2008.120. (Published on line Aug 6, 2008).
38. PMID:18688212 PMCID:PMC3066045

39. Whiting PF, Wolff RF, Deshpande S, et al. Cannabinoids for medical use: A systematic review and meta-analysis. *JAMA*. 2015; 313(24):2456-2473. Doi:10:1001/mama.2015.6358.

40. Schatman, M.E. Medical marijuana: the state of the science. *Medscape Neurology*, Feb 6, 2015 WebMD, LLC. Accessed Feb 10**,** 2015.

41. Desroches J and Beaulieu P. Opioids and cannabinoids interactions: Involvement in pain management. *Curr Drug Targets*. 2010; 11(4):462-73. PMID: 20017728

42. Elikkottil J, Gupta P, Gupta K. The analgesic potential of cannabinoids. *J Opioid Manag*. 2009; 5(6):341-57.

43. Total Marijuana Taxes, Licenses, and Fees, 2014. Marijuana Tax Data Archive Colorado Department of Revenue. https://www.colorado.gov/pacific/revenue/colorado-marijuana-tax-data. Accessed 9/11/2015.

44. Approved medical marijuana research grants. Colorado Department of Public Health and Environment. Marijuana https://www.colorado.gov/pacific/cdphe/approved-medical-marijuana-research-grants. Accessed 9 19 2012

45. Bouchery EE, Harwood HJ, Sacks JJ, Simon CJ, Brewer RD. Economic costs of excessive alcohol consumption in the U.S., 2006. *Am J Prev Med*. 2011 Nov; 41(5):516-24. doi:10.1016/j.amepre.2011.06.045.

46. Centers for Disease Control and Prevention. Smoking and tobacco use. Fast facts. Costs and expenditures. www.cdc.gov/tobacco/data_statistics/fact_sheets/fast_facts/index.htm#cost. Accessed September 15, 2015.

47. Quest Diagnostics, for companies and organizations, pre-employment drug testing. http://www.questdiagostics.com/home/companies/employer/drug-screening/testing-reasons/pre-employment. Accessed November 27, 2015.

48. The economic and societal impact of motor vehicle crashes, 2010 (Revised) http://www.nhtsa.gov/Research Search: http://www-nrd.nhtsa.dot.gov/Pubs/812013.pdf. Accessed November 27, 2015.

49. Wong K, Clarke C. (2015). The legalization of marijuana in Colorado: The impact. Impaired driving. Operators testing positive for marijuana. 2015 ;(3):16-18. http://www.rmhidta.org/default.aspx/MenuItemID/687/MenuGroup/RMHIDTAHome.htm. Accessed September 16, 2015

50. Traffic safety facts for Colorado: 2010-2014.Fatalities in crashes involving an alcohol-impaired driver (BAC = .08+). http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/STSI/8_CO/2014/Colorado_Map_5_DATA_2014.PDF. Accessed November 27, 2015.

51. Personal communication, January 2016, with Patrick Ballard, Chief Financial Officer, Penrose St. Francis Health Systems, Colorado Springs, CO.

Conflict of Interest Statement

We declare that we have no proprietary, financial, professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled *The Hidden Costs of Marijuana Use in Colorado: One Emergency Department's Experience*.

Biography for Kenneth Finn, MD

Dr. Finn received his Medical Degree from the University of Texas - Houston in 1990 and completed his internship in Internal Medicine at Presbyterian Hospital of Dallas in 1991 and his residency in Physical Medicine and Rehabilitation at the University of Utah in Salt Lake City in 1994. He has been practicing medicine in Colorado Springs since 1994 and is the owner of Springs Rehabilitation, PC since 1996. He is Board Certified in Physical Medicine and Rehabilitation, Pain Medicine, and Pain Management (through the Boards of Anesthesia and PMR). He has been practicing Pain Medicine in Colorado Springs since 1994. He served on the Governor's Task Force on Amendment 64, Consumer Safety and Social Issues Work Group and is on the Colorado Medical Marijuana Scientific Advisory Council. He has spoken to several groups regarding the societal effects of marijuana which are becoming apparent with increased acceptance and use.

Biography for Rochelle Salmore, MSN, RN, NE-B

Mrs. Salmore has worked in different management positions at Penrose St. Francis Healthcare Services for over 40 years. She was active in her professional organizations at the state and national level, and board certified in both Gastroenterology Nursing and Nursing Administration. One of her research studies, the Colorado Behavioral Numerical Pain Scale was adopted in GI

Labs statewide and incorporated into Net Health's electronic medical record for gastroenterology. Prior to retiring in 2015, she pioneered the Nurse Scientist role where she conducted nursing research while mentoring bedside nurses as they began the research and publication processes.