

MARIJUANA AND DRIVING: A LOOK AT TEXAN'S ATTITUDES AND IMPACT ON DRIVING UNDER THE INFLUENCE

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Table of Contents

Executive Summary.....	5
Introduction	6
Key Terms.....	7
Literature Review	9
Methods.....	9
Retrieval	9
Inclusion and exclusion criteria.....	9
Analysis	10
Effects of Marijuana on the Body	10
Effects of Marijuana on the Driving Task.....	12
Effects on the Driving Task.....	12
Marijuana’s Impact on Crash Rates and Trends	15
Combined Effects of Alcohol and Marijuana on the Driving Task	15
Prevalence of Marijuana Use and Opinion	16
Summary	18
Policy Review	20
Medicinal Use of Marijuana Laws.....	21
Alaska	21
California	22
Colorado.....	23
Maine	24
Massachusetts	26
Nevada	27
Oregon	29
Washington.....	30
Washington D.C.	32
Recreational Use of Marijuana Laws	33
Alaska	33
California	34
Colorado.....	36
Maine	37

Massachusetts	38
Nevada	39
Oregon	40
Washington	42
Washington D.C.	43
Evidence of Effects of Marijuana Legalization on Impaired Driving	43
Summary	44
FARS Crash Analysis	46
Methods.....	46
Data Retrieval.....	46
Data Analysis.....	46
Results.....	48
Descriptive Statistics	48
Crash Analysis: Selected States.....	52
Crash Analysis: United States.....	55
SPF Estimations for CPD fatal crashes in USA.....	58
Summary	58
Texan’s Attitudes Towards Marijuana Survey	61
Methods.....	61
Developing the Survey	61
Sampling.....	62
Analysis	64
Results.....	64
Demographics	65
Attitudes and Beliefs Regarding Marijuana	66
Reported Marijuana Use.....	67
Attitudes and Beliefs Regarding Marijuana, Alcohol, and Driving.....	73
Attitudes and Beliefs Regarding Legalization of Marijuana	76
Summary	77
Subject Matter Expert Panel	80
Location Selection.....	80
SME Recruitment and Meeting Attendees	80

Panel Discussion.....	81
Discussion.....	82
Creation of Laws and Policies to Regulate the Marijuana Industry	82
Highway Safety Programming Created to Address Marijuana Impaired Driving	83
Partnership Between the Highway Safety Office and Marijuana Industry Groups	84
The Marijuana Industry Interest Groups Role Post Legalization	85
Recommended Best Practices.....	85
Summary	87
Discussion.....	88
Recommendations	90
References	92
Appendix A. Article’s operational definition of evaluation quality.....	103
Appendix B: Marijuana Laws by State.....	104
Appendix C. Survey	106
Appendix D. Frequency Tables for Survey Responses	115
Appendix E: Denver Subject Matter Expert Panel Participant Biographies	131
Jim Burack	131
Sam Cole	131
Glenn Davis	132
Major Steve Garcia.....	132
Carol Gould	133
Brenna Hersey.....	133
Kristi Kelly.....	134
Chief Robert Ticer	134
Patrick Witcher	135
Appendix F: Panel Discussion Agenda	136

List of Figures

Figure 1. Number of fatal crashes with driver impaired by cannabinoid and proportion to all fatal crashes, 2008 to 2015, USA.	52
Figure 2. States with legalized recreational and medicinal use of marijuana.	53
Figure 3. States with legalized medicinal use of marijuana.....	54

Figure 4. Neighboring states to states with legalized medicinal and recreational use of marijuana.....	54
Figure 5. States that do not have legalized medicinal or recreational use of marijuana, nor neighboring states.....	55
Figure 6. Top 25 counties with the highest per capita alcohol related fatalities in Texas.....	63
Figure 7. Distribution of Respondents, by County.....	65
Figure 8. Percent of Respondents who Reported Marijuana Use in the Past 12 Months by County.....	67
Figure 9. Percent of Respondents who Reported Marijuana Use in the Past 30 days by County.....	68
Figure 10. Responses to the Statement: It is unsafe to drive after using marijuana, by county.....	73
Figure 11. Responses to the Statement: It is unsafe to drive under the influence of marijuana, by county.	74
Figure 12. Responses to the Statement: It is unsafe to drive within two hours of using marijuana, by county.	75
Figure 13. Responses to the Statement: Driving under the influence of marijuana is safer than driving under the influence of alcohol, by county.	76
Figure 14. Responses for Type of Legalization, by County.	77

List of Tables

Table 1. Drivers Involved in Fatal Motor Vehicle Traffic Crashes by Crash Year, Drug Test Status, and Drug Test Results, 2008 to 2015, USA.	49
Table 2. Most Common Drug Types and Interaction with Alcohol, 2008 - 2015, USA.	50
Table 3. Cannabinoid Positive Drivers by Gender and Age Group, 2008 – 2015, USA.	51
Table 4. Summary of Variables by Group and Year.	56
Table 5. Results of Generalized Linear Crash Model.	58
Table 6. Distribution of Phone Type by Age Category.	66
Table 7. Marijuana Use by Age.	69
Table 8. Marijuana Use by Gender.	69
Table 9. Marijuana Use by Race/Ethnicity.	70
Table 10. Marijuana Use by Education.	71
Table 11. Marijuana Use by Political Views.	72

Executive Summary

Currently, marijuana is the most commonly detected non-alcohol drug in drivers; however, its role in crash risk remains unresolved (Adrian 2015; Otto et. al 2016; Hartman & Huestis 2013). As of January 2017, eight states and Washington D.C. have passed laws allowing the medicinal and recreational use of marijuana (NORML 2017), while an additional four states have decriminalized marijuana possession (NORML 2017). Further, twenty more states have passed laws allowing the medicinal use of marijuana (NORML 2017).

This project investigated the impact legalization of marijuana for medicinal and recreational purposes has on traffic safety and crashes. In addition, this project sought to understand Texan's opinions on marijuana, marijuana impaired driving as well as the legalization of marijuana for medicinal or recreational purposes in Texas.

According to the results of the FARS crash analysis, gender and age are overrepresented factors in fatal crashes for drivers who tested positive for cannabinoids. In addition, male drivers and younger drivers (16 to 24 years old) are more likely to test positive for cannabinoids in fatal crashes.

This analysis also found the number of drivers who tested positive for cannabinoids involved in fatal crashes increased in 2014 and 2015 in all states selected for analysis, regardless of their status as a state with legal medicinal and/or recreational use of marijuana, neighbor to a state with legal recreational use of marijuana or neither legal medicinal or recreational use of marijuana nor a neighboring state. This suggests the impact of the legalization of marijuana is not bound by the geographic boundary of states.

Survey results for this effort are consistent with previous studies and found that 20.5% of those aged 18 to 24 years old reported marijuana use in the past 30 days, whereas 5.8% of those aged 25 years old and older reported marijuana use in the past 30 days. Survey results also suggest that males were more likely to use marijuana compared to females. With 14.3% and 8.0% of males reported use in the past 12 months and 30 days, respectively 11.8% and 5.9% of females reported use.

Through understanding the impacts of marijuana legalization on traffic safety and the population's beliefs and attitudes towards marijuana, appropriate policies and countermeasures can be developed and implemented to reduce the potential negative impact of marijuana legalization.

Introduction

Currently, marijuana is the most commonly detected non-alcohol drug in drivers; however, its role in crash risk remains unresolved (Adrian 2015; Otto et. al 2016; Hartman & Huestis 2013). As a country moving towards relaxed marijuana use and possession laws, more knowledge is needed to fully grasp the impact of marijuana use on traffic safety.

Texas' Crash Record Information System (CRIS) data indicates the number of crashes involving a driver who has been identified as a drugged driver or had a positive drug test result have been increasing over the past five years (TxDOT 2016). In 2010, Texas experienced 3,741 crashes attributed to drug impaired driving (TxDOT 2016). In 2014, that number climbed to 4,412 crashes (TxDOT 2016). This increase in crashes represents a 15 percent increase in the number of crashes on Texas roadways attributed to drug-impaired driving over the past five years. And while these crashes cannot be directly attributed to marijuana, it is critical to understand the effects of marijuana on the body and driving task to understand the current state of traffic safety in Texas better.

Further, data from the National Highway Traffic Safety Administration's (NHTSA's) 2013 - 2014 National Roadside Survey of Alcohol and Drug Use by Drivers shows alcohol use before driving is decreasing, while drug use, specifically marijuana use is increasing (NHTSA 2015). Data from this survey showed on weekday nights, 1.1% of drivers tested positive for alcohol, while 11.7% tested positive for marijuana (NHTSA 2015). Weekend night data showed 8.6% of drivers tested positive for alcohol, while 12.6% of drivers tested positive for marijuana (NHTSA 2015).

As of January 2017, eight states and Washington D.C. have passed laws allowing the medicinal and recreational use of marijuana (NORML 2017), while an additional four states have decriminalized marijuana possession (NORML 2017). Further, twenty more states have passed laws allowing the medicinal use of marijuana (NORML 2017).

This project sought to determine the effects of marijuana on the body and driving task. This project also investigated the impact legalization of marijuana for medicinal and recreational purposes has on traffic safety and crashes. In addition, this project sought to understand Texan's opinions on marijuana, marijuana impaired driving as well as the legalization of marijuana for medicinal or recreational purposes in Texas.

In order to achieve the objectives of this project, a literature review of all relevant scholarly sources related to marijuana as well as marijuana impaired driving was conducted. Researchers conducted a policy review summarizing the current statutes related to medicinal and recreational marijuana legalization. Researchers conducted a crash analysis to understand the impacts of marijuana legalization on fatal crashes. In addition, researchers surveyed Texan's in

regards to their attitudes towards marijuana use, marijuana impaired driving and marijuana legalization.

Key Terms

The following terms are used throughout the report. Additional terms are defined in the report as needed.

Affirmative defense – A defense in which the defendant introduces evidence to negate the criminal activity, even if it is proven or admitted that the defendant committed the alleged offense.

Alternate caregiver – A secondary person who is responsible for the housing, health, and/or safety of the patient. For the purposes of medicinal marijuana, an alternate caregiver will be the secondary cultivator of a patient's marijuana. This individual is also responsible in assisting the patient with their medical marijuana use.

Caregiver – A person who is responsible for the housing, health, and/or safety of the patient. For the purposes of medicinal marijuana, a caregiver will be the primary cultivator of a patient's marijuana. This individual is also responsible in assisting the patient with their medical marijuana use. In addition, simply supplying the marijuana and instructing the patient on the use of medicinal marijuana does not qualify a person as a caregiver.

Decriminalization – This occurs when a state modifies its laws to make use, possession and cultivation of marijuana illegal, but no longer subject to prosecution. In many states with decriminalization of marijuana, simple possession of marijuana is subject to a fine only.

Delta-9-tetrahydrocannabinol (Δ 9-tetrahydrocannabinol) – This is the primary psychoactive metabolite of marijuana in the body. The impairing effects of marijuana are attributed to this metabolite.

11-nor-9-carboxy-delta-9-tetrahydrocannabinol (THC-COOH) – This is the foremost secondary inactive metabolite of marijuana in the body. This metabolite of marijuana does not produce any impairing effects on the body, but its presence can indicate recent marijuana use.

Immature marijuana plants – This a nonflowering plant. Immature plants can be produced from a cutting, clipping or seedling. An immature plant has no observable flowers or buds (Nevada Administrative Code 453A.080).

Mature marijuana plants – This is a harvestable female marijuana plant that is flowering. Flowers or buds are readily observable by unaided visual observation (Nevada Administrative Code 453A.080).

Medicinal use of marijuana - Refers to the use, possession, or cultivation of marijuana used to treat or relieve pain from a number of medical issues, diseases or conditions. In order to use marijuana for medicinal purposes, the patient must have a qualifying condition, and receive a recommendation to use marijuana for medicinal purposes from a physician. Medicinal marijuana is not typically prescribed in the traditional sense.

Recreational use of marijuana - Refers to the use, possession or cultivation of marijuana for personal use. In states with legalized recreational use of marijuana, an individual will not be arrested, ticketed, or convicted for possessing and using marijuana in accordance with the age, place and amount for possession stipulated in state law.

Seed-to-sale tracking system - Seed-to-sale tracking mechanisms are employed to prevent the disappearance of products grown and cultivated for retail sale. In a seed-to-sale model, all marijuana grown for retail sales, whether for medicinal or recreational use, is tracked from the time it is planted as a seed or cloned from a mature plant, until it is sold to a consumer. Typically, a plant is assigned a tracking number and tag, which remain with the plant until it is packaged for the consumer. This allows the regulatory agency to track all marijuana being grown in the state at any given time.

Usable marijuana – Consists of the dried leaves and flowers of the marijuana plant. This does not include seeds, stalks, and roots of the plant (Nevada Revised Statutes 453A.160).

Literature Review

To better understand the effects of marijuana and perceptions of the drug, researchers reviewed the available literature on the subject of marijuana and driving. Through this effort, four themes or areas of focus of the available literature emerged. These themes are: effects of marijuana on the body; effects of marijuana on the driving task; combined effects of marijuana and alcohol on the driving task; as well as prevalence of and opinions regarding marijuana use.

Methods

Retrieval

Electronic databases were strategically selected to ensure search breadth and depth. Researchers performed a search for relevant literature via the following content areas and databases:

- transportation (Transportation Research Information Services);
- medicine (MEDLINE);
- psychology (PsycINFO, PsycARTICLES, PsycBOOKS, PsycCRITIQUES, Psychology and Behavioral Sciences Collection);
- legal collections (Westlaw, LexiNexis, Legal Source, Legal Information Reference Center, Criminal Justice Abstracts); sociology (SocINDEX); and
- bibliographic databases (National Technical Information Service).

Additionally, both Scopus and Specific search descriptors (phrases and keywords) employed to identify pertinent research articles included the following: marijuana, marihuana, cannabis, cannabinoids, hashish, hemp, sinsemilla, THC, delta 9-tetrahydrocannabinol, psychoactive substances, impaired drivers, drugged drivers, drunk driving, driving under the influence, and DUI. These search terms were used individually and in combination, with word variations, truncations, and database-specific thesaurus terms applied. Finally, the bibliographies of identified articles were also examined to locate relevant studies.

Inclusion and exclusion criteria

In order to meet the initial inclusion criteria, records had to be of English language and explore marijuana as the primary substance of the study. In an attempt to capture all of the available literature related to marijuana's effects on the body and driving task, year of publication was not an initial restriction for inclusion. The initial identification phase identified approximately 789 records for inclusion. Initial screening for duplication resulted in the removal of 189 records. Next, the following exclusion criteria were applied: studies focusing on trends or rates of use must focus on the United States, studies focusing on crash trends or rates must focus on the United States, and full-text records must be attainable. Also, studies examining marijuana usage or drug-impaired driving crash rates must not take place before 2000 as this information

is always changing. The application of these criteria resulted in the exclusion of 322 records. In addition, documents with the primary purpose of reviewing the relevant literature were excluded from the sample, and the reference lists of excluded literature reviews were cross-referenced to ensure that all pertinent sources were captured. No additional records were identified by reviewing reference lists.

Analysis

The final sample (n=278) represented a variety of disciplines, with source information ranging from traffic safety to public health. A modified Matrix Method and Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) were utilized to guide the collection and synthesis of articles included in this systematic review.

In addition to logging key descriptive bibliographic information (e.g., APA citation), the methodological categories and manuscript aspects were captured by critically examining the abstract, methods, results and discussion sections of each document. This included reviewing the: key findings, substances studied, sample selection strategy, sample size, sample representativeness, geographic location of the study, study design, study type, research methodology, and measurement strategy. Research design and methodological choices, as outlined in the Methods section of each article, were weighted to establish a quality score for each reviewed record. Appendix A outlines the relative point values applied to each of these categories. Higher quality scores indicate decreased influence of threats to internal validity.

Effects of Marijuana on the Body

The ingestion of marijuana, specifically the psychoactive substance Δ^9 – tetrahydrocannabinol (referred to as THC throughout) found in the marijuana plant, has demonstrated physical and cognitive effects on the human body (Weinstein et al.2008; Hartman et al., 2016; Otto et al., 2016). THC affects the body by interacting with specific endogenous cannabinoid receptors localized in the cerebellum, hippocampus, basal ganglia, and cortex (Laberge & Ward, 2004). Even at low concentrations of THC, research has demonstrated THC significantly decreases psychomotor skills and globally alters the activity of the main brain networks involved in cognition (Battistella et al., 2013). In addition, higher levels of THC also induce greater impairment than lower levels (Lenné et al.2010).

Following the ingestion of THC, subjects have demonstrated: significant increases in heart rate, elevated systolic blood pressure, as well as dilated pupil size (Rafaelsen et al., 1973; Perez-Reyes, 1988; Berghaus et al., 1995; Liguori et al., 1998; Weinstein et al., 2008; Khiabani et al., 2008; Bramness et al., 2010; Ronen et al., 2010; Hartman et al., 2016). In comparison to alcohol, THC has significantly affects visual autokinesis, vigilance, and measures of concentrated

attention in situations where alcohol has produced no impairment (Moskowitz et al.1976). Further, the impairment of THC does not take place at the central nervous system level that control the ability of the eyes to track environmental stimuli, as no Horizontal Gaze Nystagmus (HGN) is present in individuals under the influence of THC (Moskowitz et al., 1976). Also, THC has a demonstrated effect on decreased composite equilibrium (Liguori et al., 2002).

THC consumption impacts many areas of the brain. Research has shown THC induced a relative decrease in activation in the anterior insula, the dorsomedial thalamus, the striatum, the right dorsolateral prefrontal cortex, the right superior parietal lobule, and the cerebellum (Battistella et al., 2013). Further, both salience and central-executive networks, responsible for cognitive function are altered after THC ingestion (Battistella et al., 2013). Following the ingestion of THC, individuals need to recruit the supplementary motor area of the brain more to compensate for the decrease in activation in the cerebellum (Battistella et al., 2013). Studies indicate THC reduces critical tracking performance, the ability to make correct decisions in during a task, and increased stop reaction time (Kurzthaler et al.1999; Ramaekers et al., 2006; Weinstein et al., 2008). In addition, individuals who have smoked THC report feelings of sleepiness, reduced physical effort, decreased clear-headedness and lack of energy following smoking THC (Liguori et al.,1998; Liguori et al.2002; Ronen et al.2008; Weinstein et al.,2008; Ronen et al.,2010; Burston et al.,2015).

While the impairment from THC consumption is at its peak level during the first hour after use and then gradually declines (O’Kane et al.,2002; Laberge & Ward, 2004; Ménétrey et al.,2005; Battistella et al.,2013), it is important to note that method of ingestion impacts the rate in which users of THC feel the effects of the drug. Typically, the effects of smoked THC are felt relatively quickly, affecting mood with a quick elevation of plasma concentration of THC after smoking and a relatively fast decline over time (Perez-Reyes et al., 1982). Further, studies have demonstrated THC is metabolized by the body very rapidly and levels in the blood dissipate quickly (O’Kane et al., 2002; Laberge & Ward, 2004; Weinstein et al., 2008; Hartman et al., 2016).

While the effects of THC are expressed in a dose-dependent manner, meaning that an individual’s level of impairment will increase the amount of THC consumed increases (Ronen et al.2008). The influence of any given blood level of THC is influenced by the experience of the user, the vulnerability to psychoactive reactions, the expectations as to the effects of marijuana, and the setting of its use (Berghaus et al.,1995; Harder & Rietbrock, 1997; Hanson, 2013; Sullum 2013).

Research has demonstrated THC has short-term effects on cognitive function specifically decision making and motor coordination, which can ultimately impact the driving task and increase crash risk (Liguori et al., 1998; Otto et al., 2016).

Effects of Marijuana on the Driving Task

Effects on the Driving Task

While there is no indication that past use of THC alone affects crash risks, there is growing evidence that recent use of THC increases the risk for motor vehicle accidents compared to drug-free drivers, particularly at higher concentrations (Ramaekers et al., 2004; Ramaekers et al., 2009). Specifically, research has demonstrated recent THC use approximately doubled one's risk of traffic crash, this is especially true for fatal crashes (Asbridge et al., 2005; Asbridge et al., 2012; Hartman & Huestis, 2013; Li et al., 2013; Otto et al., 2016). Also, habitual THC users have been found to have 10 times the crash risk compared to occasional or non-users (Blows et al., 2005).

Further, THC, when taken alone, produces a moderate degree of driving impairment which is related to the consumed THC dose (Robbe & O'Hanlon, 1995). Studies which look at unsafe driver action, a proxy measure of crash responsibility, found drivers who test positive for THC are 16 – 29% more likely to commit an unsafe action than drivers who test negative for THC (Hansteen et al., 1976; Bédarad et al., 2007; Dubois et al., 2015). However, some studies have found that THC use does not significantly increase one's crash risk (Binder, 1973; Hansteen et al., 1976; Turner, 2007; Compton & Berning, 2015).

Drivers under the influence of THC appear to have a similar brake latency to drivers with a BAC of 0.05 (Liguori et al., 1998). In addition, the reaction times of drivers who are under the influence of THC are slower than sober drivers (O'Kane et al., 2002; Ramaekers et al., 2006; Grotenhermen et al., 2007; Lenné et al. 2010; Ronen et al. 2010; Adrian, 2015; Hartman et al. 2016). THC impairment has been found to impact, in a dose-dependent manner, a driver's ability to gauge time and distance (Bech et al., 1973; O'Kane et al., 2002). THC impairment has also demonstrated increased errors in recognition of the lights and delayed response times to their appearance (Moskowitz et al., 1976; O'Kane et al., 2002). Drivers under the influence of THC also demonstrate impairment in their ability to complete divided attention tasks (Barnett et al., 1985; Battistella et al., 2013; Hanson, 2013; Adrian, 2015). Research has shown drivers under the influence of THC complete fewer passes and take more time to make the decision to pass than sober drivers (Dott, 1972; Smiley et al., 1985; O'Kane et al., 2002). Further, due to the cognitive impairment of THC, drivers under the influence of THC also experience inhibitory control (Romano & Voas, 2011; Battistella et al., 2013; Hanson, 2013).

Studies have demonstrated THC use impairs fundamental road tracking ability with the degree of impairment increasing as a function of the consumed THC dose (Barnett et al., 1985; Robbe, 1994; Sexton et al., 2002; Ménétrey et al., 2005; Bosker et al., 2012; Battistella et al., 2013; Adrian, 2015). Research has shown THC affected Standard Deviation of Lateral Position (SDLP), which is associated with the risk of a crash, in a blood THC concentration-dependent manner (Smiley et al., 1985; O’Kane et al., 2002; Hartman & Huestis, 2013; Hartman, 2015). Low (1 and 2 ng/L) blood THC concentrations were associated with SDLP increases similar to 0.01 g/L blood alcohol concentration (BAC) (Hartman, 2015). At 5 ng/L THC, a 4.1% increase (relative to no THC, no alcohol) in SDLP was observed; at 10 ng/L, SDLP increased 8.2% (Hartman, 2015). This change was comparable to 0.05 g/L BAC and 0.08 g/L BAC (Hartman, 2015). Further, these SDLP increases were greater than those produced by 0.05 and 0.08 g/L BAC (Ramaekers et al., 2006; Grotenhermen et al., 2007; Lenné et al. 2010; Ronen et al. 2010; Hartman, 2015; Hartman et al. 2016). However, there were no significant blood THC effects on lane departures/min and maximum lateral acceleration. (Hartman, 2015).

Numerous studies have demonstrated THC use was associated with increase of headway and decrease in mean speed (Attwood et al., 1980; Smiley et al., 1985; O’Kane et al., 2002; Ramaekers et al., 2006; Grotenhermen et al., 2007; Ronen et al., 2008; Anderson et al., 2010; Lenné et al. 2010; Ronen et al. 2010; Romano & Voas, 2011; Hartman et al. 2016). Further, THC-impaired driving is marked with increased variability in speed, headway, and lateral position (Attwood et al., 1980; Ramaekers et al., 2004; Ramaekers et al., 2006; Grotenhermen et al., 2007; Lenné et al. 2010; Ronen et al. 2010; Hartman et al. 2016). As with previous research, in most cases these effects were dose-dependent (O’Kane et al., 2002; Ramaekers et al., 2006; Grotenhermen et al., 2007; Lenné et al. 2010; Ronen et al. 2010; Hartman et al. 2016).

Studies have shown drivers under the influence of THC retain insight in their driving performance and will attempt to compensate where they can, for example, by slowing down or increasing effort (Robbe & O’Hanlon, 1995; Sexton et al., 2002; Hartman et al., 2015). Also, studies suggest individuals who drive under the influence of THC but do not see a marked decrease in driving skills are utilizing additional compensatory skills (Anderson et al., 2010; Hanson, 2013).

Research has shown individuals are more aware of the impairing effects of THC than of alcohol (Robbe, 1994; Lamers & Ramaekers, 2001). When surveyed, individuals expressed the main negative effects of driving after THC ingestion were impaired concentration and not feeling in control (Neale, 2001; Sexton et al., 2002; Sewell et al., 2009; Ronen et al., 2010). Individuals also report that THC use made them feel too tired to drive safely (Neale, 2001; Sexton et al., 2002; Sewell et al., 2009; Ronen et al., 2010). Also, individuals report alteration of time and space perceptions, leading to a different sense of speed which results in driving more slowly (Crancer

et al., 1969; Burston et al., 2015). In addition, individuals report the effort to accomplish a driving task increased significantly after consuming THC (Robbe, 1998; Lamers & Ramaekers, 2001; Ronen et al., 2010)

Individuals who reported greater adverse effects of THC expressed a lower frequency of driving under the influence of THC (Fischer et al., 2006; MacDonald et al., 2008). However, other users of THC who experienced feelings of impairment reported driving normally under the influence of THC (Neale, 2001; Sexton et al., 2002; Fischer et al., 2006; MacDonald et al., 2008; Sewell et al., 2009; Ronen et al., 2010). Others still noticed a marginal difference but felt that they could easily overcome this by taking compensatory action: for example, by driving more slowly, sitting more upright, or avoiding busy roads. (Robbe, 1994; Lamers & Ramaekers, 2001; Neale, 2001; Sexton et al., 2002; Sewell et al., 2009; Ronen et al., 2010).

Research on the amount of time after smoking THC begins until effects on the driving task are present is mixed. The impairing effects of THC on the driving task are concentrated within the first two hours of smoking THC (O’Kane et al., 2002). However, some research has found the effects of THC can be seen on the driving task within as little as 15 minutes (Peck et al., 1986). While other research has shown that performance of the driving task is not significantly impaired until approximately 80 minutes after smoking THC (Papafotiou et al., 2005). Further complicating the matter, research has demonstrated most behavioral effects of THC use will dissipate within 3 – 5 hours after use begins, however, some studies have found effects in some skills such as complex divided attention tasks can remain long as 24 hours (Hansteen et al., 1976; Hanson, 2013). Driving under the influence of THC has a demonstrated effect on one’s driving ability, whether or not a significant decline occurs in driving ability is dependent both on the subject’s capacity to compensate and on the dose of THC (Klonoff, 1974; Smiley, 1986; Papafotiou, 2005; Bosker et al., 2012).

In addition to the studies that examined the effects of THC on the driving task and increased crash risk, studies have been conducted to determine the best psychomotor testing to determine divided attention in THC-impaired in drivers. Currently, law enforcement officers utilize the Standardized Field Sobriety Testing battery to determine impairment at roadside. Studies have identified the SFSTS are a moderate predictor of driving impairment for individuals under the influence of THC (Papafotiou, 2005; Papafotiou et al., 2005; Bosker et al., 2012; Porath-Waller & Beirness, 2014). Further evaluation of additional psychomotor testing available through the Advanced Roadside Impairment Driving Enforcement (ARIDE) and Drug Evaluation and Classification (DEC) Programs have also demonstrated a greater ability to detect THC-impairment. The Finger to Nose (FTN) test best predicts cannabis impairment when three or more misses are observed and used as the deciding criterion (Papafotiou et al., 2005; Hartman et al., 2016). In addition, the Modified Romberg Balance (MRB) eyelid tremors

appeared to be an accurate indicator of THC-impairment (Papafotiou et al., 2005; Hartman et al., 2016). Other reliable indicators included One Leg Stand (OLS) sway, 2 Walk and Turn (WAT) clues, and pupil rebound dilation. Requiring 2/4 of: 3 FTN misses, MRB eyelid tremors, 2 OLS clues, and/or 2 WAT clues produced the best results to determine THC-impairment (Papafotiou et al., 2005; Hartman et al., 2016).

In addition to psychophysical testing, studies have demonstrated blood specimens should be collected as early as possible to most accurately reflect the level of THC present at the time of driving and arrest (Papafotiou et al., 2005; Hartman et al., 2016). Combined observations on psychophysical and eye exams produce the best THC-impairment indicators. (Reeve et al., 1983; Papafotiou et al., 2005; Hartman et al., 2016).

Marijuana's Impact on Crash Rates and Trends

In both the National Roadside Survey (NRS) and the Fatality Analysis Reporting System (FARS), cannabinoids, which includes THC, are the most prevalent drug detected (Schwilke et al., 2006; Ronen et al., 2010; Hanson, 2013; Masten & Guenzburger, 2014; Romano et al., 2014; Rudisill et al., 2014). Trends have shown that non-alcohol drugs have been increasingly detected in fatally injured drivers, whereas the presence of alcohol in fatally injured drivers has remained stable (Brady & Li, 2014). Further, the largest increases in substances detected in fatally injured drivers have been seen in cannabinoids (Brady & Li, 2014).

States with the legalization of marijuana for medicinal and recreational purposes have seen an increase in fatalities with a driver who is positive for THC (Masten & Guenzburger, 2014; Salomonsen-Sautel et al., 2014; Reed, 2016). In Colorado, since mid-2009 when medical marijuana became commercially available and prevalent, the trend in the proportion of drivers in a fatal motor vehicle crash who were THC-positive has been increasing (Salomonsen-Sautel et al., 2014). Specifically, in Colorado, from 2013 to 2014, fatalities with a driver positive for THC only or THC and another substance(s) increased from 55 to 79 (Reed, 2016). During this same time period, Colorado saw the percentage of all fatalities with a THC positive driver increase from 12% to 15% (Reed, 2016). Further, Colorado drivers in fatal crashes positive for THC or THC with additional substances increased from 47 (2013) to 67 (2014) (Reed, 2016).

Combined Effects of Alcohol and Marijuana on the Driving Task

Numerous studies have found that the use of THC in combination with alcohol may produce dramatically greater impairment on the driving task than either substance on its own (Sutton, 1983; Biasotti et al., 1986; Peck et al., 1986; Longo et al., 2000; Ramaekers et al., 2000; Robbe & O'Hanlon, 2000; O'Kane et al., 2002; Sexton et al., 2002; Laberge & Ward, 2004; Ramaekers et al., 2004; Schwilke et al., 2006; Sewell et al., 2009; Bramness et al., 2010; Hanson, 2013; Caulkins,

2014). Specifically, studies suggest when alcohol and drugs are used together there is a negative interaction effect on the risk of fatal crash involvement on the multiplicative scale (Sewell et al., 2009; Li et al., 2013). The odds ratios of fatal crash involvement were 13.6 for those using alcohol alone, 2.2 for those using THC alone, and 23.2 for those using for both alcohol and THC, which is statistically significant (Sewell et al., 2009; Li et al., 2013). Further, drivers who consume alcohol and THC together are more likely to experience a rollover or single vehicle-related crash (Liu et al., 2016).

Combining THC with alcohol produces an additive effect rather than a synergistic effect on the body and ultimately the driving task (Biasotti et al., 1986; Peck et al., 1986; Perez-Reyes et al., 1988; Ramaekers et al., 2004; Lenné et al., 2010; Ronen et al., 2010; Hartman, 2015; Hartman et al., 2015). Additional studies have shown that low levels of both alcohol and THC, which would not significantly impair an individual when taken alone can have a significant impairing effect on the driving task when taken together (Sutton, 1983).

Studies which look at driver error as a proxy for crash involvement found drivers who use both alcohol and THC together are more likely to make a driving error than drivers who use either alcohol or THC alone (Dubois et al., 2015).

Studies have shown decreased lateral control was associated when THC is combined with alcohol. SDLPs were similar between 0.02, 0.05, 0.08 g/L BAC and 3.3, 8.2, 13.1 ng/L THC, respectively (Attwood et al., 1980; Hartman, 2015; Hartman et al., 2015).

Further, drivers who have consumed alcohol and THC together are less able to detect peripheral traffic while driving (Lamers & Ramaekers, 2001). Also, the use of alcohol and THC together impacts a driver's ability to perform divided attention tasks (Lamers & Ramaekers, 2001).

Prevalence of Marijuana Use and Opinion

Studies show marijuana is the most commonly used illicit drug in the United States (Adrian, 2015). In 2012, 79% of current illicit drug users had used marijuana; and about two-thirds (63%) of illicit drug users used only marijuana in the past month (Hartman & Huestis, 2013; Adrian, 2015; Otto et al., 2016). In 2013, 38% of adults in the United States said they tried marijuana, whereas 7% said they were current users (Adrian, 2015). During roadside surveys, nearly 10% of weekend nighttime drivers tested positive for THC, and in some jurisdictions, nearly 20% of weekend nighttime drivers tested positive for THC (Johnson et al., 2011). Nationwide surveys have found 21.7% of high school students had used marijuana one or more times during the 30 days before the survey (Lewis et al., 2005; Lewis et al., 2008; Kann, 2016).

Over time, surveys about marijuana use have demonstrated an increase in the number of adults who have tried marijuana or are current marijuana users. According to the National Survey on Drug Use and Health (NSDUH), past 30 day use prevalence rates for THC usage have increased significantly for adults (aged 18 – 25 years old) from 21% in 2006 to 31% in 2014 (Azofeifa et al., 2015; Otto et al., 2016; Reed, 2016). By comparison, during the same period, cigarette use is down (40% to 32%), and other illicit drug use is down (10% to 8%) (Reed, 2016).

Additionally, the perceived risk of smoking marijuana once a month declining (Reed, 2016). For adults, over age 18, the perceived risk of smoking marijuana once a month is much lower than smoking a pack of cigarettes a day (Reed, 2016).

Regarding using marijuana and driving, marijuana use among drivers exceeds the rate of alcohol use among drivers (Fergusson et al., 2008; Scherer et al., 2013; Li et al., 2016). Among marijuana users surveyed, less than half of the sample, approximately 46%, believed marijuana alone negatively impacted their driving ability by 'slowing reaction times' and 'reducing alertness' (Lenné et al., 2001). A small percentage of the sample, 12%, believed using THC improved their driving ability by 'increasing awareness and concentration' (Lenné et al., 2001).

Among marijuana users, 42.3% of users age 21 and over and 48.2% of users age 18 to 30 reported driving within four hours of using marijuana (Otto et al., 2016). By contrast, 54.4% of users aged 18 – 30 years old reported driving within four hours of using marijuana in Colorado and Washington, where medicinal and recreational use of marijuana is legal (Otto et al., 2016). Other studies have found that up to 80% of individuals surveyed reported driving after smoking THC (Ashton et al., 2016). In addition, surveys have shown a willingness among adults to ride with a driver who is under the influence of THC, as 80% of individuals surveyed reported they had ridden with a driver under the influence of THC within the past six months (Lenné et al., 2001).

Further, drivers aged 20 and younger are far more likely than adults aged 21 to 34 to use marijuana (Buchan et al., 2000; Voas et al., 2013; Azofeifa et al., 2015; Arnold & Tefft, 2016; Kann, 2016). While some surveys have found driving or riding after THC use was slightly lower 23% in 2011 than 25% found in 2001, this trend is on the rise (O'Malley & Johnston, 2003; Asbridge et al., 2005; O'Malley & Johnston, 2007; O'Malley et al., 2013; Azofeifa et al., 2015). These surveys have demonstrated that despite reducing driving or riding after alcohol use, driving or riding after THC use continues to rise (O'Malley & Johnston, 2003; Asbridge et al., 2005; O'Malley & Johnston, 2007; O'Malley et al., 2013; Azofeifa et al., 2015).

In addition, adolescents appear to be much more accepting of smoking THC and driving than drinking alcohol and driving. Regardless of whether they drink alcohol or use THC themselves, they are more likely to suggest that driving under the influence of THC is more acceptable than

driving under the influence of alcohol (Patton & Brown, 2002; Fischer et al., 2006; Glasscoff & Haddock, 2013; Ashton et al., 2016; Li et al.2016). Research has concluded that many youths perceived driving after THC use as more acceptable to their peers and they are less likely to receive the negative consequences of driving under the influence than driving after alcohol use (McCarthy et al.,2007; Glasscoff & Haddock, 2013; Ashton et al.,2016; Li et al.,2016).

Summary

Over the last forty years, numerous studies have been undertaken to determine the effects of marijuana on the body, effects of marijuana on the driving task, combined effects of marijuana and alcohol on the driving task as well as the prevalence and use of marijuana in the United States.

THC consumption has demonstrated physical and cognitive effects on the human body (Weinstein et al.2008; Hartman et al., 2016; Otto et al., 2016). Even at low concentrations of THC, THC significantly decreases psychomotor skills and globally alters the activity of the main brain networks involved in cognition (Battistella et al., 2013). The specific effects of THC consumption are: significant increases in heart rate, elevated systolic blood pressure, as well as dilated pupil size (Rafaelsen et al., 1973; Perez-Reyes, 1988; Berghaus et al., 1995; Liguori et al., 1998; Weinstein et al., 2008; Khiabani et al., 2008; Bramness et al., 2010; Ronen et al., 2010; Hartman et al., 2016).

In terms of the effects of THC on the driving task, research has demonstrated recent THC use approximately doubled one's risk of traffic crash, this is especially true for fatal crashes (Asbridge et al., 2005; Asbridge et al., 2012; Hartman & Huestis, 2013; Li et al., 2013; Otto et al., 2016). Studies have demonstrated THC use impairs:

- road tracking ability (Barnett et al.,1985; Robbe, 1994; Sexton et al.,2002; Ménétrey et al.,2005; Bosker et al.,2012; Battistella et al.,2013; Adrian, 2015);
- brake latency (Liguori et al.,1998); reaction times (O'Kane et al.,2002; Ramaekers et al., 2006; Grotenhermen et al., 2007; Lenné et al.2010; Ronen et al.2010; Adrian, 2015; Hartman et al.2016);
- a driver's ability to gauge time and distance (Bech et al.,1973; O'Kane et al.,2002);
- recognition of the lights and delayed response times to their appearance (Moskowitz et al.,1976; O'Kane et al.,2002);
- divided attention tasks (Barnett et al.,1985; Battistella et al.,2013; Hanson, 2013; Adrian, 2015);
- ability to complete passes and take more time to make the decision to pass (Dott, 1972; Smiley et al.,1985; O'Kane et al.,2002);
- inhibitory control (Romano & Voas, 2011; Battistella et al.,2013; Hanson, 2013);
- SDLP (Smiley et al.,1985; O'Kane et al.,2002; Hartman & Huestis, 2013; Hartman, 2015);

- and ability to maintain headway and decrease in mean speed (Attwood et al., 1980; Smiley et al., 1985; O’Kane et al., 2002; Ramaekers et al., 2006; Grotenhermen et al., 2007; Ronen et al., 2008; Anderson et al., 2010; Lenné et al.2010; Ronen et al.2010; Romano & Voas, 2011; Hartman et al.2016).

In addition, when taken together, alcohol and THC may produce dramatically greater impairment on the driving task than either substance on its own (Sutton, 1983; Biasotti et al.,1986; Peck et al.,1986; Longo et al.,2000; Ramaekers et al.,2000; Robbe & O’Hanlon, 2000; O’Kane et al.,2002; Sexton et al.,2002; Laberge & Ward, 2004; Ramaekers et al.,2004; Schwilke et al.,2006; Sewell et al.,2009; Bramness et al.,2010; Hanson, 2013; Caulkins, 2014). Research has demonstrated combining THC with alcohol produces an additive effect rather than a synergistic effect on the body and ultimately the driving task (Biasotti et al., 1986; Peck et al., 1986; Perez-Reyes et al., 1988; Ramaekers et al., 2004; Lenné et al., 2010; Ronen et al., 2010; Hartman, 2015; Hartman et al., 2015). Further, additional studies have shown that low levels of both alcohol and THC, which would not significantly impair an individual when taken alone can have a significant impairing effect on the driving task when taken together (Sutton, 1983).

Policy Review

Since 1996, each election cycle has brought about changing laws, policies and social norms surrounding marijuana use. There are many ways a state may change its prohibition status of marijuana. A state can choose to legalize marijuana for medicinal purposes, which includes providing patients protections from criminal charges for possessing marijuana for medicinal purposes (Marijuana Policy Project (MPP) 2017). Under this model, patients have some way to either cultivate their own marijuana or purchase marijuana for medicinal use (MPP 2017). Another model for a state looking to relax its prohibition stance on marijuana is to choose to decriminalize its possession and use. Under decriminalization, possession of marijuana is still prohibited, however, the penalties are reduced to a misdemeanor offense, civil fine for adults, and drug education and community service for minors (MPP 2017). Finally, states may choose to legalize marijuana for recreational use by adults age 21 or older. In this model, adults age 21 or older have some mechanism in which they may either grow their own marijuana or purchase marijuana in a retail location for personal consumption.

In November 2016, California, Maine, Massachusetts, and Nevada approved ballot initiatives to legalize the recreational use of marijuana among adults (MPP 2017). Bringing the total to eight states and Washington D.C. which have passed laws allowing recreational and medicinal use of marijuana (NORML 2017). The eight states with legalized medicinal and recreational marijuana are:

- Alaska
- California
- Colorado
- Maine
- Massachusetts
- Nevada
- Oregon
- Washington

An additional four states have decriminalized marijuana possession (NORML 2017). Further, an additional four states have approved ballot initiatives in November 2016 to legalize the medicinal use of marijuana bringing the total to twenty states that allow medicinal use of marijuana (NORML 2017). Appendix B lists each state and its related marijuana possession and use laws.

Medicinal Use of Marijuana Laws

Alaska

Alaska's medicinal marijuana program was established on March 4, 1999, and is outlined in the Alaska Statutes. Specifically medicinal marijuana is covered by § 17.37, which refers to the Medical Uses of Marijuana.

Qualifying for the Program

To qualify for a registry identification card, a patient must have a qualifying condition and a statement from an Alaska-licensed physician who has personally examined the patient stating that "the physician has considered other approved treatments that might provide relief and that the physician has concluded that the patient might benefit from the medical use of marijuana (Alaska Stat. § 17.37.010 et seq)." A minor patient only qualifies with the consent of their parent or guardian. In addition, the adult is required to control the dosage, acquisition, and frequency of use of the marijuana. Qualifying conditions include:

- cancer,
- HIV/AIDS,
- glaucoma,
- and conditions causing one or more of the following:
 - cachexia,
 - severe pain,
 - severe nausea,
 - seizures,
- or persistent muscle spasms, including those that are characteristic of multiple sclerosis.

However, the health department can consider and approve additional medical conditions if they are submitted as a petition under Alaska Statutes 17.37.060.

Patient Protections, Access, and Possession Limits

A patient with a registry identification card to possess one ounce of processed marijuana and cultivate up to six plants, however, only three plants can be mature. Further, Alaskan law only provides an affirmative defense, not protection from arrest.

Each patient may have one primary caregiver and one alternate caregiver. Caregivers must be 21 years of age or older and can only serve one patient, unless the caregiver is a relative of more than one patient. To qualify as a caregiver, the individual cannot be on parole or probation and cannot have been convicted of a felony possession of a controlled substance or imitation controlled substance in Alaska or other jurisdiction.

California

California's medicinal marijuana program began on November 6, 1996, and is regulated by the California Health and Safety Code (§11362.5 and 11362.7).

Qualifying for the Program

California's law is one of only two that allows doctors to recommend medical marijuana for any condition. Medical marijuana can be recommended for:

- cancer,
- anorexia,
- AIDS,
- chronic pain,
- spasticity,
- glaucoma,
- arthritis,
- migraine,
- or any other chronic medical condition that limits a person's ability to conduct one or more major life activity as defined in the Americans with Disabilities Act of 1990.

Patients may get a registry identification card from their county health department, but cards are not mandatory to purchase marijuana for medicinal purposes and the vast majority of patients rely on a written recommendation from a physician.

Patient Protections

A patient is protected from criminal prosecution if he or she has a physician's recommendation for medical marijuana. However, the California Supreme Court ruled in *Ross v. Ragingwire* that the law does not provide protection from being fired for testing positive for marijuana metabolites, even if the patient is never impaired at work.

To qualify as a primary caregiver in California, one must be designated by a patient and must have "consistently assumed responsibility for the housing, health, or safety of [the] patient (California Health and Safety Code §11362.5 and 11362.7)." Further, California law allows primary caregivers to cultivate marijuana for any number of patients.

Possession Limits and Access

California law allows a patient with a physician's recommendation to possess at least eight ounces of processed marijuana and cultivate six mature plants or 12 immature plants. The patient may also possess or grow larger amounts if the county allows a greater amount. Patients may also assert a defense in court for larger amounts that are for personal medical purposes.

Senate Bill 420 provides that patients and caregivers “who associate within the State of California in order collectively or cooperatively to cultivate marijuana for medical purposes, shall not solely on the basis of that fact be subject to state criminal sanctions.” This piece of legislation also specifies that it does not “authorize any individual or group to cultivate or distribute marijuana for profit.” However, based on this collective language, dispensaries are operating in many parts of California. While then-Attorney General Jerry Brown issued guidelines on medical marijuana, state law provided no regulation or registration of collectives and cooperatives, although several localities moved to regulate them, while others have enacted bans.

In 2015, the California legislature approved the California Medical Marijuana Regulation and Safety Act, a comprehensive law that created a regulatory and licensing system for medical marijuana businesses. Seventeen different types of annual businesses licenses are available, including indoor and outdoor cultivators of different sizes, plant nurseries, processors, testing labs, dispensaries, and distributors. Rulemaking was projected to be completed by January 1, 2017, and licensing is expected to begin by January 2018.

[Colorado](#)

In June 2010, Colorado voters approved Amendment 20, a constitutional amendment which legalized marijuana for medicinal purposes. Amendment 20 became Article XVIII, Section 14 of the State of Colorado’s Constitution. Subsequent authoritative statutes that were created and adopted are Colo. Rev. Stat. § 12-43.3-101, 18-18-406.3, and 25-1.5-106 et seq. In addition, Department of Health Rules on medical marijuana are available at 5 CCR 1006-2.

[Qualifying for the Program](#)

To qualify for a marijuana registry identification card, a patient must reside in Colorado, submit a fee and written documentation from a physician in good standing in Colorado certifying that the patient “might benefit from the medical use of marijuana” in connection with a specified qualifying medical condition. The physician must have a treatment or consulting relationship with the patient and must have done a physical exam and be available for follow up care.

Qualifying conditions for medicinal marijuana include:

- cancer,
- HIV/AIDS,
- glaucoma,
- and conditions causing one or more of the following:
 - severe pain,
 - cachexia,
 - severe nausea,
 - seizures,

- or persistent muscle spasms.

The Colorado Department of Public Health and Environment (CDPHE) administers the identification card program and may approve additional qualifying conditions. A minor patient only qualifies for medicinal marijuana treatment by having two physician authorizations, parental consent, and adult control for dosage level and frequency of use.

Patient Protections

Colorado's medicinal marijuana law created an exception from the state's criminal laws for any patient or caregiver in possession of an identification card and a permissible amount of marijuana. CDPHE is required to issue an identification card to a qualified applicant within 35 days of receiving an application. However, if CDPHE fails to issue a card within 35 days after the submission of the application, the patient's application and proof of mailing serves as an identification card. A patient and his or her caregiver may raise an affirmative defense for more than the specified amount only if the patient's physician specified that that patient needs a specific greater amount. This defense may be raised whether or not a patient has a registry identification card.

Possession Limits and Access

Under Colorado law, each patient can possess up to two ounces of marijuana and can cultivate up to six plants, three of which may be mature. To access and dispense, a caregiver must have "significant responsibility for managing the well-being of a patient." Patients can designate a single caregiver or a medical marijuana dispensary to cultivate for them. A caregiver can assist no more than five patients, unless CDPHE determines exceptional circumstances exist. Caregivers must have a waiver from CDPHE to be allowed to pick up marijuana for homebound patients. Dispensaries generally can possess no more than six plants and two ounces per patient who designates it.

The licensing authority, the Marijuana Enforcement Division (MED), which is part of the Department of Revenue, set licensing fees and developed additional regulations for medicinal marijuana dispensaries. The MED also has the authority to impose penalties, including suspending and revoking licenses. Medical marijuana is subject to sales tax, except for individual patients who the department finds are indigent.

Maine

Medicinal marijuana was established in Maine on December 22, 1999. Maine's medicinal marijuana program is governed by Me. Rev. Stat. Ann. Tit 22 § 2421. In addition, rules for the program are available at 10-144 C.M.R, Chapter 122.

Qualifying for the Program

Registry identification cards are voluntary for patients and for caregivers who are members of their patients' families or households. However, registry identification cards are mandatory for other unrelated caregivers. To qualify for a registry identification card, a patient must have a qualifying condition and a statement from a physician with which the patient has a bona fide relationship. The statement must be on tamper-resistant paper, is valid for no more than a year, and must state that the patient is "likely to receive therapeutic or palliative benefit" from the medical use of marijuana. Qualifying conditions include:

- cancer,
- HIV/AIDS,
- hepatitis C,
- amyotrophic lateral sclerosis,
- nail patella,
- glaucoma,
- agitation related to Alzheimer's disease,
- post-traumatic stress disorder (PTSD),
- inflammatory bowel disease,
- dyskinesic and spastic movement,
- and conditions causing one or more of the following:
 - intractable pain,
 - cachexia or wasting,
 - severe nausea,
 - seizures,
 - or severe and persistent muscle spasms.

A health department-created advisory panel can approve additional medical conditions and make recommendations about what an adequate supply of marijuana would be. The department of health also administers the registry identification card program. Minor patients only qualify for marijuana treatment with the consent of their parent or guardian, and the adult must control the dosage, acquisition, and frequency of use.

Caregivers must be 21 or older and cannot have a disqualifying drug conviction, such as felony-level possession of a controlled substance. They can also be hospice providers or nursing facilities, but those entities cannot grow for patients. They may have a single employee.

Patient Protections

Maine law provides that those abiding by the act may not "be denied any right or privilege or be subjected to arrest, prosecution, penalty or disciplinary action" for those medical marijuana-related actions. The law also prevents landlords and schools from discriminating based on a

person's status as a caregiver or patient, though it does allow landlords the authority to prevent cultivation. In addition, state law permits landlords and businesses to restrict smoking in their properties. The law provides additional protection for child custody and visitation rights. Maine protects patients from other states that allow medical marijuana if they have a written certification, the required identification, and if Maine's health department adds the other state's law to a list.

Possession Limits and Access

Patient or caregiver with the required documentation or registry identification card may possess 2.5 ounces of processed marijuana per patient. A total of six mature plants may be cultivated for each patient in an enclosed, locked location. The patient can choose to cultivate and/or can designate either a caregiver or a dispensary to cultivate for the patient, as long as the total amount of plants per patient does not exceed six mature plants. Plants in other stages of harvest may also be cultivated. The law has an affirmative defense for patients needing additional amounts of marijuana.

Adult patients may have a single caregiver, and a caregiver can assist no more than five patients. Caregivers can receive reasonable monetary compensation. Collective cultivation by caregivers is expressly forbidden, except that two patients or two caregivers may share an enclosed, locked facility if they live together. Caregivers may donate excess marijuana to patients, other caregivers, or to dispensaries. They may also sell up to two pounds of marijuana to dispensaries each year.

Maine law also provides for state-regulated not-for-profit dispensaries, of which there can be no more than eight in the first year. As of December 2016, eight non-profit dispensaries have been registered. Dispensaries can dispense no more than 2.5 ounces of marijuana to a patient every 15 days. The department may determine the number and location of dispensaries.

Massachusetts

Massachusetts medicinal marijuana program began on January 1, 2013, and is outlined in the Massachusetts General Laws. Specific statutes relating to the medicinal marijuana program can be found Mass. Gen. Laws ch. 94C § 1-2 to 1-17. Further, rules for the program are available at 105 CMR 725.000.

Qualifying for the Program

In order to obtain an identification card for the medicinal marijuana program, a patient must have a qualifying condition and a statement from a physician with whom the patient has a bona fide relationship which is submitted to the Department of Public Health. Qualifying conditions in Massachusetts include:

- cancer,

- glaucoma,
- HIV/AIDS,
- hepatitis C,
- amyotrophic lateral sclerosis,
- Crohn's disease,
- Parkinson's disease,
- multiple sclerosis,
- and other debilitating conditions as determined in writing by a qualifying patient's physician.

Until the Department of Public Health has fully implemented the law, a patient's written certification will serve as their identification card. Personal caregivers must be 21 or older and must also generally be registered with the health department.

Patient Protections

Massachusetts law provides that any person meeting the requirements under the Controlled Substances act shall not be penalized in any manner, or denied any right or privilege, for possession and use of marijuana for medicinal purposes. Further, to qualify for protection from arrest, a patient generally must have a registry identification card issued by the Department of Public Health. Patients, caregivers, and dispensary agents who present their identification cards to law enforcement and possess a permissible amount of marijuana may not be subject to arrest, prosecution, or civil penalty.

Possession Limits and Access

Massachusetts law allows a patient or caregiver to possess a 60-day supply of marijuana. The rules define a presumptive 60-day supply as 10 ounces, but physicians can certify that a greater amount is needed if they document the rationale. A patient with limited access to dispensaries may cultivate if he or she receives a hardship registration allowing the patient or his or her caregiver to cultivate a 60-day supply of medical marijuana. The Department of Public Health issues cultivation registrations to patients whose access to dispensaries is limited by financial hardship, the physical incapacity to access reasonable transportation, or the lack of dispensaries reasonably close to, or that deliver to, the patient.

Nevada

The medicinal marijuana program in Nevada was established on October 1, 2001. The Nevada Constitution Article 4, Section 38 provides regulations for the medical marijuana program in the state. Further, statutory provisions are codified at Nev. Rev. Stat. 453A and program rules can be found in NAC 453A.

Qualifying for the Program

To qualify for a registry identification card in Nevada, a patient must have a qualifying condition and a statement from a Nevada physician. The physician must have responsibility for caring for or treating the patient with marijuana in order to “mitigate the symptoms or effects” of their condition. Qualifying conditions in Nevada include:

- cancer,
- HIV/AIDS,
- glaucoma,
- PTSD,
- and conditions causing one or more of the following:
 - severe pain,
 - cachexia,
 - severe nausea,
 - seizures,
 - or persistent muscle spasms.

The Nevada Division of Public and Behavioral Health (DPBH) can approve additional conditions, and it was instrumental in the addition of PTSD. A minor patient only qualifies with parental consent and if the adult controls the dosage, frequency of use, and acquisition of marijuana.

In addition, Nevada’s revised law contains reciprocity provisions, which recognize patients from other medical marijuana states as long as the other state programs are substantially similar to the requirements of Nevada law. This allows patients in other states to travel to Nevada with their personal marijuana for medicinal use or purchase additional marijuana while in Nevada.

In Nevada, registered patients may designate a single caregiver. In order to be designated a caregiver, the individual must have a significant responsibility for managing a qualifying patient's wellbeing and may serve only one patient.

Patient Protections

Registered patients are exempt from prosecution for the acts allowed under Nevada law. Patients may also not be disciplined by a professional licensing board and employers must “attempt to make reasonable accommodations for the medical needs” of employees who are registered patients.

Patients with qualifying conditions may also assert an affirmative defense if they have been advised by a physician that marijuana may mitigate their condition, even if they do not have an identification card. This affirmative defense may also be raised by people assisting patients and for greater amounts of marijuana if the amounts are “medically necessary as determined by the person's attending physician.”

Possession Limits

The state law allows a total of up to 66 licensed and regulated dispensaries, which is monitored by the Nevada Division of Public and Behavioral Health. Patients and their caregivers may collectively obtain and possess two and a half ounces of marijuana. They can obtain and possess that amount each 14-day period.

Patients may cultivate marijuana plants if they do not live within 25 miles of a dispensary, if they cannot travel to one, if the dispensaries near them do not have an adequate supply of marijuana or the dispensary does not have the strain of marijuana that works best for the patient. Patients or caregivers who are allowed to grow their own marijuana plants may cultivate up to 12 plants.

Oregon

The medicinal marijuana program in Oregon was established on December 3, 1998. Oregon Revised Statutes § 475.300 provide for the medical marijuana program. In addition, temporary rules for the dispensary program can be found at OAR 333-008-1000 et seq.

Qualifying for the Program

To qualify for a registry identification card, a patient must have a qualifying condition and a statement from a physician who has primary responsibility for treating the patient that marijuana may mitigate their symptoms. Qualifying conditions in Oregon include:

- cancer,
- HIV/AIDS,
- glaucoma,
- agitation related to Alzheimer's disease,
- and conditions causing one or more of the following:
 - cachexia,
 - severe pain,
 - severe nausea,
 - seizures,
 - or persistent muscle spasms, including those that are characteristic of multiple sclerosis.

The health department can approve additional medical conditions. A minor patient only qualifies with the consent of his or her parent or guardian and if the adult controls the dosage, acquisition, and frequency of use of the marijuana.

Patient Protections

Registered patients and caregivers are exempt from the state's criminal laws for acting in accordance with the medical marijuana law. Patients may also assert an affirmative defense if

they have a qualifying condition and a physician has recommended medical marijuana even with if they do not have a registry identification card.

However, in April 2010, the Oregon Supreme Court ruled in *Emerald Steel v. BOLI* that patients are not protected from being penalized by their employers.

Possession Limits and Access

Patients can have one designated caregiver, who must have “significant responsibility for managing the well-being” of the patient. Patients can reimburse caregivers for the actual cost of supplies and utilities, but not for their labor. Oregon’s law does allow a patient with a registry identification card or a primary caregiver to possess 24 ounces of processed marijuana and cultivate six mature plants and 18 immature plants for each patient. However, each grow site must be registered with the health department.

Washington

Marijuana became available for medicinal use in Washington on November 3, 1998.

Washington’s Revised Code § 69.51A.010 et seq provides for the medicinal marijuana program in the state. Additional administrative rules are available in WAC 246-75-010.

Qualifying for the Program

The initial medical marijuana law did not include a state registry. However, in July 2016, the Cannabis Patient Protection Act was fully implemented, allowing patients to register. Those who participate in the voluntary registration system receive additional protections and privileges, including increased possession limits and protection from arrest or charges, as opposed to the affirmative defense that is available for non-registered patients.

For those who are not in the registry, a patient must have a signed statement on tamper-resistant paper from a Washington-licensed physician, physician assistant, naturopath, or advanced registered nurse practitioner who advised the patient of marijuana’s risks and benefits and advised the patient that he or she “may benefit from the medical use of marijuana.” Those who are listed in the registry are issued a recognition card. The possession, acquisition, and cultivation of marijuana by a minor patient is the parent or legal guardian’s responsibility. Qualifying conditions in Washington include:

- cancer,
- HIV,
- multiple sclerosis,
- epilepsy,
- seizure and spasm disorders,
- intractable pain,
- glaucoma,

- Crohn's disease,
- PTSD,
- traumatic brain injury,
- hepatitis C,
- and diseases causing nausea, vomiting, or appetite loss.

Of note, some conditions only qualify if they have been unrelieved by standard medical treatments. The health department's Medical Quality Assurance Commission may also add additional conditions and has done so.

Patient Protections

Washington's medical marijuana law provides protection from arrest for those who hold a state-issued recognition card. Otherwise, state law provides an affirmative defense that patients and caregivers may raise in court.

In June 2011, the state Supreme Court ruled against a person who was fired for being a medical marijuana patient in *Roe v. Teletech Customer Care Management*. Senate Bill 5073 that was passed into law in 2011, provides that an employer does not have to accommodate medical marijuana if it establishes a drug-free workplace and that it also does not require employers to allow the onsite medical use of marijuana. This particular law also states medical marijuana cannot be the "sole disqualifying factor" for an organ transplant unless it could cause rejection or organ failure. Further, Washington's law also restricts when parental rights and residential time can be limited due to the medical use of marijuana.

Possession Limits and Access

Washington's possession limits vary based on whether or not a patient participates in the state's optional registry. For those who do not participate, the law allows a patient with valid documentation and his or her designated provider to collectively possess three ounces of processed marijuana, or six ounces if the marijuana is produced from plants the patient or caregiver grows, and four plants. For those who elect to be registered in the state system, patients may possess six plants and up to eight ounces of usable marijuana.

Patients may also be authorized by their healthcare practitioner to possess up to 15 plants and 16 ounces of usable marijuana. Registrants will also be able to purchase from a medically endorsed retail store licensed by the Washington State Liquor and Cannabis Board. Finally, up to 10 patients may form a collective garden, which may contain no more than 72 ounces and 45 plants.

Caregivers may work with and on behalf of medical marijuana patients, but a person may only serve as a designated provider to one patient at a time and must wait 15 days between serving

two different patients. Providers must be 18 or older and must be designated by a patient in writing.

Washington D.C.

Washington D.C.'s medicinal marijuana program was established on July 27, 2010. The District of Columbia Official Code § 7-1671.13 et seq. provides the legal framework for the medicinal marijuana program in Washington D.C.

Qualifying for the Program

To qualify for an identification card, a patient must have a qualifying condition and physician's recommendation that medical marijuana is necessary for the patient's treatment. The physician must be licensed in Washington D.C., have a bona fide relationship with the patient, and have responsibility for ongoing treatment of the patient. Further, the physician must review other approved treatments before making the recommendations. The board of medicine may audit physician recommendations and must audit recommendations for any physician who provides more than 250 recommendations in a 12-month period.

Currently, a physician can certify a patient for medical marijuana for any condition they think will benefit from its use. Qualifying conditions in D.C. include:

- cancer,
- HIV/AIDS,
- glaucoma,
- severe and persistent muscle spasms,
- Amyotrophic Lateral Sclerosis (ALS),
- decompensated cirrhosis,
- cachexia (for adults),
- Alzheimer's,
- seizure disorders,
- and conditions treated with chemotherapy, AZT, protease inhibitors, or radiotherapy.

Terminally ill hospice patients also qualify for an identification card. The health department administers the identification card program and can approve additional qualifying conditions, which it has done. Minor patients only qualify with parental consent and as long as the adult controls the dosage, frequency of use, and acquisition of marijuana.

Patient Protections

Registered qualifying patients may possess and administer medical marijuana, and caregivers can do so for the purpose of assisting a patient. Marijuana and paraphernalia must be obtained from a registered dispensary. Medical marijuana can only be administered in a patient's residence or a medical facility that permits its administration.

The ordinance also provides an affirmative defense for an adult who assists a patient in administering medical marijuana in their home or a permitted medical facility where the caregiver was not reasonably available to assist.

Possession Limits and Access

A patient or caregiver can possess no more than two ounces of marijuana in a 30-day period and that marijuana must be obtained from a dispensary. However, the mayor may increase the amount to up to four ounces. The law does provide for regulated cultivation facilities and dispensaries. The facilities and their staff are required to register with the mayor. Cultivation facilities are allowed to produce up to 500 marijuana plants (which was initially 95) and to sell them to dispensaries. The act allows for between five and eight dispensaries. The mayor set the number of dispensaries at five and cultivation centers at 10. No employee with access to marijuana at a cultivation facility or dispensary can have a misdemeanor for a drug-related offense or any felony conviction.

Recreational Use of Marijuana Laws

Alaska

In 2014, Alaskans voted to legalize recreational use of marijuana through voter initiative. This measure became known as Ballot Measure 2. The initiative became law on February 24, 2015. Section 11.71.060 et seq. of the Alaska Statutes covers the legalization of marijuana. Of interesting note, Alaskans have been able to possess and cultivate small quantities of marijuana since 1975. However, Ballot Measure 2 extended the protections and freedoms already afforded to Alaskans under the law.

Personal Possession, Cultivation and Purchase Limits

Per statute, any one age 21 and older may purchase and possess up to one ounce of marijuana in public for personal consumption. In addition, each person age 21 and older may grow up to six plants, with three of those plants being mature. Each adult may possess all of the marijuana produced by personal cultivation in the same location where cultivation occurred.

Licensing and Regulation

Post-legalization, the Alcoholic Beverage Control Board was responsible for regulating the marijuana industry. However, in 2015, the legislature established the Marijuana Control Board. Alaska law allows for the establishment and licensure of:

- marijuana cultivation facilities,
- product manufacturing facilities
- and retail stores.

There are no statewide limits or restrictions on the number of licenses issued by business type, however, localities may restrict or ban them entirely. Further, municipal governments may

enact ordinances that establish the time, place, manner, and number of marijuana businesses that can operate within its jurisdiction. Per Alaska law, applicants for licensure must meet minimum requirements as established and adopted by the Marijuana Control Board. Alaska began formally accepting applications for business licenses on February 24, 2016, and the first retail locations opened for business in October 2016.

To track the production and growth of marijuana in Alaska, the state has adopted a seed-to-sale tracking system, similar to those implemented in Colorado and Washington. All marijuana sold in Alaska must be labeled with potency and warning information and representative samples of each harvest must be tested for potency and potential contamination.

Taxation

Currently, marijuana purchased for recreational consumption is charged an excise tax of \$50 per ounce at wholesale, meaning that those who grow the marijuana plant pay the tax at the time the plant is transferred to the retail location. There is not currently a retail tax on marijuana in Alaska.

In Alaska, money received from marijuana tax is used to fund substance abuse treatment programs. In addition, the money received from marijuana taxes is used to fund a recidivism reduction fund designed to reduce the number of repeat criminal offenders in the state.

California

In November 2016, California voters passed the Adult Use of Marijuana Act (AUMA) also known as Proposition 64, which legalized the recreational use of marijuana in the state. This initiative formally became law on November 9, 2016, however, sales of marijuana for recreational use are not set to begin until January 1, 2018. The law stipulating the conditions of recreational use of marijuana in the state can be found in California's Health & Safety §11000, et seq.

Personal Possession, Cultivation and Purchase Limits

Under the new AUMA, adults age 21 and over may possess up to one ounce, eight grams of tetrahydrocannabinol (THC) concentrate, as well as any marijuana grown from one's own adult marijuana plants (which may exceed the one ounce threshold). Adults may possess marijuana both in public as well as at establishments licensed for marijuana consumption on premise. In addition, adults over age 21 may grow up to six plants per person. However, a maximum of six plants are allowed in one household.

Licensing and Regulation

Regulation of the marijuana industry in California is the responsibility of the Bureau of Marijuana Control, which is located within the Department of Consumer Affairs. The Bureau of Marijuana Control currently regulates California's medicinal marijuana program and will be

authorize to regulate the retail sales of marijuana in the state. California's new legislation allows for the licensure of:

- marijuana cultivation,
- retail stores,
- marijuana distributors,
- marijuana testing,
- and microbusinesses.

There are no statewide limits on the number of licenses issued by business type, however, communities may restrict or ban marijuana-related businesses entirely in their jurisdiction. Under the AUMA, municipalities will have the ability to limit marijuana-related businesses until 2019. After 2019, all municipal ordinances must be determined by referendum vote. Currently, no marijuana-related businesses are licensed in the state of California, however, the AUMA stipulates the first licenses must be issued by January 1, 2018. While no businesses are licensed for the retail sale of marijuana, licensing priority will be given to applicants who can demonstrate their compliance with the Compassionate Use Act, which has provided the foundation for California's medical marijuana program.

Currently, California is undergoing the rulemaking process and has yet to determine what the tracking, testing and labeling of marijuana for retail sale will look like in the state.

Taxation

California has established a cultivation tax of \$9.25 per ounce for marijuana flowers and a \$2.75 per ounce for marijuana leaves. In addition, all marijuana purchased in retail establishments will be subject to a 15% sales tax.

While California will not begin collecting taxes until January 1, 2018, Proposition 64 outlined exactly how the taxes collected shall be allocated. Under California law, tax revenue from the sale of marijuana shall be spent:

- 4% of tax revenue will be spent regulating the marijuana industry,
- \$2 million dollars per year will fund research into the medicinal properties of marijuana,
- \$10 million dollars per year will fund research on the impacts of Proposition 64 on public health and safety as well as the economic impacts of marijuana legalization,
- \$3 million dollars per year will fund the Department of California Highway Patrol to develop protocols to detect marijuana impaired driving,
- \$10 million dollars, increasing each year by \$10 million dollars until settling at \$50 million dollars will fund local social and medical health programs such as job placement, mental health treatment, and substance abuse treatment,
- and the remaining tax revenue will be sent to California's General Tax Fund.

Colorado

In 2012, Colorado voters voted in favor of Amendment 64, a constitutional amendment legalizing the recreational possession and use of marijuana. The law stipulating the conditions of recreational use of marijuana in the state of Colorado can be found in Article XVIII, Section 16 of the Colorado State Constitution. This law formally took effect on January 1, 2014.

Personal Possession, Cultivation and Purchase Limits

Presently, anyone age 21 or older may publically possess up to one ounce of usable marijuana plus any marijuana grown from one's own marijuana plants. Anything over the one ounce threshold must be possessed at home. Adults over age 21 are also able to purchase one ounce of marijuana per transaction in a retail establishment and may also grow up to six plants, of which any three may be mature.

Licensing and Regulation

Regulation of both the medicinal and recreational marijuana industries falls under the jurisdiction of the Marijuana Enforcement Division (MED), which is housed within the Department of Revenue. Colorado's law allows for the licensure of:

- cultivation facilities,
- product manufacturers,
- testing labs,
- and retail stores.

Colorado as a state does not place any limits on the number of licenses granted to marijuana-related businesses, however, communities may restrict their numbers or ban them entirely from their jurisdiction. Cities and counties are allowed to enact ordinances that restrict the time, place and manner of business of marijuana-related sales.

Upon legalization of marijuana for recreational use, businesses that held a license for medicinal marijuana could begin applying for a license to sell recreational marijuana on October 1, 2013. Medicinal retailers were able to apply for a license as a part of the recreational marijuana program on July 1, 2014 and the first retailers opened for business on January 1, 2014.

Presently, Colorado utilizes a seed-to-sale tracking system to prevent the disappearance of products grown and cultivated for retail sale in the recreational market. As a part of this process, businesses are required to utilize specific security systems with video surveillance. In addition, businesses are required to comply with specific alarm and lock standards for their facilities. From a chemical standpoint, marijuana and marijuana products are required to be tested for potency and labeled with the results and all marijuana purchased in a retail establishment must have warning labels affixed as well.

Taxation

In addition to being subject to all current state and local sales and use taxes, marijuana is also subject to a 15% excise tax, which is paid by the cultivator at the time of transfer to the retailer and an additional 10% special sales tax at the time of purchase by the consumer.

Under Colorado law, tax revenue collected from the sale of marijuana is deposited into one of two funds, the Building Excellent Schools Today (BEST) Fund and the Marijuana Tax Cash Fund (MCTF). The portion deposited in the BEST fund is constitutionally mandated, while the guidance on the MCTF is set in state law.

Per the Colorado constitution, the first \$40 million dollars collected from marijuana excise tax revenue is deposited in the BEST fund. Any funds that exceed \$40 million dollars are deposited in the Public School Fund. The BEST fund is used to construct new or remodel existing schools in Colorado.

State sales tax revenue and 85% of the special sales tax revenue are deposited into the MCTF. Funds in the MCTF are required to be spent the year after collected, and should be used for health care, health education, substance abuse prevention and treatment, as well as law enforcement. Law enforcement primarily uses these dollars to fund training activities to aid in the detection of drug impaired drivers. In addition, some funds from the MCTF are allocated to the Colorado Department of Transportation for the marijuana impaired driving media campaign.

Maine

In November 2016, Maine voters approved Question 1, the Marijuana Legalization Act, which allowed for the recreational use of and retail sale of marijuana in the state. This initiative officially became law on January 1, 2017. However, the state has yet to establish the model for retail sales. The law relating to marijuana use and possession in the state can be found in the Maine Code Revised Title 17 – A, Chapter 45: Drugs.

Personal Possession, Cultivation and Purchase Limits

Adults age 21 and older may possess up to 2.5 ounces and any marijuana grown from one's own marijuana plants. In addition, adults age 21 and older may possess six flowering plants, twelve immature plants, and an unlimited number of seedlings.

Licensing and Regulation

Regulation of the marijuana industry will fall under the jurisdiction of the Department of Agriculture, Conservation and Forestry. The marijuana industry must comply with state laws as well as be approved by the municipality in which they are located. Maine's law allows for the licensure of:

- retail marijuana stores,
- retail marijuana cultivation facilities,
- retail marijuana products manufacturing facilities,
- retail marijuana testing facilities,
- and social clubs.

Maine law requires that those who cultivate marijuana will be limited to a maximum size plant canopy not exceeding 800,000 square feet. Maine is not currently accepting applications for licensure, however, the state anticipates that it will begin accepting applications in December 2017 or early 2018. Applicants who currently participate in the medical marijuana licensing system will be given priority in licensing for retail sales.

Currently the state is undergoing the rulemaking process, and has yet to determine what the tracking, testing and labeling of marijuana for retail sale will look like.

Taxation

Retail marijuana sales will be subject to a 10% sales tax in the state of Maine at the time of purchase. However, Maine lawmakers are currently in talks to add an additional 10% excise tax, which would be paid by the cultivator at the time of transfer of the marijuana to the retailer.

Maine law states that tax revenue collected will be deposited into a Substance Abuse Education, Prevention and Treatment fund. The fund will provide funds for substance abuse education and treatment programs, regulatory oversight of the retail marijuana industry as well as increased costs borne by law enforcement and the courts associated with marijuana legalization. However, how these funds will be allocated has yet to be determined by the legislature.

Massachusetts

Massachusetts voters approved Question 4, which legalized the recreational use of marijuana in November 2016. The law took effect on December 15, 2016. The law relating to marijuana use and possession in the state can be found in the Massachusetts General Laws, Chapter 94C, Section 31.

Personal Possession, Cultivation and Purchase Limits

Per Massachusetts law, any person age 21 and over may possess in public one ounce of marijuana or five grams of THC concentrate, in addition to any marijuana grown from one's own adult plants. Adults age 21 or older may possess up to 10 ounces in their residence and may grow up to six plants per person. However, there may be no more than 12 plants on the premises.

Licensing and Regulation

Regulation of the medical and recreational marijuana industry is under the jurisdiction of the Cannabis Control Commission.

Current law limits the number of licenses related to marijuana retail cultivation and sales and there may be no more than 75 retailers, 75 product manufacturers, and 75 cultivators in the state. Until January 1, 2018, licenses shall be issued first to applicants with the most experience operating medical marijuana businesses. After January 1, 2018, applications for licensure will be accepted if there are less than 75 licenses issued. Licenses will be issued by lottery among qualified applicants. If there fewer than 75 recreational marijuana licenses issued, applications for licensure will be accepted beginning in October 2018. In addition to guidelines established by the state, cities and towns may impose additional limits on where and when marijuana related businesses are allowed to operate.

Currently, Massachusetts is undergoing the rulemaking process, and has yet to determine what the tracking, testing and labeling of marijuana for retail sale will look like in the state.

Taxation

Retail purchases of marijuana in the state of Massachusetts are subject to a 6.25% local sales tax, 3.75% state sales tax and up to 2% optional local sales tax. At this time, it is unclear if tax revenues from retail marijuana sales have been earmarked for specific spending, such as traffic safety or education.

Nevada

In November 2016, Nevada voters approved Question 2, which legalized the recreational possession and use of marijuana in the state. This law became effective on January 1, 2017, and the first retail sales took place on that date. However, the state will continue to develop and establish the regulations that govern the recreational marijuana market until January 1, 2018. The law relating to recreational use and possession of marijuana can be found in the Nevada Revised Statutes, Chapter 453D, Regulation and Taxation of Marijuana.

Personal Possession, Cultivation and Purchase Limits

Presently, adults age 21 and older may possess one ounce of marijuana or five grams of THC concentrate and any marijuana grown from their own adult marijuana plants. In addition, if adults over age 21 reside more than 25 miles from a retail store, Nevada law permits home cultivation of up to six plants per person, with no more than a total of 12 plants on the premises.

Licensing and Regulation

Regulation of the marijuana industry rests under the jurisdiction of the Department of Taxation. Nevada law allows for the licensure of:

- cultivation facilities,
- testing facilities,
- manufacturing facilities,
- marijuana distributors,
- and retail marijuana stores.

Nevada law stipulates a maximum number of retail store licenses within the state and there may be no more than:

- 80 licenses in a county with a population greater than 700,000,
- 20 licenses in a county with a population less than 700,000 but more than 100,000,
- 4 licenses in a county with a population less than 100,000 but more than 55,000,
- 2 licenses in a county with a population less than 55,000.

For the 18 months following legalization, businesses with a current medical marijuana license received priority status for obtaining a recreational marijuana license. In addition to retail limits placed on the recreational marijuana industry, local governments have the ability to adopt and enforce local marijuana control policies related to zoning and land use for marijuana sales related businesses.

Currently, Nevada is undergoing the rulemaking process, and has yet to determine what the tracking, testing and labeling of marijuana for retail sale will look like in the state.

Taxation

Marijuana purchased in the state of Nevada is subject to a 15% excise tax at the wholesale level, and a 10% sales tax at the retail or customer level. Tax revenue derived from the excise tax on marijuana goes to the public education budget, while revenue derived from the sales tax goes to Nevada's rainy day fund.

Oregon

Oregon voters passed Measure 91 in November 2014, legalizing the possession and use of marijuana for recreational purposes. Legalization became effective on July 1, 2015. The law relating to recreational use and possession of marijuana can be found in the Oregon Revised Statutes, Chapter 475B, Cannabis Regulation.

Personal Possession, Cultivation and Purchase Limits

Presently, adults age 21 and older may possess up to one ounce of marijuana in public. In addition, adults age 21 and older may possess 16 ounces of marijuana-infused solids, such as edibles, and 72 ounces of marijuana-infused liquids, such as tinctures and beverages. Further, adults age 21 and older may possess up to 8 ounces of marijuana if the marijuana is grown in their own home. The law also allows adults age 21 and older to grow up to 4 marijuana plants.

Licensing and Regulation

The Oregon Liquor Control Commission regulates the marijuana industry for the state. Under Oregon law there are provisions for licensure of the following:

- marijuana producers (growers),
- marijuana processors (extract and product manufacturers),
- wholesalers,
- and retailers.

Current law does not limit the number of licenses that may be issued for any one of the marijuana-related business licenses. However, the Oregon Liquor Control Commission may refuse to grant a license if the location of the proposed business is not demanded by public interest or need. In addition, municipalities may enact additional time, place and manner zoning ordinances. Under certain circumstances, municipalities may ban marijuana-related retail establishments. However, the state allows all applicants who meet state standards to be licensed to operate in communities that permit marijuana-related businesses.

Despite recreational use of marijuana becoming legal on July 1, 2015, the Oregon Liquor Control Commission did not begin accepting applications for retail marijuana-related business licenses until January 4, 2016. The first marijuana-related retail establishments opened in October 2016. During this 10 month interim, dispensaries licensed for medicinal marijuana were allowed to sell marijuana to adults age 21 and older for recreational use.

In order to track marijuana grown in the state for retail sale and recreational consumption, Oregon implemented a seed-to-sale tracing system. This required licensees to utilize security measures such as video surveillance, alarm systems and on-site safes. In order to protect consumers, the state required marijuana and marijuana-products to be tested for microbiological contaminants, pesticides, other contaminants, solvents, as well as THC and cannabidiol (CBD) concentration levels. Further, all marijuana products sold for recreational use must include health and safety warning information, activation time, testing results, potency, serving size, number of servings per package, and content of the marijuana item.

Taxation

All retail marijuana and marijuana products are subject to a 17% sales tax collected at the point of sale. In addition, local governments may impose an additional local sales tax of up to 3%.

In Oregon, marijuana tax revenue is used to fund the following:

- 40% is allocated to the Common School Fund,
- 20% is allocated to Mental Health, Alcoholism, and Drug Services
- 15% is allocated to State Police,

- 10% is distributed to cities for local law enforcement,
- 10% is distributed to counties for local law enforcement,
- 5% is allocated to the Oregon Health Authority for substance abuse prevention and education services,
- and administering the marijuana tax program.

Washington

In November 2012, Washington voters approved Initiative 502, which permitted the recreational use and possession of marijuana in the state. The law took effect on December 6, 2012, however, the first sales of marijuana for recreational use did not take place until July 2014. The law relating to the recreational use and possession of marijuana in Washington can be found in the Washington Revised Code § 69.50.101, et seq.

Personal Possession, Cultivation and Purchase Limits

Presently, adults age 21 and over may possess up to one ounce of marijuana, 16 ounces of marijuana-infused solids, such as edibles, and 72 ounces of marijuana-infused liquids, such as tinctures and beverages. Washington law does not allow for home cultivation or the growth of one's own marijuana plants.

Licensing and Regulation

Currently the regulation of retail sales of marijuana for recreational use rests under the control of the Washington State Liquor and Cannabis Control Board. Washington State law provides for the licensure of the following:

- marijuana producers,
- marijuana processors,
- and marijuana retailers.

The state sets a limit for the number of licensed marijuana retailers. In 2016, the original limit was set at 556. As of January 2017, there were 414 current or pending licenses for marijuana retailers. Per Washington law, municipalities' provide local licensure advice to the Washington State Liquor and Cannabis Control Board, which is given "substantial weight" by the state in licensing decisions. In addition, the state Supreme Court ruled that municipalities may ban marijuana businesses from doing sales within their jurisdictions.

Washington State has implemented a seed-to-sale tracking system that all licensed marijuana businesses must use. Licensed marijuana businesses are required to utilize specific security systems which include perimeter alarms and video systems. In order to protect consumers, analytic tests must be performed on all marijuana grown and marijuana products sold in state. This includes testing for all usable marijuana for moisture content, THC potency, foreign matter and microbes.

Taxation

In Washington State, all marijuana sold for recreational purposes is subject to a 37% excise tax. Usable marijuana, marijuana concentrates, and marijuana-infused products are all subject to this tax. Taxes are collected by retailers at the point of sale.

Tax revenue from the retail sale of marijuana is distributed based on the plans set forth in Initiative 502. Per Washington State law, approximately 60% of marijuana tax revenue funds public health programs, such as Medicaid, substance abuse prevention and community health centers. Marijuana tax revenue funds are allocated to the Liquor and Cannabis Board to regulate the marijuana market. In addition, marijuana tax revenue funds are shared with local governments that allow marijuana sales within their jurisdictions. The remaining tax revenue is deposited into the state's general fund.

Washington D.C.

In November 2014, voters in Washington D.C. passed Initiative 71, which allowed the legalization of recreational use, possession and the cultivation of marijuana. This law became effective on February 26, 2015. The law relating to the possession and cultivation of marijuana for recreational use can be found in the Washington D.C. Code § 48-904.01.

Personal Possession, Cultivation and Purchase Limits

Washington D.C.'s law allows for the possession of up to two ounces of marijuana by adults age 21 and older. Adults age 21 and older may also grow up to 6 marijuana plants, with no more than 3 of those plants being mature, within a person's residence. The legalization of marijuana in Washington D.C. does not apply to possession or use on federal property, which is excluded from this law.

Of important note, Washington D.C.'s law does not establish the regulatory framework for a commercial retail marijuana industry and market. Presently, no retail sales of marijuana are taking place in Washington D.C. In addition, due to the political climate of Washington D.C., the D.C. City Council has been unable to move forward any laws establishing a retail sales market.

Evidence of Effects of Marijuana Legalization on Impaired Driving

In response to the legalization of marijuana, the percentage of suspected impaired driving cases with requests for cannabinoid screens has seen an increase. In Colorado, the percentage of driving under the influence (DUI) cases with a request for a cannabinoid screens for 2011 - 2013, was 35%, increasing from 28% in 2011 to 37% in 2013 (Urfer et. al., 2014). Over this same time period, the overall positive rate for cannabinoid screens was 62%, ranging from 59 to 68%, with no significant change over the three year time frame (Urfer et. al., 2014). Further, the percentage of positive cannabinoid screens confirmed for a minimum threshold value of 2

ng/mL THC increased from 28% in 2011 to 65% in 2013 (Urfer et. al., 2014) and the mean and median THC concentrations were 8.1 and 6.3 ng/mL, respectively (Urfer et. al., 2014).

Following legalization, the percentage of impaired driving cases in Washington State testing positive for THC increased to 24.9% and 40% 11-nor-9-carboxy-delta-9-tetrahydrocannabinol (THC-COOH), this represents a 5.8% and 12.1 % increase over previous time period (Couper & Peterson, 2014). Additionally, between 2005 and 2014, the proportion of Washington State DUI and DUI-related crash cases tested by toxicology, excluding those positive for alcohol, that involved THC increased significantly, from 20 percent to 30 percent (Banta-Green et. al., 2016). Among these cases, the prevalence of THC continued to grow after passage of Initiative 502 in 2012, but at a significantly slower pace (Banta-Green et. al., 2016). The median blood level of THC increased significantly from 4.0ng/mL in 2005 to 5.6ng/mL in 2014 (p for trend = 0.015) (Banta-Green et. al., 2016).

Among drivers suspected of DUI who were involved in a crash, 11 percent were positive for THC in conjunction with another potentially impairing substance (i.e. alcohol or other drugs) (Banta-Green et. al., 2016). Further, of drivers in whose blood evidence was submitted for toxicology testing following a crash, an additional 4 percent were positive for THC only (Banta-Green et. al., 2016). Laboratory results revealed the majority (53%) of crash involved drivers suspected of DUI were under the influence of alcohol at a level of 0.08 g/dL or higher (Banta-Green et. al., 2016). Of crash-involved drivers positive for alcohol at or above 0.08 g/dL, 7% met or exceeded the per se level of THC, 5ng/mL (Banta-Green et. al., 2016). However, for non-crash-involved drivers arrested for DUI, alcohol at or above 0.08 g/dL, alone, remained the most commonly detected substance (30%) (Banta-Green et. al., 2016). Of drivers suspected of DUI in the absence of a crash, 11% tested positive for THC in conjunction with another potentially impairing substance (Banta-Green et. al., 2016). Further, among drivers arrested for DUI, who tested positive for alcohol at or above 0.08 g/dL, 20% had a THC level of 5ng/mL or above (Banta-Green et. al. 2016). While an additional 26% tested positive for THC only (Banta-Green et. al., 2016).

Post legalization of recreational marijuana, Washington State found a statistically significant increase in daytime THC positive drivers (Ramirez et. al., 2016).

Summary

According to the Marijuana Policy Project, an organization dedicated to lobbying for marijuana policy reforms, an effective medical marijuana program has:

- protections for patients from criminal charges and convictions for the medical use and possession of marijuana;

- patients have in-state access to marijuana, either through private cultivation or licensed dispensaries;
- laws and policies allow for different varieties of marijuana, which vary in THC and CBD content;
- laws and policies allow for various consumption methods of the marijuana (MPP 2017).

In terms of recreational use and possession of marijuana, the Marijuana Policy Project, an effective legalized marijuana policies make it legal for adults who are age 21 or older to:

- use and possess marijuana in their home and in public,
- and allows for the legal retail sale and purchase of marijuana (MPP 2017).

From this analysis it is very clear that no two state's medicinal or recreational marijuana programs are alike. In fact, the complicated nature of each program can make it difficult to decipher exactly what is legal in what circumstance, particularly for the medicinal marijuana programs.

The implications and impacts of marijuana legalization, both medicinal and recreational, on the broader issues, such as arrest rates and traffic safety, are largely unknown. This analysis only briefly examined the impacts of marijuana legalization on traffic safety. Further study of the impacts of marijuana legalization must be done in order to make appropriate policy recommendations.

FARS Crash Analysis

States that have legalized marijuana for medicinal and recreational purposes have seen an increase in fatalities with a driver who is positive for THC (Masten & Guenzburger, 2014; Reed, 2016; Salomonsen-Sautel et al., 2014). In Colorado, since mid-2009 when medical marijuana became commercially available and prevalent, the proportion of drivers in a fatal motor vehicle crashes who were THC-positive has been increasing (Salomonsen-Sautel et al., 2014). Specifically, in Colorado, from 2013 to 2014, fatalities with a driver positive for THC only or THC and another substance(s) increased from 55 to 79 (Reed, 2016). During this same time, the percentage of all fatalities with a THC positive driver increased from 12% to 15% in Colorado (Reed, 2016). As more states legalize medicinal and recreational marijuana use, it is vital to understand the role of marijuana on crash risk.

Methods

Data Retrieval

To conduct the analysis, all fatal crashes from 2008 to 2015 were pulled from the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS). Drug impaired driving crashes from states included in the sample were pulled from the larger data set for further analysis. For purposes of this study, drug impaired includes crashes in which the driver tested positive for one or more of the following: narcotics, depressants, stimulants, hallucinogens, cannabinoids, phencyclidine, anabolic steroids, inhalants, and other drugs.

It is important to note, drug positive indicates that a drug was in the driver's system at the time of the crash based on results of a drug test (such as urine or blood) (Berning et al., 2015). It does not conclusively indicate that a driver was impaired by the drug at the time of the crash. Further, for some drug classes, a positive test result can be returned if the driver tests positive for the active or impairing metabolites of the parent drug or if the driver tests positive for the inactive or non-impairing metabolite. This is particularly true for cannabinoids where a positive drug test result can be returned for the impairing metabolite Δ^9 -tetrahydrocannabinol (THC) or the inactive metabolite 11-COOH-THC (THC-COOH). In addition, it is possible that some drugs can be detected long after any impairment (Compton et al., 2009). For example, cannabinoids (marijuana) can be detected in blood samples weeks after use.

Data Analysis

Descriptive Statistics

Descriptive statistics, such as frequency of drug impaired driving crashes and rate of toxicology testing among fatally injured drivers, were calculated for all fatal crashes in the United States by drug test status for 2008 to 2015.

Crash Analyses

Two crash analyses were conducted for selected states and for the United States as a whole. Selected states were utilized first to identify trends in states that have legalized medicinal and recreational marijuana, but also to compare at a lower-level to states with similar characteristics. Next, a crash analysis for the entire United States was conducted to identify trends across the country. Both crash analysis were based on current marijuana legalization status. Appendix B contains the status of medicinal and recreational legalization of marijuana by state.

Selected States

Legal status of marijuana for selected states was classified utilizing the following four criteria:

- 1) states with legalized use of medicinal and recreational marijuana (e. g. Colorado and Washington),
- 2) states with legalized use of medicinal marijuana (e. g. Delaware, Illinois, and Massachusetts),
- 3) states who neighbor states with legalized medicinal or recreational use of marijuana (e. g. Idaho, Oklahoma, Utah, and Wyoming),
- 4) and states with neither legalized medicinal or recreational use of marijuana nor are these states neighboring states with legalized medicinal or recreational use of marijuana (e. g. Florida, Ohio, Pennsylvania, and Texas).

United States

Using the FARS database and the Highway Statistics of the Federal Highway Administration, the numbers of drivers who tested positive for cannabinoids in fatal crashes and vehicle-miles traveled (VMT) by year (2008 – 2015) and state were collected. In addition, the numbers of licensed drivers by year, state, sex, and age group were collected from the Highway Statistics. Per capita real Gross Domestic product (GDP) by state and year was from the Bureau of Economic Analysis of the U.S. Department of Commerce. Utilizing this information, states were categorized into four groups according to the legalization of the medical/recreational use of cannabinoids and neighboring to the legalized states. The groups included:

- 1) states legalized the recreational use (Alaska, Colorado, the district of Columbia (DC), and Washington),
- 2) states legalized the medical use (Arizona, California, Connecticut, Delaware, Hawaii, Illinois, Maine, Massachusetts, Michigan, Minnesota, Montana, Nevada, New Hampshire, New Jersey, New York, Rhode Island, and Vermont),
- 3) states neighboring to the states legalized the recreational use (Idaho, Kansas, Maryland, Nebraska, New Mexico, Oklahoma, Oregon, Utah, Virginia, and Wyoming),

- 4) and control states neither legalized nor neighboring (Alabama, Arkansas, Florida, Georgia, Indiana, Iowa, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, North Dakota, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, West Virginia, and Wisconsin).

SPF Estimations

Lastly, Safety Performance Function (SPF) estimations for cannabinoids positive driving (CPD) fatal crashes in the United States were developed. The SPF was developed to predict the frequency ($[Y_{i,j}]$) of CPD fatal crashes by state (i) and year (j) using generalized linear models with a negative binomial distribution and a logarithm link function. The functional form of SPF is as follows:

$$E[Y_{i,j}] = \exp(\beta_0 + \beta_1 * \ln(VMT_{i,j}) + \beta_2 * \ln(DRV_{i,j}) + \beta_3 * DTP_{i,j} + \beta_4 * MED_{i,j} + \beta_5 * REC_{i,j} + \beta_6 * NEI_{i,j} + \beta_7 * YRS_{i,j} + \beta_8 * \ln(PCA_{i,j})) \quad (1)$$

Where,

VMT is total vehicle miles traveled,

DRV is the number of drivers aged 16 to 24,

DTP is drug-test proportion

MED is a dummy variable; 1 if state has legalized medicinal use of marijuana; otherwise 0,

REC is a dummy variable; 1 if state has legalized recreational use of marijuana; otherwise 0,

NEI is a dummy variable; 1 if state neighbors a state that has legalized recreational use of marijuana; otherwise 0,

YRS is a dummy variable; 1 if year is 2014 and 2015; otherwise 0,

and PCA is per capita.

Coefficients were combined with Eq. (1) to obtain the crash mean for CPD fatal crashes.

Results

Descriptive Statistics

According to the FARS data, there were approximately 50,000 drivers involved in fatal crashes in 2008 to 2015. Table 1 presents total number of drivers involved in fatal crashes, their drug test status and results of those drug tests. About 40% of those drivers were tested for the presence of drugs at the time of the crash. It should be noted the percentage of drivers tested changes by state and year. For example, in Maine in 2008, no drivers involved in fatal crashes were tested for the presence of drugs and subsequently reported to FARS. However, in New Mexico in 2011, 99% of drivers involved in fatal crashes were tested for the presence of drugs.

Approximately one third of the drivers tested had a positive result for one or more drugs. Since 2008, the percentage of positive drug test results has steadily increased. In 2008, 26% of tested

drivers tested positive for one or more drugs. While in 2015, 39% of drivers tested had a positive drug test for one or more drugs.

Table 1. Drivers Involved in Fatal Motor Vehicle Traffic Crashes by Crash Year, Drug Test Status, and Drug Test Results, 2008 to 2015, USA.

Crash Year	Total Drivers	Drug Test Status					Drug Test Results				
		Not Tested for Drugs		Tested for Drugs		Unknown	Drug Positive		Drug Negative		Results Unknown
		Number	% of Total Drivers	Number	% of Total Drivers		Number	% of Total Tested	Number	% of Total Tested	% of Total Tested
2008	50,416	26,883	53%	20,875	41%	5%	5,422	26%	13,099	63%	11%
2009	45,337	23,617	52%	18,357	40%	7%	5,500	30%	10,881	59%	11%
2010	44,599	23,059	52%	19,319	43%	5%	5,946	31%	11,758	61%	8%
2011	43,840	22,224	51%	18,648	43%	7%	6,096	33%	11,189	60%	7%
2012	45,664	23,879	52%	19,489	43%	5%	6,572	34%	11,181	57%	9%
2013	44,803	23,787	53%	18,558	41%	5%	6,540	35%	10,502	57%	8%
2014	44,671	23,307	52%	18,731	42%	6%	6,640	35%	10,454	56%	9%
2015	48,613	25,237	52%	17,656	36%	12%	6,833	39%	9,997	57%	5%

In 2015, 6,833 drivers tested positive for one or more drug categories. Table 2 presents the four most common drug categories drivers tested positive. The most common drug category is cannabinoids, which encompasses marijuana and its metabolites. Of the 6,833 fatally injured drivers, 2,805 tested positive for cannabinoids, which account for 41% of the drug positive fatally injured drivers. The remaining most commonly detected drug categories and the number of drivers who tested positive for each are presented in Table 2. It should be noted, a driver may test positive for more than one category of drug, which is the reason the sum of percentages can exceed 100%. About one-third of drivers who tested positive for cannabinoids also tested positive for alcohol at the time of the crash. Table 2 also presents information on the other drug categories regarding the combination of the drug category and alcohol.

Table 2. Most Common Drug Types and Interaction with Alcohol, 2008 - 2015, USA.

Year	Total Drivers of Drug Positive Tested	Drug Type							
		Cannabinoid		Stimulant		Depressant		Narcotic	
		No. of Drivers (% of Total)	With alcohol (%)	No. of Drivers (% of Total)	With alcohol (%)	No. of Drivers (% of Total)	With alcohol (%)	No. of Drivers (% of Total)	With alcohol (%)
2008	5,422	1,982 (37%)	720 (36%)	1,310 (24%)	445 (34%)	1,138 (21%)	308 (27%)	1,065 (20%)	246 (23%)
2009	5,500	1,956 (36%)	748 (38%)	1,243 (23%)	421 (34%)	1,216 (22%)	324 (27%)	1,181 (21%)	254 (22%)
2010	5,946	2,110 (35%)	805 (38%)	1,254 (21%)	418 (33%)	1,452 (24%)	376 (26%)	1,307 (22%)	286 (22%)
2011	6,096	2,055 (34%)	742 (36%)	1,256 (21%)	384 (31%)	1,379 (23%)	339 (25%)	1,380 (23%)	275 (20%)
2012	6,572	2,369 (36%)	803 (34%)	1,324 (20%)	412 (31%)	1,404 (21%)	330 (24%)	1,400 (21%)	291 (21%)
2013	6,540	2,413 (37%)	848 (35%)	1,494 (23%)	422 (28%)	1,492 (23%)	377 (25%)	1,385 (21%)	274 (20%)
2014	6,640	2,577 (39%)	826 (32%)	1,512 (23%)	427 (28%)	1,422 (21%)	357 (25%)	1,321 (20%)	265 (20%)
2015	6,833	2,805 (41%)	828 (30%)	1,622 (24%)	389 (24%)	1,476 (22%)	321 (22%)	1,440 (21%)	254 (18%)

Gender and age are significant factors in fatal crashes for drivers who tested positive for cannabinoids. The number of male drivers positive for cannabinoids is approximately five times higher than female drivers positive for cannabinoids involved in fatal crashes. Table 3 displays the number of drivers who tested positive for cannabinoids by age and gender.

In terms of age group, younger drivers are more likely to test positive for cannabinoids. This is especially true of drivers aged 16 to 24 years old. The proportion of 16 to 24-year-old drivers positive for cannabinoids accounts for about 35% of all drivers who tested positive for cannabinoids, followed by drivers aged 25 to 34 years old. However, it is important to note that the proportion of the younger group, 16 to 24 years old, is declining while that of older groups is increasing.

Table 3. Cannabinoid Positive Drivers by Gender and Age Group, 2008 – 2015, USA.

Year	Total	Gender			Age Group			
		Male	Female	Ratio of Male vs. Female	16 to 24 yrs. (%)	25 to 34 yrs. (%)	35 to 54 yrs. (%)	55 yrs. or older (%)
2008	1,982	1,659	322	5.15	863 (40%)	571 (26%)	617 (28%)	112 (5%)
2009	1,956	1,636	320	5.11	853 (39%)	556 (25%)	636 (29%)	131 (6%)
2010	2,110	1,731	378	4.58	890 (38%)	644 (28%)	606 (26%)	170 (7%)
2011	2,055	1,728	327	5.28	866 (37%)	638 (27%)	640 (27%)	176 (8%)
2012	2,369	1,975	393	5.03	1,019 (38%)	745 (28%)	703 (26%)	223 (8%)
2013	2,413	2,009	403	4.99	947 (34%)	825 (30%)	712 (26%)	255 (9%)
2014	2,577	2,156	421	5.12	1,039 (35%)	849 (29%)	817 (28%)	249 (8%)
2015	2,805	2,350	454	5.18	1,094 (34%)	987 (30%)	836 (26%)	313 (10%)

Although the total number of fatal crashes is declining, the number of fatal crashes in which the driver tested positive for cannabinoids and its proportion to all fatal crashes is steadily increasing. The total number of fatal crashes decreased to 32,166 in 2015 from 34,172 in 2008. However, the number of fatal crashes where the driver was positive for cannabinoids increased to 2,769 in 2015 from 1,957 in 2008 (Figure 1). In addition, the percentage of fatal crashes where the driver tested positive for cannabinoids to all fatal crashes has steadily increased each year from 5.7% in 2008 to 8.6% in 2015. Figure 1 illustrates the number of all fatal crashes in which the driver tested positive for cannabinoids compared to all fatal crashes from 2008 to 2015.

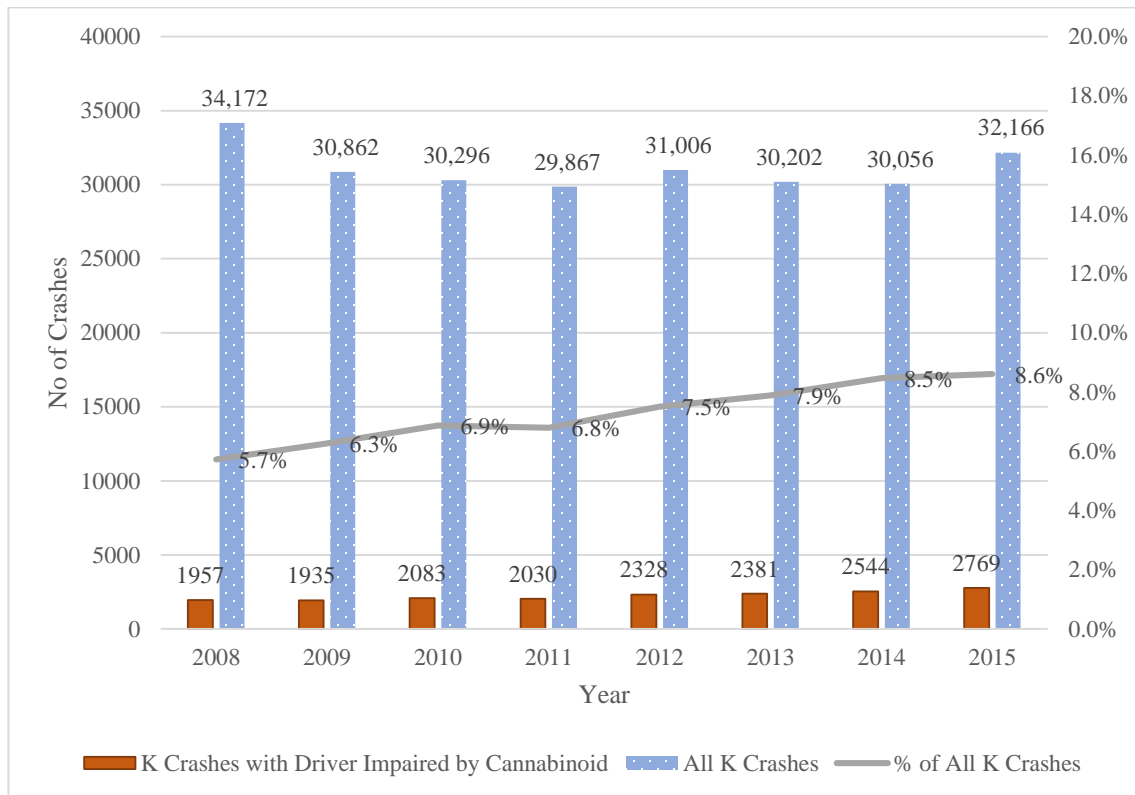


Figure 1. Number of fatal crashes with driver impaired by cannabinoid and proportion to all fatal crashes, 2008 to 2015, USA.

Crash Analysis: Selected States

To better understand the impacts of marijuana legalization on fatal crashes, a crash analysis focused on the selected sample states was conducted. Figures 2-5 present the number of fatal crashes in which the driver tested positive for cannabinoids by the legal status of marijuana within a state.

From 2008 – 2013, the average number of the fatal crashes per year in Colorado and Washington was 53, whereas in 2014 – 2015, the average number of fatal crashes increased to 80. Figure 2 illustrates the number drivers involved in fatal crashes who tested positive for cannabinoids in the states of Colorado and Washington from 2008 to 2015.

Post-legalization of marijuana for medicinal purposes states have experienced a slight increase in the number of fatally injured drivers who have tested positive for cannabinoids. For the state of Illinois, there were an average of 85 fatal crashes per year where the driver tested positive for cannabinoids prior to the legalization of marijuana for medicinal use in April 2011. Following legalization, the number of drivers who tested positive for cannabinoids slightly increased to an annual average of 99 fatal crashes. For the other two states in the sample, the number of drivers who tested positive for cannabinoids in fatal crashes similarly increased after the legalization of

the medicinal use of marijuana. Figure 3 illustrates the number of drivers who tested positive for cannabinoids in fatal crashes of these three states.

For neighboring states, similar results were observed to states with legalized medicinal and recreational use of marijuana during 2008 – 2015. In the neighboring states, the number of drivers who tested positive for cannabinoids in fatal crashes also increased in 2014 and 2015, after the legalization of the recreational use of marijuana. There were an average of 10 fatal crashes per year involving drivers who tested positive for cannabinoids in the four selected neighboring states during the years 2008 – 2013, and in 2014 – 2015, this number increased to 22 fatal crashes involving a driver who tested positive for cannabinoids. Figure 4 illustrates the number drivers involved in fatal crashes who tested positive for cannabinoids in the selected neighboring states from 2008 to 2015.

For states with neither legalized medicinal or recreational use of marijuana that are also not states neighboring states with legalized medicinal or recreational use of marijuana, in 2008 – 2013, there were an average of 120 fatal crashes in which the driver tested positive for cannabinoids per year. In 2014 and 2015, in these states the average number of fatal crashes involving a driver who tested positive for cannabinoids increased to 134 fatal crashes. This marks a slight increase in number of fatal crashes involving a driver who tested positive for cannabinoids after 2014, when the legalization of recreational use of cannabinoids was initiated. Figure 5 illustrates the number drivers involved in fatal crashes who tested positive for cannabinoids in the selected states that have neither medicinal or recreational use of marijuana nor are neighboring states of those that have legal medicinal or recreational use of marijuana from 2008 to 2015.

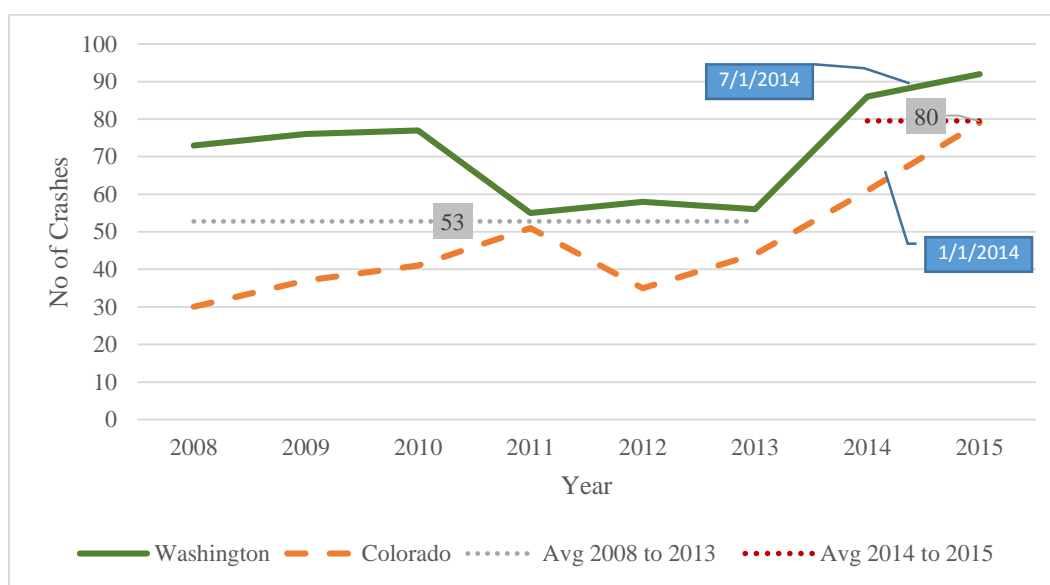


Figure 2. States with legalized recreational and medicinal use of marijuana.

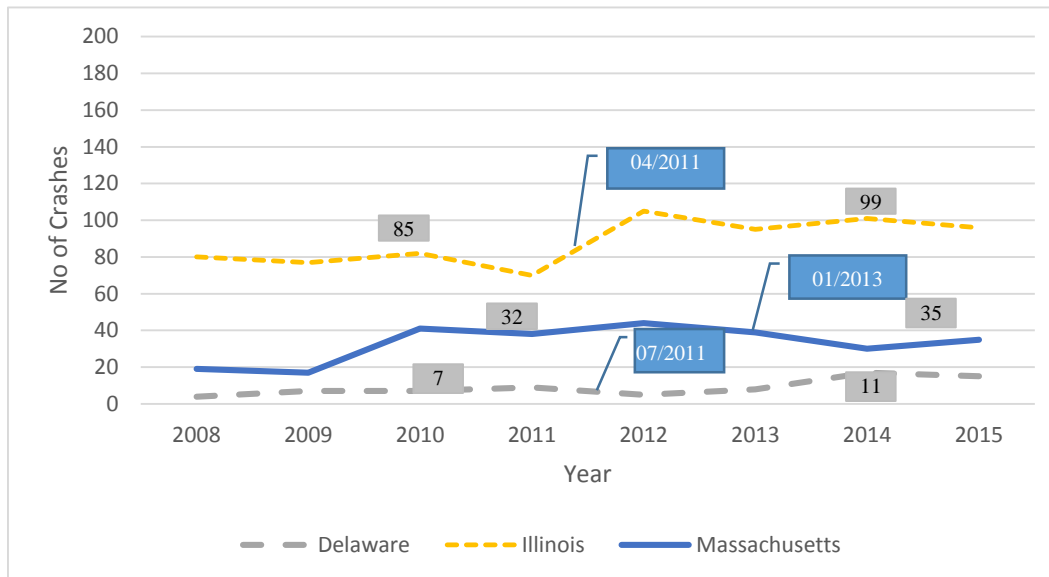


Figure 3. States with legalized medicinal use of marijuana.

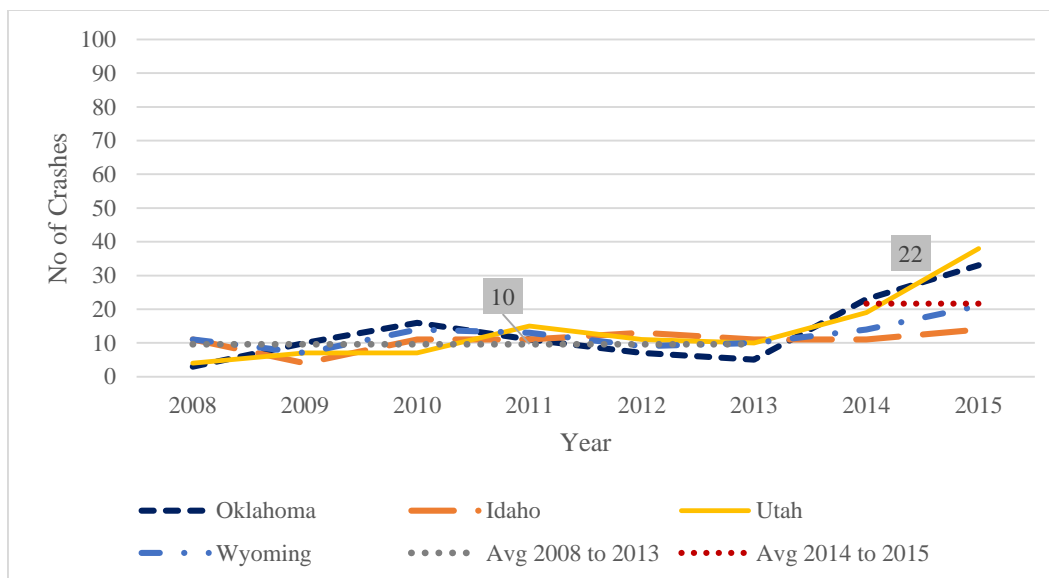


Figure 4. Neighboring states to states with legalized medicinal and recreational use of marijuana.

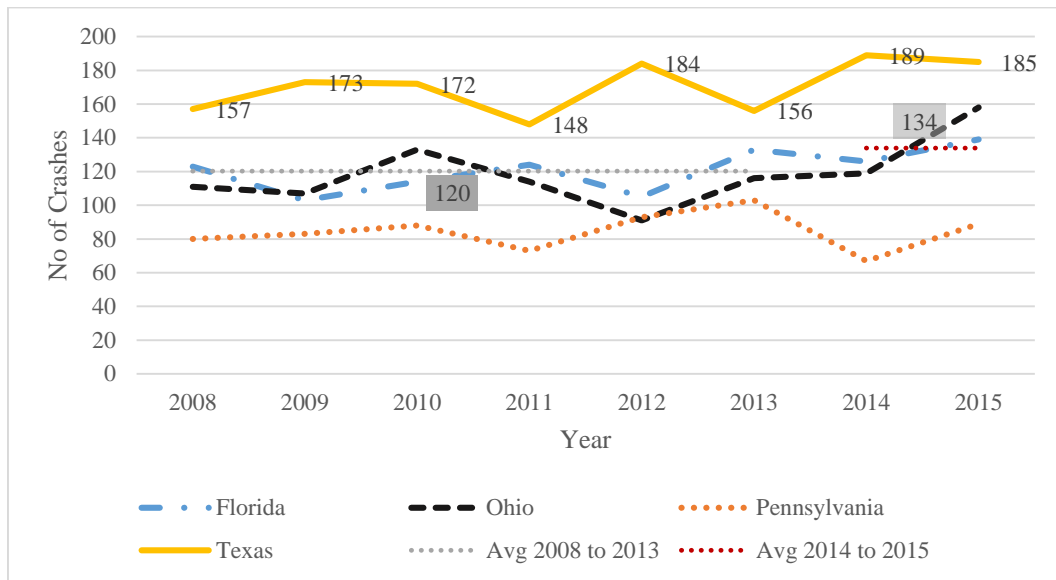


Figure 5. States that do not have legalized medicinal or recreational use of marijuana, nor neighboring states.

Crash Analysis: United States

Table 4 presents the summarized information by group and year. The information includes number of fatal crashes related to drivers who tested positive for cannabinoids (CPD), VMT in million miles, number of drivers aged 16 to 24 (DRV), drug-test proportion (DTP), and the dummy variable of the legalization of medicinal use of marijuana (MED) and legalization of recreational use of marijuana (REC) use, neighboring to states with legalized recreational use of marijuana (NEI), the year-factor of before or after 2014 (YRS), and per capita (PCA) in dollars.

Table 4. Summary of Variables by Group and Year.

Group	Variable		Year							
			2008	2009	2010	2011	2012	2013	2014	2015
Recreational	CPD Fatal Crashes	Sum	117	129	129	124	102	111	168	184
		Max.	73	76	77	55	58	56	86	92
		Min.	0	4	0	2	0	1	2	3
		Stdev	31.6	32.4	34.5	26.1	26.3	26.4	38.4	46.0
	VMT	Avg.	27,974	27,797	28,130	27,931	27,974	28,139	28,857	29,673
	DRV	Avg.	291,658	291,328	289,486	288,651	287,993	289,744	293,255	296,773
	DTP	Avg.	0.47	0.55	0.60	0.60	0.52	0.60	0.61	0.55
	PCA	Avg.	42,521	41,387	42,303	43,883	44,823	47,192	49,278	51,283
	No. of States		0	0	0	0	0	0	2	4
Medical	CPD Fatal Crashes	Sum	750	652	742	689	877	924	874	876
		Max.	262	223	201	218	292	313	325	223
		Min.	0	3	0	1	1	1	4	3
		Stdev	62.6	53.9	50.0	51.9	71.6	73.7	76.4	54.6
	VMT	Avg.	61,336	60,720	60,425	59,929	60,562	61,003	61,604	62,111
	DRV	Avg.	576,831	578,682	572,589	572,447	573,650	593,650	573,115	577,870
	DTP	Avg.	0.46	0.47	0.49	0.48	0.47	0.46	0.49	0.43
	PCA	Avg.	44,103	43,142	44,042	45,910	46,875	48,717	50,294	51,605
	No. of States		7	8	9	11	12	14	17	17
Neighboring	CPD Fatal Crashes	Sum	122	119	111	140	133	136	192	239
		Max.	44	28	27	45	37	30	43	66
		Min.	1	0	1	1	0	1	3	1
		Stdev	13.0	8.7	8.3	11.8	9.9	9.8	11.7	18.0
	VMT	Avg.	34,512	34,342	34,643	34,408	34,600	34,603	34,856	35,863
	DRV	Avg.	305,327	304,015	292,690	290,670	29,4040	291,357	283,166	292,014

	DTP	Avg.	0.37	0.38	0.42	0.43	0.41	0.38	0.38	0.36
	PCA	Avg.	38,965	38,029	38,620	40,321	41,393	43,362	45,002	45,975
	No. of States		0	0	0	0	0	0	8	10
Control	CPD Fatal Crashes	Sum	968	1,035	1,101	1,077	1,216	1,210	1,310	1,470
		Max.	157	173	172	148	184	156	189	185
		Min.	0	0	0	0	1	1	0	2
		Stdev	46.7	45.8	46.1	40.9	45.6	42.8	49.5	51.7
	VMT	Avg.	73,840	73,496	74,016	73,577	74,068	74,632	75,720	78,108
	DRV	Avg.	643,468	646,165	640,401	637,680	616,956	621,175	613,038	611,248
	DTP	Avg.	0.41	0.40	0.42	0.43	0.45	0.44	0.45	0.42
	PCA	Avg.	35,530	34,877	35,903	37,509	38,855	40,636	41,648	42,567
Total			1,957	1,935	2,083	2,030	2,328	2,381	2,544	2,769

SPF Estimations for CPD fatal crashes in USA

The estimated results suggest that CPD fatal crashes increase with VMT, number of drivers aged 16 to 24, drug-test proportion, the year-factor, and per capita at a 10% confidence level.

However, the legalization of medicinal use of marijuana legalization of /recreational use of marijuana and neighboring status are not significant variables. No significant increase in the number of fatal crashes with a driver positive for cannabinoids was found within the states with legalized medicinal or recreational use of marijuana post-legalization because there was also an increase in the number of fatal crashes in which the driver tested positive for cannabinoids in the states that neither legalized the medicinal or recreational use of marijuana nor neighbored states with the legalized medicinal or recreational use of marijuana. Table 5 displays the results of the generalized linear crash model.

Table 5. Results of Generalized Linear Crash Model.

Variable	Estimate	Standard Error	Wald 95% Confidence Limits		P-value
Intercept	-7.2509	3.2936	-13.7062	-0.7956	0.0277
Log(VMT)	0.2975	0.1722	-0.0399	0.6349	0.084
Log(DRV)	0.6464	0.1668	0.3195	0.9732	0.0001
DTP	2.5074	0.1971	2.1211	2.8937	<.0001
MED	0.0523	0.0683	-0.0816	0.1863	0.444
REC	0.1622	0.2466	-0.3211	0.6456	0.5106
NEI	-0.0009	0.1569	-0.3084	0.3066	0.9956
YRF	0.3676	0.0774	0.2158	0.5194	<.0001
PCA	-0.5699	0.1895	-0.9413	-0.1985	0.0026

Summary

This study aimed to explore the impact of legalization of marijuana for medicinal or recreational use on fatal crashes from 2008-2015 in the United States using FARS data. Although the total number of fatal crashes is declining, the number of fatal crashes in which the driver is positive for cannabinoids and its proportion to all fatal crashes is steadily increasing, from 1,957 in 2008 to 2,769 in 2015.

According to the descriptive analysis, gender and age are overrepresented factors in fatal crashes for drivers who tested positive for cannabinoids. Male drivers and younger drivers (16

to 24 years old) are more likely to test positive for cannabinoids in fatal crashes. However, it is important to note that the cannabinoids-positive driving in fatal crashes is increasingly becoming an issue among older drivers aged 25 to 34.

To determine the impact of legalization of marijuana for medicinal or recreational use, a representative sample of states were selected and grouped for analysis. In the pioneering states, the recreational use of marijuana was legalized beginning in 2014. Interestingly, this analysis found the number of drivers who tested positive for cannabinoids involved in fatal crashes increased in 2014 and 2015 in all states selected for analysis, regardless of their status as a state with legal medicinal and/or recreational use of marijuana, neighbor to a state with legal recreational use of marijuana or neither legal medicinal or recreational use of marijuana nor a neighboring state. This suggests the impact of the legalization of marijuana is not bound by the geographic boundary of states.

This study developed the SPF for cannabinoids-related fatal crashes. The SPF includes the VMT, number of younger drivers, drug-test proportion, status of the legalization of marijuana for medicinal or recreational use, status as a neighbor to a state with legalized medicinal or recreational use of marijuana, the year-factor of before or after 2014, and per capita. Among them, VMT, the number of younger drivers age 16 to 24, drug-test proportion, the year-factor, and per capita are statistically significant variables at a 90% confidence level. As states have higher VMT, more young drivers, and higher drug-test proportion, they experienced more fatal crashes involving a cannabinoid-positive driver. CPD fatal crashes also decreased with increasing per capita. Interestingly, most states experienced more fatal crashes involving a CPD in 2014 and 2015 when the legalization of the recreational use of marijuana began. However, a state's legal status of marijuana nor did its status as a state neighboring a state with the legal medicinal or recreational use of marijuana did not increase fatal crashes involving a CPD. Because fatal crashes involving a CPD increased in most states regardless of the legal status of marijuana and neighboring conditions.

Limitations of this study are primarily centered on limitations of FARS data. These limitations include not all drivers involved in fatal crashes are tested for presence of impairing substances. In addition, if toxicology testing is conducted on the deceased driver, testing varies state by state. This variance includes substances tested for as well as cut off levels for each of these substance. Further, reporting deceased driver toxicology results to FARS varies state by state. An additional limitation of the FARS data is that a positive drug test result in the FARS database does not indicate the driver was impaired at the time of the crash. Perhaps the largest limitation of the FARS data is the data does not differentiate between drivers who have tested positive for the active impairing metabolite THC and those who test positive for the inactive metabolite 11-COOH-THC (THC-COOH). Making it extremely difficult to draw conclusions about the impairment of the driver and the effects of cannabis on fatal crashes.

Despite these limitations, this study was able to explore the impact of legalization of marijuana for medicinal or recreational use on fatal crashes from 2008-2015 in the United States. Fatal crashes involving a driver who is positive for cannabinoids are becoming a growing traffic safety concern in the United States. It is likely fatal crashes involving cannabinoid-positive drivers will continue to be an issue as more states move to legalize marijuana for medicinal and recreational use. In order to better understand the impact of the legalization of marijuana on traffic safety, a before-after analysis using all severity crash data and driving under influence (DUI) citation data could provide better idea on the impact of marijuana legalization on traffic safety.

Texan's Attitudes Towards Marijuana Survey

Despite the increasing attention on marijuana and driving as more states legalize both medical and recreational use, there is very limited information on the individual's attitudes and beliefs regarding marijuana use and driving. In March 2017, the Marist College Institute for Public Opinion/Yahoo News conducted a survey entitled, "Weed and the American Family" which focused on the impact of marijuana use in relationships, changing social norms, and legalization (Marist College 2017). And while the Marist study is important in highlighting the impact that marijuana has on the family, it did not inform the literature on attitudes that Americans have on marijuana use and the adverse effect its use may have on traffic safety. One essential missing component of the Marist survey was its failure to assess Americans attitudes and beliefs regarding marijuana use pre, during and post driving.

Methods

Developing the Survey

The TTI survey was designed to be deployed via phone interview. In addition, the survey was designed to take less than ten minutes to complete to increase the likelihood of participation. The phone interview survey was divided into two sections that included: 1) background demographic questions and 2) attitude based qualitative survey questions.

The background demographic questions were composed of 10 queries and the attitude based qualitative survey questions were composed of 28 queries. In total both sections contained 38 questions.

The background demographic questions obtained information on age, gender, race and ethnicity, education, political identification, county of residence, zip code of residence, city or town of residence, and if the respondent had a Texas driver's license. These questions were utilized to confirm that the respondent met the inclusion criteria for participation. In order to participate, the respondent was required to: 1) be 18 years or older, 2) have a Texas Driver's License, and 3) be in a safe place to talk. If the respondent was not in a safe place the interviewer was directed to schedule a call back and immediately end the call. If the participant was not 18 years or older or did not have a Texas Driver's license the survey was immediately stopped.

The attitude based qualitative survey questions were divided into four sections: 1) general statements about marijuana; 2) marijuana and driving; 3) marijuana, alcohol, and driving; and 4) marijuana use. The section on general statements about marijuana included questions with Likert-scale responses (e.g., strongly agree, agree, neither agree nor disagree, disagree, strongly disagree) with options for don't know and refused. The section included questions regarding safety of marijuana use, traffic safety, impairment, and addictiveness of marijuana compared

with other substances (e.g., tobacco and alcohol); the impact of marijuana on thinking clearly and performing tasks; as well as queries regarding legalization of marijuana for various medical levels (e.g., serious and moderate medical conditions where marijuana provides relief) and recreational use.

The second and third sections addressed marijuana, alcohol, and driving through thirteen questions using the same Likert-scale responses and options that were used in the first section. The questions focused on beliefs and attitudes towards driving safety after use of marijuana; marijuana with alcohol, as well as queries regarding penalization of drivers for operating a vehicle under the influence of marijuana.

The final section inquired about marijuana use with questions focusing on: any use of marijuana ever; use marijuana in the past 12 months; use of marijuana in the past 30 days; and potential use of marijuana if it were legal. This last section did not utilize Likert-scale responses, but instead used Yes/No responses or custom answer choices. Appendix A includes a copy of the survey.

Sampling

Geographic Location

The TTI survey sample was selected randomly based on cell-phone and landline telephone numbers that were assigned to twenty-five Texas counties which included: Bell, Bexar, Brazoria, Cameron, Collin, Dallas, Denton, Ector, El Paso, Fort Bend, Galveston, Grayson, Harris, Hidalgo, Jefferson, Lubbock, McLennan, Midland, Montgomery, Nueces, Potter, Smith, Tarrant, Travis, and Williamson. These counties were purposefully selected because they represent counties with the highest per capita alcohol related fatalities in Texas (TxDOT 2016). Figure 6 provides a graphic representation of the counties with the highest alcohol related fatal crashes in Texas.

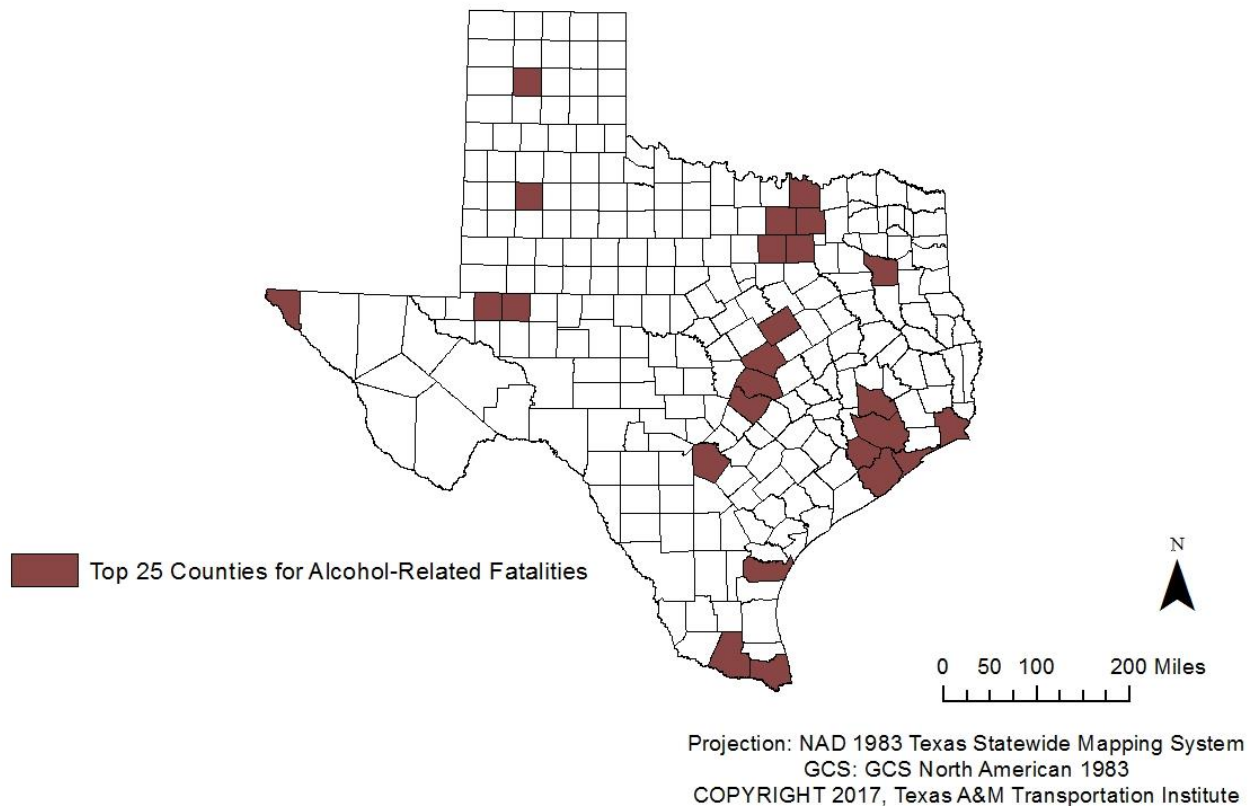


Figure 6. Top 25 counties with the highest per capita alcohol related fatalities in Texas.

Sample Size

Targeted respondents of this survey were adults age 18 and older, who reside in one of the 25 counties with the most alcohol related fatal crashes in Texas. In addition, these individuals were identified to be licensed drivers. Sample size was calculated based on the total number of licensed drivers in the 25 selected counties and 384 ($p=.05$) respondents were identified for survey data collection and analysis.

Sampling Frame

To account for the growth of the cell-phone only and cell-phone mostly populations, the sample for the TTI survey was constructed using dual-frame sampling. Dual-frame sampling was utilized for this study because it provides increased coverage of younger adults (18-29), as well as ethnic and racial minorities, who may be more difficult to reach using traditional phone-based survey methods which rely on landline phones (Guterbock et al. 2011).

According to the most recent estimates available from the National Health Interview Survey (NHIS), approximately half of all adults (49 percent) and more than two-thirds of younger adults (age 25-29) are wireless only (Blumberg et al. 2016). In addition, many of the households that still have a landline telephone are wireless mostly, meaning that they rarely (if ever) use their landline telephones. The NHIS estimates 37 percent of households with both a cell-phone and

landline telephone are wireless mostly (Blumberg et al. 2016). In dual frame sampling, independent but overlapping samples are constructed using available cell-phone and landline telephone numbers in order to capture as many respondents as possible, which leads to a more robust sample.

Geographic Confirmation

To assure the quality of the final data, self-reported counties and zip codes were compared to verify the information provided by the respondents. Where there were discrepancies, the following rules were applied:

- Respondents who did not report a county or a zip code were assigned to their sample location.
- Respondents who reported a different county than in the sample were reviewed and their zip code was used to place them in a county.
 - When the zip code was entirely within a single county that county was used.
 - When the zip code was in multiple counties the county of identification was left if one of the possible counties was named by the respondent. If the respondent did not name one of the counties then the county with the largest percentage of area was used.

Analysis

Descriptive statistics (e.g., frequencies) were calculated for all survey questions using STATA 14 SE (StataCorp LLC, College Station, TX). In addition, ArcMap 10.2 (ESRI, Redlands, CA) was utilized to display survey results by county for marijuana use, marijuana and driving, and legalization of marijuana.

Results

There were a total of 438 respondents who completed the survey. Of the respondents, there was a 47% cooperation rate which means these respondents successfully completed the survey (data not shown). Overall, the response rate was 11%, which means that of the households contacted 11% completed the survey (data not shown).

The dual sampling frame resulting in 80.6% (n=353) of respondents being reached on a cell phone and 19.4% (n=85) on a landline. Of those who participated, 87.0% (n=381) were located in the Top 25 Counties with the highest per capita alcohol related fatalities in Texas; however, 13.0% (n=57) were not in the Top 25 Counties. Figure 7 displays the counties of respondents.

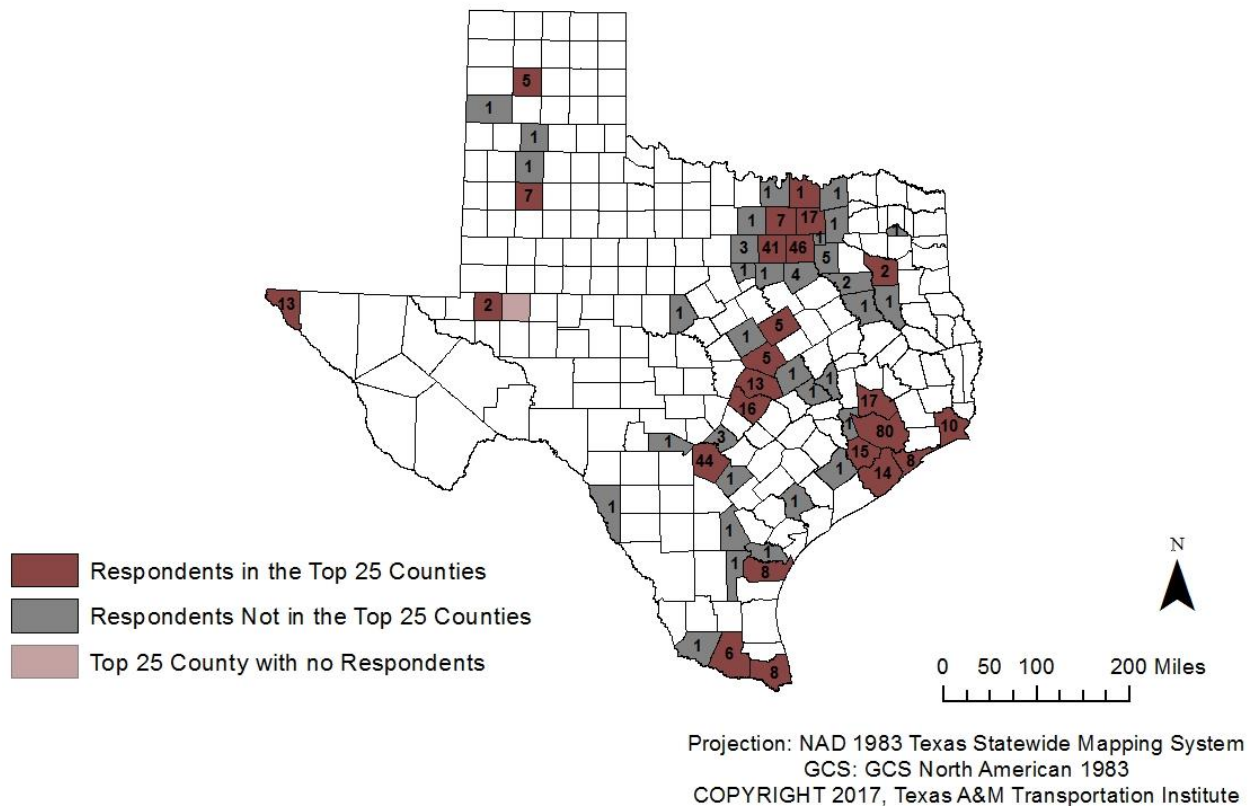


Figure 7. Distribution of Respondents, by County.

Demographics

A majority of respondents (60%; $n=263$) were older than 45 years old. Of those responding, 19.6% ($n=86$) were aged 45 to 54 years old; 18.5% ($n=81$) were aged 55 to 64 years old; and 21.9% ($n=96$) were aged 65 and older. Those that were younger than 45 years old accounted for 40% ($n=175$) of respondents including 8.9% ($n=39$) aged between 18 to 24 years old; 18.0% ($n=79$) between 25 to 34 years old; and 13.0% ($n=57$) between 35 to 44 years or age.

Interestingly, males accounted for 57.3% ($n=251$) of responses, whereas females accounted for 42.7% ($n=187$). The top three racial identification of respondents were White at 56.4%; ($n=247$) followed by Hispanic or Latino at 19.6% ($n=86$) and Black or African American at 11.9% ($n=52$).

Regarding education level, 93.4% ($n=409$) of respondents had completed at least high school or equivalent. Of the respondents, 44.0% ($n=193$) completed a collegiate bachelor's degree or higher. Of those responding, 26.0% ($n=114$) possessed a bachelor's degree; 14.6% ($n=64$) had obtained a master's or professional degree; and 3.4% ($n=15$) had obtained a doctoral degree. Table A1 in Appendix B provides an illustration of the frequencies of all demographic variables.

With regard to the method of respondent contact, 80.6% ($n=353$) were reached by a cell phone. To determine if there was a difference in age responses and type of phone (e.g., cell or landline)

a cross-tabulation of these variables was conducted (see Table 6). All age groups were the most likely to be reached on a cell phone compared to a landline. However, those aged 65 years and older had higher frequencies of being reached on a landline phone. Specifically, 39.6% (n=38) of those aged 65 years or older were reached via a landline phone.

Table 6. Distribution of Phone Type by Age Category.

	Landline	Cell Phone
18 to 24 years old	1 (2.6%)	38 (97.4%)
25 to 34 years old	5 (6.3%)	74 (93.7%)
35 to 44 years old	6 (10.5%)	51 (89.5%)
45 to 54 years old	15 (17.4%)	71 (82.6%)
55 to 64 years old	20 (24.7%)	61 (75.3%)
65 years and older	38 (39.6%)	58 (60.2%)
Total	85 (19.4%)	353 (80.6%)

Attitudes and Beliefs Regarding Marijuana

After completing the demographic questions, respondents were asked about their attitudes and beliefs regarding marijuana. Table A2 in Appendix D displays the frequencies of responses for these questions.

Approximately 46% (n=200) of respondents agreed that it is safe to use marijuana, with 35.8% (n=157) disagreeing with this statement. The two age groups that were the most likely to strongly agree that it is safe to use marijuana were the 18 to 24 years olds (35.9%; n=14) and 25 to 34 years olds (31.7%; n=25) (data not shown). Compared to tobacco, 25.6% (n=112) of respondents agreed that marijuana is less safe to use than tobacco. About 57.1% (n=250) of respondents disagreed that marijuana is less safe to use than tobacco. In comparison to alcohol, 20.8% (n=91) of respondents agreed that marijuana is less safe to use than alcohol, whereas 52.7% (n=270) of respondents disagreed. In regards to addictiveness, 20.6% (n=90) agreed that marijuana is more addictive than alcohol, while 53.2% (n=233) of participants disagreed with this statement.

This section of the survey also looked at attitudes and beliefs concerning marijuana impairment. Of the respondents, 18.3% (n=80) agreed that marijuana is more impairing than

alcohol, whereas 54.3% (n=238) of respondents disagreed. A majority (63.9%; n=280) of respondents agreed that using marijuana makes it harder to think clearly or perform tasks.

Reported Marijuana Use

The surveyors then asked respondents about their personal marijuana use and history. Table A3 in Appendix B displays the frequencies of responses regarding marijuana use. Of the respondents, 55.0% (n=241) reported ever trying marijuana; the average age for marijuana use was 18 years old, with a range from 7 to 54 years old.

Of those responding, 13.2% (n=58) reported using marijuana in the past 12 months; however, it is important to note 45.0% (n=197) of respondents refused to answer. Figure 8 shows the distribution of the percentage of respondents who reported marijuana use in the past 12 months by county. In the past 30 days, 7.1% (n=31) of respondents reported using marijuana, 6.2% (n=27) of respondents reported not using marijuana, and 86.8% (n=380) refused to answer the question. Figure 9 shows the distribution of the percentage of respondents who reported marijuana use in the past 30 days by county.

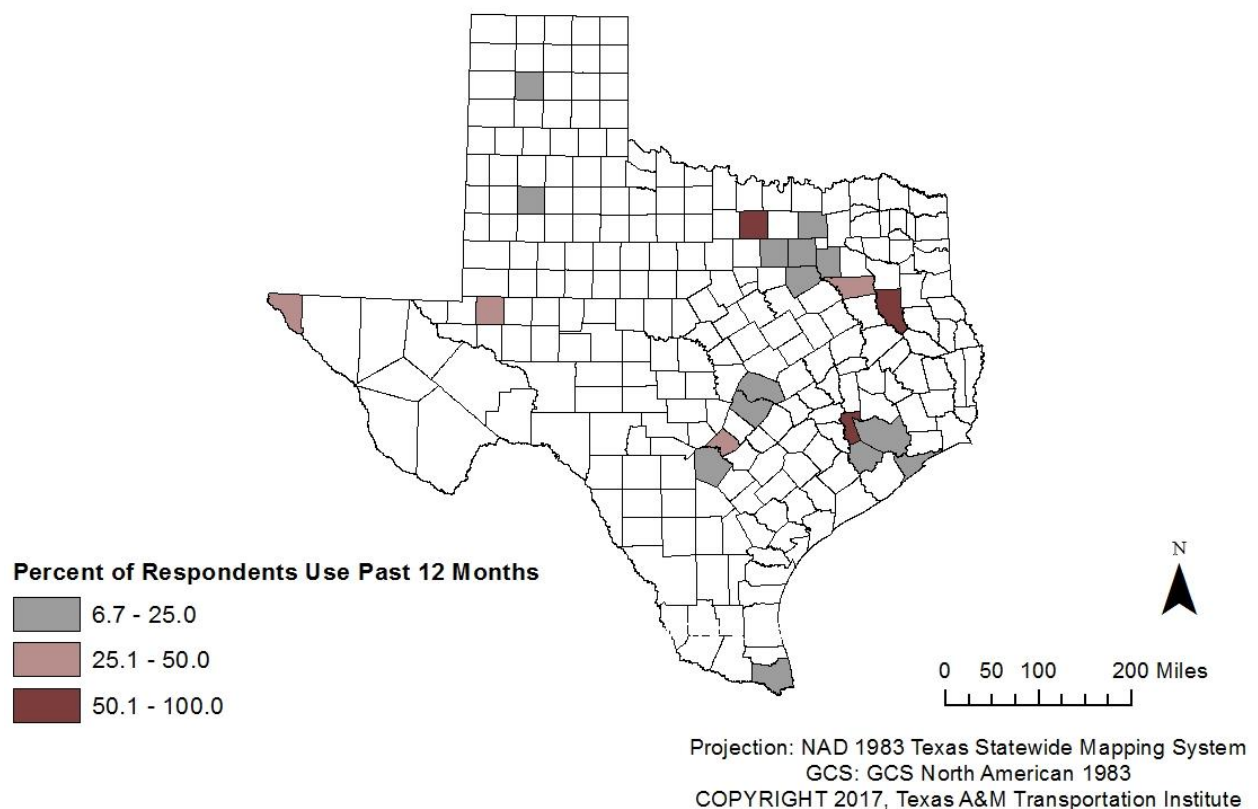


Figure 8. Percent of Respondents who Reported Marijuana Use in the Past 12 Months by County.

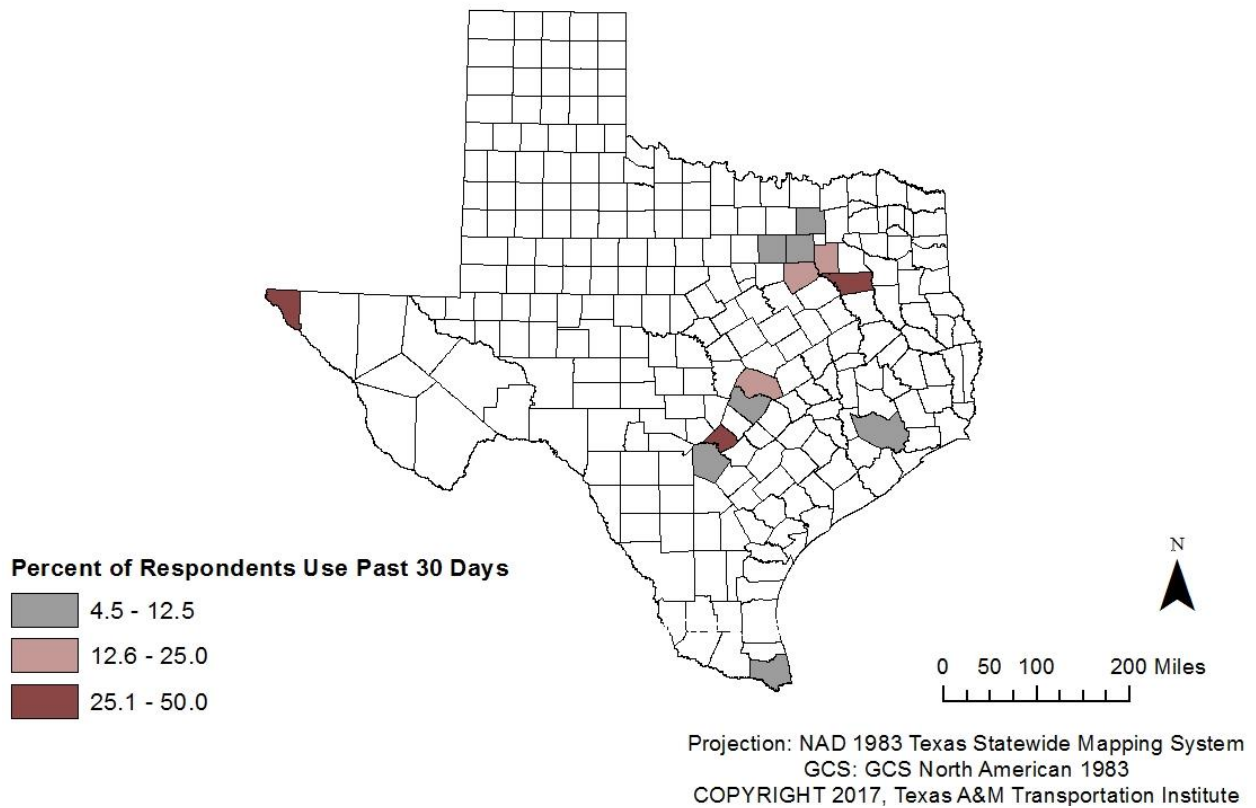


Figure 9. Percent of Respondents who Reported Marijuana Use in the Past 30 days by County.

Marijuana use in the past 12 months and past 30 days were analyzed for differences in age, race/ethnicity, and political views. Table 7 shows age by marijuana use. Overall, the percent of respondents who reported marijuana use decreased for each age category. Those aged 18 to 34 years old were most likely to report marijuana use in the past 12 months and past 30 days.

Table 7. Marijuana Use by Age.

		18 to 24 years old n (%)	25 to 34 years old n (%)	35 to 44 years old n (%)	45 to 54 years old n (%)	55 to 64 years old n (%)	65 and older n (%)
Have you used marijuana in the past 12 months?	Yes	17 (43.59%)	16 (20.25%)	9 (15.79%)	10 (11.63%)	4 (4.94%)	2 (2.08%)
	No	11 (28.21%)	40 (50.63%)	25 (43.86%)	38 (44.19%)	41 (50.62%)	28 (29.17%)
	Refused	11 (28.21%)	23 (29.11%)	23 (40.35%)	38 (44.19%)	36 (44.44%)	66 (68.75%)
Have you used marijuana in the past 30 days?	Yes	8 (20.51%)	11 (13.92%)	5 (8.77%)	5 (5.81%)	2 (2.47%)	0 (0.00%)
	No	9 (23.08%)	5 (6.33%)	4 (7.02%)	5 (5.81%)	2 (2.47%)	2 (2.08%)
	Refused	22 (56.41%)	63 (79.75%)	48 (84.21%)	76 (88.37%)	77 (95.06%)	94 (97.92%)

Table 8 reviews marijuana use by gender which found that a higher percentage of males reported marijuana use in the past 12 months and past 30 days compared to females.

Table 8. Marijuana Use by Gender.

		Male n (%)	Female n (%)
Have you used marijuana in the past 12 months?	Yes	36 (14.34%)	22 (11.76%)
	No	119 (47.41%)	64 (34.22%)
	Refused	96 (38.25%)	101 (54.01%)
Have you used marijuana in the past 30 days?	Yes	20 (7.97%)	11 (5.88%)
	No	16 (6.37%)	11 (5.88%)
	Refused	215 (85.66%)	165 (88.24%)

When analyzed by race or ethnicity, Black or African American respondents were the most likely to report marijuana use in the past 12 months (17.3%; n=9) and past 30 days (n=9.6%; n=5) then followed by White and Hispanic respondents, respectively. Table 9 provides for all responses to marijuana use in the past 12 months and past 30 days respectively by reported race/ethnicity.

Table 9. Marijuana Use by Race/Ethnicity.

		White n (%)	Hispanic n (%)	Black n (%)	Native American n (%)	Asian/Pac n (%)	Mixed n (%)	Other n (%)	Don't Know n (%)	Refused n (%)
Have you used marijuana in the past 12 months?	Yes	32 (12.96%)	11 (12.79%)	9 (17.31%)	0 (0.00%)	0 (0.00%)	6 (30.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	No	108 (43.72%)	37 (43.02%)	20 (38.46%)	0 (0.00%)	4 (57.14%)	7 (35.00%)	4 (36.36%)	0 (0.00%)	3 (30.00%)
	Refused	107 (43.32%)	38 (44.19%)	23 (44.23%)	4 (100.00%)	3 (42.86%)	7 (35.00%)	7 (63.64%)	1 (100.00%)	7 (70.00%)
Have you used marijuana in the past 30 days?	Yes	15 (6.07%)	7 (8.14%)	5 (9.62%)	0 (0.00%)	0 (0.00%)	4 (20.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	No	17 (6.88%)	4 (4.65%)	4 (7.69%)	0 (0.00%)	0 (0.00%)	2 (10.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	Refused	215 (87.04%)	75 (87.21%)	43 (82.69%)	4 (100.00%)	7 (100.00%)	14 (70.00%)	11 (100.00%)	1 (100.00%)	10 (100.00%)

Table 10 displays marijuana use by reported educational level which found for both use past 12 months and 30 days. Interestingly, respondents with high school and associate degrees were most likely to report use. Of those who completed some high school, 23.5% (n=4) reported marijuana use in the past 12 months and 17.7% (n=3) reported use in the past 30 days. Of those who completed an associate degree, 28.21% (n=11) reported marijuana use in the past 12 months and 18.0% (n=7) reported marijuana use in the past 30 days.

Table 10. Marijuana Use by Education.

	Have you used marijuana in the past 12 months?			Have you used marijuana in the past 30 days?		
	Yes	No	Refused	Yes	No	Refused
No School n (%)	1 (50.00%)	0 (0.00%)	1 (50.00%)	1 (50.00%)	0 (0.00%)	1 (50.00%)
Elementary n (%)	0 (0.00%)	3 (42.86%)	4 (57.14%)	0 (0.00%)	0 (0.00%)	7 (100.00%)
Some High School n (%)	4 (23.53%)	8 (47.06%)	5 (29.41%)	3 (17.65%)	1 (5.88%)	13 (76.47%)
High School n (%)	10 (18.18%)	27 (29.09%)	18 (32.73%)	5 (9.09%)	5 (9.09%)	45 (81.82%)
Some College n (%)	15 (16.67%)	38 (42.22%)	37 (41.11%)	8 (8.89%)	7 (7.78%)	75 (83.33%)
Trade/Technical n (%)	1 (3.13%)	14 (43.75%)	17 (53.13%)	1 (3.13%)	0 (0.00%)	31 (96.88%)
Associate n (%)	11 (28.21%)	15 (38.46%)	13 (33.33%)	7 (17.95%)	4 (10.26%)	28 (71.79%)
Bachelor's n (%)	14 (12.28%)	49 (42.98%)	51 (44.74%)	6 (5.26%)	8 (7.02%)	100 (87.72%)
Master's n (%)	2 (3.13%)	26 (40.63%)	36 (56.25%)	0 (0.00%)	2 (3.13%)	62 (96.88%)
Doctorate n (%)	0 (0.00%)	2 (13.33%)	13 (86.67%)	0 (0.00%)	0 (0.00%)	15 (100.00%)
Don't Know n (%)	0 (0.00%)	1 (50.00%)	1 (50.00%)	0 (0.00%)	0 (0.00%)	2 (100.00%)
Refused n (%)	0 (0.00%)	0 (0.00%)	1 (100.00%)	0 (0.00%)	0 (0.00%)	2 (100.00%)

Table 11 provides an illustration of marijuana use associated with political views. The top three groups to reported marijuana use in the past 12 months were very liberal (18.2%; n=2), liberals (16.3%; n=16), and neither liberal nor conservative (20.3%; n=24). Whereas, reported use in the past 30 days was most commonly reported by liberals (11.2%; n=11) and neither liberal nor conservative (10.2%; n=12).

Table 11. Marijuana Use by Political Views.

		Very liberal n (%)	Liberal n (%)	Neither Liberal or Conservative n (%)	Conservative n (%)	Very Conservative n (%)	Don't Know n (%)	Refused n (%)
Have you used marijuana in the past 12 months?	Yes	2 (18.18%)	16 (16.33%)	24 (20.34%)	10 (6.67%)	3 (9.09%)	3 (14.29%)	0 (0.00%)
	No	5 (45.45%)	39 (39.80%)	50 (42.37%)	62 (41.33%)	14 (42.42%)	10 (47.62%)	3 (42.86%)
	Refused	4 (36.36%)	43 (43.88%)	44 (37.29%)	78 (52.00%)	16 (48.48%)	8 (38.10%)	4 (57.14%)
Have you used marijuana in the past 30 days?	Yes	0 (0.00%)	11 (11.22%)	12 (10.17%)	5 (3.33%)	2 (6.06%)	1 (4.76%)	0 (0.00%)
	No	2 (18.18%)	5 (5.10%)	12 (10.17%)	5 (3.33%)	1 (3.03%)	2 (9.52%)	0 (0.00%)
	Refused	9 (81.82%)	82 (83.67%)	94 (79.66%)	140 (93.33%)	30 (90.91%)	18 (85.71%)	7 (100.00%)

In addition, respondents were asked what they would do if marijuana were legal, the top three responses are as follows: 68.3% (n=299) reported they would not use even if legal and available; 11.0% (n=48) reported they currently do not use, but would start using; and 12.3% (n=54) reported they currently use and would use the same amount.

Attitudes and Beliefs Regarding Marijuana, Alcohol, and Driving

Attitudes and Beliefs Regarding Marijuana and Driving

A majority of respondents (66.0%; n=289), agreed it is unsafe to drive after using marijuana. In addition, a majority of respondents (70.1%; n=307), agreed it is unsafe to drive under the influence of marijuana. Approximately 38% (n=168) of respondents, agreed with the statement that it was unsafe to drive within two hours of using marijuana. Figures 10 to 12 show the responses to: it is unsafe to drive after using marijuana; it is unsafe to drive under the influence of marijuana; and it is unsafe to drive within two hours of using marijuana, by county of the respondent. These figures display the distribution of responses by counties who had a majority agree, disagree, or remain neutral to the statements. Table A4 in Appendix D displays the frequencies of responses regarding attitudes and beliefs on marijuana use and driving.

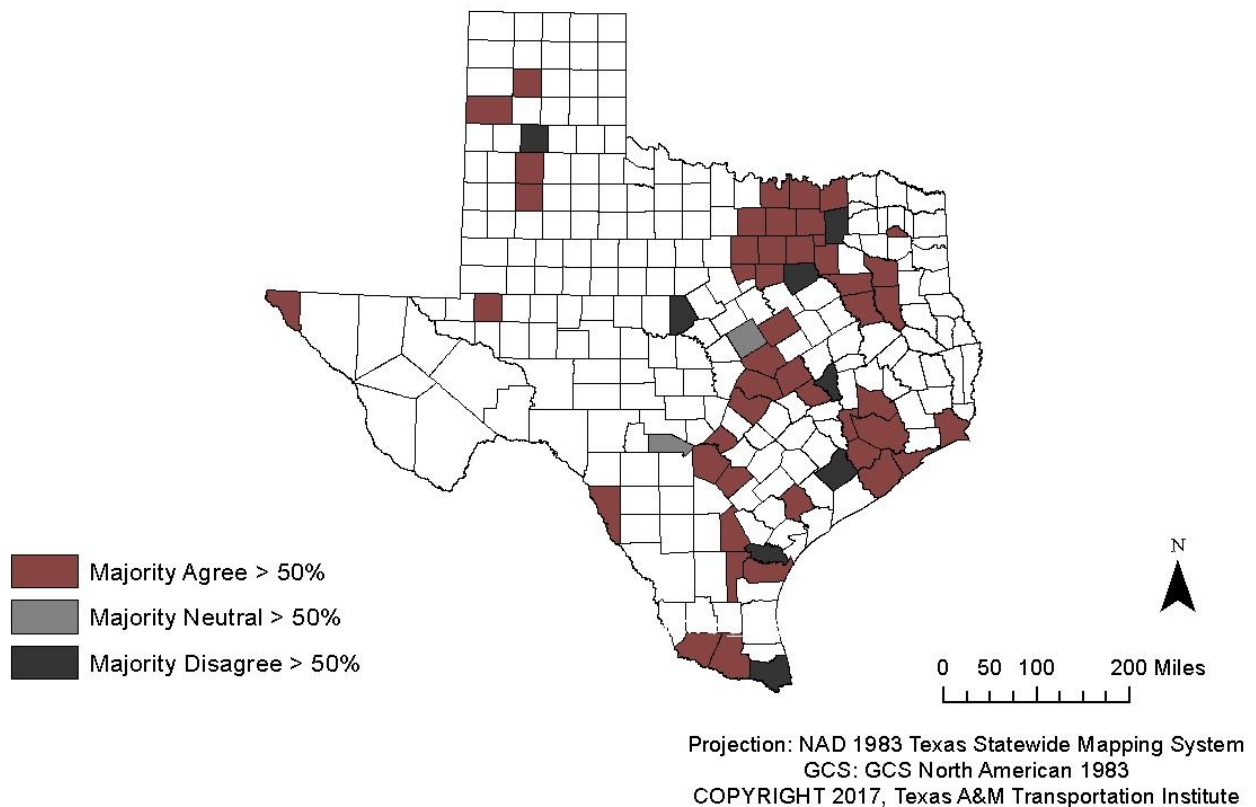


Figure 10. Responses to the Statement: It is unsafe to drive after using marijuana, by county.

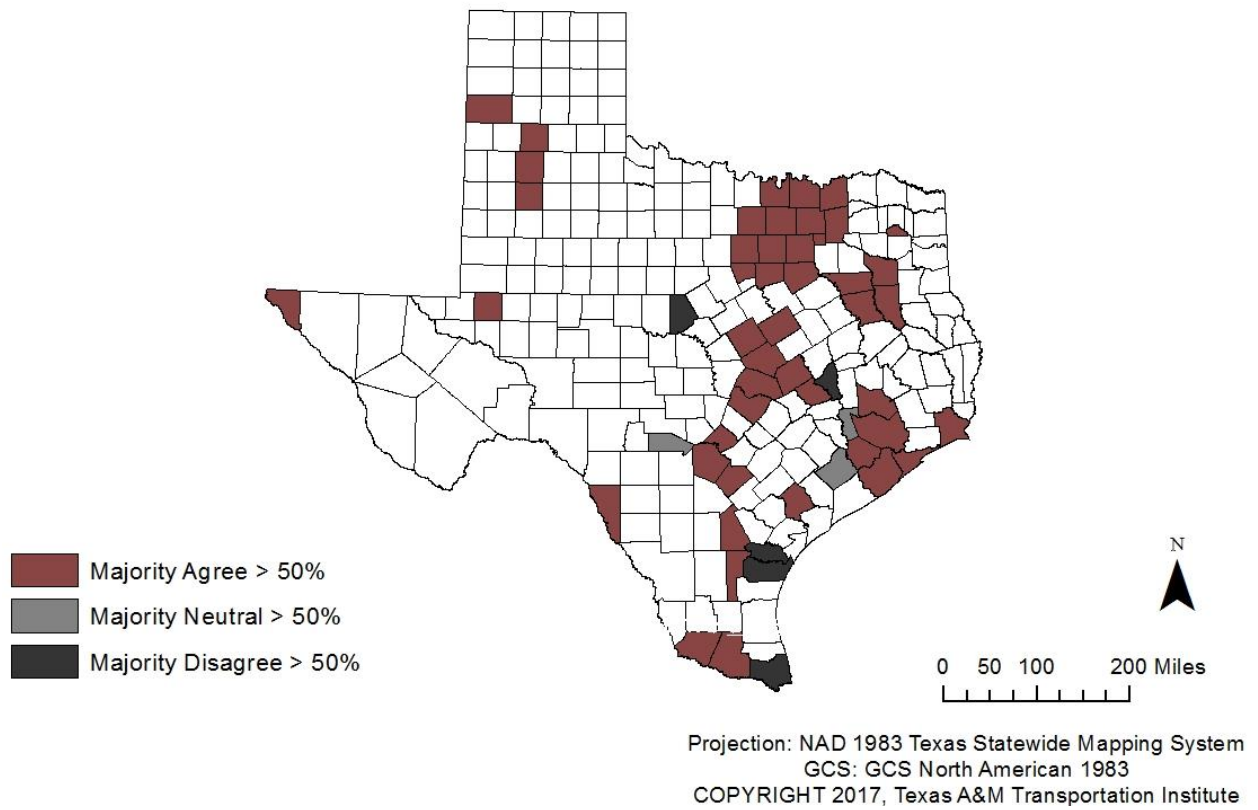


Figure 11. Responses to the Statement: It is unsafe to drive under the influence of marijuana, by county.

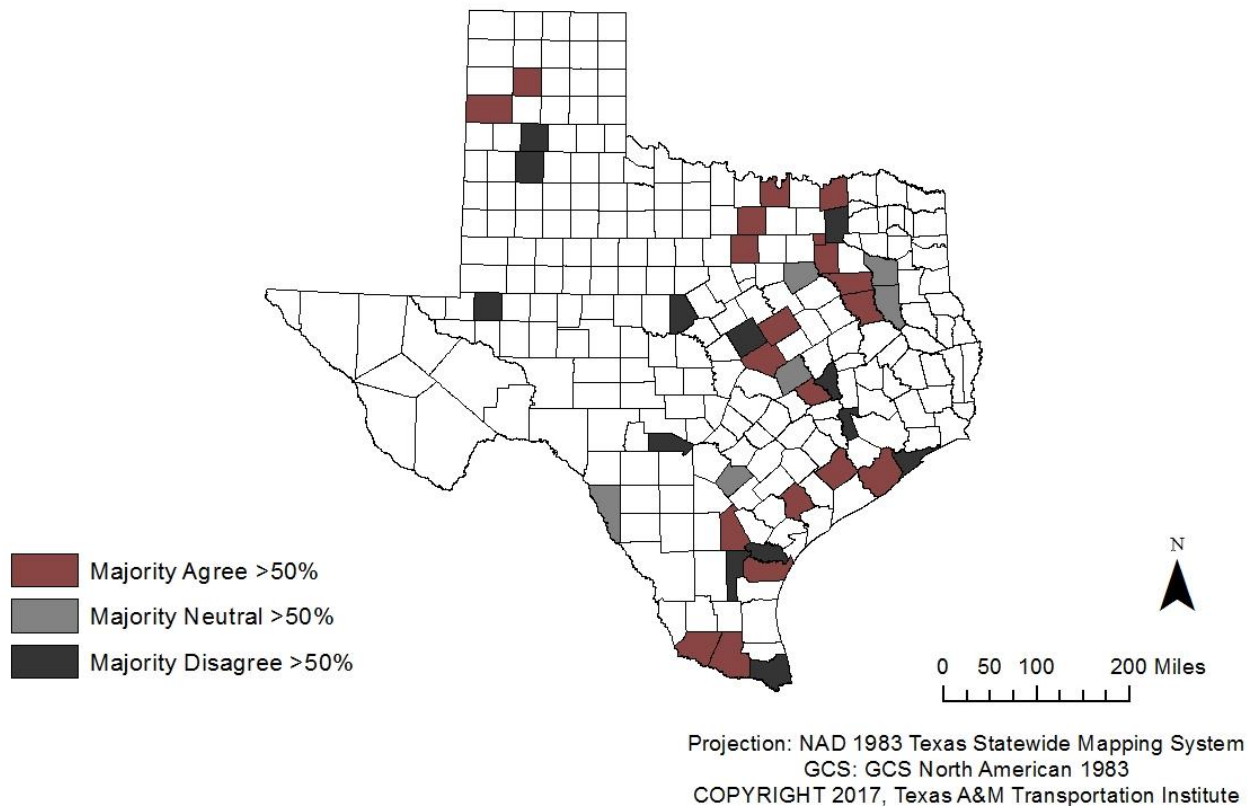


Figure 12. Responses to the Statement: It is unsafe to drive within two hours of using marijuana, by county.

Of the respondents, 55.3% agreed that drivers who use marijuana are more likely to be involved in a crash than drivers who don't. Further, 68.5% of respondents (n=300) stated that they would not feel safe riding in a car with a driver who used marijuana before driving, whereas 21.5% (n=94) stated they would feel safe.

Attitudes and Beliefs Regarding Marijuana, Alcohol, and Driving

Of the respondents, 89.5% (n=392) felt it was unsafe to drive after consuming alcohol and 92.7% (n=406) felt it is unsafe to drive after using alcohol and marijuana in combination.

Of the respondents, 39.5% (n=173) agreed and 34.0% (n=149) disagreed that driving under the influence of marijuana is safer than driving under the influence of alcohol. Figure 13 displays the responses by county to the statement: driving under the influence of marijuana is safer than driving under the influence of alcohol. Of the respondents, 39.0% (n=171) agreed that drivers under the influence of marijuana are less likely to get into a crash than drivers under the influence of alcohol, whereas 36.8% (n=161) disagreed with the statement.

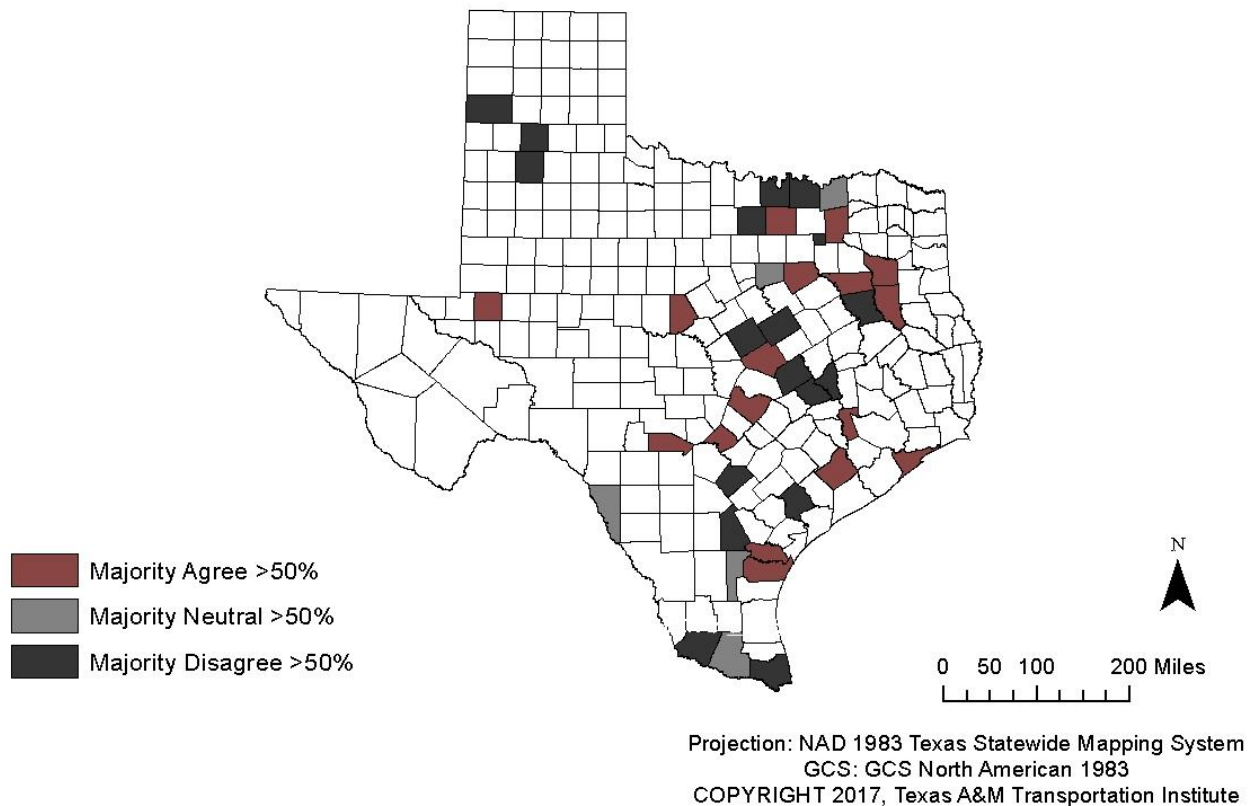


Figure 13. Responses to the Statement: Driving under the influence of marijuana is safer than driving under the influence of alcohol, by county.

In regards to punishment, 65.1% (n=285) agreed that drivers under the influence of marijuana should be penalized at the same level as drivers under the influence of alcohol, whereas 29.2% (n=125) of respondents disagreed with the statement. Table A5 in Appendix B displays the frequencies of responses regarding attitudes and beliefs on marijuana use, alcohol use, and driving.

[Attitudes and Beliefs Regarding Legalization of Marijuana](#)

A majority (87.5%, n=380) of respondents agreed that Texas should legalize marijuana for serious medical conditions (e.g., epilepsy, cancer). A smaller majority (78.8%; n=342) were in favor for legalizing marijuana for medical conditions such as arthritis, migraines, or any other illness for which marijuana provides relief. However, there were differing views on legalization for recreational purposes, 42.9% (n=188) agreed with legalization for recreational purposes and 45.7% (n=200) disagreed with legalization for recreational purposes. Figure 14 shows counties where a majority of respondents agreed, remained neutral, or disagreed with the various types of legalization.

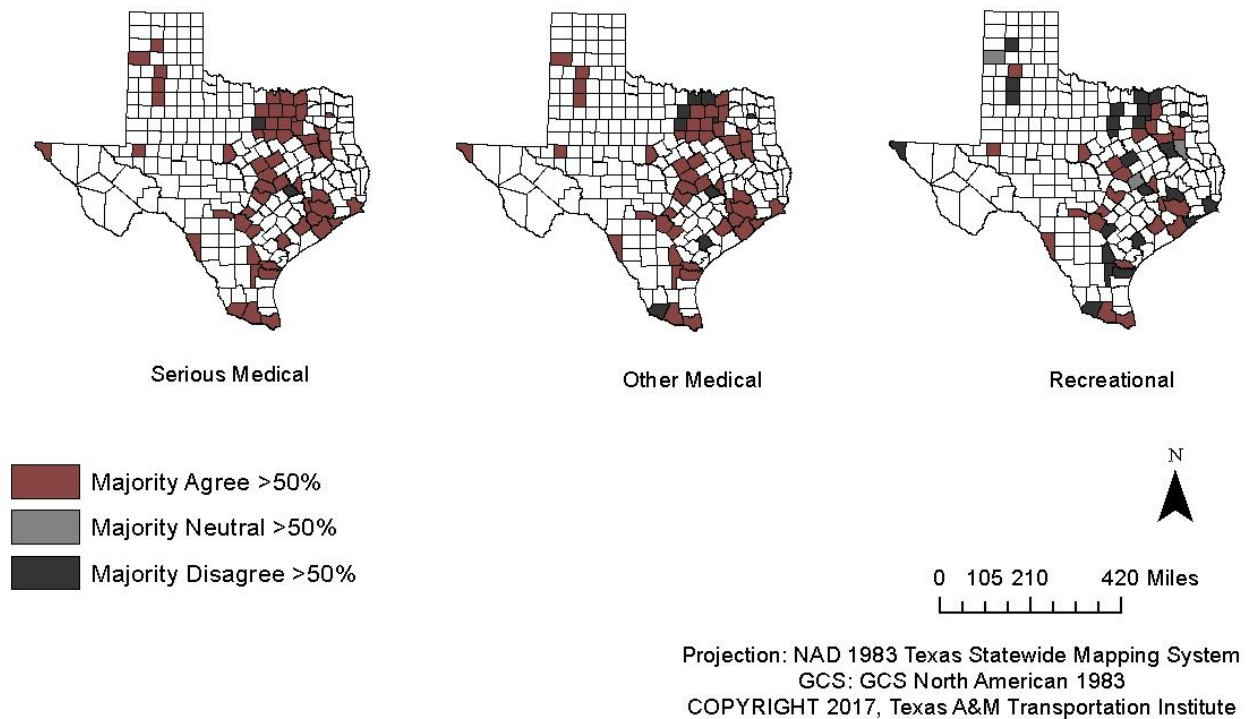


Figure 14. Responses for Type of Legalization, by County.

The next questions focus on what would happen if marijuana were legal. A majority (63.7%; n=279) of respondents agreed that if Texas were to legalize marijuana more people would start using. In addition, a majority (62.6%; n=274) of respondents agreed if legal more people would be willing to drive under the influence of marijuana.

In regards to identifying a blood drug concentration level that quantifies marijuana impairment at a per se level, a majority (80.4%; n=352) of respondents agreed this should happen if marijuana were legal. A majority (60.3%; n=264) of respondents also agreed that if marijuana were legal, drivers under the influence of marijuana should be arrested. Table A6 in Appendix D displays the frequencies of responses regarding attitudes and beliefs on legalization of marijuana.

Summary

The TTI survey findings are similar to other marijuana surveys in the United States, including the Marist College/Yahoo News Survey and the National Survey on Drug Use and Health (NSDUH). The Marist Poll is representative of each region in the United States, and interviewed 1,122 adults in the United States (Marist College 2017). The NSDUH is an annual survey of approximately 70,000 individuals aged 12 years and older in the United States (NSDUH 2017).

The NSDUH provides national and state-level estimates on tobacco, alcohol, and illicit drug use (NSDUH 2017).

The TTI survey results suggest that males were more likely to use marijuana compared to females. With 14.3% and 8.0% of males reported use in the past 12 months and 30 days, respectively 11.8% and 5.9% of females reported use. The Marist College Poll found that of those reported marijuana use 55% were male and 45% were female (Marist College 2017). However, the National Institute of Drug Abuse, has found that marijuana use is more common in females than males (NIH 2017).

The Marist Poll found that of national adults 18% believed marijuana has more of a health risk compare to tobacco use (Marist College 2017). The TTI survey findings agree with the Marist study in that 25.6% of respondents agreed that marijuana is less safe to use than tobacco. In regards to alcohol, the Marist Poll found that 18% of national adults believed marijuana was more of a health risk compared to alcohol (Marist College 2017). The TTI survey results are consistent with the Marist study which found that 20.8% of respondents agreed that marijuana is less safe to use than alcohol.

NSDUH reported that 19.8% of adults aged 18 to 25 years old and 6.5% of adults older than 26 years old reported using marijuana in the past month (Bose et al. 2015). The TTI survey results are consistent with the NSDUH survey which found that 20.5% of those aged 18 to 24 years old reported marijuana use in the past 30 days, whereas 5.8% of those aged 25 years old and older reported marijuana use in the past 30 days. The Marist Poll's results on marijuana use discovered that a majority of individuals using marijuana are millennials, that a majority do not have a college degree, and a marijuana users characterize themselves as liberal (Marist College 2017); which is consistent with the findings of the TTI survey.

The amount of refusals or missing answer for marijuana use in the past 12 months and past 30 days was alarming, but is consistent with results from other surveys. Specifically, the Marist College poll found that 40 to 45% of marijuana users hide their use in the United States (Marist College 2017).

The Marist Poll found that 83% of national adults supported legalizing the use of marijuana for medical treatment, with the lowest support coming from individuals who have not tried marijuana (70%) and those who do not use marijuana (78%) (Marist College 2017). Whereas, 49% of national adults supported legalizing marijuana for recreational use, with the highest support coming from individuals who use marijuana (89%), regularly use marijuana (93%), and those who have tried marijuana (70%) (Marist College 2017).

There were several limitations to the survey. First, the responses are not representative of the state, but of the top 25 counties with the highest per capita alcohol related fatalities in Texas.

While these counties are home to the majority of the population, caution should be given when generalizing these results to the entire state. In addition, survey results are not generalizable to the county level. Second, due to the high refusal rate/missing data for marijuana use in the past 12 months and 30 days caution should be taken when interpreting the results of this data as it may not be representative of the larger population. Third, as with all survey data, there is the possibility of recall bias, which is when individuals may not recall events correctly. This is particularly impactful when asking respondents about their first experience with marijuana, marijuana use in the past 12 months and marijuana use in the past 30 days. Fourth, there is inherently some degree of response bias due to the relatively low response rate. Finally, due to the phone interview format of this survey, there is the potential for interviewer bias in which individuals may have given different answers depending on who the interviewer is or what they think the interviewer wants to hear.

However, there were many strengths associated with this survey as well. One such strength is that the survey addressed the attitudes and beliefs of respondents regarding marijuana and driving, which many other surveys have not captured. Another strength of the survey was use of dual-frame sampling which captured populations without landlines, such as younger adults and ethnic or racial minorities.

As the national discussion on marijuana legalization continues, it is critical to understand the attitudes and beliefs of the population in regards to marijuana, and marijuana impaired driving. Through understanding the population's beliefs and attitudes towards marijuana, appropriate policies and countermeasures can be developed and implemented to reduce the potential negative impact of marijuana legalization.

Subject Matter Expert Panel

In order to better understand the impacts and challenges legalization of marijuana poses, investigators for this project conducted a Subject Matter Expert (SME) panel to discuss the tangible steps to address potential traffic safety impacts of marijuana legalization. This panel discussion provided investigators with a first-hand look at the challenges of legalization of marijuana, both for medicinal and recreational purposes, implementation the SME's faced as well as recommendations for other states moving forward with decriminalization. During the course of the panel discussion, several themes emerged as recommendations for other states that include: developing well-thought out policies based on scientific research; utilizing available data to understand how marijuana legalization impacts traffic safety; and developing partner relationships with marijuana industry stakeholders is crucial to prevent impaired driving.

Location Selection

To select a location to host the SME panel, project investigators for the Texas A&M Transportation Institute (TTI) compiled a list of five states that legally allow medicinal use of marijuana. These states included: Arizona, Hawaii, Minnesota, New Mexico, and New York. Investigators also compiled a list of five states that have legalized recreational use of marijuana. These states included: Alaska, Colorado, Oregon, Washington, and Washington D.C.

Ultimately, Colorado was selected as the location for the SME panel due to their experience with legalization of marijuana for both medicinal and recreational purposes. In addition, traffic safety partners in Colorado are regarded by many in the traffic safety community as pioneers and leaders in addressing marijuana induced impaired driving and crash issues.

SME Recruitment and Meeting Attendees

In order to recruit the most appropriate SMEs, who could share valuable insights and lessons learned, the investigative team worked with Glenn Davis, Highway Safety Manager for the Colorado Department of Transportation (CDOT). Mr. Davis supervises the Impaired Driving Program area for the state of Colorado, and works very closely with the types of experts the investigating team hoped to meet with. Through Mr. Davis, the investigating team identified nine SMEs to attend and participate in the panel discussion.

Attendees of the SME panel discussion included:

- Jim Burack – Colorado Department of Revenue, Marijuana Enforcement Division Director
- Sam Cole – Colorado Department of Transportation, Communications Manager
- Glenn Davis – Colorado Department of Transportation, Highway Safety Manager

- Major Steve Garcia – Colorado State Patrol, Commander District One (Metropolitan Denver)
- Carol Gould – Colorado Department of Transportation, Highway Safety Manager
- Brenna Hersey – Amelie Company, Account Supervisor
- Kristi Kelly – Marijuana Industry Group, Executive Director
- Chief Robert Ticer – Loveland Police Department, Chief of Police
- Patrick Witcher – Buddy Boy Brands, President

Appendix E contains short biographies for all SMEs present at the panel discussion.

Panel Discussion

In partnership with Glenn Davis and the CDOT, the panel discussion was scheduled and held on April 4, 2017, in Denver, CO. The panel discussion ran from 8:00am to 3:30pm.

Prior to the panel discussion, the investigative team met to discuss themes and concepts. Through the panel discussion, the investigative team sought to gain qualitative insight on:

- The creation of laws and policies, specifically with regard to the regulation of the marijuana industry
- How highway safety programming has been created to address marijuana-impaired driving
- How the highway safety office works with the marijuana industry to promote and facilitate traffic safety
- How the marijuana interest groups worked with the state to pass sensible legislation
- After legalization, what is the interest group's role and what is being done to facilitate traffic safety

To ensure that each of these themes was explored, discussion sessions were developed and placed on an agenda. This enabled the discussion to flow and allowed SME panel participants to attend sessions that most closely fit their expertise and excuse themselves from other sessions. Appendix F contains a full agenda of the panel discussion.

On April 5, 2017, members of the investigative team who traveled to Denver were able to tour a Buddy Boy Brands facility. Through this tour, investigative team members were educated about the different types of marijuana grown for both medicinal and recreational use. In addition, team members were able to observe how the Marijuana Enforcement Division (MED) seed-to-sale tracking mechanisms are employed in the day to day operations of a marijuana grow facility and dispensary. Seed-to-sale tracking mechanisms are employed in Colorado to prevent the disappearance of products grown and cultivated for retail sale in the recreational market. In a seed-to-sale model, all marijuana grown for retail sales, whether for medicinal or

recreational use, is tracked from the time it is planted as a seed, or more likely cloned from a mature plant, until it is sold to a consumer. Typically, a plant is assigned a tracking number and tag, which remain with the plant until it is packaged for the consumer. This allows the MED to track and regulate all marijuana being grown in the state at any given time.

Discussion

Each session of the SME panel discussion lasted for approximately one hour. During this time, the investigative team posed a series of questions to the SME panel in order to better understand the impacts of marijuana legalization on traffic safety and how the state of Colorado works with the marijuana industry to promote traffic safety.

Creation of Laws and Policies to Regulate the Marijuana Industry

Colorado originally legalized marijuana in 2000 with the passage of Amendment 20. This law created what is known as the Caregiver Model allowed for the medicinal use of marijuana. Under this law, patients were allowed to grow and possess up to 6 plants per patient, which generally equated to 2 ounces of marijuana. At this time, the Medical Marijuana Enforcement Division (MMED) was created under the Colorado Department of Revenue to enforce this law. While this amendment created the foundation for medicinal use of marijuana, it did not provide any framework for regulation to the burgeoning industry.

In 2010, House Bill 10-1284 (HB 10-1284) was passed. This particular bill created a regulatory structure for the medicinal marijuana industry, which were used to inform the industry norms and culture. Further, it provided for regulation of cultivations, product manufacturers, and centers, which were already operating under Amendment 20. This bill also provided regulations for new businesses wishing to join the industry. In addition it created the Marijuana Enforcement Division (MED) to regulate the marijuana industry and enforce the rules developed under HB 10-1284.

Finally, in 2012, Amendment 64 was passed which allowed the legal recreational use of marijuana. Under this amendment, individuals 21 years old or older are allowed to: possess, use, display, purchase, transport, and transfer (without remuneration) to individuals 21 years old or older one ounce or less of marijuana. Further, individuals are allowed to continue to grow their own marijuana plants. The 64th amendment regulated the growth, manufacture, and sale of retail marijuana and as a consequence, a system of licensed marijuana establishments were created. While this system is primarily monitored by MED, it is also overseen by other state and local authorities. Of important note, Colorado is a local control state, which means that many local ordinances regulate the time, place and manner of sale of marijuana based upon their individual community standards. These local ordinances can and do go beyond the minimum requirements of the state laws.

As a result of Amendment 64, Colorado has developed a two license system, medicinal and recreational. Under each system, there are both state and local licensing rules and policies, which industry must comply with. License types include: stores/center, cultivation, infused product manufacturers, testing facilities, operators, and transporters. Enforcement authority for both systems rests with the MED.

The primary difference between the two systems, is the amount of tax that the consumer will pay for their product. If marijuana is purchased under the medicinal system, the consumer is charged 2.9% sales and local taxes on their purchase. If the marijuana is purchased under the recreational system, the consumer is charged approximately 25% in sales and excise taxes on their purchase. In order to purchase in the medicinal system, a consumer must apply to the Medical Marijuana Registry and be granted a “Purple Card” by the Colorado Department of Public Health and Environment (CDPHE). To qualify, a patient must apply and have a recommendation from their physician to use marijuana for medicinal purposes. Currently, the CDPHE has issued around 95,000 cards for medicinal marijuana use among holders. However, SMEs stated there are some consumers who are using marijuana for medicinal purposes who chose to utilize the retail system for a multitude of reasons, such as not wanting to be on the Medical Marijuana Registry as well as other legal concerns.

[Highway Safety Programming Created to Address Marijuana Impaired Driving](#)

Many SMEs in Colorado recognized the need to be proactive to address marijuana impaired driving. SMEs recognized the changing culture around marijuana use in their state as medicinal use of marijuana was passed and more medicinal marijuana use cards were issued each year. This recognition led to awareness campaigns around the dangers of driving under the influence of marijuana before legalized use of recreational marijuana.

SMEs indicated the “Drive High, Get a DUI” campaign was in direct response to the legalization of recreational use of marijuana. This campaign sought to address the knowledge gaps of residents of Colorado. SMEs expressed the campaigns have evolved over time to continue to address the needs and knowledge gaps of users and the general public.

SMEs representing law enforcement expressed that the legalization of marijuana, both for medicinal and recreational use, has not changed the enforcement of impaired driving. However, the types of conversations officers are having with users has changed, which has freed up officers for other enforcement activities. SMEs expressed the need to adapt officers’ ways of thinking and investigating impaired driving to quickly identify and determine impairment by marijuana.

In addition, if an officer suspects marijuana impairment, they are encouraged to get blood drawn from the suspect as quickly as possible instead of completing the full Drug Recognition

Expert (DRE) evaluation protocol first. SMEs expressed support for training as many law enforcement officers as possible in Advance Roadside Impaired Driving Enforcement (ARIDE), as well as training officers who already have these foundational skills in DRE. If officers do not have the basic impaired driving apprehension skills, they are unlikely to be successful in the DRE training program.

All SMEs were in agreement that data is needed to understand the impact of marijuana legalization on traffic safety. This is an area Colorado has struggled to capture due to the limitations of the data collected. SMEs explained that due to Colorado's data it has been challenging to understand the effect legalization of marijuana has had on traffic safety, despite all SMEs being interested in using data driven approaches to preventing impaired driving. A recommendation was made for a state data coordinator to examine all of the data related to impaired driving, including marijuana impaired driving.

Further, SMEs recommended that should legalization of marijuana occur, either medicinal or recreational, Texas' Highway Safety Office should be prepared to negotiate for their portion of the tax money collected to implement programs and countermeasures to address marijuana impaired driving. In addition, SMEs recommended Texas' Highway Safety Office consider a implementing a full time Program Manager who focuses solely on marijuana impaired driving issues, as this issue has generated enough work for a full time position in their state.

Finally, as a part of the culture change, and movement towards legalization, SMEs recommended forming partnerships with marijuana industry interest groups. The SMEs stressed the importance of having representation from the marijuana industry on their Statewide Impaired Driving Task Force (SIDTF).

[Partnership Between the Highway Safety Office and Marijuana Industry Groups](#)

SMEs were in agreement that partnership between the Highway Safety Office and the marijuana industry interest groups is crucial to traffic safety and the prevention of marijuana impaired driving. In order for partnerships to be successful, it is critical to move away from the merits of the issue and focus on implementing the legislation safely and responsibly.

For Colorado, all partnerships and activities take place at their SIDTF. Further, in Colorado, this partnership developed organically as marijuana industry representatives began attending SIDTF meetings as a member of the public. Many of the SMEs present commented the marijuana industry representatives are savvy, professional business people. While traffic safety is not their primary focus, marijuana industry representatives recognize impaired driving with marijuana is a safety issue and they do not want to contribute to increasing impaired driving in their state. The marijuana industry wants to be a part of the shared solution by working with

traffic safety partners in order to increase opportunities for reducing drug impaired driving crashes, injuries and deaths.

SMEs representing the marijuana industry present cautioned Texas, that in a new market, shortly after legalization, the state will be working with many startup businesses. Unlike Colorado, who is now working with more mature businesses with the flexibility to work to address traffic safety. Representatives of the marijuana industry expressed the industry grows quickly, and will become more engaged in the issues of traffic safety as the businesses mature.

To identify potential partners in traffic safety, it was recommended stakeholders and SIDTF leadership attend legislative hearings and being engaged in the discussion towards legalization of marijuana. It was recommended that Texas identify potential partners whose values align with the mission of the SIDTF. However, SMEs cautioned taking our time in forming partnerships.

[The Marijuana Industry Interest Groups Role Post Legalization](#)

Overall, all SMEs present agreed there is place for marijuana industry representation in traffic safety and impaired driving prevention, whether this be in partnership with the SIDTF or independently. Further, opportunities exist for interested representatives from the marijuana industry to engage with other stakeholders, through SIDTF meetings, and independently through marijuana industry groups.

SMEs representing the marijuana industry strongly agreed that industry partners are stakeholders in traffic safety and that they have an interest in preventing impaired driving. SMEs stressed the importance of following the Cole Memorandum, the federal government's guiding document to states on how to handle the legalization of marijuana. As a part of the Cole Memorandum, the marijuana industry is called to prevent drug impaired driving. The Cole Memorandum, written by US Deputy Director General James Cole, instructs state prosecutors not to interfere with state marijuana legalization efforts (NORML 2017). Further, the Cole Memorandum provides a guide to those licensed to engage in marijuana production and sale (NORML 20107). The memorandum instructs the marijuana industry not to engage in marijuana sales to minors and not to sell marijuana to states that have not legalized its use, as well as to prevent drug impaired driving among other guidelines.

[Recommended Best Practices](#)

Over the course of the panel discussion, many themes and recommended best practices emerged from the conversation. These best practices are synthesized into the following list:

- Each state approaching the subject of marijuana legalization, should take time in developing legislation and policies. This will ensure that policies are well developed, thought through, and based on scientific research.
- Understanding the available data is crucial. States should know their baseline data, both crash-related and arrest-related, so they are prepared to answer questions about how marijuana legalization impacts traffic safety. Understanding baseline data will also be important to targeting countermeasures and enforcement activities. Data should reflect measurable results and outcomes and provide information to policy and decision makers at the local and state levels.
- Relationship development with the marijuana industry groups is crucial. Building strong relationships and partnerships will only help prevent impaired driving in the state.
- Highway Safety Office should be prepared and negotiate for a piece of the marijuana taxation money to pay for additional programs, countermeasures, and staff needed to manage the impact of marijuana legalization on traffic safety. Texas should consider a full time position dedicated to marijuana impairment at the state level (such as a Program Manager at TxDOT).
- It is important to continue to train law enforcement officers on the detection of impaired driving. All law enforcement officers need the foundational skills Standardized Field Sobriety Testing (SFST) training teaches. In addition, impaired driving investigation skills are crucial for law enforcement officers to detect impaired drivers. Continuing and increasing Advanced Roadside Impaired Driving Enforcement (ARIDE) and Drug Recognition Expert (DRE) training for officers is important in detecting marijuana (and other drug) impaired driving.
- It is important to find meaningful ways for media and outreach campaigns to resonate with the public about understanding that use is legal but there are consequences associated with unsafe use (i.e. vehicle operation while high, distribution or sale to persons under 21 years of age, etc.). States should realize the critical importance of culture shifts from the perspective of both law enforcement and marijuana users.
- The Colorado industry is set up into a two license system (medical and recreational). Keeping the system separated into two systems allows for medical needs patients to receive tax savings at a rate of 2.9% over the recreational excise and sales tax of 25%.
- Local en-action (city or county ordinance) can be conducted to strengthen local regulatory control but cannot be used to weaken it. Further, it is strongly recommend states, and local communities, should follow the Cole Memorandum to stay compliant with all federal standards.
- Finally, consideration should be given to any unintended consequences of implementing program or countermeasure elements. While the elements may be

meaningful, additional associated hidden costs could limit effectiveness and implementation.

Summary

Over the course of two days, the SMEs of Colorado imparted many pieces of wisdom and lessons learned through the marijuana legalization processes. During the course of the panel discussion, several themes emerged as recommendations for other states: develop well-thought out policies based on scientific research; utilize available data to understand how marijuana legalization impacts traffic safety; and develop relationships with marijuana industry stakeholders to prevent impaired driving. In addition, the SMEs made several recommendations to the research team in terms of marijuana legalization and traffic safety, which have been synthesized into a list of recommended best practices. Each of the SMEs present expressed interest in Texas implementing policies which would be practical and based on scientific research.

Discussion

With the passage of legislation legalizing the medicinal and recreational use of marijuana, the culture surrounding its use is changing. Studies show marijuana is the most commonly used illicit drug in the United States (Adrian, 2015). Studies also indicate that marijuana use is increasing over time (Azofeifa et al., 2015; Otto et al., 2016; Reed, 2016). In terms of using marijuana and driving, marijuana use among drivers exceeds the rate of alcohol use among drivers (Fergusson et al., 2008; Scherer et al., 2013; Li et al., 2016). In addition, adolescents appear to be much more accepting of smoking THC and driving than drinking alcohol and driving (Patton & Brown, 2002; Fischer et al., 2006; Glasscoff & Haddock, 2013; Ashton et al., 2016; Li et al. 2016).

Further, drivers aged 20 years old and younger are far more likely than adults aged 21 to 34 years old to use marijuana (Buchan et al., 2000; Voas et al., 2013; Azofeifa et al., 2015; Arnold & Tefft, 2016; Kann, 2016). The TTI survey results are consistent with previous studies, which found that 20.5% of those aged 18 to 24 years old reported marijuana use in the past 30 days, whereas 5.8% of those aged 25 years old and older reported marijuana use in the past 30 days. In addition, the Marist Poll's results on marijuana use discovered that a majority of individuals using marijuana are millennials, that a majority do not have a college degree, and a marijuana users characterize themselves as liberal (Marist College 2017); which is consistent with the findings of the TTI survey.

Survey results also suggest that males were more likely to use marijuana compared to females. With 14.3% and 8.0% of males reported use in the past 12 months and 30 days, respectively 11.8% and 5.9% of females reported use.

Perhaps as a byproduct of the cultural changes surround marijuana use, the number of fatal crashes in which the driver is positive for cannabinoids and its proportion to all fatal crashes is steadily increasing, from 1,957 in 2008 to 2,769 in 2015. According to the descriptive analysis, gender and age are overrepresented factors in fatal crashes for drivers who tested positive for cannabinoids. Male drivers and younger drivers (16 to 24 years old) are more likely to test positive for cannabinoids in fatal crashes.

Interestingly, this analysis found the number of drivers who tested positive for cannabinoids involved in fatal crashes increased in 2014 and 2015 in all states selected for analysis, regardless of their status as a state with legal medicinal and/or recreational use of marijuana, neighbor to a state with legal recreational use of marijuana or neither legal medicinal or recreational use of marijuana nor a neighboring state. This suggests the impact of the legalization of marijuana is not bound by the geographic boundary of states.

However, this study is not without limitations. There were several limitations to the survey and crash analysis. First, the responses are not representative of the state, but of the top 25 counties with the highest per capita alcohol related fatalities in Texas. Second, due to the high refusal rate/missing data for marijuana use in the past 12 months and 30 days caution should be taken when interpreting the results of this data as it may not be representative of the larger population. Third, as with all survey data, there is the possibility of recall bias, which is when individuals may not recall events correctly. Fourth, there is inherently some degree of response bias due to the relatively low response rate. Finally, due to the phone interview format of this survey, there is the potential for interviewer bias in which individuals may have given different answers depending on who the interviewer is or what they think the interviewer wants to hear.

Limitations of the crash analysis are primarily centered on limitations of FARS data. These limitations include not all drivers involved in fatal crashes are tested for presence of impairing substances. In addition, if toxicology testing is conducted on the deceased driver, testing varies state by state. This variance includes substances tested for as well as cut off levels for each of these substance. Further, reporting deceased driver toxicology results to FARS varies state by state. An additional limitation of the FARS data is that a positive drug test result in the FARS database does not indicate the driver was impaired at the time of the crash. Perhaps the largest limitation of the FARS data is the data does not differentiate between drivers who have tested positive for the active impairing metabolite THC and those who test positive for the inactive metabolite 11-COOH-THC (THC-COOH). Making it extremely difficult to draw conclusions about the impairment of the driver and the effects of cannabis on fatal crashes.

Despite these limitations, this study was able to explore the impact of legalization of marijuana for medicinal or recreational use on fatal crashes from 2008-2015 in the United States. Fatal crashes involving a driver who is positive for cannabinoids are becoming a growing traffic safety concern in the United States. It is likely fatal crashes involving cannabinoid-positive drivers will continue to be an issue as more states move to legalize marijuana for medicinal and recreational use.

Recommendations

Based on the results of the literature review, policy review, crash analysis, and SME panel workshop, several recommendations for policy makers and future research have been developed.

If Texas were to legalize marijuana for medicinal purposes, policymakers should consider the requirements and rules of the program prior to the implementation of such laws. Prior to implementation, state leaders must consider potential patient qualifications for the program, such as medical conditions that will qualify a patient to participate. As noted in the policy review, there are many medicinal conditions such as cancer, HIV/AIDS, and glaucoma, where marijuana is recognized as a medical treatment by some states. Thought should also be given to developing a marijuana registry identification program prior to implementation of the program. Many states have established such a registry program, with varying exemptions. State leaders should consider whether to make registration mandatory or optional.

If Texas were to legalize marijuana for recreational use, policymakers should consider the possession limits and rules of the program prior to the implementation of such laws. Texas should consider potential possession limits, both in public and in one's own home. Many states have adopted differing limits of possession and allow for possession of a larger quantity in one's residence. In addition, state leaders must consider whether to allow personal cultivation. Many states allow individuals to grow their own marijuana plants for personal consumption, but choose to limit the number of plants, both mature and immature. However, some, such as Washington bans such growth.

Finally, consideration should be given to which agency is best suited to manage the medicinal and recreational marijuana programs in the state. Some states house their medicinal and recreational marijuana program regulation in the state health department while others choose to utilize an agency responsible for collecting taxes and revenue. Others still have chosen to utilize their alcohol-regulating agency to regulate the medicinal and recreational marijuana industry. State leaders should consider which agency will be best suited to monitor and regulate the medicinal and recreational marijuana industry.

Based on the opinions of SMEs in Colorado, it is critical policy makers evaluate these considerations prior to policy implementation, which will ensure marijuana-related policies are well developed with as few unintended consequences as possible.

Additional research efforts must be undertaken to determine the effect of evolving marijuana policy on traffic crashes. An evaluation of the currently available data should be conducted in order to determine the baseline crash and arrest rates so Texas is prepared to determine the

impacts of marijuana legalization in the state. In addition, this baseline information will aid in targeting countermeasures and enforcement activities to deter marijuana impaired driving.

Despite the large body of literature that exists examining the effects of marijuana on the body and driving task, the impacts of the legalization of marijuana for medicinal and recreational purposes on traffic safety remain unclear. As a result, a complete strengths, weaknesses, opportunities, and threats assessment of medicinal and recreational marijuana legalization policies would be beneficial. The outcome of this assessment could inform the selection and implementation of countermeasures to detect and deter marijuana impaired driving.

In order to understand the impact of the legalization of marijuana on traffic safety, a before-after analysis using all severity crash data and driving under influence (DUI) citation data could provide better idea on the impact of marijuana legalization on traffic safety. Further, an in-depth analysis of the marijuana-related crash reports could provide insight into common crash factors and common characteristics of marijuana-related crashes.

Finally, further surveying of specific populations, such as adults age 18 – 24, to understand their opinions and behaviors related to marijuana legalization, use and driving. A better understanding of specific groups opinions and behaviors could inform the implementation of countermeasures to detect and deter marijuana impaired driving.

As the national discussion on marijuana legalization continues, it is critical to understand the attitudes and beliefs of the population in regards to marijuana, and marijuana impaired driving. Through understanding the population's beliefs and attitudes towards marijuana, appropriate policies and countermeasures can be developed and implemented to reduce the potential negative impact of marijuana legalization.

References

- Adrian, M. (2015). What the History of Drugs Can Teach Us About the Current Cannabis Legalization Process: Unfinished Business. *Substance use & misuse*, 50(8-9), 990-1004.
- Allen, J. A., Davis, K. C., Duke, J. C., Nonnemaker, J. M., Bradfield, B. R., Farrelly, M. C., ... & Zarkin, G. A. (2016). Association between self-reports of being high and perceptions about the safety of drugged and drunk driving. *Health education research*, 31(4), 535-541.
- Allen, R. W., Stein, A. C., & Hogue, J. R. (1982). Effects of alcohol and marihuana on driver control behavior in a driving simulator. Phase 1 (No. STI-TR-1066-1).
- Anderson, B. M., Rizzo, M., Block, R. I., Pearlson, G. D., & O'Leary, D. S. (2010). Sex differences in the effects of marijuana on simulated driving performance. *Journal of psychoactive drugs*, 42(1), 19-30.
- Anderson, D. M., Hansen, B., & Rees, D. I. (2013). Medical marijuana laws, traffic fatalities, and alcohol consumption. *Journal of Law and Economics*, 56(2), 333-369.
- Arcuri, A. (2013). Driving under the influence of cannabis: a brief review of the literature. Available at: www.ncpic.org.au
- Arnold, L & Tefft, B. (2016). *Driving Under the Influence of Alcohol and Marijuana: Beliefs and Behaviors, United States, 2013-2015*. Washington, DC: AAA Foundation for Traffic Safety.
- Asbridge, M., Hayden, J. A., & Cartwright, J. L. (2012). Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis. *Bmj*, 344, e536.
- Asbridge, M., Poulin, C., & Donato, A. (2005). Motor vehicle collision risk and driving under the influence of cannabis: evidence from adolescents in Atlantic Canada. *Accident Analysis & Prevention*, 37(6), 1025-1034.
- Aston, E. R., Merrill, J. E., McCarthy, D. M., & Metrik, J. (2016). Risk Factors for Driving After and During Marijuana Use. *Journal of studies on alcohol and drugs*, 77(2), 309-316.
- Attwood, D. & Williams, R. (1980). Braking performance of driver under the influence of alcohol and cannabis. 24th Annual Meeting, Proceedings of the Human Factors Society. Los Angeles, CA.
- Attwood, D., Williams, R., McBurney, L., & Frecker, R. (1980). Cannabis, alcohol and driving: Effects on selected closed-course tasks. *Alcohol, Drugs, and Traffic Safety*, 3, 938-953.
- Azofeifa, A., Mattson, M. E., & Lyerla, R. (2015). Driving under the influence of alcohol, marijuana, and alcohol and marijuana combined among persons aged 16–25 years — United States, 2002–2014. *MMWR*, 64(48), 1325-9.
- Baldock, M. (2007). Review of the literature on cannabis and crash risk. Centre for Automotive Safety Research.

- Baldock, M. R. J., & Lindsay, V. L. (2015). Examination of the role of the combination of alcohol and cannabis in South Australian road crashes. *Traffic injury prevention*, 16(5), 443-449.
- Banta-Green, C., Rowhani-Rahbar, A., Ebel, B., Andris, L., & Qiu, Q. (2016). Cannabis use among drivers suspected of driving under the influence or involved in collisions: Analysis of Washington State Patrol data. Washington, DC: AAA Foundation for Traffic Safety.
- Barnett, G., Licko, V., & Thompson, T. (1985). Behavioral pharmacokinetics of marijuana. *Psychopharmacology*, 85(1), 51-56. <http://dx.doi.org/10.1007/bf00427321>
- Battistella, G., Fornari, E., Thomas, A., Mall, J. F., Chtioui, H., Appenzeller, M., & Giroud, C. (2013). Weed or wheel! FMRI, behavioural, and toxicological investigations of how cannabis smoking affects skills necessary for driving. *PloS one*, 8(1), e52545.
- Bech, P., Rafaelsen, L., & Rafaelsen, O. (1973). Cannabis and alcohol: Effects on estimation of time and distance. *Psychopharmacologia*, 32(4), 373-381. <http://dx.doi.org/10.1007/bf00429474>
- Bédard, M., Dubois, S., & Weaver, B. (2007). The impact of cannabis on driving. *Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique*, 6-11.
- Bergeron, J., & Paquette, M. (2014). Relationships between frequency of driving under the influence of cannabis, self-reported reckless driving and risk-taking behavior observed in a driving simulator. *Journal of safety research*, 49, 19-e1.
- Bergeron, J., Langlois, J., & Cheang, H. S. (2014). An examination of the relationships between cannabis use, driving under the influence of cannabis and risk-taking on the road. *Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology*, 64(3), 101-109.
- Berghaus, G., Scheer, N., & Schmidt, P. (1995, August). Effects of cannabis on psychomotor skills and driving performance-a metaanalysis of experimental studies. In *Proceedings of the 13th International Conference on Alcohol, Drugs and Traffic Safety*. Adelaide, Australia: The University of Adelaide, NHMRC Road Accident Research Unit (pp. 403-409).
- Biasotti, A. A., Boland, P., Mallory, C., Peck, R., & Reeve, V. C. (1986). Marijuana and Alcohol: A Driver Performance Study.
- Binder, A. (1971). An experimental approach to driver evaluation using alcohol drinkers and marihuana smokers. *Accident Analysis & Prevention*, 3(4), 237-256.
- Bingham, C. R., Shope, J. T., & Zhu, J. (2008). Substance-involved driving: Predicting driving after using alcohol, marijuana, and other drugs. *Traffic injury prevention*, 9(6), 515-526.
- Bingham, C. R., Shope, J. T., & Zhu, J. (2008). Substance-involved driving: Predicting driving after using alcohol, marijuana, and other drugs. *Traffic injury prevention*, 9(6), 515-526.
- Blows, S., Ivers, R. Q., Connor, J., Ameratunga, S., Woodward, M., & Norton, R. (2005). Marijuana use and car crash injury. *Addiction*, 100(5), 605-611.
- Bosker, W. M., Kuypers, K. P., Theunissen, E. L., Surinx, A., Blankespoor, R. J., Skopp, G., . . . Ramaekers, J. G. (2012). Medicinal Δ^9 -tetrahydrocannabinol (dronabinol) impairs on-

- the-road driving performance of occasional and heavy cannabis users but is not detected in Standard Field Sobriety Tests. *Addiction*, 107(10), 1837-1844.
doi:10.1111/j.1360-0443.2012.03928.x
- Brady, J. E., & Li, G. (2014). Trends in alcohol and other drugs detected in fatally injured drivers in the United States, 1999–2010. *American journal of epidemiology*, 179(6), 692-699.
- Bramness, J. G., Khiabani, H. Z., & Mørland, J. (2010). Impairment due to cannabis and ethanol: clinical signs and additive effects. *Addiction*, 105(6), 1080-1087.
- Buchan, B. J., Urmann, C., Hamilton, N. L., & Tims, F. M. (2000). Marijuana use and impaired driving behavior among adolescents in Pinellas County, Florida. In *Proceedings International Council on Alcohol, Drugs and Traffic Safety Conference* (Vol. 2000). International Council on Alcohol, Drugs and Traffic Safety.
- Burston, J., Mann, R., Le Foll, B., Stoduto, G., Wickens, C., Pan, J. F., & Brands, B. (2015). Acute effects of cannabis on young drivers' performance of driving-related skills. *Drug and Alcohol Dependence*, 156, e31-e32.
- Caulkins, J. P. (2014). *Is Marijuana Safer than Alcohol? Insights from Users' Self Reports.* (Working Paper).
- Chase, P. B., Hawkins, J., Mosier, J., Jimenez, E., Boesen, K., Logan, B. K., & Walter, F. G. (2016). Differential physiological and behavioral cues observed in individuals smoking botanical marijuana versus synthetic cannabinoid drugs. *Clinical Toxicology*, 54(1), 14-19.
- Compton, R.P. & Berning, A. (2015). *Drug and Alcohol Crash Risk* (Traffic Safety Facts Research Note. DOT HS 812 117). Washington, DC: National Highway Traffic Safety Administration.
- Couper, F. J., & Peterson, B. L. (2014). The prevalence of marijuana in suspected impaired driving cases in Washington State. *Journal of analytical toxicology*, 38(8), 569-574.
- Crancer, A., Dille, J. M., Delay, J. C., Wallace, J. E., & Haykin, M. D. (1969, May). Comparison of the effects of marihuana and alcohol on simulated driving performance. *American Association for the Advancement of Science*.
- Davis, K. C., Allen, J., Duke, J., Nonnemaker, J., Bradfield, B., Farrelly, M. C., & Novak, S. (2016). Correlates of marijuana drugged driving and openness to driving while high: evidence from Colorado and Washington. *PLoS one*, 11(1), e0146853.
- Dott, A. B. (1972). Effect of marihuana on risk acceptance in a simulated passing task.
- Downey, L. A., King, R., Papafotiou, K., Swann, P., Ogden, E., Boorman, M., & Stough, C. (2013). The effects of cannabis and alcohol on simulated driving: influences of dose and experience. *Accident Analysis & Prevention*, 50, 879-886.
- Dubois, S., Mullen, N., Weaver, B., & Bedard, M. (2015). The combined effects of alcohol and cannabis on driving: impact on crash risk. *Forensic science international*, 248, 94-100.

- Fabritius, M., Augsburger, M., Chtioui, H., Favrat, B., & Giroud, C. (2014). Fitness to drive and cannabis: validation of two blood THCCOOH thresholds to distinguish occasional users from heavy smokers. *Forensic science international*, 242, 1-8. Chicago
- Fergusson, D. M., Horwood, L. J., & Boden, J. M. (2008). Is driving under the influence of cannabis becoming a greater risk to driver safety than drink driving? Findings from a longitudinal study. *Accident Analysis & Prevention*, 40(4), 1345-1350.
- Fierro, I., González-Luque, J. C., & Álvarez, F. J. (2014). The relationship between observed signs of impairment and THC concentration in oral fluid. *Drug and alcohol dependence*, 144, 231-238.
- Fischer, B., Rodopoulos, J., Rehm, J., & Ivins, A. (2006). Toking and driving: characteristics of Canadian university students who drive after cannabis use—an exploratory pilot study. *Drugs: education, prevention and policy*, 13(2), 179-187.
- Glascoff, M. A., & Haddock, R. K. (2013). Friends don't let friends drive drunk, but do they let friends drive high?. *Journal of alcohol and drug education*, 57(1), 66.
- Hanson, D. (2013). The Effects of Substances on Driving. In *Principles of Addiction* (Vol. 1, pp. 371-379). Amsterdam: Elsevier Academic Press.
- Hansteen, R. W., Miller, R. D., Lonero, L., Reid, L. D., & Jones, B. (1976). Effects of cannabis and alcohol on automobile driving and psychomotor tracking. *Annals of the New York Academy of Sciences*, 282(1), 240-256.
- Harder, S. & Rietbrock, S. (1997). Concentration-effect relationship of delta-9-tetrahydrocannabinol and prediction of psychotropic effects after smoking marijuana. *International Journal of Clinical Pharmacology and Therapeutics*, 35(4), 155-159.
- Hartman, R. L. (2015). Drug Policy Implications of Inhaled Cannabis: Driving Skills and Subjective Effects, Vaporized Cannabinoid Pharmacokinetics, and Interactions with Alcohol.
- Hartman, R. L., & Huestis, M. A. (2013). Cannabis effects on driving skills. *Clinical chemistry*, 59(3), 478-492.
- Hartman, R. L., Richman, J. E., Hayes, C. E., & Huestis, M. A. (2016). Drug Recognition Expert (DRE) examination characteristics of cannabis impairment. *Accident Analysis & Prevention*, 92, 219-229.
- Hartman, R., Brown, T., Milavetz, G., Spurgin, A., Pierce, R., & Gorelick, D. et al. (2015). Cannabis effects on driving lateral control with and without alcohol. *Drug and Alcohol Dependence*, 154, 25-37. <http://dx.doi.org/10.1016/j.drugalcdep.2015.06.015>
- Hartman, R., Brown, T., Milavetz, G., Spurgin, A., Pierce, R., & Gorelick, D. et al. (2016). Cannabis effects on driving longitudinal control with and without alcohol. *Journal of Applied Toxicology*, 36(11), 1418-1429. <http://dx.doi.org/10.1002/jat.3295>
- Johnson, M. B., Kelley-Baker, T., Voas, R. B., & Lacey, J. H. (2011). The prevalence of cannabis-involved driving in California. *Drug and alcohol dependence*, 123(1), 105-109.

- Jones, A. W., Holmgren, A., & Kugelberg, F. C. (2008). Driving under the influence of cannabis: a 10-year study of age and gender differences in the concentrations of tetrahydrocannabinol in blood. *Addiction*, 103(3), 452-461.
- Jones, C., Donnelly, N., Swift, W., & Weatherburn, D. (2005). Driving under the influence of cannabis: The problem and potential countermeasures. *BOCSAR NSW Crime and Justice Bulletins*, 15.
- Kann, L. (2016). Youth risk behavior surveillance—United States, 2015. *MMWR. Surveillance Summaries*, 65.
- Khiabani, H. Z., Mørland, J., & Bramness, J. G. (2008). Frequency and irregularity of heart rate in drivers suspected of driving under the influence of cannabis. *European journal of internal medicine*, 19(8), 608-612.
- Khiabani, H. Z., Bramness, J. R. G., Børneboe, A., & Mørland, J. R. (2006). Relationship between THC concentration in blood and impairment in apprehended drivers. *Traffic injury prevention*, 7(2), 111-116.
- Kielholz, P., Hobi, V., Ladewig, D., Miest, P., & Richter, R. (1973). An experimental investigation about the effect of cannabis on car driving behaviour. *Pharmacopsychiatry*, 6(01), 91-103.
- Klonoff, H. (1974). Marijuana and driving in real-life situations. *Science*, 186(317-23).
- Knepper, M. (1980). PUFF, THE DANGEROUS DRIVER (MARIJUANA USE AND DRIVING). *Car and Driver*, 25(HS-029 077).
- Koerth-Baker, Maggie. "Marijuana and the Sobriety Test." *New York Times* 18 Feb. 2014: D1 (L). Business Insights: Global. Web. 7 Dec. 2016.
- Krüger, H. P., & Vollrath, M. (1998). Effects of cannabis and amphetamines on driving simulator performance of recreational drug users in the natural field. Center for Traffic Sciences (IZVW).
- Kurzthaler, I., Hummer, M., Miller, C., Sperner-Unterweger, B., Günther, V., Wechdorn, H., & Fleischhacker, W. W. (1999). Effect of cannabis use on cognitive functions and driving ability. *The Journal of clinical psychiatry*.
- Laberge, J. C., & Ward, N. J. (2004). Research note: Cannabis and driving—research needs and issues for transportation policy. *Journal of Drug Issues*, 34(4), 971-990.
- Lamers, C. T., & Ramaekers, J. G. (2001). Visual search and urban driving under the influence of marijuana and alcohol. *Human Psychopharmacology: Clinical and Experimental*, 16(5), 393-401.
- Le Strat, Y., Dubertret, C., & Le Foll, B. (2015). Impact of age at onset of cannabis use on cannabis dependence and driving under the influence in the United States. *Accident Analysis & Prevention*, 76, 1-5.

- Lenné, M. G., Dietze, P. M., Triggs, T. J., Walmsley, S., Murphy, B., & Redman, J. R. (2010). The effects of cannabis and alcohol on simulated arterial driving: influences of driving experience and task demand. *Accident Analysis & Prevention*, 42(3), 859-866.
- Lenné, M., Craig LM Fry, Paul Dietze, Greg Rumbold, M. (2001). Attitudes and experiences of people who use cannabis and drive: Implications for drugs and driving legislation in Victoria, Australia. *Drugs: education, prevention and policy*, 8(4), 307-313.
- Lenné, M., Triggs, T., & Regan, M. (2004). Cannabis and Road Safety: A Review of Recent Epidemiological, Driver Impairment and Drug Screening Literature. *Monash University Accident Research Centre Reports*, (231), 41.
- Lewis, T. F., Scott Olds, R., Thombs, D. L., & Ding, K. (2008). Driving Privileges Facilitate Impaired Driving in Those Youths Who Use Alcohol or Marijuana. *Journal of Child & Adolescent Substance Abuse*, 18(1), 106-116.
- Lewis, T. F., Thombs, D. L., & Olds, R. S. (2005). Profiles of alcohol-and marijuana-impaired adolescent drivers. *Addiction Research & Theory*, 13(2), 145-154.
- Li, G., Brady, J. E., & Chen, Q. (2013). Drug use and fatal motor vehicle crashes: a case-control study. *Accident Analysis & Prevention*, 60, 205-210.
- Li, K., Simons-Morton, B., Gee, B., & Hingson, R. (2016). Marijuana-, alcohol-, and drug-impaired driving among emerging adults: Changes from high school to one-year post-high school. *Journal of Safety Research*.
- Liguori, A., Gatto, C. P., & Jarrett, D. B. (2002). Separate and combined effects of marijuana and alcohol on mood, equilibrium and simulated driving. *Psychopharmacology*, 163(3), 399-405.
- Liguori, A., Gatto, C. P., & Robinson, J. H. (1998). Effects of marijuana on equilibrium, psychomotor performance, and simulated driving. *Behavioural pharmacology*, 9(7), 599-609.
- Liguori, A., Gatto, C., Jarrett, D., Vaughn McCall, W., & Brown, T. (2003). Behavioral and subjective effects of marijuana following partial sleep deprivation. *Drug and Alcohol Dependence*, 70(3), 233-240. [http://dx.doi.org/10.1016/s0376-8716\(03\)00008-5](http://dx.doi.org/10.1016/s0376-8716(03)00008-5)
- Liu, C., Huang, Y., & Pressley, J. C. (2016). Restraint use and risky driving behaviors across drug types and drug and alcohol combinations for drivers involved in a fatal motor vehicle collision on US roadways. *Injury epidemiology*, 3(1), 9.
- Logan, B., Kacinko, S. L., & Beirness, D. J. (2016). An Evaluation of Data from Drivers Arrested for Driving under the Influence in Relation to per se Limits for Cannabis (May 2016). AAA Foundation for Traffic Safety.
- Longo, M. C., Hunter, C. E., Lokan, R. J., White, J. M., & White, M. A. (2000). The prevalence of alcohol, cannabinoids, benzodiazepines and stimulants amongst injured drivers and their role in driver culpability: part ii: the relationship between drug prevalence and

- drug concentration, and driver culpability. *Accident Analysis & Prevention*, 32(5), 623-632.
- Longo, M. C., Hunter, C. E., Lokan, R. J., White, J. M., & White, M. A. (2000). The role of alcohol, cannabinoids, benzodiazepines and stimulants in road crashes. In *Proceedings of the 15th International Conference on Alcohol, Drugs and Traffic Safety*; May (pp. 22-26).
- Macdonald, S., Anglin-Bodrug, K., Mann, R. E., & Chipman, M. (2005). Driving while impaired (DWI) by alcohol convictions among alcohol, cocaine, and cannabis clients in treatment. *Traffic injury prevention*, 6(3), 207-211.
- Macdonald, S., DeSouza, A., Mann, R., & Chipman, M. (2004). Driving behavior of alcohol, cannabis, and cocaine abuse treatment clients and population controls. *The American journal of drug and alcohol abuse*, 30(2), 429-444.
- MacDonald, S., Mann, R., Chipman, M., Pakula, B., Erickson, P., Hathaway, A., & MacIntyre, P. (2008). Driving behavior under the influence of cannabis or cocaine. *Traffic Injury Prevention*, 9(3), 190-194.
- Masten, S. & Guenzburger, G. (2014). Changes in driver cannabinoid prevalence in 12 U.S. states after implementing medical marijuana laws. *Journal of Safety Research*, 50, 35-52. <http://dx.doi.org/10.1016/j.jsr.2014.03.009>
- Maxwell, J. C., Freeman, J., & Davey, J. (2009). Too young to drink but old enough to drive under the influence: A study of underage offenders as seen in substance abuse treatment in Texas. *Drug and alcohol dependence*, 104(1), 107-112.
- McCarthy, D. M., Lynch, A. M., & Pederson, S. L. (2007). Driving after use of alcohol and marijuana in college students. *Psychology of Addictive Behaviors*, 21(3), 425.
- McGuire, F., Dawe, M., Shield, K. D., Rehm, J., & Fischer, B. (2011). Driving under the influence of cannabis or alcohol in a cohort of high-frequency cannabis users: Prevalence and reflections on current interventions 1. *Canadian Journal of Criminology and Criminal Justice*, 53(2), 247-259.
- Ménétrey, A., Augsburger, M., Favrat, B., Pin, M. A., Rothuizen, L. E., Appenzeller, M., & Giroud, C. (2005). 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 Δ^9 -THC. *Journal of analytical toxicology*, 29(5), 327-338.
- Moskowitz, H., Hulbert, S., & McGlothlin, W. H. (1976). Marijuana: Effects on simulated driving performance. *Accident Analysis & Prevention*, 8(1), 45-50.
- Moskowitz, H., Ziedman, K., & Sharma, S. (1976). Visual search behavior while viewing driving scenes under the influence of alcohol and marijuana. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 18(5), 417-431.
- Neale, J. (2001). Driving on Recreational Drugs: a qualitative investigation of experiences from behind the wheel. *Drugs: education, prevention and policy*, 8(4), 315-325.

- O'Kane, C. J., Tutt, D. C., & Bauer, L. A. (2002). Cannabis and driving: a new perspective. *Emergency medicine*, 14(3), 296-303.
- O'Malley, P. M., & Johnston, L. D. (2003). Unsafe driving by high school seniors: national trends from 1976 to 2001 in tickets and accidents after use of alcohol, marijuana and other illegal drugs. *Journal of Studies on Alcohol*, 64(3), 305-312.
- O'Malley, P. M., & Johnston, L. D. (2007). Drugs and driving by American high school seniors, 2001-2006. *Journal of Studies on Alcohol and Drugs*, 68(6), 834-842.
- O'Malley, Patrick M., and Lloyd D. Johnston. 2013. "Driving After Drug or Alcohol Use by US High School Seniors, 2001-2011." *American Journal of Public Health* 103, no. 11: 2027-2034. CINAHL Complete, EBSCOhost (accessed January 5, 2017)
- Orenstein, D. G. (2015). Voter Madness-Voter Intent and the Arizona Medical Marijuana Act. *Ariz. St. LJ*, 47, 391.
- Owusu-Bempah, A. (2014). Cannabis Impaired Driving: An Evaluation of Current Modes of Detection 1. *Canadian journal of criminology and criminal justice*, 56(2), 219-240.
- Papafotiou, K., Carter, J. D., & Stough, C. (2005). An evaluation of the sensitivity of the Standardised Field Sobriety Tests (SFSTs) to detect impairment due to marijuana intoxication. *Psychopharmacology*, 180(1), 107-114.
- Papafotiou, K., Carter, J. D., & Stough, C. (2005). The relationship between performance on the standardised field sobriety tests, driving performance and the level of Δ^9 -tetrahydrocannabinol (THC) in blood. *Forensic Science International*, 155(2), 172-178.
- Patton, D., & Brown, D. (2002). Driving drink, driving high: A comparison of student attitudes towards driving while drunk versus driving while high on cannabis. Poster Session. In *Proceedings of the 16th Annual Conference on Alcohol, Drugs, and Traffic Safety*.
- Peck, R. C., Biasotti, A., Boland, P. N., Mallory, C., & Reeve, V. (1986). The effects of marijuana and alcohol on actual driving performance. *Alcohol, drugs and driving*, 2(3-4).
- Perez-Reyes, M., Hicks, R. E., Bumbery, J., Robert Jeffcoat, A., & Cook, C. E. (1988). Interaction between marihuana and ethanol: effects on psychomotor performance. *Alcoholism: Clinical and Experimental Research*, 12(2), 268-276.
- Pilkinton, M. W., Robertson, A., & McCluskey, D. L. (2013). Drugged driving: increased traffic risks involving licit and illicit substances. *Journal of drug education*, 43(2), 183-201.
- Pollini, R. A., Romano, E., Johnson, M. B., & Lacey, J. H. (2015). The impact of marijuana decriminalization on California drivers. *Drug and alcohol dependence*, 150, 135-140.
- Porath-Waller, A. J., & Beirness, D. J. (2014). An examination of the validity of the standardized field sobriety test in detecting drug impairment using data from the Drug Evaluation and Classification program. *Traffic injury prevention*, 15(2), 125-131.
- Rafaelsen, O., Bech, P., Christiansen, J., Christrup, H., Nyboe, J., & Rafaelsen, L. (1973). Cannabis and Alcohol: Effects on Simulated Car Driving. *Science*, 179(4076), 920-923. <http://dx.doi.org/10.1126/science.179.4076.920>

- Ramaekers, J. G., Berghaus, G., van Laar, M., & Drummer, O. H. (2004). Dose related risk of motor vehicle crashes after cannabis use. *Drug and alcohol dependence*, 73(2), 109-119.
- Ramaekers, J. G., Berghaus, G., van Laar, M., & Drummer, O. H. (2009). Dose related risk of motor vehicle crashes after cannabis use: an update. In *Drugs, driving and traffic safety* (pp. 477-499). Birkhäuser Basel.
- Ramaekers, J. G., Lamers, C. T. J., Robbe, H. W. J., & O'Hanlon, J. F. (2000, May). Low doses of marijuana and alcohol severely impair driving when taken together. In *Alcohol, drugs and traffic safety. Proceedings of the 15th International Conference on Alcohol, Drugs and Traffic Safety, Stockholm, Sweden*.
- Ramaekers, J. G., Moeller, M. R., van Ruitenbeek, P., Theunissen, E. L., Schneider, E., & Kauert, G. (2006). Cognition and motor control as a function of Δ 9-THC concentration in serum and oral fluid: limits of impairment. *Drug and alcohol dependence*, 85(2), 114-122.
- Ramirez, A., Berning, A., Carr, K., Scherer, M., Lacey, J. H., Kelley-Baker, T., & Fisher, D. A. (2016). *Marijuana, Other Drugs, and Alcohol Use by Drivers in Washington State* (No. DOT HS 812 299).
- Reed, J. K. (2016). Marijuana legalization in Colorado: early findings. *A report pursuant to Senate Bill*, 13-283.
- Reeve, V. C., Grant, J. D., Robertson, W., Gillespie, H. K., & Hollister, L. E. (1983). Plasma concentrations of δ -9-tetrahydrocannabinol and impaired motor function. *Drug and alcohol dependence*, 11(2), 167-175.
- Reeve, V. C., Robertson, W. B., Grant, J., Soares, J. R., Zimmermann, E. G., Gillespie, H. K., & Hollister, L. E. (1983). Hemolyzed blood and serum levels of Δ 9-THC: Effects on the performance of roadside sobriety tests. *Journal of Forensic Science*, 28(4), 963-971.
- Richer, I., & Bergeron, J. (2009). Driving under the influence of cannabis: Links with dangerous driving, psychological predictors, and accident involvement. *Accident Analysis & Prevention*, 41(2), 299-307. Chicago
- Rizzo, M., Lamers, C. T., Sauer, C. G., Ramaekers, J. G., Bechara, A., & Andersen, G. J. (2005). Impaired perception of self-motion (heading) in abstinent ecstasy and marijuana users. *Psychopharmacology*, 179(3), 559-566.
- Robbe, H. W. J. (1994). Influence of marijuana on driving (Doctoral dissertation, Maastricht University).
- Robbe, H. W., & O'Hanlon, H. F. (1995). Marijuana and Actual Driving Performance. *Journal of Safety Research*, 4(26), 255.
- Robbe, H. W., & O'Hanlon, J. F. (2000). Marijuana, alcohol and actual driving performance. *Hum. Psychopharmacol. Clin. Exp.* 15: 551-558.
- Romano, E., & Voas, R. B. (2011). Drug and Alcohol Involvement in Four Types of Fatal Crashes*. *Journal of studies on alcohol and drugs*, 72(4), 567-576.

- Romano, E., Torres-Saavedra, P., Voas, R. B., & Lacey, J. H. (2014). Drugs and alcohol: their relative crash risk. *Journal of Studies on Alcohol and Drugs*, 75(1), 56-64.
- Ronen, A., Chassidim, H. S., Gershon, P., Parmet, Y., Rabinovich, A., Bar-Hamburger, R., & Shinar, D. (2010). The effect of alcohol, THC and their combination on perceived effects, willingness to drive and performance of driving and non-driving tasks. *Accident Analysis & Prevention*, 42(6), 1855-1865.
- Ronen, A., Gershon, P., Drobiner, H., Rabinovich, A., Bar-Hamburger, R., Mechoulam, R., & Shinar, D. (2008). Effects of THC on driving performance, physiological state and subjective feelings relative to alcohol. *Accident Analysis & Prevention*, 40(3), 926-934.
- Roth, A. (2015). Uneasy Case for Marijuana as Chemical Impairment under a Science-Based Jurisprudence of Dangerousness, *The. Cal. L. Rev.*, 103, 841.
- RTI International, United States of America, SAMHSA, Office of Applied Studies, & United States of America. (2008). *State Estimates of Persons Aged 18 or Older Driving Under the Influence of Alcohol or Illicit Drugs*.
- Rudisill, T. M., Zhao, S., Abate, M. A., Coben, J. H., & Zhu, M. (2014). Trends in drug use among drivers killed in US traffic crashes, 1999–2010. *Accident Analysis & Prevention*, 70, 178-187.
- Salomonsen-Sautel, S., Min, S. J., Sakai, J. T., Thurstone, C., & Hopfer, C. (2014). Trends in fatal motor vehicle crashes before and after marijuana commercialization in Colorado. *Drug and alcohol dependence*, 140, 137-144.
- Schechtman, E., & Shinar, D. (2005). Modeling drug detection and diagnosis with the 'drug evaluation and classification program'. *Accident Analysis & Prevention*, 37(5), 852-861.
- Scherer, M., Voas, R. B., & Furr-Holden, D. (2013). Marijuana as a predictor of concurrent substance use among motor vehicle operators. *Journal of psychoactive drugs*, 45(3), 211-217.
- Schwilke, E. W., Sampaio dos Santos, M. I., & Logan, B. K. (2006). Changing patterns of drug and alcohol use in fatally injured drivers in Washington State. *Journal of forensic sciences*, 51(5), 1191-1198.
- Sewell, R. A., Poling, J., & Sofuoglu, M. (2009). The effect of cannabis compared with alcohol on driving. *American journal on addictions*, 18(3), 185-193.
- Sexton, B. F., Tunbridge, R. J., Board, A., Jackson, P. G., Wright, K., Stark, M. M., & Engelhard, K. (2002). The influence of cannabis and alcohol on driving.
- Sexton, B. F., Tunbridge, R. J., Brook-Carter, N., Jackson, P. G., Wright, K., Stark, M. M., & Englehart, K. (2000). The influence of cannabis on driving. *TRL report*, 477, 106.
- Smiley, A. M. (1986). Marijuana: On-road and driving simulator studies. *Alcohol, Drugs and Driving*, 2(3-4), 121-134.
- Smiley, A., Moskowitz, H. M., & Ziedman, K. (1985). Effects of drugs on driving. *Driving simulator tests of secobarbital, diazepam, marijuana and alcohol (No. HS-040 208)*.

- Soderstrom, C., Dischinger, P., Kufera, J., Ho, S., & Shepard, A. (2005) Crash culpability relative to age and sex for injured drivers using alcohol, marijuana or cocaine. 49th Annual Proceedings, Association for the Advancement of Automotive Medicine. Boston, MA.
- Stein, A. C., Allen, R. W., Cook, M. L., & Karl, R. L. (1983). A simulator study of the combined effects of alcohol and marijuana on driving behaviour—phase II. *Department of Transportation, Washington DC*.
- Sullum, J. (2013). Too Stoned to Drive?. *Reason*, 45(6), 3233.
- Sutton, L. R. (1983). The effects of alcohol, marihuana and their combination on driving ability. *Journal of studies on alcohol*, 44(3), 438-445.
- Terhune, K. W., & Fell, J. C. (1982). A summary: 'The role of alcohol, marijuana, and other drugs in the accidents of injured drivers.' In Abstracts and reviews in alcohol and driving (Vol. 3, No. 6, pp. 3-6). UCLA Alcohol Research Center and UCLA Brain Information Service.
- Turner, B. M. A. (2007). Sex, drugs, and driving: The effects of marijuana.
- Urfer, S., Morton, J., Beall, V., Feldmann, J., & Gunesch, J. (2014). Analysis of Δ^9 -tetrahydrocannabinol driving under the influence of drugs cases in Colorado from January 2011 to February 2014. *Journal of analytical toxicology*, 38(8), 575-581.
- Voas, R. B., Lacey, J. H., Jones, K., Scherer, M., & Compton, R. (2013). Drinking drivers and drug use on weekend nights in the United States. *Drug and alcohol dependence*, 130(1), 215-221.
- Weinstein, A., Brickner, O., Lerman, H., Greemland, M., Bloch, M., Lester, H. & Freedman, N. (2008). A study investigating the acute dose—response effects of 13 mg and 17 mg Δ^9 -tetrahydrocannabinol on cognitive—motor skills, subjective and autonomic measures in regular users of marijuana. *Journal of psychopharmacology*, 22(4), 441-451.
- Wood, E., & Salomonsen-Sautel, S. (2016). DUID prevalence in Colorado's DUI citations. *Journal of safety research*, 57, 33-38.
- Wood, E., Brooks-Russell, A., & Drum, P. (2016). Delays in DUI blood testing: Impact on cannabis DUI assessments. *Traffic injury prevention*, 17(2), 105-108.

Appendix A. Article's operational definition of evaluation quality

Dimension of Evaluation Quality	Coding Scheme <i>(Higher Number = Quality)</i>
Sampling Selection	2 = Participants randomly selected 1 = Nonrandom, cluster, or nonsystematic 0 = No sampling selection provided/discussed
Sampling Size	3 = 500 + participants 2 = 100–499 participants 1 = 1–99 participants 0 = No participants
Sample Representativeness	6 = Multiple National Samples 5 = National Sample 4 = Region (e.g. multiple states/large area) 3 = Single state 2 = Multiple cities 1 = Single city 0 = No sample measured
Geographic Location	5 = Multiple countries 4 = National (country) 3 = Region(s) 2 = State(s) 1 = City(ies) 0 = No location
Research Methodology	2 = Quantitative 1 = Qualitative
Study Design	2 = Experimental design 1 = Quasi-experimental 0 = Non-experimental
Study Type	3 = Randomized clinical trial 2 = Longitudinal/cohort 1 = Case-control 0 = Cross-sectional
Measurement	4 = Survey/Items used in previous literature; cited references; cited alpha levels 3 = Survey/Items used in previous literature; cited references 2 = Created own survey/items; alpha levels cited and/or pilot tested 1 = Created own survey/items 0 = No measurement

Appendix B: Marijuana Laws by State

State	Possession and Use	Medical Marijuana Implemented on	Recreational Marijuana Implemented on
Alabama	Illegal		
Alaska	Legal for recreational and medical use	3/4/1999	2/24/2015
Arizona	Legal for medical use	4/14/2011	
Arkansas	Legal for medical use	11/9/2016	
California	Legal for recreational and medical use	11/6/1996	11/9/2016
Colorado	Legal for recreational and medical use	6/1/2001	1/1/2014
Connecticut	Legal for medical use	10/1/2012	
Delaware	Legal for medical use	7/1/2011	
DC	Legal for recreational and medical use	7/27/2010	2/26/2015
Florida	Legal for medical use	1/3/2017	
Georgia	Illegal	5/9/2017	
Hawaii	Legal for medical use	12/28/2000	
Idaho	Illegal		
Illinois	Legal for medical use	1/1/2014	
Indiana	Illegal		
Iowa	Illegal		
Kansas	Illegal		
Kentucky	Illegal		
Louisiana	Illegal		
Maine	Legal for recreational and medical use	12/22/1999	1/1/2017
Maryland	Legal for medical use	6/1/2014	
Massachusetts	Legal for recreational and medical use	1/1/2013	12/15/2016
Michigan	Legal for medical use	12/4/2008	
Minnesota	Legal for medical use	5/30/2014	
Mississippi	Decriminalized		
Missouri	Decriminalized		
Montana	Legal for medical use	11/2/2004	
Nebraska	Decriminalized		
Nevada	Legal for medical and recreational use	10/1/2001	1/1/2017
New Hampshire	Legal for medical use	7/23/2013	
New Jersey	Legal for medical use	7/18/2010	
New Mexico	Legal for medical use	7/1/2007	
New York	Decriminalized and legal for medical use	7/5/2014	
North Carolina	Decriminalized		
North Dakota	Legal for medical use	11/8/2016	
Ohio	Decriminalized and legal for medical use	9/8/2016	
Oklahoma	Illegal		
Oregon	Legal for medical and recreational use	12/3/1998	5/1/2017

Pennsylvania	Legal for medical use	5/17/2016	
Rhode Island	Decriminalized and legal for medical use	1/3/2006	
South Carolina	Illegal		
South Dakota	Illegal		
Tennessee	Illegal		
Texas	Illegal		
Utah	Illegal		
Vermont	Decriminalized and legal for medical use	5/30/2007	
Virginia	Illegal		
Washington	Legal for medical and recreational use	11/3/1998	7/1/2014
West Virginia	Legal for medical use	4/19/2017	
Wisconsin	Illegal		
Wyoming	Illegal		

Appendix C. Survey

Hello, this is _____ calling from the Public Policy Research Institute at Texas A&M University. We are conducting a brief research survey sponsored by the Texas Department of Transportation with about 500 adults. The purpose of this survey is to look at Texan's attitudes towards marijuana use, legalization, and driving. The information you provide will be used to understand Texan's opinions about marijuana. Your participation in this survey is completely voluntary and should only take about 8 minutes of your time. .

Your information is anonymous and I do not know your name or your phone number. You were selected randomly from people with phone numbers in 25 Texas Counties. The computer that dialed your phone number will delete this number at the conclusion of the survey. If you have any complaints I can read you a phone number and email for Jena Prescott, the head researcher you can call if you have a complaint. If you have a question about your rights as a participant in this research I can also give you a phone number or email address for the Texas A&M University Institution Review Board which reviewed this research for the purpose of protecting participants. You may skip any question that you prefer not to answer and you may stop at any time. Please let me know if you have any questions before we begin.

If requested: Jena Prescotts' phone number is (979)862-1525 and her email is j-prescott@tti.tamu.edu The IRB phone number is (979).458.4117 email is irb@tamu.edu and the head of the IRB is Aliese Seawright.

Background demographic questions:

Your answers will represent other Texans so we need to know a few things about you.

- Could you please tell me your age: _____
 - a. Please give a number.
 - ☐ DON'T KNOW
 - ☐ REFUSE

IF LESS THAN 18 or Refuse to give age, *ASK TO SPEAK WITH SOMEONE 18 OR OVER AND REPEAT INTRO*
If no person over 18 terminate interview

- a. TERMINATE INTERVIEW

<Cell Check> Have I reached you on a cell phone or a regular landline phone?

1. Cell Phone => Safe Place
2. Landline Phone => Start Survey

<Safe Place> Are you currently in a safe place to talk?

1. Yes => Continue
2. No [SCHEDULE CALL BACK - END]

- Do you have a Texas Driver's License?

☐ Yes

☐ No

IF NO TERMINATE INTERVIEW

☐ DON'T KNOW

☐ REFUSE

- Could you please tell me what County you live in?

Bell	Bexar	Brazoria	Cameron	Collin
Dallas	Denton	Ector	El Paso	Fort Bend
Galveston	Grayson	Harris	Hidalgo	Jefferson
Lubbock	McLennan	Midland	Montgomery	Nueces
Potter	Smith	Tarrant	Travis	Williamson

Other: _____

☐ DON'T KNOW

☐ REFUSE

- Could you please tell us your if you are: READ LIST

☐ Male

☐ Female

☐ OTHER

☐ DON'T KNOW

☐ REFUSE

- Do you consider yourselfREAD LIST:

☐ White

☐ Hispanic or Latino

☐ Black or African American

☐ Native American or American Indian

☐ Asian/Pacific Islander

☐ Mixed

☐ Other:

☐ DON'T KNOW

☐ REFUSE

- Could you please tell me how much education you have completed?:

☐ No schooling completed

☐ Elementary school to 8th grade

☐ Some high school, no diploma

☐ High school graduate, diploma, or GED

- ☐ Some college credit, no degree
- ☐ Trade/technical/vocational training
- ☐ Associate's degree
- ☐ Bachelor's degree
- ☐ Master's or Professional degree
- ☐ Doctorate degree
- ☐ DON'T KNOW
- ☐ REFUSE

- Could you please give me your zip code?

Zip Code : _____

- ☐ DON'T KNOW
- ☐ REFUSE

- IF RESPONDENT DOES NOT KNOW ZIP CODE PLEASE ASK: In what town or city do you live?

Town/city_____

- ☐ DON'T KNOW
- ☐ REFUSE

- In general, would you describe your political views as:

- ☐ Very Liberal
- ☐ Liberal
- ☐ Neither Liberal nor Conservative
- ☐ Conservative
- ☐ Very Conservative
- ☐ DON'T KNOW
- ☐ REFUSE

Survey Questions:

Now I would like to read you some general statements about marijuana. Please tell me how strongly you agree or disagree with the following statements.

1. It is safe to use marijuana. Would you say you (READ LIST EXCEPT DK/RF)

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

2. Marijuana is less safe to use than tobacco. Would you say you(READ LIST EXCEPT DK/RF)

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

3. Marijuana is less safe to use than alcohol.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

4. Using marijuana makes it harder to think clearly or perform tasks.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

5. Marijuana is more impairing than alcohol.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

6. Marijuana is more addictive than alcohol.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW

☐ REFUSE

7. Texas should legalize marijuana for serious medical conditions like epilepsy or cancer.

☐ Strongly Agree
☐ Agree
☐ Neither Agree nor Disagree
☐ Disagree
☐ Strongly Disagree
☐ DON'T KNOW
☐ REFUSE

8. Texas should legalize marijuana for medical conditions such as arthritis, migraine, or any other illness for which marijuana provides relief.

☐ Strongly Agree
☐ Agree
☐ Neither Agree nor Disagree
☐ Disagree
☐ Strongly Disagree
☐ DON'T KNOW
☐ REFUSE

9. Texas should legalize marijuana for recreational purposes.

☐ Strongly Agree
☐ Agree
☐ Neither Agree nor Disagree
☐ Disagree
☐ Strongly Disagree
☐ DON'T KNOW
☐ REFUSE

10. If Texas were to legalize marijuana, more people would start using marijuana.

☐ Strongly Agree
☐ Agree
☐ Neither Agree nor Disagree
☐ Disagree
☐ Strongly Disagree
☐ DON'T KNOW
☐ REFUSE

Now we have some statements about Marijuana and Driving. Please tell me how strongly you agree or disagree with the following statements.

1. It is unsafe to drive after using marijuana. Would you say you (READ LIST EXCEPT DK/RF)

☐ Strongly Agree
☐ Agree
☐ Neither Agree nor Disagree

- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

2. It is unsafe to drive under the influence of marijuana.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

3. It is unsafe to drive within two hours of using marijuana.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

4. If marijuana were legal, more people would be willing to drive under the influence of marijuana.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

5. I would feel safe riding in a car with a driver who had used marijuana before driving.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

6. Drivers who use marijuana are more likely to be involved in a crash than drivers who don't.

- ☐ Strongly Agree
- ☐ Agree

- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

7. If marijuana were legal, Texas should identify a legal blood concentration level of impairment.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

- a. Explanation: In Texas, there are two definitions of DWI. One definition is the loss of normal mental and physical abilities because of alcohol use. The other definition is a blood alcohol concentration level of 0.08 or above. This statement says that Texas should identify a legal definition of impairment for marijuana, similar to alcohol.

8. If marijuana were legal, drivers who are under the influence of marijuana should be arrested.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

Now we have some statements about comparing Marijuana and Alcohol use and driving. Please tell me how strongly you agree or disagree with the following statements.

1. It is unsafe to drive after consuming alcohol. Would you say you (READ LIST EXCEPT DK/RF)

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

2. Driving under the influence of marijuana is safer than driving under the influence of alcohol.

- ☐ Strongly Agree

- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

3. Drivers under the influence of marijuana are less likely to get into a crash than drivers under the influence of alcohol.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

4. It is unsafe to drive after using both alcohol and marijuana together.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

5. Drivers under the influence of marijuana should be penalized at the same level as drivers under the influence of alcohol.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ DON'T KNOW
- ☐ REFUSE

Now I have some general questions about marijuana.

1. Have you ever tried marijuana?

- ☐ Yes
- ☐ No (SKIP TO Q5)
- ☐ Prefer not to answer
- ☐ DON'T KNOW (SKIP TO Q5)
- ☐ REFUSE (SKIP TO Q5)

2. At what age did you first try marijuana? _____
☐ DON'T KNOW
☐ REFUSE
3. Have you used marijuana in the past 12 months?
☐ Yes
☐ No
☐ Prefer not to answer
☐ DON'T KNOW
☐ REFUSE
4. Have you used marijuana in the past 30 days?
☐ Yes
☐ No
☐ Prefer not to answer
☐ DON'T KNOW
☐ REFUSE
5. If marijuana were legal, would you:
☐ 1. Not use it, even if it were legal and available to use.
☐ 2. If not currently using marijuana, I would begin using marijuana.
☐ 3. If currently using marijuana, I would use more often than I do now.
☐ 4. If currently using marijuana, I would use less than I do now.
☐ 5. If currently using marijuana, I would quit using marijuana.
☐ 8. I DON'T KNOW
☐ 9. REFUSE

Thank you very much for your participation this is the end of the survey.

Appendix D. Frequency Tables for Survey Responses

Table A1: Frequencies of Survey Respondent Frequencies

		%	#
Age in Categories	18-24	8.9%	39
	25-34	18.0%	79
	35-44	13.0%	57
	45-54	19.6%	86
	55-64	18.5%	81
	65 and older	21.9%	96
Gender	Male	57.3%	251
	Female	42.7%	187
Racial Identification	White	56.4%	247
	Hispanic or Latino	19.6%	86
	Black or African American	11.9%	52
	Native American or American Indian	0.9%	4
	Asian/Pacific Islander	1.6%	7
	Mixed	4.6%	20
	Other:	2.5%	11
	Don't Know	0.2%	1
	Refused	2.3%	10
Education	No schooling completed	0.5%	2
	Elementary school to 8th grade	1.6%	7
	Some high school, no diploma	3.9%	17

High school graduate, diploma, or GED	12.6%	55
Some college credit, no degree	20.5%	90
Trade/technical/vocational training	7.3%	32
Associate's degree	8.9%	39
Bachelor's degree	26.0%	114
Master's or Professional degree	14.6%	64
Doctorate degree	3.4%	15
Don't Know	0.5%	2
Refused	0.2%	1

Table A2: Frequencies of Attitudes and Beliefs Regarding Marijuana

		%	#
It is safe to use marijuana.	Strongly Agree	14.84%	65
	Agree	30.82%	135
	Neither Agree nor Disagree	16.21%	71
	Disagree	21.46%	94
	Strongly Disagree	14.38%	63
	Don't Know	1.60%	7
	Refused	0.68%	3
Marijuana is less safe to use than tobacco.	Strongly Agree	7.31%	32
	Agree	18.26%	80
	Neither Agree nor Disagree	11.87%	52
	Disagree	34.70%	152
	Strongly Disagree	22.37%	98
	Don't Know	4.79%	21
	Refused	0.68%	3
Marijuana is less safe to use than alcohol.	Strongly Agree	6.39%	28
	Agree	14.38%	63
	Neither Agree nor Disagree	13.47%	59
	Disagree	39.73%	174
	Strongly Disagree	21.92%	96
	Don't Know	3.42%	15
	Refused	0.68%	3

Using marijuana makes it harder to think clearly or perform tasks	Strongly Agree	15.98%	70
	Agree	47.95%	210
	Neither Agree nor Disagree	11.42%	50
	Disagree	13.24%	58
	Strongly Disagree	5.25%	23
	Don't Know	5.25%	23
	Refused	0.91%	4
Marijuana is more impairing than alcohol.	Strongly Agree	4.34%	19
	Agree	13.93%	61
	Neither Agree nor Disagree	18.26%	80
	Disagree	37.90%	166
	Strongly Disagree	16.44%	72
	Don't Know	8.45%	37
	Refused	0.68%	3
Marijuana is more addictive than alcohol.	Strongly Agree	4.11%	18
	Agree	16.44%	72
	Neither Agree nor Disagree	15.98%	70
	Disagree	33.79%	148
	Strongly Disagree	19.41%	85
	Don't Know	9.82%	43
	Refused	0.46%	2

Table A3: Frequencies of Reported Marijuana Use

		%	#
Have you ever tried marijuana?	Yes	55.02%	241
	No	42.47%	186
	Prefer not to Answer	1.14%	5
	Don't Know	0.46%	2
	Refused	0.91%	4
At what age did you first try marijuana?*	7 years old	0.84%	2
	10 years old	0.84%	2
	12 years old	2.09%	5
	13 years old	6.69%	16
	14 years old	3.77%	9
	15 years old	10.46%	25
	16 years old	14.46%	35
	17 years old	13.39%	32
	18 to 24 years old	41.42%	99
	25 to 34 years old	4.60%	11
	35 to 44 years old	0.84%	2
	45 to 54 years old	0.42%	1
	Refused	45.43%	199
Have you used marijuana in the past 12 months?	Yes	13.24%	58
	No	41.78%	183
	Refused	44.98%	197

Have you used marijuana in the past 30 days?	Yes	7.08%	31
	No	6.16%	27
	Refused	86.76%	380
If marijuana were legal, would you:	Not use it, even if it were legal and available to use.	68.26%	299
	If not currently using marijuana, I would begin using marijuana.	10.96%	48
	If currently using marijuana, I would use more often than I do now.	2.51%	11
	If currently using marijuana, I would use less than I do now.	0.23%	1
	If currently using marijuana, I would quit using marijuana	0.68%	3
	If currently using marijuana, I would use the same as I do now.	12.33%	54
	Don't Know	3.20%	14
	Refused	1.83%	8
*if range was provided for age the value was dropped to the lowest value. For example, 15/16 was changed to 15.			

Table A4: Frequencies of Attitudes and Beliefs Regarding Marijuana and Driving

		%	#
It is unsafe to drive after using marijuana.	Strongly Agree	32.65%	143
	Agree	33.33%	146
	Neither Agree nor Disagree	9.82%	43
	Disagree	14.61%	64
	Strongly Disagree	6.85%	30
	Don't Know	2.74%	12
	Refused	0.00%	0
It is unsafe to drive under the influence of marijuana.	Strongly Agree	28.77%	126
	Agree	41.32%	181
	Neither Agree nor Disagree	5.71%	25
	Disagree	16.89%	74
	Strongly Disagree	4.79%	21
	Don't Know	2.28%	10
	Refused	0.23%	1
It is unsafe to drive within two hours of using marijuana.	Strongly Agree	11.64%	51
	Agree	26.71%	117
	Neither Agree nor Disagree	15.07%	66
	Disagree	25.34%	111
	Strongly Disagree	8.68%	38
	Don't Know	12.10%	53
	Refused	0.46%	2

I would feel safe riding in a car with a driver who had used marijuana before driving	Strongly Agree	4.34%	19
	Agree	17.12%	75
	Neither Agree nor Disagree	8.45%	37
	Disagree	35.62%	156
	Strongly Disagree	32.88%	144
	Don't Know	1.14%	5
	Refused	0.46%	2
Drivers who use marijuana are more likely to be involved in a crash than drivers who don't.	Strongly Agree	19.18%	84
	Agree	36.07%	158
	Neither Agree nor Disagree	13.93%	61
	Disagree	18.95%	83
	Strongly Disagree	6.85%	30
	Don't Know	5.02%	22
	Refused	0.00%	0

Table A5: Frequencies Attitudes and Beliefs Regarding Marijuana, Alcohol, and Driving

		%	#
It is unsafe to drive after consuming alcohol.	Strongly Agree	48.40%	212
	Agree	41.10%	180
	Neither Agree nor Disagree	3.65%	16
	Disagree	2.51%	11
	Strongly Disagree	2.74%	12
	Don't Know	0.91%	4
	Refused	0.68%	3
Driving under the influence of marijuana is safer than driving under the influence of alcohol.	Strongly Agree	15.30%	67
	Agree	24.20%	106
	Neither Agree nor Disagree	17.58%	77
	Disagree	25.57%	112
	Strongly Disagree	8.45%	37
	Don't Know	8.22%	36
	Refused	0.68%	3
Drivers under the influence of marijuana are less likely to get into a crash than drivers under the influence of alcohol.	Strongly Agree	13.24%	58
	Agree	25.80%	113
	Neither Agree nor Disagree	13.93%	61
	Disagree	28.77%	126
	Strongly Disagree	7.99%	35
	Don't Know	9.59%	42
	Refused	0.68%	3

It is unsafe to drive after using both alcohol and marijuana together.	Strongly Agree	53.65%	235
	Agree	39.04%	171
	Neither Agree nor Disagree	1.37%	6
	Disagree	2.28%	10
	Strongly Disagree	1.37%	6
	Don't Know	2.28%	10
	Refused	0.00%	0
Drivers under the influence of marijuana should be penalized at the same level as drivers under the influence of alcohol.	Strongly Agree	22.83%	100
	Agree	42.24%	185
	Neither Agree nor Disagree	3.42%	15
	Disagree	18.04%	79
	Strongly Disagree	11.19%	49
	Don't Know	2.05%	9
	Refused	0.23%	1

Table A6: Frequences of Attitudes and Beliefs Regarding Legalization of Marijuana

		%	#
Texas should legalize marijuana for serious medical conditions like epilepsy or cancer.	Strongly Agree	42.24%	185
	Agree	45.21%	198
	Neither Agree nor Disagree	3.20%	14
	Disagree	5.48%	24
	Strongly Disagree	1.60%	7
	Don't Know	2.05%	9
	Refused	0.23%	1
Texas should legalize marijuana for medical conditions such as arthritis, migraine, or any other illness for which marijuana provides relief.	Strongly Agree	34.47%	151
	Agree	44.29%	194
	Neither Agree nor Disagree	5.94%	26
	Disagree	10.96%	48
	Strongly Disagree	2.51%	11
	Don't Know	1.83%	8
	Refused	0.00%	0
Texas should legalize marijuana for recreational purposes.	Strongly Agree	15.07%	66
	Agree	27.85%	122
	Neither Agree nor Disagree	9.13%	40
	Disagree	24.89%	109
	Strongly Disagree	20.78%	91
	Don't Know	1.37%	6
	Refused	0.91%	4

If Texas were to legalize marijuana, more people would start using marijuana.	Strongly Agree	18.95%	83
	Agree	44.75%	196
	Neither Agree nor Disagree	7.53%	33
	Disagree	20.78%	91
	Strongly Disagree	4.57%	20
	Don't Know	3.20%	14
	Refused	0.23%	1
If marijuana were legal, Texas should identify a legal blood concentration level of impairment.	Strongly Agree	23.29%	102
	Agree	57.08%	250
	Neither Agree nor Disagree	4.11%	18
	Disagree	8.68%	38
	Strongly Disagree	3.65%	16
	Don't Know	2.51%	11
	Refused	0.68%	3
If marijuana were legal, drivers who are under the influence of marijuana should be arrested.	Strongly Agree	17.81%	78
	Agree	42.47%	186
	Neither Agree nor Disagree	5.71%	25
	Disagree	21.92%	96
	Strongly Disagree	8.45%	37
	Don't Know	2.28%	10
	Refused	1.37%	6

If marijuana were legal, more people would be willing to drive under the influence of marijuana.	Strongly Agree	19.18%	84
	Agree	43.38%	190
	Neither Agree nor Disagree	10.05%	44
	Disagree	18.95%	83
	Strongly Disagree	4.57%	20
	Don't Know	3.88%	17
	Refused	0.00%	0

Figure A1: Responses to the Statement: Texas should legalize marijuana for serious medical conditions like epilepsy or cancer, by county

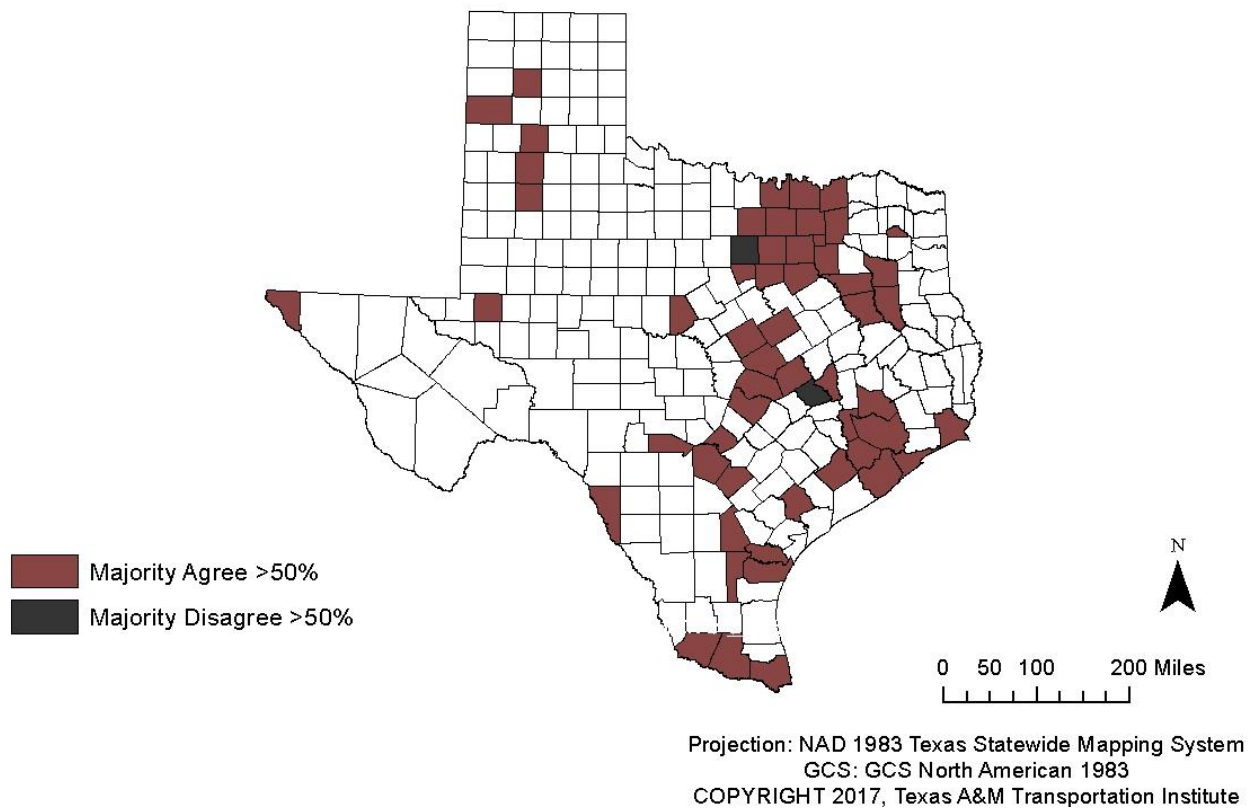


Figure A2: Responses to the Statement: Texas should legalize marijuana for medical conditions, such as arthritis, migraine, or any other illness for which marijuana provides relief, by County

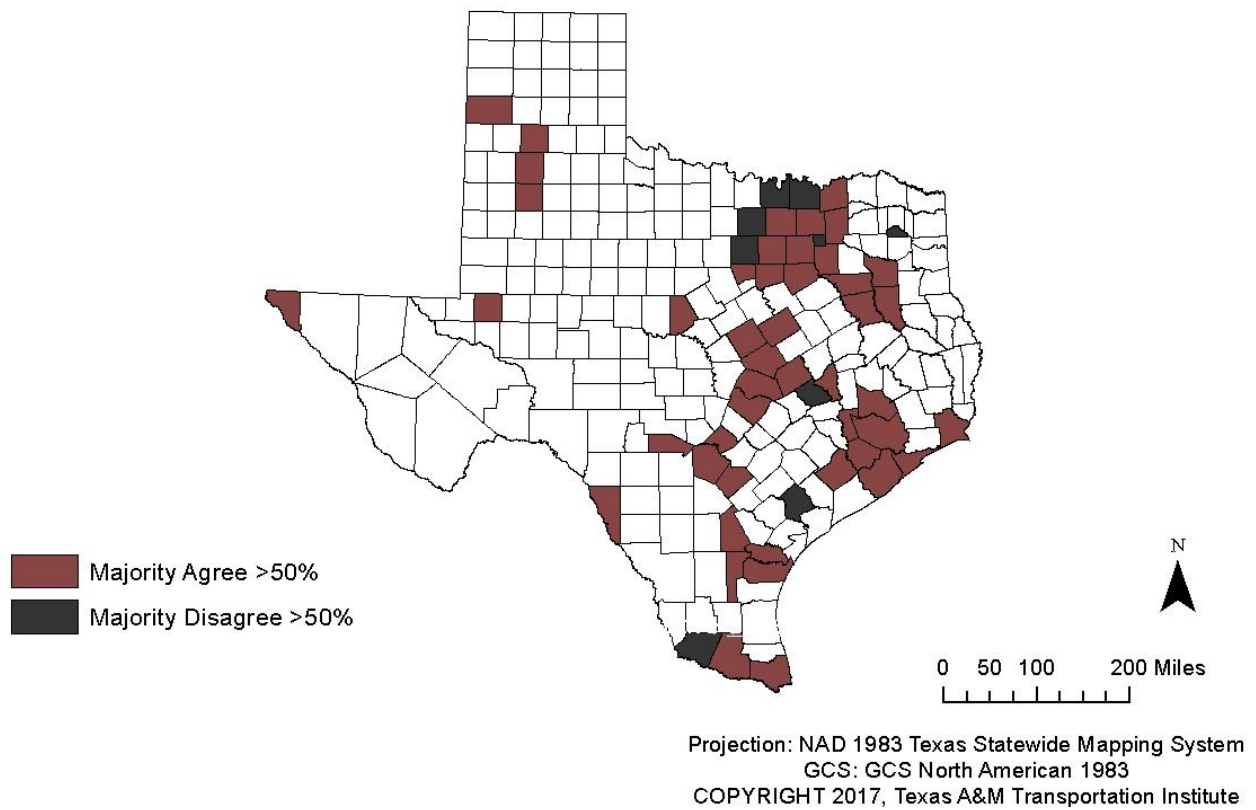
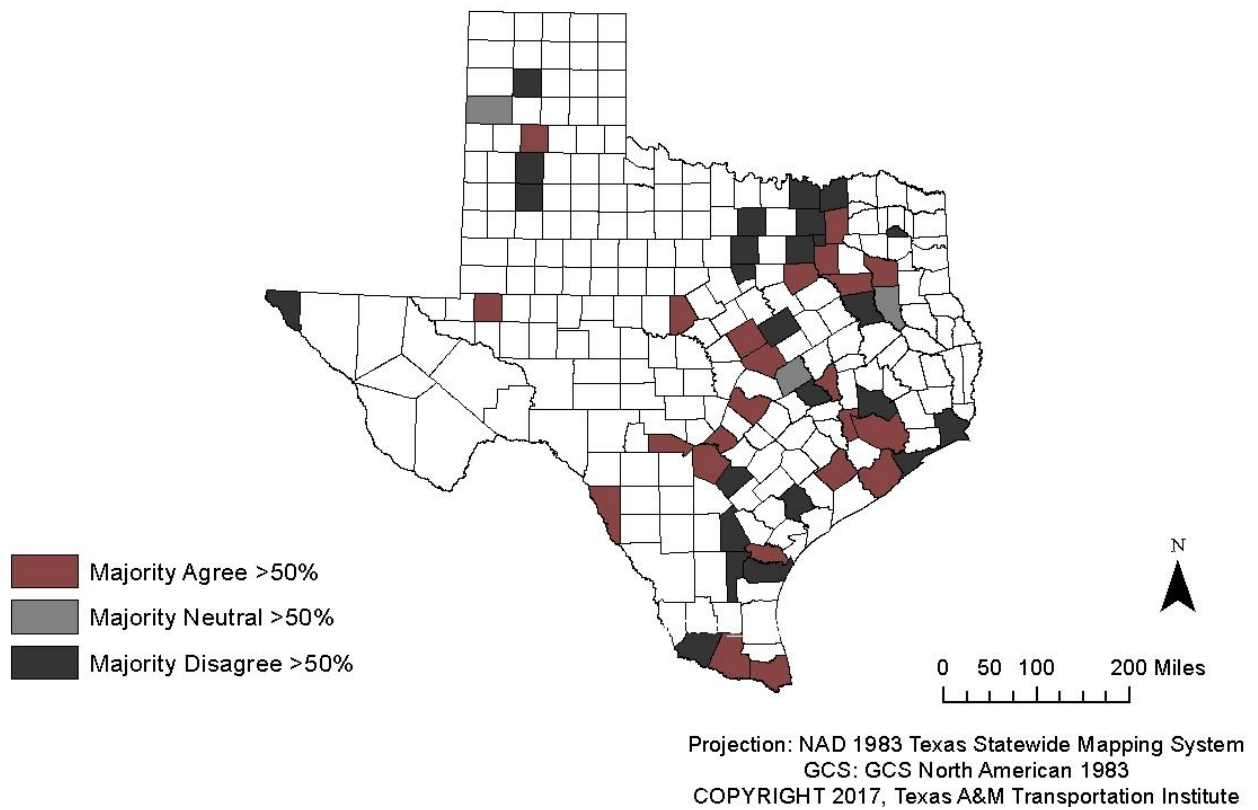


Figure A3: Responses to the Statement: Texas should legalize marijuana for recreational purposes, by county



Appendix E: Denver Subject Matter Expert Panel Participant Biographies

Jim Burack

Jim Burack promoted to the Colo. Dept. of Revenue, MED Director in Feb. 2016, Jim was previously Chief of Investigations. Prior positions include 12 years as police chief, Milliken (CO) (he also served as Town Administrator 2008-14), U.S. Senate staff assistant, Westminster (CO) Police Dept. patrol officer, and Counsel & Director of Operations, Police Executive Research Forum, Wash, DC.

A Marine Corps Reserve colonel, Jim's assignments include liaison officer, FEMA Region VIII (Denver); SJA, Marine Forces Pacific, Hawaii; and DoD IG, Pentagon. Active duty tours include civil affairs, Ramadi, Iraq, 2004-05 and Kosovo, 1999, and Kuwait, 1993, and prosecutor, security platoon commander, and Special Asst. U.S. Attorney, Central District of CA. He was also assigned to the staff of the UN International Police Task Force, Sarajevo, Bosnia in 1996.

Degrees include MA, Univ. of Colo.-Denver; JD, Univ. of Colo.; and BA, Dartmouth College. A graduate of the FBI National Academy (230th) and Senior Management Institute for Police, he also taught criminal justice and policing at the Univ. of Northern Colorado. He's a member of the CO, CA and DC bars.

Sam Cole

Sam Cole is the Communications Manager for Traffic Safety at the Colorado Department of Transportation. He has over 20 years of experience working in the public sector at the national, state and local levels as a director, spokesperson, trainer, liaison, and strategist. At CDOT he oversees marketing, PR and communications on 11 safety-related campaigns, including motorcycle safety, impaired driving, distracted driving, and seat belts. Previous to that position Mr. Cole served as Director of Community Relations at the School of Public Affairs, University of Colorado Denver. In this position he created a full range of communication tools for the university. Mr. Cole has also served as a spokesperson on auto safety issues for a national non-profit in Washington DC and worked extensively with the media and community leaders to promote traffic safety. In other work Mr. Cole has served as a trainer for the Gill Foundation in Denver and managed outreach campaigns in Boulder County. Mr.

Cole earned his Master's in Public Administration from the University of Colorado Denver and his BA in Sociology from the University of Vermont. Mr. Cole is also a dedicated member of the community, serving on numerous boards and was a commissioner with the City and County of Denver from 2010- 2014.

Glenn Davis

Glenn Davis is the Colorado Department of Transportation (CDOT) Highway Safety Manager, responsible for Impaired Driving, Police Services, Motorcycle Safety, Young Drivers and Speed Enforcement. He served on the Colorado Peace Officer Standards and Training (POST) curriculum committee, State Emergency Medical and Trauma Services Advisory and Colorado Prevention Leadership Council. Glenn holds leadership positions on the following state organizations: Colorado Task Force on Drunk and Impaired Driving, Motorcycle Safety Board, Teen Driving Alliance and Persistent Drunk Driver and Traffic committees. Glenn represents the CDOT on the Governor's Marijuana Working Group, Education Oversight Committee and POST Marijuana Working Group.

Glenn retired from Littleton Police (CO) after 25 years of law enforcement where he was the Coordinator of Impaired Driving Enforcement and Drug Recognition Expert programs. Glenn is currently a reserve sergeant in the Ft. Lupton Police Department.

Glenn has received the following awards: The International Association of Chiefs of Police DRE Emeritus; Colorado DRE Centennial Award, for dedication and support to the Colorado DRE program; and Weltzer award for dedication to traffic safety from MADD.

Glenn has a bachelor's degree in Criminal Justice and a Master's Degree in Education from Colorado State University.

Major Steve Garcia

Major Steve Garcia is currently the commander of the Colorado State Patrol (CSP) District One – Metropolitan Denver. This district encompasses four CSP Troops that cover the entire Denver Metro area to include Adams County, Castle Rock, Boulder, Golden, Idaho Springs and all operations of Executive Protection and the security at the Colorado State Capitol. He previously was the Training Services Branch commanders and served concurrently as the Director of the Colorado State Patrol Academy. This branch encompassed the CSP Academy, Special Events Unit, Media and Marketing Center, Public Affairs, Victims' Advocates and the CSP Chaplains Program.

Major Garcia started with the Colorado State Patrol in 2001 as a Trooper assigned to the Pueblo troop. During this time, he was named the 100 Club of Colorado Trooper of the Year in 2003 for the apprehension of an armed kidnapper and robber and in 2004 was the MADD Colorado Officer of the Year.

He currently serves on the Colorado POST Academy Directors Board, the Colorado Legislative Marijuana Curriculum Committee and the MADD Board of Executive Directors. He serves as the Patrol's subject matter expert on the impacts of legalized marijuana on law enforcement operations and leads the CSP Drug Recognition Expert program. He serves as the Commander

of the Patrol's management, security and operations of the USA Pro-Cycling Challenge which is the largest professional bicycle race in North America viewed across the globe on NBC Sports. He also directly oversees all security, planning and operations of all CSP special events to include the Boulder Ironman, security and operations of all visiting NFL teams playing the Denver Broncos, 9/11 Ceremonial events hosted by the CELL and other statewide events.

Major Garcia is a 21 year veteran of law enforcement and is a fourth generation law enforcement officer.

Carol Gould

Carol Gould is a Highway Safety Manager within the Office of Transportation Safety. For the past nine years Carol has administered the National Highway Traffic Safety Administration (NHTSA) highway safety program funds and focuses on a variety of traffic safety issues. Carol is passionate about traffic safety issues and helping save lives through public education and awareness. Carol works closely with law enforcement, non-profits, highway safety office grantees, regional trauma advisory councils and a variety of State and local partners to share information and improve traffic safety on Colorado's roadways. She is involved in efforts to educate the public on impaired driving and the challenges associated with the recent legalization of marijuana in Colorado. Carol also serves on the Governors' Highway Safety Association Board as the NHTSA Region 8 Representative. Prior to joining CDOT, Carol worked for the Colorado Department of Public Safety, Division of Criminal Justice, administering the Office of Juvenile Justice and Delinquency Prevention (OJJDP) grant funds. She has over 18 years of experience in navigating State and Federal grant processes and has participated in several assessments within the Highway Safety Office. Carol holds a BA from the University of Colorado and an MA from the University of Denver.

Brenna Hersey

Brenna Hersey is an Account Supervisor at Amelie Co. located in Denver, CO, and has worked on the Colorado Department of Transportation's traffic safety advertising efforts for four years. As Account Supervisor, Brenna oversees research, strategic development, brand messaging, creative development and cohesion for her clients at every communication touchpoint. Together CDOT and Amelie Co. have launched four successful campaigns educating the public on the dangers of driving while high on marijuana. Brenna led strategic and creative development of the most recent campaigns, resulting in 46% of message recall among our audience after three weeks in market. She has over eight years of advertising experience working on a variety of clients. Her focus has been on education and behavior change initiatives with clients such as The Colorado Department of Public Health and Environment, National Grid Energy, The Vermont Department of Health and Seventh Generation. Brenna received a

Bachelor's degree in Business Administration/Marketing from the University of Vermont in 2007.

Kristi Kelly

Kristi Kelly has brought her entrepreneurial passion, commitment to safe access to quality cannabis, and deep empathy for the human condition towards the advancement of marijuana businesses, as well as the environment in which colleagues, associates, patients and customers operate. Kristi is the executive director of Marijuana Industry Group, Colorado's oldest and largest trade association for licensed marijuana businesses, where she also served as vice chair and a board member. Kristi was an owner, and remains an investor in a group of marijuana cultivation, manufacturing and dispensary business in the Denver area, where she served as COO until December 2015. She is a founding board member of the Fourth Corner Credit Union, the world's first marijuana financial institution. She is also the founding trustee of CannAbility Foundation, a patient advocacy and resource network for families of children living with conditions and disabilities that can be helped by cannabis. She currently sits on Denver's Social Consumption Advisory Committee, the Colorado Task Force for Drunk and Impaired Driving, the Colorado Department of Health and Environment's Marijuana Occupational Health and Safety Workgroup, and Denver's Odor Advisory Workgroup, and has participated in numerous other appointments, workgroups, and rulemaking committees. Past roles include founding board member and former co-chair of the Association of Cannabis Trades of Colorado and founding board member of Cannabis Business Alliance. She was featured in *Breaking the Grass Ceiling: Women, Weed & Business*; recognized as one of 2016's 50 most powerful women in cannabis (#12) by Cannabis Business Executive, and one of the Industry Trailblazers by the Hemp Connoisseur.

Chief Robert Ticer

Chief Robert Ticer is a 27-year veteran law enforcement officer and is currently the Chief of Police in Loveland, Colorado. Prior to this position, he was Chief of Police in Avon, CO for 6 years following a 20-year career with the Arizona Department of Public Safety (DPS), where he retired at the rank of Major. Chief Ticer completed assignments in the Highway Patrol Division, Media Relations Office, Director's Office, Criminal Investigations Division, and a one-year fellowship at the National Highway Traffic Safety Administration in Washington, D. C.

Robert holds a Bachelor of Science Degree and a Master's of Education Degree from Northern Arizona University, is a graduate of the Northwestern University School of Police Staff and Command, and the FBI National Academy. The chief chairs the Colorado Task Force on Drunk and Impaired Driving, is a member of the IACP Highway Safety Committee, where he serves as the Chairman of the DRE Technical Advisory Panel, and is a past president of the Colorado Association of Chiefs of Police.

Patrick Witcher

Patrick Witcher is President of Buddy Boy Brands, a vertically integrated medical marijuana operation in Denver and has over 20 years of experience in local and federal law enforcement.

His service within the United States Drug Enforcement Administration as Special Agent earned him Top Secret SBI Clearance, wherein he supervised and conducted numerous high-level narcotics and money- laundering investigations, Title 3 wiretaps, served high-risk search and arrest warrants, and testified in Federal Court on countless investigations while assigned to the Las Vegas District Office. He also has highly decorated careers with the Kansas City Missouri Police Department and the United States Air Force.

In Patrick's new Position as President of Buddy Boy Brands, he has taken his vast law enforcement experience, management skills and education to run a successful, medical marijuana operation. He assisted with negotiations to take over eight dispensary and six cultivation licenses that were on administrative hold with the Marijuana Enforcement Division and the State Attorney General. He handled all aspects of securing licensing for all 14 entities and reopened them in July 2014. At the end of 2015, Buddy Boy Brands surpassed \$20,000,000.00 in annual sales. He has implemented new policies and procedures to ensure strict compliance with City and State Regulations and works closely with Marijuana Enforcement (MMED) Investigators, City Licensing and Fire Inspectors to ensure strict adherence to State and local regulations.

Patrick has worked closely with a Colorado Assistant Attorney General and the Director of Colorado Peace Officer Standards and Training (POST) to develop a training video on the marijuana industry at his facilities. In addition, Patrick hired two full time Compliance Officers who were former MMED Investigators to implement and ensure strict adherence to all new policies and procedures. Patrick has also consulted with state legislators and agencies from across the country.

Patrick has a Bachelor's degree in Criminal Justice Administration and has graduated from the US Drug Enforcement Administration Academy and the US Air Force Police Academy.

Appendix F: Panel Discussion Agenda

AGENDA – APRIL 4, 2017



Texas A & M Research Project with CDOT/CTFDID

Colorado Department of Transportation
4670 Holly St, Denver, CO 80216
Turnpike Room East and West

0800-0900:

How highway safety programming has been created to address marijuana-impaired driving:
Glenn Davis, Carol Gould, Sam Cole (CDOT), Chief Bob Ticer (Loveland Police), Major Steve Garcia (Colorado State Patrol), Brenna Hersey (Amelie Company)

0930-1030:

How the highway safety office works with the marijuana industry to facilitate traffic safety initiatives:

Glenn Davis, Carol Gould, Sam Cole (CDOT), Chief Bob Ticer (Loveland Police), Major Steve Garcia (Colorado State Patrol), Kristi Kelly (Marijuana Industry Group-MIG), Brenna Hersey (Amelie Company), Pat Witcher, President (Buddy Boy Brands)

1100-1200:

Post legalization, what is the marijuana interest group's role and what are they doing to facilitate traffic safety initiatives:

Glenn Davis, Carol Gould, Sam Cole (CDOT), Chief Bob Ticer (Loveland Police), Kristi Kelly (MIG), Brenna Hersey (Amelie Company), Pat Witcher, President (Buddy Boy Brands)

1200-1300: Lunch

1300-1400:

The creation of laws and policies, specifically the regulation of the marijuana industry:
Jim Burack Director, Marijuana Enforcement Division, (Colorado Department of Revenue), Kristi Kelly (MIG), Pat Witcher, President (Buddy Boy Brands)

1430-1530:

How the marijuana interest groups worked with the state to pass sensible legislation:

Jim Burack Director, Marijuana Enforcement Division, (CDOR), Kristi Kelly (MIG), Pat Witcher, President (Buddy Boy Brands)