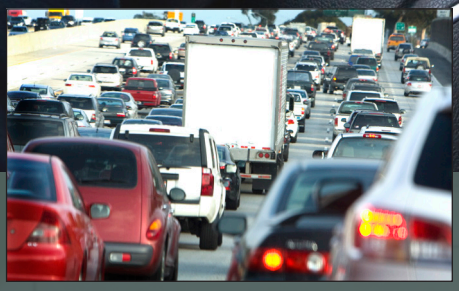
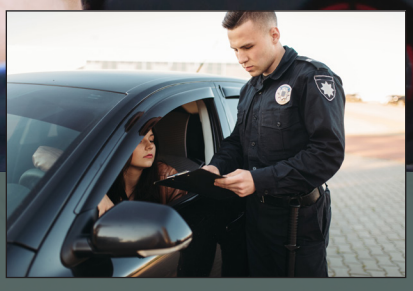
Marijuana Legalization and Impaired Driving: Solutions for Protecting our Roadways

March 2019





Prepared by the American Transportation Research Institute

ATRI American Transportation Research Institute

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March 2019

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ACKNOWLEDGEMENTS

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LIST OF ACRONYMS

AACC	American Association for Clinical Chemists
AAN	American Academy of Neurology
ARIDE	Advanced Roadside Impaired Driving Enforcement
ATRI	American Transportation Research Institute
BAC	Blood Alcohol Content
BrAC	Breath Alcohol Concentration
CBD	Cannabidiol
CDL	Commercial Driver's License
DEA	Drug Enforcement Administration
DEC	Drug Evaluation and Classification Program
DOT	Department of Transportation
DRE	Drug Recognition Expert
DUI	Driving Under the Influence
FARS	Fatality Analysis Reporting System
FAST Act	Fixing America's Surface Transportation Act
FDA	Food and Drug Administration
FMCSA	Federal Motor Carrier Safety Administration
GC-MS	Gas Chromatograph-Mass Spectrometry
HGN	Horizontal Gaze Nystagmus
HOA	Homeowner Association
IACP	International Association of Chiefs of Police
LAPD	Los Angeles Police Department
LC-MS	Liquid Chromatography-Mass Spectrometry
LOC	Lack of Convergence
LSD	Lysergic Acid Diethylamide
MMUCC	Model Minimum Uniform Crash Criteria
ng/mL	Nanograms per Milliliter
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
OLS	One Leg Stand
RAC	Research Advisory Committee
SFST	Standardized Field Sobriety Test
THC	Tetrahydrocannabinol
WAT	Walk and Turn

INTRODUCTION

Large trucks, automobiles and other vehicles share the nation's highways and surface streets, accumulating more than 3 trillion vehicle-miles-traveled each year. Of these miles, drivers of large trucks accumulate more than 180 billion miles in order to move the nation's freight and earn their living.

To operate a large truck, drivers must hold a commercial driver's license (CDL) and are subject to drug testing rules due to their safety-sensitive employee designation. The vehicles operating alongside large trucks are predominately automobiles that are driven for non-commercial purposes. While automobile drivers must hold a driver's license, there is no requirement to pass a drug test or to be randomly tested for drug use.

To ensure a safe driving environment, however, all drivers are subject to state laws that prohibit impaired driving that results from drug or alcohol consumption. Driving while under the influence carries large penalties including fines, loss of driving privileges and even jail sentences. That said, an impaired driver must be identified by law enforcement, the impairment must be documented and the individual must be successfully prosecuted in order to face such consequences.

Marijuana is one of many drugs that, when consumed, can cause significant and dangerous driving impairment.[1] As states have legalized recreational use of marijuana over the past decade, there has also been an increase in passenger vehicle drivers testing positive for marijuana.[2]

This is concerning to the trucking industry considering the large percentage of truck-involved crashes caused by the actions of car drivers. Further exacerbating this concern is the difficulty faced by law enforcement in deterring marijuana-impaired driving. While there exist accurate tools to test for and prosecute drunk driving, widely tested and accepted tools and methods are not currently available for marijuana impairment testing. As a result, truck drivers in many states now face the significant risk of having legal marijuana users drive impaired (and illegally) alongside their trucks.

Recognizing the criticality of this issue, the American Transportation Research Institute's (ATRI's) Research Advisory Committee (RAC)[3] selected transportation safety issues associated with marijuana as a top research priority in 2018. As stated earlier, central to this issue are states that have legalized marijuana possession and use, but have not fully documented and implemented procedures for effectively addressing marijuana-impaired driving. The goal of this research is to identify the most promising methods for improving safety on our nation's highway by identifying and deterring marijuana-impaired driving.

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[1] "Does Marijuana Use Affect Driving?," drugabuse.gov, June 2018, https://www.drugabuse.gov/publications/research-reports/marijuana/does-marijuana-use-affect-driving.

[2] Amy Berning, Richard Compton, and Kathryn Wochinger, "Results of the 2013–2014 National Roadside Survey of Alcohol and Drug Use by Drivers" (National Highway Traffic Safety Administration, February 2015).

[3] ATRI's Research Advisory Committee RAC is comprised of industry stakeholders representing motor carriers, trucking industry suppliers, federal government agencies, labor and driver groups, law enforcement, and academia. The RAC is charged with annually recommending a research agenda for the Institute.

BACKGROUND

After decades in which marijuana was an illegal substance in the U.S., the majority of states (33) have legalized marijuana for medical use and 10 states have legalized recreational use of the drug.[4] While the states have made these changes, the U.S. federal government still considers the production, sale, possession and use of marijuana to be a criminal activity.

While it may be legal to consume marijuana in various settings and scenarios, operating a vehicle on public roads while impaired is a criminal offense. This is due to the intoxicating effects of tetrahydrocannabinol (THC), a component of marijuana. Issues associated with marijuana impairment and driving include:[5]

- Poor judgment;
- Decreased motor coordination; and
- Decreased reaction time.

Likewise, marijuana impairment while driving is likely to become a larger problem as legal access to the drug increases. Recent national statistics for marijuana-positive drug tests, for instance, indicate that 2.6 percent of drug tests were marijuana-positive in 2017 – a 4.0 percent year-over-year increase from 2016.[6] Marijuana-positive drug tests for federally-mandated, safety-sensitive occupations have also increased by nearly eight percent from 2016 to 2017 (0.78% in 2016 to 0.84% in 2017).[7] The largest increases in marijuana positivity rates were observed in states that recently enacted recreational marijuana laws.

Driving Under the Influence (DUI)

Driving under the influence (DUI)[8] is a significant safety concern – in 2016 more than 28 percent of all traffic fatality incidents included at least one driver who was operating a vehicle under the influence of alcohol.[9] Marijuana likely contributes to the nation's fatal crash statistics as well.[10] As will be discussed in this report, however, identifying alcohol impairment is well established and far less complex than identifying marijuana impairment. The data on marijuana-involved crash rates, particularly those involving fatalities, simply are not collected at the same rate or with the same level of confidence as those involving alcohol impairment.

To deter impaired driving and prevent crashes, laws for driving while under the influence of alcohol and drugs carry serious penalties, including fines, jail time and loss of driving privileges. Proving that a driver is impaired due to alcohol consumption is relatively straightforward – there is a limit on the amount of alcohol that can be present in the blood in order to legally drive, and

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[4] The increased access to marijuana domestically is mirrored by national-scale legalization legislation for Canada and Mexico, with Canada legalizing recreational marijuana in 2018 and Mexico legalizing medical marijuana in 2017.
[5] "Does Marijuana Use Affect Driving?," drugabuse.gov, June 2018, https://www.drugabuse.gov/publications/research-reports/marijuana/does-marijuana-use-affect-driving.
[6] "Workforce Drug Positivity at Highest Rate in a Decade, Finds Analysis of More Than 10 Million Drug Test Results - May 8, 2018," accessed February 13, 2019, http://newsroom.questdiagnostics.com/2018-05-08-Workforce-Drug-Positivity-at-Highest-Rate-in-a-Decade-Finds-Analysis-of-More-Than-10-Million-Drug-Test-Results.
[7] Ibid.
[8] Also commonly referred to in the U.S. as DWI, which stands for either driving while intoxicated or driving while impaired.
[9] https://www.cdc.gov/motorvehiclesafety/impaired_driving/impaired-drv_factsheet.html
[10] "Drugged Driving Statistics," Page, Colorado Department of Transportation, accessed February 13, 2019, https://www.codot.gov/safety/alcohol-and-impaired-driving/druggeddriving/statistics.

well-established methods for testing a person for these limits are utilized by law enforcement and accepted by the scientific community. These clear-cut laws, practices and tools to combat DUI have contributed to an approximately 50 percent decrease in annual alcohol-related traffic deaths today versus the 1980s.[11] As will be discussed in this report, however, marijuana is processed by the body in a far different manner than alcohol, and therefore different approaches are needed to identify and prosecute marijuana-impaired driving.

Proof of Impairment - Marijuana Testing

Standard drug testing mechanisms today can easily identify past marijuana use by measuring metabolites. Though not generally indicative of intoxication, a positive test for past marijuana use can lead to employee termination by many employers, particularly those with strict anti-drug policies or those who employ safety-sensitive transportation workers.[12]

But the aforementioned testing is not evidence of active impairment or intoxication. Thus, a simple blood or breathalyzer test – commonly employed by law enforcement when alcohol impairment is suspected – is not ideal for identifying drivers operating under the influence of marijuana. This is due to the body's mechanisms for processing marijuana's intoxicant agent, THC.

Of the states that have legalized recreational marijuana, most have chosen to set limits on the amount of acceptable THC in blood tests when testing for driver impairment. However, there are several issues related to such tests. The National Highway Transportation Safety Administration (NHTSA), for instance, offers evidence that some state laws allow an individual to be charged with a DUI if they test positive for THC derivatives in urine following arrest, which indicates marijuana use in the past 30 days but not necessarily recent marijuana use.

[11] "Since the early 1980s, alcohol-related traffic deaths per population have been cut in half with the greatest proportional declines among persons 16-20 years old." See: https://report.nih.gov/nihfactsheets/ViewFactSheet.aspx?csid=24

[12] Federal laws require marijuana testing for truck drivers who possess an interstate commercial driver's license (CDL); if a driver tests positive there are a series of steps that must be taken which will negatively impact and may ultimately end a driver's career.

LEGALIZATION TRENDS

The U.S. Drug Enforcement Administration (DEA) classifies marijuana as a Schedule 1 drug under the Controlled Substance Act. Schedule 1 drugs are considered to have no known use for medicinal purposes and "high potential for abuse."[13] Marijuana, as well as heroin, LSD and ecstasy are all considered Schedule 1 drugs at the federal level.[14] Despite its Schedule 1 classification, many state governments have legalized marijuana for medical use and, in the case of 10 states, recreational use.

Medical Marijuana Laws

Medical marijuana has been approved to treat a substantial number of medical conditions in 33 states and the District of Columbia.[15] Other states have more restrictive medical marijuana laws where only a select few conditions qualify an individual for medical marijuana. Figure 1 highlights those states where comprehensive medical marijuana legislation has been enacted.

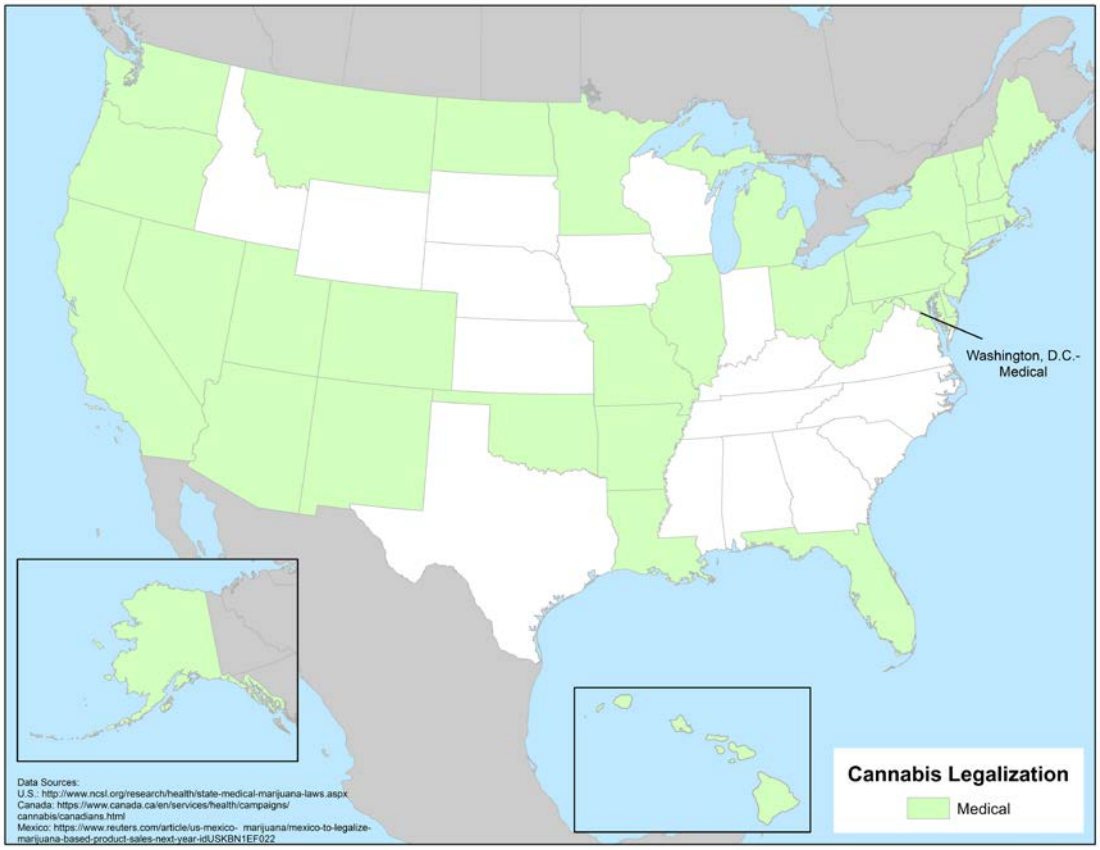
States with medical marijuana laws require patients to have an ID card and/or enroll in a patient registry in order to obtain marijuana. This database of patients is also utilized by law enforcement to ensure those who are legally carrying medical marijuana are not mistakenly arrested for illegal possession. The majority of states with medical marijuana laws have certain health conditions that are covered under their medical marijuana legislation. States vary in their recognition of medical marijuana patients from other states.

[13] United States Drug Enforcement Administration. "Drug Scheduling," accessed February 13, 2019, https://www.dea.gov/drug-scheduling.

[14] Ibid.

[15] "State Medical Marijuana Laws," accessed February 13, 2019, http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx. An additional 15 states have legislation approving cannabidiol (CBD) use for medical purposes.

Figure 1: States with Comprehensive Medical Marijuana Laws



According to the American Academy of Neurology (AAN), two forms of marijuana have been approved by the Food and Drug Administration (FDA) in pill form for medical use. Studies have also been conducted to review the effectiveness of smoked marijuana, cannabidiol (CBD) extract or a combination of CBD and THC in pill form.[16] Ongoing medical trials are being conducted to understand the effectiveness of marijuana in treating:

- Disease symptoms;
- Drug side effects; and
- Pain in cancer and chemoradiation patients.

Although additional studies are needed for conclusive evidence, diseases in which marijuana has had moderate success in treating symptoms include multiple sclerosis, epilepsy, Crohn's disease, and inflammatory bowel disease.[17]

[16] American Academy of Neurology, "Medical Marijuana in Certain Neurological Disorders," 2014, https://www.aan.com/Guidelines/Home/GetGuidelineContent/650.

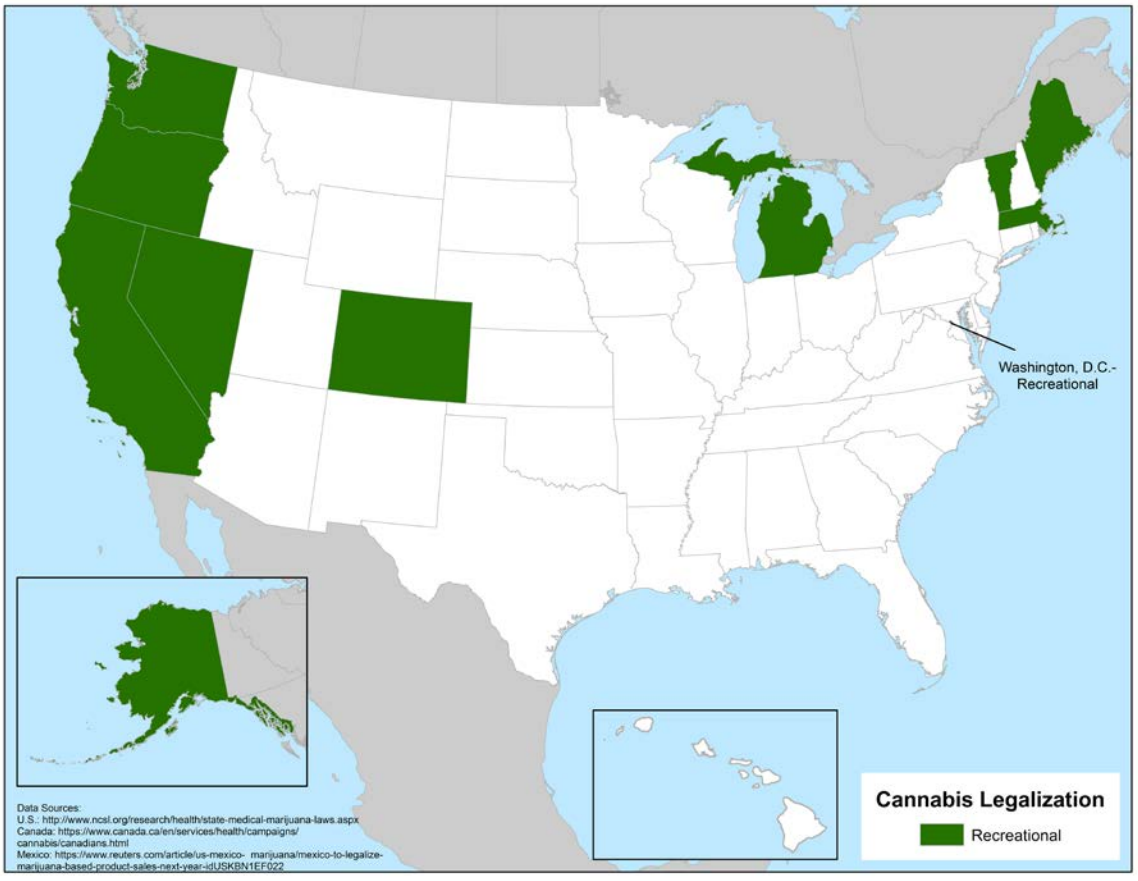
[17] "Medical Marijuana: MedlinePlus Medical Encyclopedia," Accessed February 13, 2019, https://medlineplus.gov/ency/patientinstructions/000899.htm.

Recreational Marijuana Laws

Ten states and the District of Columbia have passed legislation that allows for recreational marijuana use (Figure 2). All 11 jurisdictions require a person in possession of marijuana to be 21 years of age or older and prohibit the use of marijuana in public places. Similar to alcohol, drivers and passengers cannot actively consume marijuana in a motor vehicle that is in operation. Local laws, workplace rules, Homeowner Associations (HOAs) and rental tenants may be subject to additional regulations. Each state has separate laws regarding possession of marijuana and marijuana plants. Some states, for instance, specify whether marijuana plants can be grown on private property, where on the property they must be retained (not in public view from the street), and the number of plants each person or residence can grow in a household.

It is illegal to possess marijuana for recreational purposes according to federal law, and thus the movement of commercial marijuana over state lines (including between two states where recreational use is legal) is illegal.

Figure 2: States with Recreational Marijuana Laws



Taxation

States with legalized recreational marijuana have a tax on the drug paid by either consumers and/or producers of marijuana. A summary of state tax revenues generated by recreational marijuana, and how these funds are used is shown in Table 1. Tax revenues generated by recreational marijuana cultivation and sales are often allocated to marijuana regulatory agencies, law enforcement, substance abuse treatment/prevention programs, and state General Funds. Some states, such as California, also permit local jurisdictions to levy taxes on marijuana.

Table 1: Recreational Marijuana Tax Revenue and Allocation[18]

State	Retail Recreational Sales	Annual Tax Revenue (Millions)	Tax Revenue Allocation
Alaska	Yes	$5.4	Recidivism Reduction Program; General Fund
California	Yes	$345.20*	Marijuana Production/Sales Regulation; Recreational Marijuana Legalization Impacts Research, California Highway Patrol; Social/Medical Programs; Substance Abuse Education/Prevention/Treatment Programs; Environment Programs to Prevent/Mitigate Marijuana Cultivation Environmental Impacts
Colorado	Yes	$266.5	Education Fund; General Fund
Maine**	No		General Fund; Highway Fund; Other Special Revenue Funds
Massachusetts	Yes (11/2018)		General Fund; Commonwealth Transportation Fund; Marijuana Regulation Fund
Michigan	Pending		
Nevada	Yes	$69.8	School Account; Rainy Day Fund
Oregon	Yes	$82.2	State School Fund; Mental Health, Alcoholism and Drug Services; Oregon State Police; Oregon Health Authority for Drug Treatment and Prevention
Vermont**	No		Education Fund; State Administrative Agencies and Municipalities; Public Safety/Prevention/Intervention Programs
Washington	Yes	$528.2	Marijuana Legalization Cost-Benefit Analysis; Public Education on Marijuana Health/Safety Risks; Drug Enforcement; Local Jurisdictions

*California tax revenue includes a cultivation tax levied on both recreational and medical marijuana. The majority of marijuana tax revenue in California (90%) is generated by excise and sales taxes levied exclusively on recreational marijuana sales.
**While Maine and Vermont do not currently have retail marijuana sales, legislation/regulatory agencies have already decided how recreational marijuana tax revenues will be allocated.

[18] Citations for tax revenue and allocations can be found in Appendix A.

In 2017, federal excise taxes on alcohol generated $10.7 billion in revenue, while domestic tobacco excise taxes generated $13.0 billion in revenue.[19] While unlikely due to federal prohibition legislation and policy currently in place on marijuana, levying similar taxes on recreational marijuana cultivation and sales at a federal level has the potential to generate significant tax revenue. While legalizing recreational marijuana has generated significant tax revenues, there are also significant costs associated with marijuana industry regulation and enforcement, and other marijuana-related issues (such as impaired driving enforcement). States with legal recreational marijuana are applying for federal funds for numerous areas impacted by increased access to marijuana, including:[20]

- Law enforcement training to better identify drug-impaired driving;
- Law enforcement overtime for drug-impaired driving enforcement;
- Phlebotomy technicians to draw blood samples from suspected impaired drivers;
- Drug toxicology personnel, equipment and facilities to test suspected impaired drivers for drugs;
- Judge and prosecutor training on drug-impaired driving; and
- Public outreach on the dangers of drug-impaired driving.

The legalization of recreational marijuana has not successfully eradicated the black market for marijuana either – some marijuana producers opt to continue illegal enterprises to avoid the costs of regulatory requirements and taxes.[21] Therefore, adequate funding for marijuana regulation and enforcement is critical to states legalizing recreational marijuana use.

Product Labeling

The marijuana regulatory agencies in each state have established a variety of warning label requirements for retail marijuana products. A summary of label warning requirements is shown in Table 2.

Additionally, the symbols that indicate a product contains marijuana vary by state. Consistency from state to state would ensure that marijuana users are aware of the risks, as well as ensuring that people are aware that a product contains marijuana.

[19] "Federal Excise Taxes or Fees Reported to or Collected by the Internal Revenue Service, Alcohol and Tobacco Tax and Trade Bureau, and Customs Service" (Internal Revenue Service, n.d.), accessed February 19, 2019.
[20] "State Highway Safety Plans and Annual Reports," NHTSA, February 2, 2017, https://www.nhtsa.gov/highway-safety-grants-program/state-highway-safety-plans-and-annual-reports.
[21] "California's Weed Black Market Ramps Back Up - Bloomberg," accessed February 19, 2019, https://www.bloomberg.com/news/articles/2018-06-28/california-pot-industry-at-reckoning-as-new-rules-upend-market.

Table 2: Marijuana Label Warning Requirements

State	Vehicle Operation Warning	Age Restriction (21+) Warning	Pregnancy / Breastfeeding Warning	Delayed Onset of Effects Warning	Habit-Forming Warning	Illegal Outside of State Warning	Keep Away from Child / Pet Warning
Alaska	Y	Y	Y	N	Y	N	Y
California	Y	Y	Y	Y	N	N	Y
Colorado	Y	Y	Y	Y	N	Y	Y
Maine*	-	-	-	-	-	-	-
Massachusetts	Y	Y	Y	Y	Y	Y	Y
Michigan**	-	-	-	-	-	-	-
Nevada	Y	N	Y	Y	Y	Y	Y
Oregon	Y	Y	N	Y	N	N	Y
Vermont***	-	-	-	-	-	-	-
Washington	Y	N	N	Y	Y	Y	N

*Maine requires warning labels but does not specify label requirements.
**Label requirements were not found for Michigan.
***Label requirements are not required in Vermont, due to no current retail sales of marijuana. Labeling requirements may be enacted per the recommendations of the Governor's Marijuana Advisory Commission.

Nearly every state with recreational marijuana requires labels to warn users that marijuana impairs driving abilities, and therefore not to drive. Again, these warnings vary by state. The labeling requirements related to vehicle operation are shown in Table 3.

Table 3: Marijuana Label Driving and Machinery Warning

State	Driving and Machinery Warning
Alaska	"Marijuana impairs concentration, coordination, and judgment. Do not operate a vehicle or machinery under its influence."
California	"Consumption of cannabis products impairs your ability to drive and operate machinery. Please use extreme caution."
Colorado	"Do not drive a motor vehicle or operate heavy machinery while using marijuana."
Massachusetts	"It is against the law to drive or operate machinery when under the influence of this product." Or "Marijuana can impair concentration, coordination and judgment. Do not operate a vehicle or machinery under the influence of this drug."
Nevada*	"Marijuana or marijuana products can impair concentration, coordination and judgment. Do not operate a vehicle or machinery under the influence of this marijuana or marijuana products."
Oregon	"Do not drive a motor vehicle while under the influence of marijuana."
Washington	"It is illegal to operate a motor vehicle while under the influence of marijuana"
*Written notification provided to customer at time of purchase.	

THE SAFETY AND LEGAL IMPLICATIONS OF DRIVING UNDER THE INFLUENCE OF MARIJUANA

Safety Implications of Impaired Driving

The signs and behaviors of driver impairment include poor judgment, decreased motor skills and delayed reaction times. Impairment while driving can increase the likelihood of a vehicle crash, leading to property damage, personal injury or death.

There were 37,133 motor vehicle-related fatalities in 2017, and alcohol impairment was determined to be a factor in more than a quarter of these deaths.[22] While the relationship between vehicle crashes and alcohol is well documented, drug use among those involved in crashes is not. NHTSA, for instance, states the following:

> "[T]here is little State level data about the prevalence of use of marijuana by drivers being collected. As States continue to change their laws regarding marijuana use in general and as it relates to driving, this lack of State level data prevents evaluation of the effect of policy changes on driver behavior, including willingness to drive while under the influence of marijuana, as well as the effect of marijuana on crashes, deaths and injuries."[23]

The dearth of marijuana-related driving data severely hinders the traffic enforcement communities' ability to respond appropriately. Data is critical to understanding numerous impacts of marijuana legalization on roadway safety, and is important in identifying methods for deterring marijuana-impaired driving.

Key state and national data required to better understand the marijuana-impaired driving problem include the following:

- Prevalence of marijuana use while driving;
- Statistics on number and type of drug tests given by law enforcement, including rates of positive tests;
- Number of crashes involving marijuana impairment; and
- Number of marijuana-related DUI citations and convictions, as well as final charges for marijuana DUI citations.

Deterring marijuana-impaired driving is critical to highway safety. While there are myriad examples of negative safety impacts, one recent example – a crash investigated by the National Transportation Safety Board (NTSB) that resulted in 13 fatalities – stands out. In this case a pickup truck driver was operating erratically for a considerable distance, eventually drifting from his lane and crashing head-on into a medium-size bus carrying 13 passengers and a driver. All but one occupant of the bus were killed. It was found that the pickup truck driver (who survived

[22] "2017 Fatal Motor Vehicle Crashes" (Washington, D.C.: National Highway Traffic Safety Administration, October 2018).
[23] Richard P Compton, "Marijuana-Impaired Driving - A Report To Congress" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).

the accident and was found to be at-fault) had operated his vehicle erratically "due to impairment from the combined use of marijuana and a prescription medication."[24] This is just one example of the significant impact that operating a vehicle while impaired by marijuana use can have.

While the overall severity of the aforementioned crash led to comprehensive testing of a single at-fault driver, not all drivers involved in a vehicle crash are tested for marijuana due, in part, to a void of widely accepted testing methods.

Colorado, where recreational marijuana is legal, is one example where marijuana testing is often conducted for drivers involved in a fatal crash. In 2016, the state found that 13 percent of fatal crashes involved a driver who was actively under the influence of marijuana, and in 2017 the figure was 8 percent of fatal crashes.[25] To qualify as a driver actively under the influence of marijuana in this instance, however, THC concentrations in the blood were set at 5 nanograms per milliliter (ng/mL) or more, which follows Colorado impaired-driving laws. Some disagree, however, that this measurement is indicative of impairment, with NHTSA stating the following based on current research:

> "A number of States have set a THC limit in their laws indicating that if a suspect's THC concentration is above that level (typically 5 ng/mL of blood), then the suspect is to be considered impaired. This per se limit appears to have been based on something other than scientific evidence. Some recent studies demonstrate that such per se limits are not evidence-based."[26]

In contrast to alcohol, marijuana impairment while driving is very complex.

1) The measurement of ng/mL of THC in blood is not consistently indicative of driver impairment.
2) From a primary research perspective, the possession and consumption of marijuana was consistently illegal for decades. Thus, a significant research barrier existed for testing impacts, which limited the type and amount of research conducted.
3) Regarding secondary research, crash statistics may be incomplete because testing drivers for drug use is and has been limited. Crash reporting measures must be improved to better understand the extent and impacts of marijuana-impaired driving.
4) Additionally, the legal consequences of DUIs provide a strong incentive for drivers to not self-report marijuana impairment.

[24] "Pickup Truck Centerline Crossover Collision with Medium-Size Bus on US Highway 83, Concan, Texas, March 29, 2017" National Transportation Safety Board. October 16, 2018.
[25] "Drugged Driving Statistics," Page, Colorado Department of Transportation, Accessed February 13, 2019, https://www.codot.gov/safety/alcohol-and-impaired-driving/druggeddriving/statistics.
[26] Richard P Compton, "Marijuana-Impaired Driving - A Report To Congress." Washington, D.C.: National Highway Traffic Safety Administration. July 2017.

Thus, a review of the literature on this topic concludes that past research on the impact of marijuana impairment on roadway safety have inconsistent (and sometimes contradictory) findings on the crash risk associated with marijuana impairment.[27]

The literature review found that a number of methods have been employed to investigate the impact of marijuana on driver safety.[28] The utility of experimental studies (assessing on-road performance/simulator performance of marijuana-impaired drivers) is limited, as participants are aware they are being observed. Experimental studies provide insight on the limits of marijuana-impaired driver capabilities, rather than how impaired drivers *actually* behave on the road.

Observational studies, which attempt to identify the impact of marijuana impairment on driving safety using real-world data such as NHTSA's Fatality Analysis Reporting System (FARS), are ill-equipped to address the impact of marijuana impairment on safety outcomes due to bias.[29] A multitude of factors may be the source of bias, but ultimately bias in research prevents the accurate estimate of the impact of marijuana impairment on crash risk.

An example of bias in many studies is measuring marijuana impairment through urine drug test results – which indicate past, but not necessarily recent use. In research using this method of determining impairment, any findings related to the effects of marijuana impairment could be called into question.

Another potential source of bias is how drivers are selected. Existing datasets typically only identify marijuana-intoxicated drivers if they are engaging in dangerous behaviors such as roadway violations or are involved in a crash. Therefore, research based on these datasets is unable to ascertain whether another group of drivers that are not engaging in unsafe behaviors exists (as these drivers would not be identified through traffic enforcement). This systematic exclusion of drivers that may be under the influence of marijuana has the potential to bias research on safety outcomes associated with marijuana intoxication.

Culpability and case-control studies are preferred, due to the ability to control for more potential sources of bias.

> "Culpability studies compare the rate at which crash-involved, drug-positive drivers and drug-negative drivers are deemed to be at fault for their crashes. Case-control studies compare drug use by crash-involved drivers to drug use by non-crash involved drivers."[30]

[27] Richard P Compton and Amy Berning, "Drug and Alcohol Crash Risk" Washington, D.C. National Highway Traffic Safety Administration. February 2015.
[28] Ibid.
[29] Amy Berning and Dereece D Smither, "Understanding the Limitations of Drug Test Information, Reporting, and Testing Practices in Fatal Crashes" (Washington, D.C.: National Highway Traffic Safety Administration, November 2014).
[30] Richard P Compton and Amy Berning, "Drug and Alcohol Crash Risk" Washington, D.C. National Highway Traffic Safety Administration. February 2015.

However, culpability/case-control studies historically suffer from issues related to how marijuana impairment is measured. Studies have previously relied on self-report measures, as well as testing methods that detect past marijuana use rather than recent marijuana use.[31] As background, the psychoactive component of marijuana, THC, remains detectible in the body for only a few hours after smoking marijuana, and longer for orally ingested marijuana.[32] This is the component of marijuana that results in impairment. Over time THC is broken down by the body forming derivatives called metabolites. Though marijuana-related metabolites in the body do not cause impairment, they can be detected for weeks and in some states can result in a DUI. Marijuana tests traditionally have been used to detect drug use through the testing of metabolites (e.g. for employment purposes); such tests are not an indicator of impaired driving, though the presence of metabolites can have significant consequences for a driver based on location.

A recent meta-analysis of research on the crash risk associated with marijuana intoxication found an increase in crash risk of 20 to 30 percent.[33] This meta-analysis improved upon prior research by acknowledging potential sources of bias and attempting to reduce the impact of sources of bias in other studies. A recent study found that drivers testing positive for marijuana – THC blood content of more than 1 ng/mL – were 65 percent more likely to have a role in causing a fatal crash.[34] However, characteristics of the individuals who decide to drive under the influence of marijuana are often difficult to control for and may still introduce bias.

There are a number of confounding factors that may be impossible to rectify. Marijuana-impaired individuals tend to overestimate impairment resulting from marijuana use.[35] Therefore, marijuana-impaired drivers may represent the low-end of the impairment continuum, as acutely-impaired individuals are less likely to drive.[36,37]

On the other hand, it is possible that individuals who decide to drive while impaired by marijuana may be prone to taking risks in general. A recent NHTSA study of the effects of marijuana impairment on crash risk found no increased risk associated with marijuana impairment, after controlling for demographics characteristics (age, gender and ethnicity) and blood alcohol content (BAC).[38] Additional research is needed to assess the role that marijuana impairment – not past use, demographics or individual risk preferences – has on driver safety.

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[31] Ibid.

[32] Marilyn A. Huestis, "Human Cannabinoid Pharmacokinetics," Chem Biodivers. 4, no. 8 August 2007: 1770–1804.

[33] Ole Rogeberg and Rune Elvik, "The Effects of Cannabis Intoxication on Motor Vehicle Collision Revisited and Revised: Cannabis and Motor Vehicle Collision Risk," Addiction 111, no. 8 (August 2016): 1348–59, https://doi.org/10.1111/add.13347.

[34] Jean-Louis Martin et al., "Cannabis, Alcohol and Fatal Road Accidents," ed. Etsuro Ito, PLOS ONE 12, no. 11 (November 8, 2017): e0187320, https://doi.org/10.1371/journal.pone.0187320.

[35] J. G. Ramaekers et al., "Dose Related Risk of Motor Vehicle Crashes after Cannabis Use," Drug and Alcohol Dependence 73, no. 2 (February 7, 2004): 109–19.

[36] Annick Ménétrey et al., "Assessment of Driving Capability through the Use of Clinical and Psychomotor Tests in Relation to Blood Cannabinoids Levels Following Oral Administration of 20 Mg Dronabinol or of a Cannabis Decoction Made with 20 or 60 Mg Delta9-THC," *Journal of Analytical Toxicology* 29, no. 5 (August 2005): 327–38.

[37] Scott MacDonald et al., "Driving Behavior under the Influence of Cannabis or Cocaine," *Traffic Injury Prevention* 9, no. 3 (2008): 190–94, https://doi.org/10.1080/15389580802040295.

[38] BAC is sometimes referred to as blood alcohol concentration.

Despite some mixed findings of studies on the impact marijuana impairment has on crash risk, research indicates that cognitive functions essential for driving tasks are negatively impacted by marijuana intoxication.

Additionally, identification of marijuana impairment through blood tests and other biological testing methods is not viable for the following reasons:

1) Unlike alcohol, where impairment level is easily predicted by BAC, the severity of impairment resulting from marijuana use depends on a number of factors, including the frequency of marijuana use and consumption method.[39,40] While higher doses of marijuana often result in greater impairment, this relationship is less predictable than that of alcohol and impairment.[41,42,43]
2) Peak subjective marijuana impairment does not coincide with peak THC blood concentrations.[44]
3) THC deteriorates rapidly in a user's blood.[45]
4) Low levels of THC in a user's blood are not necessarily indicative of recent use.[46]

The perception of the driving safety risks associated with marijuana intoxication varies by age, with younger drivers being the most likely to indicate that marijuana intoxication does not impact crash risk.[47] Accordingly, drivers who believe marijuana-impaired driving is not risky are more likely to engage in marijuana-impaired driving.[48] To combat these perceptions, outreach to educate the public is being conducted by many states and by NHTSA at a national level.[49,50]

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[39] Richard P Compton, "Marijuana-Impaired Driving" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).
[40] Nathalie A. Desrosiers et al., "Smoked Cannabis' Psychomotor and Neurocognitive Effects in Occasional and Frequent Smokers," Journal of Analytical Toxicology 39, no. 4 (May 1, 2015): 251–61, https://doi.org/10.1093/jat/bkv012.
[41] Deepak Cyril D'Souza et al., "Blunted Psychotomimetic and Amnestic Effects of Delta-9-Tetrahydrocannabinol in Frequent Users of Cannabis," *Neuropsychopharmacology: Official Publication of the American College of Neuropsychopharmacology* 33, no. 10 (September 2008): 2505–16, https://doi.org/10.1038/sj.npp.1301643.
[42] J. G. Ramaekers et al., "Neurocognitive Performance during Acute THC Intoxication in Heavy and Occasional Cannabis Users," *Journal of Psychopharmacology (Oxford, England)* 23, no. 3 (May 2009): 266–77, https://doi.org/10.1177/0269881108092393.
[43] Richard P Compton, "Marijuana-Impaired Driving" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).
[44] Ibid.
[45] Ibid.
[46] Ibid.
[47] "Driving Under the Influence of Alcohol and Marijuana: Beliefs and Behaviors, United States, 2013-2015," AAA Foundation, May 12, 2016, https://aaafoundation.org/driving-influence-alcohol-marijuana-beliefs-behaviors-united-states-2013-2015/.
[48] Craig G.A. Jones et al., "Correlates of Driving under the Influence of Cannabis," Drug and Alcohol Dependence 88, no. 1 (April 17, 2007): 83–86.
[49] "CDOT Launches New Drive High, Get a DUI Campaign, Reminds Drivers to Celebrate 4/20 Responsibly —," accessed January 2, 2019, https://www.codot.gov/news/2015-news-releases/04-2015/cdot-launches-new-drive-high-get-a-dui-campaign-reminds-drivers-to-celebrate-4-20-responsibly-statewide-2014-with-a-plethora-of-marijuana-friendly-events-slated-around-the-4-20-weekend-the-colorado-department-of-transportation-cdot-is-marking-the-occas.
[50] "Drug-Impaired Driving," Text, NHTSA, November 30, 2016, https://www.nhtsa.gov/risky-driving/drug-impaired-driving.

Colorado's *Drive High, Get a DUI* advertising campaign includes advertisements at marijuana retail stores (also known as dispensaries), effectively targeting individuals that are likely to engage in drug-impaired driving.

Studies have found that marijuana intoxication impairs a number of critical cognitive functions for safe driving. While the full studies are cited in Appendix B, among the key findings of marijuana's impact on behavior and driving-related cognitive functions are the following:

Divided Attention. Driving requires the ability to focus on numerous stimuli, prioritize stimuli and respond to potential roadway risks appropriately. Examples of the numerous, competing stimuli include road signs, roadway conditions and the actions of other drivers. Marijuana intoxication impairs divided attention, and may impact a driver's ability to monitor and respond to relevant risks appropriately.

Reaction Times. Numerous studies have documented that marijuana intoxication slows reaction times. Driving safety relies on quick reactions to changing conditions to avoid risks. The slower reaction times resulting from marijuana intoxication may impact the ability of a driver to have a timely response to roadway risks.

Increased Following Distance. Marijuana-intoxicated drivers (provided they are not also under the influence of alcohol) recognize impairment and may attempt to compensate for impairment. Drivers increase following distance and are less likely to pass other vehicles.

Maintaining Lane Position. Driving simulation studies have concluded that marijuana intoxication negatively impacts a driver's ability to maintain their vehicle's position in the center of the lane.

Alcohol and Marijuana Consumption. Numerous studies have identified that DUI of both marijuana and alcohol increases crash risk significantly.

While a large body of research has not demonstrated a definitive relationship between marijuana intoxication on driving safety outcomes, the need to better understand the role that marijuana intoxication plays in crash causation is becoming a critical issue as numerous state governments, Canada and Mexico legalize recreational and/or medical marijuana.

Driving Under the Influence Laws

DUI is generally dictated in the U.S. by state laws that were initially put in place to address crashes and fatalities related to drunk driving. Laws for driving while under the influence of alcohol are relatively straightforward. Laws exist that limit the amount of alcohol that can be present in the blood in order to legally drive, and well-established methods for testing a person for these limits are utilized by law enforcement and corroborated by the scientific community. These clear-cut laws and practices to combat DUI have contributed to an approximately 50 percent decrease in annual alcohol-related traffic deaths today versus the 1980s.[51] Over the years, the application of these laws has expanded to include legal and illegal drug use.

DUI charges stem from two types of violations: per se (which relates to the quantity of a substance in the body) and impairment (which relates to behavior that is exhibited).

Per Se

A 'per se' violation is one where DUI is proven through the measurement of alcohol or drugs in a person's body. The most prominent example of this is a BAC measurement which quantifies the amount of alcohol per volume of blood. While per se violations related to drinking are fairly straightforward, quantifying marijuana consumption to show impairment is not as clear due to a lack of standard practices and scientifically valid testing as demonstrated in the literature. The greatest challenge is that unlike alcohol, which is detectable in blood for less than 24 hours, the derivatives of marijuana are detectible in urine for weeks.

The concept of implied consent is central to testing a driver for alcohol, and in many cases for drugs as well. Under implied consent laws in all states, by holding a driver's license a driver has given consent to be tested in some manner for alcohol concentrations in the body. Implied consent laws vary from state to state, both in terms of the controlled substances included in tests and the circumstances under which tests may be conducted.[52] A majority of states extend implied consent to include controlled substances.

The laws related to per se marijuana testing, however, differ widely by state. Information on per se marijuana limits, zero tolerance laws and implied consent is shown in Appendix C. In some states testing for marijuana use is generally not practiced. For instance, Alabama relies on observation of impairment, and not per se testing, to determine marijuana impairment; implied consent for testing does not apply to suspicion of marijuana impairment and therefore testing is not a consideration.[53]

Other states have far stricter laws. Georgia is one state that has per se laws where there is "zero tolerance" for illegal substances in the body of a driver. Georgia law states "a person is guilty of a DUI if that person drives a vehicle and that person has any amount of controlled substance present in the person's blood or urine, including the metabolites and derivatives of

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[51] "Since the early 1980s, alcohol-related traffic deaths per population have been cut in half with the greatest proportional declines among persons 16-20 years old." See: https://report.nih.gov/nihfactsheets/ViewFactSheet.aspx?csid=24

[52] Lindsay S. Arnold and Robert A. Scopatz, "Advancing Drugged Driving Data at the State Level: Synthesis of Barriers and Expert Panel Recommendations" (AAA, March 2016).

[53] "Alabama Drugged Driving - NORML - Working to Reform Marijuana Laws," Accessed February 13, 2019, http://norml.org/legal/item/alabama-drugged-driving.

each or both."[54] Thus a positive test for non-intoxicating metabolites, which indicate past use, are per se evidence of DUI. This could apply to a person who has not been intoxicated for several weeks.

Finally, there are states where per se testing is conducted to show evidence of impairment (and not simply past use). Colorado, Montana, Nevada, Ohio, Rhode Island and Washington State have per se laws that limit THC content in a driver's blood. The majority of states have not established legal ng/mL blood limits, but maintain that operating any motor vehicle under the influence of marijuana is illegal and unsafe.

Similar to the legal limit (0.08) of blood alcohol level for an individual operating a motor vehicle, Washington State uses a per se limit on THC blood content. A driver is legally intoxicated while driving if "the person has, within two hours after driving, a THC concentration of 5.00 [ng/mL] or higher" in a blood sample.[55]

Impairment

While per se violations rely on measurement of a substance in the body, impairment-based violations require the collection of visually observed evidence. Key factors leading to impairment violations include driving behavior (e.g. erratic driving) and the behavior of the driver while interacting with police.

Field sobriety tests are typically conducted to identify impaired speech or movements. A driver that is impaired may not understand simple statements or be able to complete simple movement tasks. The condition of eyes may also be a factor – red eyes, "glazed-over" eyes or large/small pupils may indicate intoxication and therefore impairment. Methods for identifying marijuana impairment through observation will be discussed in detail in Section 3.

Federal Laws on Marijuana Use and Testing by CMV Drivers

The Federal Motor Carrier Safety Administration (FMCSA) regulates driver use of and testing for marijuana through CFR 49 §382 (Controlled Substances and Alcohol Use and Testing) and §40 (Procedures for Transportation Workplace Drug and Alcohol Testing Programs). Through §382.109, in particular, state and local laws are preempted by federal law.

Under the federal laws, CDL holders in safety-sensitive positions (i.e. truck drivers) must be tested in a specific manner for the presence of marijuana. Testing occurs for the following reasons:

- Pre-employment screening;
- Post-accident (if accident is fatal, results in an injury, or requires a tow-away);
- Random testing throughout the year;
- Reasonable suspicion; and
- Return-to-duty and follow-up (for those testing positive in order to resume driving).

This type of marijuana test identifies past use of marijuana, and not intoxication, because it is a measure of marijuana metabolites. The testing cutoffs are listed in §40.87 for CFR 49, and

[54] Id. § 40-6-391(a)(6).
[55] Wash. Rev. Code Ann. § § 46.61.502(1), 46.61.506 http://apps.leg.wa.gov/rcw/default.aspx?cite=46.61.502

indicate that a person fails the marijuana test when marijuana metabolites are found at 50 ng/mL in the initial test and 15 ng/mL in a confirmatory test.

Employers are responsible for ensuring that tests are conducted and that drivers who fail or do not comply with testing are removed from safety-sensitive positions. An employer will face penalties for not following the U.S. Department of Transportation (U.S. DOT) regulations, ensuring compliance with these federal regulations.

In 2016, random drug testing identified drugs in 0.7 percent of commercial drivers.[56] Drivers may also test positive for marijuana as a result of CBD product use. Recently, a truck driver sued a CBD company claiming to have removed all THC from their products after losing his job as a result of failing a drug test for marijuana.[57]

While testing hair for drugs is not the best practice for determining if a driver is currently impaired by marijuana (see Section 3 for more information), hair tests provide critical information to motor carriers by revealing if applicants are "lifestyle" users that pass pre-hire urine drug tests though short-term abstinence from drugs. Some larger fleets are now performing both urine and hair tests on applicants to identify habitual users. JB Hunt reports that in the ten years they have been testing both hair and urine for drugs, over 4,700 drivers passed urine drug tests but not hair drug tests.[58] Similarly, Schneider National reports conducting over 100,000 pre-employment drug tests, of which 0.37 percent of urine tests were positive for drugs and 3.82 percent of hair tests were positive for drugs.[59] While these companies are attempting to keep unsafe drivers from operating trucks, it is likely that applicants failing the hair tests simply seek jobs at other companies that do not require hair testing.

[56] "Results from the 2016 Drug and Alcohol Testing Survey" (Federal Motor Carrier Safety Administration, January 2018).
[57] Eric Miller, "Fired Truck Driver Sues Cannabidiol Company After Using Product," Transport Topics, December 20, 2018, https://www.ttnews.com/articles/fired-truck-driver-sues-cannabidiol-company-after-using-product.
[58] Sheryl Maddox, "Truck Driver Hair Testing Moves Forward at J.B. Hunt," *Psychemedics* (blog), June 27, 2013, https://www.psychemedics.com/blog/2013/06/truck-driver-hair-testing-moves-forward-at-j-b-hunt/.
[59] "Schneider National Carriers Comments on FMCSA-2017-0002-0038," February 21, 2017, https://www.regulations.gov/document?D=FMCSA-2017-0002-0038.

MARIJUANA-IMPAIRED DRIVING: COLLECTING EVIDENCE FOR PROSECUTION

Increased access to legal marijuana is associated with an increase in the prevalence of impaired driving. From 2007 to 2014, the prevalence of THC in weekend nighttime drivers increased from 8.6 percent to 12.6 percent.[60] This increase is a relatively reliable surrogate for driving after recent marijuana use, as THC was detected in driver blood and/or oral fluid, but not necessarily impairment. Preliminary results from a survey of 11,000 anonymous marijuana users in Colorado found that 69 percent have driven under the influence of marijuana in the past year, of which 27 percent of respondents report driving under the influence of marijuana daily.[61,62]

As discussed in Section 2, marijuana-impaired driving is dangerous and illegal. Supported by state laws, it is the role of law enforcement to deter people from using drugs or alcohol before driving, thus preventing crashes, injuries and fatalities.

Identifying, documenting and prosecuting marijuana-impaired drivers, depending on state law, can be achieved through one or more of the following enforcement activities:

- Observation and documentation of behavior;
- Physical evidence;
- Drug testing in states where there are THC limits or zero tolerance laws.

Training and Methods for Identification of Marijuana-Impaired Driving

Typically a law enforcement officer's first encounter with a marijuana-impaired driver is due to a traffic stop or after a crash. A law enforcement officer may use his or her knowledge from standard field sobriety test (SFST) training to first determine if a vehicle should be pulled over or if further investigation is needed at the scene of a crash.

Standard Field Sobriety Test

Only 21 states have trained all law enforcement officers in SFST.[63] SFST was developed to identify alcohol-impaired driving and is a common first step for identifying impairment resulting from other drugs. When an impaired-driving suspect tests negative for alcohol, a law enforcement officer may check for other causes of observed impairment.

There are three phases involved in determining a DUI violation. The first phase is known as Vehicle in Motion. A law enforcement officer must gather enough evidence of a potential DUI

[60] Amy Berning, Richard Compton, and Kathryn Wochinger, "Results of the 2013–2014 National Roadside Survey of Alcohol and Drug Use by Drivers" (National Highway Traffic Safety Administration, February 2015).
[61] "CDOT Survey Reveals New Insight on Marijuana and Driving —," Colorado Department of Transportation, accessed February 12, 2019, https://www.codot.gov/news/2018/april/cdot-survey-reveals-new-insight-on-marijuana-and-driving.
[62] Since the survey was non-random in selection of participants, the findings of this survey may not reflect marijuana users as a population.
[63] James C Fell, Julie Kubelka, and Ryan Treffers, "Advancing Drugged Driving Data at the State Level: State-by-State Assessment" (AAA Foundation for Traffic Safety, April 2018).

offence by observing the driver or a vehicle while it is in motion. A few cues can lead to an officer stopping a vehicle for further investigation, including:[64]

- A moving traffic violation;
- An equipment violation;
- An expired registration or inspection sticker;
- Unusual driving actions such as weaving within a lane or moving at a slower than normal speed; and
- Evidence of drinking or drugs in vehicle.

Based on the above observations of the vehicle, a law enforcement officer can choose to stop the vehicle, continue monitoring the driver/vehicle or ignore the vehicle. If an officer chooses to pull over an observed vehicle, evidence of alcohol or drug impairment can also arise during this procedure. Once the vehicle has been stopped and engagement with the driver has been established, there are several clues to help the officer gather additional evidence as to whether or not the operator of the vehicle is impaired. [65]

The second phase when detecting a DUI is Personal Contact. This phase usually allows for definitive proof as to whether or not a driver is impaired via drugs or alcohol by observing the driver's behavior while approaching and interviewing the individual. The three primary observations include what the officer sees, what the officer hears, and any smells an officer may detect. Depending on different state laws, an officer may ask a driver to exit the vehicle based on the discussion with the driver and the evidence observed in phase one.[66]

The third phase of DUI detection is SFST. The SFST consists of three tests: Horizontal Gaze Nystagmus (HGN), Walk and Turn (WAT), and One Leg Stand (OLS). The HGN test allows an officer to determine if the driver is under the influence of alcohol and/or the potential to detect recent drug use. During this test, an officer slowly moves a pen/penlight or similar object, 12-15 inches from the driver's face, from left to right, to observe if the eyes of the driver involuntarily jerk ("nystagmus") as he/she follows the object.

The sooner the nystagmus occurs during the test, the greater the driver's impairment. The WAT and OLS are both psychophysical tests to assess how the driver handles dividing their attention while doing a physical task. During the WAT and OLS tests there are behaviors or "clues" (eight clues in the WAT test and four clues in the OLS test) that a law enforcement officer should note as potential evidence of alcohol or drug impairment. Failing to complete either the WAT and/or the OLS can result in the law enforcement officer classifying the driver's BAC at 0.08 or higher (the per se limit for BAC in many jurisdictions). In each phase of DUI detection, the ability to recall and clearly describe any evidence to a judge or lawyer is of the utmost importance to prosecution of an impaired driver. [67]

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[64] National Highway Traffic Safety Administration. "Participant Manual: DWI Detection and Standardized Field Sobriety Testing (SFST) Refresher." February 2018. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/sfst_refresher_full_participant_manual_2018.pdf

[65] Ibid.

[66] Ibid.

[67] Ibid.

Advanced Roadside Impaired Driving Enforcement

The Advanced Roadside Impaired Driving Enforcement (ARIDE) program, developed by NHTSA and the International Association of Chiefs of Police (IACP), seeks to bridge the gap between SFST and Drug Recognition Expert (DRE) evaluations of impairment. A recent survey found that only 17 states had more than 20 percent of law enforcement officers trained in ARIDE.[68] ARIDE requires 16 hours of classroom instruction and trains law enforcement officers in assessing impaired-driving suspects at the roadside. [69,70] Additionally, ARIDE seeks to better use DRE resources or, where DREs are not available, give law enforcement officers the critical information needed to test, document and report drug-impaired driving. ARIDE educates law enforcement officers in a number of topics, including:

- A refresher on SFST;
- The effects of drugs, or a combination of drugs/alcohol, as well as illnesses/injuries with symptoms similar to drug impairment (e.g. strokes);
- How to identify, document and describe impairment-related observations leading to arrest/release decisions; and
- Provide testimony on impairment related to drugs, alcohol, or a combination of drugs and alcohol.[71]

Drug Recognition Experts

Drug Recognition Experts (DREs) are specially trained law enforcement officers who are certified in recognizing and assessing individuals who are under the influence of drugs and/or alcohol. DREs are a key method that many U.S. states, Canada and the European Union use to determine marijuana impairment. DRE impairment determinations are supported by toxicology screening, which includes oral or saliva swabs, urine testing and blood sample testing. Documentation of driver impairment through DRE evaluation is critical to prosecuting DUI suspects, since biological tests for marijuana do not definitively prove whether an individual is currently impaired by marijuana, versus having consumed marijuana previously.

DRE training and certification includes three phases: DRE Pre-School (16 hours), DRE School (56 hours) and DRE Field Certification (40 to 60 hours).[72] Coordinated by IACP, DREs are certified by the International Drug Evaluation and Classification Program (DEC) with help from NHTSA. The program originated in Los Angeles in the 1970s, when the Los Angeles Police Department (LAPD) began noticing an increased number of impaired driving arrests with low blood alcohol concentration. As a result, the LAPD implemented the DRE program to help police officers determine the classification of drugs causing impairment.[73] In 2017, there were

[68] James C Fell, Julie Kubelka, and Ryan Treffers, "Advancing Drugged Driving Data at the State Level: State-by-State Assessment" (AAA Foundation for Traffic Safety, April 2018).
[69] "ARIDE: Advanced Roadside Impaired Driving Enforcement," accessed February 12, 2019, https://www.chp.ca.gov/programs-services/for-law-enforcement/drug-recognition-evaluator-program/aride-advanced-roadside-impaired-driving-enforcement.
[70] National Highway Traffic Safety Administration, Transportation Safety Institute, and International Association of Chiefs of Police, "Advanced Roadside Impaired Driving Enforcement Participant Manual," February 2018.
[71] Ibid.
[72] "DRE Training," International Association of Chiefs of Police, accessed February 12, 2019, https://www.theiacp.org/dre-training.
[73] http://www.decp.org/drug-recognition-experts-dre/

8,606 DREs in the U.S. and a total of 30,989 examinations conducted for enforcement activities.[74] Marijuana was the most frequently identified substance in these examinations.

Once a law enforcement officer has determined the need for a DRE after a SFST, a 12-step procedure is followed in order to determine the category of drug(s) causing impairment. Using the standardized 12-step procedure is necessitated by a number of factors including:

- The potential need to submit observations to support the need for toxicology screening;
- Some courts do not consider low BAC or Breath Alcohol Concentration (BrAC) in conjunction with observed impairment as supportive of the need for toxicology screening;
- A suspect may deny the request for toxicology screening;
- Toxicology screening can indicate relatively recent use rather than current impairment;
- Toxicology screening is expensive; and
- Suspected drug-impaired drivers may not be under the influence of drugs or alcohol, but experiencing injury or illness that requires immediate medical attention.[75]

The use of DREs to identify drug-impaired driving has been validated in a number of studies. The controlled laboratory experiment testing the validity of DRE drug determinations found that the DREs could reliably predict high-doses of drugs, but were less reliable for weak doses.[76] The field test of 173 suspected impaired drivers that provided blood samples for toxicology screening supported the reliability of DRE determinations – blood tests supported 78 percent of cases where the driver was determined to be under the influence of marijuana.[77] Arizona also conducted a DRE validation study, which found that 86.5 percent of DRE determinations were supported by urine toxicology tests.[78]

The 12-step method includes interviewing the individual, observing behavioral signs, taking vitals, conducting psychophysical tests and finally toxicological tests. For marijuana specifically, DRE training covers the following topics:

- How marijuana is consumed (high potency forms, smoking, eating, topical creams);
- Marijuana effects;
- The onset and duration of marijuana effects;
- The long-term effects of marijuana use; and
- Identifying impairment.

For the psychophysical tests and observations used in the DRE evaluation, marijuana impairment is evident in Lack of Convergence (LOC) presence (where the suspect's eyes do not "cross" as an object they were told to focus on is moved closer to the suspect's nose), dilated

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[74] "Drug Evaluation and Classification Program 2017 Annual Report" (IACP, n.d.).

[75] National Highway Traffic Safety Administration, International Association of Chiefs of Police, and Transportation Safety Institute, "Drug Recognition Expert Course Participant Manual," February 2018.

[76] Identify Types of Drug Intoxication: Laboratory Evaluation of a Subject Examination Procedure, May 1984 Final Report. George E. Bigelow, Ph.D. et al. Behavioral Pharmacology Research Unit, Department of Psychiatry and Behavioral Sciences.

[77] Field Evaluation of the Los Angeles Police Department Drug Detection Procedure, February, 1986, DOT HS 807 012, A NHTSA Technical Report, National Highway Traffic Safety Administration. Richard P. Compton.

[78] Eugene V Adler and Marcelline Burns, "Drug Recognition Expert Validation Study," June 1994.

pupils, increased pulse and increased blood pressure.[79] Other indicators – such as body tremors, eyelid tremors, altered perceptions of time and distance, disorientation and lack of concentration – should also be noted. DRE training also educates law enforcement officers on identifying impairment from multiple drugs and how interactions between different drug combinations may impact the results of each evaluation step.

Criticism of the practice of DRE identification of impaired drivers relates primarily to the use of law enforcement officers without medical training to make medical determinations. *Katelyn Ebner, Princess Mbamara and Ayokunle Oriyomi vs Cobb County* is a lawsuit filed by individuals arrested for marijuana-impaired driving. These individuals received DRE evaluations that did not follow the standards established by the IACP. The DRE evaluations were performed in an uncontrolled environment and did not follow the standard 12-step procedure. The plaintiffs all tested negative for marijuana and their drug-impaired driving charges were later dismissed. However, the plaintiffs' arrest records still show an arrest for drug-impaired driving.

Preparation for adjudication of drug-impaired driving is also addressed, through education on preparing the narrative report on the DRE evaluation, establishing credentials as an expert witness, teaching common defense tactics and providing guidance on case preparation and testifying in court.[80]

DRE certification is contingent on meeting a number of standards developed by the IACP, which include passing a number of written examinations and successfully completing evaluations supported by toxicology results.[81] DRE certification must be renewed every two years.[82]

NHTSA is currently creating a DRE allocation model to give states the information needed to have geographically accessible DREs available when suspected DUIs occur.

Marijuana Testing Methods

Testing for marijuana use can be done using a number of methods. Testing methods that identify recent marijuana use (blood, oral/saliva) are discussed first, followed by methods that identify use over a greater time span (urine, hair) and mass spectrometry methods that can be used on any biological specimen. Table 4 summarizes the benefits and drawbacks of each testing method for supporting drug-impaired driving investigations.

[79] Rebecca L. Hartman et al., "Drug Recognition Expert Examination Characteristics of Cannabis Impairment," Accident Analysis & Prevention 92 (July 2016): 219–29, https://doi.org/10.1016/j.aap.2016.04.012.
[80] National Highway Traffic Safety Administration, International Association of Chiefs of Police, and Transportation Safety Institute, "Drug Recognition Expert Course Participant Manual," February 2018.
[81] DEC Program Technical Advisory Panel and IACP Highway Safety Committee, "The International Standards of the Drug Evaluation and Classification Program," October 2017.
[82] Ibid.

Blood

Testing for THC in the blood is not only invasive, but challenging due to the procedural delays associated with blood testing after an arrest. THC does not stay stable in the blood after being consumed, and can be too low in concentration for a lab test after only a few hours.[83] The American Association for Clinical Chemists (AACC) suggests other cannabinoid markers are more sensitive to detection in the blood, but may not be appropriately reflected in the test results depending on how the individual consumed the marijuana – smoked, inhaled or ingested.[84]

Oral / Saliva

According to AACC, the most popular manner in which to test for cannabinoid use is with an oral/saliva sample. This type of test is easily administered and is able to detect many of the cannabinoids that are present in saliva after use. Michigan recently conducted a five-county pilot of this technology, testing suspected impaired drivers at the roadside and recommends conducting a larger pilot of the technology encompassing all Michigan counties.[85] However, this type of testing also presents some challenges. One common side effect of recent marijuana use is dry mouth. Therefore, the ability to get an appropriate amount of saliva during an oral test may be challenging. In addition, AACC has found that the testing devices may hinder positive results due to plastic tubes and testing pads that absorb THC when the testing device is in use. This instrument failure could result in a lower reading of the presence of the drug than what is realistic with the impaired individual.[86]

Urine

Urine testing can result in the presence of cannabinoids, but does not indicate impairment, as detection of these metabolites can be for days, even weeks, after marijuana has been consumed.[87] In addition, urine testing can be completed road side, but is more vulnerable to tampering.[88] While urine testing is not a viable method for identifying current impairment, it is helpful to identify lifestyle marijuana users for hiring decisions for trucking companies.

Hair

Hair testing is a noninvasive method to test an individual's marijuana use. However, using hair to test impairment at the time of arrest is ineffective. Hair tests can result in a false-positive for an individual who is not a marijuana user, but was in the vicinity of an individual smoking marijuana.[89] The hair should be cut close to the scalp and all elements of color, weight, length

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[83] "The New Era of Cannabis Testing - AACC.Org," March 15, 2018, https://www.aacc.org/publications/cln/cln-stat/2018/march/15/the-new-era-of-cannabis-testing.

[84] Ibid.

[85] "Oral Fluid Roadside Analysis Pilot Program" (Michigan State Police, February 2019).

[86] Philip Sobolesky, "Testing for Cannabis in Oral Fluid: The State of the Art - AACC.Org," May 1, 2018, https://www.aacc.org/publications/cln/articles/2018/may/testing-for-cannabis-in-oral-fluid-the-state-of-the-art.

[87] Richard P Compton, "Marijuana-Impaired Driving - A Report to Congress" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).

[88] Akwasi Owusu-Bempah, "Cannabis Impaired Driving: An Evaluation of Current Modes of Detection1," Canadian Journal of Criminology and Criminal Justice, January 1, 2014, https://doi.org/10.3138/CJCCJ.2014.ES05.

[89] Richard P Compton, "Marijuana-Impaired Driving - A Report to Congress" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).

and additives, such as dyes or bleach, should be recorded, as they can impact the result. According to the Society of Hair Testing, a positive result would contain 0.1 ng/mg of THC.[90] Again, while marijuana-positive hair tests are not ideal for identifying current impairment, these testing methods are effective for identifying lifestyle marijuana users applying to become truck drivers.

Mass Spectrometry

To confirm a drug's presence and the amount of the drug in any biological specimen type (blood, saliva, urine, hair), mass spectrometry is frequently utilized. Gas chromatograph-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS) are two of the more regularly used methods that detail the quantity and the molecular structure of the drug.[91] This testing method is particularly useful if a police officer determines an individual is impaired, but an oral sample had a negative THC result. A secondary test with a mass spectrometer can help to identify the drug and the amount resulting in impairment.[92]

[90] Society of Hair Testing, "Recommendations for Hair Testing in Forensic Cases," 2004.

[91] Richard P Compton, "Marijuana-Impaired Driving - A Report To Congress" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).

[92] "The New Era of Cannabis Testing - AACC.Org," March 15, 2018, https://www.aacc.org/publications/cln/cln-stat/2018/march/15/the-new-era-of-cannabis-testing.

Table 4: Pros and Cons of Testing Types for Identifying Current Impairment

Type of Testing	Pros	Cons
Blood	• Regularly utilized and proven to test for marijuana presence	• Does not necessarily indicate impairment • Very invasive • THC presence in blood deteriorates rapidly
Oral / Saliva	• Non invasive • Can detect recent marijuana use • Can be done quickly and roadside • Commercial devices are becoming more universal • Potential to reduce costs of testing DUI suspects	• Dry mouth as a side effect to smoking marijuana can create challenges of getting sufficient amount of saliva to test • Testing equipment issues
Urine	• Testing via urinalysis is a proven method to detect cannabinoids	• Detection does not mean impairment • Detection can be a couple days or even weeks • High vulnerability to tampering
Hair	• Room temperature storage • No "shelf-life" in terms of testing time frame after collection • Detection of marijuana is much longer[93]	• Does not necessarily mean impairment at the time of arrest • Can create positive result when just in the vicinity of smoked marijuana • Products used in hair coloring, can interfere with the result[94]
Mass Spectrometry	• Can help to determine molecular compound • Can help to indicate the amount of the drug in individual's system	• A highly sensitive mass spectrometer is often needed

Biological testing of DUI suspects for controlled substances is relatively uncommon.[95] When alcohol intoxication is confirmed, drug testing often is not performed. Insufficient funding for law enforcement agencies also poses issues in identifying drug-impaired drivers. The cost of biological testing is significantly higher than that of testing for alcohol. Blood tests for alcohol are estimated to cost $25 to $35, while drug panels range from $100 to $300. Grants from the Fixing America's Surface Transportation Act (FAST Act), are being used to mitigate issues associated with testing suspected drug-impaired drivers. Examples include training police officers as phlebotomists to reduce the time between arresting a suspect and obtaining physical evidence, and funding toxicology programs to test more samples and reduce wait times.[96]

[93] Frank Musshoff and Burkhard Madea, "Analytical Pitfalls in Hair Testing," Analytical and Bioanalytical Chemistry 388, no. 7 (August 2007): 1475–94.
[94] Richard P Compton, "Marijuana-Impaired Driving - A Report To Congress" (Washington, D.C.: National Highway Traffic Safety Administration, July 2017).
[95] Lindsay S. Arnold and Robert A. Scopatz, "Advancing Drugged Driving Data at the State Level: Synthesis of Barriers and Expert Panel Recommendations" (AAA, March 2016).
[96] "State Highway Safety Plans and Annual Reports," Text, NHTSA, February 2, 2017, https://www.nhtsa.gov/highway-safety-grants-program/state-highway-safety-plans-and-annual-reports.

Prosecution

The *Prosecuting the Drugged Driver* and *Protecting Lives/Saving Futures* courses were developed by the National Traffic Law Center to better identify and prosecute impaired drivers.[97] These courses train both law enforcement officers and prosecutors, providing insight into the challenges associated with prosecuting drugged driving cases and how to mitigate them.[98] *Protecting Lives/Saving Futures* features extensive content on the science behind sobriety testing and toxicology, while *Prosecuting the Drugged Driver* features a mock trial to provide feedback.[99] FAST Act funds are being used to educate both prosecutors and judges on drug-impaired driving cases.[100]

However, efforts to prosecute drug-impaired driving have been met with numerous setbacks. For example, Arizona requires "proof" of impaired driving but does not have per se limits on THC blood concentrations.[101] Conversely, Massachusetts has challenged the ability of field sobriety tests to accurately identify marijuana impairment.[102]

[97] Joanne Michaels, "Traffic Safety Resource Prosecutor Manual (2nd Edition)" (National Highway Traffic Safety Administration, September 2016).
[98] Ibid.
[99] Ibid.
[100] "State Highway Safety Plans and Annual Reports," Text, NHTSA, February 2, 2017, https://www.nhtsa.gov/highway-safety-grants-program/state-highway-safety-plans-and-annual-reports.
[101] "Court Ruling Is a Setback for Prosecuting Marijuana DUI Charges," Rosenstein Law Group, January 10, 2018, https://www.scottsdale-duilawyer.com/blog/2018/01/court-ruling-is-a-setback-for-prosecuting-marijuana-dui-charges.shtml.
[102] Erik Slobe, "Massachusetts Top Court Rules Field Sobriety Tests Not Definitive for Marijuana Impairment," accessed February 5, 2019, https://www.jurist.org/news/2017/09/massachusetts-top-court-rules-field-sobriety-tests-not-definitive-for-marijuana-impairment/.

CONCLUSIONS

The increasing use of medical and recreational marijuana necessitates a better understanding of the relationship between marijuana use and roadway safety. In gaining this understanding, approaches to deterring, identifying, and prosecuting marijuana-impaired driving can begin.

While increased access to marijuana has not directly impacted the trucking industry in terms of truck drivers testing positive for marijuana, the increased frequency of marijuana-positive drivers operating on the same roadways as trucks makes marijuana-impaired driving a critical safety issue for the trucking industry.

Several areas are emerging where federal leadership and cooperation with state and local governments, law enforcement and the legal system would benefit as described below.

Data Collection

Documenting the prevalence of drug-impaired driving is critical to understanding the magnitude of this issue. Whether or not the federal government recognizes the legality of marijuana, it should take the lead on related federal data collection programs. Key to this role is identifying and conveying standards for state- and local-level data collection by law enforcement and the criminal justice system. Building upon programs that exist for alcohol-impaired driving within the Departments of Transportation, Health and Human Services, and Justice, systems for collecting marijuana-impaired driving statistics could be developed or further developed in several areas, including:

- Number of crashes, injuries and fatalities;[103]
- Number of drug tests given, rate of positive drug tests, rate of negative drug tests, what drugs were tested for;
- Number of marijuana-related DUI charges, conviction rates and information on what charges DUI suspects are ultimately convicted of; and
- Prevalence of marijuana use while driving.

Public Information

Educating the public on the dangers of marijuana-impaired driving, and of the legal consequences, is critical to preventing drugged driving. Marijuana users – particularly younger users – do not perceive marijuana as having an impact on driving safety, and in a smaller number of cases, they may believe that marijuana improves driving safety. These beliefs are in direct contrast to the documented effects that marijuana has on driving-critical cognitive functions.

[103] As an example, the Model Minimum Uniform Crash Criteria (MMUCC) 5th Edition (2017) establishes guidelines for the minimum crash data requirements and NHTSA offers technical assistance to improve state crash data. Currently, the MMUCC recommends that the officer investigating the crash identify if drugs were involved or suspected to be involved in the crash, and include the results of any drug tests conducted. Changing the MMUCC to require drug tests of all drivers and non-motorists involved in fatal crashes, as well as indicate what drugs were tested for – rather than just what drugs involved parties tested positive for – would provide critical improvements to our current understanding of the role of drugs in fatal crashes.

Safety Campaigns

In 2018, NHTSA launched the *If You Feel Different, You Drive Different* advertising campaign to address the perception that drugged driving is not dangerous. Additionally, a number of states are performing public outreach on the dangers of marijuana-impaired driving, and the legal consequences of driving under the influence of marijuana. Empirical research on the impact of drugs on driving safety outcomes is crucial to convincing the public that drug-impaired driving is a serious roadway safety issue.

Publication of Statistics

Currently, many states do not differentiate between drug-impaired driving and alcohol-impaired driving when documenting DUI citations. A similar lack of distinction is present in the court system for recording DUI offenses in many locations. While some national crash databases record information on suspected drug use and drug test results, the information gaps make researching the impact of drugs through existing databases unreliable. For example, FARS suffers from insufficient data on the role of drugs in fatal crashes, as it is not standard procedure in all states to test all drivers and non-motorists involved in a fatal crash. Even for crashes where drivers and non-motorists are tested for drugs, the FARS database fails to indicate which drugs are involved.

Product Labeling

States with legalized recreational marijuana do not have consistent labeling standards to indicate that a product contains marijuana or warnings of the effects of marijuana consumption. Consistent labeling standards that warn users of potential dangers are necessary to educate marijuana users as well as to prevent accidental consumption of marijuana.

Law Enforcement Training

Unlike alcohol, THC levels in blood are not reliable indicators of driver impairment. This lack of reliability renders per se limits ineffective for enforcing laws prohibiting driving under the influence of marijuana. Without clear toxicology standards for marijuana-impaired driving, law enforcement officer training and observations become critical for identifying, prosecuting and convicting marijuana-impaired drivers. Law enforcement officers must have the knowledge and tools needed to identify marijuana-impaired driving, document their observations and effectively testify in court.

Providing law enforcement officers with the training needed to identify impaired drivers is critical to reducing the incidence of marijuana-impaired driving. The proliferation of different methods for using marijuana necessitates training law enforcement in how to effectively identify marijuana impairment. Not all law enforcement officers are trained in SFST. Additionally, the reliability of SFST for effective identification of marijuana impairment must be examined. Currently, DRE examinations use elevated blood pressure, elevated pulse and the presence of LOC to identify physiological signs of marijuana impairment. Incorporating LOC tests and checks for eyelid/body tremors into SFST has the potential to improve roadside identification of marijuana-impaired drivers. Some states have adapted their SFST procedure to target marijuana impairment as well as alcohol impairment.

Training law enforcement officers in ARIDE and as DREs goes a step further, as the ARIDE and DRE programs focus on identifying drug impairment. Positioning DREs to be geographically accessible to where assessments are needed is also critical.

Law enforcement officers also need additional resources to support DUI investigations with biological testing. The rapid degradation of THC in blood necessitates testing a DUI suspect for drugs quickly. Adoption of roadside testing of saliva/oral fluid may help mitigate this issue. Some states do not include drugs in implied consent, which presents another obstacle to testing DUI suspects for marijuana intoxication. Finally, the expense of testing DUI suspects for drugs is considerable in relation to alcohol.[104]

Criminal Justice System Action Items

Training

To better address drug-impaired driving in court, judges and prosecutors need to be educated on how drugs impact driving safety, and how to understand expert witness testimony. Drug-impaired driving prosecution also requires additional expert testimony relative to alcohol-impaired driving.[105]

Funding

Allocation of Tax Revenue

Currently, recreational marijuana tax revenue is typically allocated for state General Funds, marijuana regulatory agencies, law enforcement agencies, and drug treatment/prevention programs. State tax revenues from recreational marijuana cultivation and sales represents an opportunity to provide law enforcement agencies with the funds needed to combat drug-impaired driving.

In 2017, federal excise taxes on alcohol generated $10.7 billion in tax revenue and taxes on domestic tobacco generated $13.0 billion in tax revenue.[106] The sale of recreational marijuana, however, is not recognized as a legal activity by the federal government, and a tax directly on recreational marijuana from the federal government would therefore be unlikely. That said, taxation of recreational marijuana cultivation and sales at the federal level could help fund programs to combat drugged driving.

However, black market marijuana production and sales persist in states that have legalized recreational marijuana to avoid the costs associated with regulatory requirements and taxes. Potential benefits from recreational marijuana taxes rely on effective enforcement of regulations and collection of taxes on recreational marijuana businesses.

[104] Lindsay S. Arnold and Robert A. Scopatz, "Advancing Drugged Driving Data at the State Level: Synthesis of Barriers and Expert Panel Recommendations" (AAA, March 2016).
[105] Ibid.
[106] "Federal Excise Taxes or Fees Reported to or Collected by the Internal Revenue Service, Alcohol and Tobacco Tax and Trade Bureau, and Customs Service" (Internal Revenue Service, n.d.), accessed February 19, 2019.

Summary

The nation's highways are the trucking industry's workplace. Many safety aspects of the highway environment can be managed by both truck drivers and trucking companies; poor weather conditions can be avoided, tired drivers can take rest breaks and safety technology can be installed on vehicles. But the actions and activities of other drivers are far more difficult to predict. Thus it is left to law enforcement and the criminal justice system to protect sober drivers, including large truck operators, from those who chose to use marijuana and drive.

Through state and federal leadership, mitigating marijuana-impaired driving begins with a deeper understanding of the problem through the collection of data and distribution of public information. Additionally, better equipping law enforcement and the court system to ensure safe highways will help prevent marijuana-involved crashes through prevention and deterrence. Finally, programs can be funded through tax revenue sourced from marijuana sales.

Appendix A: Recreational Marijuana Tax Revenue and Allocation Citations

State	FY	Citations
Alaska	2017	"Alaska Department of Revenue - Tax Division," accessed January 31, 2019, http://www.tax.alaska.gov/programs/programs/reports/AnnualReport.aspx?Year=2017.
California	2018	"Cannabis Tax Revenue Increases In 2nd Quarter of 2018," accessed February 20, 2019, https://www.cdtfa.ca.gov/news/18-41.htm. "California Department of Tax and Fee Administration Reports Cannabis Tax Revenue Increases in Third Quarter of 2018," accessed February 20, 2019, https://www.cdtfa.ca.gov/news/18-58.htm. California Department of Tax and Fee Administration Reports Cannabis Tax Revenues for Fourth Quarter of 2018," accessed February 20, 2019, https://www.cdtfa.ca.gov/news/19-02.htm.
Colorado	2018	Marijuana Tax Data | Department of Revenue," accessed January 29, 2019, https://www.colorado.gov/pacific/revenue/colorado-marijuana-tax-data. "Disposition of Marijuana Tax Revenue," Department of Revenue, December 27, 2016, https://www.colorado.gov/pacific/revenue/disposition-marijuana-tax-revenue.
Maine	-	128th Maine Legislature, "Marijuana Legalization Implementation Committee Fiscal Note," April 5, 2018.
Massachusetts	-	"FY2019 H2 - Section 1A - Revenue by Source and Fund," accessed February 19, 2019, https://budget.digital.mass.gov/bb/h1/fy19h1/brec_19/hsect1a.htm.
Nevada	2018	Stephanie Klapstein, "June Marijuana Revenue Statistics News Release" (Nevada Department of Taxation, 2018).
Oregon	2018	"Oregon Department of Revenue : Government & Researchers : Oregon Marijuana Tax Statistics," accessed February 19, 2019, https://www.oregon.gov/dor/programs/gov-research/pages/research-marijuana.aspx.
Vermont	-	Subcommittee on Taxation and Regulation Governor's Marijuana Advisory Commission, "Draft Findings and Recommendations for Taxing and Regulating Adult-Use Marijuana In Vermont," October 2018.
Washington	2018	Frequently Requested Lists | Washington State Liquor and Cannabis Board," accessed January 29, 2019, https://lcb.wa.gov/records/frequently-requested-lists. "RCW 69.50.540: Dedicated Marijuana Account—Appropriations.," accessed January 29, 2019, https://app.leg.wa.gov/RCW/default.aspx?cite=69.50.540.

Appendix B: Marijuana Impacts on Driver Cognition and Behavior

Divided-attention tasks
• Smiley, A. (1998). Marijuana: on road and driving simulator studies. Geneva, Switzerland: World Health Organization. • Hartman, R.L. and Huestis, M.A. "Cannabis Effects on Driving Skills," Clinical Chemistry 59, no. 3 (March 2013): 478–92, https://doi.org/10.1373/clinchem.2012.194381. • Annick Ménétrey et al., "Assessment of Driving Capability through the Use of Clinical and Psychomotor Tests in Relation to Blood Cannabinoids Levels Following Oral Administration of 20 Mg Dronabinol or of a Cannabis Decoction Made with 20 or 60 Mg Delta9-THC," *Journal of Analytical Toxicology* 29, no. 5 (August 2005): 327–38.
Reduced ability to maintain vehicle position in the center of the lane
• Smiley, A.M., Moskowitz, H., and Zeidman, K. (1981). Driving simulator studies of marijuana alone and in combination with alcohol. Proceedings of the 25th Conference of the American Association for Automotive Medicine, 107-116, 1981. • Robbe, .H.W, O'Hanlon, J.F. (1993). Marijuana and actual driving performance. US Department of Transportation/National Highway Traffic Safety Administration November: 1-133 (1993). DOT HS 808 078. • Ramaekers JG, Berghaus G, van Laar M, Drummer OH (2004). Dose related risk of motor vehicle crashes after cannabis use. Drug and Alcohol Dependence. 73(2):109-119. • Hartman et al., "Cannabis Effects on Driving Lateral Control with and without Alcohol. - PubMed - NCBI," accessed September 27, 2018, https://www.ncbi.nlm.nih.gov/pubmed/26144593.
Slower reaction times
• Hartman, R.L. and Huestis, M.A. "Cannabis Effects on Driving Skills," Clinical Chemistry 59, no. 3 (March 2013): 478–92, https://doi.org/10.1373/clinchem.2012.194381. • Casswell, S. (1977) Cannabis and alcohol: Effects on closed course driving behaviour. In Johnson, I., (Ed.), Seventh International Conference on Alcohol, Drugs, and Traffic Safety, Melbourne, Australia, 1977. • Smiley, A.M., Moskowitz, H., and Zeidman, K. (1981). Driving simulator studies of marijuana alone and in combination with alcohol. Proceedings of the 25th Conference of the American Association for Automotive Medicine, 107-116, 1981. • Lenné, M.G., et al., (2010). The effects of cannabis and alcohol on simulated arterial driving: Influences of driving experience and task demand. Accident Analysis & Prevention, 2010. 42(3): p. 859-866.
Increased following distance
• Jones, R. K.; Shinar, D.; and Walsh, J. M., "State of Knowledge of Drug-Impaired Driving" (National Highway Traffic Safety Administration, August 2003), https://icsw.nhtsa.gov/people/injury/research/stateofknwlegedrugs/stateofknwlegedrugs/pages/4Experimental.html#Anchor-CANNABI-14445. • Lenné et al., "The Effects of Cannabis and Alcohol on Simulated Arterial Driving: Influences of Driving Experience and Task Demand," *Accident; Analysis and Prevention* 42, no. 3 (May 2010): 859–66, https://doi.org/10.1016/j.aap.2009.04.021
Decreased likelihood of passing other vehicles
• Robbe, .H.W, O'Hanlon, J.F. (1993). Marijuana and actual driving performance. US Department of Transportation/National Highway Traffic Safety Administration November: 1-133 (1993). DOT HS 808 078.

Effects of Marijuana Intoxication with Alcohol
• R. Andrew Sewell, James Poling, and Mehmet Sofuoglu, "THE EFFECT OF CANNABIS COMPARED WITH ALCOHOL ON DRIVING," The American Journal on Addictions / American Academy of Psychiatrists in Alcoholism and Addictions 18, no. 3 (2009): 185–93, https://doi.org/10.1080/10550490902786934. • Robbe, .H.W, O'Hanlon, J.F. (1993). Marijuana and actual driving performance. US Department of Transportation/National Highway Traffic Safety Administration November: 1-133 (1993). DOT HS 808 078. • Hartman et al., "Cannabis Effects on Driving Lateral Control with and without Alcohol. - PubMed - NCBI," accessed September 27, 2018, https://www.ncbi.nlm.nih.gov/pubmed/26144593. • Ole Rogeberg and Rune Elvik, "The Effects of Cannabis Intoxication on Motor Vehicle Collision Revisited and Revised," Addiction (Abingdon, England) 111, no. 8 (2016): 1348–59, https://doi.org/10.1111/add.13347. • Craig Jones et al., "Driving under the Influence of Cannabis: The Problem and Potential Countermeasures," Crime and Justice Bulletin 87 (September 2005). • G. B. Chesher, "The Effects of Alcohol and Marijuana in Combination: A Review," in Alcohol, Drugs and Driving: Abstracts and Reviews, vol. 2, 1986, https://trid.trb.org/view/1186029.
Summaries
• Rielle Capler et al., "Cannabis Use and Driving: Evidence Review" (Canadian Drug Policy Coalition & Simon Fraser University, March 2017), https://alisonmyrden.ca/wp-content/uploads/2018/03/CDPC_Cannabis-and-Driving_Evidence-Review_FINALV2_March27-2017.pdf. • Richard P Compton and Amy Berning, "Drug and Alcohol Crash Risk" (Washington, D.C.: National Highway Traffic Safety Administration, February 2015). • Ole Rogeberg and Rune Elvik, "The Effects of Cannabis Intoxication on Motor Vehicle Collision Revisited and Revised: Cannabis and Motor Vehicle Collision Risk," Addiction 111, no. 8 (August 2016): 1348–59, https://doi.org/10.1111/add.13347. • R. Andrew Sewell, James Poling, and Mehmet Sofuoglu, "THE EFFECT OF CANNABIS COMPARED WITH ALCOHOL ON DRIVING," The American Journal on Addictions / American Academy of Psychiatrists in Alcoholism and Addictions 18, no. 3 (2009): 185–93, https://doi.org/10.1080/10550490902786934.

Appendix C: State Laws – Implied Consent, Zero Tolerance and Per Se Limits[107,108]

State	Implied Consent Under Normal Circumstances Includes Controlled Substances	Zero Tolerance Law	Per Se Limits (THC ng/mL Blood)
Alabama	No		
Alaska	No		
Arizona	Yes	THC & metabolites	
Arkansas	Yes		
California	Yes		
Colorado	Yes		5
Connecticut	Yes		
Delaware	Yes	THC & metabolites	
Florida	Yes		
Georgia	Yes	THC & metabolites	
Hawaii	Yes		
Idaho	Yes		
Illinois	Yes	THC & metabolites	
Indiana	Yes	THC & metabolites	
Iowa	Yes	THC	
Kansas	Yes		
Kentucky	Yes		
Louisiana	Yes		
Maine	Yes		
Maryland	Yes		
Massachusetts	No		
Michigan	Yes	THC	
Minnesota	Yes		
Mississippi	Yes		
Missouri	Yes		
Montana	Yes		5
Nebraska	Yes		
Nevada	Yes		2
New Hampshire	Yes		
New Jersey	No		
New Mexico	Yes		
New York	Yes		
North Carolina	Yes		
North Dakota	Yes		

[107] "Legal Issues," accessed November 15, 2018, https://norml.org/legal/drugged-driving.
[108] Governors Highway Safety Assocation, "Marijuana-Related Laws," January 2018.

State	Implied Consent Under Normal Circumstances Includes Controlled Substances	Zero Tolerance Law	Per Se Limits (THC ng/mL Blood)
Ohio	Yes		2
Oklahoma	Yes	THC & metabolites	
Oregon	Yes		
Pennsylvania	Yes		
Rhode Island	Yes	THC & metabolites	1
South Carolina	Yes		
South Dakota	Yes	THC & metabolites	
Tennessee	Yes		
Texas	Yes		
Utah	Yes	THC & metabolites	
Vermont	Yes		
Virginia	Yes		
Washington	Yes		5
West Virginia	Yes		
Wisconsin	Yes	THC	
Wyoming	Yes		

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