Marijuana, Other Drugs, and Alcohol Use by Drivers
in Washington State

U.S. Department of Transportation
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NHTSA

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16. Abstract

In Washington State legal sales of marijuana began July 8, 2014. A voluntary, anonymous roadside study was conducted to assess the prevalence of drivers testing positive for alcohol and other drugs, including marijuana, on Washington's roads. Data was collected in three waves, before implementation of legal sales, about 6 months after implementation, and 1 year after implementation.

Of the almost 2,400 participants who provided an oral fluid or blood sample, 14.6 percent of drivers, 19.4 percent of drivers, and 21.4 percent of drivers were THC-positive in Waves 1, 2, and 3, respectively. There were no statistically significant differences between waves. There was a statistically significant increase in daytime prevalence of THC-positive drivers between Wave 1 (7.8%) and Wave 2 (18.4%), and also between Wave 1 and Wave 3 (18.9%). There was an increase in the percentage of THC-positive nighttime drivers with each successive wave, but these increases were not statistically significant. Synthetic marijuana was found in only 2 of the participants.

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List of Acronyms and Abbreviations

ADHD	attention deficit hyperactivity disorder
AOR	adjusted odds ratio
AUD	Alcohol Use Disorder questionnaire
BAC	blood alcohol concentration
BrAC	breath alcohol concentration
CBD	cannabidiol
CBN	cannabinol
CI	confidence interval
CNS	central nervous system
CoC	chain of custody
DUD	Drug Use Disorder questionnaire
EDDP	2-ethylidene- 1,5-dimethyl-3,3-diphenylpyrrolidine (metabolite of methadone)
FARS	Fatality Analysis Reporting System
g/dL	grams per deciliter
GC/MS	gas chromatography-mass spectrometry
IDP	Impaired Driver Protocol
IIHS	Insurance Institute for Highway Safety
LC/MS	liquid chromatography-mass spectrometry
Mg	milligrams
mg/dL	milligrams per deciliter
mL	milliliter
ng/mL	nanograms per milliliter
NCPIC	National Cannabis Prevention and Information Centre
NHTSA	National Highway Traffic Safety Administration
NIAAA	National Institute on Alcohol Abuse and Alcoholism
NIDA	National Institute on Drug Abuse
NIJ	National Institute of Justice
NRS	National Roadside Study
PAS	passive alcohol sensor
PBT	preliminary breath test
PCP	phencyclidine
PIRE	Pacific Institute for Research and Evaluation
PSU	primary sampling unit
SNRI	selective norepinephrine reuptake inhibitor
SSRI	selective serotonin reuptake inhibitor
THC	delta-9-tetrahydrocannabinol
WSLCB	Washington State Liquor and Cannabis Board
WTSC	Washington Traffic Safety Commission

Executive Summary

Background

In 2012 voters in Washington State approved a ballot initiative to legalize the sale and recreational use of marijuana. Legal recreational use began in December 2012; sales became legal on July 8, 2014. Public health and safety officials were concerned about the impact of legalized marijuana use on traffic safety, particularly on drug-involved driving. To address this issue, voluntary and anonymous roadside surveys assessed the prevalence of drivers positive for alcohol and other drugs on Washington's roads, before and after the implementation of marijuana sales. Drugs included prescription, over-the-counter, and illegal substances.

Of special interest was marijuana use by drivers. We tested for the psychoactive substance delta-9-tetrahydrocannabinol, commonly known as THC; the active metabolite 11-hydroxy-delta-9-tetrahydrocannabinol (also noted as 11-OH-THC and known as "hydroxy-THC"); and the inactive metabolite 11-nor-9-carboxy-delta-9-tetrahydrocannabinol (also known as "carboxy-THC" and noted as "THC-COOH").

Method

Voluntary and anonymous roadside survey data were collected in three waves: (1) immediately before the implementation of legal sales, (2) approximately 6 months after implementation, and (3) 1 year after implementation. Each wave of data collection included one 2-hour Friday daytime session (either 9:30 to 11:30 a.m. *or* 1:30 to 3:30 p.m.) and four 2-hour nighttime periods (10 p.m. to midnight and 1 to 3 a.m. on both Friday and Saturday nights) within six counties in Washington State.[1] Data included observational and biological measures. The biological measures were breath samples from 2,423 drivers, oral fluid samples from 2,313 drivers, and blood samples from 1,929 drivers.

Alcohol results were based on breath samples, and, in a few cases, blood sample results from drivers who did want to provide a breath sample but provided a blood sample); drug results were determined from oral fluid and blood samples. Drug results are categorized into oral fluid only, blood only, and oral fluid or blood combined.[2] In the tables, if a driver tested positive for one or more of the drugs either in the oral fluid, the blood analysis or both, the test was categorized as drug-positive. "Testing" was a two-stage process. Biological samples were first screened for the presence of drugs. The screening process is a broad-range test to detect the presence of different drugs or drug classes. When a screening test was positive for the presence of a drug, the sample moved forward to a second test to positively identify the drug. If a sample (either oral fluid or blood sample) was positive for one of our selected drugs, it was categorized as drug-positive in our results. Statistical significance is reported at the $p < .05$ level, which indicates that the probability

[1] Locations were not the same across each wave.

[2] Results for oral-fluid-only and blood-only can be found in Appendices A and B, respectively. Note: A driver testing positive for THC in oral fluid and blood is only counted once.

of encountering this difference by chance is less than 5 percent. The tables include confidence intervals, which indicate the distribution of data.[3]

All analyses compared Wave 1 to Wave 2, and Wave 1 to Wave 3. We do not present results from comparing Wave 2 and Wave 3 to each other as any changes were minor, not rising to statistical significance.

Results

More Washington State drivers were THC-positive one year after implementation of the retail sales law than immediately before. Table ES-1 shows the percentage of THC-positive drivers at each wave in oral fluid and/or blood for each wave, regardless of the presence of any other substance. Of the approximately 2,400 participants who provided an oral fluid or blood sample, there was an increase in the percentage of THC-positive drivers from Wave 1 (14.6%) to Wave 2 (19.4%), and to Wave 3 (21.4 %), but these differences were not statistically significant.

Table ES-1. Percentage of THC-Positive Drivers by Wave (Oral Fluid or Blood)

	% THC-positive	*N*	95% CI
Wave 1	14.6	908	[11.9, 17.8]
Wave 2	19.4	672	[16.4, 22.8]
Wave 3	21.4	810	[17.5, 25.9]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.

The increase of 46.6% (from 14.6% in Wave 1 to 21.4% Wave 3) was not statistically significant. Although the differences between waves appear large, statistical significance is affected by variation in a variable, and there was large variation in THC-positive drivers both between sites, and within individual sites. In Table ES-2, below, we show the percentage of drivers positive for THC by Primary Sampling Unit (PSU) and Wave to illustrate this point. Notice that in three of the PSUs, the percentage positive declined slightly over the three waves (Whatcom went from 11.8% to 11.6%, Kitsap from 15.0% to 14.5%, and Spokane from 20.5% to 19.9%). The percentage of THC positive drivers increased slightly in one PSU (Yakima rose from 14.3% to 16.2%) and increased by a larger amount in two PSUs (King went from 13.3% to 30.7% and Snohomish went from 14.1% to 23.1%).

[3] Confidence Intervals (CIs) indicate the range in which the true value lies—with 95% confidence.

Table ES-2. Percentage of THC-Positive Drivers by PSU and Wave

	Wave 1			Wave 2			Wave 3		
PSU	%	N	95% CI	%	N	95% CI	%	N	95% CI
King	13.3	13	[6.6, 24.8]	20.9	27	[15.9, 27.0]	30.7	22	[23.4, 39.1]
Snohomish	14.1	24	[10.0, 19.6]	17.9	21	[13.9, 22.8]	23.1	37	[17.2, 30.2]
Whatcom	11.8	16	[5.9, 21.9]	23.7	22	[18.0, 30.6]	11.6	13	[8.1, 16.1]
Kitsap	15.0	23	[8.6, 24.8]	17.5	20	[10.3, 28.2]	14.5	21	[11.2, 18.7]
Spokane	20.5	34	[14.3, 28.4]	23.6	20	[16.2, 33.0]	19.9	33	[16.4, 23.8]
Yakima	14.3	22	[8.1, 24.0]	12.9	17	[7.8, 20.5]	16.2	23	[8.6, 28.3]
Total	14.6	908	[11.9, 17.8]	19.4	672	[16.4, 22.9]	21.4	810	[17.5, 25.9]

In this table, *Ns* are unweighted; percentages are weighted.
THC-positive include results for THC and hydroxy-THC.

Daytime and Nighttime: There was a statistically significant increase in the percentage of daytime drivers who were THC-positive in Wave 2 (18.4%) compared to Wave 1 (7.8%) ($p < .05$). This statistically significant increase was also observed for Wave 3 (18.9%) compared to Wave 1 ($p < .05$). There were increases also in the prevalence of THC-positive nighttime drivers with each successive wave, but these increases were not statistically significant.

Table ES-3. Percentage of THC-Positive Drivers by Time of Day (Oral Fluid or Blood)

	Wave 1				Wave 2				Wave 3			
	N	*%* THC-positive	*N* THC-positive	95% CI	*N*	*%* THC-positive	*N* THC-positive	95% CI	*N*	% THC-positive	*N* THC-positive	95% CI
Daytime	271	7.8	23	[5.8, 10.4]	177	18.4*	34	[12.4, 26.4]	214	18.9*	35	[11.9, 28.8]
Nighttime	637	17.5	109	[14.0, 21.7]	495	19.8	93	[16.5, 23.5]	596	22.2	114	[17.8, 27.5]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 (p <.05).

THC prevalence by demographics: Male drivers had significantly higher rates of THC prevalence at Wave 3 compared to Wave 1 ($p < .05$). There were no other statistically significant differences in any of the other categories.

Table ES-4. Percentage of Drivers THC-Positive by Demographic Variables (Oral Fluid or Blood)

Variable		Wave 1			Wave 2			Wave 3		
		% THC-positive	*N*	95% CI	% THC-positive	*N*	95% CI	% THC-positive	*N*	95% CI
Gender	Male	14.8	563	[11.3, 19.2]	19.8	403	[15.1, 25.6]	24.7*	479	[19.8, 30.3]
	Female	14.3	343	[11.0, 18.5]	19.1	264	[15.9, 22.8]	17.3	324	[12.3, 23.8]
Race	White	13.7	807	[11.0, 16.8]	20.2	564	[16.5, 24.5]	18.9	691	[14.9, 23.6]
	Black or African American	20.7	59	[11.6, 34.1]	14.5	65	[7.7, 25.6]	40.8	58	[27.5, 55.6]
	Asian	15.5	17	[3.1, 51.0]	12.6	28	[3.4, 37.2]	13.8	20	[5.7, 29.7]
	Native American or Alaska Native	0.0	8	0	20.4	5	[4.2, 59.8]	12.9	13	[1.9, 53.2]
	Other or More than one	13.4	12	[1.5, 61.4]	35.5	6	[2.9, 91.0]	20.2	27	[5.6, 50.1]
Ethnicity	Hispanic	11.9	160	[7.4, 18.8]	14.7	118	[9.1, 22.7]	14.0	121	[7.7, 24.1]
	Non-Hispanic	15.1	747	[11.8, 19.1]	20.7	547	[17.0, 24.9]	23.3	683	[18.4, 28.9]
Age	16 to 20	17.3	106	[8.7, 31.5]	19.2	86	[11.7, 29.9]	31.2	112	[17.6, 48.9]
	21 to 34	15.7	381	[11.1, 21.6]	18.9	288	[14.1, 24.9]	22.8	326	[16.8, 30.3]
	35 to 44	15.2	150	[10.7, 21.1]	19.6	126	[12.9, 28.4]	19.4	156	[12.7, 28.5]
	45 to 64	11.8	228	[6.3, 21.1]	20.7	130	[15.1, 27.8]	18.6	178	[9.4, 33.4]
	65 and over	14.0	43	[4.3, 37.2]	21.5	37	[13.1, 33.2]	8.2	31	[2.2, 26.4]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 (p <.05).

Drug Category Prevalence by Wave: As stated earlier, more drivers at Waves 2 (19.4%) and 3 (21.4%) were THC-positive compared to drivers at Wave 1 (14.6%). There were decreases in the numbers of drivers who tested positive for illegal drugs only, from 2.4 percent in Wave 1, to 2.0 percent in Wave 2, to 0.1 percent in Wave 3. However, as there were low prevalence rates of illegal drugs only in all three waves, no meaningful interpretation can be made. Prevalence rates for medications only declined in each wave, from 16.1 percent in Wave 1, to 15.9 percent in Wave 2, to 12.1 percent in Wave 3. This decline was not statistically significant.

Table ES-5. Percentage of Drivers THC-Positive by Drug Category and Wave (Oral Fluid or Blood) (Percentage by Column)

Drug Category	Wave 1			Wave 2			Wave 3		
	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
THC-positive	14.6	132	[11.9, 17.8]	19.4	127	[16.4, 22.8]	21.4	149	[17.5, 25.9]
THC-positive only	8.7	80	[6.5, 11.5]	13.1	84	[10.6, 16.2]	12.6	92	[9.2, 16.9]
THC-positive plus any other drug	5.9	52	[3.9, 8.8]	6.3	43	[4.4, 9.0]	8.9	57	[5.4, 14.3]
Illegal only	2.4	22	[1.5, 4.0]	2.0	12	[1.2, 3.4]	0.1	2	[0.0, 0.6]
Medications only	16.1	140	[12.9, 19.9]	15.9	113	[13.2, 19.1]	12.1	106	[9.3, 15.6]
Illegal and medications	0.4	1	[0.0, 2.6]	0.5	2	[0.1, 2.0]	0.9	5	[0.2, 4.0]
Total drug-positive	33.4	295	[28.2, 39.2]	37.9	254	[34.4, 41.5]	34.5	262	[30.0, 39.4]
Total drug-negative	66.6	613	[60.8, 71.9]	62.1	418	[58.5, 65.6]	65.5	548	[60.6, 70.0]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.

Drug class prevalence by wave: There were relatively low prevalence rates for some drug classes, including antidepressants only, sedatives only, and other only in all three waves. THC-positive drivers had the highest prevalence across all waves. There were no statistically significant differences in any of the other drug classes.

Table ES-6. Percentage of Drivers THC-Positive by Drug Class and Wave (Oral Fluid or Blood) (Percentage by Column)

Drug Class	Wave 1			Wave 2			Wave 3		
	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
THC-positive	14.6	132	[11.9, 17.8]	19.4	127	[16.4, 22.8]	21.4	149	[17.5, 25.9]
THC-positive only	8.7	80	[6.5, 11.5]	13.1	84	[10.6, 16.2]	12.6	92	[9.2, 16.9]
THC-positive plus any other drug	5.9	52	[3.9, 8.8]	6.3	43	[4.4, 9.0]	8.9	57	[5.4, 14.2]
Antidepressants only	1.6	15	[0.8, 2.7]	1.8	14	[0.9, 3.3]	2.0	17	[1.1, 3.5]
Narcotic analgesics only	3.3	34	[2.3, 4.8]	5.2	35	[3.7, 7.4]	2.2	16	[1.4, 3.6]
Sedatives only	1.0	9	[0.4, 2.2]	0.8	5	[0.3, 1.9]	1.0	9	[0.4, 2.3]
Stimulants only	8.4	64	[5.8, 12.0]	6.8	47	[4.9, 9.4]	2.5	23	[1.4, 4.5]
Other only	1.9	22	[1.1, 3.3]	1.0	8	[0.4, 2.2]	0.8	8	[0.3, 1.7]
More than one class	2.6	19	[1.6, 4.3]	2.9	18	[1.9, 4.2]	4.7	40	[3.0, 7.2]
Total drug-positive	33.4	295	[28.2, 39.2]	37.9	254	[34.4, 41.5]	34.5	262	[30.0, 39.4]
Total drug-negative	66.6	613	[60.8, 71.9]	62.1	418	[58.5, 65.6]	65.5	548	[60.6, 70.0]

In this table, *N*s are unweighted; percentages are weighted.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and 11-OH-THC.

Alcohol: Table ES-7 shows prevalence rates for alcohol concentration levels across the three waves for those drivers who provided a breath sample. The column ">.00" represents all alcohol positives. At Wave 1, 6.0 percent of drivers were alcohol-positive. This proportion dropped to 3.9 percent at Wave 2, and rose slightly to 4.4 percent at Wave 3. There were no statistically significant findings between waves.

Table ES-7. Percentage of Drivers Positive for Alcohol by Concentration (Percentages by Row)

		Alcohol Concentration									
	N	% .00	95% CI	% >.00	95% CI	% .001–.049	95% CI	% .05–.079	95% CI	% .08+	95% CI
Wave 1	920	93.9	[90.4, 96.2]	6.0	[3.8, 9.6]	4.2	[2.6, 7.0]	0.7	[0.2, 3.3]	1.1	[0.6, 2.3]
Wave 2	692	96.1	[94.3, 97.3]	3.9	[2.7, 5.8]	1.8	[0.8, 4.1]	0.6	[0.2, 1.8]	1.5	[0.8, 2.7]
Wave 3	819	95.6	[92.8, 97.3]	4.4	[2.7, 7.2]	2.5	[1.3, 4.8]	1.2	[0.5, 2.7]	0.7	[0.3, 1.6]

In this table, *N*s are unweighted; percentages are weighted.
Row percentages may not total to 100 percent due to rounding.
*N*s do not match the total number of breath samples because of 8 additional cases included in this table in which alcohol concentration was determined from blood samples (BACs) as opposed to breath samples (BrACs).
The column "> .00" represents all alcohol positives (applies to the three right-most columns).

Table ES-8 shows drivers (who provided a breath sample and an oral fluid or blood sample) by wave, and whether they were positive for alcohol, THC or other drugs. There was an increase in THC-positive drivers, who were alcohol-free, at Waves 2 and 3 compared to Wave 1, however these increases were not statistically significant. There was a decrease, but not a statistically significant one, in the percentage of drivers who tested positive for any other drug (besides THC) and were alcohol-free from Wave 1 (17.2%) compared to Wave 3 (13.0%). In Wave 1, the percentage of THC-positive drivers who were alcohol free (13.2%), was double that of alcohol-positive drivers (6.2%). In Waves 2 and 3, the percentage of THC-positive drivers who were alcohol free (19.1% and 20.2%, respectively), was more than four times that of alcohol-positive drivers (4.1% and 4.3%).

Table ES-8. Percentage of Alcohol and Drug Positive Drivers by Wave (Percentage by Column)

	Wave 1			Wave 2			Wave 3		
	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
Alcohol-positive	6.2	46	[3.9, 9.8]	4.1	25	[2.8, 6.0]	4.3	28	[2.6, 7.2]
Alcohol plus THC	1.2	9	[0.6, 2.5]	0.4	3	[0.1, 1.4]	1.3	9	[0.6, 2.8]
Alcohol plus any other drug	1.8	11	[0.9, 3.5]	1.2	8	[0.7, 2.3]	0.3	3	[0.0, 0.8]
Alcohol only	3.2	26	[1.9, 5.2]	2.4	14	[1.5, 3.9]	2.7	16	[1.5, 5.0]
Alcohol-negative	93.8	858	[90.2, 96.1]	95.9	643	[94.0, 97.3]	95.7	781	[92.8, 97.4]
THC and no alcohol	13.2	121	[10.3, 16.9]	19.1	124	[16.1, 22.6]	20.2	140	[16.3, 24.7]
Any other drug and no alcohol	17.2	152	[14.4, 20.3]	17.3	119	[14.9, 20.0]	13.0	110	[9.9, 16.6]
No drugs and no alcohol	63.4	585	[57.8, 68.7]	59.5	400	[55.4, 63.5]	62.6	531	[56.8, 67.9]

In this table, Ns are unweighted; percentages are weighted.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.

THC Concentrations by Wave: The concentration of THC in driver blood samples varied across waves. Table ES-9 includes only blood samples, as Washington's illegal per se[4] level is 5 ng/mL (nanograms per milliliter) or higher of delta-9-THC in the blood. There was a statistically significant reduction in drivers over the per se limit from Wave 1 (14.5%) to Wave 2 (5.3%) ($p < .05$). At Wave 3, the percentage of drivers who had THC concentration of 5 ng/mL or higher increased to 9.2 percent. This was not a statistically significant change compared to Wave 1. There was a statistically significant increase in THC-positive drivers who had THC below the per se level (i.e., between 0 ng/mL and 5 ng/mL ($p < .05$) from Wave 2 (4.7%) and Wave 3 (11.6%) compared to Wave 1 (0.3%).

[4] Per se is a Latin phrase that means "by itself." Specifically in Washington, having a 5 ng/mL or higher level of delta-9-tetrahydrocannabinol (THC) in the blood within two hours of driving means that you are guilty of driving while under the influence of THC.

Table ES-9. Percentage of THC-Positive Drivers by THC Concentration in Blood and Wave (Percentage by Column)

THC	%	*N*	95% CI
Wave 1			
THC = 0ng/mL	85.2	607	[81.2, 88.5]
0ng/mL < THC < 5ng/mL	0.3	3	[0.0, 1.1]
THC ≥ 5ng/mL	14.5	101	[11.3, 18.3]
Wave 2			
THC = 0ng/mL	89.9	483	[84.6, 93.6]
0ng/mL < THC < 5ng/mL	4.7*	29	[2.6, 8.3]
THC ≥ 5ng/mL	5.3*	31	[3.3, 8.5]
Wave 3			
THC = 0ng/mL	79.2	558	[73.3, 84.1]
0ng/mL < THC < 5ng/mL	11.6*	74	[8.9, 14.9]
THC ≥ 5ng/mL	9.2	43	[5.3, 15.4]

In this table, Ns are unweighted; percentages are weighted.
THC-positive includes results from delta-9-tetrahydrocannabinol only.
*Significantly different from Wave 1 (p <.05).

Table ES-10 compares the prevalence of THC-positive drivers from Waves 1, 2, and 3 of the current study to drivers in the 2013–2014 National Roadside study (Berning, Compton, & Wochinger, 2015). Although the studies followed much of the same protocol, there were differences making it not possible to directly compare the results. Each wave of Washington State had significantly higher percentage of THC-positive drivers than the 2013–2014 NRS (p < .05).

Table ES-10. Percentage of Weekend Nighttime Drivers Positive for THC in the Washington State Study Compared to the 2013–2014 National Roadside Study (Oral Fluid and Blood) (Percentage by Column)

	2013–2014 NRS	Washington State Study		
		Wave 1	Wave 2	Wave 3
	N = 5,907	*N* = 637	*N* = 495	*N* = 596
THC-negative	87.4%	82.5%	80.2%	77.8%
THC-positive	12.6%	17.5%*	19.8%*	22.2%*
95% CI	[10.8, 14.8]	[14.0, 21.8]	[16.5, 23.5]	[17.7, 27.5]

In this table, *N*s are unweighted; percentages are weighted based on each study's statistical procedures.
Because this table used data from two separate studies which involved different designs and weighting procedures, significance testing was conducted by comparing 95 percent confidence intervals for both studies.
THC-positive includes results from THC and hydroxy-THC.
*Indicates statistically significant difference from the 2013-2014 NRS (p < .05).

Conclusions

The three waves of data show that the prevalence of THC among drivers increased in Washington State since the implementation of legal retail marijuana sales. There was no statistically significant difference between waves. There was a statistically significant increase in daytime prevalence of THC-positive drivers between Wave 1 and Wave 2, and also between

Wave 1 and Wave 3. Each wave of the Washington State study had a significantly higher percentage of THC-positive drivers than the 2013–2014 NRS ($p < .05$).

There was an increase in THC-positive drivers, who were alcohol-free, at Waves 2 and 3 compared to Wave 1, and a decrease in the percentage of drivers who tested positive for any other drug (besides THC) and were alcohol-free from Wave 1 to Wave 3. Illegal drug prevalence (excluding THC and 11-OH-THC), was 2.4 percent in Wave 1, 2.0 percent in Wave 2, and 0.1 percent in Wave 3. Due to the small numbers, however, no tests of significance were conducted.

Introduction and Background

Recent Changes in U.S. Marijuana Laws

Marijuana is a Schedule I drug that is illegal under Federal law. As of fall 2015, however, 23 States and the District of Columbia legalized the use of marijuana for medicinal purposes (Governing.com, 2015; ProCon.org, 2015), and 17 States and the District of Columbia had decriminalized the use of marijuana—typically meaning no prison time or criminal charge for first-time possession of a small amount for personal consumption (NORML, 2015). Additionally, four States—Alaska, Colorado, Oregon, and Washington—and the District of Columbia have passed laws legalizing the use of marijuana for recreational purposes.

In November 2012, Washington and Colorado became the first States to pass voter initiatives to legalize recreational marijuana use by people 21 and older.[5] In December 2012, Washington began implementing the provisions of legalization, which included:

- the establishment of legal possession (1 ounce or less for private consumption), and amendment of the State's driving under the influence statutes to include a per se limit for THC (5 ng/mL [nanograms per milliliter]);
- regulation, taxation, and law enforcement authority over marijuana by the Washington State Liquor and Cannabis Board (formerly the Washington State Liquor Control Board);
- a licensing system for retailers; and
- a dedicated marijuana fund, with surplus revenues earmarked for research, health care, substance abuse prevention, and education.

Under this new legislation, Washington became one of the first States to develop legal commercial systems to make nonmedicinal marijuana available to the general adult population. The first marijuana retail outlets opened on July 8, 2014.

Recent Studies on Driver Marijuana Prevalence and Crash Risk

The recent liberalization of marijuana laws has raised public safety concerns, including whether increased access to marijuana leads to increased drugged-involved driving and motor vehicle crashes. Marijuana has a variety of effects on humans and can be associated with stimulant, sedative, and hallucinogenic effects. Both the experimental and epidemiologic evidence on cannabinoids' effects on driving are mixed.

Experimental studies. Studies of neurocognitive and psychomotor skills have examined whether THC, the active ingredient in marijuana, affects reaction time, hand-eye coordination, vigilance, time and distance perception, and multiple-task processing (Downey et al., 2013; Hartman & Huestis, 2013; Lenné et al., 2010). Because these skills are central to driving, these studies suggest that marijuana use may have a detrimental effect on motor vehicle operation. In a

[5] Washington passed legislation in 1998 allowing use of medical marijuana. Colorado also previously allowed marijuana for medical use.

summary of experimental studies examining the effect of THC on driving performance, Penning et al. (2010) concluded that THC alone impairs driving performance to some extent, whereas THC in combination with alcohol has a more pronounced effect.

Laboratory studies. Laboratory studies and reviews have found evidence that cannabis use impairs driving-related skills (NCPIC, 2014). These studies indicate that performance decrements are generally dose-related and typically persist for 2 to 4 hours after consumption (Ashton, 1999; Ramaekers, Kauert, et al., 2006; Ramaekers, Moeller, et al., 2006). Although laboratory studies provide a first step in determining whether marijuana has a potential impairing effect on driving-related tasks, these studies do not provide a direct association between THC use and driving performance.

Epidemiologic studies. Epidemiologic studies can help address questions about the frequency with which people drive with cannabis in their systems and the extent to which crash risk is increased. Several types of studies provide data to address these questions, including self-report data on substance use and driving, roadside surveys of representative samples of drivers that involve collecting and analyzing biological specimens, and studies of substance use among crash-involved and non-crash-involved drivers.

Self-report. Few nationally representative surveys have gathered data on self-reported cannabis use and driving. However, crash risk studies have used drivers' self-reports of cannabis use. Using self-report data alone can be problematic because the resulting data may be subject to over- or under-reporting as a result of social desirability biases, suspicion that the data will not be anonymous or confidential, and recall biases (Compton, Vegega, & Smither, 2009).

Roadside surveys. Roadside surveys often include self-report data along with biological specimens (e.g., oral fluid and/or blood) that can be used to validate the self-report data on drug use. These biological markers can also provide direct information about the presence and concentration of drugs in drivers' systems. Comparisons of the presence of THC among U.S. drivers, as measured in oral fluid and/or blood in two national roadside surveys conducted by NHTSA in 2007 and 2013–2014, show that the percentage of THC-positive nighttime weekend drivers increased from 8.6 percent in 2007 to 12.6 percent in 2013–2014, a 47 percent proportional increase (Berning, Compton, & Wochinger, 2015). Although the presence of drugs in biological specimens does not necessarily demonstrate impairment, the findings suggest increased THC use among drivers over time.

Crash risk studies. Although studies of the frequency of drug use among crash-involved drivers provide valuable descriptive data, the inference that drug use increases crash risk requires studies that consider drug use among crash-involved versus non-crash-involved drivers. Several types of crash studies have been used to estimate risk (Compton & Berning, 2015). Culpability studies compare the rates at which drug-positive crash-involved drivers versus drug-negative crash-involved drivers are found to be at fault in their crashes. Case-control studies compare drug use by crash-involved drivers to drug use by non-crash-involved drivers and provide controls over some variables that may introduce bias in risk estimates. As noted by several reviews (Compton &

Berning, 2015; NCPIC, 2014), existing epidemiological studies (both culpability and case-control) have yielded contradictory estimates of marijuana use and crash risk, with some suggesting minimal or no effect on crash risk and others estimating a small increase in crash risk.

Pre-post studies of changes in marijuana laws. Changes in laws provide a natural experiment for investigating whether policy changes that make marijuana more accessible are associated with changes over time in THC-positive driving. In relation to Initiative 502, which legalized the recreational use of marijuana, a study on blood analyses in the Washington State toxicology laboratory (Couper & Peterson, 2014) examined the prevalence of THC among suspected impaired drivers in the State. Specifically, the prevalence of both active THC (THC and 11-OH-THC) and the inactive metabolite carboxy-THC (THC-COOH) were compared pre- and post-legalization. Before legalization (2009 to 2012), the average annual percentages of cases positive for THC and carboxy-THC were 19.1 percent and 27.9 percent, respectively. By 2013, these percentages had significantly increased to 24.9 percent and 40.0 percent, respectively ($p < .05$).

The prevalence of alcohol, and the majority of other drugs from blood toxicology results of suspected impaired drivers, did not change significantly over the 5-year period. However, it should be noted that there may be other factors that may have affected these results. Among heavy, habitual users, THC may be found in the blood days after consumption; thus, there is the possibility that some of the THC-positives are unrelated to the driving event.

Project Objectives

This study examined the prevalence of alcohol- and drug-positive drivers in Washington State, on Fridays, and Friday and Saturday nights. Of special interest was any change in the percentage THC-positive drivers before and after the implementation of legalized retail sales of recreational marijuana.

Method

National Roadside Surveys

The National Roadside Survey began in 1973 to test the breath alcohol concentration of randomly selected drivers on U.S. roads and establish objective measures of drinking and driving. Since 1973, four additional NRS studies have been conducted, providing an opportunity to identify significant changes in the prevalence of drinking and driving over time.

The Washington State Roadside Survey adapted the majority of its methods and procedures from the 2013–2014 NRS (Kelley-Baker et al., in press). This section provides a brief history of the NRS and highlights instances in which the research protocol was adapted to better serve the needs and objectives of the Washington State study.

1973, 1986, and 1996 National Roadside Surveys. The first NRS was conducted in 1973, by the University of Michigan's Highway Safety Research Institute (Wolfe, 1974). In 1986 the Insurance Institute for Highway Safety sponsored the second NRS (Lund & Wolfe, 1991), which was conducted through the University of Michigan's Transportation Research Center. In 1996, IIHS and NHTSA jointly sponsored the third NRS (Voas, Wells, Lestina, Williams, & Greene, 1998). These first three studies used the same basic methodology, which included collecting data on Friday and Saturday nights via a brief questionnaire and a breath sample to measure alcohol concentrations.

2007 National Roadside Survey. In 2007 NHTSA contracted the fourth NRS, with additional funding from the National Institute on Alcohol Abuse and Alcoholism, the National Institute on Drug Abuse, and the National Institute of Justice (Lacey et al., 2009). [6] As in the three previous studies, the 2007 NRS again included an interview and collected a breath sample, but also added a daytime session as well as a self-administered questionnaire and two additional biological samples, oral fluid and blood, to determine not only the presence of alcohol but also the presence of other drugs.[7] These additions to the protocol made the 2007 NRS more comprehensive than the previous NRS studies (which were limited to alcohol and nighttime only) and allowed for a broader understanding of alcohol and drug use in the driving population. This NRS produced the first national prevalence estimates of drug-positive drivers based on biological measures.

Differences between the 2013–2014 NRS and the Washington State Study. Aside from sampling only a single State versus the entire Nation, and the addition of a prescription drug questionnaire funded by NIDA,[8] there were procedural few the Washington State Roadside Study and the 2013-2014 National Roadside Study:

[6] Self-report surveys, including instruments on alcohol and drug use disorders, were sponsored by these other agencies.

[7] All drugs selected for testing have the potential to impair driving-related skills.

[8] PIRE received NHTSA permission to collect this additional information in conjunction with the roadside survey after determination that doing so would not detract from NHTSA-funded activities.

- **Self-report surveys.** In the 2013–2014 NRS, the self-report surveys included a drug-use questionnaire, a prescription drug-use questionnaire, the Drug Abuse Screening Test, the Drug Use Disorder questionnaire, and the Alcohol Use Disorder questionnaire. For the Washington State study, the Drug Use Disorder and Alcohol Use Disorder questionnaires were dropped and replaced with a marijuana-specific questionnaire (Appendix C). These self-report surveys were funded by IIHS.
- **Visibility of law enforcement.** For this Washington State study, police officers did not guide participants into the location nor did they direct traffic. Officers were on site for participant and staff safety; however, they remained in their vehicles.
- **Participation recruitment procedures.** For the Washington State study, members of the data collection team attempted to recruit potential participants at either a stoplight or stop sign close to the entrance to the location and invited drivers to turn into the location for more information about participating in a voluntary paid research study. In some instances, data collectors were able to talk to drivers while they were stopped, but on other occasions data collectors could only use traffic wands to guide drivers to the data collection location. It cannot be known how many drivers actually heard or saw our data collectors waving drivers into the area and chose not to turn into the location. Therefore, participation rates for this study are based on those drivers who came into the location, heard the data collector's request to participate in the study, and then decided whether to participate. Because of this difference in protocol between the two studies, the estimated prevalence of drivers in the Washington State study with impairing substances in their systems may differ relative to those in the NRS.
- **Additional questions about marijuana.** Additional questions were asked about marijuana use.[9]
- **Publicity.** The WTSC actively publicized data collection for Waves 1 and 3, including public service announcements and allowing the media to view mock data collections. No actual participants were filmed.

Table 1 summarizes the differences between the 2013–2014 NRS and Washington State Roadside Survey protocols.

[9] These questions were funded by IIHS.

Table 1. Differences Between the 2013–2014 NRS and the Washington State Study

Protocol	2013–2014 NRS	Washington State Study
Sampling	Nationwide	Within Washington State
Number of sites	60	6 sites across 3 waves
Approach	Guided in by police or research staff	Invited at intersection by research staff
Number of drugs in assay panel	99	101
Drug questionnaire contents	Drug Use Prescription Drug Use DAST DUD AUD	Drug Use Prescription Drug Use DAST THC
Police visibility	Full Protocol Partial Protocol Minimal Visibility	Minimal Visibility
Proactive publicity	None	Yes

Project Scope

Voluntary and anonymous roadside surveys were conducted in six counties across Washington State to assess the prevalence of drivers testing positive for alcohol and other drugs, including THC. Data were collected in three waves: (1) immediately before the implementation of legal sales (pre); (2) approximately 6 months after implementation (post); and (3) 1 year after implementation (post) (Figure 1).

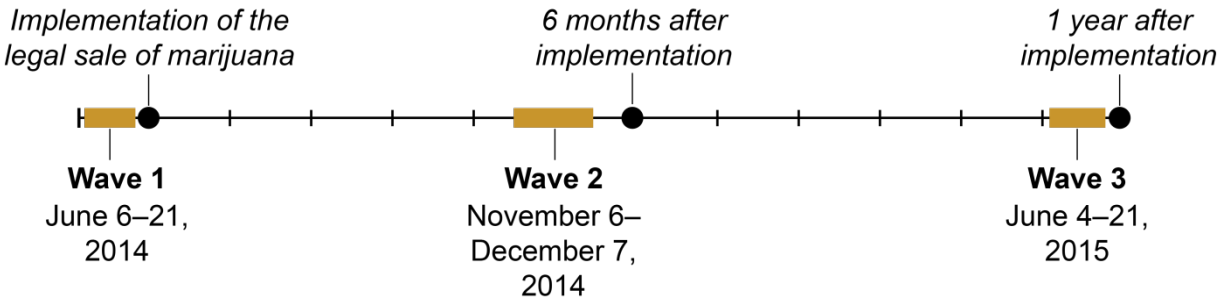

Figure 1. Timeline of the Washington State Study

Six counties participated in all three waves of data collection.

- King
- Kitsap
- Snohomish
- Spokane
- Whatcom
- Yakima

Research staff recruited drivers on roadways in the six Washington sites and collected self-report data, breath samples, oral fluid samples, and blood samples from these drivers, as well as self-report data from front-seat passengers (if applicable).[10] Vehicles were randomly selected from the traffic stream and drivers were asked to participate in the study. Drivers were told that participation was voluntary, all data were anonymous, and that they had the opportunity to receive compensation for their participation. Drivers could decline to participate in the study, could end participation at any time, or could choose to complete only certain components of it.

Five 2-hour sessions were conducted at different locations within the site.

- Friday daytime—either 9:30–11:30 a.m. *or* 1:30–3:30 p.m.
- Friday nighttime—10 p.m.–midnight
- Friday late nighttime—1–3 a.m.
- Saturday nighttime—10 p.m.–midnight
- Saturday late nighttime—1–3 a.m.

[10] Collection of self-report data (passenger survey and drug questionnaire) was funded by IIHS.

The first wave was conducted in June 2014, just prior to the legalization of recreational marijuana sales. It was important to collect data before implementation of the sales law in order to establish a baseline measure. A second wave was conducted in November and early December 2014, approximately 6 months after Wave 1. This afforded an opportunity to examine whether there were changes in prevalence rates shortly after implementation of the sales law. A third wave was conducted in June 2015, 1 year after Wave, 1 to assess whether there were longer-term changes. In addition, conducting a third wave almost exactly 1 year after implementation controlled for the possibility of seasonal differences. The difference between Wave 1 and Wave 2 may be attributable to the relatively short-term effects of legalization of sales. Comparisons between Wave 2 and Wave 3 can help estimate whether there were further changes in prevalence rates. Comparisons between Wave 1 and Wave 3 can be used to characterize the longer-term effects that legal retail sales may have on prevalence rates.

Sampling Procedures

Identifying jurisdictions. The sampling plan developed a Friday daytime and weekend nighttime sample that was as representative of drivers across Washington State as possible.

A major difference in surveying a single State versus the entire Nation is the more limited number of geographic and population units available for composing a sample that is representative of the regional, geographic, and population attributes of the State as a whole. Figure 2 shows the population by county as of April 2012.

Figure 2. Washington State Population by County (as of April 2012)

We targeted sites with varying levels of population density: A-level, urban counties that are densely populated; B-level, suburban counties that are semi-major population areas; and C-level, rural counties that are the least densely populated.

A-level, urban counties. Washington contains only one unit that is designated as an A-level (population density) stratum within the national primary sampling unit (PSU) framework: Seattle in King county. The greater Seattle-Tacoma metropolitan area (primarily King County, but also neighboring Pierce and Snohomish counties, that is, the "I-5 corridor") accounts for 3.5 million residents, over half of the State's population of 6.8 million. To obtain representativeness, it was essential to have at least one location within this area and as close to Seattle as possible. Given the large population in these three counties, two sites were desirable. We obtained cooperation from King and Snohomish counties to cover this major population cluster.

B-level, suburban counties. There were three semi-major population areas in Washington. Each is in a distinct geographic and economic sector of the State. We designated these as the B-level strata relative to Washington's size. These areas were Spokane (Spokane County); the Washington side of the Portland, Oregon, metropolitan area (Clark County, containing Vancouver City); and the "Tri-Cities" areas of Kennewick, Pasco, and Richland located in Yakima, Benton, and Franklin counties. It was important to have at least one (preferably two) B-level sites to generalize to the State. We obtained cooperation from Spokane and Yakima counties to sample the B-level population stratum, which extended our coverage into Eastern and Central Washington.

C-level, rural counties. We also attempted to obtain representation of the more rural or semi-rural areas of the State—the C-level stratum. The challenge was that with six sites to allocate to the whole State, and the need to be able to make inferences at the State level with as little weighting as possible, it was best not to over-dedicate resources to these rural areas. To capture a representative portion of the population, these two sites needed to be chosen from among the more populous C-level counties near the interstate corridors. We obtained cooperation from Kitsap and Whatcom counties to sample the C-level population stratum which extended coverage into the regionally unique area of the Puget Sound "island" peninsula. Both have social-economic environments that were significantly different from the major population clusters. Furthermore, they provided access to the majority of the State's entire C-level areas. This factor was important, as it means that the oversampling inherent in selecting any C-level site is lessened and that less extreme weighting was necessary for representing the overall State population.

The number of cases was not proportional to that site's or stratum's portion of the State's total population (i.e., some degree of oversampling and under-sampling by stratum inevitably occurred). To produce a proportionally representative sample reflective of the State's population and its distribution among strata levels, the cases from each of the six sites were weighted.

Partnership with the Washington Traffic Safety Commission (WTSC) and recruitment of law enforcement assistance. Research staff worked with the WTSC for assistance with site recruitment. WTSC's help also included briefing the Governor, the chairs of the Senate and House transportation committees, and the ACLU. The WTSC conducted proactive outreach to the media, including mock data collection activities so local news outlets could have film of what a data collection looks like, while maintaining the anonymity of participants.

Selection of locations within sites. Within each site, we randomly selected 30 grid areas of a square mile each from which locations could be sampled (Figure 3, Step 1). The goal was to identify and select five geographic locations within each site in order to obtain an overall sample that was as representative of the State as a whole as possible. To accomplish this, we created a map for each site and divided that map into a grid of approximately 1-square-mile squares. Squares containing fields, parks, airports, and harbors, or which contained few road segments, were eliminated from the sampling frame. Using simple random sampling procedure (without replacement) of all the eligible "squares," we identified 30 possible square-mile grid areas to search for potential locations. Within each grid area, one location could potentially be selected. Typically, staff selected grid areas from the total grid areas available, and if cooperation was not forthcoming from the law enforcement agency that had jurisdiction for a particular selected grid area, researchers excluded that grid area from further consideration (Figure 3, Step 2). Although locations were sometimes repeated across the waves, this was not always the case. Once at the location, survey managers met with the participating research officers for logistical positioning for traffic flow and research bays (Figure 3, Step 3).

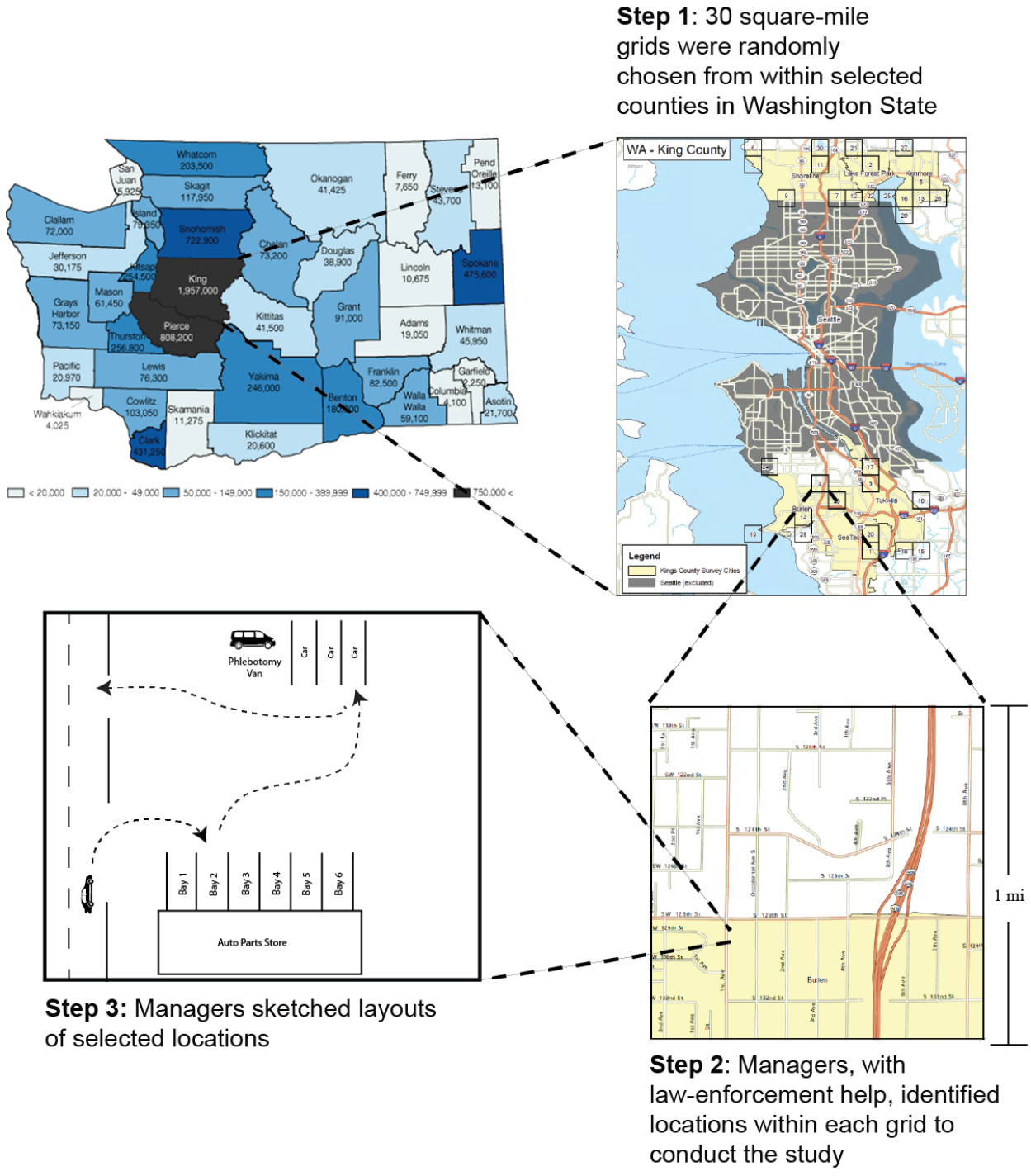

Figure 3. Washington State Study Site Selection Flowchart

Equipment

The following items were used for data collection.

Tablet. The data collector recorded the following into an iPad 2 tablet:

- observational data (e.g., race, gender, age);
- responses to interview questions;
- passive alcohol sensor results;
- preliminary breath test results; and
- chain-of-custody label numbers from oral fluid and blood samples to allow them to be matched to interviews.

Subjects used the tablet to record responses to the self-administered questionnaire. Passengers completed questionnaires on paper.

Passive alcohol sensor device. Obtaining the greatest percentage of alcohol tests as possible was critical to attaining valid data on alcohol-related driving. Each data collector used a passive alcohol sensor (PAS) to obtain estimates of breath samples.

Figure 4. The PAS Vr.

As in the 2013–2014 NRS, we used the PAS Vr. manufactured by PAS Systems International, of Fredericksburg, Virginia, to obtain passive BrAC readings (Figure 4; see Appendix D for more information). The PAS unit can detect alcohol in expired air around the face (Kiger, Lestina, & Lund, 1993). When the subject spoke, the data collector held the PAS within 6 inches of the subject's face and activated the small electrical pump that pulled in air from in front of the face (Cammisa, Ferguson, & Wells, 1996; Fiorentino, 1997). The air captured by the PAS fed into the unit's internal fuel cell alcohol detector, which measured approximate alcohol concentration. The PAS then provided both a rough indication of the individual's alcohol concentration on a color-coded, nine-element LED bar graph and a numeric display of the approximate alcohol level. This sample was taken while the driver was responding to questions. After viewing the PAS level, the data collector entered the number of lighted colored bars into the tablet. If the PAS reading entered was four yellow bars (equating to an alcohol concentration of .05 or higher), the tablet would instruct the data collector to call over the survey manger to look for signs of impairment and implement the Impaired Driver Protocol if necessary (Appendix E).

Preliminary breath test device. The data collector also requested breath samples from drivers using a preliminary breath test device. Researchers used the Mark V Alcovisor, a handheld device also manufactured by PAS Systems (Figure 5; Appendix F). This device is included on NHTSA's Conforming Products List for Evidential Breath Testing Instruments (NHTSA, 2012). The PBT

Figure 5. PBT Device, Mark V Alcovisor

uses an internal fuel cell to measure BrAC when a subject blows directly into a tube.

To help ensure anonymity, the PBTs were masked so they would not display individual BrACs at the location. Results were stored in the unit's memory and downloaded after data collection.

Oral Fluid Sample. After the driver had completed the questionnaire and provided a breath sample, the data collector then offered $10 for an oral fluid sample. Researchers used the Quantisal (manufactured by Immunalysis Corporation, Pomona, California) oral fluid collection device (Figure 6, Appendix G). The subject placed the pad of this device under the tongue; the tip turned blue when 1 mL of oral fluid was collected, indicating adequate volume. The subject then placed the device into a tube, which contained 3 mL of a stabilizing buffer solution. The data collector capped the tube.

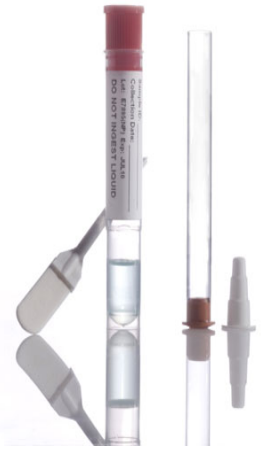

Figure 6. The Quantisal Oral Fluid Collection Device

Although less invasive than blood or urine collection, oral fluid collection does have some shortcomings (O'Neal, Crouch, Rollins, & Fatah, 2000). O'Neal's group noted differences in the levels of codeine retrieved from several types of oral fluid collection devices. This may affect whether some drugs can be detected. However, although some devices give no indication of the amount of oral fluid collected, rendering a quantitative result meaningless, the Quantisal oral fluid collection device collects 1 mL (+/-10%) of clear oral fluid from the donor. Researchers have studied the device to assess the efficiency of drug release from the collection pad (Moore, Rana, & Coulter, 2007a; Moore et al., 2006; Quintela, Crouch, & Andrenyak, 2006) and have found a high rate of extraction efficiency.

Data Collection

Overview. Each team consisted of a manager, a phlebotomist, a traffic director, and six to eight data collectors. Across the study, data collectors and phlebotomists moved from team to team to meet logistical needs. Managers early met with police officers and identify locations from the 30 square-mile grid described in Step 1 of Figure 3. These included 5 primary locations, and alternate locations. An alternate location might be needed if the parking lot was no available or there was insufficient traffic. The locations were chosen for the safety of the drivers and research team.

The daytime data collection took place on Fridays between 9:30 a.m. and 11:30 a.m. *or* between 1:30 p.m. and 3:30 p.m. The morning versus afternoon time frame was randomly selected for most sites; however, it was occasionally determined by police agency schedules. The team arrived at the daytime location 1 hour before data collection began. After data collection, managers uploaded the data.

The teams arrived at the first nighttime location 1 hour before data collection. Research teams conducted Friday and Saturday nighttime surveys from 10 p.m. to midnight and 1 a.m. to 3 a.m.

General data collection procedures

Data collection setup. The manager met with participating officers to position research bays. Data collectors marked research bays with orange traffic cones. The phlebotomist set up the blood draw station in the phlebotomy van. Team members set up signs that read "PAID VOLUNTARY SURVEY" at the side of the road approximately 200 feet ahead of the location. LED signs were mounted on a car at the entrance to the location.

Driver selection. Members of the data collection team recruited participants at either a stoplight or stop sign close to the entrance to the data collection location and invited drivers to enter for more information about participating in a voluntary paid research study. In some instances, data collectors were able to talk to drivers while they were stopped, but on other occasions, data collectors could only indicate the entrance to the location, using a traffic wand.

Eligibility. Subjects who wished to participate needed to meet eligibility requirements to protect human subjects and/or data integrity. Criteria that disqualified a participant included:

- Age – drivers under 16 years;
- Language – drivers who did not speak English or Spanish;
- Commercial vehicles – drivers in their work vehicles (i.e., emergency vehicles, delivery drivers); and
- Intoxication –drivers who were so impaired that they could not give informed consent. Once a driver left, the traffic director waited for the first vehicle approaching and guided the driver to data collection.

Field data recording and sequence. The study consisted of the following, in order of operation:

1. observational demographic measures (race, age, etc.),
2. verbal informed consent,
3. roadside interview questions,
4. PAS reading,
5. breath sample collection,
6. oral fluid sample collection ($10 incentive),
7. self-reported questionnaires (reported by subjects on tablets),
8. passenger questionnaire, self-reported on paper by front-seat passenger age 16 years or older, if any ($5 incentive),
9. blood sample collection ($50 incentive), and
10. observational vehicle measures (vehicle type, seat belt use).

Additional data (e.g., reasons for not participating, observational demographics) were also collected for drivers who declined to participate in the study and for drivers who required

assistance because of possible impairment. Managers also recorded overall information about the location (e.g., weather, traffic reports, and unexpected incidents).

Post-survey activities. When the last driver completed data collection, the team packed equipment. For each team, an experienced data collector was designated as the lead data collector and served as an assistant survey manager. After all data collection sessions were completed at that site, the survey manager packed the equipment for shipment, and the phlebotomist prepared the biological samples for transport to the lab for testing.

Impaired Driver Protocol. We could not obtain data from anyone incapable of providing informed consent. The research team had a duty to identify drivers who were so impaired that they could not properly consent to participate in the study, and to identify participants who may be too impaired to operate a motor vehicle safely and find them alternative transportation home. We had an Impaired Driver Protocol to protect these individuals.

While the data collector spoke with the driver, he or she also took a PAS reading. This reading, along with initial observations of the driver's behavior, provided the team with an indication of alcohol level for all drivers and helped to identify the need for intervention. Additionally, as the participant was engaged with the research team, the data collector continually assessed the driver for any signs of impairment.

If a participant appeared impaired or had a high PAS reading, the data collector signaled the survey manager to come over. The survey manager observed the driver and, if warranted, explained his or her concern to the driver and requested a second breath test, now with a preliminary breath test device that displayed the result. The survey manager explained that if the subject blew a BrAC of .05 grams per deciliter (g/dL) or higher, the team would get the driver home safely.

The impaired driver protocol included the following:

- another licensed occupant driving the vehicle - if he or she was below .05 g/dL;
- calling a friend or relative to pick up the driver;
- calling a taxi (paid by the study);
- arranging for a hotel room (paid by the study); or
- calling a tow truck (paid by the study).

When the driver had a low BrAC or was not alcohol-positive, but either the data collector or survey manager noticed other signs of impairment (e.g., smelled marijuana, driver couldn't focus), the survey manager would implement the impaired driver protocol. If a driver declined all options, the survey manager was instructed to tell the driver the onsite police officer would call dispatch to alert them that a potential impaired driver was on the road.[11] However, this did not

[11] The police officers were onsite for the safety of the public and the data collection team. They were not involved in any enforcement of traffic laws at the data collection location. Officers were instructed to remain outside the data collection area during the course of the study.

occur, as all such drivers accepted alternative arrangements. No drivers were arrested at the study sites at any point during data collection.

Selection of Drugs for Screening and Analysis

The Washington State Roadside Survey tested oral fluid and blood samples for over-the-counter, prescription medications, and illegal drugs that have the potential to impair driving performance. Oral fluid and blood samples with positive screens were sent for further confirmation testing (Table 2). The lab screened the samples using ELISA micro-plate technology. Confirmatory testing was performed using gas chromatography-mass spectrometry or liquid chromatography-mass spectrometry technology.[12] The methodology of this study was designed to examine the prevalence of alcohol- and drug-positive drivers – the study was not designed to examine impairment or crash risk. Many drugs may be detected in the body, especially in blood samples, days or even weeks after use.

[12] For more information on laboratory procedures, see Moore, Rana, & Coulter (2007b).

Table 2. Washington State Roadside Study Drugs and Minimum Detection Concentrations

Drug	Minimum Concentration Oral Fluid		Minimum Concentration Blood	
	Screen (mg/dL‖)	Confirm (mg/dL)	Screen (mg/dL)	Confirm (mg/dL)
Alcohol (Ethyl Alcohol)	20	20	20	20
Amphetamine/Methamphetamine (MDMA, MDA, MDEA, Methamphetamine, Amphetamine ,† Phentermine)	25	10	20	10
Antidepressants (Amitriptyline, Nortriptyline ,† Amoxapine,* Cyclobenzaprine*§, Dothiepin,* Doxepin ,‡*Desmethyldoxepin* ,‡Imipramine, Desipramine ,† Protriptyline ,‡Trimipramine, Citalopram,* Paroxetine,* Venlafaxine,* Mianserine,* Mirtazepine,* Trazodone*)	25	10	25	10
Antihistamines (Chlorpheniramine,* Diphenhydramine,* Doxylamine*)	25	10	25	10
Barbiturates (Phenobarbital, Pentobarbital, Secobarbital, Butalbital)	50	50	100	100
Benzodiazepines (Alprazolam, Bromazepam, Chlordiazepoxide, Diazepam ,† Nordiazepam ,† Oxazepam ,† Temazepam ,† Clonazepam, Estazolam ,‡Flunitrazepam, Flurazepam, Lorazepam, Midazolam, Nitrazepam, Phenazepam,* Triazolam)	5	1	20	10
Buprenorphine* (*Norbuprenorphine**)	5	2	1	1
Cannabinoids/Marijuana (delta-9-tetrahydrocannabinol [THC], *11-OH-THC (hydroxy-THC*)	4	2	10	1
THC-COOH (carboxy- THC)	0.05	0.02	10	1
Synthetic Cannabinoids (AM-1220,* AM-2201,* AM-2232,* CP47497,* CP47497-C8,* HU-210,* JWH-018,* JWH-022,* JWH-073,* JWH-200,* JWH-250,* UR-144,* XLR-11*)	0.25	0.25	5	1
Carisoprodol (Meprobamate †)	50	50	500	500
Cocaine (Cocaine, *Cocaethylene*, *Benzoylecgonine*, *Norcocaine*)	20	8	25	10
Dextromethorphan (*Dextrorphan**)	50	20	50	20
Fentanyl* (*Norfentanyl*)	1	0.50	1	0.5
Fluoxetine (*Norfluoxetine**)	50	10	50	10
Ketamine (*Norketamine*)	10	10	10	10
Meperidine (*Normeperidine*)	50	25	50	10
Methadone (*EDDP*)	50	20	50	10
Methylphenidate	10	10	10	10
Naltrexone*	40	10	25	10
Opiates/Opioids (*6-AM*, Codeine ,† Morphine ,† Hydrocodone ,† Hydromorphone †)	20	10	25	10
Oxycodone (Oxymorphone †)	20	10	25	10
Phencyclidine	10	10	10	10
Propoxyphene (*Norpropoxyphene*)	20	10	20	10
Sertraline	50	10	50	10
Tramadol (*Desmethyltramadol**)	50	25	50	10
Zolpidem	10	10	10	10

Metabolites are listed in italics.
Screening uses ELISA microplate, and confirmation uses GC/MS or LC/MS/MS technology.
† Drugs that can be either a metabolite or a drug on their own.
‡ Drugs screened using blood in 2007 that were also screened with oral fluid in 2013–2014.
§ Cyclobenzaprine* is not an antidepressant but cross-reacts with the screening procedure.
‖ milligrams per deciliter.

Drugs were grouped by class and by category. Drug classes group drugs by their active ingredient (e.g., tricyclic and tetracyclic antidepressants) or by the way they are used to treat a particular condition. Drug categories primarily sort drugs by legal status (illegal versus legal). Drugs found in the illegal only category are illegal to possess, produce, or sell. Drugs found in the medications only category are obtained in pharmacies either over-the-counter or by prescription.

Description of drug classes

Cannabinoids/marijuana. Cannabis, also known as marijuana, is a plant consisting of 483 compounds and at least 84 other cannabinoids (a class of diverse chemical compounds that act on cannabinoid receptors in cells that repress neurotransmitter release in the brain). We tested for delta-9-tetrahydrocannabinol, called THC, its active metabolite 11-hydroxy-delta-9-tetrahydrocannabinol (also noted as11-OH-THC and called "hydroxy-THC"), and its inactive metabolite 11-nor-9-carboxy-delta-9-tetrahydrocannabinol (also known as "carboxy-THC" and noted as "THC-COOH"). The main body of this report presents data on THC and hydroxy-THC.[13]

In the drug class tables, THC is sorted into THC-positive and two subheadings: THC only, and THC and other drugs.

- ***THC-positive*** includes individuals who tested positive for THC and/or its active metabolite, hydroxy-THC.
- ***THC only*** includes individuals positive for THC and/or hydroxy-THC but no other drugs.
- ***THC and other drugs*** includes drivers who tested positive for THC and/or hydroxy-TCH in combination with another drug.

Antidepressants include selective serotonin reuptake inhibitors (SSRIs) and serotonin norepinephrine reuptake inhibitors (SNRIs), tricyclics, and tetracyclics. Antidepressants, most commonly in the form of SSRIs, such as fluoxetine (Prozac) and sertraline (Zoloft) can cause impairment, especially if present in a high concentration or if they are taken outside of medical need or therapeutic treatment. There is also risk of impairment when used with alcohol (Kelly et al., 2004).

Tricyclic and tetracyclic antidepressants can cause drowsiness, sedation, and impaired psychomotor abilities. The sedating effect of antidepressants is greatest when beginning treatment or when the dose is increased (Ramaekers, 2003).

Narcotic analgesics include methadone, opiates, opioids, and the opioid antagonist Naltrexone. Narcotic analgesics have differential performance effects in naïve or recreational users versus tolerant therapeutic users (Asbridge, Cartwright, & Langille, 2015).

[13] As carboxy-THC is inactive (but may still be of interest to some readers), this data is in Appendix H. Appendix H also includes more data on hydroxy-THC.

Methadone is used medicinally for pain as well as opiate detoxification and maintenance. It can also be a drug of abuse. EDDP (2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine) is its inactive metabolite.

Opiates in the narcotic analgesic class include 6-AM (an active metabolite of heroin), codeine, and morphine. Of these, heroin is an illegal substance.

Opioids are also narcotic analgesics used as pain medications (e.g., oxycodone, hydrocodone). These drugs act as central nervous system (CNS) depressants, which could have performance-decreasing effects, particularly when used in combination with other CNS depressants, such as alcohol or benzodiazepines.

Included in this class is the opioid antagonist Naltrexone. Although not specifically a narcotic analgesic, Naltrexone is used primarily for the treatment of alcohol and opioid dependence by blocking their euphoric effects and reducing craving.

Sedatives include barbiturates, benzodiazepines, muscle relaxants, and sleep aids. Barbiturates are widely prescribed CNS depressants, primarily for migraine pain and anti-epileptic medications. Barbiturates are associated with delayed reaction times and possible loss of concentration, thus potentially affecting driving performance (Yeakel & Logan, 2013).

Benzodiazepines are prescribed to reduce anxiety, prevent seizures, and assist in sleep-related disorders. These drugs act as CNS depressants, can enhance the effects of alcohol, and are potentially associated with driver impairment (Bogstrand & Gjerde, 2014).

The desired/therapeutic effect, for example, of lorazepam (Ativan) is sedation. The most commonly prescribed benzodiazepines are alprazolam (Xanax) and diazepam (Valium) (Center for Substance Abuse Research, 2013).

Muscle relaxants such as carisoprodol (Soma) and cyclobenzaprine (Flexeril) may cause drowsiness or dizziness. These side effects have been linked to weaving, stopping in traffic, and hitting parked cars and other stationary objects (Logan, Case, & Gordon, 2000).

Sleep aids such as zolpidem (Ambien) cause drowsiness and may cause dizziness. If consumed with alcohol, there is a detrimental effect on driving ability (Farkas, Unger, & Temple, 2013).

Stimulants include attention deficit hyperactivity disorder (ADHD) medication, amphetamines, and cocaine. Medications such as methylphenidate (Ritalin) are amphetamine-like prescription drugs commonly used to treat ADHD.

Amphetamines are generally taken recreationally and to enhance performance (e.g., by truck drivers to stay awake). Ecstasy falls within this category of drugs and, as a methylated amphetamine derivative, also has hallucinogenic properties. Amphetamines have been associated with increased crash risk and may be associated with driving impairment both in the stimulation and withdrawal stages, in the latter case especially as the drug interacts with fatigue (Hjälmdahl et al., 2012; Musshoff & Madea, 2012).

Used medically as a local anesthetic, cocaine is a CNS stimulant. Although cocaine may initially be perceived as improving driving, an analyses of crashes with drivers positive for cocaine revealed increased risk for speeding, loss of control of vehicle, and inattentive driving (Narconon International, 2015).

Others included in the final drug class list (and titled "other") are antihistamines, antipsychotics, cough suppressants, phencyclidine (PCP), ketamine, and synthetic cannabinoids. Antihistamines are drugs that can have a depressive CNS effect (Hetland & Carr, 2014). Those tested included chlorpheniramine, diphenhydramine, and doxylamine. The cough suppressant dextromethorphan is a synthetic analog of codeine. In high doses, dexromethorphan is a CNS depressant and may impair driving (Logan, 2009).

Ketamine is a tranquilizer used medicinally for both animals and people, and may be used recreationally as a psychedelic and is associated with decrements in driving skills (Cheng, Ng, Chan, Mok, & Cheung, 2007). PCP is related to veterinary tranquilizers (such as ketamine) that impair motor ability, but PCP also has hallucinogenic effects and is used as a recreational drug. It has serious performance-diminishing effects and has been implicated in impaired-driving cases (Poklis, Maginn, & Barr, 1987).

Synthetic cannabinoid receptor agonists simulate the effects of cannabinoids/marijuana. Consumption of synthetic cannabinoids can lead to impairment similar to typical performance deficits caused by cannabis use, which may not be compatible with safe driving. These deficits include centrally sedating effects and impairment of fine motor skills (Musshoff et al., 2014).

More than one class. Drivers having two or more drugs from different classes were included in this category. THC is not included in this category.

Description of Drug Categories

Drug categories sort drugs by legal status. Because THC use is legal in Washington State and is a focus of this study, THC has been separated out for drug categories in the same way as drug class: THC-positive, THC only, and THC and other drugs.

Illegal only. The illegal only category includes individuals who tested positive for at least one drug that is illegal to possess, produce, or sell. These include cocaine, heroin, ketamine, PCP, or methamphetamines. THC is not included in this category because it is a legal drug in Washington State[14].

Medications only. The medications only category is made up of individuals who tested positive only for either prescription and/or over-the-counter medications that have the potential to impair driving. These are the drugs most likely to be found in the general public; they include antidepressants, opioids, antihistamines, sleep aids, cough suppressants, and benzodiazepines. Although classed as prescription medications, many of these drugs may be obtained illicitly and used recreationally or for self-medication.

[14] For our June 2104 pre-data collection, retail outlets were not licensed to sell marijuana, but personal, recreational use was legal at that data collection wave as well as in Wave 2 and Wave 3.

Illegal and medications. Drivers found to have both illegal drugs and medications in their system were listed in this category. THC is not included in this category.

Data Analysis

Weighting the Data

In terms of population sampling, the ideal would be to obtain a random sample of drivers from among all Washington drivers. However this would be logistically impossible. Thus, a multistage sampling strategy with four nested sampling frames was applied (Figure 7):

1. First, a site (county) was selected for inclusion.
2. From that site, a sampling area was randomly selected.
3. From that sampling area, roadway locations were based on safety, lighting, and vehicle maneuvering space.
4. From these roadway locations, passing vehicles were selected for study participation.

Figure 7. Multistage Sampling Strategy

The weighting developed from these sampling frames reflects the relative size of the driving population by region, as defined by the Washington State Government's Office of Financial Management, based on 2010 census data—the most recent census data available. Assuming drivers participating in the study at each site originated from within that site's geographical region, the case weights reflect the overall driving population of Washington State.

Each of the four sampling frames required a separate calculation of probability, which then became a component of the final probability computation that reflected all frames. The total weighted number (*N*) of the sample was identical to the total number of eligible drivers that entered the bays, including those that declined to participate in the study. These values were adjusted to reflect the estimated distribution of those drivers among regions in Washington State. Error terms for the analyses were computed by STATA (StataCorp, 2009) to account for the differential weights and the variance attributable to the sampling frames. Weights were calculated separately for each wave of this study.

General Statistical Procedures

To examine the prevalence of drivers positive for THC as well as each of the other drug use categories and classes, we conducted a series of one-way and two-way cross-tabulations. Analyses were conducted comparing Wave 1 to both Waves 2 and 3. This allowed for identifying potential measures that were significantly different from the baseline at both intermediate and one-year follow-up measures. Significance was determined by examining 95 percent confidence intervals, which are shown in the tables. A confidence interval consists of a range of values in which the true value of a parameter falls. Commonly, researchers use 95% confidence intervals (95% CI). This

indicates that given the data distribution, researchers are 95% confident that the true value of any variable lies in the CI range. The resulting tables show THC and other drug prevalence stratified by demographics (i.e., gender, age, race, ethnicity), environmental variables (i.e., time of day, session), and concurrent alcohol use. These tables were created using STATA v.11 (StataCorp, 2009). Unless explicitly indicated, sample size (*N*) refers to the unweighted number of respondents; percentages are weighted as described previously. Sample size may vary between tables because of missing values.

Results

Participation

Nearly 2,500 daytime and nighttime drivers participated in at least one component of the study across the three waves of data collection. Table 3 shows that participation rates were highest at Wave 1 (99.3% daytime, 97.8% nighttime), and remained high throughout Wave 2 (97.9% daytime, 96.2% nighttime) and Wave 3 (96.9% daytime, 97.4% nighttime). Those who entered the location may have been more likely to participate because they had already self-selected based on either their interaction with the data collector soliciting from the traffic stream or from having heard publicity about the study. Because of these factors, participation rates are not directly comparable between this study and the 2013-2014 NRS.

In both daytime and nighttime, at least 86 percent of drivers provided a valid breath and oral fluid sample at each wave. Additionally, in both daytime and nighttime surveys, at least 73 percent of participating drivers provided a blood sample at each wave.

Table 3. Participating Drivers (Percentages in Parentheses)

	Wave 1		Wave 2		Wave 3	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
Entered location	282	673	188	539	225	625
Eligible	276	667	188	532	225	622
Entered location and participated	274 (99.3)†	652 (97.8)†	184 (97.9)†	513 (96.4)†	218 (96.9)†	606 (97.4)†
Valid breath sample	271 (98.2)†	646 (96.9)†	184 (97.9)†	507 (95.3)†	218 (96.9)†	597 (96.0)†
Oral fluid sample	250 (90.1)†	628 (94.2)†	163 (86.7)†	466 (87.5)†	214 (95.1)†	592 (95.2)†
Blood sample	219 (79.3)†	492 (73.8)†	148 (78.7)†	395 (74.3)†	181 (85.4)†	494 (79.4)†
Oral fluid and/or blood sample	271 (98.2)†	637 (95.5)†	177 (94.1)†	495 (93.1)†	214 (95.1)†	596 (95.8)†
Standard roadside questions	273 (98.9)†	652 (97.8)†	181 (96.3)†	513 (96.4)†	218 (96.9)†	602 (96.8)†

† Percentage of eligible.

THC

THC prevalence. Table 4 shows a higher percentage of drivers positive for THC at each wave regardless of any other substance being detected. A higher percentage of drivers at Wave 2 (19.4%) and Wave 3 (21.4%) were positive for THC compared to Wave 1 (14.6%). These differences were not statistically significant.

Table 4. Percentage of THC-Positive Drivers by Wave (Oral Fluid or Blood)

	% THC-positive	*N*	95% CI
Wave 1	14.6	908	[11.9, 17.8]
Wave 2	19.4	672	[16.4, 22.8]
Wave 3	21.4	810	[17.5, 25.9]

In this table, Ns are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.

The increase of 46.6% (from 14.6% in Wave 1 to 21.4% Wave 3) was not statistically significant due to the variation in THC-positive drivers between sites, and within individual sites. In Table 5, below, we show the percentage of drivers positive for THC by Primary Sampling Unit (PSU) and Wave to illustrate this point. Notice that in three of the PSUs the percentage positive actually declined slightly over the three waves (Whatcom went from 11.8% to 11.6%, Kitsap from 15.0% to 14.5%, and Spokane from 20.5% to 19.9%). The percentage of THC positive drivers increased slightly in one PSU (Yakima went from 14.3% to 16.2%) and increased by a larger amount in two PSUs (King went from 13.3% to 30.7% and Snohomish went from 14.1% to 23.1%). In other words, there was considerably variation over time in different parts of the state.

Table 5. Percentage of THC-Positive Drivers by PSU and Wave

	Wave 1			Wave 2			Wave 3		
PSU	%	N	95% CI	%	N	95% CI	%	N	95% CI
King	13.3	13	[6.6, 24.8]	20.9	27	[15.9, 27.0]	30.7	22	[23.4, 39.1]
Snohomish	14.1	24	[10.0, 9.6]	17.9	21	[13.9, 22.8]	23.1	37	[17.2, 30.2]
Whatcom	11.8	16	[5.9, 21.9]	23.7	22	[18.0, 30.6]	11.6	13	[8.1, 16.1]
Kitsap	15.0	23	[8.6, 24.8]	17.5	20	[10.3, 28.2]	14.5	21	[11.2, 18.7]
Spokane	20.5	34	[14.3, 28.4]	23.6	20	[16.2, 33.0]	19.9	33	[16.4, 23.8]
Yakima	14.3	22	[8.1, 24.0]	12.9	17	[7.8, 20.5]	16.2	23	[8.6, 28.3]
Total	14.6	908	[11.9, 7.8]	19.4	672	[16.4%, 22.9]	21.4	810	[17.5, 25.9]

In this table, *Ns* are unweighted; percentages are weighted.
THC-positive include results for THC and hydroxy-THC

THC prevalence by time of day. Table 6 shows the prevalence of THC-positive drivers by time of day. Note that nighttime includes both sessions for Friday and Saturday nights. There was a statistically significant increase in the percentage of daytime drivers who were THC-positive at Wave 2 (18.4%) and at Wave 3 (18.9%) compared to Wave 1 (7.8%) ($p < .05$). There were increases also in the prevalence of THC-positive nighttime drivers with each successive wave, but these increases were not statistically significant.

Table 6. Percentage of THC-Positive Drivers by Time of Day (Oral Fluid or Blood)

	Wave 1				Wave 2				Wave 3			
	N	% THC-positive	*N* THC-positive	95% CI	*N*	% THC-positive	*N* THC-positive	95% CI	*N*	% THC-positive	*N* THC-positive	95% CI
Daytime	271	7.8	23	[5.8, 10.4]	177	18.4*	34	[12.4, 26.4]	214	18.9*	35	[11.9, 28.8]
Nighttime	637	17.5	109	[14.0, 21.7]	495	19.8	93	[16.5, 23.5]	596	22.2	114	[17.8, 27.5]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 (p <.05).

THC prevalence by demographic factors. Table 7 shows the prevalence of THC-positive drivers by wave and demographic variables. Males had a significantly higher rate of THC prevalence at Wave 3 compared to Wave 1 (p < .05). There were no other statistically significant findings.

Table 7. Percentage of Drivers THC-Positive by Demographic Variables (Oral Fluid or Blood)

		Wave 1			Wave 2			Wave 3		
Variable		% THC-positive	*N*	95% CI	% THC-positive	*N*	95% CI	% THC-positive	*N*	95% CI
Gender	Male	14.8	563	[11.3, 19.2]	19.8	403	[15.1, 25.6]	24.7*	479	[19.8, 30.3]
	Female	14.3	343	[11.0, 18.5]	19.1	264	[15.9, 22.8]	17.3	324	[12.3, 23.8]
Race	White	13.7	807	[11.0, 16.8]	20.2	564	[16.5, 24.5]	18.9	691	[14.9, 23.6]
	Black or African American	20.7	59	[11.6, 34.1]	14.5	65	[7.7, 25.6]	40.8	58	[27.5, 55.6]
	Asian	15.5	17	[3.1, 51.0]	12.6	28	[3.4, 37.2]	13.8	20	[5.7, 29.7]
	Native American or Alaska Native	0.0	8	0	20.4	5	[4.2, 59.8]	12.9	13	[1.9, 53.2]
	Other or More than one	13.4	12	[1.5, 61.4]	35.5	6	[2.9, 91.0]	20.2	27	[5.6, 50.1]
Ethnicity	Hispanic	11.9	160	[7.4, 18.8]	14.7	118	[9.1, 22.7]	14.0	121	[7.7, 24.1]
	Non-Hispanic	15.1	747	[11.8, 19.1]	20.7	547	[17.0, 24.9]	23.3	683	[18.4, 28.9]
Age	16 to 20	17.3	106	[8.7, 31.5]	19.2	86	[11.7, 29.9]	31.2	112	[17.6, 48.9]
	21 to 34	15.7	381	[11.1, 21.6]	18.9	288	[14.1, 24.9]	22.8	326	[16.8, 30.3]
	35 to 44	15.2	150	[10.7, 21.1]	19.6	126	[12.9, 28.4]	19.4	156	[12.7, 28.5]
	45 to 64	11.8	228	[6.3, 21.1]	20.7	130	[15.1, 27.8]	18.6	178	[9.4, 33.4]
	65 and over	14.0	43	[4.3, 37.2]	21.5	37	[13.1, 33.2]	8.2	31	[2.2, 26.4]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 (p <.05).

Drugs by Category

Drug category prevalence by wave. Table 8 shows drug category prevalence for daytime and nighttime drivers combined. As stated earlier, more drivers at Waves 2 (19.4%) and 3 (21.4%) were THC-positive compared to drivers at Wave 1 (14.6%). There was a decrease in the percent of drivers who tested positive for illegal drugs only, from 2.4 percent in Wave 1, to 2.0 percent in Wave 2, to 0.1 percent in Wave 3. However, as there were low prevalence rates of illegal only in all three waves, no meaningful interpretation can be made. Prevalence rates for medications only declined in each wave from 16.1 percent in Wave 1, to 15.9 percent in Wave 2, to 12.1 percent in Wave 3. This decline was not statistically significant.

Table 8. Percentage of Drivers THC-Positive by Drug Category and Wave (Oral Fluid or Blood) (Percentage by Column)

	Wave 1			Wave 2			Wave 3		
Drug Category	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
THC-positive	14.6	132	[11.9, 17.8]	19.4	127	[16.4, 22.8]	21.4	149	[17.5, 25.9]
THC-positive only	8.7	80	[6.5, 11.5]	13.1	84	[10.6, 16.2]	12.6	92	[9.2, 16.9]
THC-positive plus any other drug	5.9	52	[3.9, 8.8]	6.3	43	[4.4, 9.0]	8.9	57	[5.4, 14.3]
Illegal only	2.4	22	[1.5, 4.0]	2.0	12	[1.2, 3.4]	0.1	2	[0.0, 0.6]
Medications only	16.1	140	[12.9, 19.9]	15.9	113	[13.2, 19.1]	12.1	106	[9.3, 15.6]
Illegal and medications	0.4	1	[0.0, 2.6]	0.5	2	[0.1, 2.0]	0.9	5	[0.2, 4.0]
Total drug-positive	33.4	295	[28.2, 39.2]	37.9	254	[34.4, 41.5]	34.5	262	[30.0, 39.4]
Total drug-negative	66.6	613	[60.8, 71.9]	62.1	418	[58.5, 65.6]	65.5	548	[60.6, 70.0]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.

Drug category prevalence by time of day. Table 9 shows the prevalence of drug categories across waves by time of day. Note that nighttime includes both sessions for Friday and Saturday nights. As stated previously, there was a statistically significant increase in daytime THC-positives at Waves 2 and 3 compared to Wave 1, and a statistically significant increase in daytime THC-positive only at Waves 2 and 3 compared to Wave 1 ($p < .05$).

Table 9. Percentage of Drivers THC-Positive by Drug Category and Time of Day (Percentages by Column)

Drug Category	Daytime			Nighttime			Total		
	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
Wave 1									
THC-positive	7.8	23	[5.8, 10.4]	17.5	109	[14.0, 21.7]	14.6	132	[11.9, 17.8]
THC-positive only	4.6	11	[3.5, 6.0]	10.5	69	[7.4, 14.6]	8.7	80	[6.5, 11.5]
THC-positive plus any other drug	3.2	12	[1.3, 8.0]	7.0	40	[4.6, 10.7]	5.9	52	[3.9, 8.8]
Illegal only	2.2	8	[0.7, 6.6]	2.5	14	[1.5, 4.3]	2.4	22	[14.7, 4.0]
Medications only	13.1	38	[10.3, 16.4]	17.4	102	[13.1, 22.6]	16.1	140	[12.9, 19.9]
Illegal and medications	0.0	0	0	0.5	1	[0.0, 3.6]	0.4	1	[0.0, 2.6]
Total drug-positive	23.0	69	[16.8, 30.8]	37.9	226	[31.7, 44.6]	33.4	295	[28.2, 39.2]
Total drug-negative	77.0	202	[69.2, 83.2]	62.1	411	[55.4, 68.3]	66.6	613	[60.8, 71.9]
Wave 2									
THC-positive	18.4*	34	[12.4, 26.4]	19.7	93	[16.5, 23.5]	19.4	127	[16.4, 22.8]
THC-positive only	13.3*	25	[9.6, 18.1]	13.0	59	[9.9, 16.9]	13.1	84	[10.6, 16.2]
THC-positive plus any other drug	5.1	9	[2.0, 12.5]	6.7	34	[4.6, 9.8]	6.3	43	[4.4, 9.0]
Illegal only	1.9	3	[0.9, 3.9]	2.1	9	[1.1, 3.9]	2.0	12	[1.2, 3.4]
Medications only	11.2	20	[8.5, 14.7]	17.6	93	[14.0, 21.9]	15.9	113	[13.2, 19.1]
Illegal and medications	1.0	1	[0.2, 5.2]	0.4	1	[0.0, 2.5]	0.5	2	[0.1, 2.0]
Total drug-positive	32.4	58	[27.7, 37.5]	39.8	196	[35.7, 44.1]	37.9	254	[34.4, 41.5]
Total drug-negative	67.6	119	[62.5, 72.3]	60.2	299	[56.0, 64.3]	62.1	418	[59.0, 65.6]
Wave 3									
THC-positive	18.9*	35	[11.9, 28.8]	22.2	114	[17.8, 27.5]	21.4	149	[17.5, 25.9]
THC-positive only	10.4*	23	[7.8, 13.7]	13.3	69	[9.0, 19.1]	12.6	92	[9.2, 17.0]
THC-positive plus any other drug	8.6	12	[3.5, 19.5]	8.9	45	[4.9, 15.8]	8.9	57	[5.4, 14.3]
Illegal only	0.0	0	0	0.2	2	[0.0, 0.8]	0.1	2	[0.0, 0.6]
Medications only	13.6	37	[6.6, 26.0]	11.6	69	[9.0, 14.9]	12.1	106	[9.3, 15.7]
Illegal and medications	0.0	0	0	1.2	5	[0.3, 5.3]	0.9	5	[0.2, 4.0]
Total drug-positive	32.6	72	[23.2, 43.6]	35.2	190	[30.2, 40.6]	34.5	262	[30.0, 39.4]
Total drug-negative	67.4	142	[56.4, 76.8]	64.8	406	[59.4, 69.8]	65.5	548	[60.6, 70.0]

In this table, *N*s are unweighted; percentages are weighted.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 (p <.05).

Drug category prevalence by driver demographics. Table 10 shows the prevalence of drivers in each drug category by gender and age. As stated previously, male drivers had a significantly higher rate of THC-positives at Wave 3 compared to Wave 1 (p <.05). There were no statistically significant differences in any other drug category. Note that sample sizes for some groups were small and precluded meaningful interpretation.

Table 10. Percentage of Drivers THC-Positive by Drug Category and Gender and Age (Oral Fluid or Blood) (Percentages by Column)

	Gender		Age (years)				
Drug category	% Male	% Female	% 16–20	% 21–34	% 35–44	% 45–64	% 65+
Wave 1	N = 563	N = 343	N = 106	N = 381	N = 150	N = 228	N = 43
THC-positive	14.8	14.3	17.3	15.7	15.2	11.8	14.0
THC-positive only	8.8	8.5	12.7	8.4	9.8	6.8	9.2
THC-positive and any other drug	6.0	5.8	4.6	7.2	5.4	5.0	4.9
Illegal only	2.1	3.1	1.3	0.9	3.4	4.8	0.0
Medications only	14.7	18.6	3.6	17.9	18.8	16.5	16.0
Illegal and medications	0.0	1.1	0.0	0.0	0.0	1.3	0.0
Total drug-positive	31.6	37.0	22.2	34.5	37.4	34.4	30.0
Total drug-negative	68.4	63.0	77.8	65.5	62.6	65.6	70.0
Wave 2	N = 403	N = 264	N = 86	N = 288	N = 126	N = 130	N = 37
THC-positive	19.9	19.1	19.2	18.9	19.6	20.7	21.5
THC-positive only	12.6	14.2	14.4	12.1	13.1	13.0	21.5
THC-positive and any other drug	7.3	4.9	4.7	6.9	6.5	7.7	0.0
Illegal only	2.1	2.1	2.2	2.6	2.1	1.2	0.0
Medications only	15.0	16.5	13.2	16.4	16.7	14.5	17.0
Illegal and medications	0.8	0.0	2.2	0.6	0.0	0.0	0.0
Total drug-positive	37.8	37.7	36.8	38.5	38.4	36.4	38.5
Total drug-negative	62.3	62.3	63.2	61.6	61.6	63.6	61.6
Wave 3	N = 479	N = 324	N = 112	N = 326	N = 156	N = 178	N = 31
THC-positive	24.7*	17.3	31.2	22.8	19.4	18.6	8.2
THC-positive only	14.1	10.8	28.2	13.5	7.2	8.0	5.2
THC-positive and any other drug	10.6	6.5	3.0	9.3	12.2	10.7	3.0
Illegal only	0.0	0.4	0.0	0.2	0.4	0.0	0.0
Medications only	10.7	13.0	4.0	11.0	11.1	17.1	19.3
Illegal and medications	1.3	0.3	0.0	0.0	2.5	1.9	0.0
Total drug-positive	36.6	31.0	35.2	34.0	33.3	37.6	27.5
Total drug-negative	63.4	69.0	64.8	66.0	66.7	62.4	72.5

In this table, *N*s are unweighted; percentages are weighted.
See Appendix I for confidence intervals.
Column percentages may not total to 100 percent due to rounding.
Because of missing records on the demographic values, totals (*N*) do not match those in other tables.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 (p <.05).

Table 11 shows the prevalence of drivers in each drug category by race and ethnicity. There were no statistically significant differences in any of the drug categories. Note that sample sizes for some groups were small and precluded meaningful interpretation.

Table 11. Percentage of Drivers THC-Positive by Drug Category and Race and Ethnicity (Oral Fluid or Blood) (Percentages by Column)

	Race					Ethnicity	
Drug category	% White	% Black/ African-American	% Asian	% Native American/ Alaskan	% Other/ More than one	% Hispanic	% Non-Hispanic
Wave 1	N = 807	N = 59	N = 17	N = 8	N = 12	N = 160	N = 747
THC-positive	13.7	20.7	15.5	0.0	13.4	11.9	15.1
THC-positive only	8.6	9.5	10.9	0.0	13.4	8.7	8.7
THC-positive and any other drug	5.0	11.2	4.6	0.0	0.0	3.3	6.4
Illegal only	2.6	0.9	0.0	0.0	0.0	3.4	2.3
Medications only	16.8	16.6	0.0	0.0	18.7	13.0	16.6
Illegal and medications	0.4	0.0	0.0	0.0	0.0	2.4	0.0
Total drug-positive	33.5	38.1	15.5	0.0	32.1	30.7	34.0
Total drug-negative	66.5	61.9	84.6	100.0	67.9	69.3	66.0
Wave 2	N = 564	N = 65	N = 28	N = 5	N = 6	N = 118	N = 547
THC-positive	20.2	14.5	12.6	20.4	35.5	14.7	20.7
THC-positive only	13.0	12.2	12.6	0.0	35.5	12.5	13.4
THC-positive and any other drug	7.2	2.3	0.0	20.4	0.0	2.2	7.3
Illegal only	1.7	3.9	3.4	0.0	0.0	2.4	2.0
Medications only	16.7	12.3	12.8	14.1	0.0	5.2	18.1
Illegal and medications	0.6	0.0	0.0	0.0	0.0	1.5	0.3
Total drug-positive	39.2	30.7	28.7	34.5	35.5	23.7	41.0
Total drug-negative	60.8	69.3	71.3	65.5	64.5	76.3	59.0
Wave 3	N = 691	N = 58	N = 20	N = 13	N = 27	N = 121	N = 683
THC-positive	18.9	40.8	13.8	12.9	20.2	14.0	23.3
THC-positive only	10.1	28.2	13.8	6.4	17.4	8.3	13.6
THC-positive and any other drug	8.8	12.5	0.0	6.4	2.8	5.7	9.6
Illegal only	0.2	0.0	0.0	0.0	0.0	0.0	0.2
Medications only	13.3	8.1	0.0	0.0	18.0	9.1	12.2
Illegal and medications	0.9	1.7	0.0	0.0	0.0	2.5	0.7
Total drug-positive	33.2	50.5	13.8	12.9	38.2	25.5	36.3
Total drug-negative	66.8	49.5	86.2	87.1	61.8	74.5	63.7

In this table, *N*s are unweighted; percentages are weighted.
See Appendix I for confidence intervals.
Column percentages may not total to 100 percent due to rounding.
Because of missing records on the demographic values, totals (*N*) do not match those in other tables.
THC-positive includes results from THC and hydroxy-THC.

Drug Classes

Drug class prevalence by wave. Table 12 shows drug class prevalence for daytime and nighttime drivers combined. There were relatively low prevalence rates for some drug classes, including antidepressants only, sedatives only, and other only in all three waves. THC-positive drivers had the highest prevalence across all waves. There were no statistically significant differences in any of the other drug classes.

Table 12. Percentage of Drivers THC-Positive by Drug Class and Wave (Oral Fluid or Blood) (Percentage by Column)

	Wave 1			Wave 2			Wave 3		
Drug Class	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
THC-positive	14.6	132	[11.9, 17.8]	19.4	127	[16.4, 22.8]	21.4	149	[17.5, 25.9]
THC-positive only	8.7	80	[6.5, 11.5]	13.1	84	[10.6, 16.2]	12.6	92	[9.2, 16.9]
THC-positive plus any other drug	5.9	52	[3.9, 8.8]	6.3	43	[4.4, 9.0]	8.9	57	[5.4, 14.2]
Antidepressants only	1.6	15	[0.8, 2.7]	1.8	14	[0.9, 3.3]	2.0	17	[1.1, 3.5]
Narcotic analgesics only	3.3	34	[2.3, 4.8]	5.2	35	[3.7, 7.4]	2.2	16	[1.4, 3.6]
Sedatives only	1.0	9	[0.4, 2.2]	0.8	5	[0.3, 1.9]	1.0	9	[0.4, 2.3]
Stimulants only	8.4	64	[5.8, 12.0]	6.8	47	[4.9, 9.4]	2.5	23	[1.4, 4.5]
Other only	1.9	22	[1.1, 3.3]	1.0	8	[0.4, 2.2]	0.8	8	[0.3, 1.7]
More than one class	2.6	19	[1.6, 4.3]	2.9	18	[1.9, 4.2]	4.7	40	[3.0, 7.2]
Total drug-positive	33.4	295	[28.2, 39.2]	37.9	254	[34.4, 41.5]	34.5	262	[30.0, 39.4]
Total drug-negative	66.6	613	[60.8, 71.9]	62.1	418	[58.5, 65.6]	65.5	548	[60.6, 70.0]

In this table, *N*s are unweighted; percentages are weighted.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.

Drug class prevalence by time of day. Table 13 shows drug class prevalence across waves by time of day. Note that nighttime includes both sessions for Friday and Saturday nights. Low prevalence of antidepressants-only, sedatives-only, and other-only classes precluded meaningful interpretation. As stated previously, there was a statistically significant increase in THC-positive and THC-positive only daytime drivers in Waves 2 and 3 compared to Wave 1 (p <.05). There were no statistically significant differences in any other drug classes.

Table 13. Percentage of Drivers THC-Positive by Drug Class and Time of Day (Oral Fluid or Blood) (Percentages by Column)

Drug Category	Daytime			Nighttime			Total		
	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
Wave 1									
THC-positive	7.8	23	[5.8, 10.4]	17.5	109	[14.0, 21.7]	14.6	132	[11.9, 17.8]
THC-positive only	4.6	11	[3.5, 6.0]	10.5	69	[7.4, 14.6]	8.7	80	[6.5, 11.5]
THC-positive plus any other drug	3.2	12	[1.3, 8.1]	7.0	40	[4.6, 10.7]	5.9	52	[3.9, 8.8]
Antidepressants only	2.1	5	[1.3, 3.6]	1.3	10	[0.5, 3.0]	1.6	15	[0.8, 2.7]
Narcotic analgesics only	5.1	14	[3.4, 7.5]	2.6	20	[1.5, 4.6]	3.3	34	[2.3, 4.8]
Sedatives only	0.6	2	[0.1, 2.8]	1.1	7	[0.5, 2.8]	1.0	9	[0.5, 2.2]
Stimulants only	3.2	10	[1.6, 6.3]	10.6	54	[7.3, 15.3]	8.4	64	[5.8, 12.0]
Other only	3.5	12	[1.4, 8.4]	1.3	10	[0.7, 2.4]	1.9	22	[1.1, 3.3]
More than one class	0.7	3	[0.2, 2.3]	3.5	16	[2.2, 5.6]	2.6	19	[1.6, 4.3]
Total drug-positive	23.0	69	[16.8, 30.8]	37.9	226	[31.7, 44.6]	33.4	295	[28.2, 39.2]
Total drug-negative	77.0	202	[69.2, 83.2]	62.1	411	[55.4, 68.3]	66.6	613	[60.8, 71.9]
Wave 2									
THC-positive	18.4*	34	[12.4, 26.4]	19.7	93	[16.5, 23.5]	19.4	127	[16.4, 22.8]
THC-positive only	13.3*	25	[9.6, 18.1]	13.0	59	[9.9, 16.9]	13.1	84	[10.6, 16.2]
THC-positive plus any other drug	5.1	9	[2.0, 12.5]	6.7	34	[4.6, 9.8]	6.3	43	[4.4, 9.0]
Antidepressants only	0.7	2	[0.0, 5.9]	2.2	12	[1.1, 4.0]	1.8	14	[0.9, 3.3]
Narcotic analgesics only	3.6	6	[1.7, 7.7]	5.8	29	[3.9, 8.5]	5.2	35	[3.7, 7.4]
Sedatives only	0.0	0	0	1.1	5	[0.5, 2.5]	0.8	5	[0.3, 1.9]
Stimulants only	3.9	6	[1.9, 7.7]	7.9	41	[5.4, 11.3]	6.8	47	[4.9, 9.4]
Other only	1.8	4	[0.6, 5.3]	0.7	4	[0.2, 2.4]	1.0	8	[0.5, 2.2]
More than one class	4.0	6	[2.4, 6.6]	2.5	12	[1.5, 4.1]	2.9	18	[1.9, 4.2]
Total drug-positive	32.4	58	[27.7, 37.5]	39.8	196	[35.7, 44.1]	37.9	254	[34.4, 41.5]
Total drug-negative	67.6	119	[62.5, 72.3]	60.2	299	[55.9, 64.3]	62.1	418	[58.5, 65.6]
Wave 3									
THC-positive	18.9*	35	[11.9, 28.8]	22.2	114	[17.8, 27.5]	21.4	149	[17.5, 25.9]
THC-positive only	10.4*	23	[7.8, 13.7]	13.3	69	[9.0, 19.1]	12.6	92	[9.2, 16.9]
THC-positive plus any other drug	8.6	12	[3.5, 19.5]	8.9	45	[4.9, 15.8]	8.9	57	[5.4, 14.3]
Antidepressants only	3.0	9	[1.2, 7.5]	1.6	8	[0.7, 3.5]	2.0	17	[1.1, 3.5]
Narcotic analgesics only	2.0	5	[0.6, 7.1]	2.3	11	[1.4, 3.7]	2.2	16	[1.4, 3.6]
Sedatives only	0.7	2	[0.0, 2.9]	1.1	7	[0.4, 2.8]	1.0	9	[0.4, 2.3]
Stimulants only	1.8	5	[0.5, 6.6]	2.8	18	[1.5, 5.2]	2.5	23	[1.4, 4.5]
Other only	2.4	6	[1.0, 5.6]	0.2	2	[0.0, 1.7]	0.8	8	[0.3, 1.7]
More than one class	3.8	10	[1.4, 9.5]	5.0	30	[3.0, 8.1]	4.7	40	[3.0, 7.2]
Total drug-positive	32.6	72	[23.2, 43.6]	35.3	190	[30.2, 40.6]	34.5	262	[30.0, 39.4]
Total drug-negative	67.4	142	[56.4, 76.8]	64.7	406	[59.4, 69.8]	65.5	548	[60.6, 70.0]

In this table, Ns are unweighted; percentages are weighted.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.
*Significantly different from Wave 1 ($p < .05$).

Drug class prevalence by demographic factors. Table 14 shows the prevalence of drug classes by gender and age. The relatively low prevalence rates for antidepressants-only, sedatives-only, and other-only classes precluded any meaningful interpretation. As stated previously, male drivers had a statistically significant higher rate of THC-positives at Wave 3 compared to Wave 1 (p <.05). There were no statistically significant differences in any other drug class.

Table 14. Percentage of Drivers THC-Positive by Drug Class and Gender and Age (Oral Fluid or Blood) (Percentages by Column)

	Gender		Age (years)				
Drug Class	% Male	% Female	% 16–20	% 21–34	% 35–44	% 45–64	% 65+
Wave 1	*N* = 563	*N* = 343	*N* = 106	*N* = 381	*N* = 150	*N* = 228	*N* = 43
THC-positive	14.8	14.3	17.3	15.7	15.2	11.8	14.0
THC-positive only	8.8	8.5	12.7	8.4	9.8	6.8	9.2
THC-positive and any other drug	6.0	5.8	4.6	7.2	5.4	5.0	4.9
Antidepressants only	1.5	1.7	0.8	1.1	1.0	2.4	3.7
Narcotic analgesics only	2.0	5.8	1.6	2.0	2.1	5.1	12.3
Sedatives only	1.3	0.4	0.4	2.1	0.0	0.5	0.0
Stimulants only	8.3	8.6	0.6	8.9	14.2	8.7	0.0
Other only	1.3	3.1	0.6	1.6	3.2	2.4	0.0
More than one class	2.4	3.0	0.8	3.3	1.8	3.5	0.0
Total drug-positive	31.6	37.0	22.2	34.5	37.4	34.4	30.0
Total drug-negative	68.4	63.0	77.8	65.5	62.6	65.6	70.0
Wave 2	*N* = 403	*N* = 264	*N* = 86	*N* = 288	*N* = 126	*N* = 130	*N* = 37
THC-positive	19.8	19.1	19.2	18.9	19.6	20.7	21.5
THC-positive only	12.6	14.2	14.4	12.1	13.1	13.0	21.5
THC-positive and any other drug	7.3	4.9	4.7	6.9	6.5	7.7	0.0
Antidepressants only	1.8	1.8	1.3	2.5	1.2	0.8	2.0
Narcotic analgesics only	5.7	4.6	8.3	5.9	2.9	1.8	14.9
Sedatives only	0.8	0.8	0.0	0.7	1.6	0.9	0.0
Stimulants only	5.3	8.6	4.3	7.2	9.8	5.8	0.0
Other only	1.1	0.9	1.5	0.3	0.0	3.6	0.0
More than one class	3.3	1.8	2.2	2.9	3.3	2.9	0.0
Total drug-positive	37.8	37.7	36.8	38.5	38.4	36.4	38.5
Total drug-negative	62.3	62.3	63.2	61.6	61.6	63.6	61.6

Drug Class	Gender		Age (years)				
	% Male	% Female		% Male	% Female		% Male
Wave 3	*N* = 479	*N* = 324	*N* = 112	*N* = 326	*N* = 156	*N* = 178	*N* = 31
THC-positive	24.7*	17.3	31.2	22.8	19.4	18.6	8.2
THC-positive only	14.1	10.8	28.2	13.5	7.2	8.0	5.2
THC-positive and any other drug	10.6	6.5	3.0	9.3	12.2	10.7	3.0
Antidepressants only	1.3	3.1	0.8	2.9	1.2	2.2	0.0
Narcotic analgesics only	2.6	1.4	2.7	2.1	2.6	2.5	0.0
Sedatives only	1.0	1.0	0.0	0.3	1.2	1.5	9.7
Stimulants only	2.8	1.5	0.6	2.5	2.3	3.3	0.0
Other only	0.3	1.5	0.0	0.4	0.0	1.7	6.2
More than one class	4.0	5.1	0.0	3.0	6.8	7.9	3.4
Total drug-positive	36.6	31.0	35.2	34.0	33.3	37.6	27.5
Total drug-negative	63.4	69.0	64.8	66.0	66.7	62.4	72.5

In this table, Ns are unweighted; percentages are weighted.
See Appendix J for confidence intervals.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.
Because of missing records on the demographic values, totals (N) do not match those in other tables.
*Significantly different from Wave 1 ($p < .05$).

Table 15 shows the prevalence of drug classes by race and ethnicity. The relatively low prevalence rates for antidepressants-only, sedatives-only, and other-only classes precluded any meaningful interpretation. There were no statistically significant differences in any drug class.

Table 15. Percentage of Drivers THC-Positive by Drug Class and Race and Ethnicity (Oral Fluid or Blood) (Percentages by Column)

	Race					Ethnicity	
Drug Class	% White	% Black/ African American	% Asian	% Native American/ Alaskan	% Other/ More than one	% Hispanic	% Non-Hispanic
Wave 1	*N* = 807	*N* = 59	*N* = 17	*N* = 8	*N* = 12	*N* = 160	*N* = 747
THC-positive	13.6	20.7	15.5	0.0	13.4	11.9	15.1
THC-positive only	8.6	9.5	10.9	0.0	13.4	8.7	8.7
THC-positive and any other drug	5.0	11.2	4.6	0.0	0.0	3.3	6.4
Antidepressants only	1.8	0.5	0.0	0.0	0.0	3.0	1.3
Narcotic analgesics only	3.0	8.5	0.0	0.0	0.0	1.2	3.8
Sedatives only	0.7	3.8	0.0	0.0	0.0	2.2	0.8
Stimulants only	9.3	3.8	0.0	0.0	11.4	8.6	8.4
Other only	2.1	0.9	0.0	0.0	0.0	0.4	2.2
More than one class	3.0	0.0	0.0	0.0	7.3	3.4	2.5
Total drug-positive	33.5	38.1	15.5	0.0	32.1	30.7	34.0
Total drug-negative	66.5	61.9	84.6	100.0	67.9	69.3	66.0
Wave 2	*N* = 564	*N* = 65	*N* = 28	*N* = 5	*N* = 6	*N* = 118	*N* = 547
THC-positive	20.2	14.5	12.6	20.4	35.5	14.7	20.7
THC-positive only	13.0	12.2	12.6	0.0	35.5	12.5	13.4
THC-positive and any other drug	7.2	2.3	0.0	20.4	0.0	2.2	7.3
Antidepressants only	1.9	1.3	0.0	14.1	0.0	3.4	1.5
Narcotic analgesics only	5.3	5.9	5.1	0.0	0.0	1.7	6.1
Sedatives only	0.6	2.5	0.0	0.0	0.0	0.0	1.0
Stimulants only	6.9	6.6	6.2	0.0	0.0	2.0	7.8
Other only	1.3	0.0	0.0	0.0	0.0	0.0	1.2
More than one class	3.1	0.0	4.9	0.0	0.0	2.1	2.9
Total drug-positive	39.2	30.7	28.7	34.5	35.5	23.7	41.0
Total drug-negative	60.8	69.3	71.3	65.5	64.5	76.3	59.0

Drug Class	Race					Ethnicity	
	% White	% Black/ African American	% Asian	% White	% Black/ African American	% Hispanic	% White
Wave 3	*N* = 691	*N* = 58	*N* = 20	*N* = 13	*N* = 27	*N* = 121	*N* = 683
THC-positive	18.9	40.8	13.8	12.9	20.2	14.0	23.3
THC-positive only	10.1	28.2	13.8	6.4	17.4	8.3	13.6
THC-positive and any other drug	8.8	12.5	0.0	6.4	2.8	5.7	9.6
Antidepressants only	2.3	1.0	0.0	0.0	0.0	1.8	2.0
Narcotic analgesics only	2.8	0.0	0.0	0.0	0.0	0.6	2.6
Sedatives only	1.1	0.8	0.0	0.0	0.0	0.7	1.1
Stimulants only	2.2	3.6	0.0	0.0	9.0	2.4	2.2
Other only	1.0	0.0	0.0	0.0	0.0	0.0	0.9
More than one class	4.9	4.3	0.0	0.0	9.0	6.0	4.2
Total drug-positive	33.2	50.5	13.8	12.9	38.2	25.5	36.3
Total drug-negative	66.8	49.5	86.2	87.1	61.8	74.5	63.7

In this table, Ns are unweighted; percentages are weighted.
See Appendix J for confidence intervals.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.
Because of missing records on the demographic values, totals (N) do not match those in other tables.

Drugs by Alcohol Concentration

Alcohol prevalence by wave. Table 16 shows prevalence rates for alcohol concentration levels across the three waves for those drivers who provided a breath sample. The column ">.00" represents all alcohol positives. At Wave 1, 6.0 percent of drivers were alcohol-positive. This proportion dropped to 3.9 percent at Wave 2, and rose slightly to 4.4 percent at Wave 3. There were no statistically significant findings between waves.

Table 16. Percentage of Drivers Positive for Alcohol by Concentration (Percentages by Row)

		Alcohol Concentration									
	N	% .00	95% CI	% >.00	95% CI	% .001–.049	95% CI	% .05–.079	95% CI	% .08+	95% CI
Wave 1	920	93.9	[90.4, 96.2]	6.0	[3.8, 9.6]	4.2	[2.6, 7.0]	0.7	[0.2, 3.3]	1.1	[0.6, 2.3]
Wave 2	692	96.1	[94.3, 97.3]	3.9	[2.7, 5.8]	1.8	[0.8, 4.1]	0.6	[0.2, 1.8]	1.5	[0.8, 2.7]
Wave 3	819	95.6	[92.8, 97.3]	4.4	[2.7, 7.2]	2.5	[1.3, 4.8]	1.2	[0.5, 2.7]	0.7	[0.3, 1.6]

In this table, Ns are unweighted; percentages are weighted.
Row percentages may not total to 100 percent due to rounding.
N's do not match the total number of breath samples because of 8 additional cases included in this table in which BAC was determined from blood samples as opposed to breath samples.
The column "> .00" represents all alcohol positives (applies to the three right-most columns).

Alcohol and drug presence by wave. Table 17 shows drivers (who provided a breath sample and an oral fluid and/or blood sample) by wave, and whether they were positive for alcohol, THC or other drugs. There was an increase in THC-positive drivers, who were alcohol-free, at Waves 2 and 3 compared to Wave 1, however these increases were not statistically significant. There was a decrease, but not a statistically significant one, in the percentage of drivers who tested positive for any other drug (besides THC) and were alcohol-free from Wave 1 (17.2%) compared to Wave 3 (13.0%). In Wave 1, the percentage of THC-positive drivers who were alcohol-free (13.2%), was double that of alcohol- positive drivers (6.2%). In Waves 2 and 3, the percentage of THC-positive drivers who were alcohol-free (19.1% and 20.2%, respectively), was more than four times that of alcohol-positive drivers (4.1% and 4.3%).

Table 17: Percentage of Alcohol and Drug Positive Drivers by Wave (Percentage by Column)

	Wave 1			Wave 2			Wave 3		
	%	*N*	95% CI	%	*N*	95% CI	%	*N*	95% CI
Alcohol-positive	6.2	46	[3.9, 9.8]	4.1	25	[2.8, 6.0]	4.3	28	[2.6, 7.2]
Alcohol plus THC	1.2	9	[0.6, 2.5]	0.4	3	[0.1, 1.4]	1.3	9	[0.6, 2.8]
Alcohol plus any other drug	1.8	11	[0.9, 3.5]	1.2	8	[0.7, 2.3]	0.3	3	[0.0, 0.8]
Alcohol only	3.2	26	[1.9, 5.2]	2.4	14	[1.5, 3.9]	2.7	16	[1.5, 5.0]
Alcohol-negative	93.8	858	[90.2, 96.1]	95.9	643	[94.0, 97.3]	95.7	781	[92.8, 97.4]
THC and no alcohol	13.2	121	[10.3, 16.9]	19.1	124	[16.1, 22.6]	20.2	140	[16.3, 24.7]
Any other drug and no alcohol	17.2	152	[14.4, 20.3]	17.3	119	[14.9, 20.0]	13.0	110	[9.9, 16.6]
No drugs and no alcohol	63.4	585	[57.8, 68.7]	59.5	400	[55.4, 63.5]	62.6	531	[56.8, 67.9]

In this table, Ns are unweighted; percentages are weighted.
Column percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.

THC prevalence by Alcohol Concentration. Table 18 shows prevalence rates for THC by alcohol concentration. The column ">.00" represents all alcohol positives. Table 18 differs from Table 17 in that in the previous table the weighted percentage is from the number of alcohol plus THC-positive drivers out of the total sample of drivers for that wave. For example, in Wave 1 the percent of alcohol plus THC-positive drivers is derived from the 9 alcohol plus THC-positive drivers out of the 904 drivers who provided both a breath sample and an oral fluid and/or blood sample in that wave. In Table 18, the weighted percentage is from the number of alcohol plus THC-positive drivers out of the total sample of drivers who were THC-positive. In Wave 1, there were 130 THC-positive drivers and 9 of those drivers were also positive for alcohol.

Positive alcohol in conjunction with positive THCs was not common, with the highest percent occurring at Wave 1, when 8.5 percent of drivers were both THC- and alcohol-positive. The comparable figure was 2.2 percent at Wave 2 and 6.2 percent at Wave 3. The percentage of drivers who were THC-positive and had alcohol concentrations at or higher than .08 g/dL declined in each successive wave. Drivers who were THC-positive and had alcohol concentrations between .05 and .079, increased slightly at Wave 2 and had a notable increase at Wave 3. However, no statistically significant differences were found in the distribution of THC among positive alcohol levels in any wave.

Table 18. Percentage of Drivers THC-Positive by Alcohol Concentration Level and Wave (Oral Fluid or Blood) (Percentage by Row)

		Alcohol Concentration									
THC	*N*	% .00	95% CI	% >.00	95% CI	% .001–.049	95% CI	% .05–.079	95% CI	% .08+	95% CI
Wave 1											
THC-negative	774	94.2	[90.9, 96.3]	5.8	[3.7, 9.1]	4.0	[2.5, 6.4]	0.8	[0.1, 4.4]	1.0	[0.3, 2.5]
THC-positive	130	91.5	[82.0, 96.2]	8.5	[3.8, 18.0]	5.7	[2.1, 14.6]	0.6	[0.0, 4.7]	2.2	[0.3, 6.0]
Wave 2											
THC-negative	541	95.5	[93.1, 97.0]	4.5	[3.0, 6.9]	2.3	[0.9, 5.3]	0.6	[0.2, 2.3]	1.6	[0.8, 3.0]
THC-positive	127	97.8	[93.0, 99.4]	2.2	[0.6, 7.0]	0.0	0	0.8	[0.0, 5.5]	1.4	[0.3, 6.1]
Wave 3											
THC-negative	660	96.2	[93.2, 97.9]	3.8	[2.1, 6.8]	2.7	[1.2, 5.9]	0.4	[0.1, 1.4]	0.7	[0.3, 1.8]
THC-positive	149	93.8	[87.4, 97.1]	6.2	[2.9, 12.6]	1.4	[0.4, 4.7]	3.9	[1.3, 11.2]	0.9	[0.2, 4.2]

In this table, *N*s are unweighted; percentages are weighted.
THC-positive includes results from THC and hydroxy-THC.
Row percentages may not total to 100 percent due to rounding.
The column "> .00" represents all alcohol positives (applies to the three right-most columns).

Alcohol concentration by drug category. Table 19 shows the prevalence of different alcohol concentration levels among drivers in each drug category. The column ">.00" represents all alcohol positives. When examining drug categories, there were no statistically significant differences in alcohol concentration levels between waves. There was a notable decrease in THC-positive drivers at .08 or higher, from 2.2 percent in Wave 1, to 1.4 percent in Wave 2 and 0.9 percent in Wave 3, but the differences were not statistically significant. Although there are some other additional differences in drug prevalence at each alcohol concentration level across waves, the small sample sizes precluded any meaningful interpretation of these differences.

Table 19. Percentage of Drivers Positive for Alcohol by Concentration and Drug Category (Percentage by Row)

Drug category	*N*	Alcohol Concentration: % .00	95% CI	% >.00	95% CI	% .001–.049	95% CI	% .05–.079	95% CI	% .08+	95% CI
Wave 1											
THC-positive	130	91.5	[82.1, 96.2]	8.5	[38.3, 18.0]	5.7	[2.1, 14.6]	0.6	[0.0, 4.7]	2.2	[0.8, 6.0]
THC-positive only	80	93.4	[83.1, 97.6]	6.6	[2.4, 16.9]	4.0	[1.3, 11.8]	0.0	0	2.6	[0.7, 8.7]
THC-positive and any other drug	50	88.5	[65.2, 96.9]	11.5	[3.1, 34.8]	8.3	[1.5, 34.5]	1.5	[0.2, 11.3]	1.7	[0.2, 14.2]
Illegal only	22	79.9	[47.2, 96.7]	20.1	[5.3, 52.9]	8.4	[2.0, 29.4]	11.7	[1.5, 54.4]	0.0	0
Medications only	140	91.7	[83.0, 96.2]	8.3	[3.8, 17.0]	4.2	[1.3, 12.5]	0.0	0	4.1	[1.2, 12.8]
Illegal and medications	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total drug-positive	293	90.8	[84.8, 94.6]	9.2	[5.4, 15.2]	5.1	[2.8, 9.1]	1.1	[0.3, 4.8]	2.9	[1.2, 6.9]
Total drug-negative	611	95.3	[92.3, 97.1]	4.7	[2.9, 7.7]	3.9	[2.2, 6.9]	0.6	[0.1, 2.8]	0.2	[0.0, 1.2]
Wave 2											
THC-positive	127	97.9	[93.0, 99.4]	2.1	[0.6, 7.0]	0.0	0	0.7	[0, 5.5]	1.4	[0.3, 6.1]
THC-positive only	84	99.0	[92.5, 99.9]	1.0	[0.1, 7.5]	0.0	0	0.0	0	1.0	[0.1, 7.5]
THC-positive and any other drug	43	95.5	[82.3, 99.0]	4.5	[1.0, 17.7]	0.0	0	2.3	[0.3, 15.9]	2.2	[0.3, 15.8]
Illegal only	12	88.5	[53.7, 98.1]	11.5	[1.9, 46.3]	11.5	[1.9, 46.3]	0.0	0	0.0	0
Medications only	113	93.7	[87.1, 97.0]	6.3	[3.0, 12.9]	2.8	[0.7, 10.0]	1.0	[0.1, 7.8]	2.5	[0.8, 7.3]
Illegal and medications	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total drug-positive	254	95.7	[92.7, 97.4]	4.3	[2.6, 7.3]	1.8	[0.7, 4.8]	0.8	[0.2, 3.0]	1.7	[0.7, 4.2]
Total drug-negative	414	96.1	[93.7, 97.6]	3.9	[2.4, 6.3]	1.9	[0.7, 5.0]	0.6	[0.1, 2.7]	1.4	[0.6, 3.3]
Wave 3											
THC-positive	149	93.8	[87.4, 97.1]	6.2	[2.9, 12.6]	1.4	[0.4, 4.7]	3.9	[1.3, 11.2]	0.9	[0.2, 4.2]
THC-positive only	92	93.2	[82.4, 97.5]	6.8	[2.5, 17.6]	0.6	[0.0, 5.0]	5.4	[1.5, 17.5]	0.8	[0.0, 7.0]
THC-positive and any other drug	57	94.8	[86.5, 98.1]	5.2	[1.9, 13.5]	2.5	[0.5, 10.6]	1.8	[0.4, 8.8]	1.0	[0.1, 7.8]
Illegal only	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Medications only	106	97.9	[93.0, 99.4]	2.1	[0.6, 7.0]	0.8	[0.0, 6.2]	0.7	[0.0, 5.6]	0.6	[0.0, 5.1]
Illegal and medications	5	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total drug-positive	262	95.4	[91.7, 97.5]	4.6	[2.5, 8.3]	1.1	[0.4, 3.1]	2.7	[0.9, 7.3]	0.8	[0.2, 2.6]
Total drug-negative	547	95.8	[92.2, 97.8]	4.2	[2.2, 7.9]	3.1	[1.4, 7.1]	0.4	[0.0, 1.6]	0.7	[0.3, 2.0]

In this table, *N*s are unweighted; percentages are weighted.
Row percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.
The column "> .00" represents all alcohol positives (applies to the three right-most columns).

Alcohol concentration by drug class. Table 20 shows alcohol categories among drivers by drug class. The column ">.00" represents all alcohol positives. The combination of alcohol and other drugs was not common. At least 90 percent of drivers in most drug classes across the waves had no measurable alcohol concentration in their system, with a few notable exceptions. In Wave 1, 11.5 percent of drivers who were THC-positive and with any other drugs, and 11.5 percent of drivers with stimulants-only, were positive for alcohol. In Wave 2, 11.0 percent of drivers with stimulants-only, and 29.7 percent of drivers with sedatives-only, were positive for alcohol. In addition, among drivers who were positive for sedatives, over 70 percent were positive for alcohol in Wave 1. This group was relatively small and this phenomenon did not occur in the other waves. There were no statistically significant differences in alcohol levels between drug classes at any wave.

Table 20. Percentage of Drivers Positive for Alcohol by Concentration and Drug Class (Percentages by Row)

Drug class	*N*	Alcohol Concentration % .00	95% CI	% >.00	95% CI	% .001–.049	95% CI	% .05–.079	95% CI	% .08+	95% CI
Wave 1											
THC-positive	130	91.5	[82.1, 96.2]	8.5	[3.8, 18.0]	5.7	[2.1, 14.6]	0.6	[0.0, 4.7]	2.2	[0.8, 5.9]
THC-positive only	80	93.4	[83.1, 97.6]	6.6	[2.4, 16.9]	4.1	[1.3, 11.8]	0.0	0	2.6	[0.7, 8.7]
THC-positive and any other drug	50	88.5	[65.2, 96.9]	11.5	[3.1, 34.8]	8.3	[1.5, 34.5]	1.5	[0.2, 11.3]	1.8	[0.2, 14.2]
Antidepressants only	15	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Narcotic analgesics only	34	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Sedatives only	9	29.4	[7.2, 69.1]	70.7	[30.9, 92.9]	13.0	[1.5, 59.3]	0.0	0	57.7	[19.7, 88.3]
Stimulants only	64	88.5	[77.2, 94.6]	11.5	[5.4, 22.8]	7.1	[2.3, 19.9]	3.4	[0.5, 20.7]	1.0	[0.1, 7.9]
Other only	22	96.5	[76.2, 99.6]	3.5	[0.4, 23.8]	3.5	[0.4, 23.8]	0.0	0	0.0	0
More than one class	19	96.8	[76.8, 99.6]	3.2	[0.4, 23.2]	3.2	[0.4, 23.2]	0.0	0	0.0	0
Total drug-positive	293	90.8	[84.8, 94.6]	9.2	[5.4, 15.2]	5.1	[2.8, 9.1]	1.1	[0.3, 4.8]	2.9	[1.2, 6.9]
Total drug-negative	611	95.3	[92.3, 97.1]	4.7	[2.9, 7.7]	3.9	[2.2, 6.9]	0.6	[0.1, 2.8]	0.3	[0.0, 1.2]
Wave 2											
THC-positive	127	97.9	[93.0, 99.4]	2.1	[0.6, 7.0]	0.0	0	0.7	[0.0, 5.5]	1.4	[0.3, 6.1]
THC-positive only	84	99.0	[92.5, 99.9]	1.0	[0.1, 7.5]	0.0	0	0.0	0	1.0	[0.1, 7.5]
THC-positive and any other drug	43	95.5	[82.3, 99.0]	4.5	[1.0, 17.7]	0.0	0	2.3	[0.3, 15.9]	2.2	[0.3, 15.8]
Antidepressants only	14	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Narcotic analgesics only	35	95.2	[69.8, 99.4]	4.8	[0.6, 30.3]	4.8	[0.6, 30.3]	0.0	0	0.0	0
Sedatives only	5	70.3	[19.6, 95.8]	29.7	[4.2, 80.4]	29.7	[4.2, 80.4]	0.0	0	0.0	0
Stimulants only	47	89.0	[78.5, 94.7]	11.0	[5.3, 21.5]	2.8	[0.6, 12.0]	2.4	[0.3, 17.4]	5.8	[2.0, 15.7]
Other only	8	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
More than one class	18	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total drug-positive	254	95.7	[92.7, 97.4]	4.3	[2.6, 7.3]	1.8	[0.6, 4.8]	0.8	[0.2, 3.0]	1.8	[0.7, 4.2]
Total drug-negative	414	96.1	[93.7, 97.6]	3.9	[2.4, 6.3]	1.9	[0.7, 5.0]	0.6	[0.1, 2.7]	1.4	[0.6, 3.3]
Wave 3											
THC-positive	149	93.8	[87.4, 97.1]	6.2	[2.9, 12.6]	1.4	[0.4, 4.7]	3.9	[1.3, 11.2]	0.9	[0.2, 4.2]
THC-positive only	92	93.2	[82.4, 97.5]	6.8	[2.5, 17.6]	0.6	[0.0, 5.0]	5.4	[2.0, 17.5]	0.9	[0.0, 7.0]
THC-positive and any other drug	57	94.8	[86.5, 98.1]	5.3	[2.0, 13.5]	2.5	[0.5, 10.6]	1.8	[0.4, 8.8]	1.0	[0.1, 7.8]
Antidepressants only	17	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Narcotic analgesics only	16	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Sedatives only	9	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Stimulants only	23	92.9	[69.9, 98.7]	7.1	[1.4, 30.1]	3.8	[0.4, 26.7]	3.3	[0.4, 25.0]	0.0	0
Other only	8	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0
More than one class	40	98.4	[86.9, 99.8]	1.6	[0.2, 13.1]	0.0	0	0.0	0	1.6	[0.2, 13.1]
Total drug-positive	262	95.5	[91.7, 97.5]	4.5	[2.5, 8.3]	1.1	[0.4, 3.1]	2.6	[0.9, 7.3]	0.8	[0.2, 2.6]
Total drug-negative	547	95.8	[92.2, 97.8]	4.2	[2.2, 7.9]	3.1	[1.4, 7.1]	0.4	[0.0, 1.6]	0.7	[0.3, 2.0]

In this table, Ns are unweighted; percentages are weighted.
Row percentages may not total to 100 percent due to rounding.
THC-positive includes results from THC and hydroxy-THC.
The column "> .00" represents all alcohol positives (applies to the three right-most columns).

Drug Prevalence Estimates

Table 21 shows the prevalence estimates for each drug independent of whether other drugs were found in an individual driver. Thus, a driver who tested THC-positive and cocaine would appear twice in Table 20.

Table 21 shows that the most frequently encountered single drug was delta-9-tetrahydrocannabinol (THC). Delta-9-THC was detected in 10.0 percent of all daytime drivers and 15.8 percent of all nighttime drivers. Amphetamines/stimulants were the second most prevalent drug found in daytime drivers (6.7%), followed by opioids (6.2%).

Among nighttime drivers, amphetamines/stimulants were the second most prevalent drug (11.7%), followed by opioids (6.0%).

Table 21. Drug Prevalence in Oral Fluid or Blood among Daytime and Nighttime Drivers

Drug	Daytime *N* = 662		Nighttime *N* = 1,728	
	N	%	*N*	%
Cannabinoids	92	10.0	316	15.8
THC	92	10.0	316	15.8
11-OH-THC	32	2.3	103	3.7
Cocaine	8	1.6	17	1.5
Cocaine	8	1.6	16	1.5
Benzoylecgonine	5	1.0	10	1.1
Cocaethylene	1	0.4	7	0.7
Norcocaine	1	0.4	9	0.6
Opioids	42	6.2	109	6.0
Codeine	2	0.4	2	0.2
Heroin	15	0.3	23	1.8
Naltrexone	0	0.0	1	0.0
Buprenorphine	1	0.2	9	0.8
Norbuprenorphine	1	0.3	5	0.4
Fentanyl	1	0.0	0	0.0
Hydrocodone	17	2.0	28	1.6
Hydromorphone	2	0.2	1	0.0
Meperidine	0	0.0	0	0.0
Methadone	2	0.4	3	0.4
Morphine	7	1.1	35	2.1
Oxycodone	10	1.2	23	1.7
Oxymorphone	2	0.3	3	0.2
Propoxyphene	0	0.0	0	0.0
Tramadol	6	1.2	13	0.7
Amphetamines/Stimulants	40	6.7	172	11.7
MDMA	0	0.0	2	0.0
MDA	0	0.0	1	0.0
MDEA	0	0.0	0	0.0
Amphetamine	37	6.4	166	11.5

Methamphetamine	6	1.2	11	1.1
Phentermine	1	0.4	2	0.0
Methylphenidate	1	0.3	0	0.0
Dissociative Anesthetics	0	0.0	1	0.2
Ketamine	0	0.0	0	0.0
PCP	0	0.0	1	0.2
Benzodiazepines	8	1.2	31	1.9
Alprazolam	4	0.8	13	0.7
Bromazepam	0	0.0	0	0.0
Chlordiazepoxide	0	0.0	2	0.0
Clonazepam	3	0.4	9	0.5
Diazepam	1	0.1	9	0.5
Nordiazepam	1	0.1	13	0.7
Lorazepam	0	0.0	2	0.0
Oxazepam	0	0.0	6	0.4
Estazolam	0	0.0	0	0.0
Flunitrazepam	0	0.0	0	0.0
Flurazepam	0	0.0	0	0.0
Midazolam	0	0.0	0	0.0
Nitrazepam	0	0.0	0	0.0
Phenazepam	0	0.0	0	0.0
Triazolam	0	0.0	0	0.0
Temazepam	1	0.1	8	0.4
Antidepressants	17	2.2	23	1.2
Amitriptyline	5	0.7	3	0.3
Nortriptyline	7	1.2	7	0.6
Fluoxetine	7	1.0	18	1.4
Imipramine	0	0.0	0	0.0
Desipramine	0	0.0	0	0.0
Amoxapine	0	0.0	0	0.0
Dothiepin	0	0.0	0	0.0
Doxepin	0	0.0	0	0.0
Desmethyldoxepin	0	0.0	0	0.0
Protriptyline	0	0.0	0	0.0
Trimipramine	0	0.0	0	0.0
Mianserine	0	0.0	0	0.0
Mirtazepine	0	0.0	0	0.0
Trazodone	1	0.0	3	0.1
Citalopram	2	0.2	4	0.2
Paroxetine	1	0.1	0	0.0
Venlafaxine	0	0.0	2	0.0
Sertraline	9	1.4	16	0.8
Barbiturates	2	0.2	6	0.4
Butalbital	2	0.2	4	0.3
Pentobarbital	0	0.0	0	0.0
Secobarbital	0	0.0	0	0.0
Phenobarbital	0	0.0	2	0.2

Muscle Relaxants	7	0.9	7	0.6
Carisoprodol	0	0.0	0	0.0
Cyclobenzaprine	7	0.9	4	0.4
Meprobamate	0	0.0	4	0.3
Sleep Aids				
Zolpidem	1	0.1	2	0.2
Cough Suppressants				
Dextromethorphan	1	0.3	9	0.6
Antihistamines	19	2.6	29	1.4
Chlorpheniramine	0	0.0	0	0.0
Diphenhydramine	19	2.6	27	1.4
Doxylamine	2	0.3	3	0.3
Antipsychotics				
Chlorpromazine	0	0.0	0	0.0
Synthetic Cannabinoids	1	0.2	1	0.0
AM-1220	0	0.0	0	0.0
AM-2201	1	0.1	0	0.0
AM-2232	0	0.0	0	0.0
CP47497	0	0.0	0	0.0
CP47497-C8	0	0.0	0	0.0
HU-210	0	0.0	0	0.0
JWH-018	1	0.1	1	0.0
JWH-022	1	0.1	1	0.0
JWH-073	0	0.0	0	0.0
JWH-200	0	0.0	0	0.0
JWH-250	0	0.0	1	0.1
XLR-11	1	0.1	0	0.0
UR-144	0	0.0	0	0.0
All Drug-positives[†]	353		1,050	
All Tested Drivers [††]	199	28.5	612	37.5

In this table, *N*s are unweighted; percentages are weighted.
[†] Indicates the total number of positive screenings regardless of how many substances were found in each driver.
[††] Indicates number and percentage of drivers who screened positively for at least one substance.

Additional Analyses

Synthetic marijuana prevalence by wave. Synthetic cannabinoid preparations are available in various forms and claim to have similar effects as THC. We tested for thirteen types of synthetic marijuana.

Table 22 shows the prevalence, 2 drivers, who tested positive for synthetic marijuana across the study. Both drivers were from Wave 1 and were male. One was between 21and 34 years and the other was in the 45 and 64 age range.

Table 22. Percentage of Drivers Positive for Synthetic Marijuana by Wave (Oral Fluid or Blood)

Region	*N*	Positive *N*	% positive
Wave 1	908	2	0.2
Wave 2	672	0	0.0
Wave 3	810	0	0.0

In this table, Ns are unweighted; percentages are weighted.
No statistical comparisons were attempted on items with small sample sizes.

THC concentration levels by wave. Table 23 shows the THC concentration based on blood analyses. Blood was used in this specific analysis as the Washington State per se limit for delta-9-THC specifies 5 ng/mL or higher as measured in blood. There was a statistically significant reduction in drivers over the per se limit in Wave 2 (5.3%) compared to Wave 1 (14.5%) ($p < .05$). At Wave 3, the percentage of drivers who had THC concentration levels at 5 ng/mL or higher increased to 9.2 percent. At Wave 2 (4.7%) and Wave 3 (11.6%), there was a statistically significant increase in drivers who tested positive for THC, with THC levels below the per se level (i.e., between 0 ng/mL and 5 ng/mL) ($p < .05$).

Table 23. Percentage of THC-Positive Drivers by THC Concentration in Blood and Wave ((Percentage by Column)

THC	%	*N*	95% CI
Wave 1			
THC = 0ng/mL	85.2	607	[81.2, 88.5]
0ng/mL < THC < 5ng/mL	0.3	3	[0.0, 1.1]
THC ≥ 5ng/mL	14.5	101	[11.3, 18.3]
Wave 2			
THC = 0ng/mL	89.9	483	[84.6, 93.6]
0ng/mL < THC < 5ng/mL	4.7*	29	[2.6, 8.3]
THC ≥ 5ng/mL	5.3*	31	[3.3, 8.5]
Wave 3			
THC = 0ng/mL	79.2	558	[73.3, 84.1]
0ng/mL < THC < 5ng/mL	11.6*	74	[8.9, 14.9]
THC ≥ 5ng/mL	9.2	43	[5.3, 15.4]

In this table, Ns are unweighted; percentages are weighted.
THC-positive includes results from delta-9-tetrahydrocannabinol only.
*Significantly different from Wave 1 (p <.05).

Comparing Washington State results to the 2013-2014 NRS results.

Table 24 shows the prevalence of THC-positive drivers from Waves 1, 2, and 3 of the current study and drivers in the 2013–2014 National Roadside Study (Berning, Compton, & Wochinger, 2015). Although the studies followed much of the same protocol, there were differences making it not possible to directly compare the results.

As discussed in greater detail in the Method section, there were differences in the sampling objectives between the 2013-2014 NRS and the Washington State Study. Both employed randomized stratified sampling techniques to develop prevalence estimates relative to their overall sampling frame. The Washington State sampling objective was to develop prevalence estimates specific to that State alone; the NRS sampling plan was designed to develop a national prevalence estimate. There were also differences in law enforcement visibility, participant recruitment, and publicity between the two studies.

Each wave in Washington State had a significantly higher percentage of THC-positive drivers than the 2013-2014 NRS (p < .05).

Table 24. Percentage of Weekend Nighttime Drivers Positive for THC in the Washington State Study Compared to the 2013–2014 National Roadside Study (Oral Fluid or Blood) (Percentage by Column)

	2013–2014 NRS	Washington State Study		
		Wave 1	Wave 2	Wave 3
	N = 5,907	*N* = 637	*N* = 495	*N* = 596
THC-negative	87.4%	82.5%	80.2%	77.8%
THC-positive	12.6%	17.5%*	19.8%*	22.2%*
95% CI	[10.8, 14.8]	[14.0, 21.8]	[16.5, 23.5]	[17.7, 27.5]

In this table, *N*s are unweighted; percentages are weighted based on each study's statistical procedures.
Because this table used data from two separate studies which involved different designs and weighting procedures, significance testing was conducted by comparing 95 percent confidence intervals for both studies.
THC-positive includes results from THC and hydroxy-THC.
*Indicates statistically significant difference from the 2013-2014 NRS ($p < .05$).

Discussion

This study sought to examine the effects of legalizing the recreational use of marijuana on traffic safety. One would expect an increase in use of marijuana after legalization and that would probably lead to an increase in driving after marijuana use.

It is likely that Washington had a number of people illegally consuming marijuana after it was declared a Schedule I drug in 1970 (according to the Controlled Substances Act, a Schedule I drug must have a "high potential for abuse" and "no currently accepted medical use in treatment in the United States"). Washington legalized medical marijuana use in 1998, which may have increased the use of marijuana in the state by some unknown amount.

We measured the prevalence of drivers testing positive for alcohol and other drugs, including marijuana, on Washington's roads. Data was collected in three waves, before implementation of legal sales, approximately 6 months after implementation, and 1 year after implementation.

The reader is cautioned that drug presence does not necessarily imply impairment. For many drug types, drug presence can be detected long after any impairment that might affect driving has passed. For example, traces of marijuana use can be detected in blood samples several weeks after chronic users stop ingestion. In this study, for marijuana, we consider a driver positive only if we found THC (delta-9-tetrahydrocannabinol) the psychoactive substance in marijuana, or 11-OH-THC, its active metabolite.

Of almost 2,400 participants who provided an oral fluid or blood sample, the percentage of drivers who were THC-positive in the three waves was 14.6 percent of drivers in Wave 1, 19.4 percent of drivers in Wave 2, and 21.4 percent of drivers in Wave 3. The differences were not statistically significant.

There was a statistically significant increase in daytime prevalence of THC-positive drivers between Wave 1 (7.8%) and Wave 2 (18.4%), and also between Wave 1 and Wave 3 (18.9%). There was an increase in the percentage of THC-positive nighttime drivers with each successive wave (Wave 1 – 17.5%, Wave 2 – 19.8%, and Wave 3 – 22.2%), but these increases were not statistically significant. The difference between daytime and nighttime use is due to the relatively low percentage of THC positive *daytime* drivers in Wave 1 (7.8%) compared to Wave 2 (18.4%) and Wave 3 (18.9%). *Nighttime* THC positive drivers were a much higher percentage during Wave 1 (17.5%, and this percentage increased only slightly in each wave (Wave 2 – 19.8% and Wave 3 - 22.2%).

The legalization of recreational use of marijuana presented drivers with a choice of two "legal" drugs (alcohol and marijuana) both of which can impair driving related skills. This may have had (1) no effect on alcohol use by drivers, (2) decreased the use of alcohol if people switched to marijuana use, or (3) resulted in the combined use of alcohol and marijuana. We examined the interaction of marijuana use with alcohol use by drivers.

The percentage of alcohol positive drivers declined slightly across the three waves with 6.2 percent in Wave 1, 4.1 percent in Wave 2, and 4.3 percent in Wave 3. This was not a statistically significant decrease. Interestingly, there was an increase in THC-positive drivers who were alcohol-free, at Waves 2 and 3 (19.0% and 20.2%) compared to Wave 1 (13.2%). There was a decrease in the percentage of drivers who tested positive for any other drug (with no THC) and were alcohol-free from Wave 1 (17.2%) to Wave 3 (13.0%).

Washington has set 5ng/mL (nanograms per milliliter) or higher of delta-9-THC in the blood within two hours of driving as the per se level at which the driver is guilty of driving while under the influence of THC. The study found a statistically significant reduction in the percentage of THC-positive drivers who were over the per se limit. In Wave 1 there were 14.5 percent of drivers over the 5 ng/mL limit while in Wave 2 the percentage decreased to 5.3 percent of THC-positive drivers. In Wave 3 the percentage over the limit was to 9.2 percent.

This study measured prevalence of THC-positive drivers. It did not address whether an increased prevalence of THC-positive drivers is related to greater impairment among drivers or greater crash risk.

As in all field research, there are limitations in this study, including.

- A larger number of sites across the state of Washington would have increased the representativeness of the sample. Also, in some cases the locations within sites were not always the same between waves.
- A larger number of participants would have increased the accuracy of the results.
- We cannot be sure that drivers who chose not to participate and thus did not enter the study were not somehow different from those who did participate (non-response bias).
- We did not sample drivers across all seven days of the week and all hours of the day. This limits the generalizability of the results.

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