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Drug and Alcohol Crash Risk

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Background and Introduction

While the extent of use of alcohol by drivers and the risks posed by alcohol use have been well known for many decades, relatively little has been known about the use of other drugs by drivers and the associated risks. However, drug-impaired driving has recently become an issue of increasing public and governmental concern in the United States and in many other countries (Compton et al., 2009; Asbridge et al., 2012; ICADTS, 2007). While it is readily apparent that driving-related skills can be impaired by a wide variety of illegal substances and medications, the nature and scope of the drug-impaired driving problem has been difficult to define (Jones et al., 2003; DuPont et al., 2012; Houwing, 2013). In the United States, recent State actions to legalize the use of marijuana for medical and recreational use have further exacerbated concern over potential risks of driving impaired by marijuana.

Marijuana is the most frequently detected drug (other than alcohol) in crash-involved drivers as well as the general driving population (Terhune, 1982; Terhune et al., 1992; Lacey et al., 2009; Walsh et al., 2005). There is evidence that marijuana use impairs psychomotor skills, divided attention, lane tracking, and cognitive functions (Robbe et al., 1993; Moskowitz, 1995; Hartman and Huestis, 2013). However, its role in contributing to the occurrence of crashes remains less clear. Many studies, using a variety of methods have attempted to estimate the risk of driving after use of marijuana (Li et al., 2012; Asbridge et al., 2012). The methods have included experimental studies, observational studies, and epidemiological studies. While useful in identifying how marijuana affects the performance of driving tasks, experimental and observational studies do not lend themselves to predicting real world crash risk.

Epidemiological Studies

Epidemiological studies differ in how they estimate risk. Culpability studies compare the rate at which crash-involved, drug-positive drivers and drug-negative drivers are deemed to be at fault for their crashes. Case-control studies compare drug use by crash-involved drivers to drug use by non-crash involved drivers. In general, the case-control method is preferable since it can eliminate more sources of potential bias in estimating crash risk resulting from drug use (e.g., alcohol use is much higher at night and on weekends than during the day or on weekdays). The existing epidemiological research (both culpability and case-control studies) have produced contradictory estimates of risk for marijuana use. Some of these studies have suggested that marijuana use has minimal or no effect on the likelihood of crash involvement, while others have estimated a small increase in the risk of crash involvement.

Two recent population-based case control studies have estimated the crash risk of drug use by drivers by using NHTSA's Fatality Analysis Reporting System (FARS) 2007 data for the crash-involved driver population and the 2007 National Roadside Survey of Alcohol and Drug Use by Drivers for the control drivers (Lia, Bradya, & Chen, 2013; Romano, Torres-Saavedra, Voas, & Lacey, 2014). The Li study estimated the increased risk of crash involvement for drivers using marijuana at 1.83 times that of drug-free drivers, while the Romano study found no increased risk of crash involvement for those drivers testing positive for THC (the main psychoactive substance in marijuana). However, current limitations in the FARS dataset do not allow calculation of unbiased, reliable and valid estimates of the risk of crash involvement that results from drug use.

Challenges in Estimating Crash Risk from Drug Use

Conducting case-control studies to estimate the risk of crash involvement from drug use presents many difficulties. The first challenge has been getting reliable and accurate estimates of drug use. Many studies rely on self-report (which have obvious inherent problems) rather than actual measurement of THC in blood or oral fluid.

Also, the method of selecting truly comparable control drivers in an unbiased fashion for the crash involved drivers has varied considerably. The more carefully controlled studies, that actually measured marijuana (THC) use by drivers rather than relying on self-report, and that had more actual control of covariates that could bias the results, generally show reduced risk estimates or no risk associated with marijuana use (Elvik, 2013).

Meta-Analysis

For example, a recent meta-analysis by Li (2012) used nine studies, five of which were based on self-report; of the remaining four studies, marijuana use was inferred from a urine test in three of the studies (which really only indicates the drivers were marijuana users but not necessarily had used marijuana prior to driving). The studies that used self-reporting produced increased crash risk estimates that ranged from 1.7 to 7.16 times as a result of marijuana use by drivers. The two studies that used urine to determine marijuana use resulted in risk estimates of 0.85 to 3.43 times, while the two studies using blood analysis had risk estimates of 2.10 and 2.11 times. The overall pooled risk estimate was 2.66 times.

Similarly, a meta-analysis by Asbridge (2012) also used nine studies, but six were culpability studies with only three using a case-control approach. One of the culpability studies used only FARS data and was of questionable value. Of the three using case-control methods, two used self-report by the control drivers and one used non-drug positive crash-involved drivers (meaning the controls were drug-free, crash-involved drivers). The risk estimates resulting from marijuana use ranged from 0.82 to 7.16 (two studies showing marijuana use reduced the risk of crash involvement while seven studies showed an increased risk). The pooled odds ratio for all nine studies was 1.92.

Recently, a fairly large-scale population-based case control study (in which an attempt was made to have the crash and non-crash control drivers represent all crash-involved drivers and all non-crash involved drivers in the same jurisdiction) was conducted by the European Union to estimate the crash risk of drug use by drivers. A population-based study can benefit from a large sample of drivers covering a wide geographic area which may improve the generalizability of findings. However, the scale of such studies typically limits the control of subject selection. In a population-based case control study, the case and control drivers are selected from different sources. For example, the crash-involved drivers might be injured drivers taken to a hospital after a crash, while the control drivers might be selected from general traffic. This method lacks the careful matching (day of week, time of day, location, direction of travel, etc.) used in smaller-scale studies, so it involves some compromise of control for the benefit of a much larger sample size.

DRUID Study

The recent population-based study known as Driving Under the Influence of Drugs, Alcohol and Medicines (DRUID), is the largest study of this type (Hels et al., 2010). This study, conducted in nine European Union (EU) countries: Belgium, Denmark, Finland, Italy, Lithuania, and the Netherlands used seriously injured crash-involved drivers while Norway, Portugal, and Sweden used fatally injured drivers. The crash-involved fatally injured driver sample came from a group of drivers for whom a drug test had been conducted, over a period of two to three years. Seriously injured drivers came from a sample of drivers taken to a hospital. Controls came from a roadside survey conducted in each of the respective countries, around the same general time period (e.g., over a year) in each country and represented a sample of drivers, in some cases, from the same general area from which the fatally and seriously injured drivers' crashes occurred. However, in only two of the countries did the controls come from the exact same area of the country as the crash-involved drivers. The specific locations of the crashes were not matched to the sites used to obtain the non-crash involved control drivers. Also, drug presence was determined from blood samples for all the crash-involved drivers, but eight of the countries used oral fluid to determine drug presence in the non-crash involved drivers (four countries also used blood for some control drivers).

Odds ratios were used to estimate the risk of crash involvement after marijuana use in the fatally and seriously injured drivers. The results for the seriously injured drivers showed considerable national variability, ranging from 0.29 times (reduced crash involvement) to 25.38 times (increased crash involvement). The combined risk was 1.39 times that of drug-free drivers, but this was not statistically significant. For fatally injured drivers the estimated risk ranged from 3.91 to 28.88, while the combined risk was 1.33 times (also not statistically significant).

In a pooled analysis of the DRUID data, the highest risk of crash involvement was for drivers with high alcohol concentrations (above .12 BAC)—they had a crash risk 20–200 times that of sober drivers. Drivers with BACs between .08 and .12 were estimated to be 5–30 times more likely to crash than sober drivers. Drivers positive for THC were estimated to be at elevated risk (1–3 times that of sober drivers), similar to drivers with BAC levels between .01 to < 0.05. The DRUID report noted that some of the risk

estimates were based on few positive cases and/or controls which resulted in wide confidence intervals.

In order to further understand the risk of drug use by drivers, the National Highway Traffic Safety Administration (NHTSA), with funding support from the National Institute on Alcohol Abuse and Alcoholism (NIAAA), contracted with the Pacific Institute for Research and Evaluation (PIRE) to conduct the largest and most comprehensive study to address alcohol and drug crash risk in the United States through a case-control study, that employed a rigorous design involving a precise matching of cases and controls.

This case control study collected information from crash-involved and non-crash involved drivers for 20 months in Virginia Beach, Virginia.

NHTSA's "Crash Risk" Study

The case control crash risk study reported here is the first large-scale study in the United States to include drugs other than alcohol. It was designed to estimate the risk associated with alcohol- and drug-positive driving. Virginia Beach, Virginia, was selected for this study because of the outstanding cooperation of the Virginia Beach Police Department and other local agencies with our stringent research protocol. Another reason for selection was that Virginia Beach is large enough to provide a sufficient number of crashes for meaningful analysis. Data was collected from more than 3,000 crash-involved drivers and 6,000 control drivers (not involved in crashes). Breath alcohol measurements were obtained from a total of 10,221 drivers, oral fluid samples from 9,285 drivers, and blood samples from 1,764 drivers.

Research teams responded to crashes 24 hours a day, 7 days a week over a 20-month period. In order to maximize comparability, efforts were made to match control drivers to each crash-involved driver. One week after a driver involved in a crash provided data for the study, control drivers were selected at the same location, day of week, time of day, and direction of travel as the original crash. This allowed a comparison to be made between use of alcohol and other drugs by drivers involved in a crash with drivers not in a crash, resulting in an estimation of the relative risk of crash involvement associated with alcohol or drug use. In this study, the term marijuana is used to refer to drivers who tested positive for delta-9-tetrahydrocannabinal (THC). THC is associated with the psychoactive effects of ingesting marijuana. Drivers who tested positive for inactive cannabinoids were not considered positive for marijuana. More information on the methodology of this study and other methods of estimating crash risk is presented later in this Research Note.

Drugs Found in Crash-Involved and Control Drivers

Tables 1 and 2 show the number and percent of drivers that were positive for various classes and types of drugs. The use of alcohol is not included in these two tables. The drug most frequently used by drivers was THC, detected in 7.6 percent (n = 234) of the crash-involved drivers and 6.1 percent (n = 379) of the control drivers. In contrast, alcohol was detected in 5.0 percent (n = 168) of the crash-involved drivers and 2.7 percent (n = 187) of the control drivers (Table 7). The next most frequently detected drugs were narcotic-analgesics (opiates) found in 3.4 percent (n = 105) of the crash-involved drivers and 3.0 percent (n = 188) of the control drivers, followed by stimulants with 3.8 percent (n = 116) of the crash-involved drivers and 3.6 percent (n = 225) of the control drivers, with sedatives found in 2.9 percent (n = 90) of the crash-involved drivers and 2.3 percent (n = 139) of the control drivers.

Some 3.0 percent (n = 92) of the crash-involved drivers tested positive for more than one class of drug, while 2.1 percent (n = 132) of the control drivers tested positive for more than one drug. Based on simple proportions, crash-involved drivers were significantly more likely to test positive for THC and sedatives, to have used more than one class of drug, and to have used any type of drug than were control drivers. In this paper, p-values < 0.05 are considered statistically significant.

Table 1
Percent Crash and Control Drivers Positive by Drug Classes (Oral Fluid)

Drug or Drug Class	Crash		Control		P Value
	N	%	N	%	
THC (Marijuana)	234	7.6%	379	6.1%	0.01
Stimulants	116	3.8%	225	3.6%	0.78
Narcotic-Analgesics	105	3.4%	188	3.0%	0.36
Sedatives	90	2.9%	139	2.3%	0.05
Antidepressants	44	1.4%	82	1.3%	0.70
Other	23	0.7%	30	0.5%	0.12
More than 1 Class	92	3.0%	132	2.1%	0.01
Overall Drug Positive	495	16.0%	889	14.4%	0.04
Negative	2,600	84.0%	5,301	85.6%	0.04
All	**3,095**		**6,190**		

Some drivers were positive for more than one drug. Thus, the sum of the number of drugs detected will be larger than the number of drivers positive for drugs. P-Values based on z test of proportions (equivalent to Pearson's Chi Square). Shading indicates statistical significance (<0.05) between crash and control drivers.

Caution should be exercised in assuming that drug presence implies driver impairment. Drug tests do not necessarily indicate current impairment. Also, in some cases, drug presence can be detected for a period of days or weeks after ingestion.

Table 2
Percent Crash and Control Drivers Positive by Drug Type (Oral Fluid)

Drug Category	Crash		Control		P Value
	N	%	N	%	
Illegal	322	10.4%	546	8.8%	0.01
Legal	173	5.6%	343	5.5%	0.92
Negative	2,600	84.0%	5,301	85.6%	0.04
All	**3,095**	**100.0%**	**6,190**	**100.0%**	

P-Values based on z test of proportions (equivalent to Pearson's Chi Square). Shading indicates statistical significance.

Looking at the differences between illegal drugs and legal drugs (which may have been used according to a prescription or used illegally), there appears to be virtually no difference in the percentage of crash-involved drivers testing positive for legal drugs at 5.6 percent (n = 173) and control drivers testing positive for legal drugs at 5.5 percent (n = 343). However, that is not the case for illegal drugs, where statistically significantly more of the crash-involved drivers tested positive at 10.4 percent (n = 322), while 8.8 percent (n = 546) of control drivers tested positive for illegal drugs (see Table 2).

Drug Relative Crash Risk Estimates

To estimate the risk of crashing associated with drug use, logistic regression was used to obtain odds ratios for certain variables. Odds ratios estimate the probability of an event (i.e., crash) over the probability that such an event does not occur. If a variable (i.e., drug use) is not associated with a crash, the odds ratio of crash involvement associated with that variable will be 1.00. Odds ratios above 1.00 indicate a positive relationship, with stronger relationships reflected by higher odds ratios. Univariate and multivariate analyses were used to estimate the crash risk attributable to:

- Individual drugs;
- Drug classes (e.g., THC, stimulants, antidepressants);
- Drug categories (i.e., illegal drugs versus legal drugs or medications);
- Multiple drug use;
- Alcohol; and
- Combined use of alcohol and drugs.

Not all of these results are presented in this summary (see the report by Lacey et al., 2015, report in preparation).

Table 3 shows the unadjusted odds ratios for crash involvement for selected drug classes (THC, antidepressants, narcotic analgesics, sedatives and stimulants). It also shows the odds ratios for crash involvement for the two types of drugs: illegal drugs and legal (medicinal) drugs. From this table, it appears that THC is associated with a significantly elevated risk of crashing (by about 1.25 times or 25%). Similarly, the use of any illegal drugs is associated with a significant increase in the risk of crashing (by 1.21 times or 21%).

Table 3
Unadjusted Odds Ratios Between Drug Class Use and Crash Risk

Drug of Interest	Unadjusted Odds Ratio	P Value
THC (Marijuana)	1.25	0.01
Sedatives	1.30	0.06
Narcotic Analgesics	1.15	0.26
Antidepressants	1.06	0.75
Stimulants	1.01	0.40
Illegal Drugs	1.21	0.01
Legal Drugs	1.07	0.43

The risk of crash involvement for each category and class of drug is compared to the crash involvement rate for drug-negative drivers. An odds ratio of 1.00 means the crash involvement rate is the same. P Values from logistic regression (Wald Test). Shading indicates statistical significance.

These unadjusted odds ratios must be interpreted with caution as they do not account for other factors that may contribute to increased crash risk. Other factors, such as demographic variables, have been shown to have a significant effect on crash risk. For example, male drivers have a higher crash rate than female drivers. Likewise, young drivers have a higher crash rate than older drivers. To the extent that these demographic variables are correlated with specific types of drug use, they may account for some of the increased crash risk associated with drug use.

Table 4 examines the odds ratios for the same categories and classes of drugs, adjusted for the demographic variables of age, gender, and race/ethnicity. This analysis shows that the significant increased risk of crash involvement associated with THC and illegal drugs shown in Table 3 is not found after adjusting for these demographic variables. This finding suggests that these demographic variables may have co-varied with drug use and accounted for most of the increased crash risk. For example, if the THC-positive drivers were predominantly young males, their apparent crash risk may have been related to age and gender rather than use of THC.

Table 4
Adjusted Odds Ratios Between Drug Class Use and Crash Risk (Adjusted for Demographic Variables: Age, Gender And Race/Ethnicity)

Drug of Interest	Adjusted Odds Ratio	95% CI*	P Value
THC (Marijuana)	1.05	0.86 – 1.27	0.65
Antidepressants	0.87	0.57 – 1.32	0.51
Narcotic Analgesics	1.14	0.85 – 1.51	0.39
Sedatives	1.27	0.93 – 1.75	0.13
Stimulants	0.94	0.72 – 1.22	0.64
Illegal Drugs	1.04	0.88 – 1.23	0.65
Legal Drugs	1.03	0.84 – 1.27	0.79

The risk of crash involvement for each category and class of drug is compared to the crash involvement rate for drug-negative drivers. An odds ratio of 1.00 means the crash involvement rate is the same. *(CI = Confidence Interval).

Relative Crash Risk Estimates of Drugs in Combination With Alcohol

Table 5 adjusts the odds ratios by both demographic variables and the presence of alcohol. When the effect of alcohol is removed, the odds ratios decline further (except for a non-significant increase for narcotic analgesics).

As was described above, there was no difference in crash risk for marijuana (THC)-positive drivers who were also positive for alcohol than for marijuana (THC)-positive drivers with no alcohol, beyond the risk attributable to alcohol. Further analyses examined the potential interaction between drug use and breath alcohol concentration (BrAC). No statistically significant interaction effect on crash risk was found between any drug class or drug category and BrAC level.

Table 5
Adjusted Odds Ratios Between Drug Use and Crash Risk (Adjusted for Demographic Variables and Alcohol Use)

Drug of Interest	Adjusted Odds Ratio	95% CI*	P Value
THC (Marijuana)	1.00	0.83 – 1.22	0.98
Antidepressants	0.86	0.56 – 1.33	0.50
Narcotic Analgesics	1.17	0.87 – 1.56	0.30
Sedatives	1.19	0.86 – 1.64	0.29
Stimulants	0.92	0.70 – 1.19	0.51
Illegal Drugs	0.99	0.84 – 1.18	0.99
Legal Drugs	1.02	0.83 – 1.26	0.83

The risk of crash involvement for each category and class of drug is compared to the crash involvement rate for drug-negative drivers. An odds ratio of 1.00 means the crash involvement rate is the same. *(CI = Confidence Interval)

To further explore the relationship between alcohol and drug use on crash risk, we collapsed drug use into two categories: positive drug use or negative drug use, and collapsed alcohol use into three categories: no alcohol use, alcohol use below 0.05 BrAC and alcohol use at or above 0.05 BrAC. A BrAC of 0.05 was used for this purpose because at this level the risk of crash involvement is double that of a sober driver. Drivers who were negative for drug use and alcohol use were the reference in this conditional logistic regression analysis.

The results in Table 6 show that alcohol (≥0.05 BrAC), together with no drug presence, has the greatest effect on crash risk (shaded), raising the risk 6.75 times over that for drivers with no alcohol and no drugs. The adjusted odds ratios for alcohol levels ≥ 0.05 BrAC with drugs, and for alcohol levels ≥ 0.05 BrAC without drugs, are both significantly increased (more than 5 times higher). The relatively small difference between the odds ratio associated with alcohol levels at or above 0.05 BrAC, with and without drugs, was not statistically significant.

Table 6
Contribution of Alcohol and Drugs to Crash Risk

Drug and Alcohol Use	Adjusted Odds Ratio	95% CI*	P Value
No Alcohol / No Drug	1.00		
No Alcohol / Positive Drug	1.02	0.88 – 1.17	0.83
Positive Alcohol (< 0.05) / No Drug	0.84	0.55 – 1.29	0.43
Positive Alcohol (< 0.05) Positive Drug	1.03	0.55 – 1.94	0.93
Positive Alcohol (≥ 0.05) / No Drug	6.75	4.20 – 10.84	<0.0001
Positive Alcohol (≥ 0.05) / Positive Drug	5.34	2.75 – 10.37	<0.0001

Shading indicates statistical significance. Reference for all conditions was no drug and no alcohol. *CI = Confidence Interval

Alcohol Use in Crash-Involved and Control Drivers

Table 7 shows the number and percentage of drivers using alcohol at various BrAC levels for the crash-involved and control drivers. Some 10,221 crash and control drivers provided breath samples (3,353 crash-involved drivers and 6,868 control drivers). Drivers with BrACs at or above 0.08 were clearly overrepresented in the crash population compared to the control population (2.83% of the crash-involved drivers versus 0.38% of the control drivers).

The percentage of crash-involved drivers with BrACs at or above 0.05 but below 0.08 was slightly larger than, but did not differ significantly from, the percentage of control drivers (0.54% versus 0.33%). Also, for drivers with BrACs over zero but below 0.05, there was a slightly larger, but non-significant percentage of control drivers than crash-involved drivers in this BrAC range (2.01% versus 1.64%).

The percentage of crash-involved drivers who were alcohol-positive was almost double the percentage of control drivers who were alcohol-positive (5.01% versus 2.72%).

Table 7
Percent Crash and Control Drivers Alcohol-Positive by BrAC Level (Breath Test)

Alcohol Level	Crash		Control		P Value
	N	%	N	%	
BrAC > 0.08	95	2.83%	26	0.38%	< 0.0001
BrAC ≥ 0.05 – < 0.08	18	0.54%	23	0.33%	0.13
BrAC > 0.00 – < 0.05	55	1.64%	138	2.01%	0.20
BrAC = 0.00	3,185	94.99%	6,681	97.28%	< 0.0001
All	3,353	100.00%	6,868	100.00%	
BrAC ≥ 0.05	113	3.37%	49	0.71%	< 0.0001
BrAC > 0.00	168	5.01%	187	2.72%	< 0.0001

The data in Table 7 come from all breath tested drivers, crash-involved or control, rather than only drivers who also took an oral fluid test (which is the basis for all other tables). The total number of cases in this table is slightly larger than shown in all other tables. Shading indicates statistical significance. Note: the next to last row is the combination of the first two rows, while the last row combines the first three rows.

Alcohol Crash Risk Estimate

An analysis was conducted to estimate the crash risk of driving at various individual BrAC levels. Table 8 shows the crash risk of alcohol-positive drivers compared to alcohol-free drivers. The second column shows the unadjusted relative risk by BrAC level, while the third column shows the relative risk adjusted for age and gender. The unadjusted risks are somewhat lower than those shown when adjusted for age and gender for alcohol levels below 0.05 BrAC. The unadjusted risk is the same at 0.06 BrAC. The unadjusted risk is higher at alcohol levels, at and above, 0.07 BrAC.

Table 8
BrAC Relative Risk Unadjusted and Adjusted for Age and Gender

BrAC	Unadjusted Risk	Adjusted Risk (Age and Gender)
0.00	1.00	1.00
0.01	0.51	0.54
0.02	0.82	0.85
0.03	1.17	1.20
0.04	1.57	1.60
0.05	2.05	2.07
0.06	2.61	2.61
0.07	3.25	3.22
0.08	3.98	3.93
0.09	4.83	4.73
0.10	5.79	5.64
0.11	6.88	6.67
0.12	8.11	7.82
0.13	9.51	9.11
0.14	11.07	10.56
0.15	12.82	12.18
0.16	14.78	13.97
0.17	16.97	15.96
0.18	19.40	18.17
0.19	22.09	20.60
0.20+	25.08	23.29

Note: (Relative to BrAC = .00)

Based on the adjusted risk, drivers with a BrAC of 0.05 are approximately 2 times more likely to crash than drivers at zero BrAC. At 0.08 BrAC the adjusted relative risk of crashing is approximately four times that of drivers at zero BrAC. At a BrAC of 0.10 the adjusted risk increases to approximately 6 times, and at 0.15 BrAC drivers are at least 12 times as likely to crash.

Case Control Study Procedure

Data was collected from more than 3,000 crash-involved drivers and 6,000 non-crash involved (control) drivers. Crash-involved drivers were recruited at the scene of police-reported crashes. In order to match characteristics of control drivers with those of crash-involved drivers as closely as possible while maintaining random selection, the non-crash involved drivers were recruited one week later at the same locations where crash-involved drivers were recruited. Two controls for each crash-involved driver were randomly selected from traffic passing the crash location, driving in the same direction of travel, on the same day of week and at the same time of day one week later. To accomplish this selection methodology, research teams operated 24 hours a day, seven days a week.

All study participants (crash-involved and control drivers) were asked for a breath alcohol test, oral fluid sample and blood sample. Participation in the study was voluntary and anonymous and met Federal standards regarding the protection of human subjects. Any subject who was unsafe to drive was provided with alternative transportation home.

Types of Crashes

It should be noted that this study included all types of police-reported crashes. Other studies have focused solely on more serious crashes (injury or fatal crashes). The survey staff responded to 2,682 crashes in which one or more crash-involved drivers participated in the survey by providing oral fluid or blood samples. Approximately one sixth (16% or 431) were single-vehicle crashes and 84 percent were multiple-vehicle crashes (n = 2,251). As shown in Table 9, 33.6 percent were crashes involving an injury (n = 886) or fatality (n = 15).

Table 9
Types of Crashes

Type of Crash	Number	Percent
All Crashes	2,682	100.0%
Fatal	15	0.6%
Injury	886	33.0%
Property Damage	1,781	66.4%

Study Participants and Participation Rates

The 2,682 crashes noted above resulted in 3,887 eligible crash-involved drivers (ineligible drivers included drivers of commercial vehicles, drivers too impaired to give informed consent, drivers under age 18, and drivers with language barriers). One week later, 7,397 eligible control drivers were identified. Of the eligible crash-involved drivers 3,682 provided informed consent to participate in the study and 7,176 of the eligible control drivers provided informed consent to participate (see Table 10). This represented an overall 96.2% participation rate. Most of these drivers (90.6%) agreed to take a breath test (86.3% or 3,353 of the crash-involved drivers and 92.8% or 6,868 of the control drivers). Finally, 82.3 percent of the eligible drivers provided an oral fluid sample (79.6% of the crash-involved drivers and 83.7% of the control drivers). Only crash-involved drivers for whom two matched control drivers were obtained were included in the crash risk analyses.

Table 10
Number of Participants and Participation Rates

	Crash-Involved	Control	Total
Drivers	Number (%)	Number (%)	Number (%)
Eligible	3,887	7,397	11,284
Participated	3,682 (94.7%)	7,176 (97.0%)	10,858 (96.2%)
Breath Test	3,353 (86.3%)	6,868 (92.8%)	10,221 (90.6%)
Oral Fluid	3,095 (79.6%)	6,190 (83.7%)	9,285 (82.3%)

Participation rates based on the percentage of eligible crash-involved and control drivers. The numbers and percentages shown for drivers providing a breath test or oral fluid sample include only crash-involved and control drivers where two control drivers participated who matched a participating crash-involved driver.

Consistency With Previous Research Findings

Findings from this study corroborate those from other important studies in several key aspects, adding further assurance that this study sample was not unusual or highly biased in some unknown fashion. In particular, the findings from this study regarding the prevalence of alcohol and drug use by drivers reflect recent findings from NHTSA's 2007 National Roadside Survey of Alcohol and Drug Use by Drivers, and findings from this study regarding the crash risks of drivers at various Breath Alcohol (BrAC) levels reflect those of prior alcohol crash risk analyses.

Comparison With Results From the 2007 National Roadside Survey of Alcohol and Drug Use by Drivers

In 2007, NHTSA conducted the fourth decennial roadside survey of alcohol use by drivers. The 2007 survey also collected information on drivers' use of a wide variety of potentially impairing drugs. The survey provided nationally representative information on the prevalence of alcohol and drug use by drivers (Compton & Berning, 2009; Lacey et al., 2009). As shown in Table 11, the 2007 survey showed that 9.7 percent of all drivers tested were alcohol-positive (based on a breath test), while 13.6 percent were drug-positive (based on an oral fluid test). The current study found a much smaller percentage of drivers tested (during similar hours used for data collection in the 2007 roadside survey) who were alcohol positive (2.9%), while a slightly larger 14.4 percent of the control drivers were drug-positive (Table 11).

The differences between the two studies in the proportion of drivers found to be alcohol-positive are likely to have resulted from the concentration of Roadside Survey data collection on weekend nighttime hours, while this study included data from all days of the week and all hours of the day. For example, in the 2007 Roadside Survey the percentage of alcohol-positive weekday daytime drivers was only 1.0 percent, while on weekend nights 12.4 percent of the drivers were alcohol-positive. In this study, 1.9 percent of weekday daytime drivers were alcohol-positive, while 9.4 percent of weekend nighttime drivers were alcohol-positive.

In terms of THC use, the 2007 Roadside Survey found 7.7 percent of weekend nighttime drivers were positive for THC, while, in this study, 9.4 percent of the weekend nighttime control drivers were positive for THC. Both studies showed a similar pattern in which THC use on weekend nights appear to be almost double the daytime use rate.

The higher drug prevalence rate at nighttime strongly suggests that recreational use is a significant component of overall drug use. Medical drug use would not be expected to differ between day and night, nor weekday or weekend. In addition, a comparison of the distribution of THC concentrations between the two studies showed generally similar distributions.

Table 11
Comparison of the Weekend Nighttime and Weekday Daytime Alcohol, Drug and Marijuana (THC) Prevalence Between the 2007 NRS and Crash Risk Control Drivers (Breath Test and Oral Fluid Test)

Substance	2007 NRS	Crash Risk Controls
Alcohol Positive	9.7%	2.9%
Alcohol Positive Nighttime	12.4%	9.4%
Alcohol Positive Daytime	1.0%	1.9%
Alcohol ≥ 0.08	1.7%	0.4%
Alcohol ≥ 0.08 Nighttime	2.2%	2.1%
Alcohol ≥ 0.08 Daytime	0.1%	0.1%
Drug Positive	13.6%	14.4%
Drug Positive Nighttime	14.4%	18.4%
Drug Positive Daytime	11.0%	14.6%
THC (Marijuana) Positive	6.9%	6.1%
THC (Marijuana) Nighttime	7.7%	9.4%
THC (Marijuana) Daytime	4.5%	5.4%

Note: Weekend Nighttime drivers refers to drivers from Friday and Saturday nights from 10 p.m. – midnight and 1 a.m. – 3 a.m. for the 2007 National Roadside Survey, and 9 p.m. to 3 a.m. for the control drivers from this crash risk study. Weekday Daytime refers to 9:30 a.m. – 11:30 a.m. and 1:30 p.m. – 3:30 p.m. for the 2007 National Roadside Survey and 9 a.m. – 3 p.m. for the control drivers from this crash risk study.

Comparison With Prior Alcohol Relative Crash Risk Estimates

A considerable body of research has demonstrated the impairing effects of alcohol on driving-related skills. The relationship between BAC and crash risk was first well established by the "Grand Rapids Study" in 1964 (Borkenstein et al., 1964). That study provided compelling evidence that even moderate BAC levels were associated with increased crash risk and that the risk grew rapidly at BACs of .10 or higher. A study by NHTSA in the late 1990s provided more precise estimates of the risk of driving at lower BrACs (Blomberg, Peck, Moskowitz, Burns & Florentino, 2005).

To compare the findings of this study with the existing body of evidence regarding alcohol crash risk, analyses similar to those used in earlier studies were performed using data collected from this current study. These analyses compare the crash risk of alcohol-positive drivers with those of alcohol-free drivers (zero BrAC). This comparison provides a good indication whether this new study's sample was consistent with previous studies, and is useful as an indicator of any possible bias in the sample. The analyses also compare the crash risk of alcohol-positive drivers with those of alcohol-free drivers (zero BrAC) among those drivers who tested negative for drugs.

The results of the comparison showed a high degree of consistency with prior results and therefore suggest that the sample utilized in this study was comparable to those of prior studies. We compared the relative risk by BrAC level for the subjects in this study (calculated using the model used by Blomberg) with the relative risk curve from the Blomberg et al. (2005) study and found no significant difference between studies. The model presented above in Table 8 is slightly different from the Blomberg model, but fits the data better. There are some differences in risk estimates between the model presented in Table 8 and the Blomberg model. For example, at a 0.04 BrAC our model estimated the relative risk at 1.60 versus 1.00 for the Blomberg model, while at a 0.10 BrAC the estimates were 5.64 for our model and 2.66 for the Blomberg model. The risk estimates from this study were, for the most part, higher than those in the Blomberg study but they were for the most part within the 95-percent confidence limits.

Summary and Discussion

This study of crash risk found a statistically significant increase in unadjusted crash risk for drivers who tested positive for use of illegal drugs (1.21 times), and THC specifically (1.25 times). However, analyses incorporating adjustments for age, gender, ethnicity, and alcohol concentration level did not show a significant increase in levels of crash risk associated with the presence of drugs. This finding indicates that these other variables (age, gender ethnicity and alcohol use) were highly correlated with drug use and account for much of the increased risk associated with the use of illegal drugs and with THC.

This study found a statistically significant association between driver alcohol level and crash risk both before and after adjustment for demographic factors. These findings were generally consistent with similar analyses conducted in prior crash risk studies. Findings from this study indicate that crash risk grows exponentially with increasing BrAC. The study shows that at low levels of alcohol (e.g., 0.03 BrAC) the risk of crashing is increased by 20 percent, at moderate alcohol levels (0.05 BrAC) risk increases to double that of sober drivers, and at a higher level (0.10 BrAC) the risk increases to five and a half times. At a BrAC of 0.15, the risk is 12 times, and by BrACs of 0.20+ the risk is over 23 times higher.

This is the first large-scale case control study in the United States to assess the crash risks associated with both drug and alcohol use by drivers. Findings from this study provide valuable insights concerning the current nature of the impaired driving problem. However, considering the complexity of the impaired driving issue, especially concerning use of drugs other than alcohol, and the challenges of obtaining relevant information on this topic, these findings should be viewed in the context of the established body of scientific evidence on the subject.

Strengths of this study include the large number of crashes in the sample, the care taken in matching control subjects to the crash-involved driver sample, and the consistency in data resulting from rigorous adherence to data collection procedures and analytical methods. Inherent limitations of such a study design include a localized sample of crashes with unknown generalizability, and a bias toward less severe crashes. These limitations are primarily the result of practical constraints presented by available time and financial resources. It is possible that the findings could have differed if data were collected in another location or if there had been additional severe crashes.

The Blomberg study of alcohol crash risk used data collected on both coasts of the United States and did not find a significant difference between sites. Also a sample less representative of crashes across the country (in which most crashes are property damage crashes with a smaller number of injury crashes and an even smaller number of fatal crashes), that was restricted to only serious injury and fatal crashes, would undoubtedly result in a greater percentage of drivers with higher BrAC levels, and possibly higher drug levels.

In the background and introduction section (above) we reviewed previous studies that have estimated the risk of crash involvement associated with marijuana use by drivers. The results of this study are In line with the previous research on the effects of marijuana on the risk of crash involvement. While a number of previous studies have shown some increased risk associated with marijuana use by drivers, many studies have not found increased risk. As was noted previously, studies that measure the presence of THC in the drivers' blood or oral fluid, rather than relying on self-report tend to have much lower (or no elevated) crash risk estimates. Likewise, better controlled studies have found lower (or no) elevated crash risk estimates. Thus, the results of this study are consistent with the previous well controlled studies.

While the findings of this case control study were equivocal with regard to the crash risk associated with drug use by drivers, these results do not indicate that drug use by drivers is risk-free. The study limitations cited above, together with the findings of numerous other studies using different and complementary methods, need to be carefully considered before more definitive conclusions about drug use and crash risk can be reached.

The findings of this study notwithstanding, the established body of scientific evidence on the subject of drug impairment indicates that in some situations, drugs other than alcohol can seriously impair driving ability. This study provides further confirmation that driver impairment is a very serious safety concern and that it is involves a very certain element of alcohol impairment and a less-certain element of drug impairment. The 2007 National Roadside Survey of Alcohol and Drug Use by Drivers indicates the prevalence of drivers with levels of alcohol at or above the illegal per se limit of .08 BrAC has declined sharply over the past several decades. Such trend information regarding drug use by drivers is not yet available. However, recent policy changes regarding the medicinal and recreational use of marijuana suggest that further monitoring and research in this area are critical for public safety. NHTSA plans to release the results of a recent study, the 2013–2014 National Roadside Survey of Alcohol and Drug Use by Drivers, this month which will for the first time contain trend Information on drug use by drivers.

Background on Drug Use and Driving

This case control study contributes to a better understanding of the nature and scope of the drugged driving problem. From a public health perspective, relatively little is known about the contribution of drugs other than alcohol to traffic crashes. Understanding the effects of other drugs on driving is considerably more complicated than is the case for alcohol impairment. This stems from the fact that there are many potentially impairing drugs and the relationship between dosage levels and driving impairment is complex and uncertain in many cases. Additional challenges include the large differences among individuals with regard to response to the same dose of many drugs, and differences in impairment resulting from acute versus chronic use of some drugs.

Many drugs have been shown to impair driving related skills in laboratory dosing studies. Simulator studies, and closed-course driving studies employing psychomotor tasks like vigilance, reaction time, divided attention tasks, cognitive and executive functions, car following, lane keeping, speed control, and emergency maneuvers have shown reductions in driving-related functions due to drug effects. Individual drugs or drug combinations produce different impairing effects that are likely to increase the risk of crashing in various ways. For example, some may produce risk-taking behaviors, while others may reduce visual scanning, result in poor judgment, or lead to inattention.

For More Information

For questions regarding the information presented in this document, please contact Amy Berning at amy.berning@dot.gov.

Detailed information about the study design and results will be available in a technical report to be released in the near future (see Lacey, J.H., Kelley-Baker, T., Berning, A., Romano, E., Ramirez, A., Yao, J. Moore, C. Brainard, K., Carr, K., and Pell, K. (2015, report in preparation). *Alcohol and Drug Crash Risk: A Case Control Study,* Washington, DC: National Highway Traffic Safety Administration).

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