Cannabis & Motor Vehicle Crashes
What is the Evidence?

Jeff Brubacher, MD, MSc, FRCPC(EM)
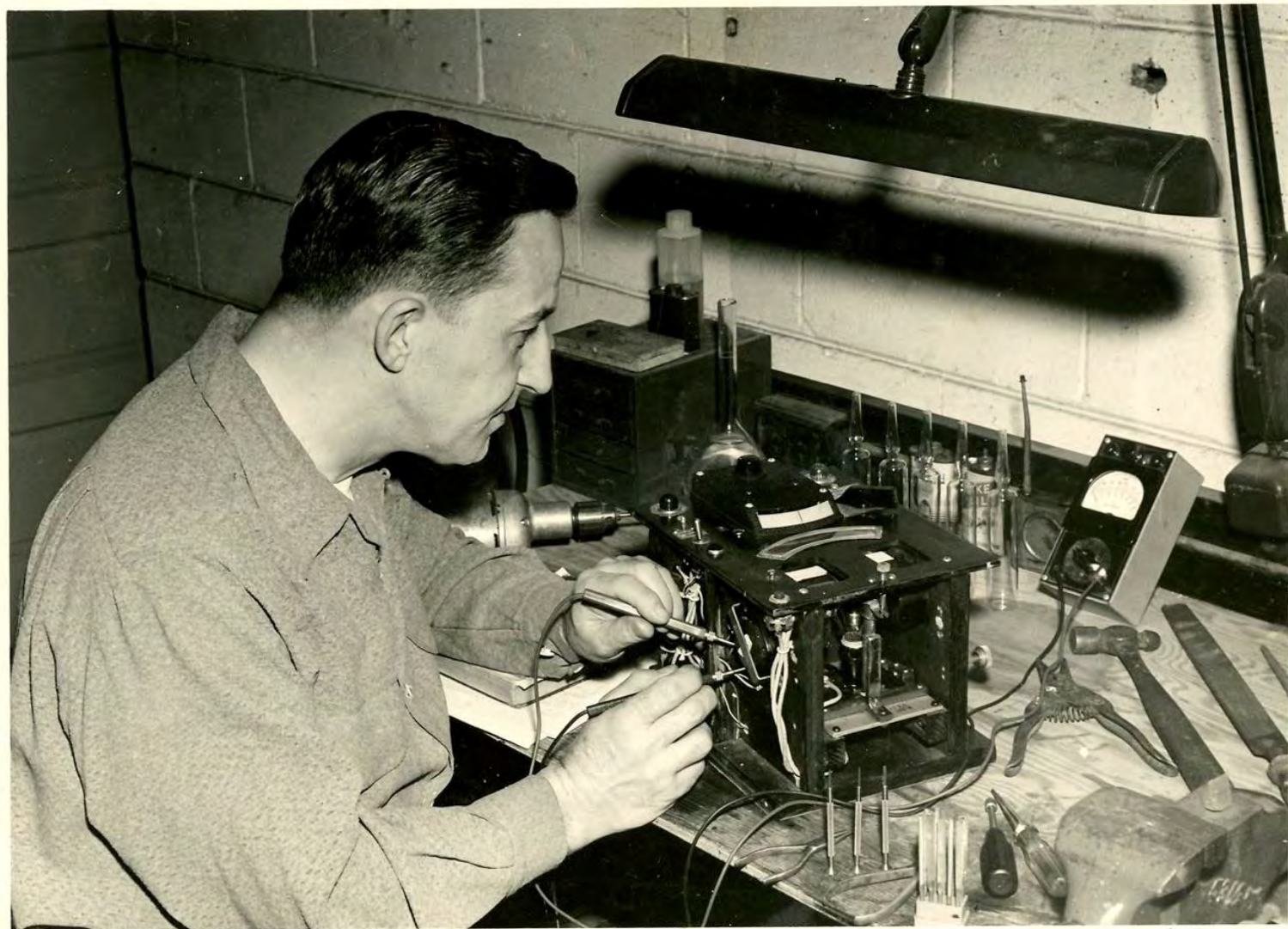
University of British Columbia

CCMTA – June 2018

Objectives

- How do we know alcohol causes crashes?
- What does cannabis impairment look like?
- What is known about cannabis & MVC risk?
- Why is cannabis so hard to study?
- BC research on cannabis and crash risk.
- How can cannabis and driving be monitored?
- What will happen with legalization?

Alcohol and Crash Risk - 101

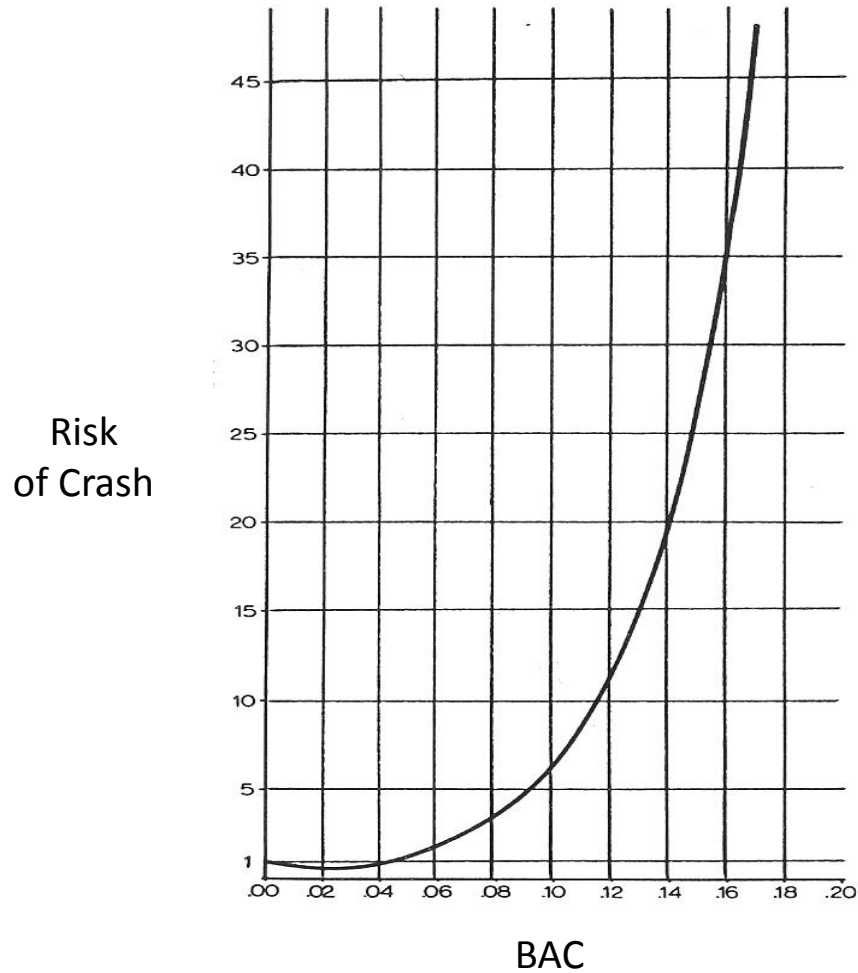|	Case	Control
Alcohol	*a*	*c*
No Alcohol	*b*	*d*

"Odds Ratio" = (*a/b*) / (*c/d*) = *ad / bc*

Compares the odds of testing positive for alcohol
in drivers in a crash with that in control drivers
Or
The likelihood of crashing in alcohol positive versus alcohol negative drivers

Grand Rapids Study, 1962 – 63

Risk of Crash

BAC

The risk of crashing increases dramatically when BAC > 0.08%

What does cannabis impairment look like?

WHERE MARIJUANA ACTS

The drug *Cannabis sativa* binds to the brain's own cannabinoid receptors in many different areas, including those highlighted below. This widespread influence accounts for the diverse effects the drug—and its relatives made by the brain—can have and offers exciting opportunities for devising medications that can specifically target certain sites to control, say, appetite or pain.

HYPOTHALAMUS
Controls appetite, hormonal levels and sexual behavior

BASAL GANGLIA
Involved in motor control and planning, as well as the initiation and termination of action
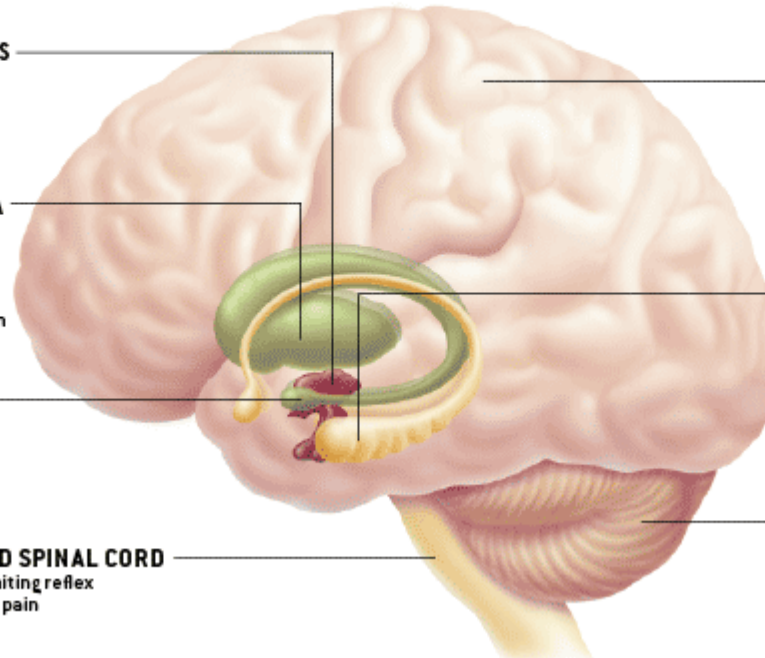
AMYGDALA
Responsible for anxiety, emotion and fear

BRAIN STEM AND SPINAL CORD
Important in the vomiting reflex and the sensation of pain

ALICE CHEN

NEOCORTEX
Responsible for higher cognitive functions and the integration of sensory information

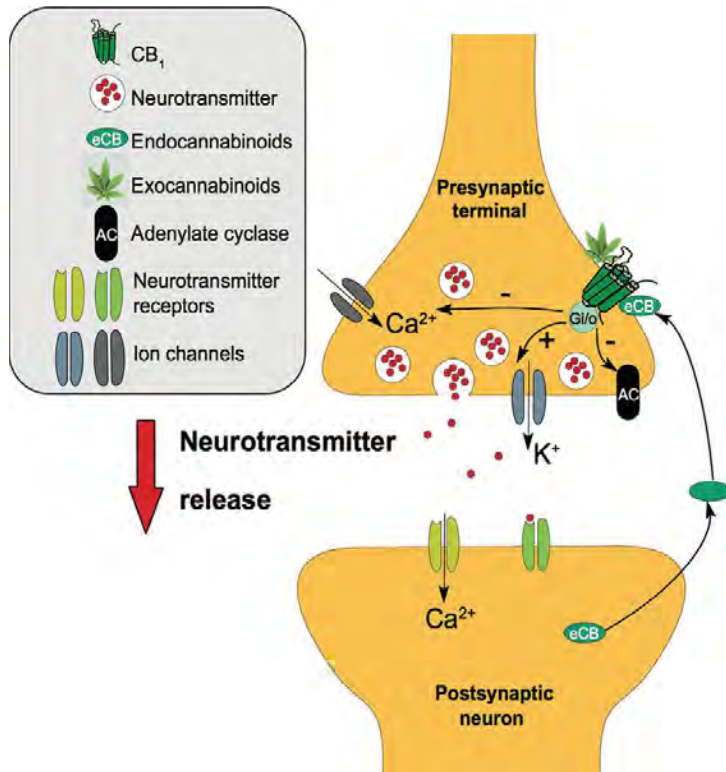**HIPPOCAMPUS**
Important for memory and the learning of facts, sequences and places

CEREBELLUM
Center for motor control and coordination

Cannabis Impairment
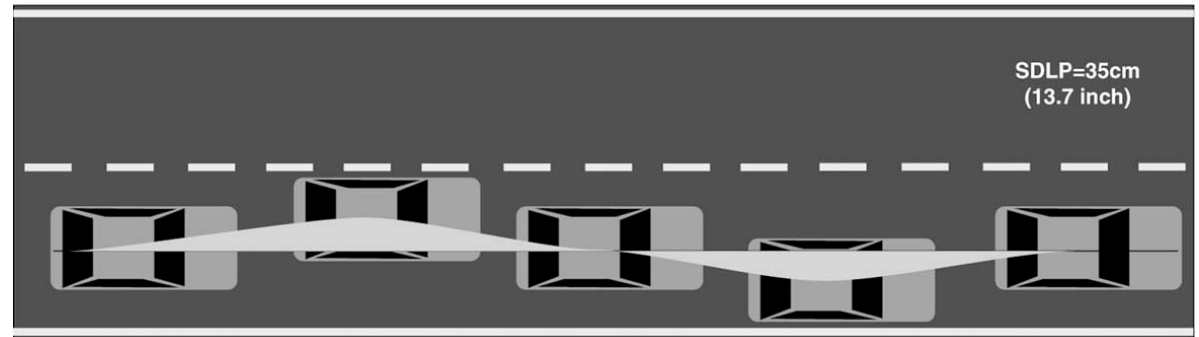

Busquets-Garcia, 2015

- Receptors throughout CNS
- Mediate inhibition
- Euphoria and relaxation
- Panic and paranoia
- Altered time sense
- Attention deficits
- Slow information processing
- Impaired coordination
- Slowed reactions

Ramaekers: on the road driving test
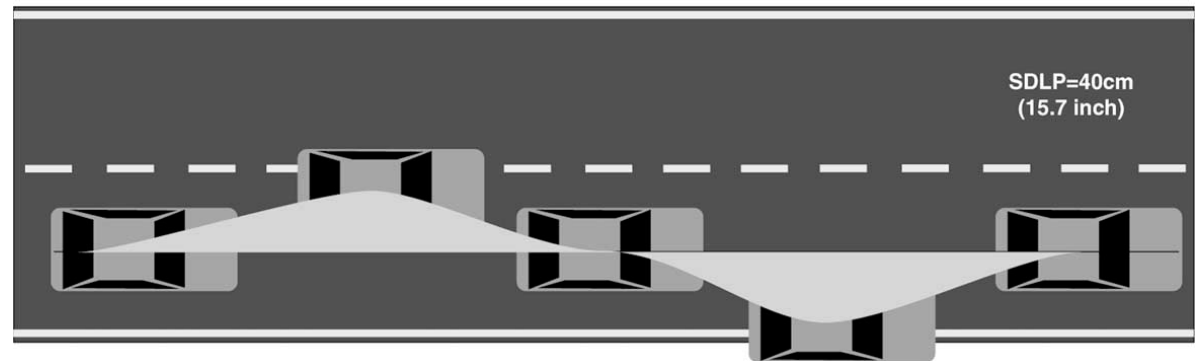
Whole blood THC of 3 ng/mL ≈ BAC of 0.05%
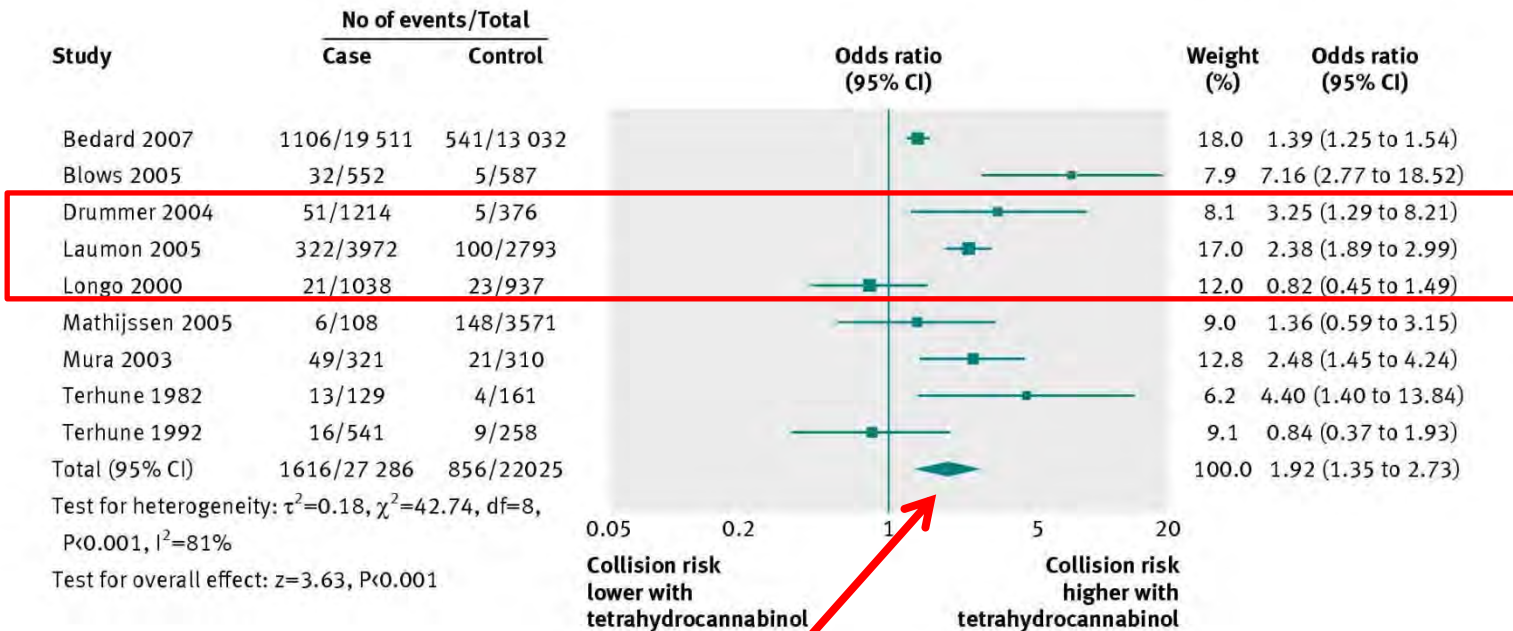5 ng/mL ≈ BAC of 0.08%

Can drivers compensate?

What do we know?

Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis

Mark Asbridge *associate professor*, Jill A Hayden *assistant professor*, Jennifer L Cartwright *research coordinator*

Study	No of events/Total Case	No of events/Total Control	Weight (%)	Odds ratio (95% CI)
Bedard 2007	1106/19 511	541/13 032	18.0	1.39 (1.25 to 1.54)
Blows 2005	32/552	5/587	7.9	7.16 (2.77 to 18.52)
Drummer 2004	51/1214	5/376	8.1	3.25 (1.29 to 8.21)
Laumon 2005	322/3972	100/2793	17.0	2.38 (1.89 to 2.99)
Longo 2000	21/1038	23/937	12.0	0.82 (0.45 to 1.49)
Mathijssen 2005	6/108	148/3571	9.0	1.36 (0.59 to 3.15)
Mura 2003	49/321	21/310	12.8	2.48 (1.45 to 4.24)
Terhune 1982	13/129	4/161	6.2	4.40 (1.40 to 13.84)
Terhune 1992	16/541	9/258	9.1	0.84 (0.37 to 1.93)
Total (95% CI)	1616/27 286	856/22025	100.0	1.92 (1.35 to 2.73)

Test for heterogeneity: $\tau^2=0.18$, $\chi^2=42.74$, df=8, P<0.001, $I^2=81\%$

Test for overall effect: z=3.63, P<0.001

Collision risk lower with tetrahydrocannabinol — Collision risk higher with tetrahydrocannabinol

Risk = 1.65

Risk = 1.92
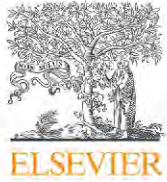
Risk of severe driver injury by driving with psychoactive substances

CrossMark

Tove Hels [a,*], Allan Lyckegaard [a,1], Kirsten Wiese Simonsen [b,2], Anni Steentoft [b,2], Inger Marie Bernhoft [a,1]

[a] Technical University of Denmark, Department of Transport, Bygningstorvet 116B, DK-2800 Lyngby, Denmark
[b] Section of Forensic Chemistry, Department of Forensic Medicine, Faculty of Health Sciences, University of Copenhagen, Frederik V's Vej 11, 3., DK-2100 Copenhagen, Denmark

Case

Control

Cases

Belgium   348
Denmark   839
Finland   54
Italy   676
Lithuania 385
Holland   188
Total   2490

Controls 15832
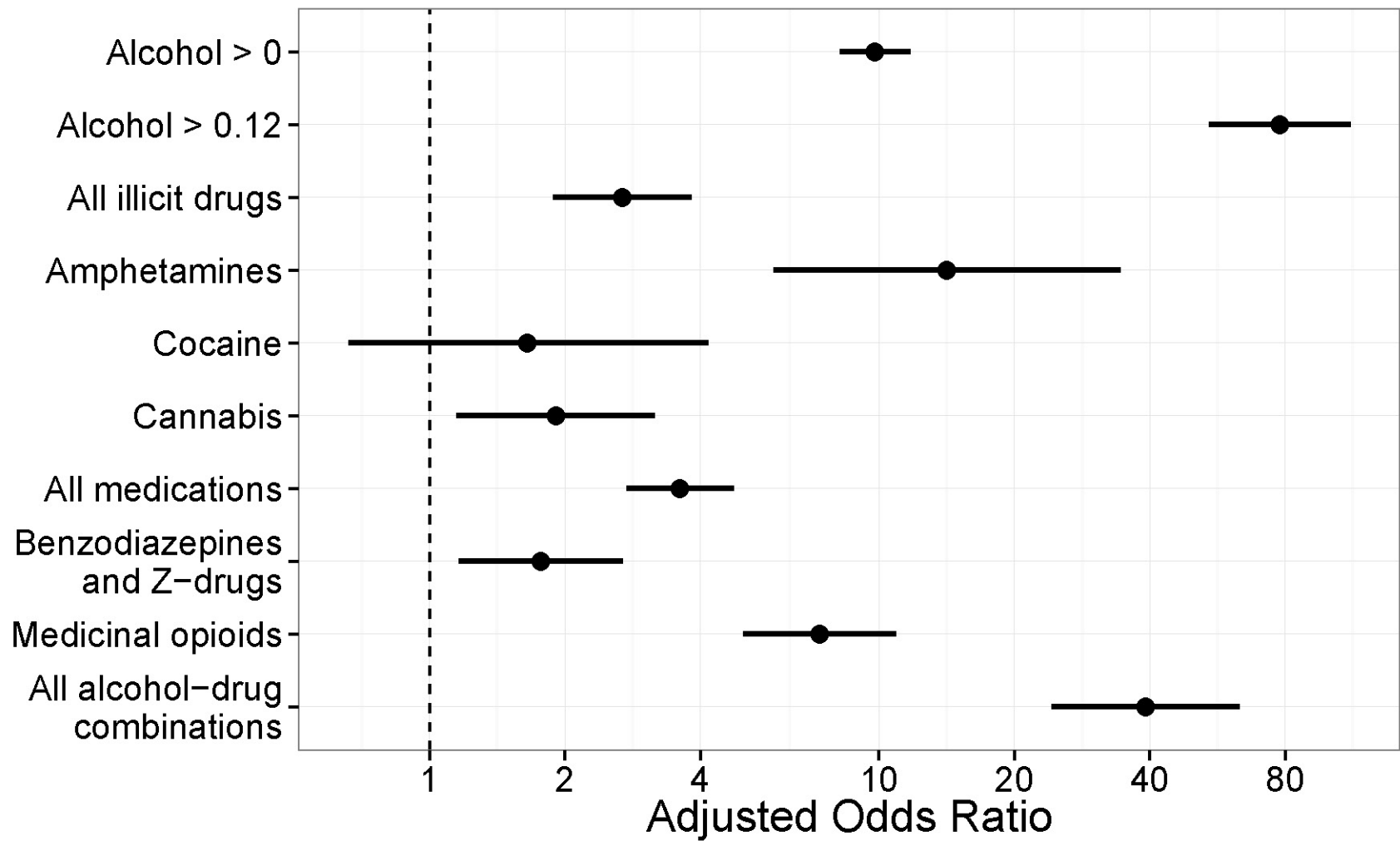
U.S. Department
of Transportation

National Highway
Traffic Safety
Administration

TRAFFIC SAFETY FACTS
Research Note

NHTSA
www.nhtsa.gov

Drug and Alcohol Crash Risk

Richard P. Compton and Amy Berning

Cases

Controls

3887 → eligible ← 7397

3682 → participated ← 7176

534 (13.7%)

529 (7.2%)

3353 — breathe test (alcohol) — 6868

792 (20.4%)

1207 (16.3%)

3095 — oral fluid (drugs) — 6190

Drug and Alcohol Crash Risk

Richard P. Compton and Amy Berning

Forest plot of Adjusted Odds Ratio by substance:
- Alcohol > 0.05
- THC (Marijuana)
- Antidepressants
- Narcotic analgesics
- Sedatives
- Stimulants
- Illegal drugs
- Legal drugs

X-axis: Adjusted Odds Ratio (1, 2, 4, 10)
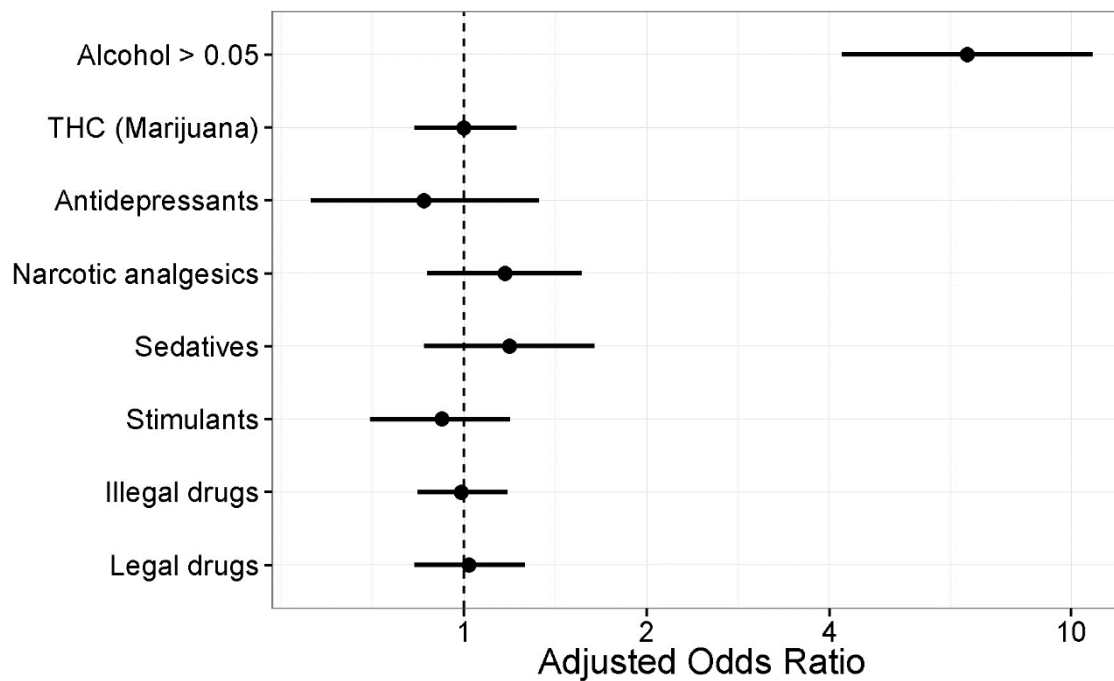
Problems with the NHSTA study

- High refusal rate in both cases and controls
- Included mostly minor crashes (2/3 PDO)
- Counted very low THC levels as positive
- High levels of drug screening in Virginia Beach since it is near a military base

The effects of cannabis intoxication on motor vehicle collision revisited and revised

Ole Rogeberg[1] & Rune Elvik[2]

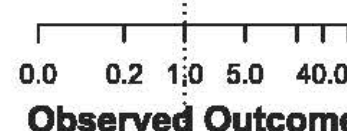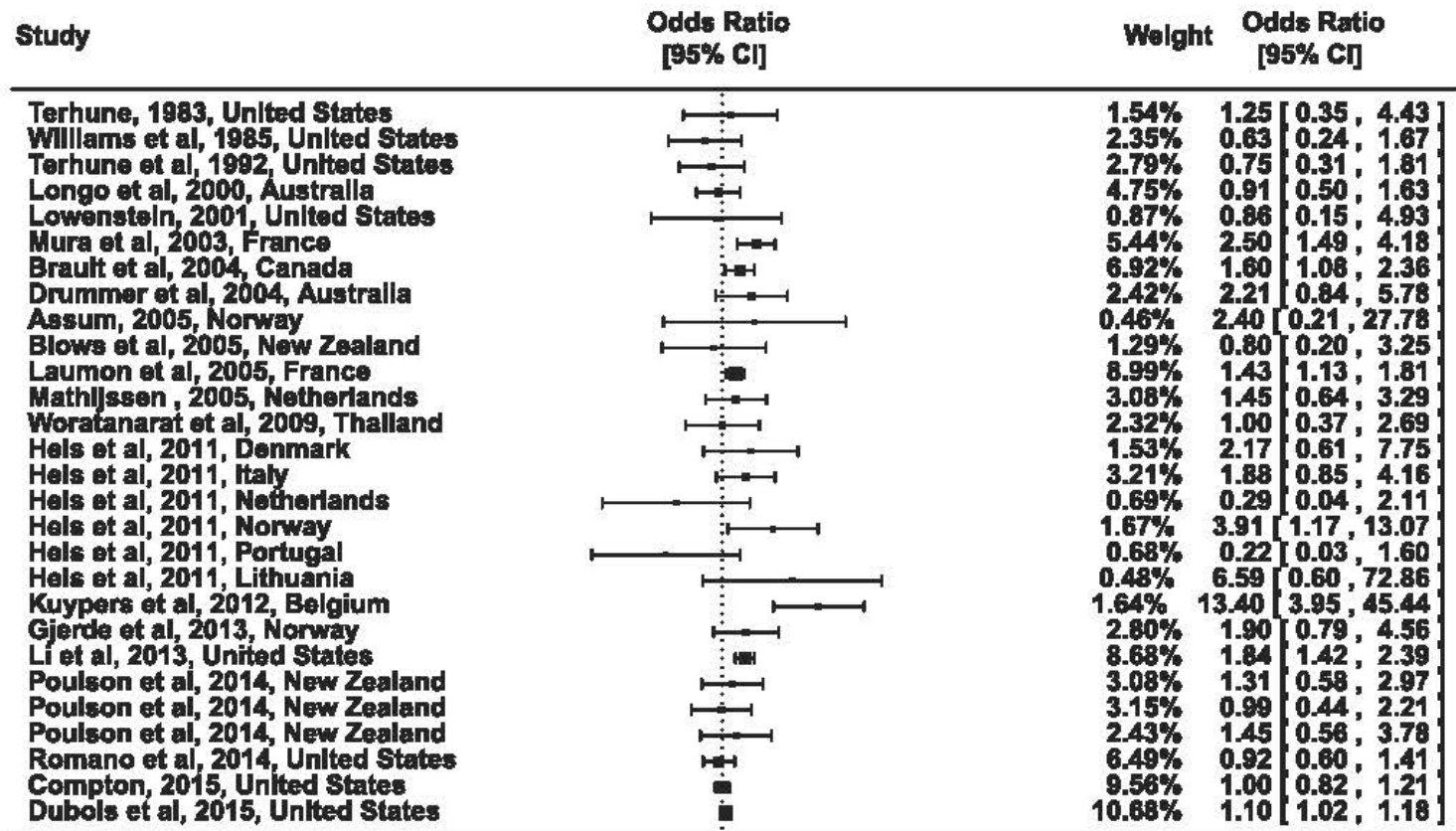| Study	Odds Ratio [95% CI]	Weight	Odds Ratio [95% CI]
Terhune, 1983, United States		1.54%	1.25 [0.35, 4.43]
Williams et al, 1985, United States		2.35%	0.63 [0.24, 1.67]
Terhune et al, 1992, United States		2.79%	0.75 [0.31, 1.81]
Longo et al, 2000, Australia		4.75%	0.91 [0.50, 1.63]
Lowenstein, 2001, United States		0.87%	0.86 [0.15, 4.93]
Mura et al, 2003, France		5.44%	2.50 [1.49, 4.18]
Brault et al, 2004, Canada		6.92%	1.60 [1.08, 2.36]
Drummer et al, 2004, Australia		2.42%	2.21 [0.84, 5.78]
Assum, 2005, Norway		0.46%	2.40 [0.21, 27.78]
Blows et al, 2005, New Zealand		1.29%	0.80 [0.20, 3.25]
Laumon et al, 2005, France		8.99%	1.43 [1.13, 1.81]
Mathijssen, 2005, Netherlands		3.08%	1.45 [0.64, 3.29]
Woratanarat et al, 2009, Thailand		2.32%	1.00 [0.37, 2.69]
Hels et al, 2011, Denmark		1.53%	2.17 [0.61, 7.75]
Hels et al, 2011, Italy		3.21%	1.88 [0.85, 4.16]
Hels et al, 2011, Netherlands		0.69%	0.29 [0.04, 2.11]
Hels et al, 2011, Norway		1.67%	3.91 [1.17, 13.07]
Hels et al, 2011, Portugal		0.68%	0.22 [0.03, 1.60]
Hels et al, 2011, Lithuania		0.48%	6.59 [0.60, 72.86]
Kuypers et al, 2012, Belgium		1.64%	13.40 [3.95, 45.44]
Gjerde et al, 2013, Norway		2.80%	1.90 [0.79, 4.56]
Li et al, 2013, United States		8.68%	1.84 [1.42, 2.39]
Poulson et al, 2014, New Zealand		3.08%	1.31 [0.58, 2.97]
Poulson et al, 2014, New Zealand		3.15%	0.99 [0.44, 2.21]
Poulson et al, 2014, New Zealand		2.43%	1.45 [0.56, 3.78]
Romano et al, 2014, United States		6.49%	0.92 [0.60, 1.41]
Compton, 2015, United States		9.56%	1.00 [0.82, 1.21]
Dubois et al, 2015, United States		10.68%	1.10 [1.02, 1.18]
Total (95% CI)		100.00%	1.36 [1.15, 1.61]

0.0   0.2   1.0   5.0   40.0

Observed Outcome

OR = 1.36

RESEARCH ARTICLE

Cannabis, alcohol and fatal road accidents

Jean-Louis Martin*, Blandine Gadegbeku, Dan Wu, Vivian Viallon, Bernard Laumon

Table 4. Adjusted ORs* for driver responsibility linked to driving under the influence (n = 4,047**, data source Voiesur 2011, fatal accidents).

	OR	95% CI
THC < 1 ng/l	1	
1 ≤ THC < 3 ng/l	1.35	0.86–2.14
3 ≤ THC < 5 ng/l	3.59	1.36–9.48
THC ≥ 5 ng/l	1.59	0.85–2.97
All doses THC ≥ 1 ng/ml	1.65	1.16–2.34
ALC < 0.5 g/l	1	
0.5 ≤ Alc <0.8 g/l	6.40	2.70–15.2
0.8 ≤ Alc < 1.2 g/l	8.30	4.52–15.2
1.2 ≤ Alc < 2 g/l	24.4	11.9–50.1
Alc ≥ 2 g/l	44.4	18.1–109
All doses ALC ≥ 0.5 g/l	17.8	12.1–26.1
OPI < 20 ng/ml	1	
OPI ≥ 20 ng/ml	2.21	1.02–4.78

* Adjustment factors included in the model: age, gender, vehicle category, time of accident

** Known alcohol and narcotic status: responsibility determined by expert and age known (2,562 cases and 1,485 controls)

# Why is cannabis so hard to study?
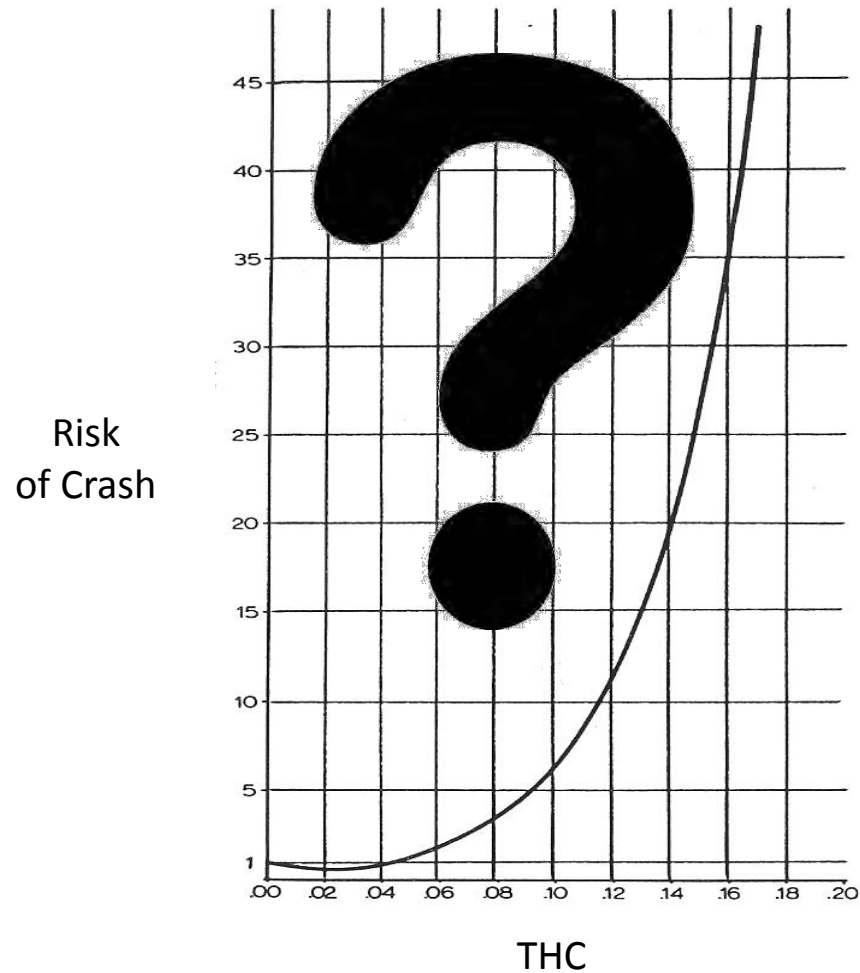
Which body fluid?

Smoked Cannabis

- Deposited in oral cavity
- Rapidly absorbed from lungs into blood
- Blood carries THC to brain
- Equilibrium between blood and brain
- THC is stored in fat
- Metabolized to COOH-THC
- Eliminated in urine

Test	Interpretation
Positive urine (COOH-THC)	Marijuana use in last month
Saliva THC positive	Marijuana smoked <2 d ago*
Saliva THC level	Poor correlation with blood THC
Saliva THC + CBD / CBN	Marijuana smoked < 13 h ago
Blood THC positive	Marijuana use in last week*
Blood THC > 2	Marijuana use in last 4 hours
Blood THC > 3, 5, 7, etc	Correlates with impairment especially in occasional users
Postmortem blood THC	Complex postmortem changes Postmortem > premortem levels

Timing is important

Blood Levels of THC & Metabolite
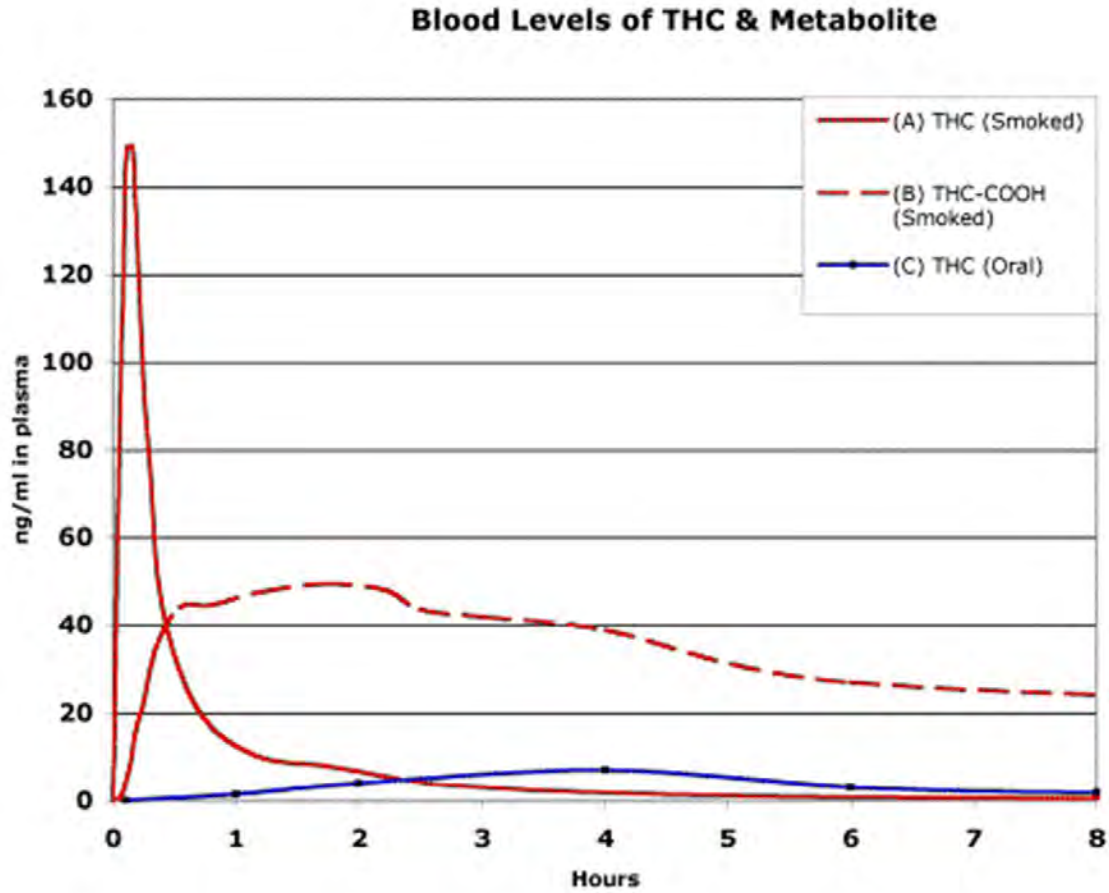
Which comparison group?

What Outcome?

Other Risk Factors
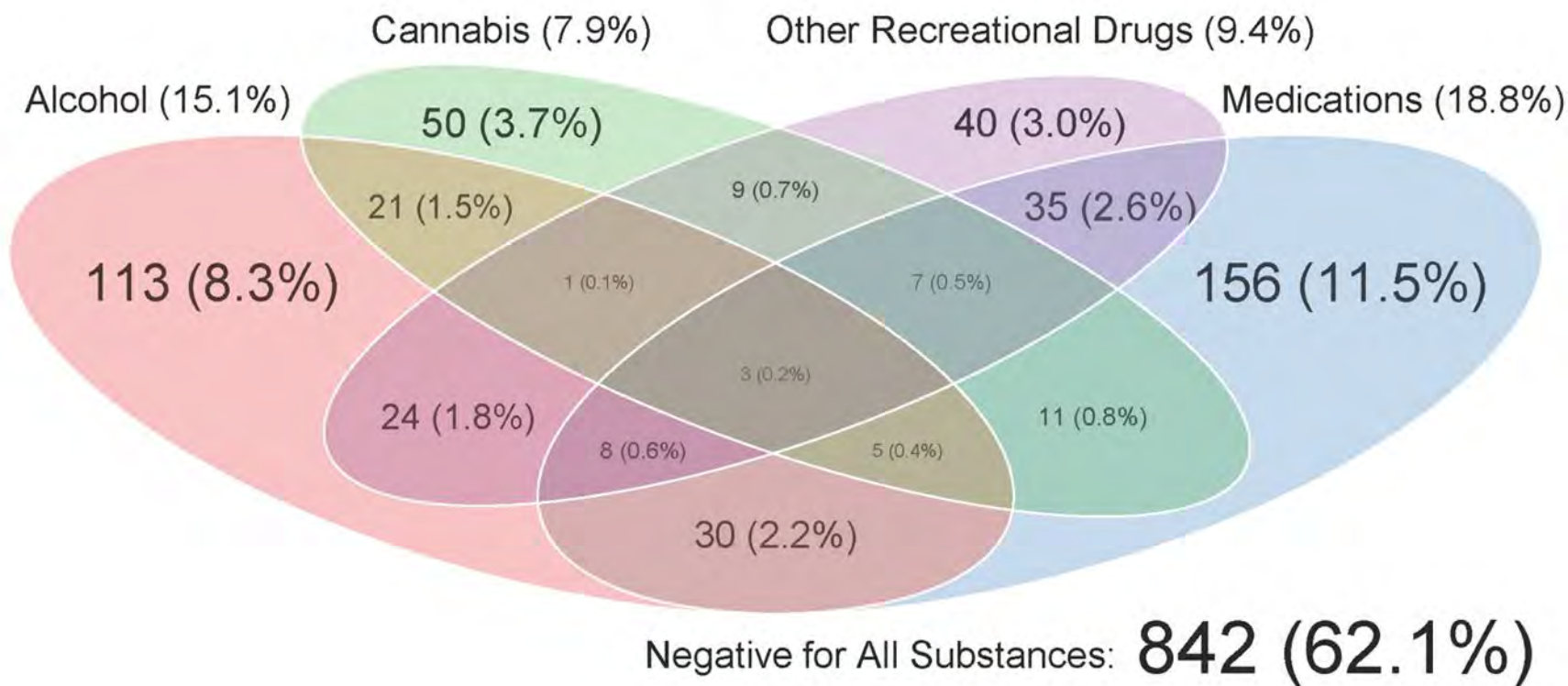
Cannabis and Motor Vehicle Crashes: A Multicentre Culpability Study.

BRUBACHER, Jeffrey R; ASBRIDGE, Mark; BRANT, Rollin F; MANN, Robert E; MARTZ, Walter; ANDOLFATTO, Gary; BRYAN, Stirling; DRUMMER, Olaf H; MACDONALD, Scott A; PURSSELL, Roy A; SCHREIBER, William E

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Faculty of Medicine

CENTRE *for*
Clinical Epidemiology
and Evaluation

CIHR IRSC
Canadian Institutes of Instituts de recherche
Health Research   en santé du Canada

Disclosure

- Co-Investigators: Herb Chan, Shannon Erdelyi

- Funded by: CIHR, Transport Canada

- My Funding: Michael Smith Foundation for Health Research

- Department of Emergency Medicine, UBC

- No conflict of interest or commercial affiliation that can be a potential source of bias

What is a culpability study?

Case

Control

Taylor & Francis
Taylor & Francis Group
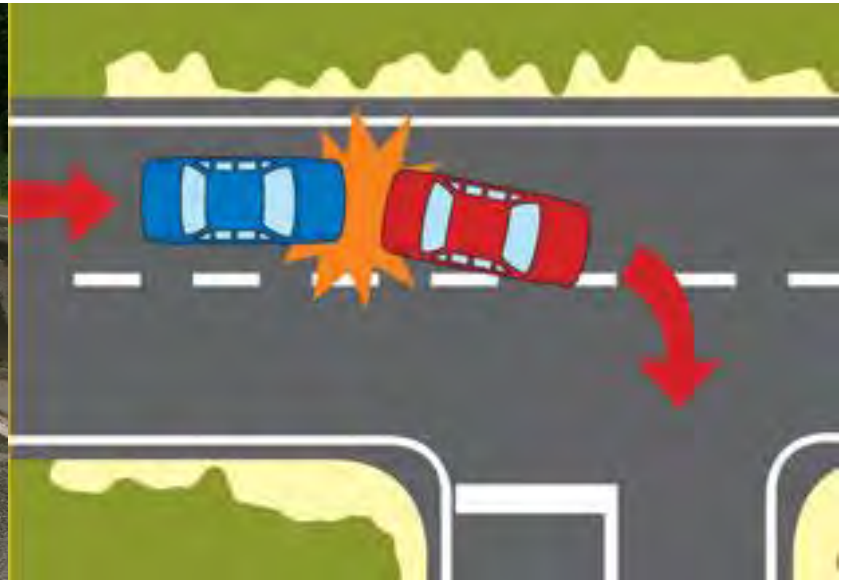
Development and Validation of a Crash Culpability Scoring Tool

JEFF BRUBACHER,[1] HERBERT CHAN,[2] and MARK ASBRIDGE[3]

1. Road Type
2. Driving conditions
3. Vehicle Condition
4. Unsafe driving actions
5. Contribution from others
6. Type of Collision
7. Difficulty of task
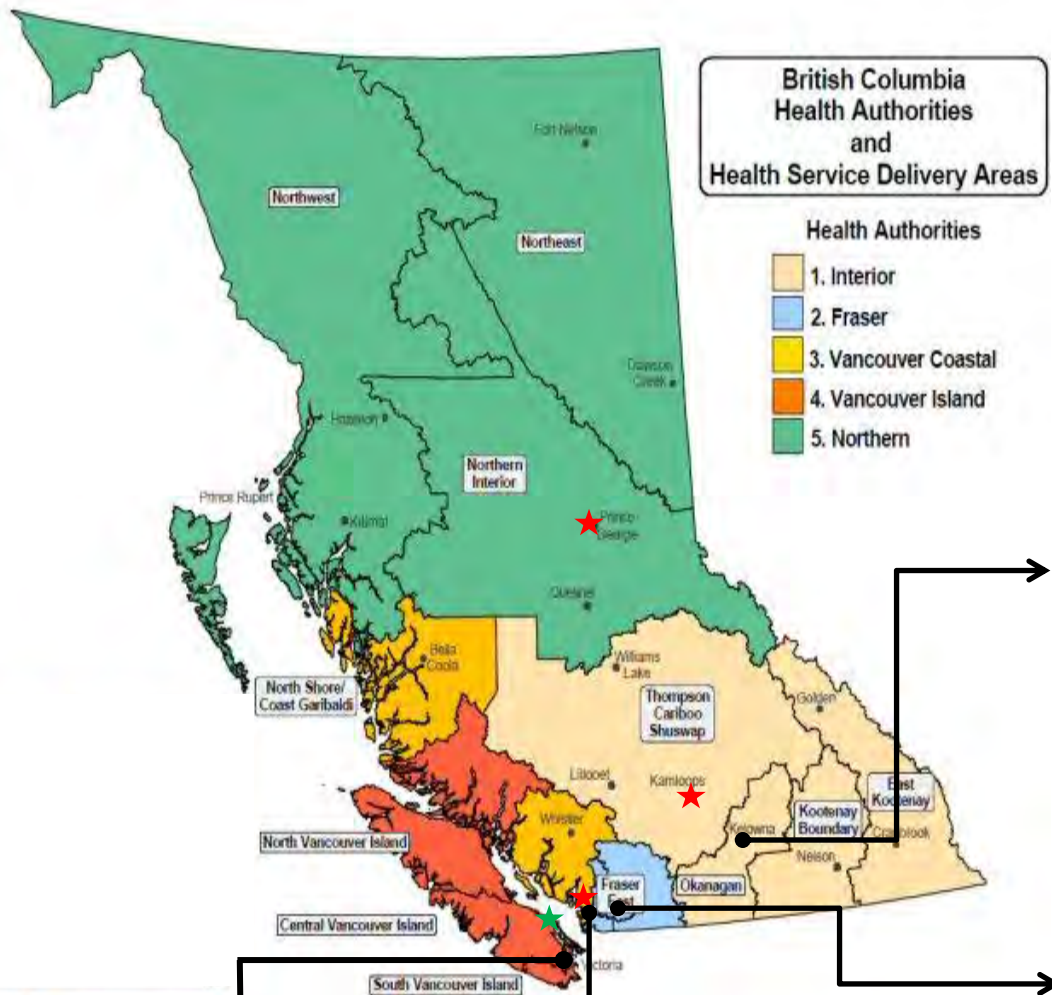
Kelowna General

Royal Columbian

Victoria General

Vancouver General

T = 0 min.

All drivers of car or light truck
Blood obtained within 6 hours of crash
Police crash reports available

T < 90 min

T = 3 hours

Patient Flow Chart

3149 = Injured drivers with bloodwork

142 missing crash times or later than 6 hours

3006 = Eligible drivers

687 = no matching police records

2319 = matched to police records

494 = indeterminate culpability

1825

1178 (65%) = Culpable
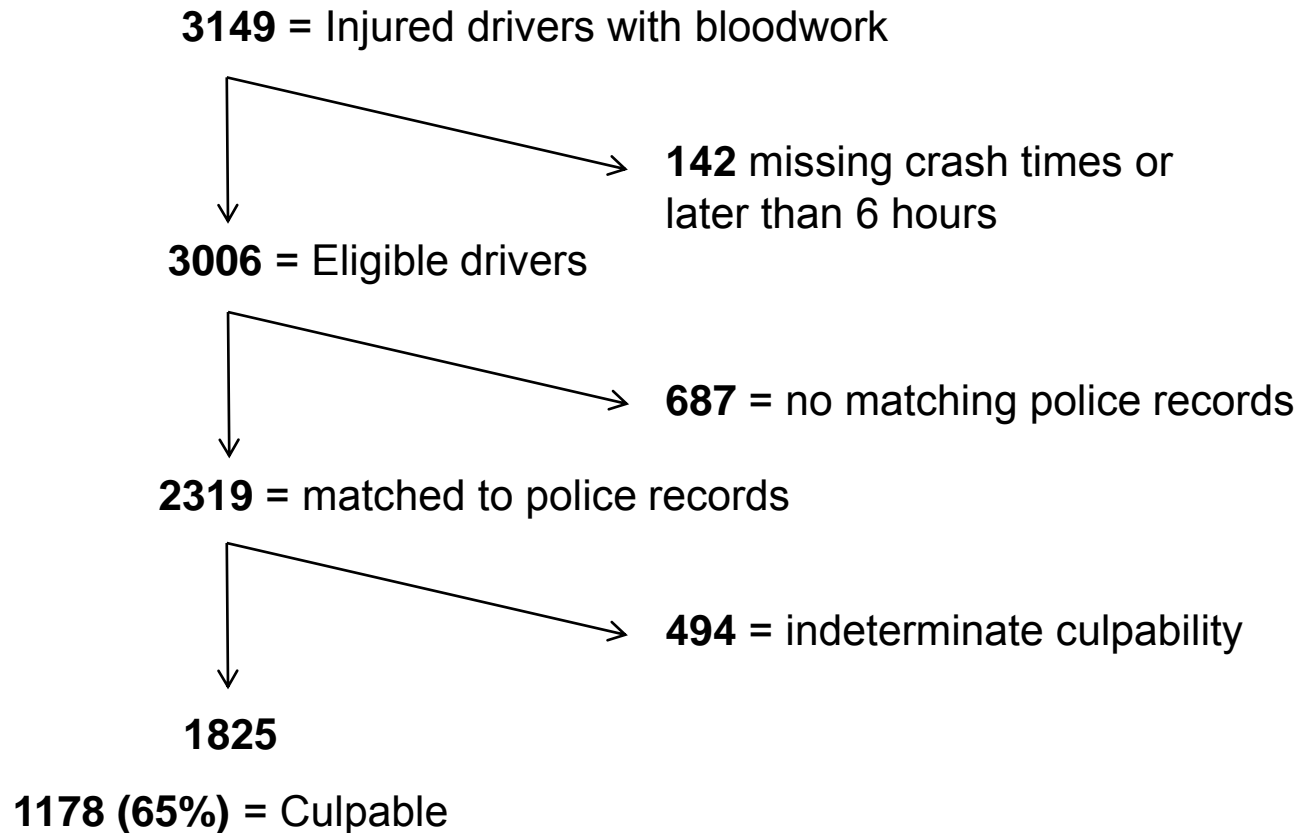
Demographics

Drivers linked to TAS	1825
Age	
mean (SD)	44 (18)
range	16, 93
Male	n = 1163 (63.7%)
Crash type	
Single vehicle crash	n = 648 (35.5%)
Nighttime crash	n = 706 (38.7%)
SVNC	n = 316 (17.3%)
Admitted	n = 487 (26.7%)
Time from crash to blood draw (min)	
mean (SD)	101 (65)
median (IQR)	84 (56)
Within 60 min	n = 439 (24.1%)
60 to 120 min	n = 944 (51.7%)
120 to 240 min	n = 357 (19.6%)

Toxicology Results
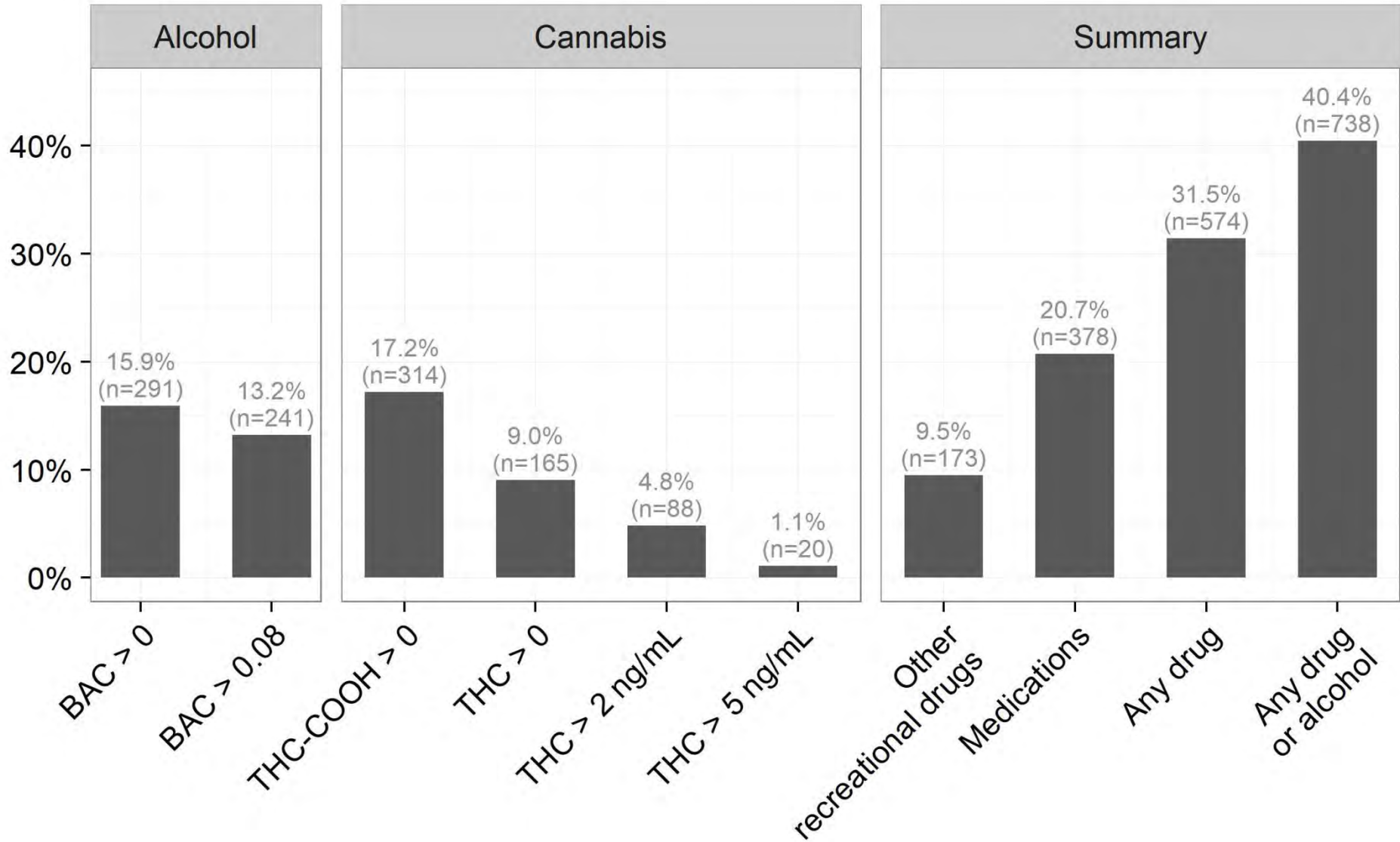
Adjusted Risk Estimates
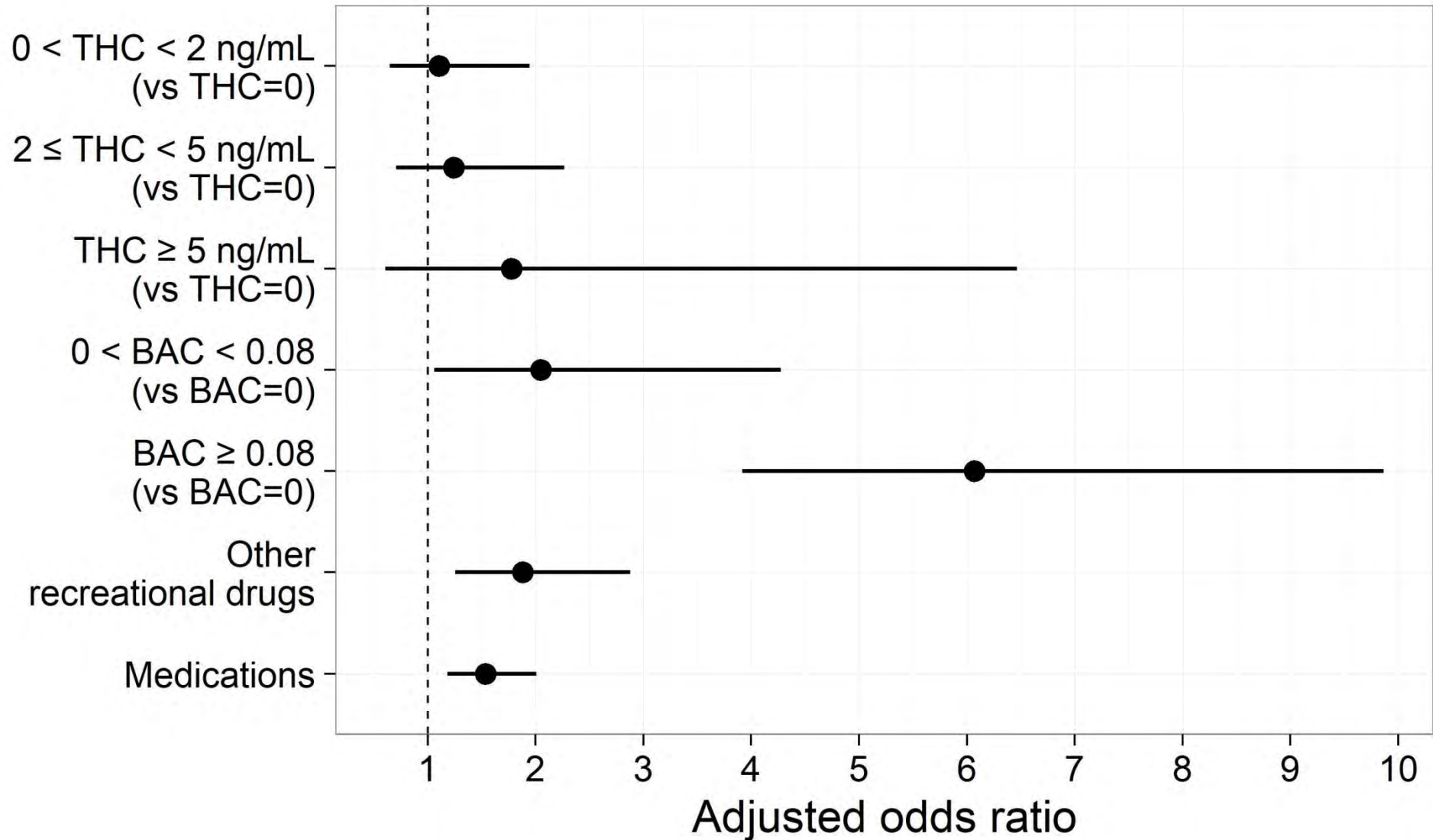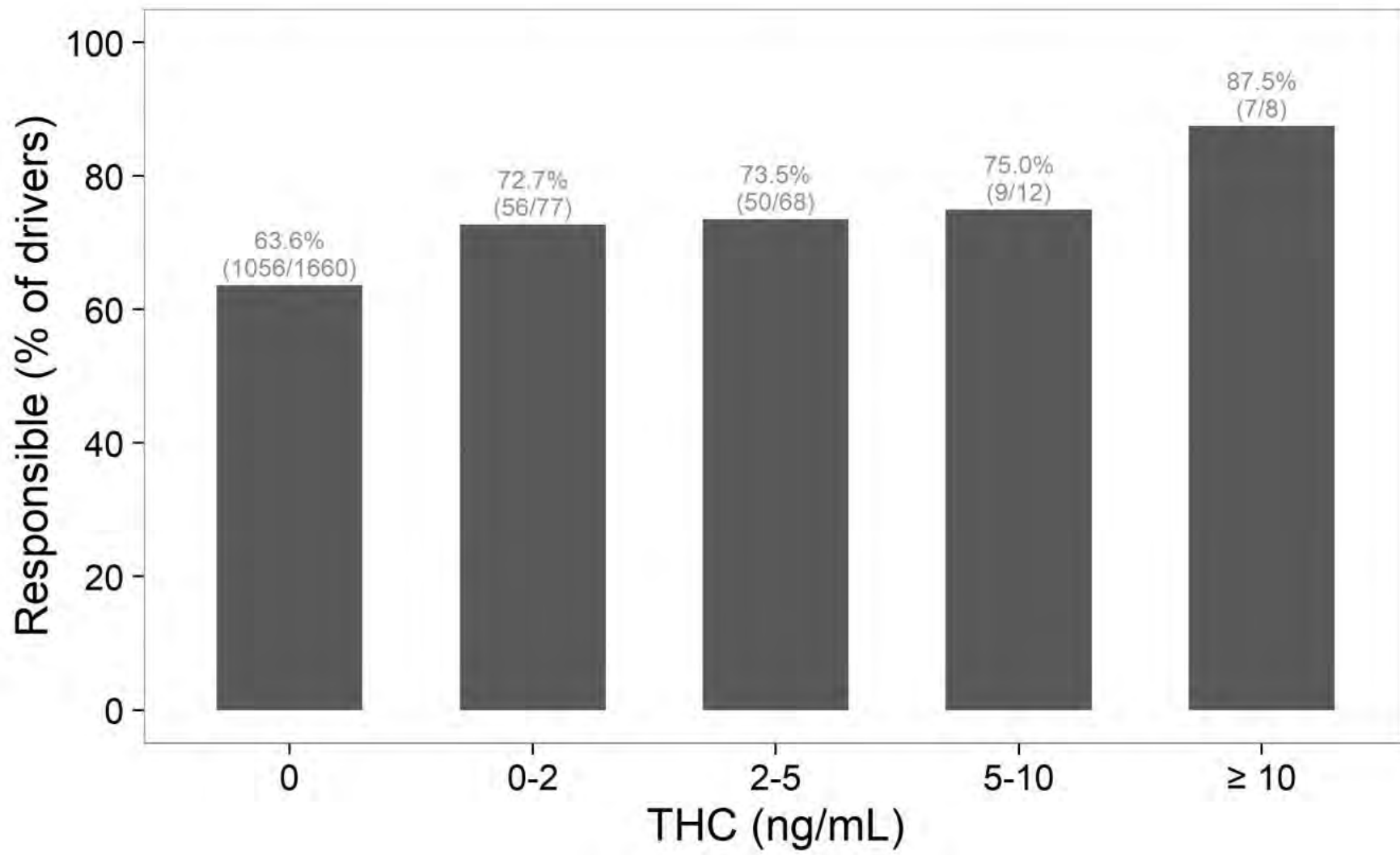
Interpretation

- There is little evidence that drivers with THC <5 ng/mL have increased crash risk.

- Cannabis, at higher levels (THC > 5ng/mL), is likely associated with increased risk.

- Other recreational drugs and impairing medications do increase crash risk.

- Alcohol remains our biggest problem.

How can we monitor cannabis use?

Roadside Surveys

Pros
- Quick (lots of samples)

Cons
- Refusals
- Cost
- Use saliva not blood
- Not for continuous monitoring
- Relevance? (no crashes)

Coroner's series

Pros
- Uses blood
- Relevant population

Cons
- Few samples
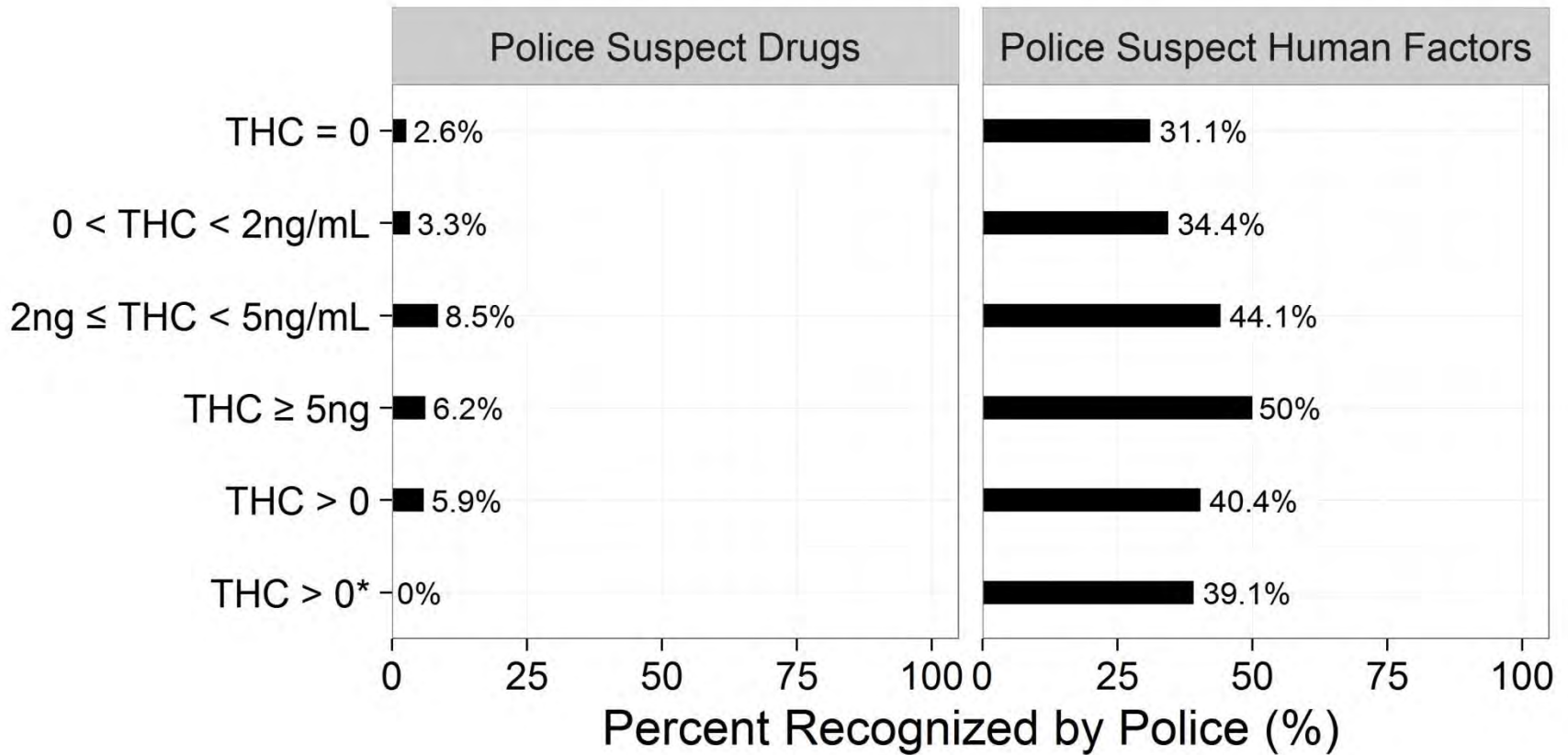- Post-mortem changes
- Selection bias?

Police crash reports

Pros

– Inexpensive (administrative data)

– Relevant population

Cons

– Police have difficulty recognizing drivers who used cannabis

Police do not recognize drivers who use cannabis

Injured drivers

- Pros
  - Relevant population
  - Use blood
  - Timing (soon after crash)
  - More cases than coroners
  - Could become part of routine care

- Cons
 - Cost and logistics
  - Fewer cases than with roadside surveys

Demographic and regional variation of drug impaired driving in Canada

British Columbia
Victoria
Vancouver
New Westminster
Kelowna
Alberta
Calgary
Edmonton
Saskatchewan
Saskatoon
Manitoba
(Winnipeg)
Ontario
Toronto
Ottawa
Quebec
(Montreal)
(Quebec City)
Maritimes
(Halifax)
(St John's)

What will happen with legalization?
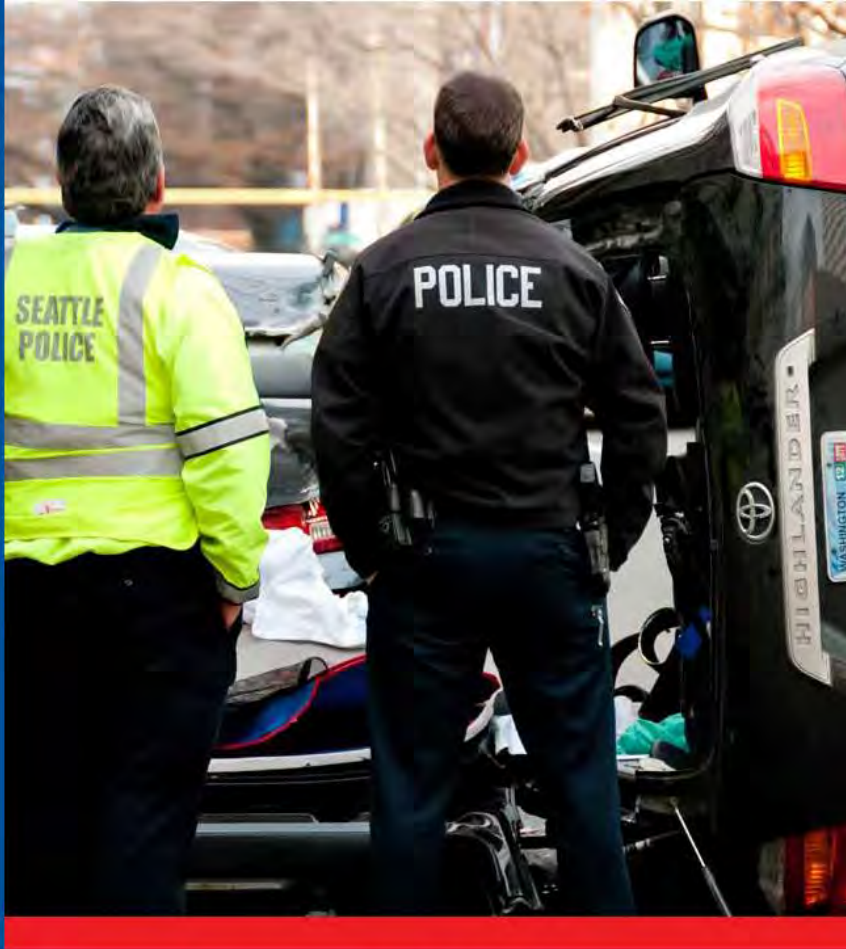
Prevalence of Marijuana Involvement in Fatal Crashes: Washington, 2010-2014

May 2016

Marijuana was legalized in Washington state in Dec 2012

A *per se* limit for THC of 5 ng/mL was introduced at the same time.

Following legalization there was a 50% increase in the prevalence of THC in drivers involved in fatal crashes.

The increase started about 9 months after legalization.

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.
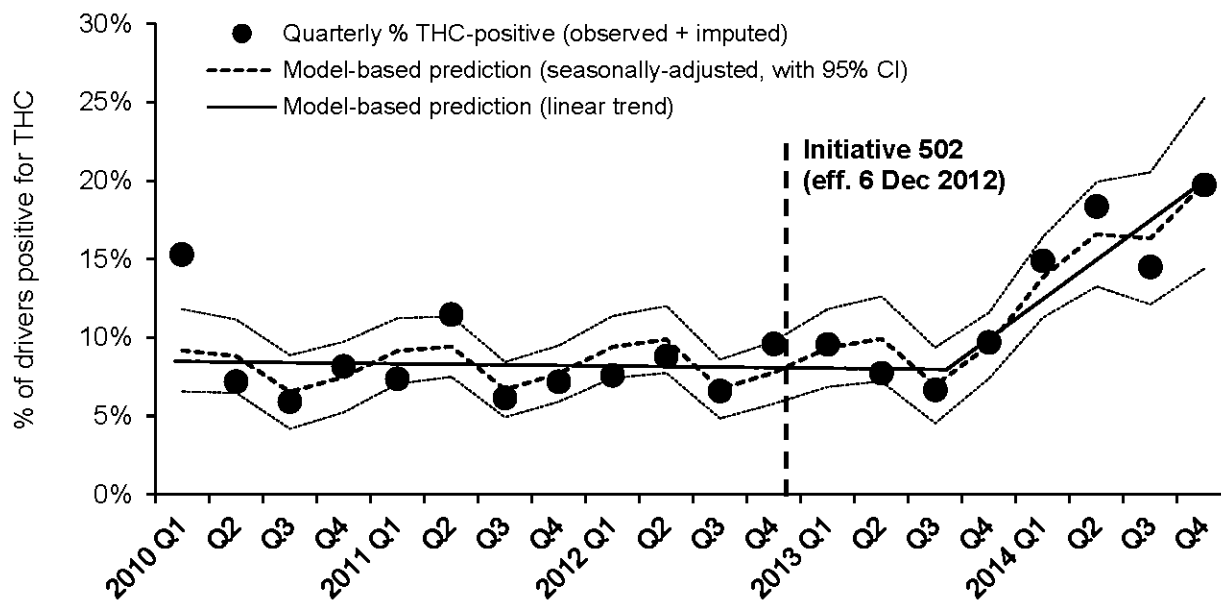
Data: Washington Traffic Safety Commission, 2010 – 2014.
Drivers positive for THC based on results of blood toxicological tests. Results imputed 10 times when driver was not tested or test results were unknown; results reflect averages from 10 imputed values for each driver. Model-based predictions are 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).

THE LEGALIZATION OF MARIJUANA IN COLORADO
THE IMPACT

Volume 3
September 2015

Rocky Mountain High Intensity
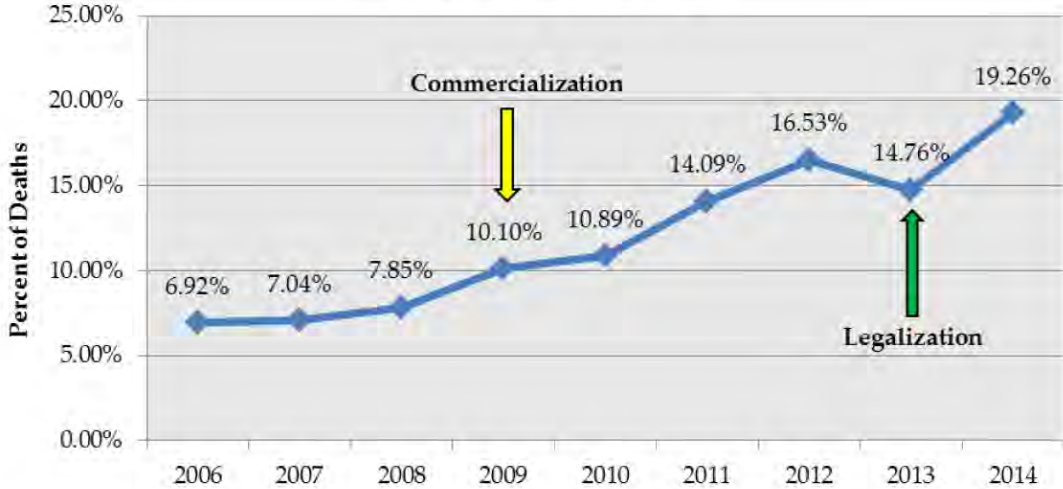Drug Trafficking Area
www.rmhidta.org

Colorado legalized marijuana in November 2013

They also introduced a 5 ng/mL *per se* limit for THC

They reported a 92% increase in cannabis-related traffic deaths between 2010 and 2014

And a 32% increase in traffic deaths in just one year (2014)

Percent of All Traffic Deaths That Were Marijuana Related*

*Percent of __All__ Fatalities Where the Operators Tested Positive for Marijuana

SOURCE: National Highway Transportation Safety Administration, Fatality Analysis Reporting System (FARS), 2006-2013 and CDOT/RMHIDTA 2014

# Trends in fatal motor vehicle crashes before and after marijuana commercialization in Colorado

Stacy Salomonsen-Sautel[a,*], Sung-Joon Min[a], Joseph T. Sakai[a], Christian Thurstone[a,b], Christian Hopfer[a]

[a] Department of Psychiatry, University of Colorado Anschutz Medical Campus, Aurora, CO 80045, United States
[b] Denver Health and Hospital Authority, Denver, CO 80204, United States
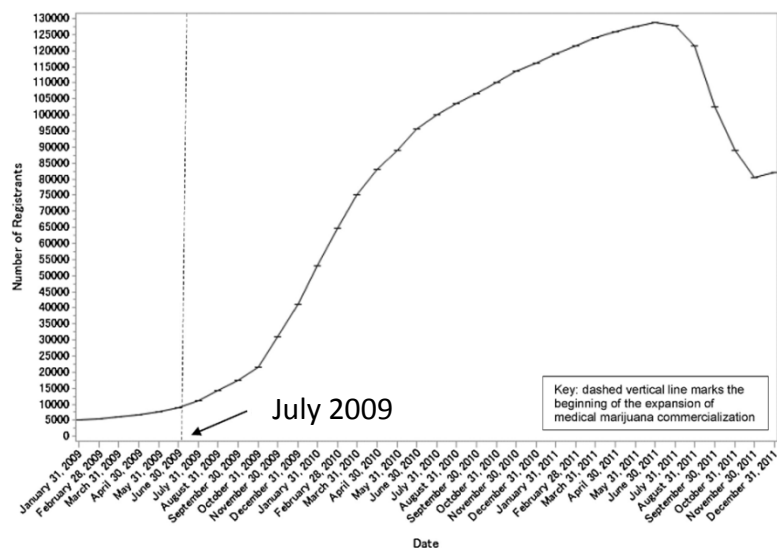
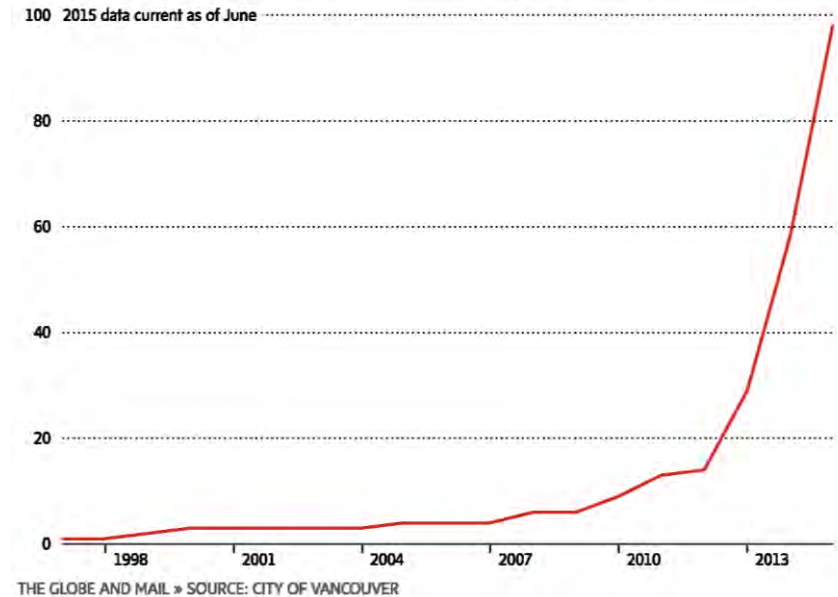Number of registered medical marijuana users
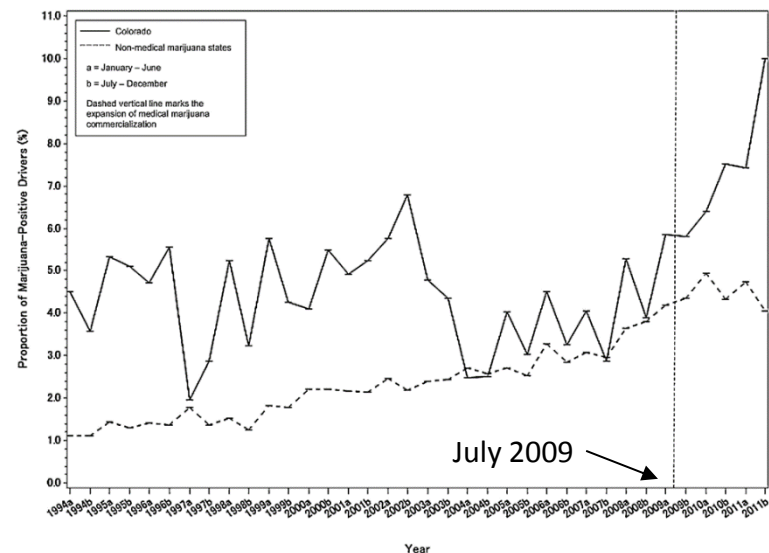
Percentage of drivers in a fatal crash who had used marijuana

Commercialization of medical marijuana

Compassion club - 1997

Growth of medical marijuana dispensaries in the City of Vancouver

100 2015 data current as of June

80

60

40

20

0

1998   2001   2004   2007   2010   2013

THE GLOBE AND MAIL » SOURCE: CITY OF VANCOUVER

THE GLOBE AND MAIL*

Vancouver issues its first business licence to a marijuana dispensary

Mike Hager
VANCOUVER — The Globe and Mail
Published Tuesday, May 17, 2016 10:17PM EDT
Last updated Wednesday, May 18, 2016 8:25PM EDT

No doctor's note for pot? No problem, say Vancouver dispensaries

GLEN SCHAEFER
More from Glen Schaefer (HTTP://VANCOUVERSUN.COM/AUTHOR/GLENSCHAEFER)

Published on: July 14, 2016 | Last Updated: July 14, 2016 4:51 PM PDT

More marijuana less alcohol

Medical Marijuana Laws, Traffic Fatalities, and Alcohol Consumption

D. Mark Anderson   *Montana State University*

Benjamin Hansen   *University of Oregon*

Daniel I. Rees   *University of Colorado Denver*

Abstract

To date, 19 states have passed medical marijuana laws, yet very little is known about their effects. The current study examines the relationship between the legalization of medical marijuana and traffic fatalities, the leading cause of death among Americans ages 5–34. The first full year after coming into effect, legalization is associated with an 8–11 percent decrease in traffic fatalities. The impact of legalization on traffic fatalities involving alcohol is larger and estimated with more precision than its impact on traffic fatalities that do not involve alcohol. Legalization is also associated with sharp decreases in the price of marijuana and alcohol consumption, which suggests that marijuana and alcohol are substitutes. Because alternative mechanisms cannot be ruled out, the negative relationship between legalization and alcohol-related traffic fatalities does not necessarily imply that driving under the influence of marijuana is safer than driving under the influence of alcohol.

The first full year after coming into effect, legalization is associated with an 8-11 percent decrease in traffic fatalities.

Or … more marijuana with alcohol?

Summary

- Legalization might result in more drivers using cannabis & more cannabis related crashes.
- The proposed *per se* laws might deter people from driving after using cannabis.
- Maybe the number of drivers who use cannabis has already peaked.
- There might be a substitution effect and fewer drinking drivers.
- Or maybe more drinking drivers will also use cannabis.

QUESTIONS?

CCMTA|CCATM

Canadian Council of Motor Transport Administrators
Conseil canadien des administrateurs en transport motorisé