Interaction of Marijuana and Alcohol on Fatal Motor Vehicle Crash Risk: A Case-Control Study

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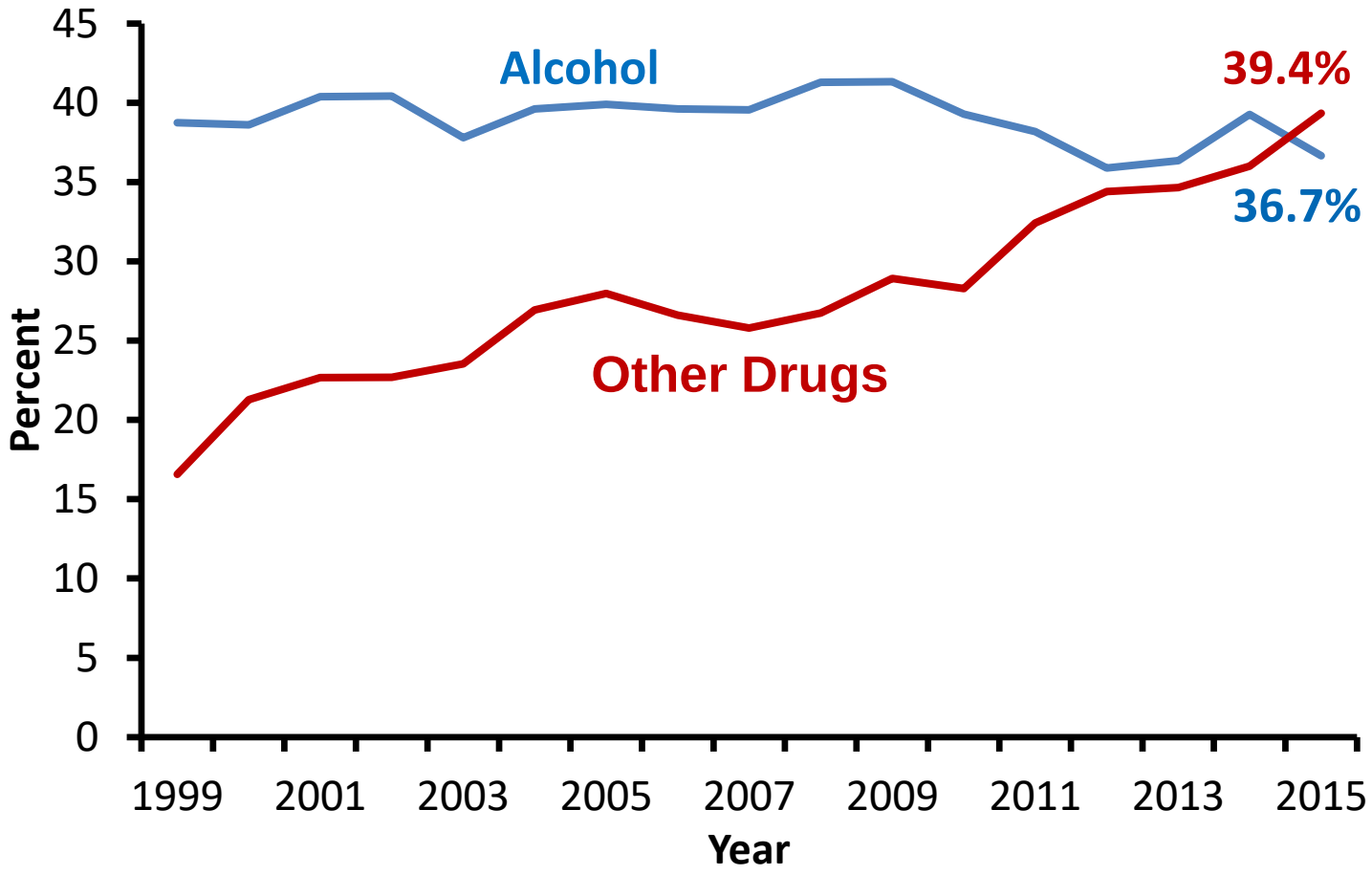
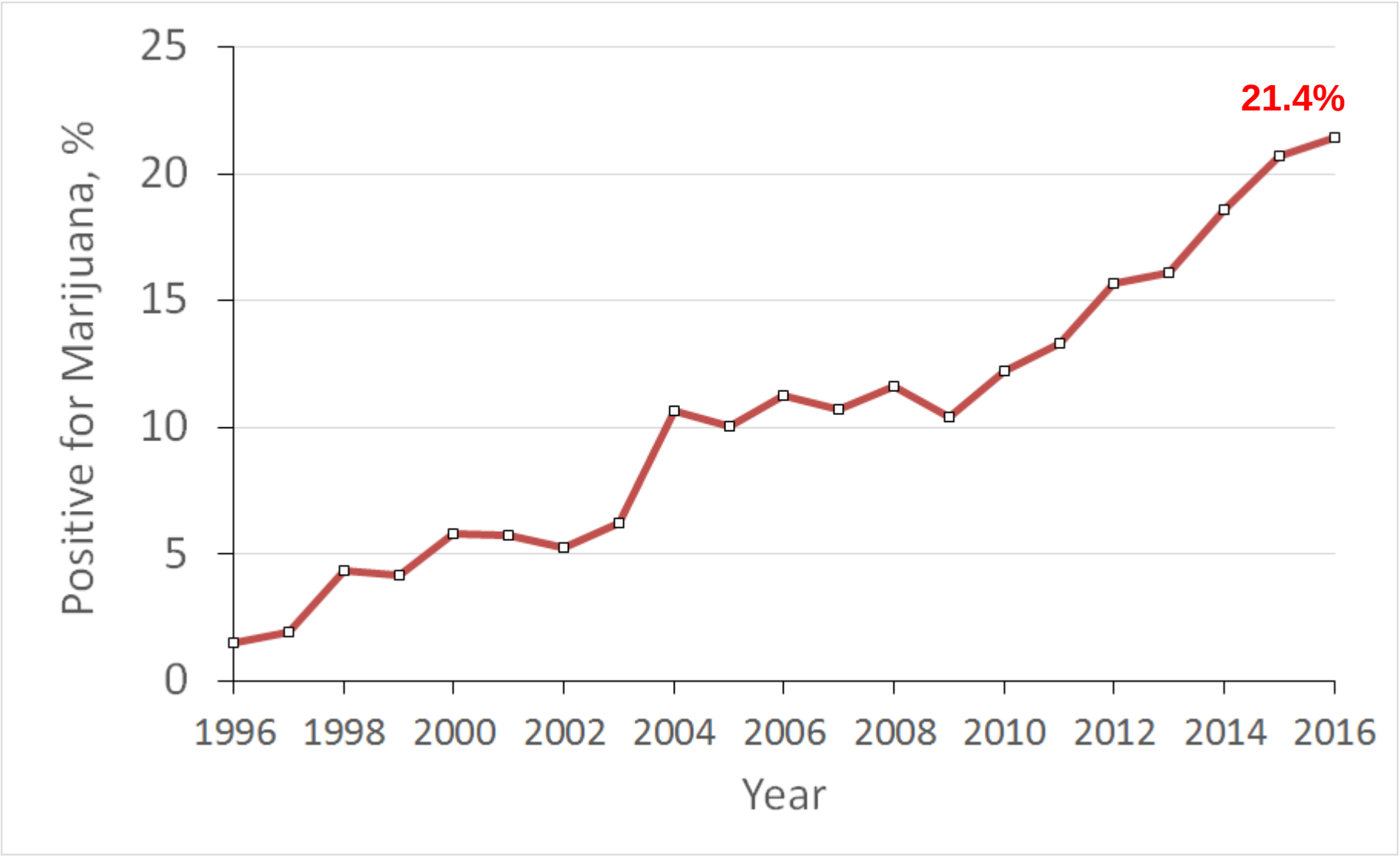
- Background; magnitude of DUID
- Study Methods and Results
- Summary of findings
- Interventions

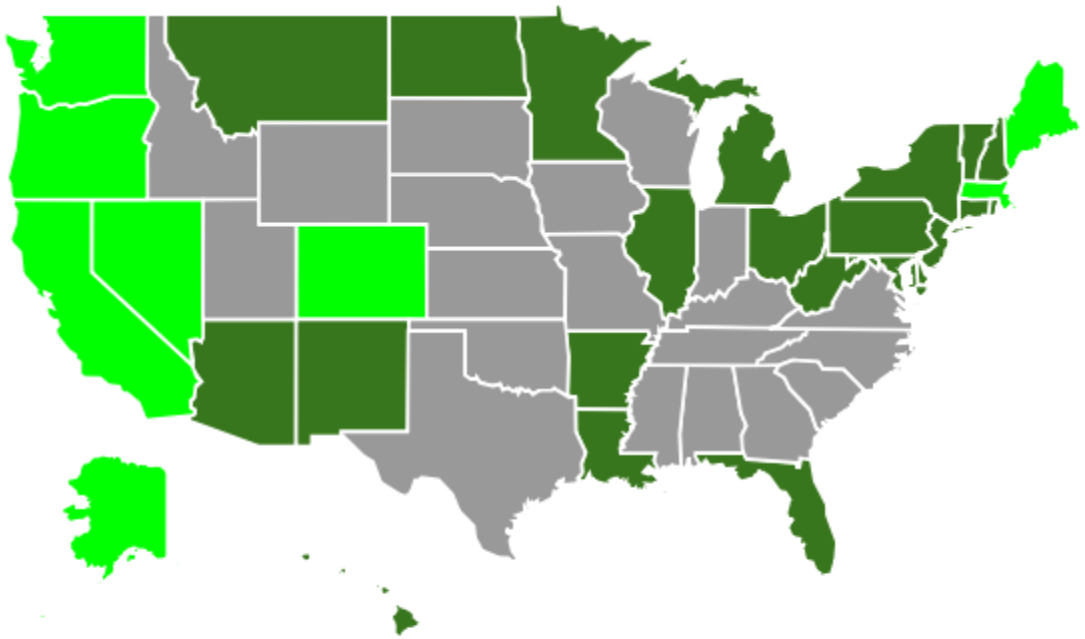
Prevalence of Alcohol and Other Drugs in Fatally Injured Drivers, Select US States, 1999-2015



Brady & Li, 2013; FARS 2015

Prevalence of marijuana involvement in drivers who died within 1 hour of a crash by year and drug category, Fatality Analysis Reporting System, selected states, 1996–2016.





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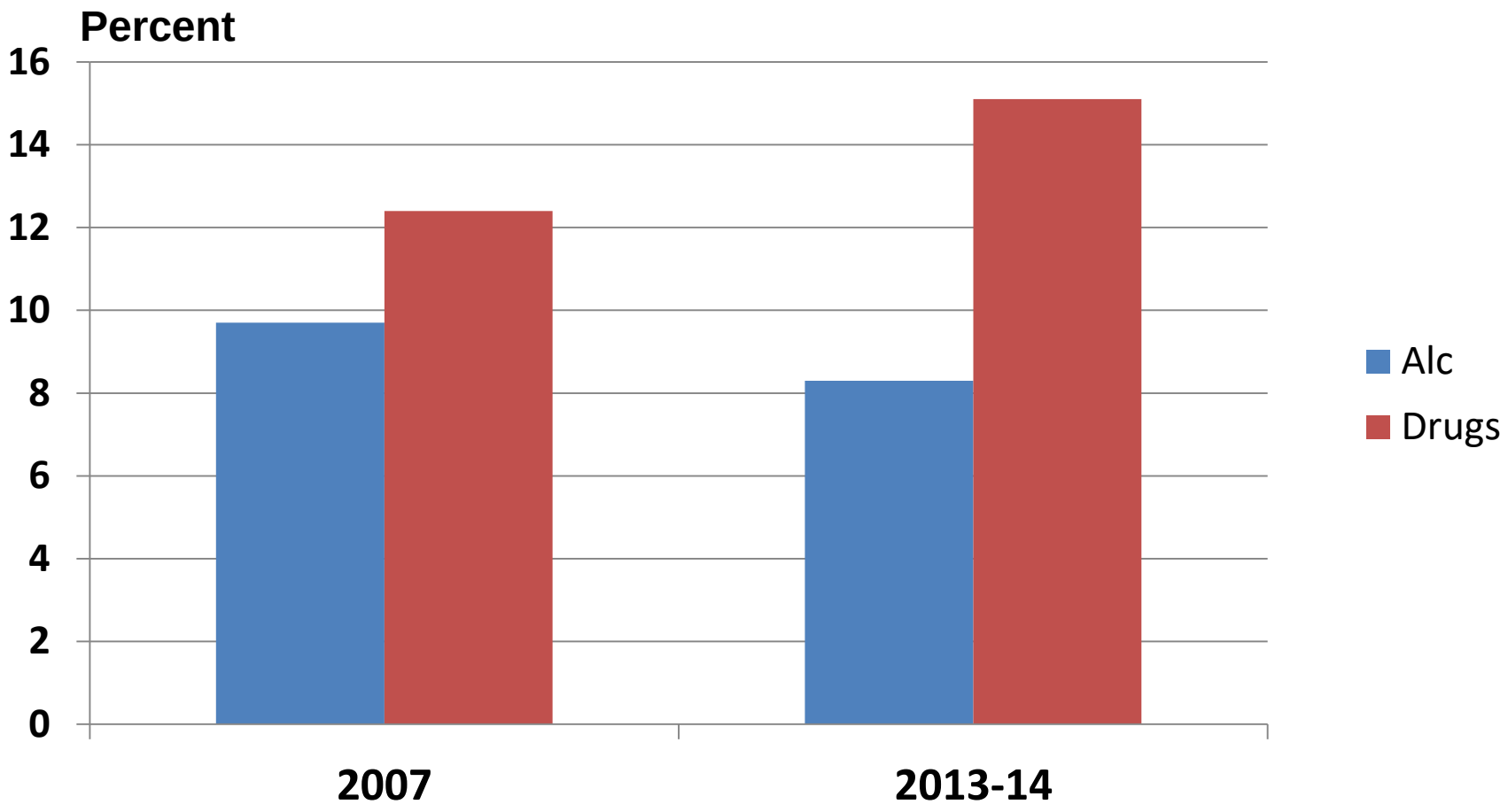
Source :http://www.governing.com

Prevalence of Alcohol and Drugs in Drivers, United States, 2007 vs. 2013-14



Data source: National Roadside Survey of Alcohol and Drug Use by Drivers, 2007 and 2013-14. NHTSA, 2015.

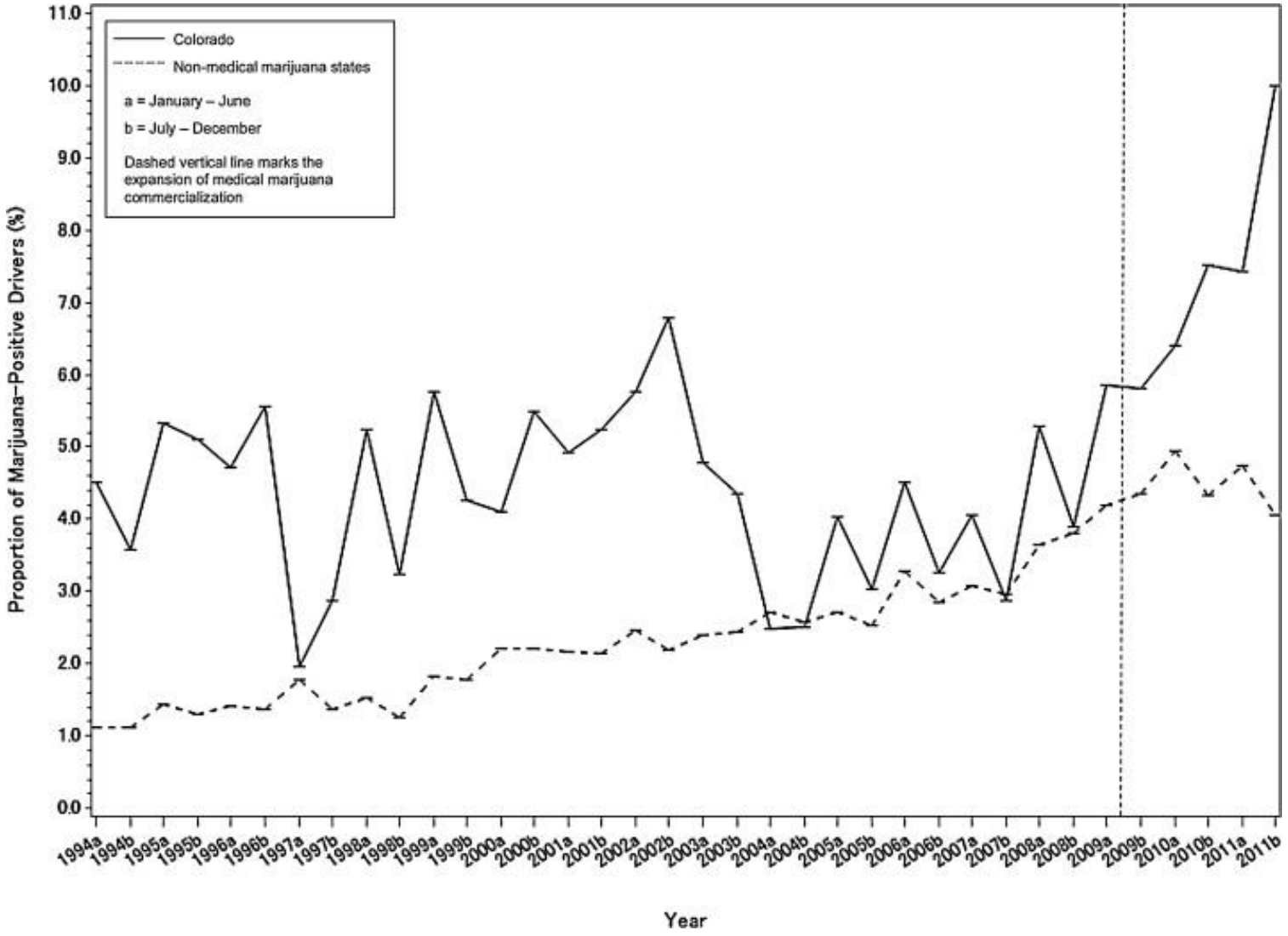
Prevalence of Drug Use by Drivers 2013-14 NRS (n=7,898), United States, 2006-2008

	Number of Drivers Testing Positive	%
Cannabis	758	**9.6**
Narcotic	196	**2.5**
Antidepressant	97	**1.2**
Stimulant	150	**1.9**
Polydrug use	164	**2.1**
Any drug	**1773**	**22.4**

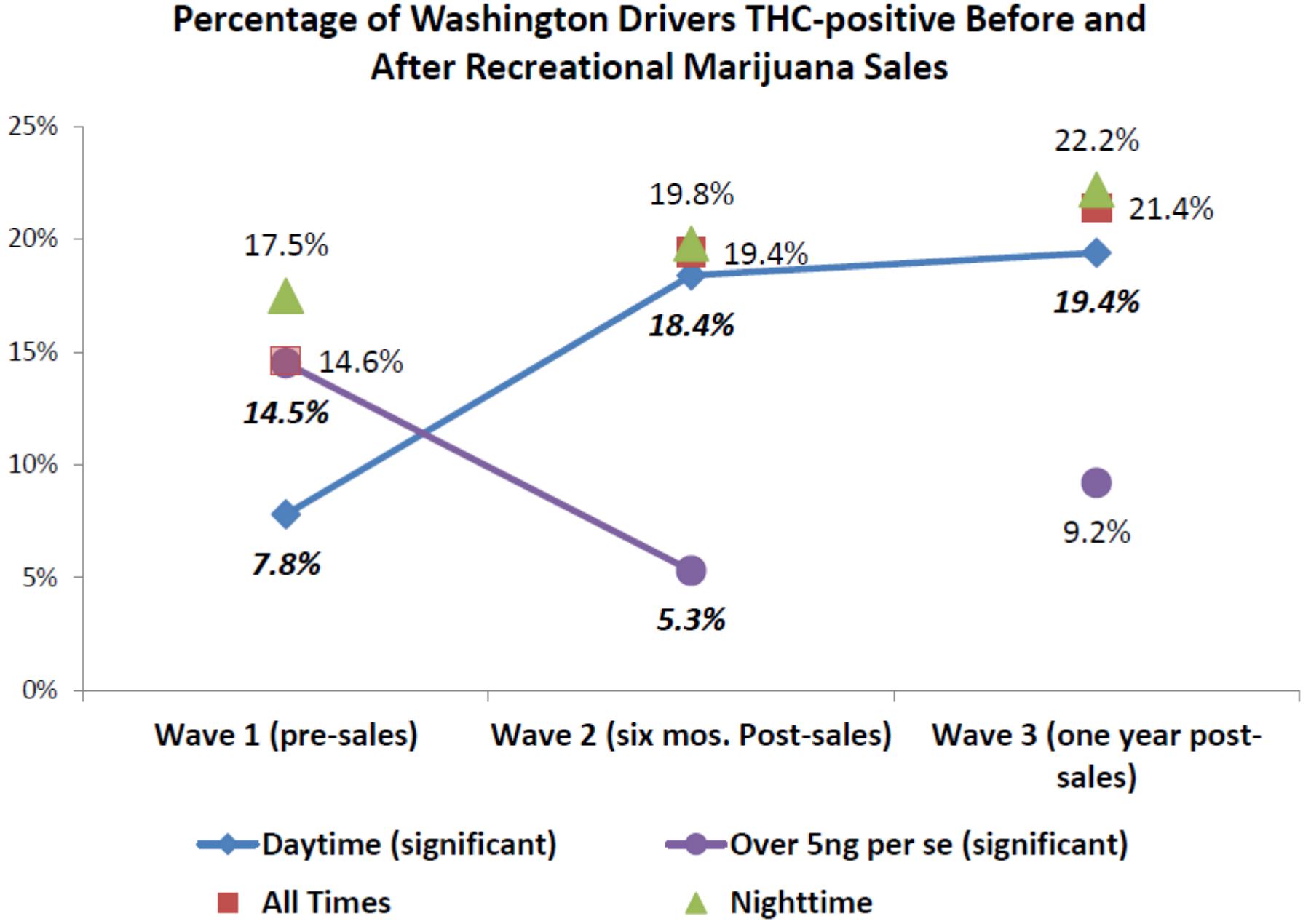
Kelley-Baker et al. 2017


MARIJUANA:
Safer than alcohol... and football.
CBS

Proportion of drivers in a fatal motor vehicle crash who were marijuana-positive in Colorado and 34 states without medical marijuana laws from 1994 to 2011



Salomonsen-Sautel et al 2014


Percentage of Washington Drivers THC-positive Before and After Recreational Marijuana Sales
25%
20%
15%
10%
5%
0%
17.5%
14.6%
14.5%
7.8%
19.8%
19.4%
18.4%
5.3%
22.2%
21.4%
19.4%
9.2%
Wave 1 (pre-sales)
Wave 2 (six mos. Post-sales)
Wave 3 (one year post-sales)
Daytime (significant)
Over 5ng per se (significant)
All Times
Nighttime

Marijuana, Alcohol and Driving Safety

- **Alcohol impairs all aspects of driving**
- **Marijuana impairs psychomotor skills such as lateral control and reaction time**
- **Evidence suggests marijuana may double the risk of crash involvement**

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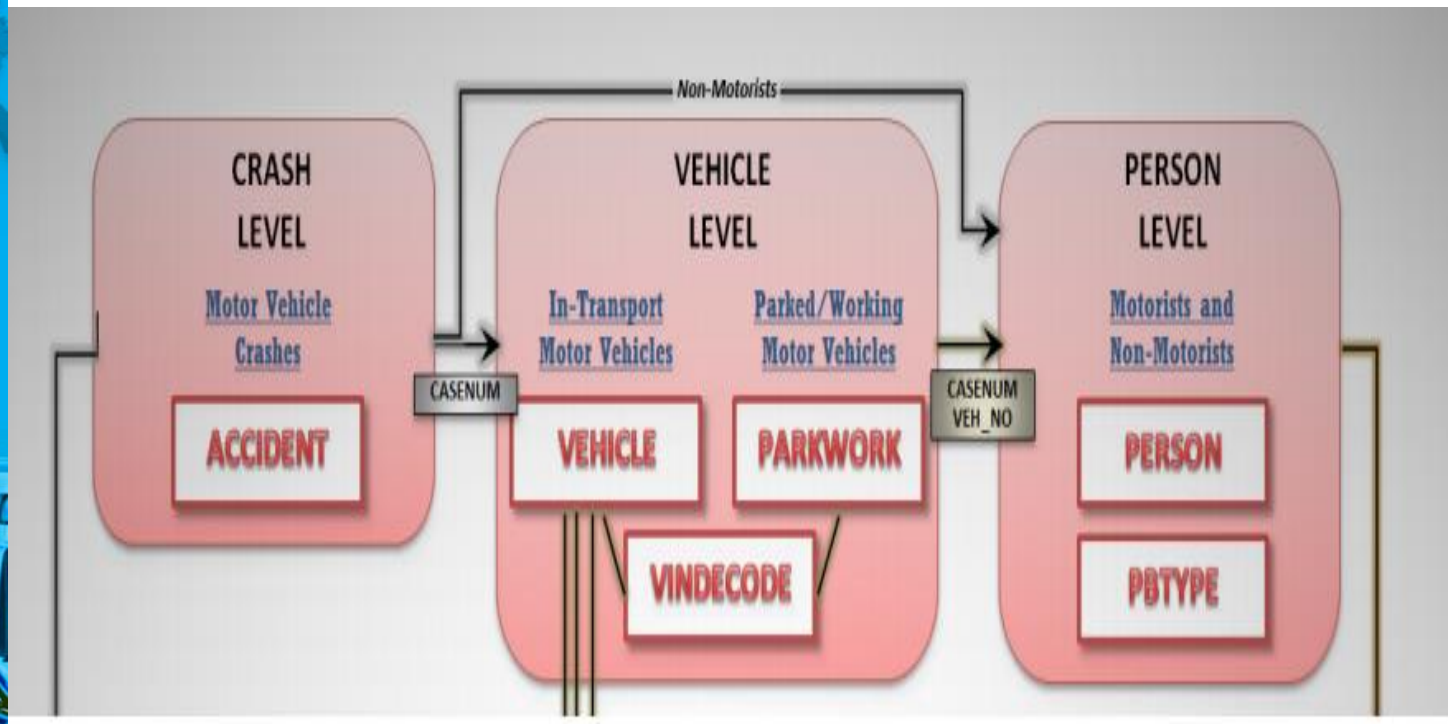
Objective

To assess the interaction of marijuana and alcohol on fatal motor vehicle crash risk among US drivers

Study Design: Population-based Case-Control

- **Cases (n=1,944): fatally injured drivers tested for alcohol and drugs**
- **Identified from 2006-2008 Fatality Analysis Reporting System (FARS)**



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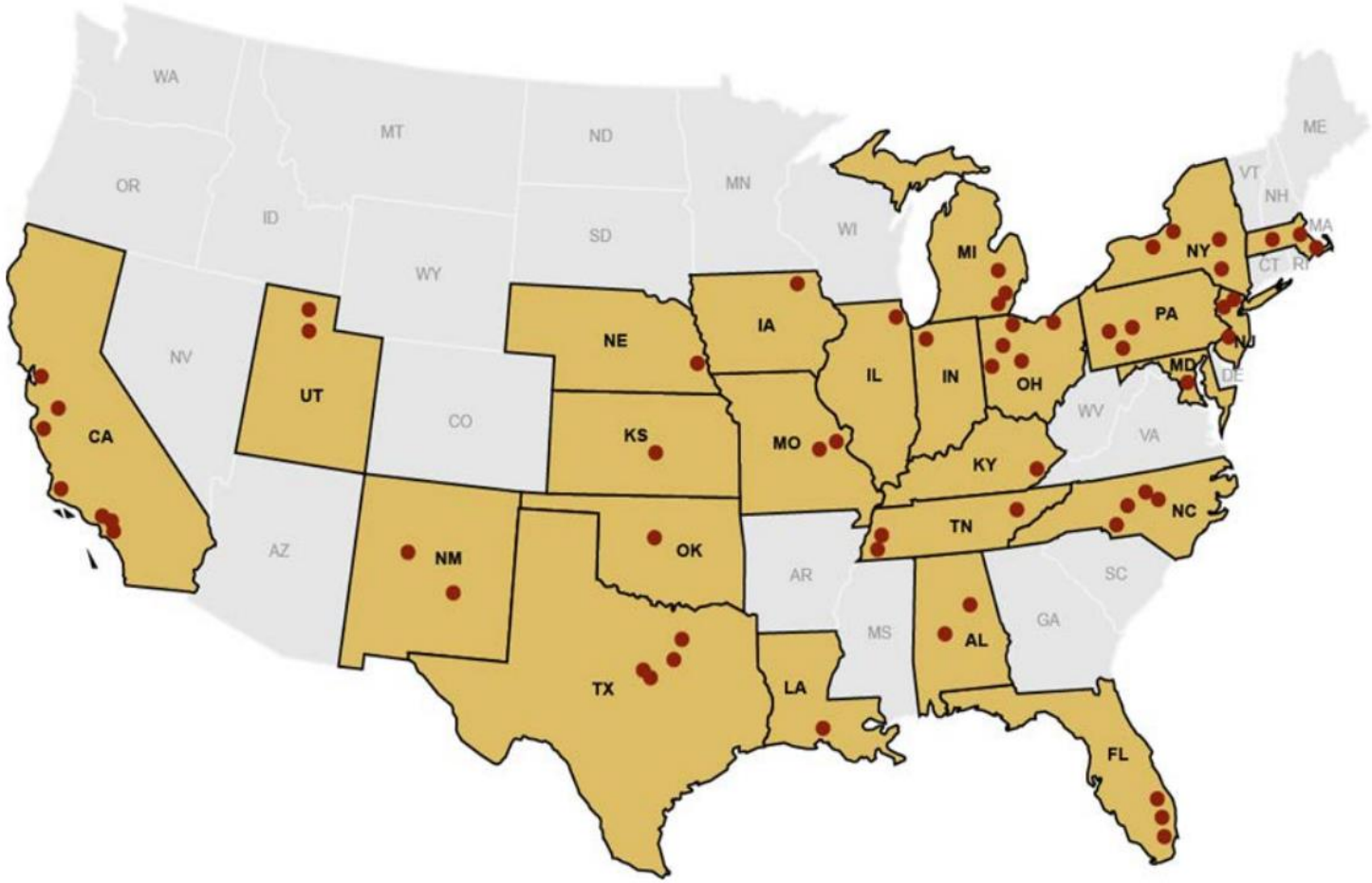
Study Design: Population-based Case-Control

- **Controls (n=7,719): participants in the 2007 National Roadside Survey of Alcohol and Drug Use by Drivers (NRS)**

NRS locations



Oral fluid testing

Study Design: Population-based Case-Control

- Cases were restricted to drivers who crashed at the same time windows as the NRS was conducted
- 10pm-12:00am & 1-3 am on Fridays and Saturdays
- 9:30-11:30 am & 1:30-3:30pm on Fridays
- July 20 to December 1st 2007

Specimens for Drug and Alcohol Tests

	Cases	Controls
Drugs	Blood	Oral liquid
Alcohol	Blood	breath

Interaction assessment

- Two scales; additive vs. multiplicative scale
- Additive scale is important for assessing public health impact; corresponds to biological notion of synergism*

*Rothman K.J. Causes. *American Journal of Epidemiology*,104:587-592

Interaction assessment

- Relative excess risk due to interaction(**RERI**)

- $RERI = OR_{alc+,mar+} - OR_{alc+,mar-} - OR_{alc-,mar+} + 1$

Where RERI>0, positive additive interaction

and RERI<0, negative additive interaction

Interaction assessment

- Attributable Proportion due to Interaction (API)

- $API = \frac{RERI}{OR_{alc+,mar+}}$

Where API>1, positive additive interaction

and API<1, negative additive interaction

Interaction assessment

- Synergy Index (S)

- $$S = \frac{OR_{alc+,mar+} - 1}{[(OR_{alc+} - 1) + OR_{mar+} - 1)]}$$

Where S>1, positive additive interaction

and S<1, negative additive interaction

Results

	Cases (n=1944)	Control (n=7719)	Crude OR	95% CI
Alcohol + (BAC ≥ 0 g/dL)	57.8%	7.7%	16.42	14.52, 18.57
Marijuana +	12.2%	5.9%	2.21	1.87, 2.60
Positive for both Alcohol and Marijuana	8.9%	0.8%	23.31	16.92, 32.12

Estimated Odds Ratios and 95% Confidence Intervals of fatal crash involvement according to marijuana and alcohol and testing results

Marijuana	Alcohol	Adjusted Odds Ratio (95% CI)
-	-	1.00
+	-	1.54 (1.16 - 2.03)
-	+	16.33 (14.23 - 18.75)
+	+	25.09 (17.97 – 35.03)

Positive interaction on additive scale; RERI=2.94 (0.60, 5.28)
Adjusted for age, sex and region.

Estimated Odds Ratios and 95% Confidence Intervals of fatal crash involvement according to marijuana and BAC level testing results

Marijuana	BAC level (g/dL)	Adjusted Odds Ratio (95% CI)
-	0	1.00
+	0	1.56 (1.18 - 2.06)
-	0.01-0.07	2.81 (2.25 – 3.50)
+	0.01-0.07	4.38 (3.01 – 6.37)
-	≥0.08	61.11 (49.50 - 75.46)
+	≥0.08	95.26 (65.75 - 138.02)

Positive interaction on additive scale; $RERI_{0.01\text{-}0.07}$ =1.01,$RERI_{\geq 0.08}$ =32.59

Adjusted for age, sex and region.

Estimated Odds Ratios and 95% Confidence Intervals according to weighted marijuana and BAC level testing results

Marijuana	BAC level (g/dL)	Adjusted Odds Ratio (95% CI)
-	0	1.00
+	0	1.52 (1.10 - 2.08)
-	0.01-0.07	3.01 (2.31 – 3.93)
+	0.01-0.07	4.56 (2.96 – 7.04)
-	≥0.08	66.50 (47.51 – 93.08)
+	≥0.08	100.78 (61.78 - 164.37)

Adjusted for age, sex and region.

Estimated Odds Ratios and 95% Confidence Intervals of fatal crash involvement in states that tested at least 80% of all fatally injured drivers

Marijuana	BAC level (g/dL)	Adjusted Odds Ratio (95% CI)
-	0	1.00
+	0	1.76 (1.17 - 2.66)
-	0.01-0.07	2.66 (1.91 – 3.70)
+	0.01-0.07	4.69 (2.69 – 8.19)
-	≥0.08	58.33 (44.91 - 75.75)
+	≥0.08	102.94 (61.13 – 173.32)

Adjusted for age, sex and region.

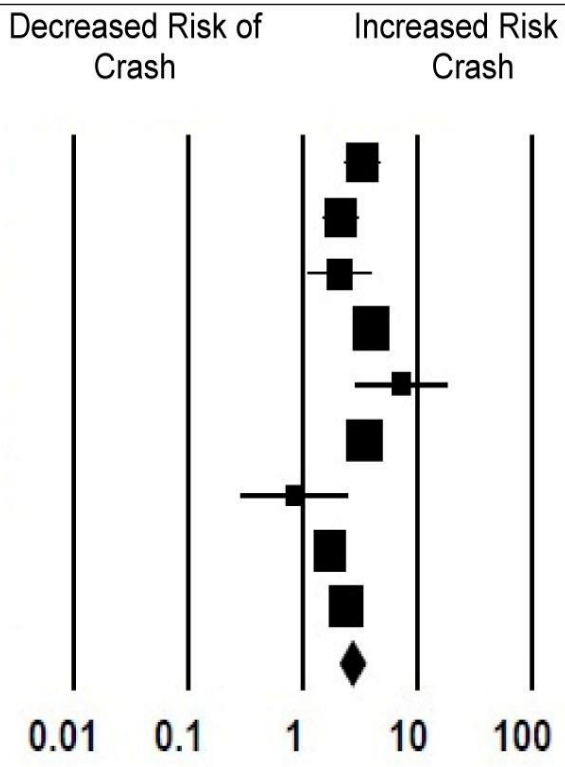
Estimated Odds Ratios and 95% Confidence Intervals of fatal crash involvement using multiply imputed marijuana testing results

Marijuana	BAC level (g/dL)	Adjusted Odds Ratio (95% CI)
-	0	1.00
+	0	1.84 (1.43 - 2.36)
-	0.01-0.07	2.34 (1.90 – 2.89)
+	0.01-0.07	2.49 (1.40 – 4.40)
-	≥0.08	60.43 (49.37 – 73.98)
+	≥0.08	101.93 (56.70 – 183.25)

Adjusted for age, sex and region.

Forrest Plot of Study-level and Summary Odds Ratios and 95% Confidence Intervals (CI) Of Crash Involvement Associated with Marijuana Use

Study Name	Statistics for Each Study		
	Odds Ratio	(95% CI)	Relative Weight
Mann et al 2010	3.28	(2.29–4.71)	7.50
Mura et al 2003	2.11	(1.46–3.06)	7.13
Movig et al 2004	2.10	(1.10–4.01)	2.34
Asbridge et al 2005	3.88	(3.17–4.75)	24.11
Blows et al 2005	7.16	(2.77–18.52)	1.08
Brault et al 2004	3.43	(2.69–4.36)	16.95
Woratanarat et al 2009	0.85	(0.29–2.50)	8.30
Gerberich et al 2003	1.70	(1.25–2.32)	10.37
Fergusson et al 2001	2.37	(1.98–2.84)	29.69
Random-effects model: P<.0001	2.66	(2.07–3.41)	
Heterogeneity: Q=38.21; P<.0001; I^2=79.1			

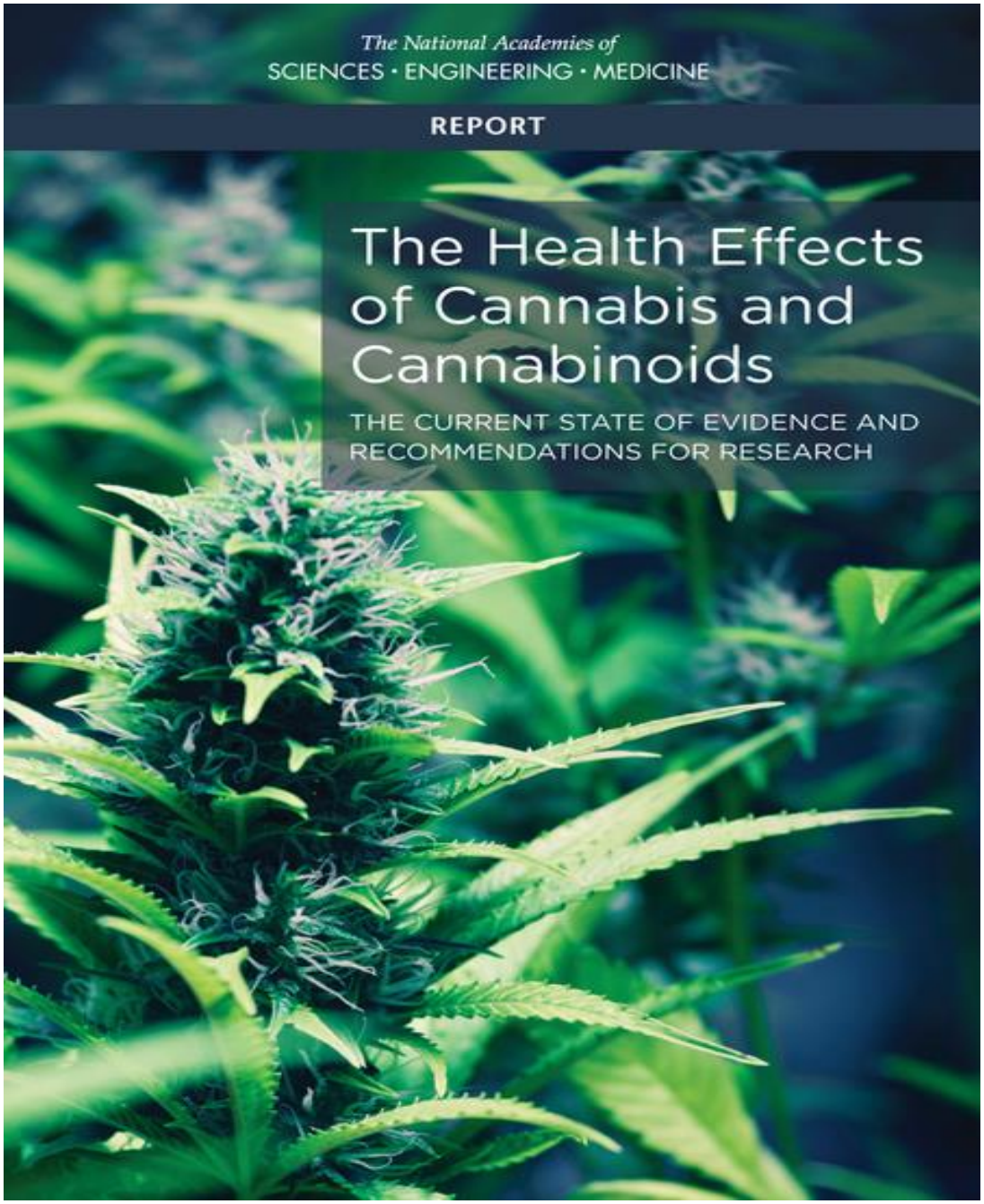


Li et al, 2012.

Prevalence of Drug Use in Cases and Controls by Drug Class

Drug Class	Cases (n=737)	Controls (n=7,719)	Estimated OR	95% CI
Marijuana	9.8%	5.6%	1.83	1.39-2.39
Narcotic	4.8%	1.6%	3.03	2.00-4.48
Stimulants	9.4%	2.8%	3.57	2.63-4.76
Depressants	5.2%	1.1%	4.83	3.18-7.21
Poly-drug	7.1%	2.2%	3.41	2.43-4.73

Li, Brady & Chen, 2013


The National Academies of
SCIENCES · ENGINEERING · MEDICINE
REPORT
The Health Effects of Cannabis and Cannabinoids
THE CURRENT STATE OF EVIDENCE AND RECOMMENDATIONS FOR RESEARCH

Limitations

- **Differences in drug and alcohol tests between cases and controls**
- **No quantitative testing data on THC**
- **Drug use vs. drug-induced impairment**

How Much Is Too Much Marijuana to Drive? Lawmakers Wonder

As more states consider legalizing marijuana, legislators are challenged to create laws on driving while impaired by marijuana. Matthew Staver for The New York Times

ORIGINAL CONTRIBUTION Open Access

Validity of oral fluid test for Delta-9-tetrahydrocannabinol in drivers using the 2013 National Roadside Survey Data

Huiyan Jin[1], Sharifa Z. Williams[1], Stanford T. Chihuri[2], Guohua Li[2,3] and Qixuan Chen[1*]

Abstract

Background: Driving under the influence of marijuana is a serious traffic safety concern in the United States. Delta 9-tetrahydrocannabinol (THC) is the main active compound in marijuana. Although blood THC testing is a more accurate measure of THC-induced impairment, measuring THC in oral fluid is a less intrusive and less costly method of testing.

Methods: We examined whether the oral fluid THC test can be used as a valid alternative to the blood THC test using a sensitivity and specificity analysis and a logistic regression, and estimate the quantitative relationship between oral fluid THC concentration and blood THC concentration using a correlation analysis and a linear regression on the log-transformed THC concentrations. We used data from 4596 drivers who participated in the 2013 National Roadside Survey of Alcohol and Drug Use by Drivers and for whom THC testing results from both oral fluid and whole blood samples were available.

Results: Overall, 8.9% and 9.4% of the participants tested positive for THC in oral fluid and whole blood samples, respectively. Using blood test as the reference criterion, oral fluid test for THC positivity showed a sensitivity of 79.4% (95% CI: 75.2%, 83.1%) and a specificity of 98.3% (95% CI: 97.9%, 98.7%). The log-transformed oral fluid THC concentration accounted for about 29% of the variation in the log-transformed blood THC concentration. That is, there is still 71% of the variation in the log-transformed blood THC concentration unexplained by the log-transformed oral fluid THC concentration. Back-transforming to the original scale, we estimated that each 10% increase in the oral fluid THC concentration was associated with a 2.4% (95% CI: 2.1%, 2.8%) increase in the blood THC concentration.

Conclusions: The oral fluid test is a highly valid method for detecting the presence of THC in the blood but cannot be used to accurately measure the blood THC concentration.

Summary

- **Marijuana and alcohol are each associated with a significantly increased risk of fatal crash involvement**

- **Positive synergistic effects on fatal crash risk between marijuana and alcohol**

Pharmacokinetic interaction

- **Alcohol appears to increase THC levels**
- **Vasodilation in lung capillaries increase THC absorption**
- **After drinking, consumption THC increases**

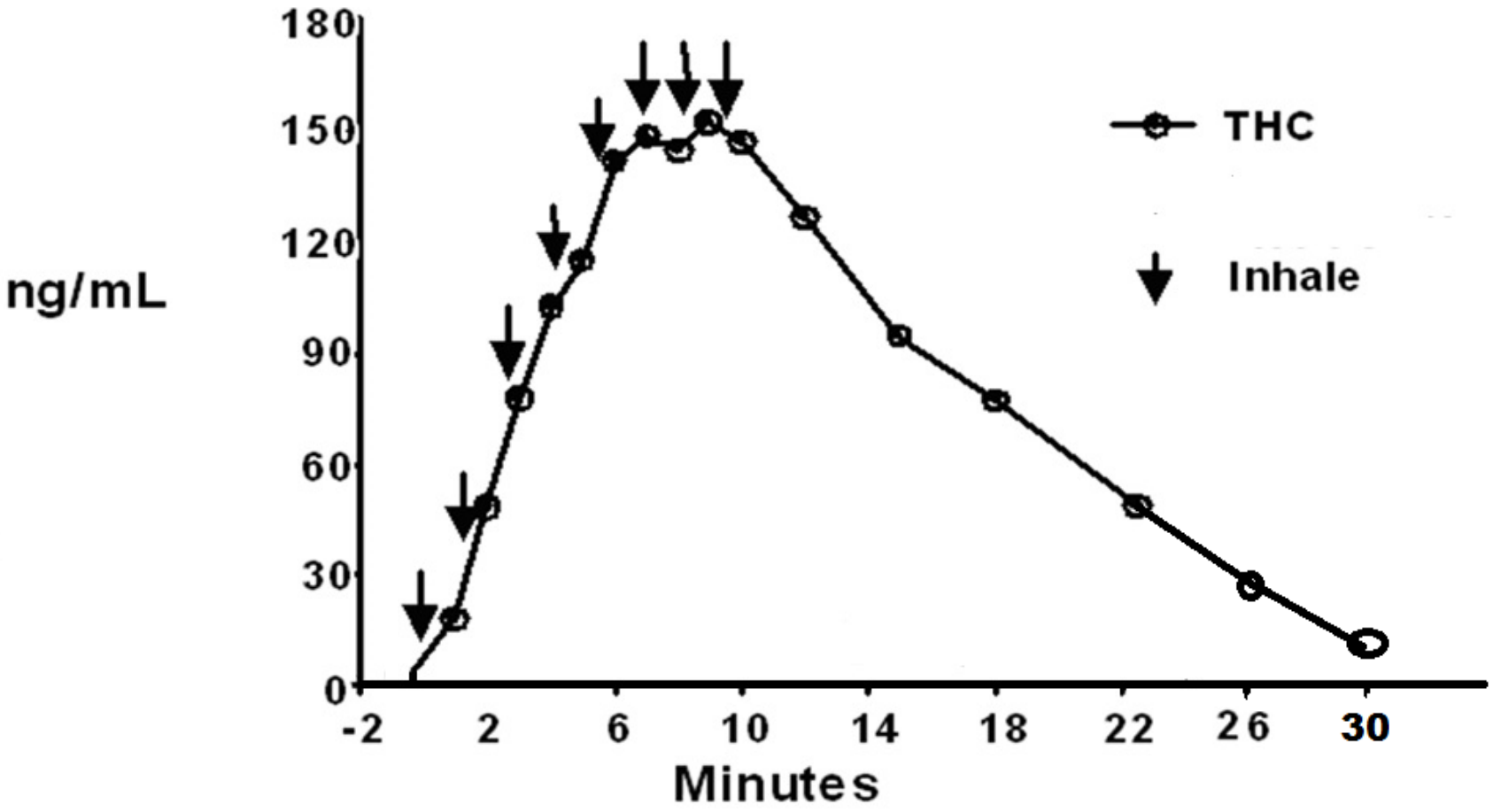
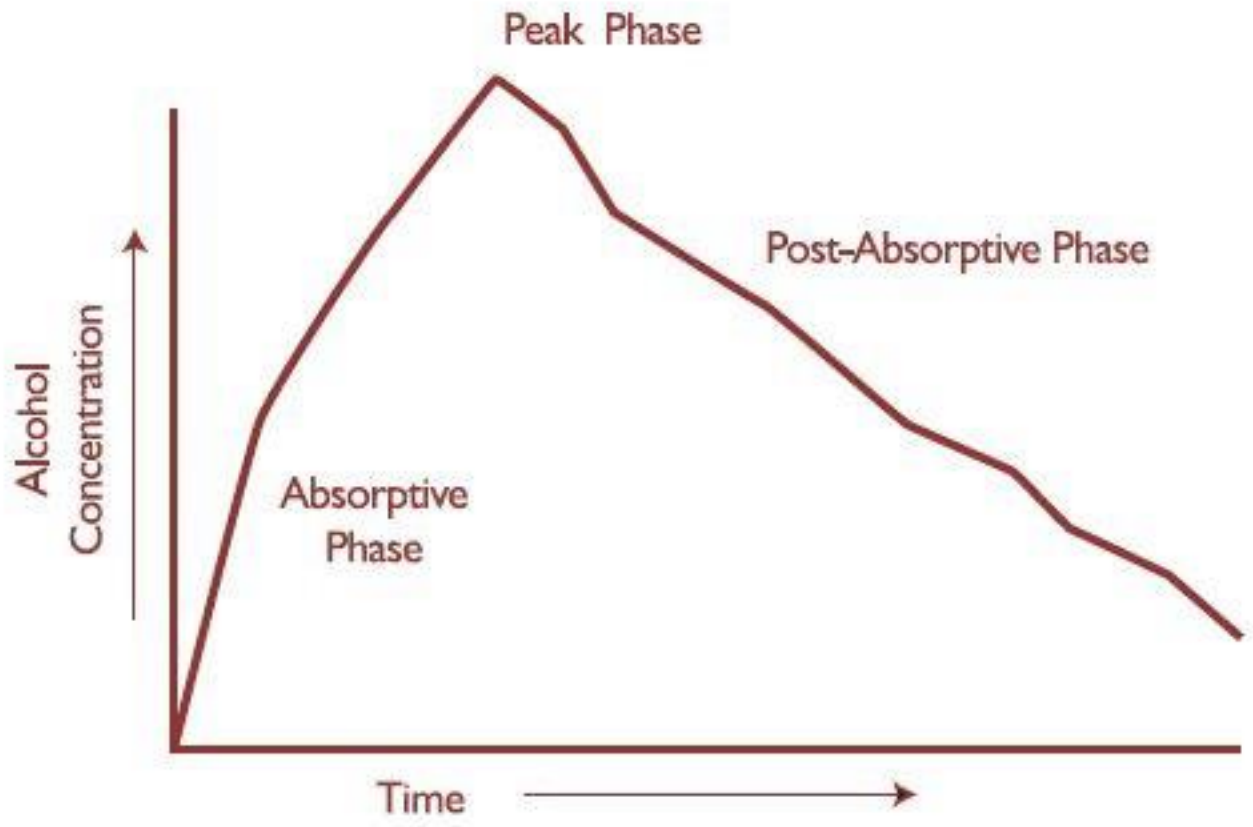

ng/mL
180
150
120
90
60
30
0
-2
2
6
10
14
18
22
26
30
Minutes
THC
Inhale

FIGURE 1

General Alcohol Concentration Curve



Source: New York Times

source: http://wwwapps.dotd.la.gov

Legal Δ^9-tetrahydrocannabinol (THC) thresholds for drivers in states with per se laws

State	Legal THC limit	Collected specimen	Year effective
Colorado	5.0 µg/L in blood	Blood, urine, or OF	2013
Iowa	THC-COOH: 50.0 µg/L in urine	Blood or urine	2010
Montana	5.0 µg/L in blood	Blood	2013
Nevada	THC: 10.0 µg/L in urine, 2.0 µg/L in blood THC-COOH: 15.0 µg/L in urine, 5.0 µg/L in blood	Blood, urine, or other bodily substance	2003
Ohio	THC: 10.0 µg/L in urine, 2.0 µg/L in blood THC-COOH: 35.0 µg/L in urine, 50.0 µg/L in blood THC-COOH in combination with alcohol or other drugs: 15.0 µg/L in urine, 5.0 µg/L in blood	Blood, urine, or other bodily substance	2006
Pennsylvania	THC or THC-COOH: 1.0 µg/L in blood or urine	Blood or urine	2011
Washington	5.0 µg/L in blood	Blood	2013

Wong, Brady & Li 2014.

Questions?