

Health and Safety Endpoints: Injury and Death, and Crime Rates

Executive Order 15-17

Report to the Governor's Marijuana Advisory Commission

Provided by the Roadway Safety Subcommittee

November 9, 2017

Thomas D. Anderson

Commissioner, Department of Public Safety

Joe Flynn

Secretary, Agency of Transportation

Captain Mike Major

Designee of Criminal Justice Training Council

Chief Jennifer Morrison

Designee of Vermont League of Cities and Towns

Marshall Pahl

Designee of Defender General

Trisha Conti

Director, Vermont Forensic Laboratory

Honorable Brian Grearson

Representative of the Judiciary appointed by the Chief Justice of the Vermont Supreme Court

Bill Mapes

Emergency Medical Service Provider

Other participants:

John Campbell

Executive Director, Department of State's Attorneys and Sheriffs

Joe Benning

Senator, Vermont General Assembly

Maxine Grad

Representative, Vermont General Assembly

INTRODUCTION

Overview

In satisfaction of its obligations under Executive Order 15-17, the Roadway Safety Subcommittee presents the following report to the Governor's Marijuana Advisory Commission.¹ As detailed more fully below, the Roadway Safety Subcommittee has assessed and compiled high-quality primary research and Vermont data for two health and safety endpoints listed in the Executive Order: "Injury and Death," and "Crime Rates." The Subcommittee anticipates that the information provided below will help inform the policy discussions surrounding the potential impacts of marijuana use and marijuana legalization on the health and safety of Vermonters.

Executive Order 15-17

On September 7, 2017, Governor Philip B. Scott signed Executive Order 15-17, creating the Governor's Marijuana Advisory Commission ("Commission"). The Executive Order also established three subcommittees: Roadway Safety, Education and Prevention, and Taxation and Regulation. The three subcommittees are advisory to the Governor.

Executive Order 15-17 outlines tasks and timelines for the Commission and subcommittees. The Roadway Safety Subcommittee's overarching mandate is "to examine and present findings on drugged driving and recommend appropriate measures to ensure roadway safety," and to "pursue a regional impairment threshold for the New England states, and parity in drugged driving roadway safety laws and penalties." In the Executive Order, the specific tasks outlined to meet this mandate are organized by phases, and this report fulfills the obligations of the Roadway Safety Subcommittee under the Commission's first phase.

With respect to the first phase of the Commission's work, Executive Order 15-17 instructs as follows:

In order to establish a common baseline understanding of the most credible data regarding health endpoints of marijuana use and safety impacts of legalization, on or before November 15, 2017, the Subcommittees on Highway Safety and Education and Prevention shall assess high-quality primary research, including evidence-based Vermont data to the extent it is available, for the following groups of health and safety endpoints and report to the Commission

In coordination with the Subcommittee on Education and Prevention, the Subcommittee on Roadway Safety identified two health and safety endpoints that relate directly to its charge: Injury and Death, and

¹ The Roadway Safety Subcommittee is comprised of the Commissioner of Public Safety (chair), the Secretary of the Agency of Transportation, one member designated by the Criminal Justice Training Council, one member designated by the Vermont League of Cities and Towns, one designee of the Defender General, the Director of the Vermont Forensic Laboratory, one representative of the Judiciary appointed by the Chief Justice of the Vermont Supreme Court, and one emergency medical service provider. Members of the Vermont General Assembly and the Executive Director of the Department of State's Attorneys and Sheriffs are also Subcommittee participants, by virtue of their membership on the larger Commission.

Crime Rates. Based on these two endpoints, the Roadway Safety Subcommittee focused on the following research questions:

- Is marijuana **use**, alone or in combination with other substances, associated with an increased risk of (1) motor vehicle crashes and (2) motor vehicle fatalities?
- Is marijuana **legalization** associated with an increased risk of (1) motor vehicle crashes and (2) motor vehicle fatalities?
- Do crime rates (i.e., rates of violent crime, property crimes or other collateral crimes) increase or decrease when marijuana is (1) decriminalized or (2) legalized for recreational use?

Between September 28, 2017—the inaugural meetings of the Commission and subcommittees—and November 9, 2017, the Roadway Safety Subcommittee compiled and assessed existing high-quality primary research and Vermont data relating to its research questions. Two informal study groups reviewed a variety of relevant studies and reports, identifying those that were authoritative, recent, and of high quality, and also reviewed Vermont data. The studies and reports summarized in this report include peer-reviewed studies, state government reports, and reports compiled by non-governmental entities. The full Subcommittee also reviewed and evaluated the study groups' research. Appendix A attached to this report contains a list of the studies, other reports, and data sources reviewed by the two study groups, including those not summarized in this report.

Accordingly, the Roadway Safety Subcommittee presents the following report, dated November 9, 2017, to the Governor's Marijuana Advisory Commission as required by Executive Order 15-17. High-quality primary research and data relating to the "Injury and Death" and "Crime Rates" endpoints are set forth below.

INJURY AND DEATH ENDPOINT: MOTOR VEHICLES

Introduction

Between September 28, 2017 and November 9, 2017, the Roadway Safety Subcommittee compiled and assessed high-quality primary research and data relating to the “Injury and Death” endpoint set forth in Executive Order 15-17. Specifically, an informal working group of the Subcommittee compiled research and data in response to the following two questions:

- Is marijuana **use**, alone or in combination with other substances, associated with an increased risk of (1) motor vehicle crashes and (2) motor vehicle fatalities?
- Is marijuana **legalization** associated with an increased risk of (1) motor vehicle crashes and (2) motor vehicle fatalities?

The Subcommittee presents the following summaries for consideration in response to the research questions noted above. Although the Subcommittee reviewed all the studies contained in Appendix A, the following are highlighted because they were deemed to present “high-quality primary research” and data on the two research questions referenced above. The Subcommittee also presents currently available Vermont crash data. Finally, as reflected in multiple studies below, *association* does not necessarily indicate *causation*.

I. Is marijuana use, alone or in combination with other substances, associated with an increased risk of (1) motor vehicle crashes and (2) motor vehicle fatalities?

1. National Academies of Sciences, Engineering, and Medicine. 2017. *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research*. Washington, DC: The National Academies Press. doi: 10.17226/24625 (available online at <https://www.nap.edu/read/24625/chapter/11#230>).

Summary

The National Academies of Sciences, Engineering, and Medicine (NAS) published a study in early 2017 that concluded the following: “There is substantial evidence of a statistical association between cannabis use and increased risk of motor vehicle crashes” (230). Also, based on a “meta-analysis” conducted by Rogeberg and Elvik 2016 (a study further described below), the magnitude of the impact of marijuana use on motor vehicle crashes was “low to moderate in range” (229).

Discussion

To compile this report, the NAS committee focused on “recently published systematic reviews (since 2011) and high-quality primary research that studied 1 or more of 11 groups of health endpoints” (31). In chapter 9, “Injury and Death,” the NAS committee identified multiple systematic reviews “that summarized the association between driving under the influence of cannabis (DUIC) and [motor vehicle crashes]” (228). Specifically, the NAS committee reviewed the following studies identified as “fair or good quality” (228):

Asbridge, M., J. A. Hayden, and J. L. Cartwright. 2012. Acute cannabis consumption and motor vehicle collision risk: Systematic review of observational studies and meta-analysis. *BMJ* 344:e536.

Calabria, B., L. Degenhardt, W. Hall, and M. Lynskey. 2010. Does cannabis use increase the risk of death? Systematic review of epidemiological evidence on adverse effects of cannabis use. *Drug and Alcohol Review* 29(3):318–330.

Elvik, R. 2013. Risk of road accident associated with the use of drugs: A systematic review and meta-analysis of evidence from epidemiological studies. *Accident Analysis & Prevention* 60:254–267.

Hartman, R. L., and M. A. Huestis. 2013. Cannabis effects on driving skills. *Clinical Chemistry* 59(3):478–492.

Li, M. C., J. E. Brady, C. J. DiMaggio, A. R. Lusardi, K. Y. Tzong, and G. Li. 2012. Marijuana use and motor vehicle crashes. *Epidemiologic Reviews* 34:65–72.

Rogeberg, O., and R. Elvik. 2016. The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction* 111(8):1348–1359.

Rogeberg and Elvik 2016 is identified as the most “comprehensive” and recent, and the NAS report’s discussion focuses on that study’s findings (228). In sum, the NAS committee describes that study’s findings as follows: “Overall, the meta-analysis by Rogeberg and Elvik (2016) found that [driving under the influence of cannabis], as indicated by self-reported cannabis use or the presence of THC metabolite in blood, saliva, or urine, was associated with 20 to 30 percent higher odds of [a motor vehicle crash]” (228–229). The magnitude of the association was “low to moderate in range” (229), and the NAS committee agreed (229). (Rogeberg and Elvik 2016 is described more fully below.)

Lastly, the NAS report identifies a few limitations of the Rogeberg and Elvik study (229–230). One limitation—which was pointed out by a different study, and reiterated here by the NAS—was that driving under the influence in Rogeberg and Elvik’s study “may have not just referred to acute intoxication” (229). Drivers included in Rogeberg and Elvik may not have been intoxicated or impaired (229). Also, according to the NAS report, Rogeberg and Elvik’s review assessed studies with different methodologies and did not include “laboratory and simulator studies”—i.e., those that assess the affect of cannabis intoxication on “psychomotor skills” (230). The NAS committee suggests epidemiological studies may address noted limitations (230).

2. Rogeberg, O., and R. Elvik. 2016. The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction* 111(8):1348–1359. doi:10.1111/add.13347 (available at <http://onlinelibrary.wiley.com/doi/10.1111/add.13347/epdf>).

Summary

Rogeberg and Elvik conclude that acute cannabis intoxication “is related to a statistically significant risk increase” for motor vehicle crashes, and “[t]he increase is of low to medium magnitude” (1357, 1348). In this study, the authors reviewed previous studies that were conducted between 1982 and 2015 (1353). Rogeberg and Elvik lowered the risk estimates of earlier studies based on “methodological issues—in particular, the use of counts data without adjustment for known confounders” (1357).

Discussion

More specifically, Rogeberg and Elvik found that “roughly 20–30% of traffic crashes involving cannabis use occur because of the cannabis use” (1355). The authors equate this risk to alcohol: the risk “is comparable to the increased risk for any traffic crash found for a blood alcohol content (BAC) of 0.04–0.05” (1356). The authors discuss that their estimate revises earlier studies’ estimates; Rogeberg and Elvik made adjustments based on methodological issues with those previous studies (i.e., confounding factors) (1355, 1357). However, despite their conclusion of a “low to moderate” increase in crash risk, the authors are careful to point out the complexity of causation (1357).

For instance, the authors discuss alternative interpretations of their study’s results (1357). First, the authors note, “if users are more likely to drive when they judge their impairment to be low, then the estimates above will underestimate the (unobserved) crash risk of the currently non-driving users” (1357). On the other hand, they also state, “deciding to drive while intoxicated is a decision correlated with traits that predict higher crash risk independently of cannabis use: high speeds, close following, dangerous lane shifts and drunk driving” (1357). The authors state that “[t]his would give estimates an upward bias, in that ‘driving after cannabis use’ functions as an indicator of an underlying high-risk type of driver” (1357).

Lastly, the authors caution readers with respect to the various policy implications of their study’s conclusion, raising other possible “causal channels” (1357). For example, the authors cite a prior study that found there was “a net reduction in traffic crashes” associated with the introduction of medical marijuana laws in the United States (1357). As that prior study noted, the explanation for such a finding might be “consumers shifting from alcohol (with high crash risk) to cannabis (with lower crash risk), or due to cannabis users driving less than they would have after drinking (e.g. smoking at home rather than driving to a bar)” (1357). The authors therefore stress that “a low-to-moderate causal effect of acute cannabis intoxication on crash rates is likely to play a limited role in the overall policy picture surrounding cannabis legislation” (1357).

3. Compton, R. (2017, July). Marijuana-Impaired Driving - A Report to Congress. (DOT HS 812 440). Washington, DC: National Highway Traffic Safety Administration (available at <https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812440-marijuana-impaired-driving-report-to-congress.pdf>).

Summary

In July 2017, the National Highway Traffic Safety Administration (NHTSA) submitted this report to Congress. The report contains a section entitled, “Review of Research on the Effects of Marijuana use on Driving” (11). Within this section, the NHTSA study discusses multiple studies, and summarizes its conclusion as follows: “Despite the variability in results, this research has demonstrated the potential of marijuana to impair driving related skills” (11).

The report also describes a handful of studies that evaluate the combined effects of marijuana and alcohol on driving ability (12–13). The report does not appear to draw a conclusion on this point, instead noting “[f]urther research may help clarify the effects of combined alcohol and marijuana use” (13).

4. Li G, Chihuri S, Brady JE. *Role of alcohol and marijuana use in the initiation of fatal two-vehicle crashes*. Ann Epidemiol. 2017;27(5):342-347.
<http://dx.doi.org/10.1016/j.annepidem.2017.05.003>.

Summary

This study assessed the effects of alcohol and marijuana individually and jointly “on the initiation of fatal two-vehicle crashes” (342). The authors conclude, “Alcohol and marijuana each play a significant role in fatal crash initiation. When used in combination, alcohol and marijuana appear to have a positive interaction effect on the risk of fatal crash initiation on the additive scale” (342). Stated another way, the study’s results “indicate that the risk of crash initiation from concurrent use of alcohol and marijuana among drivers may increase by more than fivefold when compared with drivers who test negative for alcohol and marijuana controlling for age, sex, and driving history within the previous 3 years” (345). The authors state the study also “confirms” that marijuana use “alone increases crash culpability significantly” (345).

Discussion

This study analyzed NHTSA Fatality Analysis Reporting System (FARS) data on drivers who initiated two-vehicle fatal crashes, and drivers who did not initiate such crashes (343–344). A total of 14,742 crashes were analyzed, involving 14,742 initiators and 14,742 non-initiators (344). The study adjusted for the following factors: age, sex, and driving history in the last 3 years (344). Based on the data and subsequent adjustments, the authors found risk for crash initiation increased “by more than fivefold” with the concurrent use of marijuana and alcohol (345).

Nonetheless, the authors note various limitations of the study. For instance, the authors clarify that drivers testing positive for marijuana were not necessarily impaired due to marijuana use at the time of the accident (346). The authors also raise the possibility of variation among states’ “toxicological testing methods and specimens,” but they do not believe that this variation had a “significant impact” on the results (346). The authors finally note that the increased crash risk could be attributed to some “unmeasured confounding factors” (346).²

5. *Monitoring Health Concerns Related to Marijuana in Colorado: 2016 – Changes in Marijuana Use Patterns, Systematic Literature Review, and Possible Marijuana-Related Health Effects*. Colorado Department of Public Health and Environment (2016) (available at <https://drive.google.com/file/d/0B0tmPQ67k3NVQIFnY3VzZGVmdFk/view>).

Summary

The Retail Marijuana Public Health Advisory Committee (“Committee”), appointed by the Colorado Department of Public Health and Environment, published this report pursuant to its legislative charge (iii). The report concludes as follows: “the risk of a motor vehicle crash increases among drivers

² Recent research suggests possible limitations on the use of the FARS database to determine trends in drug use or to obtain risk estimates. For example, see Romano, E., Torres-Saavedra, P., Voas, R.B. et al. *Marijuana and the Risk of Fatal Car Crashes: What Can We Learn from FARS and NRS Data?* J Primary Prevent (2017) 38: 315. <https://doi.org/10.1007/s10935-017-0478-3>.

with recent marijuana use” (vii). The Committee also concludes, “Furthermore, the higher the blood THC level, the higher the motor vehicle crash risk” (vii). With respect to marijuana use in combination with other substances, “using alcohol and marijuana together increases impairment and the risk of a motor vehicle crash more than using either substance alone” (vii). On related issues the Committee concludes, “For less than weekly marijuana users, using marijuana containing 10 milligrams or more of THC is likely to impair the ability to safely drive, bike, or perform other safety sensitive activities. Less than weekly users should wait at least six hours after smoking or eight hours after eating or drinking marijuana to allow time for impairment to resolve” (vii).

Discussion

To satisfy its legislative charge and reach its conclusions, the Committee reviewed existing scientific evidence relating to marijuana use and driving (147). With respect to the Roadway Safety Subcommittee’s first research question, the Committee’s conclusions include the following:

- “We found SUBSTANTIAL evidence that recent marijuana use by a driver increases their risk of motor vehicle crash” (150).
- “We found SUBSTANTIAL evidence that the combined use of marijuana and alcohol increases impairment and motor vehicle crash risk more than use of either substance alone” (150).

The Committee’s other conclusions relate to THC levels, frequency of use, impairment, and waiting time before driving (150–151).

In the report, the limitations of the Committee’s findings are also discussed. First, “the available research evaluated the association between marijuana use and potential adverse health outcomes. This association does not prove that the marijuana use alone caused the effect” (v). Other possible causal factors “were not identified” (v). The report adds, “marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use” (v).

Lastly, the Committee notes certain “research gaps.” Those include “the need for more research on the relationship of THC levels in saliva, blood and urine, and how these biomarkers relate to measures of functional impairment” (148). Moreover, “Research focusing on impairment in daily or near-daily marijuana users is needed, as the relationship between timing of use, THC levels and impairment may differ from these effects in less-than-weekly users” (148). The report encourages the state of Colorado to fund research on these and other topics (153).

II. *Is marijuana legalization associated with an increased risk of (1) motor vehicle crashes and (2) motor vehicle fatalities?*

1. Jayson D. Aydelotte et al. "Crash Fatality Rates After Recreational Marijuana Legalization in Washington and Colorado", *American Journal of Public Health* 107, no. 8 (August 1, 2017): pp. 1329-1331. doi: 10.2105/AJPH.2017.303848.

Summary

This study concludes, "Three years after recreational marijuana legalization, changes in motor vehicle crash fatality rates for Washington and Colorado were not statistically different from those in similar states without recreational marijuana legalization" (Aydelotte et al. 1329). The control states in the study were Alabama, Indiana, Kentucky, Missouri, South Carolina, Tennessee, Texas, and Wisconsin (1330). However, the authors also note that additional studies over a longer period are necessary (1331).

Discussion

This study analyzed WA and CO data as compared to data from the control states (1329). The control states were selected based on certain comparable characteristics to WA and CO—i.e., traffic, population, drivers, and traffic laws (1329). The authors used FARS data "to determine the annual number of motor vehicle crash fatalities" in WA, CO, and the control states between 2009 and 2015 (1329); they also assessed motor vehicle fatalities per "billion vehicle miles traveled" (1329). In sum, the authors compared year-to-year changes in the WA and CO data with the data from the control states, focusing on pre- and post-legalization of marijuana for recreational use in WA and CO (1329).

Overall, the authors "found no significant association between recreational marijuana legalization in Washington and Colorado and subsequent changes in motor vehicle crash fatality rates in the first 3 years after recreational marijuana legalization" (1330). However, the authors acknowledge that while their analysis did not consider the "excess" fatalities since legalization to be a "clinically significant effect," others may view the results differently (1330).³

In the study, the authors also discuss certain limitations of their approach. For example, they discuss the control-state comparisons: states are unique and certain factors likely affect rates of crashes (i.e., enforcement, and law or policy) (1330). A smaller pool of control states, they add, may have increased the similarity between the states studied, but it also may have "increased the risk of selection bias" (1331). The authors note that their study did not assess WA and CO "separately," despite differences in the legalization laws in those two states (1331). They also did not assess the difference in effects between legalization of recreational use and legalization of the commercial sale of marijuana; this, they state, deserves future study (1331). Finally, the authors stress an important distinction: their

³ Specifically, the authors state, "The difference-in-differences coefficient we observed, 0.2 fatalities per billion vehicle miles traveled, would equate to approximately 77 excess crash fatalities (of 2890 total) over nearly 38 million person years of exposure in the 3 years since legalization" (1330). The Subcommittee does not comment on the clinical significance of the study's reported "excess crash fatalities," but notes that it is unsure whether an increase of the same magnitude in Vermont might be analyzed or viewed differently.

study looked at “total crashes” and not “marijuana-impaired crashes” (1331). The authors state that further studies with more states are necessary (1331).

2. Rocky Mountain High Intensity Drug Trafficking Area. *The Legalization of Marijuana in Colorado: The Impact*. Volume 5, October 2017 (available at <http://www.rmhidta.org/html/FINAL%202017%20Legalization%20of%20Marijuana%20in%20Colorado%20The%20Impact.pdf>).

Summary

In October 2017, the Rocky Mountain High Intensity Drug Trafficking Area (RMHIDTA) released Volume 5 of its annual report: *The Legalization of Marijuana in Colorado: The Impact*. The report addresses multiple topics relating to the legalization of marijuana in Colorado, one of which is “Impaired Driving and Fatalities” (1).

This year’s report summarizes multiple findings in its section on impaired driving, including increases in marijuana-related traffic deaths in Colorado from 2013 to 2015, and increases in the percentage of “marijuana-related traffic deaths involving drivers testing positive for marijuana” from 2009 to 2016 (13). The report also notes the following: “This report will cite datasets with terms such as ‘marijuana-related’ or ‘tested positive for marijuana.’ That does not necessarily prove that marijuana was the cause of the incident” (11).

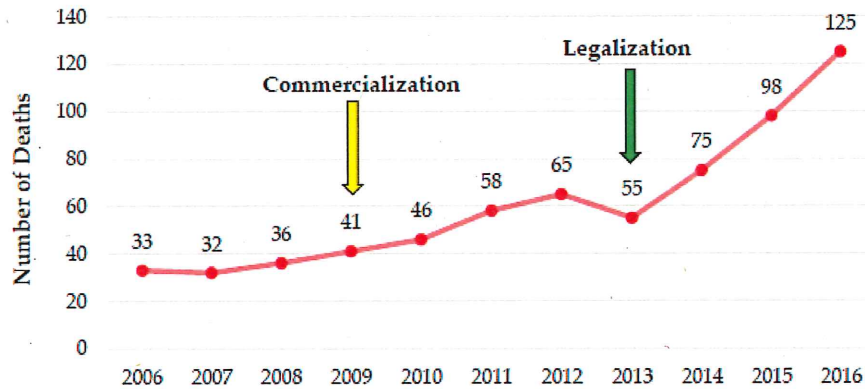
Discussion

The RMHIDTA report presents multiple findings in its 2017 report, which include the following⁴:

- “Marijuana-related traffic deaths when a driver tested positive for marijuana more than doubled from **55** deaths in 2013 to **125** deaths in 2016” (13). (See graph below.)

⁴ All the emphasis in the following quotations is in the original RMHIDTA report.

Traffic Deaths Related to Marijuana when a Driver Tested Positive for Marijuana



SOURCE: National Highway Traffic Safety Administration, Fatality Analysis Reporting System (FARS), 2006-2011 and Colorado Department of Transportation 2012-2016

(Source: Rocky Mountain High Intensity Drug Trafficking Area, page 17)

- "Marijuana-related traffic deaths **increased 66 percent** in the four-year average (2013-2016) since Colorado legalized recreational marijuana compared to the four-year average (2009-2012) prior to legalization" (13).
 - o "During the same time period, all traffic deaths increased 16 percent" (13)
- "In 2009, Colorado marijuana-related traffic deaths involving drivers testing positive for marijuana represented **9 percent** of all traffic deaths. By 2016, that number has more than doubled to **21 percent**" (13). (See chart below.)

**Traffic Deaths Related to Marijuana
When a DRIVER Tested Positive for Marijuana**

Crash Year	Total Statewide Fatalities	Fatalities with Drivers Testing Positive for Marijuana	Percentage Total Fatalities
2006	535	33	6.17%
2007	554	32	5.78%
2008	548	36	6.57%
2009	465	41	8.82%
2010	450	46	10.22%
2011	447	58	12.98%
2012	472	65	13.77%
2013	481	55	11.43%
2014	488	75	15.37%
2015	547	98	17.92%
2016	608	125	20.56%

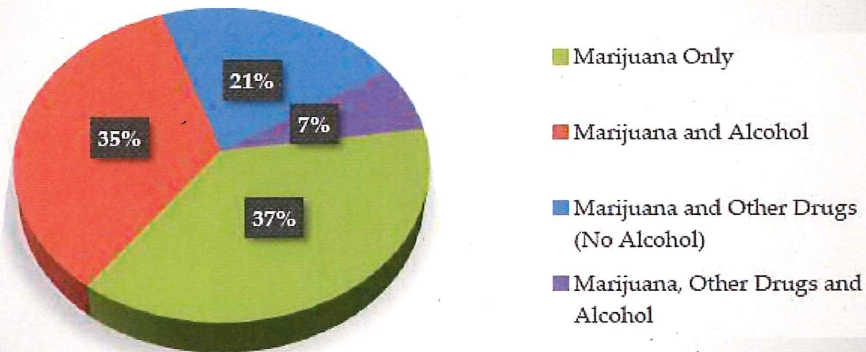
SOURCE: National Highway Traffic Safety Administration, Fatality Analysis Reporting System (FARS), 2006-2011 and Colorado Department of Transportation 2012-2016

- ❖ In 2016 there were a total of 125 marijuana-related traffic deaths when a driver tested positive for marijuana. Of which:
- 102 were drivers
 - 19 were passengers
 - 2 were pedestrians
 - 2 were bicyclists

(Source: Rocky Mountain High Intensity Drug Trafficking Area, page 16)

- “Consistent with the past, in 2016, less than half of drivers (**44 percent**) or operators (**48 percent**) involved in traffic deaths were tested for drug impairment” (13).
- “The number of toxicology screens positive for marijuana (primarily DUID) **increased 63 percent** in the four-year average (2013-2016) since Colorado legalized recreational marijuana compared to the four-year average (2009-2012) prior to legalization” (13).

Drug Combinations for Drivers Positive for Marijuana*, 2016



*Toxicology results for all substances present in individuals who tested positive for

SOURCE: National Highway Traffic Safety Administration, Fatality Analysis Reporting System (FARS), 2006-2011 and Colorado Department of Transportation 2012-2016

(Source: Rocky Mountain High Intensity Drug Trafficking Area, page 18)

3. AAA Foundation for Traffic Safety. *Prevalence of Marijuana Involvement in Fatal Crashes: Washington, 2010-2014* (May 2016) (available at <https://www.aaafoundation.org/sites/default/files/PrevalenceOfMarijuanaInvolvement.pdf>).

Summary

This study was conducted “to estimate the number and proportion of drivers involved in fatal crashes in Washington state who had a detectable concentration of THC in their blood at or shortly after the time of the crash each year for years 2010 – 2014,” and also “to investigate whether the proportion of fatal-crash-involved drivers with detectable THC changed after recreational use of marijuana by adults was legalized [by Initiative 502]” (3).

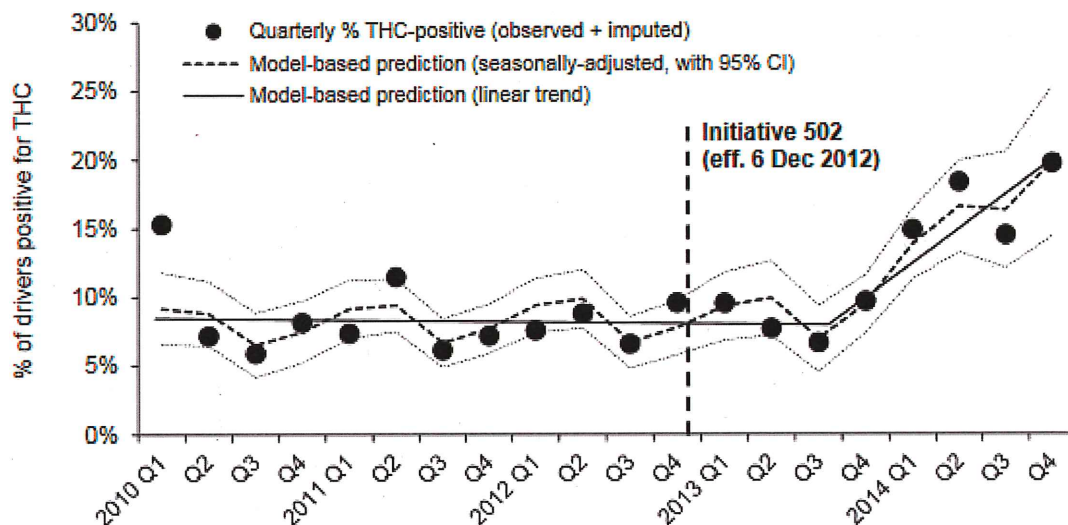
The study found that before and immediately after Initiative 502 took effect the “proportion of drivers positive for THC was generally flat” (1). However, the study further found that the proportion “began increasing significantly at a rate of 9.7 percentage points per year approximately 9 months after Initiative 502 took effect” (1). Specifically, in the year 2014, “the number and proportion of drivers in fatal crashes who were positive for THC were both more than double the averages from the prior four years” (15). Nonetheless, the authors point out that the study does not determine whether Initiative 502 caused the eventual increase, or whether the increase was caused by some other factor (11).

Discussion

In addition to the general findings described above, this study’s findings that relate to the Roadway Safety Subcommittee’s research question include the following:

- “[T]here was a large increase in the estimated number and proportion of THC-positive drivers in 2014” (8). The figure below from the report shows the quarterly results for drivers positive for THC pre-legalization and post-legalization in fatal crashes.

Figure 1. Quarterly average proportion of drivers involved in fatal crashes who were positive for THC and modeled seasonally-adjusted linear trend before and after Washington Initiative 502 took effect on 6 December 2012 legalizing recreational use of marijuana for adults aged 21 years and older, Washington, 2010 – 2014.



Data: Washington Traffic Safety Commission, 2010 – 2014.

Drivers positive for THC based on results of blood toxicological tests. Results imputed 10 times when driver was not tested or test results were unknown; results reflect averages from 10 imputed values for each driver. Model-based predictions are from binomial regression model with identity link function, indicator variables for seasons, and a linear spline with change in slope on 5 September 2013 (39 weeks after effective date of Initiative 502).

(Source: AAA Foundation for Traffic Safety, page 3)

Additionally, the study found as follows:

- Drivers with suspended or revoked licenses “were much more likely than drivers with a valid license to have been THC-positive” (9).
- “THC-positive drivers who died tended to have higher THC concentrations than did drivers who survived” (9).
- “The majority of drivers who had detectable levels of THC also had alcohol and/or other drugs in their blood at the time of the crash” (9).
 - o The study notes, however, that “*post hoc* analysis” indicates this likely was due to seatbelt use: “drivers positive for alcohol and/or other drugs in addition to THC had much lower rates of seatbelt use than did drivers positive for THC alone, and thus were more likely to die given involvement in a crash” (9).

The study describes that “sensitivity analyses” were conducted to account for multiple changes during the study period, including “changes in the state laboratory’s minimum threshold for detection of THC” (10). Nevertheless, after those analyses were conducted, the study found a similar trend in the

proportion of drivers testing positive for THC (10). While there was no discernible change in the proportion before or immediately after Initiative 502, there was an eventual increasing trend in the proportion months later (10).

The authors also discuss limitations of the study. For instance, the authors note the possibility that the numbers may underestimate the prevalence of THC in fatal crashes due to the timing of tests and the resulting effect a delay has on THC concentration (13). Also, the study notes that frequent marijuana users may have detectable THC in their systems long after using marijuana, and thus the authors raise the possibility that some THC-positive drivers may have used marijuana hours or days before the crash (13). However, they also state that impairment may still have been possible in such drivers (14). In addition, the authors state that “at least half of all drivers had missing values of THC” for various reasons, thus possibly leading to bias (14). And lastly, the study makes it clear that “actual impairment” and “fault status” of drivers with detectable THC were beyond the scope of the study (14).

Vermont Crash Data

Introduction

Executive Order 15-17 also directs the Roadway Safety Subcommittee to assess “Vermont data to the extent it is available.” Pursuant to that mandate, the Subcommittee presents Vermont crash data below.⁵

On July 1, 2013, marijuana was decriminalized in Vermont. Even before that date, Vermont was tracking the presence of marijuana, cannabis, and Delta-9 THC in crashes. Starting in 2010, the Vermont uniform crash report form changed to collect drugs by category instead of type. Of particular note, the report collects “Cannabis” instead of “Marijuana.”

Pre- and Post-Decriminalization

The data below shows crashes by crash type pre-decriminalization and post-decriminalization in Vermont, where at least one driver was reported to have cannabis in their system. These two charts compile data for all crashes, not just fatalities.

Pre-Decriminalization of Cannabis:		Post Decriminalization of Cannabis:	
Crash Type	Number of Crashes	Crash Type	Number of Crashes
Fatal	33	Fatal	44
Injury	25	Injury	26
Property Damage Only	13	Property Damage Only	21
Grand Total	71	Grand Total	91
<i>*Dates used: 1/1/2010 - 6/30/13</i>		<i>*Dates used: 7/1/2013 - 12/31/16</i>	

⁵ In the data included in this section, the term “impairment” or “impaired” is used with respect to alcohol and marijuana (and other drugs). That term, as it is used with respect to marijuana (and other drugs), indicates “presence” of the drug in a person’s system, and not actual impairment.

Vermont Fatal Crash Data

The chart below shows only fatal crashes where a report lists a driver with alcohol, drugs, or both in their system. The data below is pulled from a report supplied by the Medical Examiner's Office to the Highway Safety Office for the purposes of Vermont's Fatality Analysis Reporting System (FARS) reporting requirements. This data specifically lists "Delta-9 THC" because the report from the Medical Examiner's Office breaks the categories down to the different types of cannabinoids.

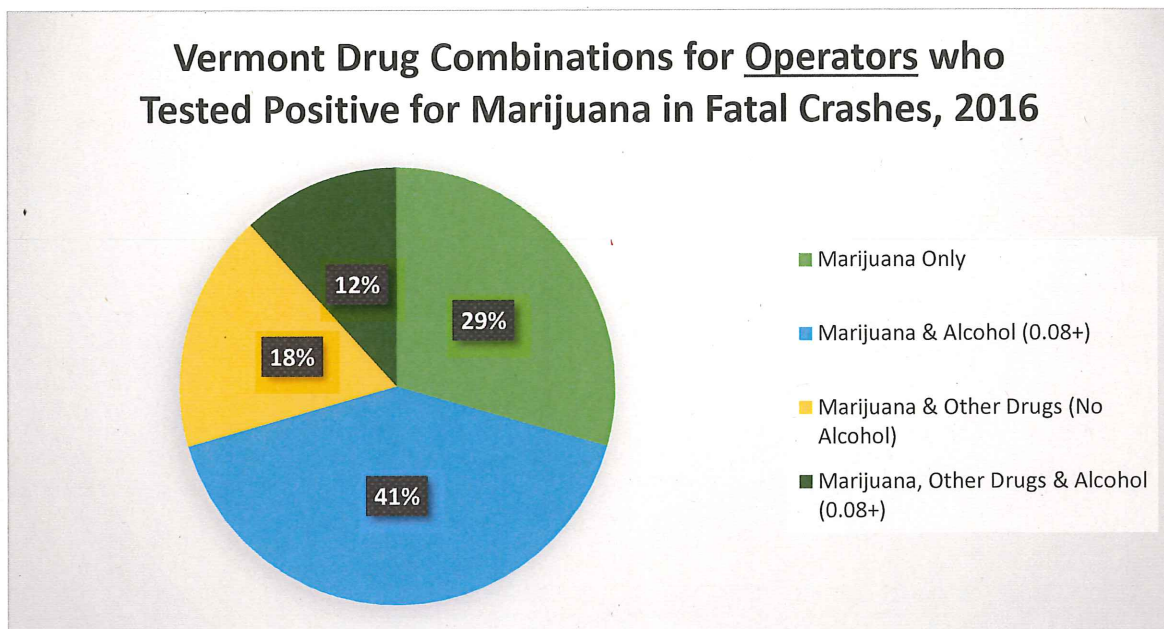
Fatal Crashes with Impairment 2012-2017 (to date)						
Categories	2012	2013	2014	2015	2016	2017
Alcohol Only (0.08+)	13	9	3	4	14	5
Alcohol (0.08+) & Delta-9 THC	4	5	0	5	7	2
Alcohol & Other Drugs (inc. Delta-9 THC)	6	5	3	4	3	3
Drug: Delta-9 THC Only	5	3	5	3	5	4
Drug: Other* (includes Delta-9 THC)	11	6	5	8	4	7
Total Impaired Fatal Crashes	39	28	16	24	33	21
Total Fatal Crashes	70	64	42	50	59	45
Impaired Percentage of Fatal Crashes	55.7%	43.8%	38.1%	48.0%	55.9%	46.7%
Note: The 2016 data shows the confirmed alcohol & drug data as received by law enforcement and/ the medical examiner's office as of 9/30/17. There are still results pending.						
*Other Drug categories include: Central Nervous System Depressants, Central Nervous System Stimulants, Hallucinogens, Dissociative Anesthetics, Narcotic Analgesics, Inhalants, & Cannabis.						

The table below counts the number of all fatalities where at least one operator is impaired by the listed category. For example, as noted in the chart above, in 2014 there were 42 crashes, 16 of which are considered "impaired fatal crashes." As shown below, of the 44 fatalities in 2014, 17 deaths involved an impaired driver. Also, starting with 2014 the percentage of deaths related to impaired driving has been increasing each year.

Year	Total All Fatalities	Alcohol Only Involved Fatalities	Delta-9 THC Only Involved Fatalities	Alcohol & Delta-9 THC Only Involved Fatalities	*All other Alcohol & Drug Combinations Involved Fatalities	Total Fatalities where Driver Impaired	Percentage of Fatalities where Driver Impaired
2017 (to date)	53	6	7	2	10	25	47.2%
2016	64	14	5	8	9	36	56.3%
2015	57	4	4	6	12	26	45.6%
2014	44	2	6	0	9	17	38.6%
2013	70	9	4	4	13	30	42.9%
2012	77	17	5	5	19	46	59.7%

*All Other Column may include multiple drugs and or alcohol and multiple drugs, to include Delta-9 THC.

For those drivers in fatal crashes that tested positive for marijuana, the figure below is showing the percentage that only had marijuana versus marijuana and other substances.



For the 2017 fatal crashes, the below is a breakdown of where Vermont currently stands with suspected alcohol and drug use. As the chart states below, all of the operators with Delta-9 THC have been confirmed by the Medical Examiner's toxicology reports.

Vermont Fatal Crash Data for 2017:

2017 Fatal Crash data known to-date (October 23, 2017):

- 6** Operators **suspected** as driving under the influence of alcohol only.
- 10** Operators **suspected** as driving under the influence of drugs only.
- 6** Operators **suspected** as driving under the influence of both alcohol & drugs
- 11 Active Cannabis – Delta 9 THC confirmed***

*Of the 16 operators with alcohol & drugs or drugs alone in their system, 11 were positive for Active Cannabis – Delta 9 THC.

CRIME RATES ENDPOINT

Introduction

Pursuant to Executive Order No. 15-17, the Roadway Safety Subcommittee was tasked with assessing high-quality primary research, “including evidence-based Vermont data,” in order to establish “a common baseline understanding” of the safety impacts of legalizing marijuana. After the first meeting of the Subcommittee on September 28, 2017, Chair Thomas Anderson formed a Crime Rates study group, consisting of Mike Major (Chittenden County Sheriff’s Office), John Campbell (Department of State’s Attorneys and Sheriffs), and Marshall Pahl (Office of the Defender General) to research the following questions:

- Do crime rates (i.e., rates of violent crime, property crimes or other collateral crimes) increase or decrease when marijuana is decriminalized; and
- Do crime rates (i.e., rates of violent crime, property crimes or other collateral crimes) increase or decrease when marijuana is legalized for recreational use?

In researching these questions, the study group found that data sources and policy decisions regarding decriminalization and legalization for medical and recreational use vary considerably from state to state. Further, the methods for collecting data and the specific data points being collected have also evolved over time. Consequently, it is difficult to draw conclusions regarding the specific impact on decriminalization or legalization on crime rates. With these limitations in mind, the Crime Rates study group considers the research contained below to be responsive to the questions presented.

I. Do crime rates (i.e., rates of violent crime, property crimes or other collateral crimes) increase or decrease when marijuana is decriminalized?

1. Arthur Huber III, Rebecca Newman, Daniel LaFave, *Cannabis Control and Crime: Medicinal Use, Depenalization and the War on Drugs*, The B.E. Journal of Economic Analysis & Policy, Vol. 16, Issue 4 (available at <https://www.degruyter.com/view/j/bejeap.ahead-of-print/bejeap-2015-0167/bejeap-2015-0167.xml>).

Summary

This study examines the relationship between the depenalization of possession of marijuana and the incidence of non-drug crime. The researchers used data on crime rates collected through the Federal Bureau of Investigation’s Universal Crime Reporting program from 1970 to 2012. The research model looked at how crime rates were impacted pre- and post-depenalization, controlled for unemployment rate, poverty rate, state population, real per capita income, incarceration rate, police count, beer excise tax, and minimum legal drinking age as well as indicator variables for five additional laws—legalized abortion, castle doctrine/stand your ground laws, shall-issue handgun laws, BAC 0.08 laws, and zero-tolerance DUI laws. The study was published in the B.E. Journal of Economic Analysis & Policy, a peer-reviewed public policy journal.

This article found a statistically significant increase in burglaries (6.6%) and robberies (11.6%) in the 5 years following depenalization of marijuana. These magnitudes are in line with the estimated impact of a 2 to 3 percentage point increase in the unemployment rate or a 6% decrease in retail wages.

Discussion

The Subcommittee notes the following limitations. A national decline in crime rates beginning in the 1990s coincided with the passage of many of the decriminalization laws examined in the study. The increase in burglary and robbery rates were discovered only after applying time-varying control variables and year fixed effects to account for the overall downward crime rate trend.

The study identifies a relationship between crime rates and decriminalization not causation. The increases could be explained by other factors such as a shifting of police resources and priorities towards these types of non-drug crimes.

Finally, the crime rate numbers from the Federal Bureau of Investigation's Universal Crime Reporting program are incomplete. The numbers are voluntarily submitted by local law enforcement agencies, so variations exist year-to-year among and within the reporting states.

2. Jerome Adda, Brendon McConnell, and Imran Rasul, *Crime and the Depenalization of Cannabis Possession: Evidence from a Policing Experiment*, Journal of Political Economy, Volume 122, Number 5 (October 2014) (available at <http://www.journals.uchicago.edu/doi/10.1086/676932>).

Summary

This study evaluates the impact on crime of a localized policing experiment that decriminalized the possession of small quantities of cannabis in the London borough of Lambeth over a thirteen-month period beginning in 2001. The researchers used administrative records obtained from the London Metropolitan Police Service to construct monthly panel data sets for various crimes. They also used *Quarterly Labor Force Survey Local Area* data to obtain borough level demographic and labor market characteristics, and information from the *UK Land Registry* to compare housing prices in Lambeth relative to the rest of London. This article appeared in the bi-monthly peer-reviewed academic Journal of Political Economy published by the University of Chicago Press.

Arrest rates for non-drug crimes (violence against the person, sexual offenses, robbery, burglary, theft and handling, fraud and forgery, and criminal damage) rose 28.4% in Lambeth relative to the rest of London during the thirteen-month policy period. Researchers attribute this rise to a reallocation of police resources towards these crimes.

In the post-policy period, the offense rate for total non-drug crime in Lambeth fell 9.4% more than the London-wide average. Also, housing prices in Lambeth fell by 5% relative to the London-wide average after the decriminalization policy was introduced.

Discussion

The Subcommittee notes the following limitations. Variations in population size and density, economic conditions, employment rates, and prosecutorial, judicial, and correctional policies make it difficult to compare Lambeth with Vermont. Also, differing historical attitudes regarding cannabis in the UK vs. US also make it a difficult comparison. In addition, the short timeframe of the policy period (thirteen months) makes it difficult to identify trends that may have historical roots. Finally, too many

variables affect the housing market to draw a causal link between the decriminalization policy and a decrease in housing prices.

II. *Do crime rates (i.e., rates of violent crime, property crimes or other collateral crimes) increase or decrease when marijuana is legalized for recreational use?*

1. Colorado Department of Public Safety. *Marijuana Legalization in Colorado: Early Findings* (March 2016) (available at <https://cdpsdocs.state.co.us/ors/docs/reports/2016-SB13-283-Rpt.pdf>).

Summary

Following the passage of Amendment 64, which allows for the retail sale and possession of marijuana, the Colorado General Assembly mandated the Department of Public Safety to conduct a study of the impacts of Amendment 64 on law enforcement activities. This report, released in March 2016, is the product of that mandate. It contains data collected from all state departments that are directly or indirectly impacted by Amendment 64, as well as Denver municipal offices and the federal government. All data presentations in the report were sent to the original data sources for comment to ensure the original information is accurately represented. It should be noted that the purpose of this report is to establish pre-commercialization, baseline data for Colorado using standardized collection methodologies that can be used in future reports to draw conclusions regarding the impact of Amendment 64. Therefore, the Subcommittee refers to the following as “Findings” and not “Conclusions.”

Findings: In Colorado, arrest rates for property crime increased 15% in 2013 and another 10% in 2014. Also, Denver saw a slight increase in the number of reported crimes committed in and around marijuana establishments, from 170 reports in 2012 to 183 in 2015. The most common reported crime is burglary, representing 62% of all industry-related crimes. Moreover, Colorado saw a decrease in the number of plants being seized on public land from a high of 46,662 in 2012 to 25,030 in 2015. Lastly, overall juvenile marijuana arrests have increased 5% from 3,235 in 2012 to 3,400 in 2014. Juvenile arrest rates are based on Colorado population aged 10–17. Reported marijuana offenses occurring in elementary and secondary schools have increased 34% from 1,766 in 2012 to 2,363 in 2014.

Discussion

The Subcommittee notes the following limitations. The data presented in the report should be considered “pre-commercialization, baseline data” since many of the data points presented were not reliably collected and methodologies for collecting the data were not standardized in Colorado prior to Amendment 64. Also, complex and sometimes conflicting marijuana laws in Colorado may be driving irregularities in the data particularly with these early findings.

2. Rocky Mountain High Intensity Drug Trafficking Area. *The Legalization of Marijuana in Colorado: The Impact*. Volume 5, October 2017 (available at <http://www.rmhidta.org/html/FINAL%202017%20Legalization%20of%20Marijuana%20in%20Colorado%20The%20Impact.pdf>).

Summary

As noted above, this report is prepared annually by the Rocky Mountain High Intensity Drug Trafficking Area (RMHIDTA), a federal program that provides assistance to law enforcement agencies “operating in areas determined to be critical drug-trafficking regions of the United States” (High Intensity Drug Trafficking Areas (HIDTA) Program, <https://www.whitehouse.gov/ondcp/high-intensity-drug-trafficking-areas-program>).⁶

Findings: The number of marijuana interdiction seizures increased from a pre-legalization high of 321 in 2011 to 346 in 2016. Similarly, the US Postal Inspection Service reported an increase in the number of parcels containing marijuana mailed from Colorado to another state from 158 in 2012 to 854 in 2016. In Denver, crimes against property increased approximately 8% from 2014 to 2016. Also, in Denver, unlawful public display/consumption of marijuana increased from a pre-legalization low of 8 incidences in 2012 to 590 in 2016.

⁶ RMHIDTA is federally funded through the Office of National Drug Control Policy (ONDCP). See 21 U.S.C. § 1706. By statute, the Director of ONDCP must, among other responsibilities,

ensure that no Federal funds appropriated to the Office of National Drug Control Policy shall be expended for any study or contract relating to the legalization (for a medical use or any other use) of a substance listed in schedule I of section 812 of this title and take such actions as necessary to oppose any attempt to legalize the use of a substance (in any form) that is listed in schedule I of [the Controlled Substances Act].

21 U.S.C. § 1703(b)(12). Another statutory responsibility of the ONDCP Director is to “ensure that drug prevention and drug treatment research and information is effectively disseminated by National Drug Control Program agencies to State and local governments and nongovernmental entities involved in demand reduction” *Id.* §1703(b)(15).

The High Intensity Drug Trafficking Areas Program (HIDTA) also has specific statutory mandates. See 21 U.S.C. § 1706. The purpose of HIDTA, as set forth in federal statute, “is to reduce drug trafficking and drug production in the United States” *Id.* § 1706(a)(2). And HIDTA is tasked with carrying out that purpose by “facilitating cooperation,” “enhancing law enforcement intelligence sharing,” and “supporting coordinated” strategies among law enforcement entities; and “providing reliable law enforcement intelligence to law enforcement agencies needed to design effective enforcement strategies and operations.” See *id.* § 1706(a)(2)(A), (B), (C), (D).

Because of the relationship between ONDCP and HIDTA, many advocates of legalization are skeptical of the conclusions contained in the RMHIDTA report. This sentiment was echoed by the experts from Colorado and Washington with whom the Crime Rates study group spoke. With this limitation in mind, the “Findings” presented here seem to have reliable data sources and are relevant to the question presented in this section.

Discussion

The Subcommittee notes the following limitation: these findings demonstrate a correlation between marijuana legalization and increased interdictions, mailings, property crimes and public consumption, but not necessarily a causal link.

CONCLUSION

Pursuant to Executive Order 15-17, the above report presents the Roadway Safety Subcommittee's research relating to the "Injury and Death" and "Crimes Rates" endpoints. The research compiled here includes high quality, authoritative, and recent studies and other reports, and Vermont data responsive to the Subcommittee's research questions. As the Commission and the three subcommittees proceed through the next two phases of work, this report serves "to establish a common baseline understanding of the most credible data regarding health endpoints of marijuana use and safety impacts of legalization," as directed by Executive Order 15-17. The Subcommittee also anticipates that the report will inform the Commission's recommendations to the Governor, which will issue on or before January 15, 2018, and, subsequently, on or before December 15, 2018.

APPENDIX A

Injury and Death: Motor Vehicles

National Academies of Sciences, Engineering, and Medicine. 2017. *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research*. Washington, DC: The National Academies Press. doi: 10.17226/24625 (available online at <https://www.nap.edu/read/24625/chapter/11#230>).

Rogeberg, O., and R. Elvik. 2016. The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction* 111(8):1348–1359. doi:10.1111/add.13347 (available at <http://onlinelibrary.wiley.com/doi/10.1111/add.13347/epdf>).

Compton, R. (2017, July). Marijuana-Impaired Driving - A Report to Congress. (DOT HS 812 440). Washington, DC: National Highway Traffic Safety Administration (available at <https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812440-marijuana-impaired-driving-report-to-congress.pdf>).

Li G, Chihuri S, Brady JE. *Role of alcohol and marijuana use in the initiation of fatal two-vehicle crashes*. *Ann Epidemiol*. 2017;27(5):342-347. <http://dx.doi.org/10.1016/j.annepidem.2017.05.003>.

Monitoring Health Concerns Related to Marijuana in Colorado: 2016 – Changes in Marijuana Use Patterns, Systematic Literature Review, and Possible Marijuana-Related Health Effects. Colorado Department of Public Health and Environment (2016) (available at <https://drive.google.com/file/d/0B0tmPQ67k3NVQlFnY3VzZGVmdFk/view>).

Jayson D. Aydelotte et al. "Crash Fatality Rates After Recreational Marijuana Legalization in Washington and Colorado", *American Journal of Public Health* 107, no. 8 (August 1, 2017): pp. 1329-1331. doi: 10.2105/AJPH.2017.303848.

Rocky Mountain High Intensity Drug Trafficking Area. *The Legalization of Marijuana in Colorado: The Impact*. Volume 5, October 2017 (available at <http://www.rmhidta.org/html/FINAL%202017%20Legalization%20of%20Marijuana%20in%20Colorado%20The%20Impact.pdf>).

AAA Foundation for Traffic Safety. *Prevalence of Marijuana Involvement in Fatal Crashes: Washington, 2010-2014* (May 2016) (available at <https://www.aaafoundation.org/sites/default/files/PrevalenceOfMarijuanaInvolvement.pdf>).

* Study group staffers also reviewed various testimonies and many other materials relating to bills in the Vermont Legislature, specifically H.170, S.22, and H.20.

* Vermont data reviewed by the study group is publicly available on the following websites:

<http://vtrans.vermont.gov/highway/safety>

<http://ghsp.vermont.gov/content/reports-and-data>

The Governor's Highway Safety Program website includes a link to the Vermont Public Crash Data Query Tool: <http://apps.vtrans.vermont.gov/CrashPublicQueryTool/>.

Crime Rates

Arthur Huber III, Rebecca Newman, Daniel LaFave, *Cannabis Control and Crime: Medicinal Use, Depenalization and the War on Drugs*, The B.E. Journal of Economic Analysis & Policy, Vol. 16, Issue 4 (available at <https://www.degruyter.com/view/j/bejeap.ahead-of-print/bejeap-2015-0167/bejeap-2015-0167.xml>).

Jerome Adda, Brendon McConnell, and Imran Rasul, *Crime and the Depenalization of Cannabis Possession: Evidence from a Policing Experiment*, Journal of Political Economy, Volume 122, Number 5 (October 2014) (available at <http://www.journals.uchicago.edu/doi/10.1086/676932>).

Colorado Department of Public Safety. *Marijuana Legalization in Colorado: Early Findings* (March 2016) (available at <https://cdpsdocs.state.co.us/ors/docs/reports/2016-SB13-283-Rpt.pdf>)

Rocky Mountain High Intensity Drug Trafficking Area. *The Legalization of Marijuana in Colorado: The Impact*. Volume 5, October 2017 (available at <http://www.rmhidta.org/html/FINAL%202017%20Legalization%20of%20Marijuana%20in%20Colorado%20The%20Impact.pdf>).

Oregon State Police - Drug Enforcement Section, *A Baseline Evaluation of Cannabis Enforcement Priorities in Oregon* (January 2017).

Bridget Freisthler, Andrew Gaidus, Christina Tam, William R. Ponicki, Paul J. Gruenewald, *From Medical to Recreational Marijuana Sales: Marijuana Outlets and Crime in an Era of Changing Marijuana Legislation*, The Journal of Primary Prevention, Vol. 38, Issue 3 (June 2017).