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Marijuana use and outcomes in adult and pediatric trauma patients after legalization in California

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ABSTRACT

Background: Marijuana has become legal in eight states since 2012. We hypothesized the incidence of marijuana-positive trauma patients and rate of mortality has increased post-legalization.
Methods: A single level-I trauma center was used to identify patients screening positive for marijuana on urine-toxicology. Patients in the pre-legalization and post-legalization periods were compared.
Results: In the pre-legalization cohort 9.4% were marijuana-positive versus 11.0% in the post-legalization cohort ($p = 0.001$). Marijuana-positive patients post-legalization had higher rates of critical trauma activation (20.0% vs. 15.0%, $p = 0.01$) and mortality (2.6% vs. 1.2%, $p = 0.03$). In the pediatric (age 12–17) subgroup, the incidence of marijuana-positive patients did not change after legalization (pre: 39.3%, post: 46.4%, $p = 0.24$).
Conclusion: The incidence of marijuana-positive trauma patients increased post-legalization. Adult marijuana-positive trauma patients post-legalization were more likely to meet criteria for critical trauma activation and have a higher mortality rate. A subgroup of pediatric patients had an alarmingly high rate of marijuana use.
Summary: The rate of marijuana use among trauma patients increased post-legalization in California. The rate of critical trauma activation also increased as well as the mortality rate.

Introduction

Marijuana is the most commonly cultivated and abused illicit drug worldwide with nearly 2.5% of the world's population consuming marijuana or a cannabis byproduct.[1] In the United States, up to 22-million Americans older than 12-years of age use marijuana annually.[2] Tetrahydrocannabinol (THC) is the active ingredient in marijuana and its medicinal properties provide treatment for chronic pain, nausea, and anorexia. The earliest medicinal use of marijuana was in 400 AD.[3] California was the first state to decriminalize marijuana in 1998 and allow for medicinal use under the discretion of a physician.[4] Since that time, 30 states have followed California's initiative and allowed for the medicinal use of cannabis.[5–7] THC is most commonly prescribed for relief of symptoms involving cancer, glaucoma, immunodeficiency and/or multiple sclerosis.[8,9]

The recreational use of marijuana has been illegal for most of the past 80 years but has garnered increased public acceptance. According to a national survey in 2016, up to 60% of Americans feel that marijuana should be legalized.[10] In 2012, Washington and Colorado were the first states to legalize the recreational use of marijuana.[11] Two years later, Alaska and Oregon legalized the recreational use of marijuana and in 2016, three more states legalized recreational marijuana including California.[12,13] Currently, over 20% of the population now lives in a state where recreational use of marijuana is legal with more than half of them residing in California.[6]

Marijuana intoxication has been demonstrated to affect attention span and reaction time which can increase exposure to traumatic injury.[14] In previous reports, the recreational legalization of marijuana has been demonstrated to double the rate of cannabis use by teenagers and young adults in states where the law was passed.[15,16] The majority of the literature regarding the recreational

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legalization of marijuana has been centered on patients from Colorado or Washington. For example, the University of Colorado burn center has experienced an increase in the number of marijuana-related burns since legalization.[17] However, in other reports, the recreational legalization of marijuana has not changed outcomes. In a single center-analysis, Sokoya et al. reported a similar rate of facial fractures before and after the legalization of marijuana.[18] Three years after recreational marijuana legalization, the rate of fatal motor vehicle crashes in Colorado and Washington were similar to states without recreational marijuana legalization.[19]

Little is known about the outcomes of legalizing the recreational use of marijuana in California, the most populous state in the country, representing 12% of the United States' population. The purpose of this research is to investigate the impact of recreational marijuana legalization on patients presenting to a level-I trauma center in California, hypothesizing the incidence of marijuana-positive patients and risk of death has increased post-legalization. We also sought to determine if a pediatric subgroup of patients had an increase in use of marijuana after legalization.

Methods

This retrospective, uncontrolled study was approved by the Institutional Review Board (IRB) at the University of California, Irvine. Our center is a level-I adult, level-II pediatric trauma center. We queried all patients within our trauma registry to identify those presenting after trauma between January 2013 and December 2017. The primary outcome was a positive urine toxicology screen for THC, the active ingredient in marijuana. Our laboratory uses the Beckman-Coulter AU2700 Chemistry Analyzer utilizing enzyme multiplied immunoassay technique (EMIT) methodology. Patients presenting to the hospital between 2013 and 2016 (pre-legalization) and in 2017 (post-legalization) were compared.

The secondary outcomes were the rates of concurrent illicit drug (i.e. cocaine, benzodiazepine, barbiturate, opioids, methamphetamine, methylenedioxymethamphetamine [MDMA]) and alcohol use, trauma level activation, as well as mortality. Serum or urine nicotine is not part of our standard trauma activation work-up and so was not studied in our analysis. Trauma level activation at our institution is tiered into moderate and critical activations, the latter requiring attending trauma surgeon presence as well as the presence of additional support staff including respiratory therapy and availability of blood products prior to the patient's arrival. Other measured outcomes included total hospital length of stay (LOS), intensive care unit (ICU) LOS, ventilator days and two commonly performed surgical interventions for our trauma patients, exploratory laparotomy and open-reduction-internal fixation (ORIF) of long-bone extremity fractures. In-hospital complications included respiratory failure and pneumonia. Respiratory failure was defined by a patient requiring mechanical ventilation with either endotracheal intubation or tracheostomy. Pneumonia was a clinical diagnosis based on radiographic findings (infiltrate), laboratory evaluations (i.e. white blood cell count), vital signs (fever), and clinical factors such as productive cough and/or discolored sputum, as well as quantitative sputum cultures with the diagnosis of pneumonia given only if the attending physician documented it as such. A subgroup of pediatric patients (age 12-17-years-old) were also analyzed. This age group was selected as routine urine toxicology screening is not performed on patients <12-years-old. It is our practice to screen all trauma patients 12-years of age or older for alcohol ingestion with serum ethyl alcohol testing, as well as illicit drugs, including THC with urine toxicology testing.

Demographic variables collected included age, gender, as well as systolic blood pressure (SBP) on admission, injury severity score (ISS) and GCS score. All variables were coded as present or absent. Descriptive statistics were performed for all variables. A Student's *t*-test or Mann-Whitney-U test were used to compare continuous variables and chi-square was used to compare categorical variables for bivariate analysis. Categorical data was reported as percentages, and continuous data was reported as medians with interquartile range or as means with standard deviation. All statistical analyses were performed with IBM SPSS Statistics for Windows, Version 24. (Armonk, NY: IBM Corp).

Results

Demographics of trauma patients and incidence of marijuana post-legalization

From 21,173 trauma admissions, 16,718 presented in the pre-legalization period and 4455 presented in the post-legalization period. In the pre-legalization period, 86.8% of trauma patients had a urine toxicology and in the post-legalization period, 77.3% did ($p < 0.001$). A total of 2055 (9.7%) patients screened positive for THC on urine toxicology. Of these, 1564 presented in the pre-legalization period while 491 presented in the post-legalization period. The incidence of marijuana-positive patients in the pre-legalization cohort was 9.4% and 11.0% in the post-legalization cohort ($p = 0.001$). The most common overall mechanism of injury in both groups was motor vehicle accident (MVA) (pre: 31.5%, post: 31.6%, p = NS [not significant]). Compared to those in the pre-legalization group, patients in the post-legalization group had a similar median age (26 vs. 25 years, p = NS), ISS (9 vs. 8, p = NS), SBP on admission (134 vs. 132 mmHg, p = NS) and GCS score on admission (15, p = NS) (Table 1). The under-triage rate remained statistically similar from 7.9% in the pre-legalization period to 7.6% in the post-legalization period (p = NS), while the over-triage rate increased from 5.3% to 7.6% in the same period ($p < 0.001$) (Table 2).

Concurrent alcohol/illicit drug use, critical trauma activation, and mortality

Compared to those in the pre-legalization group, patients in the post-legalization group had similar rates of positive serum alcohol screen (25.7% vs. 29.0%, p = NS) and urine screen of opiates (27.5% vs. 24.6%, p = NS), methamphetamine (22.4% vs. 19.8%, p = NS), benzodiazepine/barbiturate (14.1% vs. 11.3%, p = NS) and MDMA (1.2% vs. 0.6%, p = NS). The post-legalization cohort did have a higher rate of screening positive for cocaine (8.4% vs. 4.7%, $p = 0.002$) and presenting as a critical trauma activation (20.0% vs. 15.1%, $p = 0.01$) (Table 1). Patients in the post-legalization group also had a higher in-hospital mortality rate (2.6% vs. 1.2%, $p = 0.03$). Most deaths in both groups were due to polytrauma with traumatic brain injury.

Other clinical outcomes in trauma patients screening positive for marijuana

Compared to those in the pre-legalization cohort, patients in the post-legalization group had similar hospital LOS (2 days, $p = 0.97$) and ICU LOS (2 vs. 3 days, $p = 0.78$). The rate of in-hospital complications and surgical interventions were also similar (p = NS) except for pneumonia which was higher in the post-legalization cohort (0.8% vs. 0.2%, $p = 0.04$).

Subgroup analysis of pediatric trauma patients and incidence of marijuana

From 387 pediatric trauma admissions, 158 (40.1%) patients screened positive for THC on urine toxicology. Of these, 119

Table 1
Demographics of trauma patients screened positive for marijuana stratified by pre and post-legalization.

Characteristic	Pre-legalization (2013–2016) (n = 1564)	Post-legalization (2017) (n = 491)	p-value
Incidence of marijuana +, %	9.4%	11.0%	**0.0008**
Age, year, median (IQR)	25.0 (15)	26.0 (15)	0.17
Male, n (%)	1303 (83.3%)	411 (83.7%)	0.84
ISS, median (IQR)	8.0 (4)	9.0 (3)	0.81
Systolic Blood Pressure, median (IQR)	132.0 (26)	134.0 (26)	0.08
Glasgow Coma Scale, median (IQR)	15.0 (1)	15.0 (1)	0.98
Trauma level activation, n (%)			**0.01**
Moderate	1319 (84.9%)	380 (80.0%)	
Critical	234 (15.1%)	95 (20.0%)	
Mechanism, n (%)			
Motor vehicle accident	492 (31.5%)	155 (31.6%)	0.96
Motorcycle accident	203 (13.0%)	55 (11.2%)	0.30
Pedestrian struck	123 (7.9%)	28 (5.7%)	0.11
Bicycle accident	104 (6.6%)	34 (6.9%)	0.83
Fall	144 (9.2%)	43 (8.8%)	0.76
Assault	355 (22.7%)	114 (23.2%)	0.81
Suicide	10 (0.6%)	1 (0.2%)	0.25
Serum alcohol positive, n (%)	454 (29.0%)	126 (25.7%)	0.15
Urine toxicology, n (%)			
Opiate	385 (24.6%)	135 (27.5%)	0.20
Methamphetamine	310 (19.8%)	110 (22.4%)	0.22
Benzodiazepine/barbiturate	176 (11.3%)	69 (14.1%)	0.10
Cocaine	73 (4.7%)	41 (8.4%)	**0.002**
MDMA	9 (0.6%)	6 (1.2%)	0.14
Phencyclidine	2 (0.1%)	0	0.43

AIS = abbreviated injury scale, ISS = injury severity score, IQR = interquartile range.

presented in the pre-legalization period while 39 presented in the post-legalization period. The incidence of marijuana-positive patients in the pre-legalization cohort was 39.3% and 46.4% in the post-legalization cohort (p = NS). The most common overall mechanism of injury was assault (40.5%). Compared to those in the pre-legalization group, pediatric patients in the post-legalization group had a similar median age (17-years, p = NS), ISS (9 vs. 8, p = NS), SBP on admission (126 vs. 130 mmHg, p = NS) and GCS score on admission (15, p = NS) (Table 3).

Pediatric subgroup outcomes

Compared to those in the pre-legalization group, pediatric patients in the post-legalization group had similar rates of positive serum alcohol screen (23.1% vs. 23.5%, p = NS) and urine screen for opiates (28.2% vs. 17.6%, p = NS), methamphetamine (10.3% vs. 16.8%, p = NS), and cocaine (5.1% vs. 1.7%, p = NS). The post-legalization cohort did have a higher rate of screening positive for benzodiazepine/barbiturate (30.8% vs. 10.1%, p = 0.002) and a similar rate of critical trauma activation (35.9% vs. 24.4%, p = NS) (Table 3). Pediatric patients in the post-legalization group also had a higher in-hospital mortality rate (7.7% vs. 0.8%, p = 0.02). Compared to those in the pre-legalization cohort, pediatric patients in the post-legalization group had similar hospital LOS (2 days, p = NS) and ICU LOS (2 days, p = NS). The rate of in-hospital complications was also similar (all p = NS) (Table 4).

Discussion

This retrospective, uncontrolled study analyzed trauma patients presenting to a single adult level-I and pediatric level-II trauma center in the three years prior and one year after the recreational legalization of marijuana passed in California. In support of our hypothesis, we demonstrate the incidence of THC + urine toxicology among patients presenting after a traumatic injury has increased after legalization. However, while the rate of THC + urine toxicology has statistically increased after legalization, it is not an epidemiologically significant rise (1.6% increase). The rate of critical trauma activation and in-hospital mortality has also risen in patients screening positive for marijuana after recreational

Table 2
Demographics of trauma patients screened positive for marijuana stratified by pre and post-legalization.

Outcome	Pre-legalization (2013–2016) (n = 1564)	Post-legalization (2017) (n = 491)	p-value
LOS, days, median (IQR)	2.0 (3)	2.0 (3)	0.97
ICU, days, median (IQR)	3.0 (3)	2.0 (3)	0.78
Complications, n (%)			
Respiratory failure	5 (0.3%)	3 (0.6%)	0.37
Cardiac arrest	1 (0.1%)	0	0.58
Pneumonia	3 (0.2%)	4 (0.8%)	**0.04**
Procedure, n (%)			
Exploratory laparotomy	42 (2.7%)	12 (2.4%)	0.67
ORIF lower extremity	29 (1.9%)	8 (1.6%)	0.78
ORIF upper extremity	69 (4.4%)	29 (4.9%)	0.13
Mortality, n (%)	19 (1.2%)	13 (2.6%)	**0.03**

LOS = length of stay, IQT = inter-quartile range, ICU = intensive care unit, ORIF = open-reduction internal fixation.

Table 3
Demographics of subgroup pediatric trauma patients screened positive for marijuana stratified by pre and post-legalization.

Characteristic	Pre-legalization (2013–2016) (n = 119)	Post-legalization (2017) (n = 39)	p-value
Incidence of marijuana +, %	39.3%	46.4%	0.24
Age, year, median (IQR)	17.0 (1)	17.0 (1)	0.87
Male, n (%)	104 (87.4%)	33 (84.6%)	0.66
ISS, median (IQR)	8.0 (4)	9.0 (4)	0.76
Systolic Blood Pressure, median (IQR)	130.0 (26)	126.0 (22)	0.58
Glasgow Coma Scale, median (IQR)	15.0 (1)	15.0 (1)	0.98
Trauma level activation, n (%)			0.16
Moderate	90 (75.6%)	25 (64.1%)	
Critical	29 (24.4%)	14 (35.9%)	
Mechanism, n (%)			
Motor vehicle accident	31 (26.1%)	11 (28.2%)	0.79
Motorcycle accident	3 (2.5%)	1 (2.6%)	0.99
Pedestrian struck	12 (10.1%)	1 (2.6%)	0.14
Bicycle accident	8 (6.7%)	4 (10.3%)	0.47
Fall	5 (4.2%)	2 (5.1%)	0.81
Assault	47 (39.5%)	17 (43.6%)	0.65
Suicide	1 (0.8%)	0	0.57
Serum alcohol positive, n (%)	28 (23.5%)	9 (23.1%)	0.95
Urine toxicology, n (%)			
Opiate	21 (17.6%)	11 (28.2%)	0.15
Methamphetamine	20 (16.8%)	4 (10.3%)	0.32
Benzodiazepine/barbiturate	12 (10.1%)	12 (30.8%)	**0.002**
Cocaine	2 (1.7%)	2 (5.1%)	0.23
MDMA	1 (0.8%)	0	0.57

AIS = abbreviated injury scale, ISS = injury severity score, IQR = interquartile range.

legalization. The differences in critical trauma activation and mortality that we report may be unrelated to THC use and may be a result of trauma system changes and compliance with activation criteria. Unfortunately, over 45% of pediatric trauma patents aged 12-17 years-old screen positive for marijuana on admission after legalization and the most common mechanism of injury involved assault. Although pediatric trauma patients had a trend towards increased marijuana use after legalization, this did not reach statistical significance. The rate of concurrent drug use involving cocaine and benzodiazepine/barbiturates also increased in adults and pediatric trauma patients, respectively, after legalization.

It is unclear if marijuana legalization leads to increased cannabis use. Hall et al. suggest that without public health policies, resolution of Federal and State laws, and restricted cannabis prices, the full effects of legalized cannabis policies on use and harm is unknown.[20] The United States has some of the strictest drug laws in the world. Compared to countries with more liberalized drug-laws, such as Netherlands, the overall rate of cannabis use among Americans has been reported to be similar or up to twice as high compared to the Dutch.[21] After legalization in Colorado, Jones et al. reported the rates of marijuana use in Colorado college students dropped 15% in two years.[22] Similarly, according to the National Survey on Drug Use and Health (NSDUH), the use among children and teenagers (aged 12–17 years) in Colorado also dropped from 10.2% to 9.1%.[23] In another report, Cerda et al. reported that marijuana consumption among high-schoolers did not change after legalization.[24] In an estimation sample of over 1 million high-school students, there was no increase in adolescent marijuana use related to legalization of marijuana.[25] And finally, in a systematic review and meta-analysis published in 2014, medical marijuana laws were not found to be associated with increased adolescent marijuana use.[26] However, our study found an associated increased rate of marijuana use among trauma patients in the year following the recreational legalization of marijuana in California. In pediatric trauma patients, over 45% screened positive for marijuana the year following legalization. Part of the discrepancy between our results and other reports is their data relies on self-reporting with associated bias, whereas our data utilizes objective urine toxicology screening. The increased trend in cannabis-use may also be explained by more positive views of marijuana among Americans, partly due to social media. In fact, pro-marijuana tweets outnumber anti-marijuana tweets by a factor of greater than 15.[27]

Screening for drugs and alcohol has been sporadic among pediatric trauma patients.[28] According to the National Pediatric Trauma Registry in 1995, the rate of alcohol or marijuana use in patients aged 10-14 years-old was 9%.[29] Our data suggests that cannabis use has risen dramatically in California children presenting with traumatic injuries. This is even more troubling considering the relative potency of THC in California has increased from 3.9% in

Table 4
Demographics of subgroup pediatric trauma patients screened positive for marijuana stratified by pre and post-legalization.

Outcome	Pre-legalization (2013–2016) (n = 119)	Post-legalization (2017) (n = 39)	p-value
LOS, days, median (IQR)	2.0 (1)	2.0 (2)	0.32
ICU, days, median (IQR)	2.0 (2)	2.0 (1)	0.19
Complications, n (%)			
Respiratory failure	1 (0.8%)	2 (5.1%)	0.09
Cardiac arrest	0	0	–
Pneumonia	0	1 (2.6%)	0.08
Mortality, n (%)	1 (0.8%)	3 (7.7%)	**0.02**

LOS = length of stay, IQT = inter-quartile range, ICU = intensive care unit.

1995 to 10.8% in 2010.[30] Higher concentration of THC might have a stronger effect on mental and physical health outcomes leading to more aggressive and/or high-risk behavior.[31–33] This is supported by our study as pediatric trauma patients screening positive for marijuana most commonly presented after a mechanism involving assault. Trauma care providers are in a unique position to implement drug counseling to provide education on the dangers of marijuana and other illicit substances, particularly for pediatric trauma patients. In the community setting, motivational interviewing has been shown to reduce the use of cannabis, alcohol and cigarettes among teenagers by up to 66%.[34] This involves implementing a goal-directed client-centered counseling style to elicit behavior change by helping the patient explore and resolve ambivalence.[35] Bernstein et al. subsequently attempted a brief motivational interviewing technique to reduce marijuana use and related consequences among pediatric patients treated at a single level-I trauma center.[36] They report that teenagers randomized to motivational interviewing were 3x more likely to abstain from marijuana use 12-months later. Future research to determine if similar programs are beneficial at California trauma centers, which have a high incidence of pediatric trauma patients presenting with positive drug screen, is warranted.

Recreational marijuana may indirectly lead to increased traumatic injuries. Johnson et al. randomly obtained oral fluid samples from more than 900 weekend nighttime drivers in California and reported the prevalence of cannabis-involved driving increased by nearly 60% following marijuana decriminalization.[37] In a subsequent report, Pollini et al. found no difference in the prevalence of cannabis-involved driving among weekend nighttime drivers in California but did report an increased prevalence among fatally injured drivers after cannabis decriminalization.[38] Our study reports no difference in the incidence of MVAs in patients who have used marijuana. However, our study demonstrates that recreational legalization of marijuana in California has led to a 22% increase in marijuana positive trauma patients with a 33% increase in the rate of critical trauma activations and doubling of the mortality rate. Similar findings have not been consistently shown in other states. Three years after recreational marijuana legalization, the rate of fatal motor vehicle crashes in Colorado and Washington were similar to states without recreational marijuana legalization.[19] The associations we report could be from unrelated trauma system changes and compliance with activation criteria. That said, our activation criteria did not change during the study period, for both moderate and critical trauma activations. However, activation may at times be subjective. For example, the Glasgow Coma Scale score (GCS) or heart rate could be different in the field, possibly due to drug use like methamphetamine, cocaine or marijuana, and effect the trauma level activation. Additionally, when the patient arrives to the hospital, their vitals and/or GCS may be different and what we report in our manuscript are the vitals and GCS on arrival. Furthermore, the vitals reported by EMS or the reason why a trauma activation was labeled moderate or critical is not explicitly documented in our charting. Improved (or worsened) compliance, albeit difficult to measure, may certainly have played a role in the increase in critical trauma activation. Future state-wide research is needed to determine if our findings are applicable to all Californians and to determine what factors are responsible for the higher rate of critical trauma activations and mortality in the post-legalization period.

The legalization of marijuana may have an impact on concurrent substance abuse. The “gateway theory” proposes that marijuana is associated with a higher likelihood to use a stronger illicit drug (e.g. cocaine) later in life.[39] Thus, there is a concern that after legalization and widespread availability of marijuana, the rates of non-cannabis substance abuse would increase significantly. This is particularly concerning for alcohol abuse as concurrent alcohol and marijuana use has a positive synergistic effect on the risk for fatal motor vehicle crashes.[40] Chaloupka et al. reported that marijuana decriminalization was associated with less frequent alcohol-abuse, lower likelihood of heavy drinking and decreases in alcohol-related driver fatality rates among youth.[41] Several other reports found a higher prevalence of alcohol use after decriminalization.[42,43] In contrast, multiple other reports found no association between marijuana decriminalization and alcohol abuse.[44–46] In our study, we found no difference in the rate of concurrent alcohol use in trauma patients presenting before and after the recreational legalization of marijuana in California. However, adult trauma patients screening positive for marijuana in the post-legalization period had a doubling in the rate of concurrent cocaine use. In pediatric patients presenting with positive THC urine toxicology, we found the concurrent use of benzodiazepine/barbiturates to be increased in the post-legalization period. Future studies are needed to elucidate the impact of marijuana recreational legalization on trauma patients presenting with concurrent substance abuse.

This study included an analysis of patients from a single trauma center in California, thus limiting generalizability of our findings. In addition, urine toxicology is unable to determine which patients were intoxicated with marijuana at the time of injury or if metabolites were still present in the patient's urine without exerting a clinical impact. The half-life of cannabinoids in urine is about 4–27 days, depending on frequency and amount of use.[47] Furthermore, it is possible that marijuana had no effect on the trauma mechanism. For example, a passenger in a MVA is unlikely the cause of the MVA. Since we did not compare time periods prior to legalization, the increase seen post-legalization may have been an already present trend, unrelated to the legalization. The study was not sufficiently powered to run a multivariable logistic regression analysis controlling for confounding variables such as concurrent cocaine use. However, we hope this study will lay the foundation to promote a multi-institutional coalition to study outcomes of marijuana decriminalization in California. We ran a power analysis to detect a 5% increase in THC + pediatric trauma patients after decriminalization. To have enough power for this analysis, we needed 1564 pediatric trauma activations. However, we only had 402 during the study period. Marijuana tourism may have had an effect on the results we found. Unfortunately, out of state residence is poorly documented in our electronic medical record. The criteria leading to moderate or critical trauma activation is also not documented. Additionally, we did not determine the effects of recreational legalization of marijuana in pediatric patients <12-years-old as we do not routinely perform urine toxicology on these patients. Finally, other substance use such as benzodiazepines may be related to a medical condition and not a concomitant substance of abuse.

Conclusion

The incidence of trauma patients who screened positive for marijuana has increased post-legalization. However, while the rate of THC + urine toxicology has statistically increased after legalization, it is not an epidemiologically significant rise. Adult trauma patients screening positive for marijuana post-legalization were more likely to meet criteria for critical trauma activation and have a higher mortality rate compared to the pre-legalization group. This may be unrelated to THC use itself and explained by confounding variables that are difficult to measure such as trauma system changes and compliance with activation criteria. A subgroup of pediatric patients aged 12–17 years old had an alarmingly high incidence of THC found on urine toxicology. Marijuana legalization was associated with an increase in the incidence of concurrent cocaine and benzodiazepine/barbiturate use among adult and

pediatric trauma patients, respectively. Future research regarding the implementation of drug counseling and/or motivational interviewing, especially for pediatric patients appears warranted.

Conflict of interest statement

The authors do not have any conflicts of interest to report, financial or otherwise.

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Appendix A. Supplementary data

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