Drug and Alcohol Crash Risk: A Case-Control Study

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16. Abstract

This study used a "case-control" design to estimate the risk of crashes involving drivers using drugs, alcohol or both. Data was collected in Virginia Beach, Virginia, for 20 months. The study obtained biological measures on more than 3,000 crash drivers at the scenes of the crashes, and 6,000 control (comparison) drivers. Control drivers were recruited one week after the crashes at the same time, day of week, location, and direction of travel as the crash-involved drivers. Data included 10,221 breath samples, 9,285 oral fluid samples, and 1,764 blood samples. Oral fluid and blood samples were screened and confirmed for the presence of alcohol and drugs. The crash risk associated with alcohol and other drugs was estimated using odds ratios that indicate the probability of acrash occurring over the probability that such an event does not occur. If a variable (alcohol and/or drugs) is not associated with a crash, the odds ratio for that variable will be 1.00. A higher or lower number indicates a stronger relationship between the probability of a crash occurring and the presence of that variable (alcohol and/or drugs in the driver). Confidence intervals (CIs) of an odds ratio indicate the range in which the true value lies—with 95 percent confidence.

Alcohol: Alcohol was the largest contributor to crash risk. The unadjusted crash risk estimates for alcohol indicated drivers with a breath alcohol concentrations (BrACs) of .05 grams per 210 liters (g/210L) are 2.05 times more likely to crash than drivers with no alcohol. For drivers with BrACs of .08 g/210L, the unadjusted relative risk of crashing is 3.98 times that of drivers with no alcohol. When adjusted for age and gender, drivers with BrACs of .05 g/210L are 2.07 times more likely to crash than drivers with no alcohol. The adjusted crash risk for drivers at .08 g/210L is 3.93 times that of drivers with no alcohol.

Drugs: Unadjusted drug odds ratio estimates indicated a significant increase in crash risk. For the active ingredient in marijuana, delta-9-tetrahydrocannabinol (THC), this yielded an unadjusted odds ratio of 1.25. However, after adjusting for gender, age, race/ethnicity, and alcohol, there was no indication that any drug significantly contributed to crash risk. The adjusted odds ratios for THC were 1.00, 95 percent CI [.83, 1.22], indicating no increased or decreased crash risk. Odds ratios for antidepressants were .86, 95 percent CI [.56, 1.33]; narcotic analgesics were 1.17, 95% percent drugs as an overall category were .99, 95 percent CI [.84, 1.18], and prescription and over-the-counter medications were 1.02, 95 percent CI [.83, 1.26].

Alcohol and Drugs: Analyses found no statistically significant interaction effects when drivers were positive for both alcohol and drugs. Although initial analyses suggested that the combination of alcohol and other drugs were contributors to increased crash risk, additional analyses adjusting for other risk factors indicated no significant effect. When both alcohol and other drugs were consumed, alcohol alone was associated with crash risk.

17. Key Words	18. Distribution Statement
Alcohol and driving, drugs and driving, alcohol and drug crash risk, case-control study, alcohol-involved driving, drug-involved driving	Available to the public from the National Technical Information Service (www.ntis.gov) and the National Highway Traffic Safety Administration (www.nhtsa.gov).

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NHTSA provided permission for researchers to collect additional information funded by other agencies in conjunction with its survey of alcohol and drug use by drivers, after a determination was made that doing so would not detract or impede the activities funded by NHTSA. Results of the survey questions will be made available via the other funding agencies.

List of Acronyms and Abbreviations

AA	Alcoholics Anonymous
AC	alcohol concentration
ADC	assistant data collector
ADHD	attention deficit hyperactivity disorder
AUD	alcohol use disorders
AUDADIS	Alcohol Use Disorders and Associated Disabilities Diagnostic Interview Schedule
AUDIT	Alcohol Use Disorders Identification Test
BAC	blood alcohol concentration
BrAC	breath alcohol concentration
CI	confidence interval
CNS	central nervous system
CoC	chain of custody
dL	deciliter
DIN	driver information number
DOT	Department of Transportation
DSM	Diagnostic and Statistical Manual
DRUID	Driving Under the Influence of Drugs, Alcohol and Medicines
DUD	drug use disorders
DUID	driving under the influence of drugs
DWI	driving while intoxicated
ELISA	enzyme-linked immunosorbent assay
FAA	Federal Aviation Administration
FARS	Fatality Analysis Reporting System
FWA	Federal-wide Assurance
GC/MS	gas chromatography-mass spectrometry
g/210 L	grams per 210 liter
g/dL	grams per deciliter
HHS	Department of Health and Human Services
IDP	Impaired Driver Protocol
IIHS	Insurance Institute on Highway Safety
IRB	Institutional Review Board
LC/MS	liquid chromatography-mass spectrometry
MDMA	methylenedioxymethamphetamine
MDT	mobile data terminal
mL	milliliter
ng/mL	nanograms per milliliter
NA	Narcotics Anonymous
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
NPV	negative predictive value
NRS	National Roadside Survey
NSDUH	National Survey on Drug Use and Health

OHRP	Office of Human Research Protection
OSHA	Occupational Safety and Health Administration
PAS	passive alcohol sensor
PBT	preliminary breath tester
PCP	phencyclidine
PI	principal investigator
PIRE	Pacific Institute for Research and Evaluation
PPV	positive predictive value
SE	standard error
SQL	Structured Query Language
SSRI	selective serotonin reuptake inhibitor
THC	delta-9-tetrahydrocannabinol

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Executive Summary

Background

This Drug and Alcohol Crash Risk Study examined risks associated with drug- and alcohol- positive driving. The study used data from crash-involved and non-crash-involved drivers over a 20-month period in Virginia Beach, Virginia.

The research was funded by the National Highway Traffic Safety Administration of the U.S. Department of Transportation,[1] with additional funding from the National Institute on Alcohol Abuse and Alcoholism,[2] NHTSA contracted with the Pacific Institute for Research and Evaluation to conduct the study.

Unlike alcohol, relatively little is known about the drug use of drivers, and the risks drugs pose to crash involvement. Much of the information on drivers using drugs has come from self-report surveys, such as the National Survey on Drug Use and Health.[3] Although useful as a measure of the prevalence of drug and alcohol use among drivers, it is possible that self-report data on drug use and driving may be underreported. Injury and fatality data also have been useful. Risk analyses based on injury data can either retrospectively attribute presumed causation to drugs in the fatally injured drivers (responsibility analysis) or attempt to match the data with archival non-crash data.

The European study, *Driving Under the Influence of Drugs, Alcohol and Medicines* (DRUID) developed risk estimates for driving under the influence of substances based on roadside surveys and blood analyses of approximately 3,600 drivers seriously injured or killed in a crash (Hels et al., 2011). Alcohol was the most frequent substance in the driving population, as well as in drivers who were seriously injured or killed. Within the crash-involved drivers, delta-9-tetrahydrocannabinol (THC)[4] was the most frequent illicit drug, followed by cocaine. There was variability, with the relative risk of serious injury or fatality for different substances ranging from a slight increase in risk for drivers with alcohol in the blood alcohol concentration (BAC) range of .01 grams per deciliter (g/dL)[5] to < .05 g/dL and drivers positive for THC, to a large

[1] Project funded by NHTSA under subtask 4A Contract DTNH22-06-C-0040.
[2] Grant R01 AA018352-02S1, "Drivers with Alcohol Use Disorders: At high risk for crashes?"
[3] NSDUH; formerly known as the National Household Survey on Drug Abuse.
[4] THC is the psychoactive drug in marijuana. When marijuana is smoked or ingested, THC is absorbed into the blood stream and distributed into areas of the body, including the brain.
[5] In the United States, .08 g/dL (grams per deciliter) BAC is the illegal limit for alcohol.

increase in risk for amphetamines, multiple drugs, and BAC levels between .08 g/dL and < .12 g/dL.

In the United States, the National Roadside Surveys examine the prevalence of alcohol- and drug-positive drivers on the road, and examine changes across years. These have been conducted on Friday and Saturday nights, and starting in 2007 on Friday days as well, and include a breath sample to estimate breath alcohol concentration (BrAC[6]), and oral fluid and blood samples to learn about drug use. Although these studies provide a wealth of information about prevalence, they do not address driver impairment (Berning, Compton, & Wochinger, 2015).

This Crash Risk Study is the largest and most comprehensive study to address alcohol and drug crash risk in the United States through a case-control study design.[7] The study is based on a rigorous design that sought a precise matching of cases and controls, similar to that used by NHTSA for the estimation of alcohol-related crash risk (Blomberg, Peck, Moskowitz, Burns, & Fiorentino, 2005). Case-control studies are useful when complete randomization of individuals to experimental conditions (e.g., a random allocation of drivers to crashes or controls) is not possible. To increase the precision of the case-control matching, this study collected information from crash-involved drivers, and, one week later, from two control drivers randomly selected from the traffic stream on the same day of the week, time of day, location, and direction of travel as the crash-involved driver. This type of research design allows for a well-controlled, precise matching of crash-involved cases to control cases.

Objective

The objective of this study was to estimates the crash risk of alcohol-positive, drug-positive, and alcohol-plus-drug-positive drivers using a case-control design. Drugs included over-the-counter, prescription, and illegal drugs.

[6] In this report, the alcohol concentration in the alcohol crash risk estimates refer to breath alcohol concentrations (BrACs). The alcohol concentration in the drug crash risk estimates include includes results from both BrACs and BACs. Those instances will be noted as alcohol concentration (AC) and will not have units.

[7] A case-control study is a type of research comparing two matching groups in which one group exhibits a specific disease or effect (e.g., crash involvement) and the other does not (i.e., the control condition).

Methodology

NHTSA selected Virginia Beach, Virginia, for data collection because of the willingness of the police department and other agencies to cooperate with a stringent research protocol, and as the area had sufficient crashes for statistical analysis.

Data collection spanned 20 months. Researchers collected data from more than 3,000 crash-involved drivers and 6,000 non-crash-involved (control) drivers. Researchers recruited the crash-involved drivers where crashes occurred. Crashes included property-damage, injury, and fatal crashes. One week later, they recruited drivers to participate in the study (two control drivers for each crash-involved driver). The control drivers were randomly selected from the traffic stream at the same location, direction of travel, time of day, and day of week as each crash-involved driver. A research team was always on call to respond to crashes.

Participation in the study was voluntary and anonymous, and met Federal human subjects' protection standards. Any subjects who were unable to drive safely received alternative transportation home.

Participating subjects were asked to provide a breath test, an oral fluid sample, and a blood sample. The oral fluid and blood samples went to a laboratory to determine the presence of 89 drugs – these selected drugs are known to have the potential to affect driving ability.

Descriptive analyses (chi square tests) and logistic regression techniques were used to examine the data. Logistic regressions estimated relative risk of crash involvement, that is, the driver's risk of being involved in a crash after consuming drugs or alcohol, relative to that of individuals who had not consumed drugs or alcohol. Researchers examined characteristics including age, gender, and race/ethnicity. This was done for all drug positive drivers as a whole, and for drug class (e.g., amphetamines, sedatives), and for drug category (e.g., over-the-counter, prescription medications[8], and illegal drugs).

Relative risk is the driver's risk of being in a crash after consuming alcohol and/or drugs, relative to drivers who have not consumed alcohol or drugs. Relative crash risk was estimated by computing unadjusted odds ratios, and adjusted odds ratios, for alcohol-positive and drug-

[8] The term "medications" refers to the over-the-counter and prescription drugs.

positive drivers.[9] The unadjusted odds ratios were calculated by comparing crash-involved drivers to control drivers. Odds ratios for alcohol were statistically adjusted for other known factors for crash risk - age and gender. Odds ratios for drugs were statically adjusted for age, gender, and race/ethnicity.

Results

Alcohol Crash Risk Estimate

The unadjusted crash risk estimates for alcohol indicated that drivers with BrACs of .05 grams per 210 liters g/210L are 2.05 times more likely to crash than drivers with no alcohol. For drivers with BrACs of .08 g/210L, the unadjusted crash risk is 3.98 times that of drivers with no alcohol. When adjusted for age and gender,[10] drivers with BrACs of .05 g/210L are 2.07 times more likely to crash than drivers with no alcohol. The adjusted crash risk for drivers at .08 g/210L is 3.93 times that of drivers with no alcohol.

Drug Crash Risk Estimates

Drug odds ratio estimates, when unadjusted, indicated an increase in crash risk. For marijuana, the unadjusted odds ratio was 1.25, but after statistically adjusting for gender, age, race/ethnicity, and driver alcohol concentration (AC), [11] there was no significant contribution to crash risk from any drug. The adjusted odds ratios were:

- THC[12]: 1.00, 95% CI [.83, 1.22],
- Antidepressants: .86, 95% CI [.56, 1.33],
- Narcotic analgesics: 1.17, 95% CI [.87, 1.56],
- Sedatives: 1.19, 95% CI [.86, 1.64],
- Stimulants: .92, 95% CI [.70, 1.19],
- Illegal drugs: .99, 95% CI [.84, 1.18],
- Medications: 1.02, 95% CI [.83, 1.26].

[9] An odds ratio is the probability that an event will occur (in this study, a crash) over the probability that such an event will not occur. If a variable (i.e., alcohol or another drug) is not associated with a crash, the odds ratio for that variable will be 1 or less. A higher number indicates a stronger relationship between the probability of a crash occurring and the presence of alcohol and/or drugs in the driver. A lower number indicates a reverse relationship.

[10] Risk estimates for alcohol only were adjusted by age and gender (but not race/ethnicity) so that comparisons could be made to previous alcohol crash risk studies.

[11] Risk estimates for drugs were adjusted by age, gender, race/ethnicity, and alcohol, in an effort to account for any possible impacts that these factors may have.

[12] This report uses the terms *marijuana* and *THC* interchangeably. THC is the principal active ingredient of marijuana; marijuana describes the plant itself. Metabolites are new drugs formed as the body processes the parent (original) drug (e.g., through metabolism in the liver), are noted they are included. Hydroxy-THC and carboxy-THC are metabolites of THC, the active drug in marijuana.

Alcohol and Drugs

To examine the relative crash risk estimates of drugs in combination with alcohol, drug use was collapsed into two categories: positive drug use or negative drug use. Alcohol was collapsed into three categories: no alcohol use, AC below .05, AC at or above .05.

After adjusting for the characteristics of gender, age, and race/ethnicity, adjusted odds ratios indicated that alcohol is the largest contributor to crashes. This is found when alcohol is used by itself (positive AC at or above .05 and negative drug, adjusted odds ratio = 6.750) or with other drugs (positive AC at or above .05 and positive for at least one drug, adjusted odds ratio = 5.342).

Conclusions

The study confirmed previous research indicating alcohol is a greater contributor to crash risk than drugs (Bernhoft, 2011; Hargutt, Krüger, & Knoche, 2011; Hels et al., 2011; Romano & Pollini, 2013; Romano, Torres-Saavedra, Voas, & Lacey, 2014; Romano & Voas, 2011; Sewell, Poling, & Sofuoglu, 2009). When age, gender, race/ethnicity, and alcohol consumption are taken into account, there was no significant contribution of drugs to crash risk. This finding seems to contradict previous studies (Asbridge, Hayden, & Cartwright, 2012; Blows et al., 2005; Hels et al., 2011) that indicate a statistically significant contribution of drugs to crash risk, even if sometimes small or moderate. However, the strength of this study lays in its rigorous methodology, stringent data collection procedures, controlled case-control matching, comprehensive laboratory testing, and sophisticated statistical analyses.

There are several plausible explanations for the findings regarding drug use and crash risk. One relates to the severity of the crashes examined in this study. The consumption of alcohol is associated with not only to the likelihood of a crash occurring, but also to the severity of the resulting injuries (e.g., Waller et al., 1997; Waller, Hill, Maio, & Blow, 2003). It is reasonable, therefore, to hypothesize that the consumption of drugs other than alcohol may also be associated with the severity of a crash (although such association was not found by Waller and colleagues in their 1997 study). If that is the case, then the limited contribution of drugs other than alcohol to crash risk found by this study could be related partly to the relatively low severity of the crashes included in this study. Unlike previous case-control studies that focused on fatal (e.g., Li, Brady, & Chen, 2013; Romano et al., 2014) or serious injury crashes (Hels et

al., 2011), most crashes in this study were property-damage only.[13] Property-damage only crashes are the most common, and as such provide information on overall crash risk. Additionally, because drug classes affect driving skills differently, overall crash risk estimates may underestimate the contribution of certain drugs to specific types of crashes. The role of THC may differ in its crash risk profile than stimulants. The results indicate that alcohol remains the main contributor to crash risk. Drugs other than alcohol, and when combined with alcohol was not a significant factor in crash risk. A possible reason is that some of the drug-positive drivers may not have been impaired at the time they were tested. Some drugs, such as THC, stay in a person's system for a long period of time, even after the effects of the drug are no longer felt.

This study should not be interpreted to mean that it is safe for individuals who have used substances to operate a vehicle – this is a complex issue. It is important for law enforcement officers to carefully observe drivers and consider the totality of the circumstances if they suspect a driver is impaired by drugs.

[13] The majority of crashes in the United States do not involve injuries. While most studies focus only on crashes with a fatality, this study covered all crashes, the majority of which were property-only crashes.

Introduction

Purpose

This report summarizes the methods and results from the National Highway Traffic Safety Administration's research on alcohol, drugs and crash risk, conducted by the Pacific Institute for Research and Evaluation.[14] The study also received support through a National Institute on Alcohol Abuse and Alcoholism grant[15]. The findings are intended to help inform public policy about drugs and driving, much like the landmark studies (Blomberg, Peck, Moskowitz, Burns, & Fiorentino, 2009; Borkenstein, Crowther, Shumante, Ziel, & Zylman, 1964) that helped inform the development of the nation's alcohol-impaired driving laws, policies, and programs.

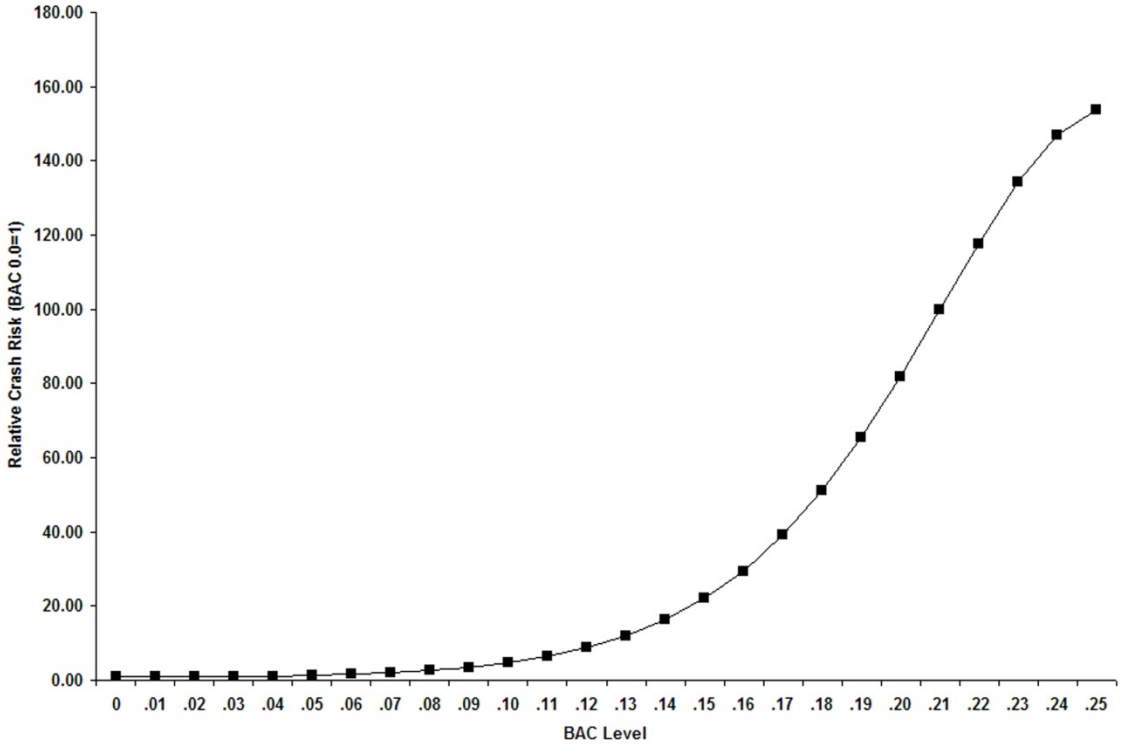
Background

Relative Crash Risk Studies

Much is known about the risks of alcohol-positive driving; less is known about the risks from other drugs. A quantitative relationship between alcohol concentrations and crash risk was not well-established until publication of the *Grand Rapids Study* in 1964 (Borkenstein et al., 1964; Borkenstein, Crowther, Shumate, Ziel, & Zylman, 1974). That study provided compelling evidence that moderate BrAC levels (~.04 g/210L) were associated with increased crash risk for drivers, and the risk grew exponentially at higher BrACs.

NHTSA conducted a case control study of the crash risk of alcohol in Long Beach, California and Fort Lauderdale, Florida (Blomberg et al., 2005). The analyses showed elevated relative risk at BAC of .04 g/dL, and a strongly accelerated risk at BACs greater than 0.10 g/dL (Figure 1).

[14] Project funded by NHTSA under subtask 4A Contract DTNH22-06-C-0040.
[15] Grant R01 AA018352-02S1, "Drivers with Alcohol Use Disorders: At high risk for crashes?"



Source: Blomberg, Peck, Moskowitz, Burns, & Fiorentino (2005)

Figure 1. Adjusted Relative Risk Estimates Reported by Blomberg et al. in 2005

Zador and colleagues (Zador, Krawchuk, & Voas, 2000) applied logistic regression to crash data from the Fatality Analysis Reporting System (FARS) with exposure data from the 1996 NRS of drivers. This allowed them to estimate age- and gender-specific relative risk as a function of the (AC) for drivers involved in a fatal crash and for drivers fatally injured in a crash. Results found that the relative risk of involvement in a fatal vehicle crash increased steadily as the driver's AC increased across every age and gender group among fatally injured and surviving drivers.

Improved Drug Detection Enables New Research

Fatal crash studies, such as Terhune et al. (1992), used crash reports to attribute presumed causation. The responsibility was then retrospectively related to the presence or absence of drugs in the fatally injured drivers. A stronger alternative method is to conduct a case-control study in which researchers obtain biological measures, such as breath, oral fluid, or blood samples from the population at risk (drivers on the roadway but not crash-involved), and compare them to

those obtained from the crash-involved population. This type of study has been long desired, but until recently it was not feasible to obtain biological samples from drivers on the road. NHTSA's National Roadside Studies in 2007 and 2013-2014 showed that obtaining biological samples from drivers was possible (Berning, Compton, &Wochinger, 2015).

The European study, *Driving under the Influence of Drugs, Alcohol and Medicines* (DRUID) involved roadside data collection across nine countries to estimate the prevalence of psychoactive substances in the driving population. Researchers analyzed the bodily fluids, primarily oral fluid of more than 37,000 randomly selected drivers. They derived risk estimates for driving under the influence of these substances and compared them to blood analyses of approximately 3,600 drivers who were seriously injured or killed in crashes. The most frequent substance in the driving population, as well as in drivers seriously injured or killed, was alcohol. Within crash-involved drivers, delta-9-tetrahydrocannabinol (THC) was the most frequently detected illicit drug, followed by cocaine. Merging the findings from countries, the authors presented the level of risk of a crash for each drug or drug class, multiple drugs, drugs and alcohol, and four ranges of alcohol concentration compared to sober drivers (Table 1). The odds ratios[16] were expressed in terms of confidence intervals[17] and included:

- The "slightly increased risk" group included drivers with alcohol in the range of .01 g/dL to < .05 g/dL and drivers positive for THC, at an odds ratio range of 1–3 times that of drivers negative for alcohol and drugs.
- The "medium increased risk" group included drivers with alcohol concentrations of .05 g/dL to < .08 g/dL , cocaine, benzoylecgonine,[18] benzodiazepines, Z-drugs (Zolpidem, Zopiclone, and Zaleplon), and illicit and medicinal opiates at an odds ratio range of 2–10 times that of drivers negative for drugs.
- The "highly increased risk" group included amphetamines, multiple drugs, and BAC levels between .08 g/dL and < .12 g/dL, which fell in an odds ratio range of 5–30 times that of drivers negative for drugs.
- The "extremely increased risk" group included drivers with BACs of .12 g/dL or greater, as well as drivers with both alcohol and other drugs with an odds ratio range of 20–200 times that of drivers negative for drugs.

[16] An odds ratio is the probability that an event will occur (in this study, a crash) over the probability that such an event will not occur. If a variable (i.e., alcohol or another drug) is not associated with a crash, the odds ratio for that variable will be 1. A higher number indicates a stronger relationship between the probability of a crash occurring and the presence of alcohol and/or drugs in the driver. A lower number indicates a reverse relationship.

[17] A confidence interval refers to a range of values in which the true value of a desired outcome lies. That is, for a 95% confidence interval, researchers are stating that they are 95% confident that the true value exists within a given range.

[18] Benzoylecgonine is the main metabolite of cocaine.

Table 1. The Relative Risk Level of Serious Injury or Death for Various Substance Groups in the DRUID Project

Risk Level	Risk	Substance Group
Slightly increased risk	1–3	.01 g/dL < alcohol in blood < .05 g/dL Cannabis
Medium increased risk	2–10	.05 g/dL ≤ alcohol in blood < .08 g/dL Benzoylecgonine Cocaine Illicit opiates Benzodiazepines and Z-drugs Medicinal opioids
Highly increased risk	5–30	.08 g/dL ≤ alcohol in blood < .12 g/dL Amphetamines Multiple drugs
Extremely increased risk	20–200	Alcohol in blood ≥ .12 g/dL Alcohol in combination with drugs

Note: Due to very different single country estimates, the risk estimates for cannabis and amphetamines must be treated with caution.
Due to few positive cases and controls, the risk estimates for benzoylecgonine, cocaine, and illicit opiates must also be treated with caution.
Source: The European Integrated Project DRUID (Hels et al., 2011)

Some of the risk estimates varied to a high degree among the countries, and others were based on few positive cases and/or controls, which resulted in wide confidence intervals. The authors therefore reported the estimates as uncertain.

With respect to THC and risk specifically, Blows et al. (2005) investigated the relationship between THC (self-reported marijuana use in the three hours prior to crash/survey and habitual THC use in the previous 12 months) and crash injury with a population-based case-control study in Auckland, New Zealand. The authors collected self-reported THC use from 588 control and 571 case drivers. They found acute THC use to be significantly associated with crash injury after controlling for age, gender, race/ethnicity, education level, vehicle type, driving exposure, and time of day (odds ratio 3.9, 95% CI [1.2, 12.9]). However, after adjusting for these variables plus other risky driving (e.g., BAC, seat-belt use, speed, and a sleepiness score) at the time of the crash, the effect of acute THC intake was no longer significant (odds ratio .8, 95% CI [.2, 3.3]). There was a strong significant association between habitual THC use and crash risk injury after adjusting for confounding variables plus acute use prior to driving (odds ratio 9.5, 95% CI [2.8, 32.3]).

Asbridge, Hayden, and Cartwright (2012) conducted a meta-analysis to determine whether acute cannabis consumption increased motor vehicle collision risk. Using nine studies, the authors assessed recent cannabis use by toxicological analysis of whole blood or self-report. The authors combined risk estimates using random effects models. The authors found that driving under the influence of cannabis was associated with a significant increase in risk of motor vehicle collisions compared with drivers who had not used cannabis (odds ratio 1.92, 95% CI [1.35, 2.73]; p[19] = .0003). Collision risk estimates were higher in case-control studies (odds ratio 2.79, 95% CI [1.23, 6.33]; p = .01) and studies of fatal collisions (odds ratio 2.10, 95% CI [1.31, 3.36]; p = .002) than in culpability studies (odds ratio 1.65, 95% CI [1.11, 2.46]; p = .07) and studies of non-fatal collisions (odds ratio 1.74, 95% CI [.88, 3.46]; p = .11).

Objective

The objective of this study was to estimates the crash risk of alcohol-positive, drug-positive, and alcohol-plus-drug-positive drivers using a case-control design. Drugs included over-the-counter, prescription, and illegal drugs.

[19] A *p*-value is the probability of obtaining an outcome not likely to be the result of chance. If a *p*-value is less than .05, then the outcome has a 5% likelihood or less of being the result of chance. Hence, if an outcome has a *p*-value of less than .05, the outcome is deemed unlikely to occur by chance, and is referred to as "significant." If an outcome has a *p*-value equal or greater than .05, it is considered "non-significant" as the outcome has greater than a 5% likelihood of being the result of chance. A *p*-value of less than .05 is commonly used as a cut-off criterion. P values help guide the interpretation of results, but are not construed as definitive.

Methodology[20]

Summary

Research teams collected data in Virginia Beach for 20 months using a case-control methodology. The teams collected data from more than 3,000 crash drivers and more than 6,000 control drivers to estimate the relative crash risk of drivers at positive for alcohol and/or drugs, including medications (prescription and over-the-counter) and illegal drugs. Data collection was 24 hours a day, 7 days a week, except when national holidays or extreme weather.

Case-control studies identify factors that may contribute to a condition of interest (e.g., crash involvement) by comparing characteristics (e.g., alcohol and/or drug use) of a group of individuals who show the condition of interest (e.g., crash involvement) with a group who do not (e.g., drivers not involved in a crash). They are an epidemiological research strategy that can be used when randomized controlled trials are not possible (MacMahon & Pugh, 1970). A key element of the case-control design is the matching of cases by exposure conditions, such as day of the week, time of the day, location, and driving direction; and then assessing the change in risk attributable to alcohol or other drug use.

Crashes within Virginia Beach that were police-reported, including property damage, injury, and fatal crashes were used in this study - due to safety concerns, freeways and limited access roadways were excluded. The research teams consisted of a data collector, who was also a licensed phlebotomist; a law enforcement officer (research officer); and at times, an assistant data collector. As the police dispatcher notified the team of a crash, they responded in the officer's vehicle. At the crash scene, the research officer made initial contact with the on-scene investigating officer and the driver(s), and introduced the data collector to the driver. The data collector then asked the driver to participate in the study, explaining that it was a voluntary and confidential.

Observational data: The data collector recorded basic information about the vehicle (such passenger vehicle or pickup truck) and passengers (such as gender, age range, and seat-belt use).

[20] PIRE's Institutional Review Board #2 (IRB00000631) reviewed and approved all research design and data collection procedures. PIRE's Federal-wide Assurance (FWA) number is FWA00003078, and its organization number is IIORG0000373.

Consent for interview: The data collector explained the study, including it was voluntary and confidential. If the driver participant provided verbal consent, the study continued. If the driver declined, the data collector asked for only a quick breath sample – many "non participating" drivers were willing to do this.

First PAS reading: As the data collector spoke with the driver, he or she obtained an initial passive alcohol sensor (PAS) reading.

Financial incentives: Drivers were offered financial incentives to provide oral fluid and blood samples, as well as for completing an Alcohol Use Disorder (AUD) screening instrument. Additionally, a sample of those who initially declined was offered an additional incentive to participate in the study. This was to examine the question of whether those who initially declined did so because they were more likely to have used alcohol or drugs.

Questions: The data collector asked the driver a few questions regarding general drinking behavior and driving patterns.

Second PAS reading: The data collector obtained a second PAS reading from the driver.

Breath test: The data collector requested a breath sample from the driver using a preliminary breath test (PBT) device. Theses PBTs only stored the result, as opposed to displaying it.

Oral fluid test: The data collector requested an oral fluid sample from the driver. The driver placed the swab in his or her mouth for 3–5 minutes until 1 milliliter (mL) of saliva had been obtained.

AUD questions: While the oral fluid swab was in the mouth, the driver filled out a paper-and-pencil AUD screening instrument.

DUD questions: While the oral fluid swab was in the mouth, the driver filled out a paper-and-pencil drug use disorder (DUD) screening instrument.

Payment: The participant was provided the incentive ($10 for an oral fluid sample; $5 for the AUD).

Blood sample: The data collector then requested a blood sample, and drew one vial of blood.[21] The subject received a $50 money order.

For a subsample of drivers who initially declined to participate but who then decided provided an oral fluid or blood sample, received an additional $100.

Impaired driver protocol: If the data collector suspected that the driver had been drinking or was otherwise impaired, he or she requested a sample of the driver's breath - now using a PBT that did display the alcohol concentration. If the driver had a BrAC of .05 g/210L[22] or greater, the data collector ensured the subject's safe passage home by offering several options, including calling a taxi, calling a friend or relative[23] to pick up the driver, and/or calling a tow truck to take the driver and vehicle home. This was provided at no cost to the driver.

Injured, Fatal, Arrested or Hit-and-Run Driver Information: Data were also obtained from crash-involved drivers who were injured or died, including drivers transported to a hospital or the morgue; drivers arrested, and hit-and-run drivers.

Researchers recruited control drivers at random from the traffic stream one week later, on the same day, at the same time of day, at the same location, and in the same direction of travel as each crash-involved driver. These drivers were also asked to provide breath, oral fluid, and blood samples. Data were collected from two control drivers for each crash-involved driver. These drivers served as "controls" (comparisons) to the crash-involved drivers.

[21] The data collector/phlebotomist drew blood according to Occupational Safety and Health Administration standards.
[22] The illegal per se alcohol limit in all U.S. States is .08; the study's protocol used a lower AC for the safety of participants.
[23] Any friend or relative who came to pick up a driver also provided a breath sample to ensure they were below .05 g/210L.

Selection and Recruitment Procedures

This study required a jurisdiction with a population of approximately 400,000 to 500,000 to provide a sufficient sample size of crashes. It was also critical to have participation from local police, hospitals, and the medical examiner.

Law Enforcement: The Virginia Beach Police Department (VBPD) was ideal for this study because of their willingness to commit dedication, leadership, off-duty officers, and patrol vehicles – the department was a key to the success of this project.

Hospitals: Hospitals in the Virginia Beach area are under the direction of Sentara Healthcare. As most crash-involved drivers were transported to Virginia Beach General and Princess Anne, these were recruited to participate.

Typically, hospital personnel drew blood for the study at the same time they drew for medical purposes. In other instances, the data collector collected biological specimens when medical personal deemed it safe and the driver consented.[24]

Medical Examiner: Researchers worked with the Virginia Medical Examiner's Office Regional Administrator to obtain blood samples from deceased crash-involved drivers.

Driver Recruitment: For a case-control study such as this, data are collected from both drivers involved in a crash and control drivers not involved in a crash, but matched as closely as possible to the initial crash. For this study, location of the crash, direction of travel, day of week, and time of day were the matching variables.

Crash-Involved Driver Recruitment: When the team received notification of a crash, it drove to the crash in the officer's law enforcement vehicle. The research officer waited until the investigating officer finished with the driver(s).[25] The research officer then approached each driver and explained the study. Officers introduced the study with:

> Hello, I'm Officer (name). How are you doing today/tonight? Are you feeling OK? "With your permission, I would like to introduce you to

[24] Sentara Healthcare's Internal Review Boards ensured the methodology of this study complied with hospital and trauma center standards.

[25] At times, the research officers served as the investigating officer as well.

(data collector's name), a researcher with the Pacific Institute for Research and Evaluation. "He/she is conducting an important research study for the U.S. Department of Transportation and National Institutes of Health. Participation is completely voluntary. If you are willing to talk to (data collector's name), he/she will describe the study. Your decision about whether or not to talk to (data collector's name) or participate in the study will neither hurt nor help you regarding the crash investigation. Would you be willing to let the data collector talk to you about the study?

If YES: OK, I am going to step away so that you and the data collector can talk confidentially.
If NO: Thank you for your time.

Control Driver Recruitment: When a crash-involved driver participated, the team returned to the crash site one week later to for "control" data collection. This was conducted on the same day of the week, time of day as crash, and direction of traffic as the crash. Officers randomly alerted drivers to the research bay – typically in an empty parking lot. To ensure an unbiased selection of vehicles, vehicle recruitment began with the third driver after the bay was set up. Data collection continued until two drivers participated (or two hours elapsed).

Research Teams

Research teams consisted of a data collector/phlebotomist and an off-duty, uniformed police officer. On some shifts, an assistant data collector was added. The officers drove a VBPD vehicle. Research assistants followed up on data in hospitals and with the medical examiner's office. Team members participated in extensive trainings[26], including classroom instruction and comprehensive practice. Data collectors were trained to estimate the intoxication level of drivers (Table 3, Item #3). If needed, an impaired driving protocol (IDP, Appendix D) was initiated to ensure all drivers and passengers had safe transport after participation.

[26] PIRE operates under a Federal-wide Assurance from the Office of Human Research Protection, an agency of the Office of the Secretary of the Department of Health and Human Services in compliance with Federal regulations concerning research involving human subjects. This includes the ethical principles outlined in the "Belmont Report." Staff completed Human Subjects Protection Training Modules (Pacific Institute for Research and Evaluation, n.d.).

Data Collectors/Phlebotomists: The data collector talked with the drivers, and obtained the breath, oral fluid, and/or blood samples. They were either had a phlebotomy certification or had training in phlebotomy, such as a nursing degree or Emergency Medical Services certificate.

*Research Officers***:** The research officers provided a safe environment for participants and the team. Although they were off-duty, they wore their uniforms and drove police vehicles to assure the public the study was legitimate and the setting was safe. The officer had initial contact with drivers and provided traffic enforcement.

Research Assistants: Assistants obtained blood specimens from hospitals, collected crash reports from the police, and calibrated equipment.

Equipment

Passive Alcohol Sensor Device

To obtain valid data on alcohol-involved driving and to ensure the safety of drivers, obtaining as high a percentage of breath tests as possible was important. One way to accomplish this – even if the request for a breath test was declined – was through a passive alcohol sensor. The PAS[27] (Figure 2; Appendix A) detected alcohol in expired air around the subject's face. The data collector held the PAS within 6 inches of the subject's face and, when the subject spoke, activated the small electrical pump that pulled air from in front of the face (Cammisa, Ferguson, & Wells, 1996; Fiorentino, 1997). The air fed into the unit's internal fuel cell alcohol detector, which measured alcohol concentration and provided a rough indication of the presence of alcohol on a color-coded, nine-element LED bar graph and numeric display of the approximate alcohol level (Table 2).

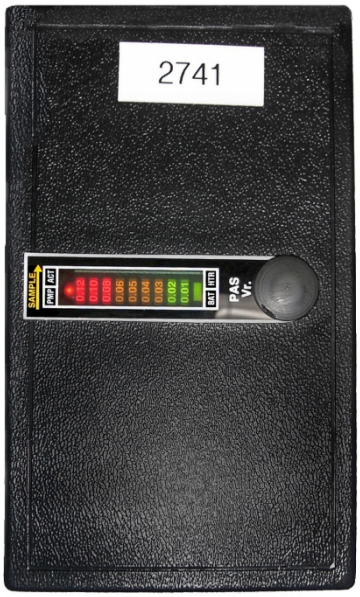


Figure 2. Passive Alcohol Sensor (PAS)

Table 2. Levels of Alcohol Detected on the PAS Device

00 (no alcohol detected)
Green 1 (presence of alcohol detected)
Green 2
Yellow 1
Yellow 2
Yellow 3
Yellow 4 (implement IDP[28], potential for impairment)
Red 1 (implement IDP)
Red 2 (implement IDP)
Red 3 (implement IDP)

Two passive breath samples were collected for each driver: the first at the very beginning of the interview during the consenting procedure, and the second in the middle of the interview.

[27] PAS Vr., from PAS International, Inc.
[28] The project's Impaired Driver Protocol (IDP) is discussed in Appendix D.

Preliminary Breath Test Device

The data collector invited the participant to provide a breath sample, via a preliminary breath test device[29] (Figure 3; Appendix B) which uses an internal fuel cell to measure BrAC when air is blown into the breath tube.

To ensure the privacy of drivers' data, the results were stored in the unit's memory rather than displayed. Additional PBTs, which did display results, were on hand for instances when the team needed to implement an impaired driving protocol.

Figure 3. Preliminary Breath Test (PBT) Device

Oral Fluid Collection Device

The data collector invited the participant to provide an oral fluid sample and receive $10. The Quantisal[30] collection device (Figure 4; Appendix C) was used by the driver placing the device under his or her tongue. An indicator stick the data collector could see changed from white to blue, alerting the needed 1 mL was collected. The subject then placed the stick into a tube containing 3 mL of a stabilizing buffer solution.

Throughout data collection, chain of custody (CoC) labels were used to link participant data. No identifying information about the driver was included.

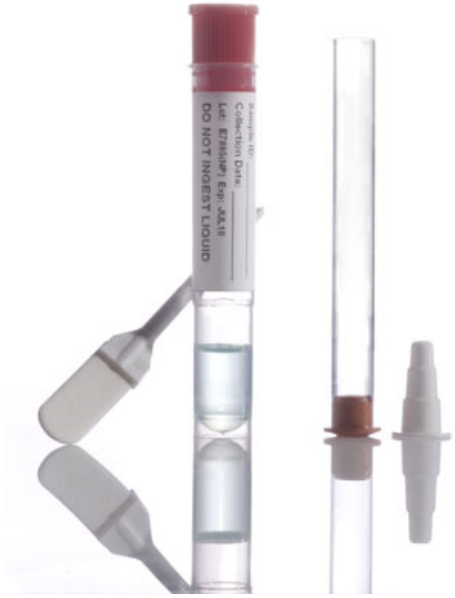


Figure 4. The Quantisal Oral Fluid Collection Device

[29] The Intoxilyzer PA-400, a handheld device manufactured by CMI, Inc. This device has been tested was on NHTSA's Conforming Products List (Fed. Reg. 78(89)).
[30] Immunalysis Corporation

Surveys

The National Institute of Alcohol Abuse and Alcoholism funded the self-report survey components, including interview time. Any results from the surveys will be released through that agency. There were questions similar to those on the 2007 NRS, covering drinking, drinking and driving; and whether the subject was acting as a designated driver (Appendix E).

Table 3. Alcohol and Drug Crash Risk Questions

Item #	Questions
1	The average driver drives about 15,000 miles a year. What would you say you drive?
2	About how many miles away are you now from where you live? *[PROMPT TO TAKE SECOND PASSIVE SENSOR READING]*
3	Where are you coming from?/Where are you headed? *[ASSESS ESTIMATED INTOXICATION LEVEL]* *[PROMPT TO ENTER PAS LEVEL ONTO FORM]*
4	In the past year, how often did you have a drink containing alcohol?
5	In the past year, have you ever had (5: male/4: female) or more drinks in a TWO-hour period?
6	Have you had anything to drink today/tonight?
7	How long ago did you finish your last drink? _____Hours _____Minutes
8	Was that beer, wine, liquor, or a combination?
9	About how old were you when you first started drinking alcohol not including small sips?
10	Are you the designated driver today/tonight? That is, someone who did not drink alcohol so that you could safely get people home?
11	During the last week, how many hours did you sleep on average each night?
12	The last time that you slept, how many hours did you sleep?
13	What time did you wake up?
14	Crash Driver: At the time of the crash, were you using a cell phone or other electronic device? Control Driver: When you saw the officer up ahead and were approaching us, were you using a cell phone or other electronic device?
15	Were you doing anything else in addition to driving such as eating, grooming, or talking to a passenger?
16	How frequently do you use a cell phone, hands free device, or text while driving?
17	What is your age?
18	How old were you when you obtained your license?
19	What is your ZIP code?
20	What is the highest degree or level of school you have completed?
21	Are you currently a student?
22	Are you currently employed, unemployed, homemaker, on disability, retired, or other?
23	Are you on active military duty?
24	Are you a veteran? If yes, how long ago were you discharged?
25	What is your marital status?
26	Are you Hispanic or Latino?
27	To which racial group would you say you belong?

Screening Instruments: This screened for alcohol use disorders (AUDs). Researchers used a similar instrument to screen for drug use disorders (DUDs).

The Booklet: While the Quantisal was in the participant's mouth, he or she completed the drug questionnaire, the DUD questionnaire, and the AUD questionnaire (Appendix F). Researchers asked each participant who agreed to provide an oral fluid sample to complete drug questionnaire and DUD. Persons who drank in the past year completed the AUD.

Drug Questionnaire: This covered over-the-counter, prescription, and illegal drugs. Drivers indicated the last time they used a medication/drug by responding "*Past 24 hours*," "*Past* 2 *days*," "*Past month*," "*Past year*," "*Over a year ago*," or "*Never*." A few questions related to drug use and drivers; others to experience with the criminal justice system or treatment (Table 4).

Table 4. Drug Items

Item #	Drugs
1	Tobacco (e.g., cigarettes, cigars)
2	Cough medicines (e.g., Robitussin, Vicks 44)
3	Other over-the-counter medicines (e.g., Tylenol, Benadryl)
4	Prescription pain killers (e.g., Percocet, Oxycontin, Oxycodone, Demerol, Darvon)
5	Sleep aids (e.g., Ambien)
6	ADHD medications (e.g., Ritalin, Adderall, Concerta)
7	Muscle relaxants (e.g., Soma, Miltown)
8	Prescription dietary supplements (e.g., Phentermine)
9	Antidepressants (e.g., Prozac, Zoloft)
10	Marijuana (e.g., pot, hash, weed)
11	Cocaine (e.g., crack or coke)
12	Heroin
13	Methadone
14	LSD (acid)
15	Morphine or codeine (e.g., Tylenol with codeine)
16	Ecstasy (e.g., "E", Extc, MDMA, "X")
17	Amphetamine or Methamphetamine (e.g., speed, crank, crystal meth)
18	GHB (e.g., Liquid E, Gamma-Oh, Fantasy)
19	PCP (e.g., Angel dust)
20	Rohypnol (Ruffies)
21	Ketamine (Special K)
22	Benzodiazepines (e.g., Valium, Xanax or tranquilizers)
23	Barbiturates (e.g., Phenobarbital, Luminal, Nembutal)

24	During the past 12 months, were you arrested and booked for driving under the influence of alcohol or drugs?
25	During the past 12 months, as a result of an arrest and/or conviction for driving under the influence of alcohol or drugs: a. Was your license suspended? b. Was your license revoked? c. Did you serve time in jail or prison? d. Did you pay a fine? e. Were you required to perform community service?
	f. Were you placed on probation? g. Were you required to attend an educational program? h. Were you required to attend a treatment program? i. Other punishment (if Yes, describe below)
26	In the past year, have you sought help because of your drinking?
27	In the past year, have you been told by a medical person you needed help for your drinking?
28	Have you visited a medical facility in the past year for your drinking (for example, seen a doctor or medical person, been to the hospital)?
30	During the past 12 months, have you received treatment for your drug or alcohol use in a self-help group such as Alcoholics Anonymous or Narcotics Anonymous?
31	Have you ever been admitted to an outpatient drug or alcohol treatment program, NOT including meetings like AA or NA? (An "outpatient program" is meant as a drug or alcohol treatment program where you do not stay overnight.)
32	During the past 12 months, did you ever stay at least overnight in an inpatient or residential drug or alcohol treatment program (for example, detox, rehab, a therapeutic community, or a hospital)?

DUD Questionnaire: A screener item prompted the driver on whether to proceed: *The following questions are about your use of marijuana, cocaine, and non-prescribed use or overuse of prescription painkillers in the past year. If not used in the past year, mark NO USE and turn page.* Participants received no additional incentive for completing the DUD (Table 5; Appendix F).

The DUD was fashioned after the AUD and Associated Disabilities Diagnostic Interview Schedule (AUDADIS) (Cottler et al., 1997; Grant & Dawson, 1997; Pull et al., 1997) and contains one item per symptom on the DSM-IV section on Substance Abuse and Dependence. Diagnosis of substance or drug use disorders required a separate assessment for each drug. This was used for the drugs expected to be most frequently encountered - THC, cocaine, and extra-medical use of prescription painkillers. The section measured abuse; the second section was on dependence.

Table 5. Drug Use Disorder

Item #	Drug Questions	Marijuana	Cocaine	Prescription Pain Killers
Screener	The following questions are about your use of marijuana, cocaine, and nonprescribed use or overuse of prescription painkillers in the past year. If not used in the past year, mark NO USE and turn page.			
1	In the past year, did your use often interfere with taking care of your home or family or cause you problems at work or school?			
2	In the past year, did you more than once get into a situation while using or after using that increased your chances of getting hurt, like driving a car or other vehicle or using heavy machinery?			
3	In the past year, did you get arrested, held at a police station, or have legal problems because of your use?			
4	In the past year, did you continue to use even though it was causing you trouble with your family and friends?			
5	In the past year, have you found that you have to use more than you once did to get the effect you want?			
6	In the past year, did you find that your usual amount had less effect on you than it once did?			
7	In the past year, did you more than once want to try to stop or cut down on your use, but you couldn't do it?			
8	In the past year, did you end up using more or using for a longer period than you intended?			
9	In the past year, did you give up or cut down on activities that were important to you or gave you pleasure in order to use?			
10	In the past year, when the medication/drug effects were wearing off, did you experience some of the bad after effects, like trouble sleeping, feeling nervous, restless, anxious, sweating, or shaking, or did you have seizures or sense things that weren't really there?			
11	In the past year, did you spend a lot of time using or getting over the bad aftereffects of use?			
12	In the past year, did you continue to use even though it was causing you to feel depressed or anxious or causing a health problem or making one worse?			

Alcohol Use Disorder Screening Instrument: There was a screening item to determine whether to pursue AUD questions - *"In the past year, how often did you have a drink containing alcohol?"* Subjects who had had a drink were administered the full AUD instrument (Table 6; Appendix F) and received a $5 incentive.

Table 6. Alcohol Use Disorder (AUD) Questionnaire

Item #	AUD Questions
Screener	In the past year, how often did you have a drink containing alcohol?
1	In the past year, how many drinks containing alcohol did you have on a typical day when you were drinking?
2	In the past year, how often did you have six (five for a woman) or more drinks on one occasion?
3	Did your drinking often interfere with taking care of your home or family or cause you problems at work or school?
4	Did you more than once get into a situation while drinking or after drinking that increased your chances of getting hurt—like driving a car or other vehicle or using heavy machinery after having had too much to drink?
5	Did you get arrested, held at a police station, or have legal problems because of your drinking?
6	Did you continue to drink even though it was causing you trouble with your family or friends?
7	Have you found that you have to drink more than you once did to get the effect you want?
8	Did you find that your usual number of drinks had less effect on you than it once did?
9	Did you more than once want to try to stop or cut down on your drinking but couldn't do it?
10	Did you end up drinking more or drinking for a longer period than you intended?
11	Did you give up or cut down on activities that were important to you or gave you pleasure in order to drink?
12	When the effects of alcohol were wearing off, did you experience some of the bad after effects of drinking, – like trouble sleeping, feeling nervous, restless, anxious, sweating or shaking, or did you have seizures or sense things that weren't really there?
13	Did you spend a lot of time drinking or getting over the bad after effects of drinking?
14	Did you continue to drink even though it was causing you to feel depressed or anxious or causing a health problem or making one worse?

Some items of the AUD were derived from the Alcohol Use Disorders Identification Test (AUDIT). The items represented the AUDIT consumption subscale, also known as the AUDIT-C (Babor, de la Fuente, Saunders, & Grant, 1992; Chung, Colby, Barnett, & Monti, 2002; Conley, 2001). Other questions were derived from the AUDADIS (Cottler et al., 1997; Grant & Dawson, 1997; Pull et al., 1997). The AUDADIS was constructed with one item per symptom on the DSM-IV section on Alcohol Abuse and Dependence.

Data Collection Procedures

At least one team was always in the field, 24 hours a day, 7 days a week. Additional teams were on hand for high crash periods. As part of human subjects' protections, steps were taken to ensure that all participants understood the study's purpose and procedures, the risk and benefits of participating, that participation was voluntary, that they could skip any question or part of the study, and they could stop participating any time. Research officers had minimal interaction with drivers, to minimize any possible sense of coercion due to law enforcement. Data collectors needed to receive verbal consents for the questionnaire and breath test, the oral fluid sample, drug questionnaire, the AUD instrument, and the blood sample for a driver to participate.

Crash Procedures

A crash met the criteria if it was "reportable" (damage was estimated at more than $1,500, or there was an injury). Crashes that were excluded:

- occurred on a limited access highway or private property.
- involved only commercial vehicles
- involved emergency vehicles, such as police, ambulance, or fire trucks.

The officer assisted with the crash investigation or provided traffic control. In some cases, the research officer became the investigating officer. All crashes included the same major components; however, some procedures differed depending on the type of crash, such as whether there was an injury or impaired driver. The data collector met with each driver individually, and requested a breath, oral fluid, and blood sample. The blood draws were conducted in the subject's vehicle, the research officer's vehicle, or another safe place at the scene. The incentive was given in as a money order.[31] If impairment was suspected, the impaired driving protocol was initiated.

[31] This was as a precaution so a subject could not spend the money immediately on alcohol or other drugs and then return to driving.

Hospital Procedures

If a driver went to a hospital, the team temporarily obtained information on the driver to follow up at the hospital. In those cases, the research officer obtained the driver's name, which hospital, and the ambulance number (Appendix G). Once the team was at the hospital with the driver, the information card was destroyed for privacy protection.

Driver in Emergency or Waiting Room: If medical staff were treating the driver, a time was arranged for data collection. If the driver consented and the driver was waiting to be seen by medical personnel, the data collector drew blood. If medical personnel were going to draw blood, the data collector provided a gray top tube, for a separate research sample.

After Driver Seen by Physician: For drivers already been seen by a physician, the officer asked for a private place to talk with the driver.

Seriously Injured Drivers: Typically medical personnel drew and stored an additional 10 mL of blood using a research gray top tube. Once the driver was able, a research assistant asked for research use of the blood sample previously drawn (Appendix H). If the driver consented, the $50 incentive was provided. If the driver did not consent, the hospital staff destroyed the research blood sample, and the information card was destroyed.

Medical Examiner

For drivers who died in the crash, the medical examiner drew a vial of blood for the study.

Drivers Arrested for Impaired Driving (Both Non-Injury and Minor-Injury Crashes)

When a driver was arrested for impaired driving or another offense, the team sometimes was still able to obtain data at the crash scene or police booking facility. Usually the suspect had provided breath samples as part of the arrest process. The data collector read a Detained Driver consent, which noted that neither participating nor declining would benefit or harm the detention status. As NHTSA wanted to ensure the research did not compromise the arrest process, data collectors did not request a breath or blood sample. If the driver consented, the result of the police-obtained test was obtained. If an arrestee did not consent, the researcher did not obtain the

BrAC from the police. Data collectors did asked for an oral fluid sample.[32] If the driver participated, the data collector conducted data collection in a private manner but within view of the officer.

Hit-and-Run Crashes: If a hit-and-run crash involved more than one driver, the officer gathered information from drivers or pedestrians at the scene, and if the other driver was apprehended within two hours, the team followed the protocol for arrested drivers.

Control Procedures

One week after a crash, the team returned to the crash location to obtain data from two drivers for every crash driver who participated. This was at the same location, on the same day of week and at the same time of day as the crash. There were situations where vehicles collided in a perpendicular fashion (e.g., northbound and eastbound); if both crash drivers agreed to participate, the team collected two samples for the crash driver who was northbound and two samples for the driver who was eastbound.

The data collector and officer sought a safe location close to the crash site, such as a parking lot. The data collector created research bay, set up equipment, and placed two large orange diamond-shaped "Voluntary Survey" signs on the road (Figure 5). One sign was approximately 100 feet ahead of the entrance to the bay and the other at the entrance to the bay. The officer arranged the police vehicle and any other appropriate lighting/safety equipment so that passing vehicles clearly saw the officer. The data collector signaled the research officer when ready. To prevent the possible bias in the subject selection, the officer waited for three vehicles to pass before alerting an approaching

Figure 5. Voluntary Survey Signage used at Control Data Collection Sites

[32] Oral fluid was not used in court cases in Virginia Beach.

driver about the research area. If a vehicle entered, the data collector began the consent process.[33] The same participation criteria as for crash drivers applied for control drivers.

Reporting

All of the forms were coded to allow a participant's data to be linked. No identifying information was kept on drivers.

Crash Report Form (Gray Card, Appendix I): The officer completed a form that included number divers, time of crash, roadway, and direction of vehicle.

Crash Site Observation Form/Site Report Form (Yellow Card, Appendix J): This form had a unique crash number, and included time, weather, lighting, roadway conditions, traffic flow, injuries, and the number of vehicles, pedestrians, or bicycles. The site report form was printed on the reverse of the crash site observation form and was used for each crash site and case-control session. It included day of week, month, shift number, PAS and PBT numbers, participant fees dispensed, samples obtained, and any impaired diving protocols.

Driver Information Card (Blue Card, Appendix K): This indicated which study components were conducted and merged drivers' data across the study components.

Driver Observation Form (Appendix L): If a driver declined to participate at initiation, the data collector recorded age, gender, ethnicity, race, vehicle type, and passengers, and seat belt or helmet use.

Blood Draw (Appendix M): Drivers consented to provide a blood sample by initialing or writing an "X" on the consent form. Participants received an unsigned copy. Chain of Custody labels linked a blood sample to a participant's other data. The phlebotomist drew one gray-top tube (10 mL) of blood.[34] [35]

[33] In some instances control drivers participated partially in the survey but did not provide either an oral fluid sample or a blood sample. Further drivers were then recruited until at least an oral fluid sample from two control drivers had been obtained.

[34] Toennes & Kauert (2001) found gray-top tubes (containing potassium oxalate and sodium fluoride) can help avoid the degradation of drugs in blood samples. Additionally, gray-top tubes are helpful in conducting ethanol analysis because the sodium fluoride is an effective antibacterial agent, which inhibits endogenous alcohol production.

Injured Driver Information Card (Pink Card, Appendix G): If a driver was transported to a hospital via ambulance, the officer noted the date, driver's name, the ambulance number, and the name of the hospital. This information was destroyed after contact with the driver at the hospital.

Analysis of Biological Samples

The drugs for this study were over-the-counter, prescription, and illegal drugs that have the potential to impair driving performance and could be expected in the general driver population. Oral fluid and blood samples were screened and confirmed for the drugs (Table 7; Appendix N) using enzyme-linked immunosorbent assay (ELISA) micro-plate technology. The lab provided all confirmations via gas chromatography-mass spectrometry (GC/MS) or liquid chromatography-mass spectrometry (LC/MS) technology (Moore, Coulter, Crompton, & Zumwalt, 2007). For samples with insufficient volume, the laboratory could conduct an initial screening test but could not conduct a confirmatory analysis by GC/MS.

Table 7 includes the National Institute on Drug Abuse (NIDA)-5 drugs, (amphetamines [amphetamine, methamphetamine], cocaine, THC, opiates, and phencyclidine [PCP]), which are prevalent drugs of abuse and are of universal interest in the study of drug involvement. The NIDA-5 constitutes routine components of a drug-screening panel (Substance Abuse and Mental Health Services Administration, 2012). Other drugs have been identified as presenting potential traffic safety risks (NHTSA, 2014). The presence of a drug does not necessarily indicate that the driver was impaired by that drug at the time they were driving.

[35] Glass tubes were used to better maintain reliable drug results. In a study on the stability of THC in whole blood during storage in both polystyrene and glass vials (Brogan et al., 1992), THC concentration in blood stored in glass vials for three weeks at -20°C remained unchanged; however, blood stored in plastic vials lost 60%–100% of its THC content during storage. Thus, glass vials are preferred for collection of samples that may contain THC.

Table 7. Drugs and Minimum Detection Concentrations[†]

Drug Class	Drug Type[a]	Minimum concentration oral fluid (ng/mL[b])		Minimum concentration blood (ng/mL)	
		Screen	Confirm	Screen	Confirm
Marijuana	Cannabinoids (THC)	4	2	10	1
Antidepressants	Fluoxetine	25	10	50	10
	Sertraline	25	10	50	10
	Tricyclic antidepressants	25	25	25	10
Narcotic analgesics	Buprenorphine	5	5	1	1
	Fentanyl	1	.5	1	.5
	Meperidine	50	25	50	10
	Methadone	50	20	50	10
	Naltrexone	40	10	25	10
	Opiates	40	10	25	10
	Oxycodone	40	10	25	10
	Propoxyphene	40	10	20	10
	Tramadol	50	25	50	10
Sedatives	Barbiturates	50	50	100	100
	Benzodiazepines	5	1	20	10
	Zolpidem	10	5	10	10
Stimulants	Cocaine, Benzoylecgonine	20	8	25	10
	Methamphetamine/Amphetamine	50	25	20	10
	Methylphenidate	10	10	10	10
Other	Carisoprodol	50	50	500	500
	Dextromethorphan	50	20	50	20
	Ketamine	10	10	10	10
	Phencyclidine (PCP)	10	10	10	10

[†]Screening: ELISA micro-plate technology; Confirmation: GC/MS or LC/MS/MS technology.
[a] For a complete list of drugs, see Appendix N.
[b] Nanograms per milliliter.

Marijuana

Marijuana is a mixture of the dried and shredded flowers, seeds, and leaves of the hemp plant, *Cannabis sativa* (Couper & Logan, 2014a). Marijuana contains chemicals called cannabinoids, including delta-9-tetrahydrocannabinol (THC), cannabinol, cannabidiol, cannabinolidic acids, cannabigerol, cannabichromene, and several isomers of THC. Cannabinoids, including THC, which is the psychoactive component of the marijuana plant, have 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. However, when THC is found in drivers, it is often in conjunction with alcohol, where an impairing effect is more likely (Couper & Logan, 2004). A positive oral fluid result for the parent compound is likely to be associated with very recent THC use. Other than alcohol, THC was the most prevalent drug in the 2007 NRS (Lacey, Kelley-Baker, Furr-Holden, Voas, Romano, Ramirez, et al., 2009).

Antidepressants

Antidepressants, most commonly in the form of selective serotonin reuptake inhibitors (SSRIs), such as fluoxetine (Prozac) and sertraline (Zoloft), can cause impairment in circumstances of high concentrations or when taken outside of therapeutic treatment. Tricyclic antidepressants can cause drowsiness, sedation, and negatively affect psychomotor abilities. The sedating effect of tricyclic antidepressants is greatest when beginning treatment or when the dose is increased. There is an additional risk of impairment associated when use is combined with alcohol.

Narcotic Analgesics

Narcotic analgesics are used both medically and as drugs of abuse. After the initial euphoria, they act as central nervous system depressants, which could have adverse effects on driver performance.

Methadone is used medically for opiate detoxification pain treatment. It is a drug of abuse. It may have differential performance effects in naïve or recreational users versus tolerant therapeutic users.

Opiate painkillers are a class of drugs that may lead to driving impairment, especially when combined with alcohol. Commonly used painkillers include oxycodone, tramadol, propoxyphene, and meperidine.

Sedatives

Barbiturates are widely prescribed as anti-convulsant medications. Because of their CNS depressant effects, they are associated with delayed reaction times and loss of concentration, thus potentially affecting driving performance. Benzodiazepines such as Valium, Xanax, lorazepam (Ativan) may be prescribed to sedate and reduce anxiety.

Stimulants

Amphetamine and methamphetamine are central nervous system stimulants used medically to treat attention deficit hyperactivity disorder or assist with weight loss. Amphetamines may be taken recreationally and to enhance performance or stay awake. Ecstasy is a methylated amphetamine derivative with hallucinogenic properties.

Cocaine is mainly a drug of abuse and little is known about its effects on human performance at higher levels or in combination with alcohol.

Other stimulants, such as methylphenidate (Ritalin), are amphetamine-like prescription drugs commonly used to treat attention deficit hyperactivity disorder.

Other

Phencyclidine (PCP) has hallucinogenic and dissociative effects. It has serious performance-diminishing effects and has been found in impaired-driving cases.

Sleep aids, such as Ambien cause drowsiness and may cause dizziness. These symptoms may increase with alcohol.

Dextromethorphan, a synthetic analog of codeine, is an antitussive widely used in cough medicines It may cause CNS depressant effects, and with extreme dosing, dissociative effects – similar to PCP.

Ketamine (Special K) is a tranquilizer that is sometimes used recreationally as a psychedelic and dissociative.

Prescription muscle relaxants, such as carisoprodol (Soma), are CNS depressants and are often abused.

Laboratory Quality and Proficiency

All the analytical procedures were validated according to established protocols.[36] Negative, low- and high-level controls were run in each batch, along with calibration standards.

[36] Immunalysis Corporation is enrolled in the proficiency testing program for oral fluid, administered by Research Triangle Institute which serves as a monitor of accuracy.

Oral Fluid Sample Analysis Procedures

Screening analysis was conducted using ELISA at specified cut-off concentrations (Table 7). Samples that were positive during the screening process then analyzed, using a separate sample of the fluid, using GC/MS or LC/MS/MS.

Gas Chromatography-Mass Spectrometry (GC/MS)

Instrumentation

Agilent 6890 gas chromatography - 5973 or 5975 mass selective detector (GC/MSD); electron impact (EI) mode.

Extraction

Oral fluid (1 ml) of diluted specimen (1:3 buffer) was extracted using mixed mode solid phase methods with drug specific column phases.

Derivatization

Drug-specific derivatives if required for maximum detectability and stability.

Liquid Chromatography-Mass Spectrometry (LC/MS/MS)

Instrumentation:

Agilent LC/MS/MS System: 1200 Series LC pump 6410 Triple Quadrupole; or
6430 Tripe Quadrupole

Zorbax Eclipse XDB C18 (4.6 x 50mm x 1.8μm) column

Derivatization:

THC-COOH in oral fluid only (Coulter, Garnier, & Moore, 2012)

Blood Sample Analysis Procedures

Screening analysis was carried out using ELISA at specified cut-off concentrations (Table 7). Samples that were positive during the screening process were confirmed using either GC/MS or LC/MS.

Ethanol (Oral Fluid and Blood)

Positively screened alcohol specimens were analyzed using headspace GC-with flame ionization detection. The dilution technique involved spiking an oral fluid sample with N-propanol (1-propanol) as an internal standard. Both ethanol and the internal standard are volatile; therefore, they evaporate into the "headspace" of the vial upon heating. The concentration of the volatile substance in the headspace was determined according to calibration standards.

Instrumentation

Perkin Elmer Turbo Matrix 40 Headspace analyzer
Agilent 5890 Gas Chromatograph with flame ionization detector
Column: DB-624 J&W Scientific (122-1334) (30 meter, .25mm ID, 1.4µm thickness)

Specimen Preparation

Add .25mL neat oral fluid + buffer in the Quantisal collection device or blood to a 20mL headspace vial with crimp top closure.
Add 100µL of 20mg/dL N-propanol (internal standard) to all calibrators, controls, and specimens.

Data Handling and Processing

Descriptions of data handling and processing are in Appendix O.

Data Analysis

Measures and Working Variables

Crash Drivers/Control Drivers

To model the likelihood of crash involvement, statisticians used a binary (0,1) dependent variable identifier indicating whether the individual was a crash-involved or control driver. Odds ratios reported for driver age, gender, race/ethnicity, alcohol concentration, and presence of drugs, measure the odds of crash involvement.

Driver's Age

Research has indicated that crash risk varies with driver's age,[37] with younger (16–20) drivers being at greatest risk (Zador et al., 2000). To account for the contribution of age to crash risk, these categories based on "years old" were examined: 16–20, 21–34, 35–44, 45–64, and 65+. For logistic regression analyses and to avoid unnecessary loss of degrees of freedom, 35–44 and 45–64 were grouped into a single category. The contribution of each age group to crash risk was measured relative to that by drivers aged 21–34 (named the reference group[38] for this variable). We chose 21-34 (the youngest group legally able to drink) as the reference group to provide meaningful comparison to underage drivers (the 16-20 age group) and drivers 35 and older.

Driver's Gender

Research has shown risk of crash involvement varies by the driver's gender, with males at far greater risk[39] Females were chosen as the reference group in this particular case because, as a whole, they tend to be at lower crash risk than males.

[37] (Beirness & Simpson, 1988; Braitman, Kirley, McCartt, & Chaudhary, 2008; Kelley-Baker et al., 2013; Masten, Foss, & Marshall, 2011; McCartt, Mayhew, Braitman, Ferguson, & Simpson, 2009; Peck, Gebers, Voas, & Romano, 2008; Preusser, Williams, Nichols, Tison, & Chaudhary, 2008; Shope & Bingham, 2008; Tsai, Anderson, & Vaca, 2010; Voas, Torres, Romano, & Lacey, 2012; Williams, 2003; Zador et al., 2000).

[38] A reference group denotes, for each variable, the group used for comparisons.

[39] (Elliott, Shope, Raghunathan, & Waller, 2006; and ; Kelley-Baker, Falb, Voas, & Lacey, 2003; Kelley-Baker & Romano, 2010; Marelich, Berger, & McKenna, 2000; Massie, Green, & Campbell, 1997; Mayhew, Ferguson, Desmond, & Simpson, 2003; Robertson, Liew, & Gardner, 2011; Robertson, Holmes, & Marcoux, 2011; Romano, Kelley-Baker, & Voas, 2008; Swedler, Bowman, & Baker, 2012; Zador et al., 2000).

Driver's Race/Ethnicity

Although alcohol-related fatalities have decreased in the last 20 to 25 years, this trend may not be a uniform trend for all racial/ethnic groups. Crash data (Voas, Tippetts, & Tippetts, 2000; Hilton, 2006) and arrest data (Chang, Lapham, & Barton, 1996; Caetano & McGrath, 2005) consistently show a larger involvement of Latinos and Native Americans in impaired-driving events. Interestingly, while arrest and crash data show an overrepresentation of these groups in impaired-driving events, data from national surveys show rates of impaired driving for these groups that are lower or equal to those for non-Hispanic whites (Romano, Voas, & Lacey, 2010). Because race/ethnicity has been suggested as a contributing factor to alcohol-related crashes, it was included in the analyses. For the logistic regression analyses, due to small sample sizes, analyses were limited to Hispanics, non-Hispanic African-Americans/Blacks, non-Hispanic whites, and "other" (for other race/ethnicities for who sample size was not large enough for individual comparisons). Non-Hispanic white drivers were the reference group as they were the largest group.

Alcohol Concentration (AC)

The AC variable was categorized into four levels:

1. AC = .00 (equal to zero)
2. .00 < AC < .05 (greater than zero but less than .05)
3. .05 ≤ AC < .08 (equal to or greater than .05 but less than .08)
4. AC ≥ .08 (equal to or greater than .08)

The reference category was AC = .00, as it was the most common result. For regression analyses, a continuous measure of AC was used.

Drugs

Previous literature has described blood as the gold standard for examining drug concentrations and relationship to behavioral impairment (Jones, Shinar, & Walsh, 2003). On the other hand, oral fluid provides greater detail on recent use of some drugs, such as THC, and is less invasive and more cost effective (Langel et al., 2008). As such, in an attempt to reach the gold standard of drug screening and provide more comprehensive information concerning recent drug use, NHTSA gathered both blood and oral fluid samples in the current study. The laboratory tested the oral fluid and blood samples for presence and concentration of substances with potentially impairing effects on driving, including both parent drugs and metabolites. Inactive metabolites not known to have an impairing effect were not included in the analyses.

Active metabolites were classified from their parent drug, according to the laboratory's guidelines (Appendix N).

The relative risk analyses were based on the presence or absence of a drug. Because of the reduced sample size (thus, reduced statistical power) of the blood-based matched data set relative to the oral fluid-based matched pairs, and to avoid the confounding effect of mixing results from two different biological sources, estimates of drug crash risk were based only on information from perfect oral fluid-based 1:2 matches (i.e., triads of 1 case and 2 controls with full oral fluid information). Ideally, crash risk would be estimated for all individual drugs in the sample; however, that was not possible. Sample size for most individual drugs (with the exception of THC) was not large enough to allow for meaningful statistical analyses (Appendix P). To address this limitation, individual drugs were aggregated into drug categories and drug classes. The two broad drug categories were illegal and medications. The five drug classes were THC, antidepressants, narcotic-analgesics, sedatives, and stimulants. The few rarely encountered drugs that did not fall into any of these classes were recorded as a miscellaneous "other" class. The classes were mutually exclusive. To facilitate comparisons, two of the categories and all classes corresponded to the 2007 and 2013–2014 NRS (Appendix N).

Further information on blood sample results are in Appendices P, Q, and R.

Descriptive Analyses

Age, gender, and race/ethnicity, and alcohol were analyzed by prevalence of drug-positive, drug class, and drug category. Chi-square statistical tests compared differences in drug prevalence within demographic groups.

Relative Risk Estimation

As alcohol was the target drug for previous case-control studies and, thus, the one for which analytical procedures are largely documented, statisticians estimated the contribution of alcohol to crash risk.

Second, statisticians applied univariate conditional logistic regression to estimate the likelihood of crash involvement with a drug present. This estimated the contribution of drugs to crash risk unadjusted by any other factor.

Third, researchers estimated drug relative crash risk adjusted by age, gender, and race/ethnicity, and by driver AC.

This report does not distinguish between relative risk and odds ratios estimates. As is customary in epidemiologic studies, estimates of odds ratios for fatal crashes based on exposure data (vehicle miles traveled) can be obtained using logistic regressions in the context of a case-control study (Agresti, 2002). As in Blomberg et al. (2005), Zador et al. (2000), and Voas et al. (2012), the relative risk of crash involvement was approximated by computing odds ratios. Relative risk measures the probability of an event occurring among the exposed population, compared to the probability of the same event occurring among the non-exposed population. This study defines relative risk as the driver's risk of being involved in a crash (the event) after consuming drugs or alcohol (exposed population), relative to individuals involved in a crash who had not consumed drugs or alcohol (non-exposed population). For example, a resulting relative risk of 7.0 means that the exposed population has seven times the risk of being involved in a crash, as compared with the non-exposed population.

Logistic regression analyses provide estimates of odds ratios, which are slightly different from measures of relative risk. Odds ratios are very accurate estimates of relative risk when the frequency of the event is small (< 10.0%) relative to the exposed population (Agresti, 2002; Hogue, Gaylor, & Schulz, 1983). In this study, the frequency of drug-positive crashes (the event) is small, compared to the frequency of drug-negative crashes (the exposed population). Odds ratios are used for the drug analyses because of the small number of drug-positive crashes. There were a larger number of alcohol-positive crashes. Thus, we used relative risk comparisons for all other alcohol-related analyses.

Statisticians estimated two types of odds ratios: unadjusted and adjusted. Unadjusted odds ratios are obtained by directly comparing crash-involved and control drivers, without taking the contribution of other factors (e.g., age and alcohol), into account. Adjusted odds ratios are estimated after taking other variables into account. For example, as shown by previous studies, male drivers are more likely to be involved in a crash than female drivers. If male drivers were also more likely than females to use a drug of interest and researchers did not adjust findings for gender, the resulting unadjusted odds ratios would not be able to disentangle the separate contribution of gender and the drug of interest to crash risk.

Alcohol Crash Risk (Alcohol Alone; Not Adjusted for Drugs)

Although alcohol crash risk has been studied extensively in the past, new relative risk estimates allow for a more current examination of the contribution of alcohol to crash risk. Obtaining alcohol risk estimates that are unadjusted by the presence of drugs also allows for further validation of the current data set through a comparison of estimates with those reported in previous case-control studies.

The risk of crash involvement associated with a positive BrAC was estimated, relative to the crash risk, at BrAC = .00. Plotting the resulting relative risk as a function of increasing BrAC values produced an alcohol relative risk curve, which represents the extent to which each level of BrAC affects the crash risk of drivers at that BrAC level, compared to the crash risk of drivers with no alcohol. Similar to NHTSA's previous study (Blomberg et al., 2005), linear, quadratic, and cubic BrAC variables were included to capture the nonlinear nature of the BrAC curve.

The study design followed a 1:2 case-control study (two controls per crash-involved driver). There were many control drivers who did not give oral fluid samples but gave breath samples. These drivers were included in the analyses for alcohol crash risk but not drug crash risk. Therefore, the sample size for the alcohol analyses sometimes was larger than for other analyses. Thus, for estimating BrAC relative risk, researchers conducted conditional $1{:}N \geq 2$ logistic regression analyses on 10,221 drivers. Given the sparse data at very high BrACs, the BrAC values were capped at .20 g/210L, and drivers with higher BrACs received that value. The analyses were conducted with centered BrAC values to reduce multicollinearity (Darlington, 1990).

Statisticians began by examining linear, quadratic, and cubic polynomial models. None of the BrAC terms (linear, quadratic, or cubic) were statistically significant. To improve the fit of the model, statisticians transformed the BrAC linear variable using fractional polynomials. To do so, researchers searched through a simplified set of power transformations (-2, -1, -0.5, 0.0, 0.5, 1, 2, 3), where zero denotes the natural logarithm transformation (Hosmer & Lemeshow, 2000). They then compared models and selected the best model based on deviance tests.[40] They found that a model containing the $1/BrAC^2$ and $\sqrt{BrAC}$ transformations provided the best fit. They added a very small constant .00001 to each BrAC value to allow transformations for zero BrACs.

[40] Stata Data Analysis and Statistical Software, version 13, produced by StataCorp LP

Drug Crash Risk

The statistical strategy pursued for the estimation of drug-related crash risk was similar to that for alcohol. Statisticians used a conditional logistic regression analyses with the regression conditional to membership in a matched crash-control triad. Only perfect matches (oral fluid information for both the crash-involved driver and the two matched control drivers) were used in the analyses. Oral fluid data was used in the regression analyses rather than blood data as there were more oral fluid than blood samples.

Crash risk was estimated for each drug by class: THC, antidepressants, narcotic analgesics, sedatives, and stimulants; drug presence by category (illegal versus medications), relative to the drug's absence. For each drug of interest (drug class, drug category), there was a three-level, non-overlapping variable to indicate:

1. Presence of the drug class or category
2. Presence of another drug class or category
3. Negative result for any drug (the analysis' reference group)

Separately, there was another binary (0,1) variable to represent multiple-drug use. Interaction terms were tested to examine alcohol by drug use interaction.

Participation Data

Table 8 presents broad participation information on crash-involved drivers. Crashes were as follows:

- Property damage only: No injuries or fatalities
- Injury: No vehicle occupant died but at least one required medical attention (either at a health care center or at the scene of the crash)
- Fatal: One or more individuals died in the crash

Teams responded to 2,682 crashes, of which approximately16% (n = 431) were single-vehicle crashes, and 84% (n = 2,251) were multiple-vehicle crashes. Approximately 66% (n = 1,781) were property-damage only crashes, and 34% were crashes involving an injury (n = 886) or fatality (n = 15). The small number of fatal crashes precluded separate analyses of crash risk.

Table 8. Types of Crashes

Type of Crash	N	%
Crashes	2,682	100.0
Single-vehicle crash	431	16.1
Multiple-vehicle crash	2,251	83.9
Property damage only	1,781	66.4
Injury	886	33.0
Fatal	15	.6

The flow of data appears in Figure 6, tracking the data through analysis. Researchers approached a total of 12,790 drivers (5,375 crash-involved and 7,415 controls). Of these, 3,887 crash-involved drivers and 7,397 control drivers were eligible.

As indicated in Figure 6, 94.7% of the eligible drivers in crashes (n = 3,682) and 97% of the matched control drivers (n = 7,176) participated in the self-report components. The combined number constitutes the 10,858 drivers who initially consented to the study. Among those who consented, 3,467 crash-involved drivers and 7,078 control drivers provided a breath sample using a PBT device. When researchers matched crash-involved and control drivers based solely on the PBT information, 10,221 drivers (3,353 crash-involved and 6,868 control drivers) remained in the sample.

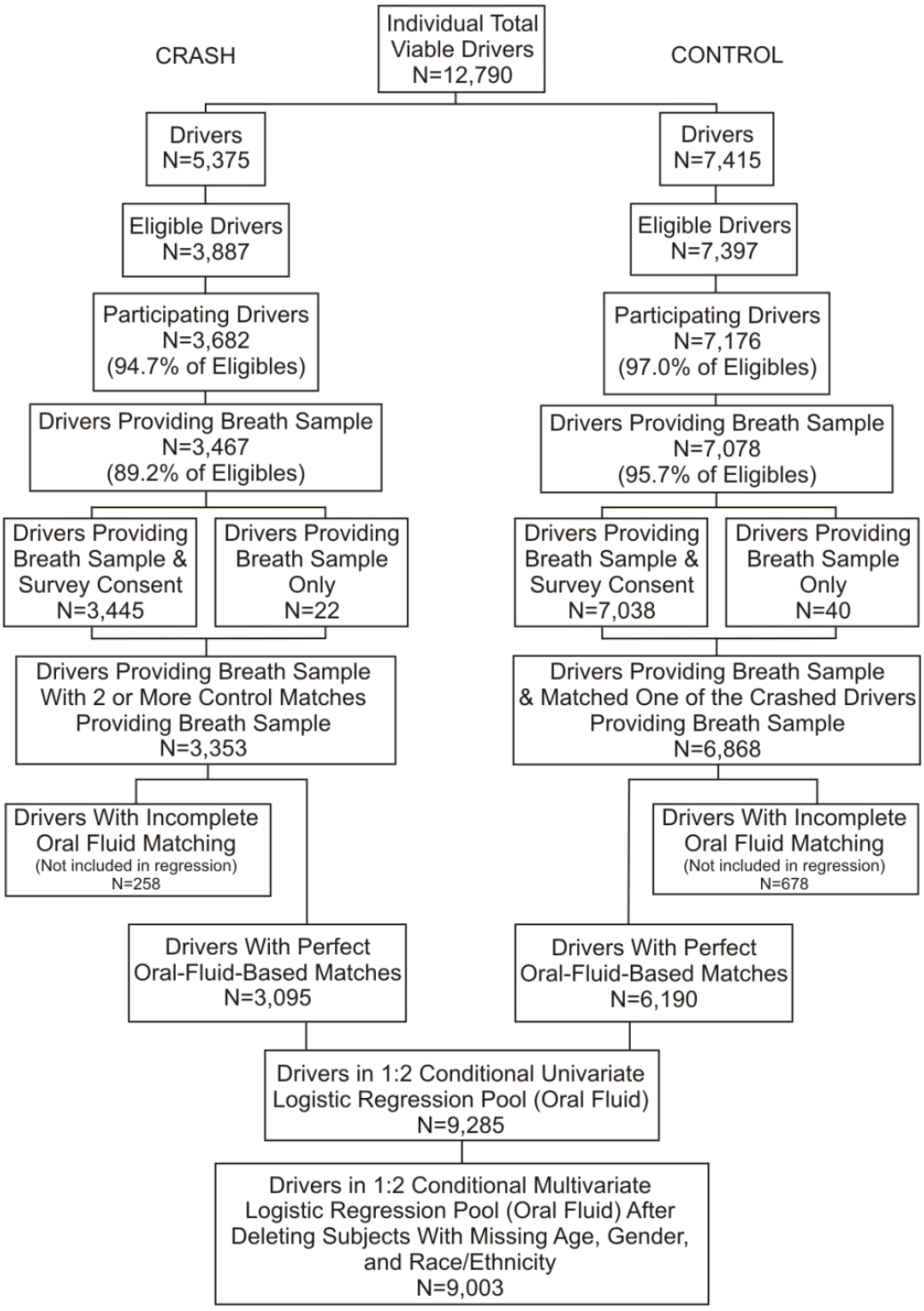


Figure 6. Flow of Sample Sizes of Crash and Control Drivers Included in Risk Analyses Using Oral Fluid

Occasionally data could not be collected from two control drivers during the allotted time These 258 cases (Figure 6) were excluded from the analyses.[41]

In a few instances, the data collectors obtained control breath alcohol data from more than two control drivers because, before reaching the two control drivers who provided oral fluid information quota, other drivers provided a breath sample (but declined to provide an oral fluid sample).

A total of 3,196 crash-involved and 6,935 control drivers provided oral fluid and/or blood samples, which constituted 82.2% of the crash-involved drivers and 93.8% of the control drivers eligible for the study. After eliminating less than perfect (1:2) crash-control matches, 3,095 crash-involved and 6,190 control drivers remained for the logistic regression analyses of drug-related crash risk based on oral fluid analysis results. However, due to missing information on other relevant covariates (age, gender, race/ethnicity), statisticians used 9,003 1:2 matched drivers.

More detail regarding the collection of oral fluid and blood data appears in Table 9.

Table 9. Total Number of Oral Fluid and/or Blood Samples

	Crash-Involved Drivers	Control Drivers
Total provided oral fluid and/or blood sample	3,196	6,935
(percentage of eligible drivers)	(82.2%)	(93.8%)
Provided oral fluid sample (not blood)	1,852	2,881
Provided blood sample (not oral fluid)	25	16
Provided oral fluid *and* blood samples	1,319	4,038
Perfect oral fluid-based matches (1:2)	3,095	6,190
Perfect blood-based matches (1:2)	588	1,176

Among 5,375 crash-involved drivers, 729 were transported to a hospital (Table 10). Of these drivers, 393 were eligible and, of these, 362 (92.1%) participated. Oral fluid samples were obtained from 308 drivers (78.4%).

There were 18 fatalities within the study; we received blood samples for 10 from the medical examiner. There were 205 crash-involved drivers arrested or transported to jail or booking facility. Of these, 120 were eligible, and 109 (90.8%) participated. Table 10 shows

[41] Incomplete oral fluid matching refers to a crash where one or more of the drivers did not provide an oral fluid sample. We have kept these drivers into our sampling pool; however, for regression analyses they were not included.

information from the 84 crash-involved "hit and run" drivers. Of these, 42 were apprehended within two hours of the crash. Twenty-seven were eligible; 24 (88.9%) participated.

The number who gave blood but not oral fluid was very low. In the case of drivers transported to the hospital, only 9 drivers provided blood but did not give an oral fluid sample - out of 393 eligible participants (2.3%).

Table 10. Attempts to Collect Data from Crash-Involved Drivers in Hospitals, Fatalities, in Jail/Arrested, and Hit-and-Runs

	Crash-Involved Drivers	
Drivers transported to hospital	729	
Eligible	393	
Consented (percentage of eligible)	362	(92.1%)
Oral fluid sample (percentage of eligible)	308	(78.4%)
Blood sample (percentage of eligible)	144	(36.6%)
Oral fluid and blood samples (percent of eligible)	135	(34.4%)
Fatalities	18	
Blood sample	10	(55.6%)
Drivers transported to jail/arrested	205	
Eligible	120	
Consented (percentage of eligible)	109	(90.8%)
Oral fluid sample (percentage of eligible)	88	(73.3%)
Blood sample (percentage of eligible)	13	(10.8%)
Oral fluid and blood samples (percent of eligible)	13	(10.8%)
Hit and run	84	
Hit and run (caught)	42	
Eligible	27	
Consented (percentage of eligible)	24	(88.9%)
Oral fluid sample (percentage of eligible)	18	(66.7%)
Blood sample (percentage of eligible)	6	(22.2%)
Oral fluid and blood samples (percent of eligible)	2	(7.4%)

Conversion Attempts in Crash-Involved and Control Drivers

There were 156 attempts to "convert" drivers who initially declined. Of these, 91 decided to participate when offered an additional $100 (80 were control drivers and 11 were crash-involved drivers). The success of the conversion attempts was significantly higher among control drivers (73.4%) than among crash-involved drivers (23.4%), $p < .0001$ (Table 11).

Table 11. Conversion Attempts Among Crash-Involved and Control Drivers

		Successful		
		Yes	No	Total
Crash-Involved Drivers	*N*	11	36	47
		23.4%	76.6%	
Control Drivers	*N*	80	29	109
		73.4%	26.6%	
p-value		<.001		
Total		91	65	156

Shading indicates statistical significance.

Alcohol

The prevalence of alcohol among drivers who did convert and participated appears in Table 12. For crash-involved drivers, the prevalence of alcohol-positives was significantly higher ($p < .003$) (27.3%) than for those who immediately accepted (5.8%). For control drivers, there was no significant difference in the prevalence of alcohol between converters and immediate participants ($p = .37$). This is similar to results in the 2007 NRS (Lacey, Kelley-Baker, Furr-Holden, Voas, Moore, et al., 2009).

Table 12. BrAC Prevalence by Conversion Attempts Among Crash-Involved and Control Drivers

		Crash-Involved Drivers		Control Drivers	
		BrAC = .00 g/210L	BrAC > .00 g/210L	BrAC = .00 g/210L	BrAC > .00 g/210L
Drivers who initially agreed to participate	N	3,328	203	6,832	208
		94.25%	5.75%	97.05%	2.95%
Drivers who initially declined, but then participated	N	8	3	79	1
		72.73%	27.27%	98.75%	1.25%
p-value			.003		.37

Shading indicates statistical significance.

Drugs

Table 13 compares the prevalence of drug categories among drivers for those who converted and participated. For controls, there was no significant difference in the prevalence of drug categories between immediate participants and converters (p = .84). There was no significant difference in the prevalence of drug categories among crash-involved drivers (p = .06). This result should be viewed with caution as the p-value is only marginally non-significant.

Table 13. Drug Prevalence by Conversion Attempts Among Crash-Involved and Control Drivers

		Crash-Involved Drivers					Control Drivers				
		Illegal	RX	OTC	> 1 Class	Negative	Illegal	RX	OTC	> 1 Class	Negative
Drivers who initially agreed to participate	N	266	129	12	95	2,657	504	317	12	149	5,857
	%	8.4	4.1	0.4	3.0	84.1	7.4	4.6	.9	2.2	85.6
Drivers who initially declined, but then participated	N	2	2	0	1	6	7	2	0	2	69
	%	18.2	18.2	0	9.1	54.6	8.8	2.5	0	2.5	86.3
p-value						.06					.84

Results

Descriptive Analyses

This section presents the prevalence of drugs and alcohol for each level of the variable of interest (e.g., THC among male versus female drivers). Only the association between age, gender, race/ethnicity and drugs, as well as the association between AC and being drug-positive are presented. For data on the association between demographics and alcohol prevalence, by drug class and category, see Appendix Q. At times sample size was too small for meaningful comparison (n < 10); for these *p*-values are not reported.

Overall Drug Prevalence

Tables 14–17 summarize the results for the oral fluid and blood samples. Because of the reduced sample size and, thus, reduced power of the blood-based matched data set relative to the oral fluid-based matched pairs, other tables present only the oral fluid results. Additional information on blood analysis results is in Appendices P, Q, and R.

Table 14 shows the number and percentage of drug-positives among crash-involved and control drivers, for the oral fluid and blood samples.

The percentage of drug-positives as from the oral fluid sample was significantly higher among crash-involved drivers (16%) than among control drivers (14.4%) ($p < .05$). There was no statistically significant difference based on blood samples, perhaps due to the small sample size.

Table 14. Percentage of Crash-Involved and Control Drivers Drug Positive in Oral Fluid and Blood

	Crash-Involved Drivers			Control Drivers			
	N	Positives	% of Positives	N	Positives	% of Positives	*p*-value
Oral fluid samples	3,095	495	16.0	6,190	889	14.4	.04
Blood samples	588	107	18.2	1,176	188	16.0	.18

Shading indicates statistical significance between crash-involved and control drivers.

Table 15 shows the distribution of drug classes among crash-involved and control drivers, for the oral fluid and blood samples. In the oral fluid samples, THC was the most prevalent individual drug, in 7.6% of crash-involved drivers and 6.1% of control drivers, a difference that was statistically significant ($p < .05$). Also in the oral fluid samples, the presence of drivers positive for more than one drug class was significantly higher among crash-involved

drivers (3.0%) than among control drivers (2.1%) ($p < .01$) and the percentage of drivers who tested negative for any drug was significantly lower among crash-involved drivers (84%) than among control drivers (85.6%) ($p < .05$). In the blood samples, the prevalence of antidepressants was significantly higher among crash-involved drivers, at 4.3% compared to control drivers at 2.5% ($p < .01$). There were no other statistically significant differences in prevalence of drug classes in crash-involved and control drivers in the blood samples. See Appendix Q for additional results.

Table 15. Drug Class Distribution in Oral Fluid and Blood

	Oral Fluid					Blood				
	Crash-Involved Drivers		Control Drivers		*p*-value	Crash-Involved Drivers		Control Drivers		*p*-value
	N	%	N	%		N	%	N	%	
Marijuana (THC)	234	7.6	379	6.1	.01	33	5.6	79	6.7	.37
Antidepressants	44	1.4	82	1.3	.70	25	4.3	29	2.5	.04
Narcotic analgesics	105	3.4	188	3.0	.36	8	1.4	21	1.8	.90
Sedatives	90	2.9	139	2.3	.05	29	4.9	45	3.8	.27
Stimulants	116	3.8	225	3.6	.78	30	5.1	39	3.3	.07
Other	23	.7	30	.5	.12	9	1.5	8	.7	--
More than one class	92	3.0	132	2.1	.01	24	4.1	30	2.6	.08
Negative	2,600	84.0	5,301	85.6	.04	481	81.8	988	84.0	.18
Total	3,095		6,190			588		1,176		

Shading indicates statistically significant differences between crash-involved and control drivers.
p-values are based on z test of proportions (equivalent to Pearson's Chi Square).
Drug classes with fewer than 10 samples in either crash-involved or control drivers were considered too few for statistical testing.

Table 16 lists the prevalence rates of drugs other than alcohol in the "More than one class" category. Narcotic analgesics (54.4%), sedatives (48.9%), and THC (47.8%) were the most prevalent drugs found in multi-drug users.

Table 16. Distribution of Drug Classes Within the "More Than One Class" Category

	Oral Fluid					Blood				
	Crash-Involved Drivers		Control Drivers		*p*-value	Crash-Involved Drivers		Control Drivers		*p*-value
Drug Class	N	%	N	%		N	%	N	%	
Marijuana (THC)	44	47.8	59	44.7	.64	6	25.0	6	20.0	--*
Antidepressants	23	25.0	32	24.2	.90	12	50.0	9	30.0	--
Narcotic analgesics	50	54.4	63	47.7	.33	5	20.8	11	36.7	--
Sedatives	45	48.9	47	35.6	.05	13	54.2	18	60.0	.67
Stimulants	36	39.1	67	50.8	.09	11	45.8	14	46.7	.95
Other	11	12.0	18	13.6	.71	4	16.7	5	16.7	--
Total	92		132			24		30		

* Drug classes with fewer than 10 samples in either crash-involved or control drivers were considered too few for statistical testing.

Table 17 shows the distribution of drug categories among crash-involved and control drivers, for oral fluid and blood samples. For oral fluid, the percentage of illegal drugs was significantly higher among crash-involved drivers (10.4%) than controls (8.8%) ($p < .01$). As stated previously, the percentage of drivers who tested negative for any drug was significantly lower among crash-involved drivers (84%) than among control drivers (85.6%) ($p < .05$). No such differences were in the blood samples. Although not shown in Table 17, THC was the most common illegal drug. THC was present in 72.7% of those crash-involved drivers who tested positive for an illegal drug.

Table 17. Drug Category Distribution in Oral Fluid and Blood

	Oral Fluid					Blood				
	Crash-Involved Drivers		Control Drivers		*p*-value	Crash-Involved Drivers		Control Drivers		*p*-value
Drug Category	N	%	N	%		N	%	N	%	
Illegal [a]	322	10.4	546	8.8	.01	59	10.0	109	9.3	.61
Medications only	173	5.6	343	5.5	.92	51	8.7	81	6.9	.18
Negative	2,600	84.0	5,301	85.6	.04	481	81.8	988	84.0	.18
Total	3,095	100.0	6,190	100.0		588	100.0	1,176	100.0	

[a] Some participants in this category may also have used medications, but all used an illegal drug.
Shading indicates statistically significant differences between crash-involved and control drivers.

The analyses of crash risk by drug class and category used the oral fluid data as a higher proportion of participants provided oral fluid, allowing greater statistical power.

Comparing Oral Fluid and Blood Results

Drug prevalence estimates from oral fluid compared to those from blood samples have indicated very similar results (Kelley-Baker, Moore, Lacey, & Yao, 2014). This project also examined matching oral fluid and blood results. The study obtained 5,357 corresponding oral fluid and blood samples. Of the oral fluid samples, 800 were positive for drugs other than alcohol; of the blood samples, 913 were positive. This resulted in 615 pairs of samples that were both positive, 185 samples that were oral fluid positive with corresponding negative blood samples, and 298 specimens were oral fluid negative and blood positive. For these drugs (THC, amphetamine/methamphetamine, cocaine, and opiates[42]), the following values were calculated (Table 18):

- *Specificity* is the ability of the assay to identify those samples that are truly drug-free or that contain a concentration of target analyte below the cut-off level (in other words, the ability to indicate few false negatives). It is expressed here as: Number of negatives in oral fluid and blood samples/Total number of blood negatives.

- *Sensitivity* is the ability of the assay to identify those samples that truly contain a concentration of target analyte above a certain cut-off level (to yield few false positives). It is expressed as: Number of positives in oral fluid and blood samples/Total number of blood positives.

- *Positive Predictive Value (PPV)* is the probability that a positive test result is a true positive, expressed as: Number of positives in both oral fluid and blood samples /Total number of oral fluid positives.

- *Negative Predictive Value (NPV)* is the probability that a negative test result is a true negative, expressed as: Number of negatives in oral fluid and blood samples /Total number of oral fluid negatives.

[42] To achieve a sufficient sample size for meaningful prevalence and statistical studies, this report focuses on drug classes or categories. Because sensitivity and specificity analyses were not designed to yield population estimates but rather evaluate the screening ability of specific tests (as shown here), the statisticians conducted those analyses aimed to screen drugs as specifically as possible.

Table 18. Drugs Detected in Blood and Oral Fluid Specimens

		THC	Amp/Meth	Cocaine	Opiates
Positive in blood	Positive in oral fluid	250	122	9	11
Positive in blood	Negative in oral fluid	83	26	1	5
Negative in blood	Positive in oral fluid	118	11	31	5
Negative in blood	Negative in oral fluid	4,906	5,198	5,316	5,336
	Sensitivity	75.1%	82.4%	90.0%	68.8%
	Specificity	97.7%	99.8%	99.4%	99.9%
	PPV	67.9%	91.7%	22.5%	68.7%
	NPV	98.3%	99.5%	100.0%	99.9%

A comparison of the blood and oral fluid data (Table 18) indicates an overall PPV of 91.7% for amphetamines, 67.9% for THC and 68.7% for opiates, but a low agreement of 22.5% for cocaine. Thirty-one more positive specimens for cocaine were detected in oral fluid than in blood. The large number of negatives to positives for specific drugs may skew interpretation of NPV as positive values were relatively rare. This is the case in both the oral fluid and blood. The NPV was 98% or more for each drug, indicating that false-negative results using oral fluid are not likely. The specificity (> 97%) and sensitivity (> 75%, except for opiates) of the oral fluid test were very high for all individual drug classes, indicating oral fluid missed a low number of drug-positive drivers in the study.

With these findings, and as more participants provided oral fluid than blood, our oral fluid results provide more robust estimates of risk than use of only blood data.

Alcohol (AC)

Of the 3,095 crash-involved drivers, 94.7% (n = 2,932) had no alcohol present. Among control drivers, 97.1% (6,013 of 6,190) had an AC = .00. Overall, the vast majority of drivers had an AC of .00 (Table 19).

At any of the AC levels, the percentage of drug-positive drivers among crash-involved drivers was not statistically significant from that among control drivers.

Table 19. Comparison Between Crash-Involved and Control Drivers Drug-Positive (Oral Fluid) by AC

	Crash-Involved Drivers			Control Drivers			
		Drug-Positive			Drug-Positive		*p*-
Alcohol Concentration	N	N	%	N	N	%	value
AC = 0.00 (no alcohol)	2,932	445	15.2	6,013	842	14.0	.14
AC > 0.00	163	50	30.7	177	47	26.6	.40
0.00 < AC < 0.05	50	18	36.0	128	31	24.2	.11
0.05 ≤ AC < 0.08	20	7	35.0	27	9	33.3	.91
AC ≥ 0.08	93	25	26.9	22	7	31.8	.64
Total	3,095	495	16.0	6,190	889	14.4	

Note: the second row is the combination of the next three rows.

For crash-involved drivers, the prevalence who were both drug- and alcohol-positive (30.7%) was twice that of drivers who were drug-positive but alcohol negative (15.2%), a statistically significant finding ($p < .001$), see Table 20. This pattern holds for control drivers. Drivers who were both drug- and alcohol-positive were nearly twice as prevalent (26.6%) as drivers who were drug-positive but alcohol-negative (14.0%), a statistically significant finding ($p < .001$). This relationship was statistically significant for all levels of alcohol positive drivers for both crash-involved and control drivers ($p < .05$), but caution is needed with interpretation due to small sample sizes. At any AC greater than zero, the prevalence of drug positives is about twice that of drivers with no alcohol for both crash and control drivers ($p < .05$).

Table 20. Comparison Within Crash-Involved and Control Drivers Drug-Positive (Oral Fluid) by AC

	Crash-Involved Drivers				Control Drivers			
		Drug-Positive		*p*-		Drug-Positive		*p*-
Alcohol Concentration	N	N	%	value	N	N	%	value
AC = 0.00 (no alcohol)	2,932	445	15.2	(ref)	6,013	842	14.0	(ref)
AC > 0.00	163	50	30.7	<.001	177	47	26.6	<.001
0.00 < AC < 0.05	50	18	36.0	<.001	128	31	24.2	.001
0.05 ≤ AC < 0.08	20	7	35.0	.019	27	9	33.3	.006
AC ≥ 0.08	93	25	26.9	.030	22	7	31.8	.022
Total	3,095	495	16.0		6,190	889	14.4	

Shading indicates statistical significance.
p-values correspond to comparisons of drug positive drivers within conditions. Comparisons of alcohol positive drivers and alcohol positive drivers broken down by AC ranges are made to alcohol negative drivers.
Note: the second row is the combination of the next three rows.

Drugs, Alcohol and Percentage of Injuries

Table 21 presents the percentage of injured drivers among both drug-positive and drug-negative drivers. There was no significant difference in the percentage of injured drivers among drug-positive (31.5%) and drug-negative (29.2%) drivers (p = .31).

Table 21. Percentage of Crash-Involved Injured and Not Injured Drivers Drug-Positive (Oral Fluid)

		Injured		Not Injured	
Drug Status	Total	N	%	N	%
Drug-negative	2,600	760	29.2	1,840	70.8
Drug-positive	495	156	31.5	339	68.5
p-value			.31		
Total	3,095	916	29.6	2,179	70.4

Table 22 examines the percentage of injured drivers at different alcohol levels. As with drug positives, there was no significant difference in the percentage of injured drivers among alcohol-negative drivers (29.6%), drivers with an AC between .00 and .05 (30.0%), and drivers with an AC greater or equal to .05 (29.2%) (p = .99).

Table 22. Percentage of Injured and Not Injured Drivers Alcohol-Positive by AC Level

Alcohol		Injured			Not Injured		
Concentration	Total	N	%	*p*-value	N	%	*p*-value
AC = 0.00	2,932	868	29.6%	(ref)	2,064	70.4%	(ref)
0.00 < AC < 0.05	50	15	30.0%	.97	35	70.0%	.98
AC ≥ 0.05	113	33	29.2%	.99	80	70.8%	.92
Total	3,095	916	29.6%		2,179	70.4%	

Drug Prevalence by Driver Demographics

Age

Table 23 shows the percentage of drug-positive drivers by age group. The *p*-values refer to comparisons between drug-positives among crash-involved and control drivers, with each *p*-value for a separate age group. Among both crash-involved (n = 3,084) and control drivers (n = 6,173), those with the highest percentage positive for drugs were in the 16-20 (18.6% for crash-involved; 17.4% for controls) and 21–34 year categories (17.7% for crash-involved; 15.7% for controls). However, there was no statistical difference in the prevalence of drug-positives between crash-involved and control drivers in any age groups.

Table 23. Percentage of Crash-Involved and Control Drivers Drug-Positive by Age Group (Oral Fluid)

	Crash-Involved Drivers			Control Drivers			
		Drug-Positive			Drug-Positive		
	Total	N	%	All	N	%	*p*-value
16–20	548	102	18.6	476	83	17.4	.62
21–34	1,144	203	17.7	2,231	351	15.7	.14
35–44	451	66	14.6	1,200	160	13.3	.49
45–64	719	95	13.2	1,897	253	13.3	.93
65+	222	25	11.3	369	40	10.8	.87
Total	3,084	491	15.9	6,173	887	14.4	

Because some drivers did not report race/ethnicity, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Gender

Table 24 shows the distribution of oral fluid drug positives by gender. There was a fairly even distribution of oral fluid drug positives among males and females in both crash-involved and control groups. The *p*-values refer to comparisons regarding the percentage of drug-positives among crash-involved and control drivers, with each *p*-value referring to males and females separately.

Although the prevalence of drug-positives was slightly higher among male drivers than among female, both among crash-involved and control drivers, the difference was not statistically significant. The inclusion of gender in the models, even where it is not a statistically significant factor, is appropriate in light of prior research showing gender effects on risk (Vaca, Romano, & Fell, 2014; Romano, Kelley-Baker, & Voas, 2008; Walsh et al, 2004). It is common in statistical analyses to include such "known important" factors even when not significant in order to be conservative (to not attribute too much to the main effect of interest).

Table 24. Percentage of Crash-Involved and Control Drivers Drug-Positive by Gender (Oral Fluid)

	Crash-Involved Drivers			Control Drivers			
		Drug-Positive			Drug-Positive		
	Total	N	%	All	N	%	*p*-value
Male	1,551	259	16.7	3,231	480	14.9	.10
Female	1,532	234	15.3	2,931	408	13.9	.22
Total	3,083	493	16.0	6,162	888	14.4	

Because some drivers did not gender, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Race/Ethnicity

Table 25 shows the distribution of oral fluid drug positives by race/ethnicity. The *p*-values refer to comparisons regarding the percentage of drug-positives among crash-involved and control drivers, with each *p*-value referring to the racial/ethnic groups. There was no statistically significant difference in the prevalence of drug positive drivers measured by oral fluid, between crash-involved and control drivers for race/ethnicity. Race/ethnicity has been associated with alcohol and drug use, and to have an effect on crash risk (Pacek, Malcom, & Martins, 2012; Torres et al, 2014; McCabe et al, 2007). Accordingly, the inclusion of race/ethnicity in the models for this study, even when it was not statistically significant, is appropriate given prior research. (As stated above, to be statistically conservative and not overly attribute differences to the main variables of interest).

Table 25. Percentage of Crash-Involved and Control Drivers Drug-Positive by Race/Ethnicity (Oral Fluid)

	Crash-Involved Drivers			Control Drivers			
		Drug-Positive			Drug-Positive		
	N	N	%	N	N	%	*p*-value
Asian	108	10	9.3	142	8	5.6	.27
Black/African American	518	58	11.2	1,235	156	12.6	.40
Hawaiian/other Pacific Islander	38	9	23.7	55	6	10.9	.10
Hispanic	189	32	16.9	388	52	13.4	.26
Native American/Alaska Native	28	7	25.0	47	5	10.6	.12
White	2,085	348	16.7	4,115	621	15.1	.10
More than one race/ethnicity	78	18	23.1	115	20	17.4	.33
Other	45	12	26.7	71	14	19.7	.38
Total	3,089	494	16.0	6,168	882	14.3	

Because some drivers did not report race/ethnicity, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Relative Risk Estimates

Alcohol

Breath samples were sometimes available for more than two controls per crash-involved driver, when the number of breath samples was larger than oral fluid samples. This oversampling provided two alternative data sets for estimating alcohol-related relative risk: using all of the available information (the 1:N ≥ 2 design) or using only those drivers who also provided an oral fluid sample (the 1:2 design).

Table 26 shows the number and percentage of drivers with alcohol at various BrAC levels for the crash-involved and control drivers, based on the 1:N ≥ 2 design.

Table 26. Percentage of Crash-Involved and Control Drivers Alcohol-Positive by BrAC Level

	Crash-Involved Drivers		Control Drivers		
Alcohol Level (g/210L)	N	%	N	%	*p*-value
BrAC ≥ .08	95	2.8	26	.4	<.0001
.05 ≤ BrAC < .08	18	.5	23	.3	.13
.00 < BrAC < .05	55	1.6	138	2.0	.20
BrAC = .00	3,185	95.0	6,681	97.3	<.0001
Total	3,353	100.0	6,868	100.0	
BrAC ≥ .05	113	3.4	49	.7	<.0001
BrAC > .00	168	5.0	187	2.7	<.0001

Some drivers only provided a breath sample. Those drivers are included in this table; therefore the sample size is slightly larger than those presented in other tables which show information on drivers who gave both a breath and oral fluid sample. Shading indicates statistical significance between crash-involved and control drivers.
Note: the next to last row is the combination of the first two rows, while the last row combines the first three rows.

Table 26 shows that drivers with BrACs at .08 g/210L or higher were overrepresented in the crash population compared to the control population (2.8% of the crash-involved drivers versus .4% of the control drivers -statistically significant at the $p < .0001$ level). The percentage of crash-involved drivers with BrACs at .05 g/210L or higher, but less than .08 g/210L, was slightly larger than the percentage of control drivers (.5% versus .3%), but was not statistically significant. For drivers with BrACs over zero but less than .05 g/210L, there was a slightly larger percentage of crash-involved drivers, compared to control drivers (2.0% versus 1.6%), but the difference was non-significant. The percentage of alcohol-positive crash-involved drivers was almost double the percentage of alcohol-positive control drivers (5.0% versus 2.7%), which was statistically significant ($p < .0001$). Further, the percentage of crash-involved drivers with BrACs at .05 g/210L or greater was almost five times higher than that of control drivers (3.4% versus .7%), which was also statistically significant ($p < .0001$).

To take into account any possible systematic difference between these two data sets (i.e., 1:N ≥ 2 breath sample matches versus the 1:2 oral fluid matches), statisticians estimated separate BrAC relative risk curves, adjusted by age and gender only, for both data subsets. In terms of differential use or differential risk, age and gender are generally the most significant demographic attributes that can produce a bias if the groups are not equivalently distributed or

matched. In addition, adjusting for age and gender only permitted a comparison to the previous crash risk study published by Blomberg et al (2005) (Figure 7). To obtain an estimate of the contribution of alcohol to crash risk, free of the possible confounding effects of drugs, statisticians also estimated the BrAC relative risk of drivers who tested negative for drugs. These three relative risk estimates are presented in Table 27, presented as Model I, Model II and Model III.

Table 27. Alcohol Relative Risks: Unadjusted and Adjusted for Age and Gender

BrAC (g/210L)	Unadjusted Relative Risk	Adjusted Relative Risk (Relative to BrAC = .00)		
		1:N ≥ 2 Design	1:2 Design	
	All Drivers (Breath Sample Matches)	All Drivers (Breath Sample Matches) (Model I)	All Drivers (Oral Fluid Matches) (Model II)	Drug-negative (Oral Fluid Matches) (Model III)
.00	1.00	1.00	1.00	1.00
.01	.51	.54	.49	.48
.02	.82	.85	.79	.78
.03	1.17	1.20	1.14	1.13
.04	1.57	1.60	1.56	1.54
.05	2.05	2.07	2.05	2.03
.06	2.61	2.61	2.63	2.60
.07	3.25	3.22	3.30	3.26
.08	3.98	3.93	4.08	4.03
.09	4.83	4.73	4.98	4.92
.10	5.79	5.64	6.02	5.94
.11	6.88	6.67	7.20	7.11
.12	8.11	7.82	8.54	8.43
.13	9.51	9.11	10.07	9.93
.14	11.07	10.56	11.79	11.63
.15	12.82	12.18	13.73	13.55
.16	14.78	13.97	15.91	15.70
.17	16.97	15.96	18.36	18.11
.18	19.40	18.17	21.09	20.80
.19	22.09	20.60	24.14	23.80
.20+	25.08	23.29	27.53	27.14
N	10,221	9,858	9,084	7,739

Table 27 illustrates crash risk increasing as a function of alcohol, relative to the crash risk at BrAC = .00 g/210L. As common with relative risk studies, the analysis takes into account the

risk of a being in a crash when at various BrACs compared to drivers who have not been drinking - BrAC = .00 g/210L is the reference group.

- The first column provides results "unadjusted" for other factors - thus a driver at a BrAC of .08 g/210L has a relative risk of 3.98 - a driver at BrAC = .08 g/210L is 3.98 times more likely to be in a crash than a driver with a .00 g/210L BrAC.
- The next three columns provide alcohol relative risk estimates statistically adjusted for age and gender. The second column relates to all drivers with breath sample readings, and used all available alcohol information for matched crash and control cases. In this column, a driver at a BrAC of .08 g/210L has a relative risk of 3.93.
- The third column is limited to drivers who provided oral fluid samples as well as breath samples. In this column, a driver at a BrAC of .08 g/210L has a relative risk of 4.08.
- The fourth column includes those among the group in column three who did not have any drugs present in their system; that is, the true alcohol risk uninfluenced by drug involvement. In this column, a driver at a BrAC of .08 g/210L has a relative risk of 4.03.

Figure 7 illustrates the alcohol crash risk curves from this study, as well as Blomberg et al (2005). The presence of drugs other than alcohol has a relatively low influence on crash risk in these analyses. The curves follow the same pattern, including the "Grand Rapids Dip[43]" as reported by Borkenstein et al. (1974). The plot of Model II and that of Model III are so similar, there is overlap in the figure. The similarity of this study's alcohol crash risk curve to past studies lends additional confidence of this study's results.

[43] The "Grand Rapids Dip" is a reduction in crash risk observed at low BACs, first identified in Zylman's examination of the Grand Rapids data (Zylman, 1968).

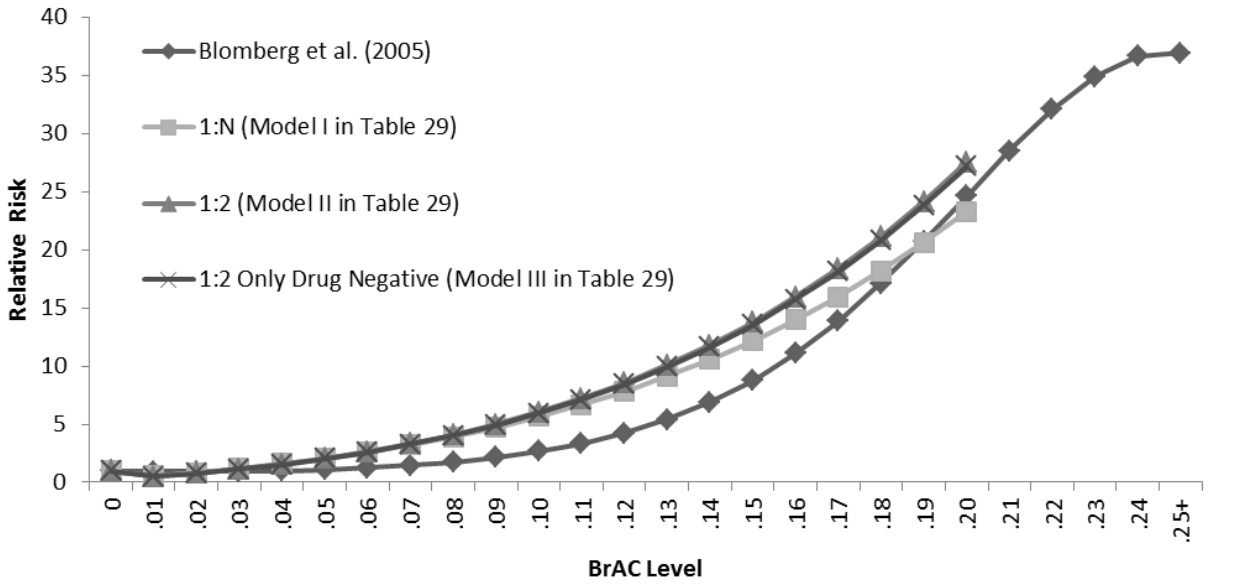


Figure 7. Crash Risk at Alcohol Levels Relative to Crash Risk with No Alcohol[44]

The alcohol relative risk estimates in Table 27 and the corresponding curves in Figure 7 (other than the "1:2 Only Drug Negative Model III" in Figure 7 relating to relative risk curve III from Table 27) do not take into account the presence of drugs. The similarity between the three alcohol relative risk curves, particularly between the one based on all drivers who provided an oral fluid sample, and the one based only on those who were drug-negative, suggests drug presence did not have a large impact on the alcohol crash risk relationship. That is, there was no significant alcohol-by-drug interaction, which indicates that presence of a drug, in addition to alcohol, did not increase crash risk.

Drugs Other than Alcohol

Drug Classes

It was not possible to estimate relative risk curves for each of the 89 drugs tested due to the limited sample size of drivers with these individual drugs. Therefore, a sequential modeling approach was applied, in which the crash risk associated with each drug class or category was estimated:

[44] Blomberg et al. risk curve extends beyond other curves because there were more high-BAC drivers in the 1996 Blomberg study.

- Based solely on the presence of the drug class or category (unadjusted odds ratios).
- By taking the driver's age, gender, and race/ethnicity into account (adjusted odds ratios – Table 28, Model A).
- By adjusting the driver's age, gender, race/ethnicity, and AC level (adjusted odds ratios – Table 28, Model B).

In addition to reporting unadjusted odds ratios and adjusted odds ratios for each drug class, the interaction effects between each drug class and three levels of alcohol (AC = .00 g/; AC > .00 < .05 ; AC $\geq$ .05)[45] were examined. In each of these models, the presence of the drug of interest was compared to the drug-negative (reference group).

Researchers examined the additive effects of alcohol and drugs on crash risk after adjusting for gender, age, and race/ethnicity. For this purpose, the analyses of alcohol at the three AC levels used a binary coding for drugs to indicate whether the participant was negative or positive for drugs in any of the classes.

Table 28 examines the unadjusted odds ratios of the contribution of each drug class to crash risk. However, unadjusted odds ratios should always be interpreted with caution, as they do not account for age, gender, and race/ethnicity that have been found in previous studies to have a significant impact on crash risk and may otherwise account for variance in an outcome.

This analysis, based on the unadjusted odds ratios, suggests that drivers positive for THC were 1.25 times more likely to be in a crash than drug-negative drivers, and drivers positive for illegal drugs were 1.21 times more likely to be in a crash than drug-negative drivers, both of which were statistically significant findings (p = .01). Drivers testing positive for sedatives were 1.3 times more likely to be in a crash than drug-negative drivers, though this finding did not reach significance at the .05 level (p = .06).

Table 28. Unadjusted Odds Ratios of the Association Between Drug Class and Category and Crash Risk

Drug Class or Category	Unadjusted Odds Ratio	*p*-value
Class		
Marijuana (THC)	1.25	.01
Antidepressants	1.06	.75
Narcotic analgesics	1.15	.26
Sedatives	1.30	.06
Stimulants	1.01	.40

[45] Because of sample size concerns and the relatively small number of drivers at very high BrAC levels (e.g., at AC = .08 and above), the statisticians collapsed all ACs $\geq$ .05 into a single level.

Category		
Illegal drugs [a]	1.21	.01
Medications only	1.07	.43

[a] All drivers in this category used an illegal drug, although some may also have used medications. Shading indicates statistical significance.

Table 29 examines the odds ratios when adjusted for gender, race/ethnicity, and age (see Appendix R for estimates of these demographic variables). Table 29 shows two separate models. Model A describes odds ratios adjusted for demographic variables (age, gender, and race/ethnicity), while Model B describes odds ratios adjusted for both demographic variables as well as the presence of alcohol.

After adjusting the odds ratios for age, gender, and race/ethnicity, the significant results in Table 28 are no longer present. This finding indicates that the demographic factors (age in particular), rather than drug use, appear to account for the majority of the variance in crash risk. Further, in Model B, when statisticians adjusted results for both the demographic factors and alcohol, none of the findings are significant. This may suggest that alcohol independently accounts for the vast majority of variance in determining crash risk, and drugs do not significantly impact the likelihood of crash risk above and beyond alcohol use or demographic variables (age, gender, or race/ethnicity).

Age, gender, and race covariates were analyzed in a hierarchical fashion (as opposed to simultaneously). That is, all the covariates were tested first and allowed to have the full effect on the outcome before the drug variable (and/or alcohol) was included. Age was the only variable found to have significance. This is consistent with other research that has shown younger drivers to be more likely to take risks and be involved in crashes than older drivers (Masten et al., 2011; McCartt et al., 2009). However, adjusting for the non-significant covariates of gender and race/ethnicity is a conservative overall approach. The lack of significance we found for gender and race/ethnicity should not be interpreted as a proof that these factors have no influence on drug crash risk; it might be possible that these factors would become significant with a larger sample size.

Table 29. Adjusted Odds Ratios for Conditional Logistic Models of Drugs by Class and Category

	Model A (Not Adjusted for Alcohol)		Model B (Adjusted for Alcohol)	
	AOR [95% CI]	*p*-value	AOR [95% CI]	*p*-value
Class				
Marijuana (THC)	1.05 [0.86, 1.27]	.65	1.00 [0.83, 1.22]	.98
Antidepressants	0.87 [0.57, 1.32]	.51	0.86 [0.56, 1.33]	.50
Narcotic analgesics	1.14 [0.85, 1.51]	.39	1.17 [0.87, 1.56]	.30
Sedatives	1.27 [0.93, 1.75]	.13	1.19 [0.86, 1.64]	.29
Stimulants	0.94 [0.72, 1.22]	.64	0.92 [0.70, 1.19]	.51
Category				
Illegal drugs [a]	1.04 [0.88, 1.23]	.65	0.99 [0.84, 1.18]	.99
Medications only	1.03 [0.84, 1.27]	.79	1.02 [0.83, 1.26]	.83

AOR and CI denote adjusted odds ratio and confidence interval, respectively.
Referent for each condition is drug-negative for all substances.
[a] All drivers in this category used an illegal drug, although some may also have used medications.

Tables 28 and 29 describe the unique contribution of each drug class to crash risk; however, they do not address the potential interaction effect between each drug class and alcohol. That is, they do not address whether the concurrent use of alcohol and any of these drug classes interact synergistically in a way that would increase or decrease crash risk beyond the additive risk of each substance separately.

Table 30 examines potential interaction effects of each drug class by alcohol. For example, the first row (THC by .00 < AC < .05) examines whether the crash risk for drivers positive for THC, with a .00 < AC < .05 , was higher than would be expected by just combining the individually measured crash risk estimates attributable to THC and that of low levels of alcohol (i.e., to determine whether these factors show a synergistic effect). The corresponding *p*-value (.27) indicates there is no evidence for a synergistic effect between alcohol and THC. None of the interactions in this table were statistically significant; the results did not support an interaction effect between any drug class, and any level of alcohol (.00 < AC < .05 or AC ≥ .05). This table is based on information in Appendix R.

Table 30. Drug Class/Category by AC Interaction Estimates

Drug Class/Category by AC Interaction[a]	Coefficient (SE)	*p*-value
Marijuana (THC) by .00 < AC < .05	.533 (.481)	.27
Marijuana (THC) by AC ≥ .05	-.037 (.476)	.94
Narcotic analgesics by .00 < AC < .05	-.036 (.732)	.62
Narcotic analgesics by AC ≥ .05	-1.757 (1.34)	.19
Sedatives by .00 < AC < .05	-.162 (.881)	.85
Sedatives by AC ≥ .05	.547 (1.106)	.62
Stimulants by .00 < AC < .05	.224 (.694)	.75
Stimulants by AC ≥ .05	-.703 (.67)	.29
Illegal drugs by .00 < AC < .05	.344 (.434)	.43
Illegal drugs by AC ≥ .05	-.118 (.428)	.78
Medicinal drugs by .00 < AC < .05	-.098 (.589)	.87
Medicinal drugs by AC ≥ .05	-.037 (.731)	.96

[a] Antidepressant interactions with alcohol are not displayed due to insufficient sample of individuals with antidepressants and a measurable alcohol concentration.
The coefficient denotes the estimated regression coefficient which is a numerical value that helps determine the slope of a trend or other line in a graph.
SE (standard error) refers to a statistic used to measure the accuracy of a sample distribution. It refers to the difference between the mean of the study sample and the mean of the actual population the study was intended to represent.

To further examine the joint impact of alcohol and drug classes on crash risk, logistic analyses were conducted collapsing the alcohol and drug information into a single variable, with levels including:

- Negative for drugs and negative for alcohol (AC = .00)
- Negative for alcohol (AC = .00) and positive for drugs
- Positive for alcohol (.00 < AC < .05) and negative for drugs
- Positive for alcohol (AC ≥ .05) and negative for drugs
- Positive for alcohol (.00 < AC < .05) and positive for drugs
- Positive for alcohol (AC ≥ .05) and positive for drugs

After adjusting for age, gender, and race/ethnicity, the respective adjusted odds ratios (AORs) are shown in Table 31 which indicates that alcohol at .05 or greater, either alone (positive alcohol (≥ .05) and negative drugs; AOR = 6.750) or with the presence of drugs (positive alcohol (≥ .05) and positive drugs; AOR = 5.342), is the largest contributor to crashes.

Table 31. Unique and Additive Contributions of Alcohol and Drugs to Crash Risk

	AOR	95% CI	*p*-value
Negative drug and negative alcohol	*Reference*		
Negative for alcohol and positive for drugs	1.016	[.881, 1.172]	.83
Positive for alcohol (< 0.05) and negative for drugs	.844	[.554, 1.288]	.43
Positive for alcohol (≥ 0.05) and negative for drugs	6.750	[4.202, 10.842]	<.01
Positive for alcohol (< 0.05) and positive for drugs	1.028	[.545, 1.939]	.93
Positive for alcohol (≥ 0.05) and positive for drugs	5.342	[2.751, 10.372]	<.01

Shading indicates that odds ratios are statistically significant (statistically different from OR = 1, which denotes no effect).

AOR and 95% CI denote adjusted odds ratio and its 95% confidence interval. "Positive for alcohol (≥ 0.05) and negative for drugs" and "positive for alcohol (≥ 0.05) and positive for drugs" are significant because their *p*-value is <.01. In addition, based on their AOR, they are estimated to be 6.75 and 5.342 (respectively) more likely to be involved in a crash than a driver who is negative for drugs and negative for alcohol. In addition, with 95% confidence, true AOR is within an interval [4.202, 10.842] and [2.751, 10.372], respectively) that does not include "1" (the value, at which there is no difference).

Summary

This study further confirms the important role alcohol has on crash risk. The estimates of alcohol-related crash risk correspond with several well-known features of BrAC-based crash risk curves: a decrease in relative risk at very low alcohol levels (i.e., the "Grand Rapids dip"), followed by a steady increase in risk. Also, the alcohol-based risk curves were very similar to those reported in NHTSA's previous case-control study (Blomberg et al., 2005). Replicating the results for alcohol crash risk of these studies adds further assurance of the strong methodology of this study's design and data set.

This study conducted two analyses. The first was an unadjusted odds ratio. The second was an adjusted odds ratio, based on demographic factors, including age, gender and race/ethnicity, as well as for presence of alcohol. These adjustments were made based on previous research establishing these factors as being strongly associated with crash risk.

The unadjusted odds ratio showed that the contribution of illegal drugs in general, and THC specifically, to crash risk was statistically significant (1.21 and 1.25 respectively). Drivers positive for sedatives were 1.3 times more likely to be involved in a crash than drug-negative drivers, though this finding was only marginally did not reach statistical significance ($p = .06$).

However, the odds ratio was adjusted by gender, age, race/ethnicity, and AC level (Models A and B in Table 29), no illegal drugs were associated with increased crash risk. This indicates that the individual contribution of each drug class becomes non-significant once crash risk is adjusted by age, gender, and race/ethnicity (Model A) and age, gender, and race/ethnicity plus alcohol use (Model B). The study tested each drug class for interaction effects with alcohol (Table 29), and none were statistically significant. This indicates that there was no synergistic effect from the combination of alcohol and drugs, including THC.

Based on the findings of drug class as predictors of crash risk (Table 28), the unique contribution of alcohol to crash risk (Table 31), and the lack of a significant interaction effect (Table 30), Table 32 provides an overall estimate of crash risk.

Table 32. Crash Risk Estimates: 95% Confidence Interval by Substance Groups

Alcohol and Other Drugs	AOR	95% CI	*p*-value
AC ≥ .05 and drug negative	6.75	[4.20, 10.84]	<.01
AC ≥ .05 and drug positive	5.34	[2.75, 10.37]	<.01
AC < .05 and drug positive	1.03	[.55, 1.94]	.93
AC < .05	.84	[.55, 1.94]	.43
Antidepressants	.86	[.56, 1.33]	.50
Marijuana (THC)	1.00	[.83, 1.22]	.98
Narcotic analgesics	1.17	[.87, 1.56]	.30
Sedatives	1.19	[.86, 1.64]	.29
Stimulants	.92	[.70, 1.19]	.51
Negative alcohol/negative drug	*Reference*		

CI denotes confidence interval for the estimated odds ratios.
Negative alcohol/negative drug is the reference group and indicates a driver who was negative for alcohol and negative for drugs.
Shading indicates statistical significance.

Table 32 shows that, with a 95% confidence interval, the only significant predictors of increased crash risk were those that had alcohol concentrations of .05 or greater, regardless of any other drug use. Thus, an AC of .05 or higher was the only predictor of crash risk.

Discussion

This study in Virginia Beach is the largest and most comprehensive study addressing alcohol and drug crash risk ever conducted in the United States. For the drugs examined in this study, alcohol was the largest contributor to crash risk. This finding is not surprising because, regardless of study location or design, previous research efforts have consistently reported alcohol to be the drug that contributes most to crash risk.

Compared to that of alcohol, the contributions of other drugs to crash risk were minimal. In the initial data analysis, THC seemed to be a significant contributor to crash risk. However, with more sophisticated analysis controlling for variables known (based on previous research) to be associated with age, gender, race/ethnicity, and alcohol, drugs did not show a significant crash risk. The findings from this study may be surprising in light of some studies that have reported crash risk to be significantly related to drug use and driving.

There are potential explanations for this finding. One relates to the severity of the crashes examined, as this study included a broad range of severity of crashes, including property-damage-only crashes. The majority of crashes covered in this study were property damage-only crashes (66.4%), with very few fatal crashes (0.6%). Only 13.6% of crash-involved drivers were taken to a hospital. It is widely accepted that the consumption of alcohol is associated not only with the likelihood of a crash, but also to the likelihood of an injury and its severity (e.g., Waller et al., 1997; Waller et al., 2003). It is therefore reasonable to hypothesize that the consumption of other drugs may, like alcohol, have an effect on the severity of a crash (albeit such association was not found by Waller and colleagues in their 1997 study). If that is the case, then the limited contribution of drugs other than alcohol to crash risk found in this effort may at least in part be related to the predominance of lower severity crashes. Including property-damage only crashes was a unique strength of this study because, unlike previous efforts, it better represents the full spectrum of crash severity found on U.S. roads, but it also allows for more focused investigation of higher-severity crashes.

This study examined the presence of a drug, but due to small sample sizes was unable to separate analyses by concentration levels. It may be that those drivers with a higher contraction of a drug may be at higher risk. With the exception of THC (6.1%), the other drugs detected in drivers were less than 3%. Further, for drugs comparing effects by quantity or concentration is

complex, for example, requiring knowing when the drug was taken. THC's particular concentration may have either a small or a large effect on crash risk, depending on the time elapsed since consumption (Huestis, 2002).

Finally, like all previous studies on drug crash risk, this study does not differentiate by crash type but examines the contribution of alcohol and drugs to crash risk, regardless of the type of crash. While this strategy has proven sound for the examination of alcohol-related crash risk, that might not be the case for other drugs. It is likely that the contribution of individual drugs to crash risk varies depending on the type of crash and the specific impairing effects of a particular drug. For example, the consumption of THC may have a larger impact on attention-related skills than on behaviors that influence aggressive driving. Therefore, it could be argued that the contribution of THC to inattention-related crashes may be higher than to crashes involving speeding or aggressive driving (in which it may be null). Similarly, it could be hypothesized that the consumption of stimulants may increase alertness and reduce crashes related to drowsiness, while simultaneously increasing the likelihood of speed-related crashes. The reliance on aggregated crash data which is not separated by crash type may dilute effect of some drugs on the risk of involvement in certain types of crashes. Future research should consider strategies to examine drug use by crash severity.

The results of this study should not be interpreted to mean that it is safe for individual drivers to operate a vehicle while impaired by drugs. The study's limitations, along with the findings of 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. This is why it is critically important for law enforcement officers to carefully observe drivers and consider the totality of the circumstances if they suspect the drivers are impaired by drugs.

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Appendix A: Passive Alcohol Sensor

Passive Alcohol Sensor -- the PAS Vr.

It is important to obtain PAS readings on all drivers pulling into the interview bays, whether they later give a breath test or not, because we need to be able to relate PAS readings to breath test readings for those who fully participate to be able to better understand the values of PAS readings for those who otherwise do not participate.

Initializing

When turning on the passive alcohol sensor (PAS Vr.) for testing, you must first initialize the device using the following steps:

Figure 8. The PAS Vr.

- Note that there are two black switches on the instrument, located on opposite sides of the device. One switch is the on/off button. The other switch is to indicate whether the PAS device is on passive mode (PAS ON) or active mode (AS ON). You ALWAYS want to be in PAS ON mode.
- In the middle of the PAS device is the BAC bar graph (that will light up when alcohol is detected) and a small black button located below the BAC bar graph, known as the sampling button.
- While facing the front of the instrument and with the sampling port on the top of the device, locate the black power switch on the left side and slide it to the “ON” position.
- The red lamp located on the far left side of the BAC bar graph, on the left side of the device, will illuminate. The red light will remain on as long as the instrument is in use.
- At the base of the display or on the far right side of the BAC bar graph, an orange lamp for the heater (HTR on the PAS device) will light up and intermittently cycle on and off. This orange light indicates that the heater is in use. The heater continues to run while the

instrument is on in order to maintain the fuel cell at a constant temperature of 104 degrees F +/– 5 degrees.

- Wait approximately 2 minutes for the instrument to heat up.
- After 2 minutes have elapsed, press the small round black button located below the orange heater indicator and on the right side of the device. This is the sampling button.
- A yellow light will illuminate at the top of the BAC bar graph (PMP on the PAS device) and a small green bar will appear at the base of the graph display. After approximately 5 seconds, the yellow light will disappear.
- Press the round black button again to turn off the sensor and reset the device for the first test (please note that you must turn off).
- Located next to the orange heater indicator, is a red light battery indicator (BAT on the PAS device). If this red light appears and begins to flash at any time, change the battery.

Passive Sampling Test

Before beginning, be certain that the black switch located on the top right side of the device is in the “PAS ON” position. If the switch is in the Active position, the green light (ACT on the PAS device) will illuminate. You NEVER want to have the device on the Active position.

Check to ensure that the intake sampling port is free of debris and not blocked by your fingers. Place the device approximately 5 to 7 inches from the face of the respondent. Ask the participant an open ended question that requires a 5 second or longer response. While the participant provides an answer, press the small round sampling button located at the base of the BAC bar graph and on right side of the instrument.

One green bar will appear at the base of the BAC bar graph display and the yellow pump light will illuminate above the bar graph once the reading has been taken. This smaller green bar will always appear when the device is activated and indicates a “00” reading. A positive reading occurs when TWO green bars are present (0.01). The survey form will have a bar scale that is

equivalent to the PAS light scale – when entering your PAS data onto the survey, simply match the number of bars to the corresponding box (.i.e., one green bar on the PAS = “G1” on the survey; four yellow bars on the PAS = “Y4” on the survey, and so on). Hold the instrument steady during this process.

Once the yellow light has turned off, the test has completed and you can remove the instrument from the breath stream of the participant. If alcohol is present, the multicolor display on the bar graph display will begin to rise, from green to yellow to red. The greater the amount of alcohol present, the higher the bar graph will rise.

The instrument will reach a peak reading within 5 to 15 seconds after the yellow indicator light goes out. Immediately record the highest illuminated numerical value on the BAC graph display. The numbers range from 0.01 to 0.12. Press the round black sampling button again and the display will turn off while the fuel cell recovers.

Remember that you will be activating the PAS device while talking to the participant and continuing with the interview process. You will not have time to stop the interview process while you activate the PAS and wait for the results.

You will take two PAS samples during the interview process. The survey instruments will have prompts alerting you when to take the PAS samples and where to record the results. Taking the PAS sample and recording the results will be done in smooth, fluid steps combined with other interviewing steps.

Maintenance Note: the PAS uses a 9-volt battery that will need to be changed out from time to time in the field.

Appendix B: Preliminary Breath Tester

The Preliminary Breath Tester

Data collectors will use a preliminary breath tester (PBT; Figure 1) to assess a participant's breath alcohol concentration. PBTs are specialized devices that measure a participants BACs by use of a fuel cell inside the instrument. For this study, the BAC result will not be displayed; results will be downloaded to a computer after a shift. Data collectors will carry a PBT that displays the BAC result. This PBT will only be used during an Impaired Driving Protocol.

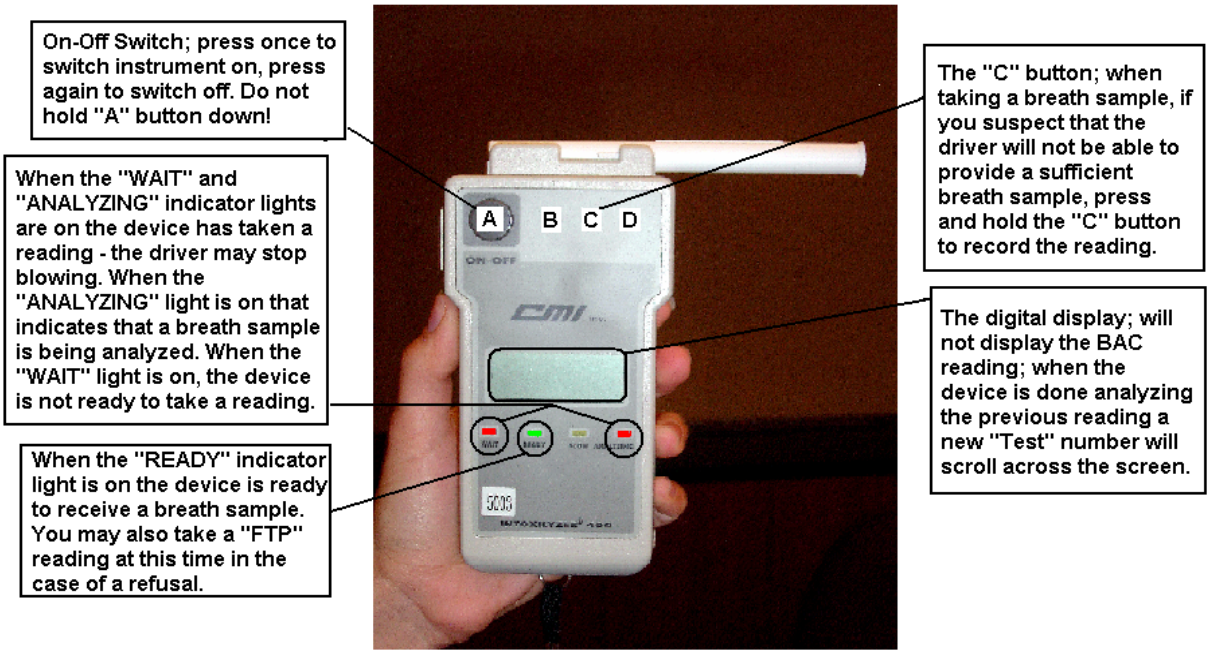


Figure 9. The Preliminary Breath Tester

Taking the Breath Sample

After receiving consent from the participant to obtain a breath sample, follow these steps to instruct participants on how to give the breath sample and the proper method for obtaining a breath sample

"I would like to ask you to provide a voluntary anonymous breath sample for research purposes. The result is stored inside the device and is not displayed. Please take a deep breath

and blow slow and steady into the tube until I tell you to stop." Speak with authority, without a question in your voice. As you speak, pull the sanitary wrapper off of the breath tube (within sight of the participant) and position the PBT just in front of the participant's mouth. While there is no way to guarantee that the participant will give a breath sample, interviewing methodology studies show that making requests in a calm, matter-of-fact, and business-like manner will most likely elicit cooperation, and that the vast majority of respondents do try to be helpful. If the participant has difficulty understanding your request, say "Like this." and demonstrate taking a deep breath and exhaling steadily for few seconds.

The participant should continue to blow into the breath tube until the "ANALYZING" light comes on, at which time the PBT will vibrate gently. If the participant does not provide a long enough breath and stops blowing before the "ANALYZING" light comes on, the PBT will make a warning beep and no sample will be taken. Once the "WAIT" light goes off and the "READY" light is on, the Participant can try again to provide a breath sample.

If the participant does not provide an adequate breath sample on his or her first try, the data collector explains the directions again to the participant; additionally, the data collector should be prepared to take a manual reading on the second attempt (see below).

Once a breath sample has been taken (i.e., the "ANALYZING" light has come on), the participant can be thanked.

At the end of each breath sample, the data collector removes the used breath tube, places it in the trash bag, and records the test number on the survey and Driver Information Card.

Taking a Manual Reading

If the participant does not provide an adequate breath sample on his or her first attempt, you should be prepared to take a manual reading on the second try.

Press down on the “C” button (see Figure 1) while the participant is blowing into the breath tube. The data collector should wait as long as possible before pressing on this button, since the reliability of the BrAC reading is a function of how long the participant blows into the breath tube: the longer the better. However, it is important that the data collector use his or her best judgment in anticipating and taking a manual reading, while the participant is still blowing.

Once the “C” button is pressed down, the PBT will react exactly as if a normal reading has been taken. The “ANALYZING” light will come on and the PBT will vibrate. Shortly thereafter, the PBT should go into “WAIT” mode and then into “READY” mode, indicating that it is ready to take a new breath sample.

NOTE: Cigarette smoke can permanently damage the fuel cell. All participants should be instructed to not smoke (extinguish their cigarette) or chew anything at least 2 minutes prior to collecting the breath sample.

Warning Indicators and Error Messages: If any warning sounds, lights, or messages appear while using the PBT, switch PBTs and make note of the switch on the Site Report Form. At the office, notify a research assistant of the warning or error message.

NOTE: Moisture (rain/damp night air) can harm the PBTs; thus, the devices need to be protected. If a unit is dropped, it should be switched out with a different unit (a dropped PBT will be sent back to the office to have its calibration checked). Each PBT is an expensive scientific piece of equipment and should be treated carefully.

Appendix C: Oral Fluid Device

Collecting Oral Fluid Specimens

Upon completion of the verbal survey and breath sample collection, the next step will be to obtain consent for an oral fluid specimen. If the participant agrees to provide an oral fluid sample, he or she is given the Quantisal device to put under the tongue to collect a saliva sample.

Figure 10. The Quantisal Oral Fluid Collection Device

If the participant agrees to provide an oral fluid sample and complete the drug questionnaire, clearly instruct him or her, "Please DO NOT chew or suck the on pad and DO NOT move pad during collection. Please keep the collector under your tongue until the indicator turns completely blue. This may take a few minutes."

Place the Quantisal package in front of the respondent and ask, "Please remove the collector from the pouch, position it under your tongue and close your mouth."

Instruct the participant on how to complete the Drug Questionnaire. Give the participant the tablet and instruct them on how to fill out the Drug Questionnaire.

If the indicator has not turned blue within 5 minutes, the pad should be removed from the mouth and discarded. Another collection attempt with a new device may begin immediately but only after saliva has accumulated in the mouth. The swab should be placed in the same position.

Remove cap from transport tube once the indicator is blue.

Ask the participant to please open their mouth, lift their tongue, remove the collector from mouth and insert the collector into the transport tub. Fluid from the transport tube should never enter the participant's mouth.

Carefully place cap over the top of the collector stem in tube. FORCEFULLY push cap downward until cap snaps flush with top of tube.

Place the chain-of-custody label on the tube and on the DIN card.

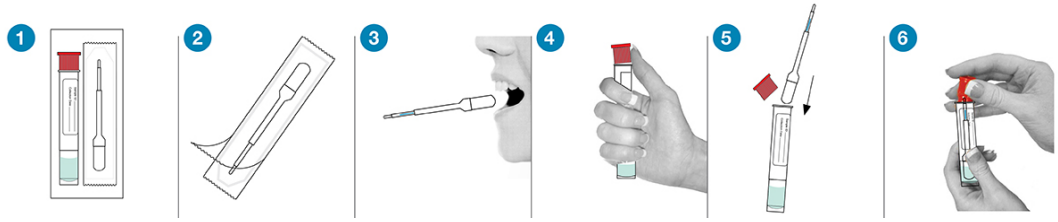


Figure 11. The Quantisal Oral Fluid Collection Device Procedure

Mix saturated collector with buffer fluid by gently shaking tube. Return the oral fluid sample to your kit for storage.

Give the respondent a $10 incentive for their participation and the additional $5 if the participant completed the AUD portion of the Drug Questionnaire booklet.

Appendix D: Impaired Driver Protocol

Impaired Driver Protocol

Establishing fitness to complete assessment and/or operate a motor vehicle:

To establish if a subject is fit to complete the survey, as well as safely operate a motor vehicle upon exit, a three-level rating system has been established.

- **Level 1** indicates that there was no evidence of substance (alcohol or drugs) use.
- **Level 2** indicates that there is some evidence of use (e.g., the data collector can smell alcohol, the PAS registers 6 bars or less indicating a BAC of approximately less than .05 g/dL) but the respondent displays no signs of intoxicated behavior such as slurred speech or bloodshot eyes.
- **Level 3** is evidence of use and signs of intoxication. At Level 3, the data collector will decide whether the interview should proceed and whether the subject needs assistance. We will not continue the survey on obviously inebriated and severely impaired individuals. We will offer safe transportation alternatives to the next destination for individuals who show obvious signs of Level 3 impairment. A PAS reading of 6 bars or more (which indicates approximately .05 g/dL or higher) REQUIRES a further assessment. A BAC of .05 g/dL or higher is the standard for actually implementing the Impaired Driving Protocol.

You will be prompted by the survey to enter your assessment level rating (1, 2, or 3) after question number 3 of the questionnaire. There will be cases where the subject will show signs of impairment, but is fit to complete the survey. The criteria for participation are that subject is able to understand the informed consent and able to provide informed consent. The criteria for consent to be informed are that the subject can understand the nature of the study as explained to him or her, that he or she understands the risks and benefits of participation, and that he or she understands that participation is voluntary. Simply being intoxicated does not preclude a person from being able to comprehend these basic concepts and process this information. Each data collector will be responsible for determining whether a subject is fit to proceed with the

interview. As soon as a data collector identifies a subject as Level 3, implement the Impaired Driver Protocol.

How to Identify Level 3 Respondents

To identify intoxicated subjects (Level-3), look for a clustering of the following signs and symptoms. No one sign or symptom is a direct indication of alcohol intoxication but, when combined, warrant the data collector conducting a more in-depth evaluation. Remember that alcohol affects each individual differently. The effect of alcohol on a person will vary according to the person's height, weight, drinking history, mood, the time of day, amount of food in the stomach, the mixer used, how fast the person drinks, and what and why they are drinking, etc. If a person displays a combination of the signs and symptoms of intoxication OR has a PAS reading of 6 or more bars, you MUST implement the Impaired Driving Protocol.

Signs of Intoxication

- A positive PAS reading
- A strong scent of alcohol
- Being overly friendly
- Talking loudly, bragging, or using foul language
- Being especially annoying or arguing with others
- Inability to light a cigarette, or attempting to light more than one cigarette at the same time
- Slurred or slowed speech, or tending to lose the train of thought
- Glassy eyes, dilated pupils, inability to focus, sleepy look, and bobbing head
- Sudden or unexplained mood changes
- Marked lack of coordination (e.g., inability to stand or walk, unable to hold a pen)

Why this matters and key points to remember

We are required by our IRB to ensure the safety of our subjects. Our goals include:

Identifying respondents who may be unable to provide informed consent because they are too intoxicated to understand the risks and benefits of participation and agree to be in the survey.

Identifying respondents who may be too impaired to operate a motor vehicle safely.

When you identify a Level 3 intoxicated person, implement the Impaired Driving Protocol. We have set procedures to assess and evaluate the subject, and also get them safely to their next location.

Protocol for Handling an Impaired Driver

We will offer safe transportation alternatives to the next destination for any individual who shows obvious signs of substantial impairment. When you observe behavior, odor, and appearance that lead you to believe that a subject is moderately or heavily intoxicated and therefore a possible danger to him/her self, his/her passengers, other drivers, or pedestrians, please follow this procedure.

The data collector will be equipped a PBT with unmasked BAC numbers, and will request a breath test on the subject. If the BAC is .05 g/dL and above, the data collector will present these options to the subject:

LET A PASSENGER DRIVE

If a passenger in the vehicle has a valid driver's license, the data collector can give that person a breath test. If the BAC is .05 g/dL or below and shows no signs of obvious intoxication, then the data collector will offer to let the passenger drive the subject home. The passenger's BAC must be recorded on the Driver Information Card.

CALL A FRIEND OR RELATIVE OF THE DRIVER

The data collector can use a cell phone to call a friend or relative of the subject and request that someone come and assist the driver (ideally, two people should come so that one can drive the subject home and the other can drive the friend's car home).

If neither of the above alternatives is satisfactory, then:

OFFER THE DRIVER A RIDE HOME FROM TAXI or TOWING SERVICES

If the driver does not have funds, then the project will pay for the ride. The subject's vehicle can be left at the site, moved to a nearby parking area, or towed. When using a taxi or towing service, the data collector will get pre-paid receipts. If using a taxi service, the data collector will give the subject the car keys and the address noting where the vehicle will be located when the individual is capable of retrieving it. If a towing service is used, the subject can simply ride with the tow driver to their home.

OFFER WAITING OPTION

If the BAC is relatively low, the data collector may offer to re-test the subject's BAC after some time has passed. When the BAC falls to .05 g/dL or below and the subject seems alert, the subject may drive themselves home.

SUBJECT'S SUGGESTION TO WALK HOME

Subjects may request to walk home. Their BAC must be .05 g/dL or below and given that the walk is practical (short enough in distance). Female subjects should not walk home for safety reasons unless accompanied by a data collector or sober companion.

OFFER TO PAY FOR A HOTEL

If the subject lives too far away for any of the above options, the data collector may arrange for the subject to stay in a nearby hotel and pay for a one night stay.

FINAL OPTION

If the driver refuses all options, the data collector will tell the individual that they cannot in good conscience let him/her drive, and that they will have to let the police officers know that, in their judgment, the subject is not fit to drive. This is usually sufficient to get the driver to

cooperate and take the data collector up on one of the proposed options. However, if the driver continues to refuse, the data collector will involve the police officers, who will (1) repeat the options and, if that fails, (2) call an on-duty officer to warn that an apparently impaired driver has left/is leaving the survey site and report the pertinent vehicle information. Prior to calling the on-duty police, the off-duty officer will inform the driver that he will "call it in" if the driver leaves the site. Police are then alerted to the potential hazard; if an on-duty officer determines probable cause (e.g., swerving while driving), then the driver will be pulled over and will be subject to a police intervention. It is important to note that alerting the police to an impaired driver is not sufficient cause for the police to make an arrest or even pull a car over. The driver has to give the police probable cause to pull the vehicle over. Therefore, there is no excess risk of arrest as a direct result of the data collector calling over the officer, but rather the driver's behavior after leaving the site produces the risk of being pulled over and possibly arrested.

Appendix E: Survey
Funded by the National Institute on Alcohol Abuse and Alcoholism

DIN: _ _ _ _ - _ _ - _ _
CRASH *DRIVER* *CONTROL*

We are from the Pacific Institute for Research and Evaluation, a non-profit research company, and we are conducting a voluntary and confidential driver survey. You are being asked to VOLUNTARILY PARTICIPATE in a research study designed to better understand the drug crash risk patterns on our nation's streets and highways. The survey takes just a few minutes. We would like to ask you some questions about your driving behavior and take a sample of your breath to be analyzed later for alcohol. You may skip any question or stop participation at any time. The risks associated with taking part in this study are very small. Some questions ask about sensitive behaviors and might be embarrassing to answer, but you may skip any. Also, there is a slight possibility that information you provide may be linked to you. However, given the strict confidentiality procedures in place, this is unlikely to occur. The steps to be followed to ensure your data remain confidential include coding the survey and breath sample with a research study case number rather than your name or any other identifying information. Also, we will conduct the interview privately where no one else can hear us. Absolutely none of the individual information collected by me will be shared with anyone outside the research project, including law enforcement. There are no direct benefits to you participating, although you will be providing important information for improved traffic safety. If eligible, you can earn some money for completing some ADDITIONAL parts of the study. May I begin?"

SURVEY QUESTIONS

The average driver drives about 15,000 miles a year. Would you say you drive:

☐ More than average
☐ Average
☐ Less than average
☐ Did not answer

About how many miles away are you now from where you live?

☐ 0-5
☐ 6-10
☐ 11-20
☐ More than 20
☐ Did not answer

Activate PAS for second reading

Where are you coming from?

☐ Own home
☐ Someone else's home
☐ Work
☐ Restaurant/Eating place
☐ Bar/Tavern/Club
☐ Sport or Rec facility/Park
☐ School/Church
☐ Store/Gas station
☐ Hotel/Motel
☐ Beach
☐ Military Base
☐ Other
☐ Did not answer

Where are you headed?

☐ Own home
☐ Someone else's home
☐ Work
☐ Restaurant/Eating place
☐ Bar/Tavern/Club
☐ Sport or Rec facility/Park
☐ School/Church
☐ Store/Gas station
☐ Hotel/Motel
☐ Beach
☐ Military base
☐ Other
☐ Did not answer

Assess estimated level of intoxication

☐ No signs of alcohol or drug use (Level 1)
☐ Signs of use but no intoxication (Level 2)
☐ Signs of use and intoxication (Level 3)
If level 3– ***Implement IDP***

Rev: 5/16/11

For Level 3 subjects: Continue asking questions while observing subject and determine: (1) if subject has the ability to give consent, and (2) if the interview should be stopped and the IDP activated.

Record PAS reading

☐ 00
☐ 1 green
☐ 2 green
☐ 1 yellow
☐ 2 yellow
☐ 3 yellow
☐ 4 yellow (Implement IDP)
☐ 1 red (Implement IDP)
☐ 2 red (Implement IDP)
☐ 3 red (Implement IDP)
☐ Not used

(AUD screener question)
In the past year, how often did you have a drink containing alcohol?

☐ Never ***[Skip to Q9. Driver NOT eligible for AUD]***
☐ Monthly or less
☐ 2-4 times/month
☐ 2-3 times/week
☐ 4 or more times/week
☐ Did not answer

In the past year, have you ever had (5: male/4: female) or more drinks in a TWO-hour period?
☐ Yes
☐ No
☐ Did not answer

Have you had a drink containing alcohol today/tonight?
☐ Yes
☐ No ***[Skip to Q9]***
☐ Did not answer ***[Skip to Q9]***

How long ago did you finish your last drink?
Hours _____ Min _____ ☐ Did not answer

Was that beer, wine, or liquor or a combination?

☐ Beer
☐ Wine/Champagne
☐ Liquor
☐ Combination
☐ Did not answer

About how old were you when you first started drinking, not counting small tastes or sips of alcohol?

Age _____
☐ Never had alcohol
☐ Did not answer

Are you the designated driver today/tonight? That is, someone who did not drink alcohol so that you could safely get people home?

☐ Yes
☐ No
☐ Intended to be
☐ Did not answer

During the last week, how many hours did you sleep *on average* each night?

_____ Hours ☐ Did not answer

The *last time* that you slept, how many hours did you sleep?

_____ Hours ☐ Did not answer

What time did you wake up?

_____ AM/PM ☐ Did not answer

(Distracted Driver - next 3 questions)
Crash Driver: At the time of the crash, were you using a cell phone or other electronic device?
Control Driver: When you saw the officer up ahead and were approaching us, were you using a cell phone or other electronic device?

☐ Yes
☐ No
☐ Did not answer

If YES, check all that apply.

☐ Cell phone
☐ IPod/ music
☐ GPS
☐ Other_____
☐ Did not answer

Were you doing anything else in addition to driving such as eating, grooming, or talking to a passenger?

☐Yes
☐ No
☐ Did not answer

If YES, check all that apply;

☐ Eating
☐ Grooming
☐ Talking
☐ Radio dials
☐ Reading
☐ Singing
☐ Other _____
☐ Did not answer

How frequently do you use the following devices while driving?

Cell phone	Hands-free device	Texting
☐ Never	☐ Never	☐ Never
☐ Sometimes	☐ Sometimes	☐ Sometimes
☐ Regularly	☐ Regularly	☐ Regularly
☐ No answer	☐ No answer	☐ No answer

What is your age?

Years _____ ☐ Did not answer

How old were you when you obtained your license?

Years _____ ☐ Did not answer

What is your zip code?

Zip code _____ ☐ Did not answer

What is the highest degree or level of school you have completed?

☐ None - 8th grade
☐ 9th - 11th grade
☐ High school graduate
☐ Some college – no degree
☐ Associate's degree
☐ Bachelor's degree
☐ Master's degree
☐ Professional degree
☐ Doctoral degree
☐ Did not answer

Are you currently a student?

☐ High School
☐ College
☐ No
☐ Other
☐ Did not answer

Are you currently employed, unemployed, homemaker, on disability, retired, or other?

☐ Employed
- ☐ **Full-time** ☐ **Part-time**
- ☐ Did not answer

☐ Unemployed

How long have you been unemployed?

_____Months _____Years

☐ Did not answer
☐ Homemaker
☐ On Disability
☐ Retired
☐ Other _____
☐ Did not answer

Are you on active military duty?

☐ Yes ***[Skip to Q25]***
☐ No
☐ Did not answer

Are you a veteran?

☐ Yes
☐ No
☐ Did not answer

If YES, how long ago were you discharged?

☐ 0-1 month
☐ <1-6 months
☐ <6 months to 1 year
☐ <1 year to 5 years
☐ Over 5 years
☐ Did not answer

What is your marital status?

☐ Single
☐ Living together
☐ Married
☐ Separated
☐ Divorced
☐ Widowed
☐ Did not answer

Are you Hispanic or Latino?

☐ Yes
☐ No
☐ Did not answer

To which racial group would you say you belong?

☐ White
☐ Black or African American
☐ Native American or Alaska Native
☐ Asian
☐ Hawaiian or Pacific Islander
☐ More than one race
☐ Other_____
☐ Unknown
☐ Refused to identify

Survey Questions Complete

BREATH SAMPLE:

"Now I'd like to get a sample of your breath. Our device does not display any readings and there is no risk to you." (Show PBT to subject) "This will take just a few seconds."

"I will indicate on my survey that you said": ☐ YES ☐ NO

Take breath sample with PBT.

RECORD PBT TEST NUMBER:___ ___ ___ ___ BAC Result: .___ ___ ___

Oral fluid (OF)/Drug questionnaire (DQ)/AUD

"For $10 cash, I will now ask you to VOLUNTARILY PARTICIPATE in two research activities about prescription and non-prescription drug use. This will take a few minutes. It involves collecting a sample of your saliva for LATER analysis in a lab AND filling out a questionnaire about your use of substances. As before, your data will be coded with a research study case number and you may stop participating at any time. May I begin?"

"I will indicate on my survey that you said": ☐ YES ☐ NO

AUD consent script

Is Participant AUD Eligible? (Per Survey Q4): ☐ Eligible ☐ Ineligible

"For an additional $5, I will now ask you to voluntarily answer a few questions about your use of alcohol in the past year. Your answers to these questions are confidential. As before, you may stop participating at any time."

"I will indicate on my survey that you said": ☐ YES ☐ NO

ORAL FLUID COC label:

Blue COC label for Oral Fluid here

Distribute funds

Blood Draw:

"***Are you over 18 years of age?" ☐ YES****/Eligible* ☐ ***NO****/Ineligible*

☐ DCs riding alone: *Consent driver for blood draw* ***DC Code_____***
☐ ADCs riding alone: *Skip Blood Consent and continue on to Driving Record Consent.*
☐ DC drawing for ADC: *Consent driver for blood draw.* ***DC Code_____***

"I would like to offer you a $50 money order to provide a quick blood sample. The purpose is to measure some blood components that may reflect alcohol or drug use. This is completely voluntary and confidential. I am (with) a licensed phlebotomist and it should take about 5 or 10 minutes. Would you be willing to participate in this part of the study?"

"I will indicate on my survey that you said": ☐ *YES* ☐ *NO*

BLOOD COC label:

Red COC label for Blood here

Distribute funds

THANK YOU FOR YOUR TIME! (Participants)

I am from the Pacific Institute for Research and Evaluation, a non-profit research company, and we are conducting a voluntary and confidential survey. This project is funded by the Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA). You were asked to **VOLUNTARILY PARTICIPATE** in a research study designed to better understand the drug crash risk patterns on our nation's streets and highways. This type of study has proven to be a valuable tool for learning how we can improve highway and traffic safety.

In keeping with our mission of protecting our nation's drivers, I collect observational data on all drivers that I talk to and an estimate of recent alcohol use from the air surrounding drivers using a passive alcohol sensor before the consent process has been completed. These approximate readings are used to help us better understand the drug crash risk patterns on our streets and highways. They are also used to ensure that all drivers who are asked to participate in this survey are able to make it safely to their next location.

Aside from the passive sensor reading which only provides an estimate of alcohol use, I also requested the opportunity to collect a sample of your breath for later analysis for breath alcohol. This active sample is taken by having you blow into the breath test unit. I will not know the results of the analysis until much later. This sample, along with many other samples I will collect today, will provide valuable statistical information about the frequency of safety-related events and drinking and driving in our nation. I also noted your gender and age and asked you some questions about your drinking and other driving activities for statistical purposes in a 10-minute interview.

You may not benefit directly from participation in this study, but you will be making an important contribution to society by providing information to aid in the development of future drinking and driving prevention programs in our nation.

Our breath test instrument cannot provide information at the time of the interview about your drinking. However, I wish to inform you that if you have been drinking, there is risk of accidental injury and death to you and others if you drive. You should not conclude from my brief interview that it is safe for you to drive if you have been drinking. I encourage you to let me assist you if you have been drinking and do not feel comfortable driving.

Participation in this survey is completely **VOLUNTARY AND CONFIDENTIAL**. If you choose to participate, you may withdraw your consent and discontinue participation at any time. If you have any additional questions related to this study, you may contact PIRE's Principal Investigator for this project, _____at _____ or toll free at_____. If you have questions regarding your rights as a research participant in this study, you may contact_____, Pacific Institute for Research and Evaluation, _____or toll free:_____.

Thank you for your time! (Non-Participants)

I am from the Pacific Institute for Research and Evaluation, a non-profit research company, and we are conducting a voluntary and confidential survey. This project is funded by the Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA). You were asked to **VOLUNTARILY PARTICIPATE** in a research study designed to better understand the drug crash risk patterns on our nation's streets and highways. This type of study has proven to be a valuable tool for learning how we can improve highway and traffic safety.

In keeping with our mission of protecting our nation's drivers, I collect observational data on all drivers that I talk to and an estimate of recent alcohol use from the air surrounding drivers using a passive alcohol sensor before the consent process has been completed. I do not collect any identifying information and this data can in no way be associated with you. These approximate readings are used to help us better understand the drug crash risk patterns on our streets and highways. They are also used to ensure that all drivers who are asked to participate in this survey are able to make it safely to their next location.

If you have concerns about making it to your next location safely, please inform the person who surveyed you before leaving the site. My assessment is not a replacement for your own judgment of your ability to drive safely. As part of our effort, I am prepared to provide assistance to any drivers to make it to their next location safely.

If you have any additional questions related to this voluntary and confidential study, you may contact PIRE's Principal Investigator, ____ at ____ or toll free at _____.

If you have questions regarding your rights as a research participant in this study, you may contact _____ , Pacific Institute for Research and Evaluation, _____ or toll free: _____ .

Appendix F: Drug Questionnaire Funded by the National Institute on Alcohol Abuse and Alcoholism

Drug Questionnaire

DIN:_ _ _ _ - _ _ _ - _ _
CRASH DRIVER CONTROL

The following questions ask about use of medications and drugs and driving. This is for research purposes only. All your responses are completely confidential. The following is a list of medications/drugs people may use. Please indicate when was the last time (if ever) you used that particular medication/drug.

REV: 1/27/10

	Past 24 hours	Past 2 days	Past month	Past year	Over a year ago	Never
Tobacco (e.g., cigarettes, cigar)	○	○	○	○	○	○
Cough medicines (e.g., Robitussin, Vicks 44, etc.)	○	○	○	○	○	○
Other over-the-counter medicines (e.g., Tylenol, Benadryl)	○	○	○	○	○	○
Prescription pain killers (e.g., Percocet, oxycontin, oxycodone, Demerol, Darvon)	○	○	○	○	○	○
Sleep aids (e.g., Ambien)	○	○	○	○	○	○
ADHD medications (e.g., Ritalin, Aderall, Concerta)	○	○	○	○	○	○
Muscle relaxants (e.g., Soma, Miltown)	○	○	○	○	○	○
Prescription dietary supplements (e.g., Phentermine)	○	○	○	○	○	○
Anti-depressants (e.g., Prozac, Zoloft)	○	○	○	○	○	○
Marijuana (e.g., pot, hash, weed)	○	○	○	○	○	○
Cocaine (e.g., crack or coke)	○	○	○	○	○	○
Heroin	○	○	○	○	○	○
Methadone	○	○	○	○	○	○
LSD (acid)	○	○	○	○	○	○
Morphine or Codeine (e.g., Tylenol with Codeine)	○	○	○	○	○	○
Ecstasy (e.g., “E”, Extc, MDMA, “X”)	○	○	○	○	○	○
Amphetamine or Methamphetamine (e.g., speed, crank, crystal meth)	○	○	○	○	○	○
GHB (e.g., Liquid E, Gamma-Oh, Fantasy)	○	○	○	○	○	○
PCP (e.g., Angel dust)	○	○	○	○	○	○
Rohypnol (Roofies)	○	○	○	○	○	○
Ketamine (Special K)	○	○	○	○	○	○
Benzodiazepines (e.g., Valium, Xanax or tranquilizers)	○	○	○	○	○	○
Barbiturates (e.g., Phenobarbital, luminal, Nembutal)	○	○	○	○	○	○

Drug Questionnaire

24. During the past 12 months, were you arrested and booked for driving under the influence of alcohol or drugs?

○ Yes ○ No **(If no, skip to question #26)**

25. During the past 12 months, as a result of an arrest and/or conviction for driving under the influence of alcohol or drugs:

a. Was your license suspended?	○ Yes	○ No
b. Was your license revoked?	○ Yes	○ No
c. Did you serve time in jail or prison?	○ Yes	○ No
d. Did you pay a fine?	○ Yes	○ No
e. Were you required to perform community service?	○ Yes	○ No
f. Were you placed on probation?	○ Yes	○ No
g. Were you required to attend an education program?	○ Yes	○ No
h. Were you required to attend a treatment program?	○ Yes	○ No
i. Other punishment (if yes, please explain below)	○ Yes	○ No

Please print clearly (for "Other punishment"): _____

26. In the past year, have you sought help because of your drinking?	○ Yes ○ No
27. In the past year, have you been told by a medical person you needed help for your drinking?	○ Yes ○ No
28. Have you visited a medical facility in the past year for your drinking (for example, seen a doctor or medical person, been to the hospital, etc.)?	○ Yes ○ No
29. In the past year, have you been to an emergency room because of something related to your drinking?	○ Yes ○ No
30. During the past 12 months, have you received help for your drug or alcohol use in a self-help group, such as Alcoholics Anonymous (AA) or Narcotics Anonymous (NA)?	○ Yes ○ No
31. Have you ever been admitted to an outpatient drug or alcohol treatment program **NOT** including meetings like AA or NA? (An "outpatient program" is meant as a drug or alcohol treatment program where you do not stay overnight.)	○ Yes ○ No
32. During the past 12 months, did you ever stay at least overnight in an inpatient or residential drug or alcohol treatment program, (for example, detox, rehab, a therapeutic community or a hospital)?	○ Yes ○ No

Drug Questionnaire

The following questions are about your use of marijuana, cocaine and non-prescribed use or overuse of <u>prescription</u> pain killers in the past year.

	Marijuana	**Cocaine**	**Prescription Pain Killers**
If not used in the past year, mark NO USE and turn page.	**O No Use**	**O No Use**	**O No Use**
In the past year, did your use often interfere with taking care of your home or family or cause you problems at work or school?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you more than once get into a situation while using or after using that increased your chances of getting hurt, such as driving a car or other vehicle or using heavy machinery?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you get arrested, held at a police station or have legal problems because of your use?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you continue to use even though it was causing you trouble with your family or friends?	O Yes O No	O Yes O No	O Yes O No
In the past year, have you found that you have to use more than you once did to get the effect you want?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you find that your usual amount had less effect on you than it once did?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you more than once want to try to stop or cut down on your use, but you couldn't do it?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you end up using more or using for a longer period than you intended?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you give up or cut down on activities that were important to you or gave you pleasure in order to use?	O Yes O No	O Yes O No	O Yes O No
In the past year, when the medication/drug effects were wearing off did you experience some bad after-effects such as trouble sleeping, feeling nervous, restless, anxious, sweating or shaking, or did you have seizures or sense things that weren't really there?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you spend a lot of time using or getting over the bad after effects of use?	O Yes O No	O Yes O No	O Yes O No
In the past year, did you continue to use even though it was causing you to feel depressed or anxious, or causing a health problem or making one worse?	O Yes O No	O Yes O No	O Yes O No

AUD Questions

☐ Eligible ☐ Ineligible Consented:
☐ Yes ☐ No

In the past year, how many drinks containing alcohol did you have on a typical day when you were drinking? ○ 1 -2 ○ 3 - 4 ○ 5 - 6 ○ 7 - 9 ○ 10 or more	Did you find that your usual number of drinks had less effect on you than it once did? ○ Yes ○ No
In the past year, how often did you have six (five for a woman) or more drinks on one occasion? ○ Never ○ Less than monthly ○ Monthly ○ Weekly ○ Daily/almost daily	Did you more than once want to try to stop or cut down on your drinking, but you couldn't do it? ○ Yes ○ No
Did your drinking often interfere with taking care of your home or family or cause you problems at work or school? ○ Yes ○ No	Did you end up drinking more or drinking for a longer period than you intended? ○ Yes ○ No
Did you more than once get into a situation while drinking or after drinking that increased your chances of getting hurt—like driving a car or other vehicle or using heavy machinery after having had too much to drink? ○ Yes ○ No	Did you give up or cut down on activities that were important to you or gave you pleasure in order to drink? ○ Yes ○ No
Did you get arrested, held at a police station or have legal problems because of your drinking? ○ Yes ○ No	When the effects of alcohol were wearing off, did you experience some of the bad after effects of drinking—like trouble sleeping, feeling nervous, restless, anxious, sweating or shaking, or did you have seizures or sense things that weren't really there? ○ Yes ○ No
Did you continue to drink even though it was causing you trouble with your family or friends? ○ Yes ○ No	Did you spend a lot of time drinking or getting over the bad after-effects of drinking? ○ Yes ○ No
Have you found that you have to drink more than you once did to get the effect you want? ○ Yes ○ No	Did you continue to drink even though it was causing you to feel depressed or anxious or causing a health problem or making one worse? ○ Yes ○ No

Appendix G: Injured Driver Information Card

Office use only:	Document to be Destroyed
Drug Crash Risk Study	
Date:	Time:
DIN: __ __ __ __ -- __ __ -- __ __	Name
Hospital:	Ambulance #:

Office use only:	Document to be Destroyed
Drug Crash Risk Study	
Date:	Time:
DIN: __ __ __ __ -- __ __ -- __ __	Name
Hospital:	Ambulance #:

Office use only:	Document to be Destroyed
Drug Crash Risk Study	
Date:	Time:
DIN: __ __ __ __ -- __ __ -- __ __	Name
Hospital:	Ambulance #:

Office use only:	Document to be Destroyed
Drug Crash Risk Study	
Date:	Time:
DIN: __ __ __ __ -- __ __ -- __ __	Name
Hospital:	Ambulance #:

Office use only:	Document to be Destroyed
Drug Crash Risk Study	
Date:	Time:
DIN: __ __ __ __ -- __ __ -- __ __	Name
Hospital:	Ambulance #:

REV: 1/27/10

Appendix H: Consent to Use Blood Form

Consent to Use Blood Sample

Purpose: You are invited to participate in a research study that is sponsored by the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) and conducted by the Pacific Institute for Research and Evaluation (PIRE), a non-profit research organization. Please ask the researcher to explain anything you don't understand.

Procedures: I am conducting a study to assess the crash risk presented by alcohol and drug use. You have been invited to take part in this study because you were a driver involved in a vehicle crash. A blood sample was drawn when you entered the hospital by hospital staff. I am asking you to voluntarily and confidentially allow us to include your blood sample in our study. The sample will be assessed for blood components that measure recent alcohol and drug use. I have access to a 10 ml sample of your blood but I will not include it in the study unless you voluntarily agree to allow me to use the blood sample.

Possible Risks or Discomforts: The risks associated with taking part in this study are very small. There is a slight possibility that information may be linked to you. However, given the strict confidential procedures in place, this is very unlikely to occur.

Confidentiality Safeguards: The information you provide while participating in the study will be kept strictly confidential by the researcher. The blood sample will be assigned a bar code number. You will be asked to provide initials or put an X on the signature line as a means of not providing any identifying information.

Payment: You will receive a $50 money order for voluntarily providing us permission to use your blood sample in our study. Other than the payment, you will not benefit personally from participating in this part of the study.

Voluntary Participation: You do not have to participate in this portion of the study. Participation is voluntary.

Contact Information: If you have any questions about the study, you may call PIRE's Principal Investigator,_____ at _____or toll free at _____. If you have any questions about your rights as a study participant, you may call PIRE's headquarters toll-free and ask for _____, _____, at _____.

Participant Statement

I certify that I am at least 18 years old. I acknowledge that the study has been explained to me and that I have had the opportunity to discuss any concerns with the researcher. I understand that all blood results are confidential. I further understand that my participation is completely voluntary.

I have read the foregoing consent and agree to the terms set out for being a volunteer participant, and I give my consent to allow use of my blood sample in the study.

Participant Initials_____

You are not required to sign your full name, please sign only your initials.

Witness _____

Date: _____

Appendix I: Crash Report Form

Crash#: _ _ _ _

Abbreviated Crash Reporting Form

Precinct: 1□ 2□ 3□ 4□

Vehicle #1	Vehicle #2
DIN: __ __ __ __ - __ __	DIN: __ __ __ __ - __ __
Driver Consented Officer: □ Yes □ No	Driver Consented Officer: □ Yes □ No
If no, why?: □ Refused Officer □ Taken to Hospital □ Absent □ Commercial □ Not Approached If Not approached, why?_____	If no, why?: □ Refused Officer □ Taken to Hospital □ Absent □ Commercial □ Not Approached If Not approached, why?_____
Responsibility Code - Vehicle 1 Driver: *(Check one)* □ Responsible □ Responsible/Contributory □ Contributory □ Contributory/Neither □ Not responsible or Contributory □ Unknown	Responsibility Code - Vehicle 2 Driver: *(Check one)* □ Responsible □ Responsible/Contributory □ Contributory □ Contributory/Neither □ Not responsible or Contributory □ Unknown
Crash Type: / Injury Type:	Crash Type: / Injury Type:
Length of DC interview: minutes	Length of DC interview: minutes

Vehicle #3	Vehicle #4
DIN: __ __ __ __ - __ __	DIN: __ __ __ __ - __ __
Driver Consented Officer: □ Yes □ No	Driver Consented Officer: □ Yes □ No
If no, why?: □ Refused Officer □ Taken to Hospital □ Absent □ Commercial □ Not Approached If Not approached, why?_____	If no, why?: □ Refused Officer □ Taken to Hospital □ Absent □ Commercial □ Not Approached If Not approached, why?_____
Responsibility Code - Vehicle 3 Driver: *(Check one)* □ Responsible □ Responsible/Contributory □ Contributory □ Contributory/Neither □ Not responsible or Contributory □ Unknown	Responsibility Code - Vehicle 4 Driver: *(Check one)* □ Responsible □ Responsible/Contributory □ Contributory □ Contributory/Neither □ Not responsible or Contributory □ Unknown
Crash Type: / Injury Type:	Crash Type: / Injury Type:
Length of DC interview: minutes	Length of DC interview: minutes

REV: 6/29/10

Abbreviated Crash Reporting Form

Driver's Action	V1	V2	V3	V4
No improper action				
Exceed speed limit				
Exceed safe speed but not speed limit				
Overtaking on hill				
Overtaking on curve				
Overtaking at intersection				
Improper Passing of School Bus				
Cutting in				
Other improper passing				
Wrong side of the road – no overtaking				
Did not have right-of-way				
Following too close				
Fail to signal or improper signal				
Improper turn – wide turn				
Improper turn – Cut corner on left turn				
Improper turn – From wrong lane				
Other improper turn				
Improper backing				
Improper start from parked position				
Disregarded officer or flagger				
Disregarded traffic signal				
Disregarded stop or yield sign				
Driver distracted				
Fail to stop at through high way : No signal				
Drive through work zone				
Fail to set out flares or flags				
Fail to dim headlights				
Driving without lights				
Improper parking location				
Avoiding pedestrian				
Avoiding other vehicle				
Avoiding animal				
Crowded off highway				
Hit and run				
Car ran away – no driver				
Blinded by headlights				
Other				
Avoiding objects in roadway				
Eluding police				
Fail to maintain proper control				
Improper passing				
Improper or unsafe lane change				
Over correction				

Condition of Responsible Driver	V1	V2	V3	V4
No defects				
Eyesight defective				
Hearing defective				
Other body defects				
Illness				
Fatigued				
Apparently asleep				
Other				
Unknown				

Type of Driver Distractions	V1	V2	V3	V4
Looking at roadside incident				
Driver fatigue				
Looking at scenery				
Passengers				
Radio/CD, etc.				
Cell phone				
Eyes not on road				
Daydreaming				
Eating/drinking				
Adjusting vehicle controls				
Navigation device				
Other				
None				

By Crash

Type of Crash	
Single	
Multiple	
If Multiple: Number of Vehicles	

Relation to Roadway	
Interchanging Area	
Main-line roadway	
Acceleration/Deceleration lanes	
Gore area (between ramp/highway edge lines)	
Collector/Distributor road	
On entrance/exit ramp	
Intersection at end of ramp	
Median	
Shoulder	
Roadside	
Other	
Intersection Area	
Non-intersection	
Within intersection	
Intersection related (within 150 feet)	
Intersection related (outside 150 feet)	
Other Location	
Crossover related	
Driveway related	
Railway grade crossing	
Other crossing (bikes, schools, etc.)	

Intersection Type	
Not an intersection	
Two approaches	
Three approaches	
Four approaches	
Five point or more	
Roundabout	

Crash#: _ _ _ _

Office Use Only

Document to be destroyed

Sketch of Crash Site: (Include layout of crash site, where data collectors and police officers were located, location of crash vehicles, and any other relevant elements.)

Notes: (Brief description of site)

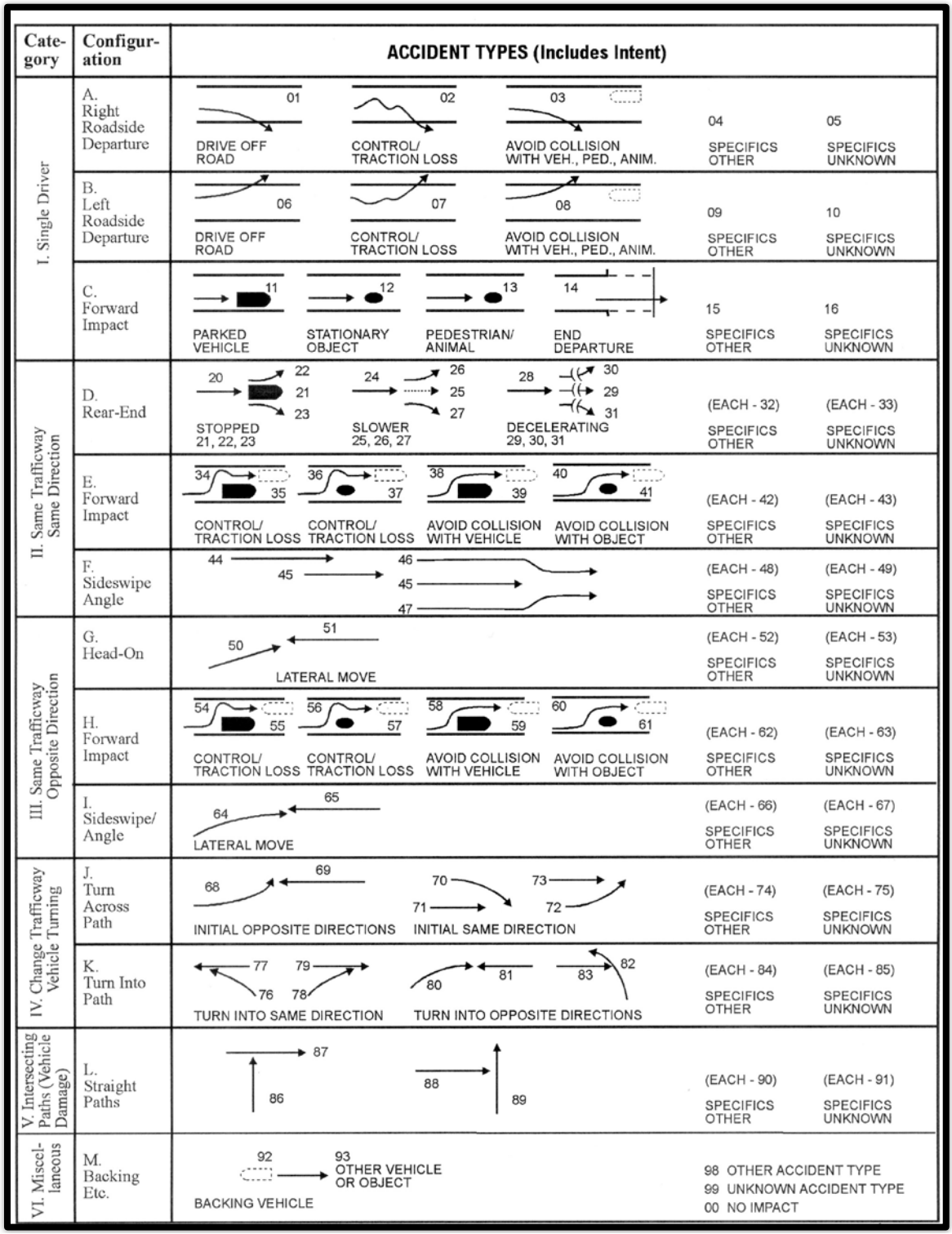
V1 DIN: Make/ Model: V2 DIN: Make/ Model:

V3 DIN: Make/ Model: V4 DIN: Make/ Model:

Crash#: _ _ _ _

Office Use Only Document to be destroyed			
Crash Date:	Data Collector:	EMS #:	
Time of crash : AM/PM	Time arrived on site: AM/PM	DC Start time: AM/PM	DC End time: AM/PM
Police Report # (IBR):	Research Officer Code:	Investigating Officer Code:	
Road Name: (write out “road,” “street,” etc.)			
Intersecting Road Name: (write out “road,” “street,” etc.)			

Notes



Injury type Coding:	
1	**Dead before report made.**
2	**Visible signs of injury, as bleeding wound, distorted member or had to be carried from scene.**
3	**Other visible injury, as bruises, abrasions, swelling, limping, etc.**
4	**No visible injury, but complaint of pain or momentary unconsciousness.**
6	**No injury. (driver only)**

Appendix J: Observation Report Form

Crash Site Observation Form (all items) Crash#: __ __ __ __
Control Site Observation (Q1-Q6)

Time: ☐12a ☐3a ☐6a ☐9a
☐12p ☐3p ☐6p ☐9p

Weather (check 1-2 items)
☐ Clear
☐ Cloudy
☐ Raining
☐ Light ☐ Heavy
☐ Snowing
☐ Light ☐ Heavy
☐ Fog
☐ Wind
☐ Other (describe) _____

Lighting
☐ Daylight
☐ Dusk
☐ Dawn
☐ Dark: street lights
☐ Dark: no street lights
☐ Dark: street lights not functioning

Roadway Surface
☐ Dry
☐ Wet
☐ Snowy/Ice
☐ Slippery (muddy, oily, etc.)

Roadway Conditions (check 1-2 items)
☐ No unusual conditions
☐ Holes/deep ruts
☐ Loose material on roadway
☐ Obstruction on roadway
☐ Construction/Repair zone
☐ Reduced roadway width
☐ Flooded
☐ Other_____

Type of Roadway
☐ City surface
☐ Alley way
☐ Intersection (describe)_____
☐ Other (describe)_____

How many lanes on the roadway? _____

REV 12/6/10

Type of crash (check all that apply)
☐ Head-on
☐ Sideswipe
☐ Rear-end
☐ Broadside
☐ Hit object
☐ Overturned
☐ Vehicle/pedestrian
☐ Vehicle/train
☐ Vehicle/bicycle
☐ Vehicle/motorcycle
☐ Vehicle/animal
☐ Other_____

What can be seen within one block of crash location (check all that apply)
☐ Alcohol outlet (on site: bar/ tavern/ restaurant)
☐ Alcohol outlet (off-site: liquor store/ market)
☐ Restaurant
☐ Homes
☐ Apartment buildings
☐ Hotel/Motel
☐ Professional buildings
☐ Retail stores/Small businesses
☐ Warehouses/Industry/Manufacturing
☐ Beachfront
☐ Military base
☐ Other:_____

Injury involved?
☐ No injury (Property damage only)
☐ Injury
☐ Fatality

Was the crash a hit and run?
☐ Yes
☐ No

Traffic Flow
☐ Congested
☐ Moderate
☐ Light

Number of motor vehicles involved_____

Number of pedestrians involved_____

Number of bicycles involved_____

Crash Site Report Form (all items)
Control Site Report Form (all items)

Crash#: __ __ __ __

Day of the Week:	Data Collection Month:	Shift #: ☐ 1 ☐**1.5** ☐ 2 ☐**2.5** ☐ 3 ☐ P/S **1** ☐ P/S **2**
PAS Instrument #:	**PBT Instrument #:**	**Total Cash Dispensed:** **$**

Crash	Control
# DICs Completed:	# DICs Completed:
# AUD Completed:	# AUD Completed:
# Oral Fluids:	# Oral Fluids:
# Blood Samples:	# Blood Samples:
# Conversions Attempted:	# Conversions Attempted:
# IDPs Attempted:	# IDPs Attempted:
# Crash Drivers Involved:	**Total Vehicle Counts Completed by Officers**
# Crash Drivers to Hospital:	Total Session Count:
(Scratch pad for math, vehicle counts, etc)	Pulled Over for Interview:
	Non-Qualifying (Emergency, etc):
	Evading Site/Left Before Bay:

Notes: **Length of time at Control: ___Hrs ____Min**

Appendix K: Driver Information Card

Driver Information Card

DIN:_ _ _ _ - _ _ - _ _
CRASH DRIVER CONTROL

First Contact: ☐Officer ☐Trauma ☐None ☐M.E. ☐Control **DC Code: ___ ___** **Paid:$_____**

Declined All: ☐At Officer ☐Absent ☐Commercial ☐Yes ☐No ☐Not approached – Why?_____

Oral Fluid Label

Time Block: ☐12a ☐3a ☐6a ☐9a ☐12p ☐3p ☐6p ☐**9p**

Place Blue CoC Label here

PAS#:__ __ __ __ **PBT#:__ __ __ __**

PBT Test#:__ __ __ __ **Result (BAC):.__ __ __**

Transported to Hospital: ☐Yes **(back)** ☐No ☐Control

Blood Label

If Yes, driver approached by: ☐ DC ☐ RA ☐ Unavailable

Driver Arrested: ☐Yes ☐No ☐Control

Hit and Run Driver: ☐Yes ☐No ☐Control

Place Red CoC Label here

Conduct a Control: ☐Yes ☐No ☐Control

Converted Attempt ☐Yes ☐No

Successful? ☐Yes ☐No **If No, why?**: ☐No time ☐No interest ☐Other_____

Amount offered:$_____ **Difficulty:** ☐1 ☐2 ☐3 ☐4 ☐5

Impaired Driver Protocol (IDP) Implemented ☐Yes ☐No

Survey completed? ☐Yes ☐No **BAC:.__ __ __**

Action taken:

Switched Driver: BAC of new driver:_____ Valid License? ☐Yes ☐No

Friend/Family came: BAC of Friend/Family: _____

Waited until BAC .05 or below: Final BAC: _____

Taxi: Amount $ given: _____

Other (specify):_____

Number of passengers (up to 6)_____

Approximate ages of passengers: P1:_____ P2:_____ P3:_____ P4:_____ P5:_____ P6:_____

Office Use

Quality Control purposes only

Note any unusual circumstances at site or during data entry:

Name of hospital driver was transported to: _____

♥ **If driver approached by RA, was blood sample obtained by hospital staff:** ☐ Yes ☐ No

If No, why not?

☐ Refused consent
☐ Subject released from hospital before consent could be given
☐ Subject too ill to provide consent
☐ Subject passed away
☐ Other: _____

☐ **Police Report Obtained**

Input Initial: _____

Appendix L. Driver Observation Form

DIN: _ _ _ _ - _ _ - _ _
CRASH *DRIVER* *CONTROL*

Observational Data

Estimate Driver's Age:

☐ 16-20
☐ 21-34
☐ 35-64
☐ 65+

Driver's Sex:

☐ Male
☐ Female

Vehicle Type:

☐ Car
☐ SUV
☐ Minivan
☐ Van
☐ Pickup
☐ Motorcycle
☐ Other: _____

Number of Passengers:_____

Any under 15?
☐ Yes
☐ No

Driver's Ethnicity: Hispanic or Latino?

☐ Yes
☐ No

Driver's Race:

☐ White
☐ Black or African-American
☐ Native American or Alaska Native
☐ Asian
☐ Native Hawaiian or Other Pacific Islander
☐ More than one race
☐ Unknown
☐ Other: _____

Seat Belts: (If crash, ask driver and any front seat passenger if they were wearing their seat belts)

Driver	Passenger	
☐	☐	Lap and shoulder belts
☐	☐	Shoulder belt only
☐	☐	Lap belt only
☐	☐	No use/no belt
☐	☐	Unknown
☐	☐	Not applicable (no passengers)

Motorcycles:

Driver	Passenger	
☐	☐	Helmet used
☐	☐	No helmet used
☐	☐	Unknown
☐	☐	Not applicable (no passengers)

DC/ADC Approached Driver: ☐ Yes ☐ No (**If NO**, leave back page blank)

REV: 9/30/10

Activate PAS for first reading

Record PAS reading

☐ 00
☐ 1 green
☐ 2 green
☐ 1 yellow
☐ 2 yellow
☐ 3 yellow
☐ 4 yellow (Implement IDP)
☐ 1 red (Implement IDP)
☐ 2 red (Implement IDP)
☐ 3 red (Implement IDP)
☐ Not used

Is the Driver Eligible to participate? ☐ **YES** ☐ **NO**

If NO: ☐ Commercial ☐ Age ☐ Intoxicated ☐ Other

_____

Will Driver participate in survey? ☐ **YES** ☐ **NO** ☐ **Breath Test Only** ☐ **M.E.**

If NO: Ask for a breath test.

"Can I just get a sample of your breath? Our device does not display any readings and there is no risk to you." (Show PBT to subject) "This will take just a few seconds".

If Breath Test Only: *Take breath sample with PBT and record PBT test number in space below.* Give driver **WHITE CONSENT FORM and verbal warning about drinking, drugged, and fatigued driving. Thank and release driver.**

RECORD PBT TEST NUMBER:___ ___ ___ ___ **BAC Result: .**___ ___ ___

Only for drivers that refuse the survey

If NO: Give driver **YELLOW FORM and verbal warning about drinking, drugged, and fatigued driving. Thank and release driver.**

Appendix M: Blood Consent Form

Consent for Blood Draw

Purpose: We are now asking you to voluntarily and confidentially provide a blood sample for later analysis. The sample will be assessed for blood components that measure recent alcohol and/or drug use. To participate in the blood draw, you must (1) be at least 18 years old, (2) not be taking any blood thinners (like Coumadin), or receiving injections such as Calciparine or Liquaemin, and (3) not have a blood disorder such as hemophilia. If any of these conditions apply, you MUST decline to participate.

Procedures: A trained specialist known as a phlebotomist will insert a needle in a vein and withdraw 10 ml of blood, which is equal to about 2 teaspoons.

Possible Risks or Discomforts: Although the phlebotomist will be using standard medical practices to draw blood safely, venipuncture is not entirely without risk. Such risks consist of but are not limited to the following:

- Dizziness
- Nausea
- Fainting
- Passing out and falling with injury
- Nerve injury at or near the phlebotomy site
- Under rare circumstances a phlebotomy procedure can lead to a need for medical treatment

Safeguards: A person specially trained to take blood samples will draw your blood using procedures that are recognized as safe.

Confidentiality: The blood sample will be assigned a bar code number without any identifying information such as your name.

Payment: You will receive a $50 money order for being a volunteer participant. Other than the payment, you will not benefit personally from participating in this part of the study.

Voluntary Participation: Your participation in the blood draw is completely voluntary and you may withdraw at any time. If you withdraw before the blood collection, however, you will not receive the $50.

Contact Information: If you have any questions about the study, you may call PIRE's Principal Investigator,_____ at _____ or toll free at _____. If you have any questions about your rights as a study participant, you may call PIRE's headquarters toll-free and ask for _____, at _____ or toll free: _____

Participant Statement

I certify that I am at least 18 years old. I am not taking any blood thinners and have not been diagnosed with any blood conditions such as hemophilia.

I acknowledge that the procedure has been explained to me and that I have had the opportunity to discuss the blood draw procedure with the Certified Phlebotomist. I understand that all blood results are confidential. I further understand that my participation is completely voluntary and that I may withdraw from this part of the study at any time.

I have read the foregoing consent and agree to the terms set out for being a volunteer participant, and I give my consent to have the Certified Phlebotomist draw my blood today

Participant Initials_____

You are not required to sign your full name, please sign only your initials.

Witness _____

Month: _____ **Year**: _____

REV: 1/27/10

Appendix N: List of Drugs Tested

Table 33. Drug Class Composition—Oral Fluid and Blood Combined

Marijuana	Antidepressants	Narcotic Analgesics	Sedatives	Stimulants	Other
Cannabinoids	**SSRIs***	**Opioids**	**Barbiturates**	**Amphetamines**	**Cough Suppressants**
THC	Fluoxetine	Methadone	Butalbital	Amphetamine	Dextromethorphan
11-OH-THC	*Norfluoxetine*	*EDDP*	Phenobarbital	MDA	
THC-COOH	Sertraline	Hydrocodone	Pentobarbital	MDMA	**Pain Drugs**
	Desmethylsertraline	Hydromorphone	Secobarbital	MDEA	Ketamine
	Citalopram	Oxycodone		Methamphetamine	*Norketamine*
	Paroxetine	Oxymorphone	**Benzodiazepines**	Phentermine	PCP
	Trazodone	Fentanyl	Alprazolam	Pseudoephedrine	
	Fluvoxamine	Naltrexone	*Alpha-hydroxyalprazolam*		**Phenothiazine**
			Nordiazepam	**ADHD Medications**	Chlorpromazine
	Tricyclics	**Atypical Opioids**	Chlordiazepoxide	Methylphenidate	
	Amitriptyline	Tramadol	Diazepam		**Analgesics**
	Nortriptyline	Meperidine	Lorazepam	**Cocaine**	Carisoprodol
	Doxepin	*Normeperidine*	Oxazepam	Cocaine	Meprobamate
	Desmethyldoxepin	Buprenorphine	Temazepam	*Benzoylecgonine*	Cyclobenzaprine
	Imipramine	Norbuprenorphine	Triazolam	*Norcocaine*	
	Desipramine	Propoxyphene	Alpha-hydroxytriazolam	Cocaethylene	
	Trimipramine	*Norpropoxyphene*	Flurazepam		
	Clomipramine		Flunitrazepam		
	Norclomipramine	**Opiates**	*7-aminoflunitrazepam*		
	Amoxapine	6-AM (Heroin)	Nitrazepam		
	Protriptyline	*6-AC (Heroin impurity)*	Midazolam		
	Dothiepin	Codeine	Bromazepam		
	Mianserine	Morphine	Clonazepam		
	Mirtazapine		Estazolam		
			Phenazepam		
	SNRI**				
	Venlafaxine		**Sleep Aids**		
			Zolpidem		

Note: Shaded entries indicate drugs identified through blood analyses only. Non-shaded entries are drugs identified through both blood and oral fluid analyses.
* Selective Serotonin Uptake Inhibitors (SSRIs). ** Serotonin–norepinephrine reuptake inhibitors (SNRIs).

Table 34. Drug Category Composition—Oral Fluid and Blood Combined

Illegal	Medication			
Stimulants, Cocaine	**Sedatives, Benzodiazepines**	**Tricyclics, Antidepressants**	**Opioids, Narcotic Analgesics**	**Cough Suppressant**
Cocaine	Alprazolam	Amitriptyline	Methadone	Dextromethorphan
Benzoylecgonine	*Alpha-hydroxyalprazolam*	Nortriptyline	*EDDP*	
Norcocaine	Nordiazepam	Doxepin	Hydrocodone	**Phenothiazine, Anti-psychotic**
Cocaethylene	Chlordiazepoxide	*Desmethyldoxepin*	Hydromorphone	Chlorpromazine
	Diazepam	Imipramine	Oxycodone	
Marijuana, Cannabinoids	Lorazepam	*Desipramine*	Oxymorphone	**Sleep Aids**
THC	Oxazepam	Trimipramine	Fentanyl	Zolpidem
11-OH-THC	Temazepam	Clomipramine	Naltrexone	
THC-COOH	Triazolam	*Norclomipramine*		**Analgesics (Orig. Carisoprodol)**
	Alpha-hydroxytriazolam	Amoxapine	**Stimulants, ADHD**	Carisoprodol
	Flurazepam	Protriptyline	Methylphenidate	Meprobamate
Other, Pain Drugs	Flunitrazepam	Dothiepin		
Ketamine	*7-aminoflunitrazepam*	Mianserine	**Opiates, Narcotic**	**Analgesics, Muscle Relaxant**
Norketamine	Nitrazepam	Mirtazapine	**Analgesics**	Cyclobenzaprine
PCP	Midazolam		Codeine	
	Bromazepam	**SNRI**	Morphine	
Strimulant, Amphetamines	Clonazepam	Venlafaxine		
Amphetamine	Estazolam			
MDA	Phenazepam	**Stimulants, Amphetamines**	**Atypical Opioids**	
MDMA		Phentermine	Tramadol	
MDEA	**SSRIs*, Antidepressants**	Pseudoephedrine	Meperidine	
Methamphetamine	Fluoxetine		*Normeperidine*	
	Norfluoxetine	**Sedatives, Barbiturates**	Buprenorphine	
	Sertraline	Butalbital	Norbuprenorphine	
Opiates, Narcotic	*Desmethylsertraline*	Phenobarbital	Propoxyphene	
Analgesics	Citalopram	Pentobarbital	*Norpropoxyphene*	
6-AM (Heroin)	Paroxetine	Secobarbital		
6-AC (Heroin impurity)	Trazodone			
	Fluvoxamine			

Note: Shaded entries indicate drugs identified through blood analyses only. Non-shaded entries are drugs identified through both blood and oral fluid analyses.
* Selective Serotonin Uptake Inhibitors (SSRIs). ** Serotonin–norepinephrine reuptake inhibitors (SNRIs); Italics = metabolite.

Appendix O: Data Handling and Processing

Operations and Procedures

Equipment

Packing and Transportation of Equipment and Supplies

It was essential that all field supplies be properly maintained, and that everything needed for the survey arrive at the field destination intact and fully stocked. When supplies returned from the field each day, research assistants unpacked, inventoried, calibrated, and restocked equipment and supplies. Data collectors then assembled and packed all their supplies, equipment, forms, and materials necessary for the following shift's data collection activities, using the list of supplies and equipment shown in Table 1.

Table 35. List of Supplies and Equipment

Uniform	Data collector	Hospital scrubs Reflective safety vests Research team jackets Research team hats Closed-toe shoes Apron for supplies
	Research assistant	Khakis Blue "PIRE" polo shirt Reflective safety vests Research team jackets Research team hats Closed-toe shoes Apron for supplies
Equipment	2 PBTs (no display of BAC) 1 PBT with display of BAC 2 PAS Vr's Breath tubes Extra supply of batteries (AA for PBT; 9V for PAS)	
Participant fees	Cash/money orders	
Paper documents	Abbreviated crash report forms Driver information cards Crash/control site observation form Observation form Survey Drug questionnaire/AUD booklet Consent to draw blood Consent to use blood Driver's record consent form	

	Driver's license information card Injured driver information card Phlebotomist incident form Statement for participants Statement for those who decline to participate Driver consent scripts Incentive log Crash and injury type coding form COC labels for oral fluid samples COC labels for blood samples
Biological sample supplies	Quantisal™ oral fluid collection device Single-draw kits (plastic case to hold blood draw equipment for one draw) Needles Butterfly needles Vaccutainer Gray-top tubes (blood collection tubes) Gloves (powder-free nonlatex) Prewrapped BZK wipes Sterile 2x2 gauze pads Band-Aids Sharps container (for safe disposal of needles and tubes) First aid kit Biohazard spill kit Tourniquets Absorbent shipping pads (for blood specimens) Cooler and ice packs Specified cardboard container for shipping
Additional	Eye wash CPR mask 2 Traffic signs: "VOLUNTARY SURVEY" Plastic file folders 2 Traffic sign stands Orange traffic cones Garbage bags Traffic wands Clipboards (3 per data collector) Hand warmers Binder clips Coloring books w/crayons (to provide to any child in the vehicle) Glow sticks Clip light Lantern/flashlights (extra source of light) Hand tally counters Money bag for incentives Rubber bands Ziploc bags Bungee cords Dog treats (to provide to any dog in the vehicle) Ballpoint pens

To facilitate transportation of data collection materials and supplies in the field, each data collector was assigned his/her equipment that they were responsible for, including:

- Wheeled survey bag (for essential survey items, shown in Figure 1)
- Toolbox (for phlebotomy items, shown in Figures 1 and 2)
- Small cooler with ice packs to store/cool biological samples (Figure 3)

This ensured that the wide array of necessary equipment and materials were ready to go when the data collector arrived at a crash or control site. Each data collector was expected to keep all supplies accessible and organized in the field at all times in the field.

PBTs and PAS Equipment

Each data collector was assigned three PBTs and two PAS devices. If any device presented technical issues, the data collector replaced the malfunctioning unit with the backup device.

During the field shift, data collectors stored biological samples in a cooler/storage box cooled with ice packs. When the field shift ended, the oral fluid and blood samples were collected and transferred to a specially designated refrigerator in the office (used only for storage of biological samples until shipped to the laboratory for analysis).

Contents of Survey Bags

Each wheeled survey bag (Figure 1) contained all items of equipment, forms, and materials necessary for the field data collection process. Table 2 and 3 show a list of items contained in the survey bag and list of paperwork that was included.

Figure 12. Data Collector's Survey Bag and Toolbox

Table 36. Contents of the Data Collector's Survey Bag

Description	Quantity
PAS	2
PBT	2
Display PBT	1
Breath tubes	16
Quantisal	16
9-volt batteries	2
Clipboard lights	2
Clipboards	3
Pens	10
Binder clips	10
Headlamps	1
Extra paperwork	8 cases

Table 37. Paperwork in the Data Collector's Notebook

Description	Quantity
Officer report form (gray)	8
Site report/observation form (yellow)	8
Driver information card (blue)	16
Survey with verbal consents	16
Drug questionnaire	16
Consent for blood draw	16
Study statement for participants	16
Driver's record consent form	16
Driver's license information card	16
Injured driver consent card	16
Study statement for those who decline	16

Contents of the Data Collector Toolbox

Each data collector's toolbox (Figure 2) contained blood draw supplies, which were organized when packed so that the phlebotomist could access the correct equipment in the order needed in the field. Contents of the toolbox are listed in Table 4.

Figure 2. Contents of the Data Collector Toolbox

Table 38. Contents of the Data Collector Toolbox

Description		Quantity
Single-draw kit		8
	Butterfly needle	1
	Band-Aid	1
	Gauze	1
	BZK wipe	1
	Straight needle	1
	Tourniquet	1
	Glass collection tube	1
	Barrel	1
	Gloves	1
Extra blood collection supplies		Enough for 5 additional blood draws
First aid kit		1
Eye wash		1
CPR mask		1
Hand sanitizer		1
Heat packs		1
Cold packs		1
Universal precaution	compliance kit	1
Candy (for participants)		1 bag

Contents of Biological Specimen Coolers

Each data collector's biological specimen cooler (Figure 3), which was packed prior to the field shift and kept organized in the field, contained supplies listed in Table 5.

Figure 14. Contents of Data Collector's Biological Specimen Cooler

Table 39. Contents of Data Collector's Biological Specimen Cooler

Description	Quantity
Sharps container	1
Specimen container (red box)	1
Absorbent pads	1
Frozen Ice Pack	10

Packing and Transportation of Biological Samples

Following a data collector's shift, oral fluid and blood samples returning from the field were stored in the specially designated biological specimen refrigerator in the office. Research assistants prepared and shipped the samples to the lab twice weekly. The biological samples were packed in red specimen container boxes, which were then placed in Styrofoam coolers with ice packs. Each Styrofoam cooler was marked with a biohazard sticker, sealed, and shipped to the Immunalysis Corporation's lab in California for testing.

Data Handling and Processing

Biological Samples

Biological samples collected in the field were refrigerated immediately when the data collector returned to the office at the end of the shift. Low blood samples were noted as potentially resulting in a "not sufficient sample" (NSF). Research assistants shipped the biological samples twice weekly to Immunalysis Corporation in California for analysis. When sample results were available, those results were matched with CoC numbers assigned at the time of sample collection. Research assistants entered that data into the database.

Preliminary Breath Test Results

PBT results were uploaded to a Microsoft Excel file at the end of every data collection shift. The files were sorted chronologically according to time of use by PBT device number, and only included time of test, test number, and result, to further reduce likelihood of a specific result being traced back to a specific participant. This information was uploaded to the main servers at PIRE headquarters in Maryland daily.

Completed Survey and Consent Forms

Data collectors, assistant data collectors, and research assistants worked collaboratively to ensure that all data entered into the database were complete and accurate.

When data collectors and assistant data collectors returned to the office at the end of a shift, they refrigerated the biological samples, recorded PBT results, and reviewed paperwork for errors or missing information. Any information missing from the forms during crash or control activities would then be completed. After paperwork review, data collectors and assistant data collectors submitted the forms to research assistants for secondary review, and entry into the database.

Research assistants reviewed all incoming forms, marked any items requiring data collector clarification and, additionally, as a quality-control measure, entered any questions and/or inconsistencies on a clarification log. Research assistants then placed the paperwork in the data-collector's mailbox, and contacted the data collector/assistant data collector for clarification.

When all questions were resolved, research assistants entered the data into an Access database using a series of tabs representing the forms used in the field. Data were saved as tables, which were exported into Microsoft Excel and SAS formats for analysis and review. Responses were recorded with a combination of dropdown menus, identifying check boxes, and hand-entered fields, including free entry space for notes. To facilitate matching data, the database allowed searching by case, driver identification number (DIN), and oral fluid and blood labels.

While entering data from the forms, research assistants tracked specific aspects of the crashes separately through several electronic logs, using Microsoft Word and Microsoft Excel. These logs were a quality-control measure ensuring that data collectors and assistant data collectors performed certain procedures in the field (when appropriate), and also to readily provide information on special cases. The logs also kept track of week-to-week crash-control progress.

For example, conversion logs tracked the frequency with which drivers declined to participate (e.g., neither answered questions nor provided a sample), thereby assisting the data collector in keeping track of when to attempt a conversion (Figure 4).

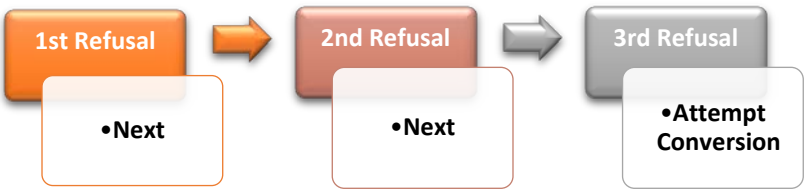


Figure 15. Screenshot of Conversion Log

An Impaired-Driving Protocol (IDP) log noted all drivers for whom IDPs were implemented (Table 6). The only information recorded on the IDP log was the driver's DIN and any pertinent notes, such as reason for IDP implementation and action taken. Fatalities were noted in a similar manner (Table 7).

Table 40. Example from IDP Log

Date	DIN	Demographics	BAC	Action taken
10/09/2010	8545-01	29 year old black male	.112	Driver arranged to be picked up from crash site
10/15/2010	8546-01	24 year old white male	.063	Walked home, lived one street down
11/06/2010	8550-01-01	21-34 year old black male	.045	No action needed.

Table 41. Example from Fatality Log

Week	Core ID	Case Number	Crash Notes	Notes
12	509	6028	Pedestrian fatality	6028: Pedestrian was a 25yr old white female who was believed to be inebriated and wandering the street. Police report that patrons of two bars which face each other from opposite sides of the streets regularly run across lanes of traffic from one establishment to the other.
14	580	6034	1 vehicle/ driver ejected from car fatal* No control*	6034-01: 24 year old male driver dead on scene. Driver was ejected from vehicle. Car was torn completely in half after colliding with underground drainage pipe made of concrete.

When a research assistant completed data entry of all crash data for a given case, the data was logged and then entered into the Access database. Finally, the data was stored in a locked file cabinet.

Prior to a control activity, a research assistant retrieved the appropriate forms needed to perform the control on the designated date. When the data collector completed the controls, they returned the forms and the research assistant reviewed, logged, and entered the additional information into the database. The control forms were then stored with their respective crash forms in a locked filing cabinet.

Although all project forms were stored in locked cabinets, they were not all stored together, or even sequentially, to ensure that no crash could be associated with the identity of a specific driver. Only crash and control forms with no identifying information were stored together by case number.

The second page of the crash report form, known as the "shred sheet," was completed by the research officer at the crash site and contained identifying information that was used to plan and execute the control, such as the address of the crash and time of day the crash occurred. This information was also used to obtain the official police report (FR300; Figure 5) if one had not been procured at the time of the crash. Upon completion of the control activity, obtaining the FR300, and removal of all identifying information, the shred sheet was temporarily stored in a separate locked file along with the FR300s, until destroyed.

	Responsibility Code				Tie Breaker				Data Entry Completed? (Initials)
Crash Number	Veh#1	Veh#2	Veh#3	Veh#4	Veh#1	Veh#2	Veh#3	Veh#4	

Figure 16. The Crash Responsibility Log (From Police Report FR300)

Consent forms and forms containing identifying information were stored separately from other completed survey forms. Consent forms for the driver's record, blood draw, and consent for the use of blood were stored in a locked file that was organized by month for the duration of the project.

Determining which driver (if multiple drivers) was responsible for the crash was assigned by a pair of research officers who had not participated in the data collection activity. Each officer separately noted the responsibility code for each crash, ensuring independent responses. Responsibility was assessed using only the FR300 form completed by the investigating officer at the scene of the crash. The research assistants blacked out any identifying information before the two research officers evaluated the crashes and any information related to suspected alcohol or drug use. Each officer assigned a separate responsibility code to the crash. Each officer used separate cover sheets, so that neither officer knew the other officer's decision. If the two officers disagreed, a third officer also evaluated responsibility, acting as a "tiebreaker." Results were given to a research assistant for entry into the database. Upon entry, research assistants logged that the crash had been evaluated and the FR300 was stored in a locked filing cabinet.

Database

The database for the ADCRS was created using Microsoft Access and Microsoft Structured Query Language (SQL) Server 2005.

Setting up the Alcohol and Drug Crash Risk Study Database

The database used to store data collected for the ADCRS was created in a Microsoft SQL Server 2005. The database was broken into 84 tables, with each table being made up of records. Each record stored information pertaining to a specific crash and was broken into fields, with each field storing a specific piece of information (e.g., crash number, vehicle ID, injury code).

Eighteen of these tables were used to store the collected data, with each table consisting of fields that matched a specific data collection form (i.e., driver information card, crash site observation form). The remaining tables were populated with the response codes that were listed throughout the forms. The purpose for this was to give the research assistants who were entering data into the database the ability to select the responses from a dropdown menu to ensure consistency and limit the amount of typing required (ultimately reducing data-entry error).

Once the Microsoft SQL database was created, a Microsoft Access database was then created that was linked to the SQL database. Within Access, the data tables were created to match the actual field forms (i.e., items were listed in the same order in the database as in the form). This way, the research assistants could follow through each field on the printed form when entering data into the database. The data for a particular crash were connected between tables by way of a "relationship," which enabled a matching ID in each table to link the data in one table with that of another table. By creating the appropriate relationships between the database tables, the data were saved in separate tables but still linked.

When entering a new record into the database, the research assistants began by entering the crash number, number of vehicles involved, and precinct information into the “crash report” table. Once this information was entered, it created a record that allowed the research assistant to go to additional tabs to enter information in other forms that linked to crash report (e.g., vehicle information, observation form [crash and control], site report [crash and control], and roadway crash). Within the vehicle information section of the database, the research assistants were required to enter information into the vehicle form for each vehicle (multiple-vehicle crashes elicited multiple-vehicle records). This gave the research assistants the basic information for each crash and control driver (e.g., driver number, control number, vehicle number, injury code). For each vehicle record developed, information was added to the other tables, which linked to that specific vehicle (e.g., driver information card, converted refusal, injured driver information, survey, drug questionnaire, driver’s actions, lab – oral fluid, lab – blood, and responsibility).

Microsoft Access was chosen because it facilitated creating queries and reports that enabled us to examine the data more easily. Figure 7 shows the form tabs within the Access database. The top row lists which forms are linked directly to the crash report, which is the main form. Within the bottom row is the vehicle form, which contains components of the vehicle information section. This form also links to the crash report. All of the other forms under the vehicle information section link directly to the vehicle form.

Figure 6 also shows the order in which tabs are linked within the Access database through auto-generated IDs and core IDs. The top row is composed of forms linked directly to the crash report, which is the main data-entry form. All main tabs (or, tabs on the top row) were directly linked to the crash report tab. The vehicle information tab reflects how many vehicles (or drivers) were entered. All tabs on the second row are linked to the vehicle information tab just as

all tabs on the top row are linked to the crash report. The tabs within the form on the screen (e.g., last time used, arrested) were only linked to a particular driver through the vehicle tab under the vehicle information tab.

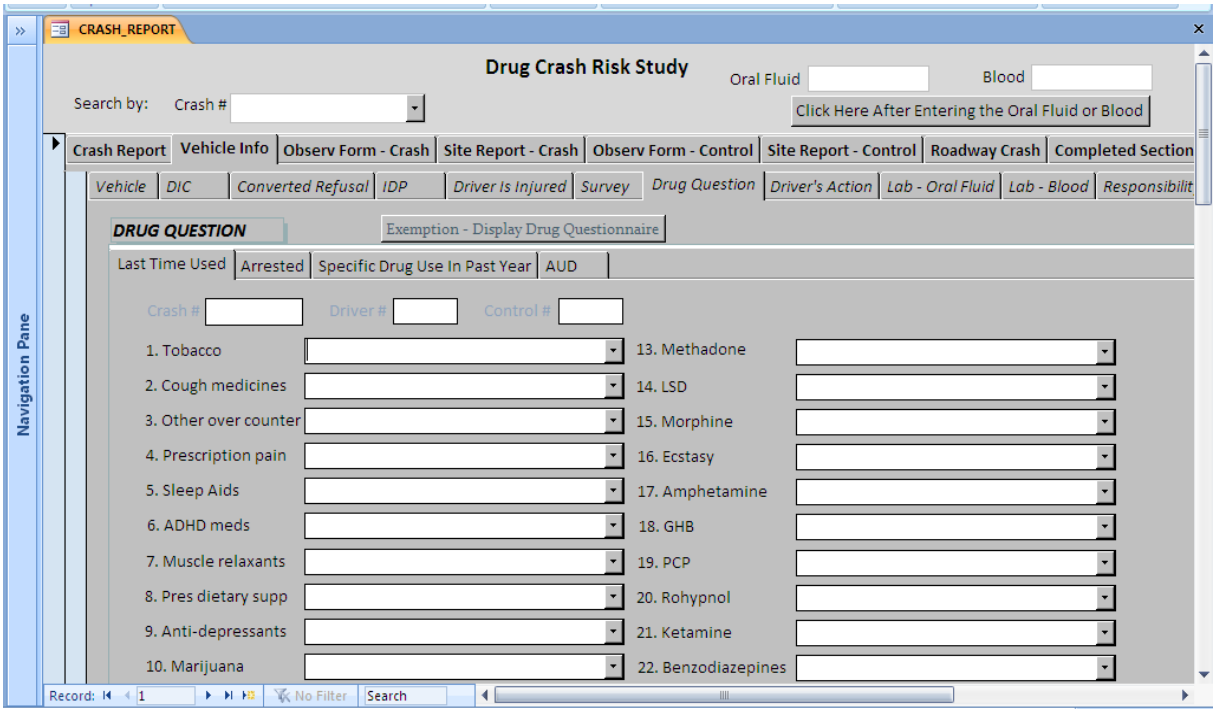


Figure 17. Screenshot of the Access Database

Management

The Access database created for this project was considered a "live" database, meaning that data was nearly always being entered; thus, the database was constantly changing. For this reason, time had to be reserved for an analyst to "freeze" the database for weekly review. Freezing allowed a record of data encompassing a specific timeframe to be analyzed and checked without data outside the given range skewing the results. This was used as a quality-control measure and allowed analysts to catch inconsistencies and mistakes in a timely manner.

To freeze the database, all users exited the database with the exception of a single analyst. Queries that included all variables were saved to export data into Excel files. For this

study, three files were needed to accommodate the large number of variables. The Excel files were saved for merging and conversion into SAS-compatible files.

In addition to saving the data as individual files, a copy of the entire database was localized, meaning that the tables in which the data were saved were no longer linked to the live database and could be manipulated without affecting the live data. To localize the database, a copy of the database was created and saved under a local file name, such as "DrugCrashRisk – week 1 – local – [date].mdb." After opening the database, the analyst created copies of each table (beginning with "dbo_") that included both structure and data. After deleting the original (live) tables, copies of the original tables were renamed to match each of the original tables. The new copy changed from "Copy of [table name]" to simply "[table name]." The local database could then be used to manipulate data in the same manner as in the live database, except that no further data would be added to the local database. The local database contained information pertaining only to the data that had been entered up to the date it was frozen.

Quality Control

Quality Control for Training Sessions

The initial training session held in December of 2009 was conducted over four days and included two days of intense classroom study of policy and procedures, and two days of hands-on mock field training.

Table 42. Training Scenario 1 - One Car Crash, No Injuries

Scene Setup	Driver Roles
• 3 separate crash scenes • 6 cars needed (3 crash cars and 3 mock police cars) • Police cars drive around block and approach crash scene • Car position: Perpendicular	• Driver 1 - Nervous - Complete survey • Driver 2 – Cooperative - Survey until PBT • Driver 3 - Angry - Initial refusal, complete through blood

Trainers used checklists to assess the progress of the trainees during the mock exercises (Figure 7), which included both crash and control scenarios of different forms (Table 8). The focus was on proper enactment of the consent process, the protocol steps of data collection, safety precautions, and time management.

Minutes with Subjects	
Set-up	
Consent	
Survey	
DQ/ AUD	
Blood	
Driver Rec	
Completion	
Break Down	
TOTAL	

Figure 18. Quality Control Timing Log for Training

After the initial group training, data collectors went on training runs with research officers and experienced quality-control staff. One or two data collectors rode with a research officer and responded to crash calls; the quality-control person watched the data collectors while

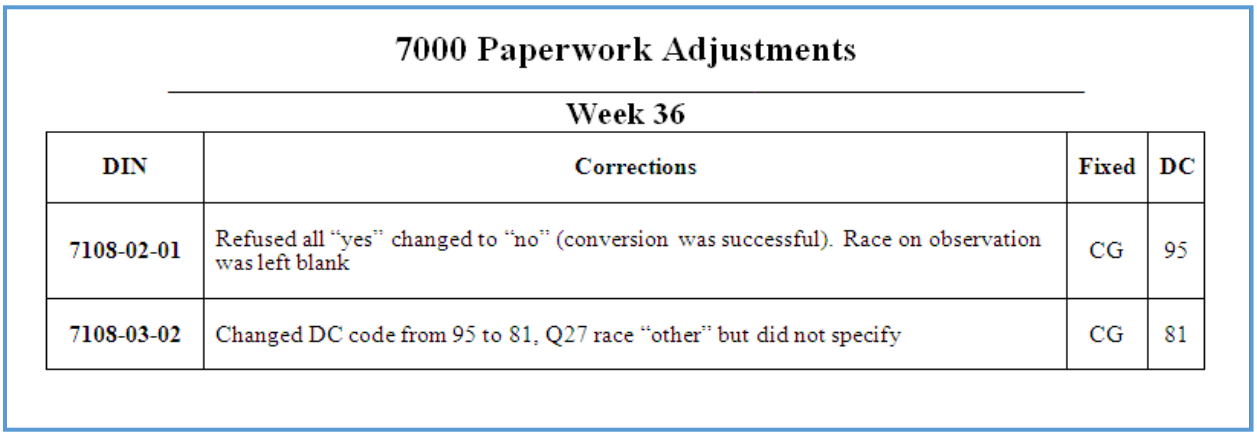
they completed the survey activity and provided immediate feedback upon conclusion of the activity. This practice not only allowed the data collectors and research officers to become more comfortable with the survey process, but also allowed for adjustments in protocol and data forms before the official start date.

Quality Control for Data Collection Activities

The methods and policies in place for data collection were step-by-step procedures that had to be followed in a particular order. The variable nature of this project made it so no two scenarios would be exactly the same; however, the policies and procedures did not change, regardless of circumstances. Quality control for data collection activities was largely focused on professionalism, consent rates, adherence to protocol, and attention to detail. The field managers worked closely with the data collectors and assistant data collectors on overall job performance. The field managers also used report queries from the Access database were used as a tool to evaluate job performance of data collectors and assistant data collectors by evaluating consent rates for each step in the data collection process.

The quality-control queries were run weekly, on the same day as the data freeze that was performed for record keeping and reporting purposes. The quality-control results were reported two weeks after the crash date, to allow time for the controls to be conducted and entered into the database. The data from the queries were then broken into two Excel spreadsheet reports, one of which reflected all of the data collection activities that took place during each week, and the second of which reported data per data collector/assistant data collector and was broken down per quarter to allow review of a particular data collector's/assistant data collector's progress throughout the length of the project. These spreadsheets were stored on PIRE's internal files and were available to management staff.

In addition to using the data entered as a quality-control measure, research assistants kept logs of discrepancies found on paperwork. These clarification logs were kept for the benefit of the data collectors and as a quality-control measure for the research assistants (Figure 8). The forms that data collectors used in the field could be difficult to complete because of the complicated nature of the crash and/or control situations; to remain consistent, data must fit into a particular format. When in the field, a situation may not have fit a standard set of response criteria, so when the data collectors/assistant data collectors submitted paperwork, the research assistants reviewed it for accuracy and for completion. If a particular item was left blank or did not accurately reflect what occurred in the field according to other submitted paperwork, research assistants marked questions or circled missing entries directly on the forms, logged them on paper for the data collectors to review, and also logged them in an electronic log. The data collectors were instructed to follow-up with their research assistants at the end and/or beginning of their shifts. This line of communication was critical, as only the data collector could answer questions about what happened in the field.



7000 Paperwork Adjustments

Week 36

DIN	Corrections	Fixed	DC
7108-02-01	Refused all "yes" changed to "no" (conversion was successful). Race on observation was left blank	CG	95
7108-03-02	Changed DC code from 95 to 81, Q27 race "other" but did not specify	CG	81

Figure 19. Screenshot of the Clarification Log

After data collectors/assistant data collectors and research assistants ensured that the information on the forms was complete and accurate, research assistants entered the cases into the Access database. The research assistant daily tracking log (Figure 9) was used not only as a quality-control measure to ensure that data collectors and assistant data collectors were filling out the survey forms completely, but also as a measure for the analyst to track data-entry discrepancies that resulted from research assistant errors. These measures allowed evaluation of employee performance for data collectors, assistant data collectors, and research assistants.

Crash Number Tracking / Communication Log

Crash #	Driver #	Crash Status									Control Status						
		Paper	Hosp	survey	PBT	orl fld	blood	drvr rcd	Police	Resp	Paper	Survey	PBT	Orl Fld	Blood	Drvr Rcd	Money
8066	1	yes	no	yes	yes	yes	yes	no	yes	yes							65
	01-01										yes	yes	yes	yes	no	no	15
	01-02										yes	yes	yes	yes	yes	no	65
	2	yes	no	no	no	no	no	no	yes	yes							0
	3	yes	no	no	no	no	no	no	yes	yes							0
8067	1	yes	no	yes	yes	yes	no	no	yes	yes							15
	01-01										yes	yes	yes	yes	yes	no	65
	01-02										yes	yes	yes	yes	yes	no	65
	2	yes	no	yes	yes	yes	yes	yes	yes	yes							65
	02-01										yes	yes	yes	yes	yes	yes	60
	02-02										yes	yes	yes	yes	no	no	10
8068	1	yes	no	yes	yes	yes	yes	no	yes	yes							65
	01-01										yes	yes	yes	yes	no	no	15
	01-02										yes	yes	yes	yes	no	yes	10
	2	yes	no	yes	yes	yes	yes	no	yes	yes							60
	02-01										yes	yes	yes	yes	no	no	15

Figure 20. Screenshot of the Research Assistant Daily Tracking Log

Quality Control for Data Entry

Dual Entry Basic Principles

To further monitor research assistants for data-entry consistency, a quality-control database was created. One week's worth of data per month was entered into our quality-control database by research assistants at PIRE headquarters, and then compared to the data that had been entered by the research assistants in the local office using a specific set of data-entry guidelines (Figures 10 and 11).

Basics of Numeric Codes		
2 digit codes	99 / 98	Used when no other answer is available to you.
3 digit codes	999 / 555 / 666	3 digit codes are reserved for BAC readings only.
5 digit codes	55555 / 66666 / 77777 / 88888	Used in place of CoC labels and/or lab results.
Note: there are no 4 digit codes used in the database.		
February Retro Data: Injury codes		
	2=injured and transported to hospital 3=injured no hospital 6=not injured	
This information is for reference only. Enter the injury code provided by the police officers on the "Gray Card".		
Numeric codes	**Meaning**	**Circumstances where the code is used.**
98	Other (can't read, multiple responses, etc.)	You will almost never enter this code. It has been added as an option in the drop-down menu. However, you will enter it for those fields where is applies that do not have a drop-down menu.
99	Blank/ not used	• The DC did not fill something out and cannot accurately fill in the information at a later time. • The DC did not use their PBT or PAS device.
555 / 55555	Sample not obtained, post consent, and not the DC's fault.	BAC result was FTP (failed to provide) when downloaded, nurse missed blood draw in hospital.
666 / 6666 / 66666	Missed Sample. (breath sample failed /skipped or unsuccessful blood draw)	BAC was not in downloaded list, PBT test number was skipped, DC missed blood draw.
77777	"Traces" of drugs in biological samples	If there is a lab result that is measured numerically and there was too small an amount to measure, you would use this.
88888	Indicates a "POS" (positive) biological sample.	There are some drugs that are not measured numerically. They are either POS or NEG results. If the result is POS, you would use this code.

Figure 21. Data Entry Guidelines

Rules to Remember	
Instance	**Instructions**
Crash codes	Numeric/alpha/numeric – no spaces (2D23)
Injury codes from Feb retro data	2= injured and transported to hospital 3= injured no hospital 6= not injured
Language barriers	Consented Officer = Did not answer Refused all = Did not answer
Consented drivers that leave prior to interview	Consented officer = Yes Refused all = Absent Eligible=leave this blank
Drivers excused by investigating officer prior to Research Team arrival	Consented Officer = No If no, why = Absent First Contact=None Refused all= Unavailable Eligible= _____
No blood because RA interviewed	Blood eligible = yes (if yes is true) Consent = did not answer
Arrested drivers BAC	**On the DIC** PBT Test number and device number = 99 – Enter BAC. **On Survey** BAC Consent = yes Test number = 99 – Enter BAC.
Survey Q.9 answered "never had alcohol"	Enter all lower case "never" into the text field in the database.
Responsibility Study	Only enter Responsibility Study data once the tie-breaker has been decided, if necessary. There should not be an instance where 99/98 is entered.
Entering Power Shifts (P/S) on Site Report Form	P/S1 = Enter as "5" P/S2 = Enter as "4" Note: This can be confusing. P/S2 has been part of the study since Feb 10, but P/S 1 was added in July so its sequential number is higher for data entry.

Figure 22. Data Entry Rules to Remember

The dates were chosen by computer-generated random selection (Table 9). Once a month, the research assistants copied the paperwork for the listed week and sent it to headquarters, where it was logged and then assigned to research assistants for the first step in dual data entry.

Table 43. Dual Entry Dates

April - 3rd Week	July - 1st Week	Oct - 3rd Week
May - 2nd Week	Aug - 4th Week	Nov - 4th Week
June - 3rd Week	Sept - 1st Week	Dec - 2nd Week

Prepping Data for Comparison

After the data were entered into the quality-control database, the analyst provided output of data from both the live and quality-control databases. Data were extracted from the quality-control database into three separate Excel files for analysis (six files total). Files were e-mailed to the designated quality-control research assistants for manual review. This detailed review entailed merging the spreadsheets for side-by-side comparison into a new spreadsheet that was used as the workspace for evaluation. Any markings (highlighting, change of font color, etc.) were made only in the merged spreadsheets and not in the initial Excel files sent by the analyst. The newly merged files were saved in a designated location for further review.

Evaluating Dual Data Entry

After merging the files, saving the files as indicated, and reporting differences between the quality control and live input, discrepancies were counted and evaluated by the standards displayed in Table 8. This information was saved in a separate tab in the spreadsheet. Upon completion, the spreadsheet was e-mailed to quality-control staff and the analyst.

Definitions for the required results tab output were as follows:

Total Variables: A total of the number of variables in only live and quality-control files for each table; the total number of variables had to be consistent between the live and quality-control files for a given table.

Total Records: A total of the number of records in only live and quality-control files for each table; the total number of records had to be consistent between the live and quality-control files for a given table.

Major Discrepancies: Included any difference between live and quality-control data; (e.g., missing answers, different answers such as live read “1” and quality-control read “2”).

Differences were highlighted but not changed; responsibility for the inconsistency was determined by referring back to the case paperwork.

Minor Discrepancies: Included invalid responses, such as using text when a numeric response was required, extra digits, misspellings, etc.

Total Discrepancies: A total of all differences and inconsistencies in the live and quality-control files; the total differences should have theoretically added up to the sum of major and minor discrepancies.

The dual data-entry and quality-control comparisons created a means of determining the total potential errors and, ultimately, a data-entry error rate. First, research assistants counted the total number of variables in the live and quality-control databases. To complete an accurate comparison, both databases had to have the same number of variables. Next, research assistants performed a count for total number of cases. Again, this required an equal number of cases in both databases for the comparison to continue. Then, the total number of variables was multiplied by the total number of cases to determine the total number of items being evaluated, which could also be considered the total number of potential errors.

After finding the total number of potential discrepancies, a research assistant at office headquarters manually counted the discrepancies, indicating if the error was made in the live, quality-control, or both databases by comparing it to the paperwork. An error was marked as "both" if there was a discrepancy between the two responses, and upon checking the paperwork, neither entered response was correct. The error rate was then determined by taking the desired discrepancy count (major, minor, or total for either the live only, quality control only, or both) and dividing it by the total number of items (potential errors). The result provided an accuracy

rating for data entry at any level. Table 10 provides a sample of a completed quality-control analysis for a given month.

Table 44. Error Rate Table Example

	Error Rate			
	Live Only	Quality-control Only	Both	Totals
Total variables	476	476		
Total records	245	245		
Total items/potential errors	116,620	116,620		
Major discrepancies		0.36014%		
Responsible for error	0.17235%	0.18264%	0.00514%	0.36014%
Minor discrepancies		0.01286%		
Responsible for error	0.00171%	0.01115%	0.00000%	0.01286%
Total discrepancies		0.37301%		
Responsible for error	0.17407%	0.19379%	0.00514%	0.37301%
Live + both responsible	0.17921%			0.17921%

Appendix P: Prevalence of Individual Drugs Among Crash-Involved and Control Drivers

Table 1. Prevalence of Individual Drugs Among Crash Involved and Control Drivers

	Oral Fluid				Blood			
	Crashes		Controls		Crashes		Controls	
	N	%	N	%	N	%	N	%
Marijuana	234	7.6%	379	6.1%	33	5.6%	79	6.7%
Tetrahydrocannabinol (THC)	234	7.6%	379	6.1%	33	5.6%	79	6.7%
Antidepressants	44	1.4%	82	1.3%	25	4.3%	29	2.5%
Amitriptyline	6	0.2%	7	0.1%	1	0.2%	4	0.3%
Nortriptyline*	5	0.2%	5	0.1%	1	0.2%	1	0.1%
Citalopram	4	0.1%	9	0.1%	2	0.3%	2	0.2%
Doxepin	0	0.0%	2	0.0%	0	0.0%	0	0.0%
Fluoxetine	18	0.6%	29	0.5%	11	1.9%	11	0.9%
Imipramine	0	0.0%	1	0.0%	0	0.0%	0	0.0%
Paroxetine	0	0.0%	1	0.0%	0	0.0%	0	0.0%
Sertraline	9	0.3%	28	0.5%	10	1.7%	12	1.0%
Trazodone	1	0.0%	6	0.1%	1	0.2%	3	0.3%
Venlafaxine	2	0.1%	5	0.1%	1	0.2%	2	0.2%
Narcotic Analgesics	105	3.4%	188	3.0%	11	1.9%	23	2.0%
6-AM (Heroin)	8	0.3%	6	0.1%	1	0.2%	0	0.0%
Buprenorphine	1	0.0%	3	0.0%	0	0.0%	2	0.2%
Codeine (COD)	3	0.1%	8	0.1%	1	0.2%	0	0.0%
Fentanyl	2	0.1%	6	0.1%	0	0.0%	2	0.2%
Hydrocodone	32	1.0%	68	1.1%	3	0.5%	7	0.6%
Hydromorphone (HYM)*	0	0.0%	1	0.0%	0	0.0%	0	0.0%
Meperidine	1	0.0%	1	0.0%	0	0.0%	0	0.0%
Methadone (MTD)	7	0.2%	8	0.1%	0	0.0%	1	0.1%
Morphine (MOR)	11	0.4%	11	0.2%	4	0.7%	2	0.2%
Oxycodone (OXY, OXYC)	29	0.9%	41	0.7%	0	0.0%	5	0.4%
Oxymorphone*	2	0.1%	2	0.0%	1	0.2%	0	0.0%
Propoxyphene	7	0.2%	13	0.2%	1	0.2%	2	0.2%
Tramadol	25	0.8%	54	0.9%	2	0.3%	4	0.3%
Sedatives	90	2.9%	139	2.3%	29	4.9%	45	3.8%
Alprazolam (ALP)	33	1.1%	49	0.8%	5	0.9%	3	0.3%
Bromazepam	1	0.0%	0	0.0%	0	0.0%	0	0.0%
Butalbital	18	0.6%	22	0.4%	1	0.2%	8	0.7%
Clonazepam	10	0.3%	13	0.2%	4	0.7%	4	0.3%
Diazepam	18	0.6%	15	0.2%	7	1.2%	11	0.9%
Lorazepam	7	0.2%	7	0.1%	3	0.5%	2	0.2%
Nordiazepam*	5	0.2%	13	0.2%	3	0.5%	6	0.5%
Oxazepam*	0	0.0%	0	0.0%	1	0.2%	0	0.0%
Temazepam*	4	0.1%	12	0.2%	3	0.5%	3	0.3%
Midazolam	0	0.0%	0	0.0%	1	0.2%	0	0.0%
Phenobarbital	0	0.0%	5	0.1%	0	0.0%	2	0.2%
Zolpidem	5	0.2%	8	0.1%	2	0.3%	8	0.7%
Stimulants	116	3.8%	225	3.6%	30	5.1%	39	3.3%
Amphetamine (AMP)*	77	2.5%	139	2.2%	25	4.3%	31	2.6%
Methamphetamine (METH)	3	0.1%	8	0.1%	0	0.0%	0	0.0%
Cocaine (COC)	21	0.7%	48	0.8%	2	0.3%	2	0.2%
MDMA (Ecstasy)	2	0.1%	0	0.0%	0	0.0%	0	0.0%
Methylphenidate (Ritalin)	4	0.1%	7	0.1%	1	0.2%	0	0.0%
Phentermine	9	0.3%	26	0.4%	2	0.3%	6	0.5%

	Oral Fluid				Blood			
	Crashes		Controls		Crashes		Controls	
	N	%	N	%	N	%	N	%
Other	23	0.7%	30	0.5%	9	1.5%	8	0.7%
Carisoprodol	1	0.0%	4	0.1%	1	0.2%	1	0.1%
Meprobamate*	3	0.1%	3	0.0%	0	0.0%	0	0.0%
Cyclobenzaprine	4	0.1%	2	0.0%	4	0.7%	4	0.3%
Dextromethorphan	16	0.5%	21	0.3%	4	0.7%	3	0.3%
Ketamine	1	0.0%	0	0.0%	0	0.0%	0	0.0%
Drug-Negatives	2,600		5,301		478		986	
Total	3,095		6,190		588		1,176	

*A drug substance that is both a parent drug and a metabolite is counted as the parent drug, unless the substance is present in the sample by itself. 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.

Appendix Q: Demographics and Alcohol Prevalence by Drug Class and Category

Table 45. Gender by Drug Class

	Case					Control				
	Female		Male			Female		Male		
Class	Count	Percent	Count	Percent	Total	Count	Percent	Count	Percent	Total
Oral Fluid										
Marijuana	59	3.9%	130	8.4%	189	97	3.3%	223	6.9%	320
Antidepressants	17	1.1%	4	0.3%	21	32	1.1%	18	0.6%	50
Narcotic	30	2.0%	25	1.6%	55	50	1.7%	74	2.3%	124
Sedatives	26	1.7%	18	1.2%	44	53	1.8%	39	1.2%	92
Stimulants	48	3.1%	32	2.1%	80	101	3.5%	57	1.8%	158
Other	9	0.6%	3	0.2%	12	8	0.3%	4	0.1%	12
More than 1 Class	45	2.9%	47	3.0%	92	67	2.3%	65	2.0%	132
Negative	1298	84.7%	1292	83.3%	2590	2523	86.1%	2751	85.1%	5274
Total	1532	100.0%	1551	100.0%	3083	2931	100.0%	3231	100.0%	6162
Blood										
Marijuana	9	3.1%	18	6.0%	27	27	4.8%	46	7.5%	73
Antidepressants	8	2.8%	5	1.7%	13	14	2.5%	6	1.0%	20
Narcotic	2	0.7%	4	1.3%	6	7	1.2%	5	0.8%	12
Sedatives	11	3.8%	5	1.7%	16	21	3.7%	6	1.0%	27
Stimulants	11	3.8%	8	2.7%	19	16	2.8%	9	1.5%	25
Other	3	1.1%	2	0.7%	5	2	0.4%	1	0.2%	3
More than 1 Class	14	4.9%	10	3.3%	24	18	3.2%	12	2.0%	30
Negative	229	79.8%	247	82.6%	476	458	81.4%	526	86.1%	984
Total	287	100.0%	299	100.0%	586	563	100.0%	611	100.0%	1174

*Because some drivers did not report gender, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 46. Gender by Drug Category

Class	Case					Control				
	Female		Male		Total	Female		Male		Total
	Count	Percent	Count	Percent		Count	Percent	Count	Percent	
Oral Fluid										
Illegal	124	8.1%	197	12.7%	321	216	7.4%	330	10.2%	546
Medications only	110	7.2%	62	4.0%	172	192	6.6%	150	4.6%	342
Negative	1298	84.7%	1292	83.3%	2590	2523	86.1%	2751	85.1%	5274
Total	1532	100.0%	1551	100.0%	3083	2931	100.0%	3231	100.0%	6162
Blood										
Illegal	27	9.4%	32	10.7%	59	47	8.4%	62	10.2%	109
Medications only	31	10.8%	20	6.7%	51	58	10.3%	23	3.8%	81
Negative	229	79.8%	247	82.6%	476	458	81.4%	526	86.1%	984
Total	287	100.0%	299	100.0%	586	563	100.0%	611	100.0%	1174

*Because some drivers did not report gender, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 47. Age by Drug Class

Class	Case						Control					
	Age					Total	Age					Total
	16-20	21-34	35-44	45-64	65+		16-20	21-34	35-44	45-64	65+	
Oral Fluid												
Marijuana	63 11.5%	88 7.7%	20 4.4%	15 2.1%	2 0.9%	188	48 10.1%	187 8.4%	41 3.4%	42 2.2%	2 0.5%	320
Antidepressants	2 0.4%	8 0.7%	1 0.2%	7 1.0%	3 1.4%	21	0 0.0%	13 0.6%	8 0.7%	20 1.1%	9 2.4%	50
Narcotic Analgesics	4 0.7%	13 1.1%	9 2.0%	19 2.6%	10 4.5%	55	2 0.4%	34 1.5%	17 1.4%	62 3.3%	9 2.4%	124
Sedatives	4 0.7%	14 1.2%	5 1.1%	21 2.9%	0 0.0%	44	2 0.4%	26 1.2%	15 1.3%	36 1.9%	13 3.5%	92
Stimulants	13 2.4%	35 3.1%	16 3.6%	14 2.0%	2 0.9%	80	20 4.2%	45 2.0%	46 3.8%	46 2.4%	1 0.3%	158
Other	0 0.0%	5 0.4%	2 0.4%	2 0.3%	2 0.9%	11	0 0.0%	3 0.1%	3 0.3%	5 0.3%	1 0.3%	12
More than 1 Class	16 2.9%	40 3.5%	13 2.9%	17 2.4%	6 2.7%	92	11 2.3%	43 1.9%	30 2.5%	42 2.2%	5 1.4%	131
Negative	446 81.4%	941 82.3%	385 85.4%	624 86.8%	197 88.7%	2593	393 82.6%	1880 84.3%	1040 86.7%	1644 86.7%	329 89.2%	5286
Total	548 100.0%	1144 100.0%	451 100.0%	719 100.0%	222 100.0%	3084	476 100.0%	2231 100.0%	1200 100.0%	1897 100.0%	369 100.0%	6173
Blood												
Marijuana	7 6.9%	15 6.3%	2 2.3%	2 1.6%	0 0.0%	26	11 9.9%	50 10.4%	8 3.6%	3 1.0%	1 2.1%	73
Antidepressants	5 5.0%	3 1.3%	1 1.1%	2 1.6%	2 6.1%	13	0 0.0%	3 0.6%	6 2.7%	8 2.6%	3 6.4%	20
Narcotic Analgesics	1 1.0%	0 0.0%	3 3.4%	0 0.0%	2 6.1%	6	1 0.9%	4 0.8%	2 0.9%	4 1.3%	1 2.1%	12
Sedatives	1 1.0%	4 1.7%	2 2.3%	8 6.6%	0 0.0%	15	2 1.8%	7 1.5%	5 2.2%	13 4.2%	0 0.0%	27
Stimulants	3 3.0%	5 2.1%	4 4.5%	7 5.7%	0 0.0%	19	5 4.5%	8 1.7%	9 4.0%	3 1.0%	0 0.0%	25
Other	1 1.0%	1 0.4%	2 2.3%	1 0.8%	0 0.0%	5	0 0.0%	0 0.0%	1 0.5%	2 0.7%	0 0.0%	3
More than 1 Class	2 2.0%	11 4.6%	3 3.4%	6 4.9%	2 6.1%	24	1 0.9%	10 2.1%	7 3.1%	10 3.2%	2 4.3%	30
Negative	81 80.2%	200 83.7%	72 80.9%	96 78.7%	27 81.8%	476	91 82.0%	399 83.0%	186 83.0%	266 86.1%	40 85.1%	982
Total	101 100.0%	239 100.0%	89 100.0%	122 100.0%	33 100.0%	584	111 100.0%	481 100.0%	224 100.0%	309 100.0%	47 100.0%	1172

*Because some drivers did not report age, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 48. Age by Drug Category

	Case						Control					
	Age						Age					
Class	16-20	21-34	35-44	45-64	65+	Total	16-20	21-34	35-44	45-64	65+	Total
Oral Fluid												
Illegal	91 16.6%	151 13.2%	40 8.9%	34 4.7%	4 1.8%	320	76 16.0%	262 11.7%	103 8.6%	103 5.4%	2 0.5%	546
Medications only	11 2.0%	52 4.6%	26 5.8%	61 8.5%	21 9.5%	171	7 1.5%	89 4.0%	57 4.8%	150 7.9%	38 10.3%	341
Negative	446 81.4%	941 82.3%	385 85.4%	624 86.8%	197 88.7%	2593	393 82.6%	1880 84.3%	1040 86.7%	1644 86.7%	329 89.2%	5286
Total	548 100.0%	1144 100.0%	451 100.0%	719 100.0%	222 100.0%	3084	476 100.0%	2231 100.0%	1200 100.0%	1897 100.0%	369 100.0	6173
Blood												
Illegal	12 11.8%	28 11.7%	10 11.2%	8 6.6%	0 0.0%	58	17 15.3%	60 12.5%	19 8.5%	12 3.9%	1 2.1%	109
Medications only	8 7.9%	11 4.6%	7 7.9%	18 14.8%	6 18.2%	50	3 2.7%	22 4.6%	19 8.5%	31 10.1%	6 12.8%	81
Negative	81 80.2%	200 83.7%	72 80.9%	96 78.7%	27 81.8%	476	91 82.0%	399 83.0%	186 83.0%	266 86.1%	40 85.1%	982
Total	101 100.00	239 100.0%	89 100.0%	122 100.0%	33 100.0%	584	111 100.0%	481 100.0%	224 100.0%	309 100.0%	47 100.0	1172

*Because some drivers did not report age, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 49A. Race/Ethnicity in Oral Fluid by Drug Class

	Race/Ethnicity								
Class	Asian	Black or African American	Hawaiian or other Pacific Islander	Hispanic	Native American or Alaska Native	White	More than one race	Other	Total
Case									
Marijuana	4 3.7%	33 6.4%	5 13.2%	16 8.5%	1 3.6%	117 5.6%	9 11.5%	4 8.9%	189
Antidepressants	1 0.9%	1 0.2%	1 2.6%	0 0.0%	1 3.6%	16 0.8%	1 1.3%	0 0.0%	21
Narcotic Analgesics	1 0.9%	8 1.5%	1 2.6%	2 1.1%	1 3.6%	38 1.8%	0 0.0%	4 8.9%	55
Sedatives	1 0.9%	3 0.6%	0 0.0%	4 2.1%	1 3.6%	35 1.7%	1 1.3%	0 0.0%	45
Stimulants	3 2.8%	5 1.0%	0 0.0%	4 2.1%	3 10.7%	60 2.9%	3 3.9%	2 4.4%	80
Other	0 0.0%	2 0.4%	0 0.0%	1 0.5%	0 0.0%	9 0.4%	0 0.0%	0 0.0%	12
More than 1 Class	0 0.0%	6 1.2%	2 5.3%	5 2.7%	0 0.0%	73 3.5%	4 5.1%	2 4.4%	92
Negative	98 90.7%	460 88.8%	29 76.3%	157 83.1%	21 75.0%	1737 83.3%	60 76.9%	33 73.3%	2595
Total	108 100.0%	518 100.0%	38 100.0%	189 100.0%	28 100.0%	2085 100.0%	78 100.0%	45 100.0	3089
Control									
Marijuana	2 1.4%	90 7.3%	3 5.5%	26 6.7%	3 6.4%	175 4.3%	11 9.6%	8 11.3%	318
Antidepressants	0 0.0%	6 0.5%	0 0.0%	1 0.3%	0 0.0%	40 1.0%	1 0.9%	2 2.8%	50
Narcotic Analgesics	3 2.1%	19 1.5%	1 1.8%	4 1.0%	0 0.0%	95 2.3%	1 0.9%	0 0.0%	123
Sedatives	0 0.0%	7 0.6%	0 0.0%	6 1.6%	1 2.1%	76 1.9%	2 1.7%	0 0.0%	92
Stimulants	2 1.4%	24 1.9%	2 3.6%	6 1.6%	0 0.0%	122 3.0%	0 0.0%	0 0.0%	156
Other	0 0.0%	1 0.1%	0 0.0%	1 0.3%	0 0.0%	10 0.2%	0 0.0%	0 0.0%	12
More than 1 Class	1 0.7%	9 0.7%	0 0.0%	8 2.1%	1 2.1%	103 2.5%	5 4.4%	4 5.6%	131
Negative	134 94.4%	1079 87.4%	49 89.1%	336 86.6%	42 89.4%	3494 84.9%	95 82.6%	57 80.3%	5286
Total	142 100.0%	1235 100.0%	55 100.0%	388 100.0%	47 100.0%	4115 100.0%	115 100.0%	71 100.0	6168

*Because some drivers did not report race/ethnicity, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 5B. Race/Ethnicity in Blood by Drug Class

	Race/Ethnicity								
Class	Asian	Black or African American	Hawaiian or other Pacific Islander	Hispanic	Native American or Alaska Native	White	More than one race	Other	Total
Case									
Marijuana	0 0.0%	5 4.8%	0 0.0%	1 2.6%	0 0.0%	16 4.0%	2 22.2%	1 12.5%	25
Antidepressants	0 0.0%	1 1.0%	0 0.0%	0 0.0%	0 0.0%	10 2.5%	2 22.2%	0 0.0%	13
Narcotic Analgesics	0 0.0%	2 1.9%	0 0.0%	1 2.6%	0 0.0%	3 0.8%	0 0.0%	0 0.0%	6
Sedatives	0 0.0%	1 1.0%	0 0.0%	0 0.0%	1 16.7%	13 3.3%	0 0.0%	0 0.0%	15
Stimulants	0 0.0%	4 3.9%	0 0.0%	3 7.9%	0 0.0%	12 3.0%	0 0.0%	0 0.0%	19
Other	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	5 1.3%	0 0.0%	0 0.0%	5
More than 1 Class	0 0.0%	0 0.0%	1 14.3%	2 5.3%	0 0.0%	20 5.0%	0 0.0%	1 12.5%	24
Negative	13 100.0%	91 87.5%	6 85.7%	31 81.6%	5 83.3%	319 80.2%	5 55.6%	6 75.0%	476
Total	13 100.0%	104 100.0%	7 100.0%	38 100.0%	6 100.0%	398 100.0%	9 100.0%	8 100.0	583
Control									
Marijuana	0 0.0%	25 10.3%	1 11.1%	4 5.2%	1 8.3%	40 5.2%	1 3.6%	0 0.0%	72
Antidepressants	0 0.0%	1 0.4%	0 0.0%	1 1.3%	0 0.0%	18 2.4%	0 0.0%	0 0.0%	20
Narcotic Analgesics	0 0.0%	1 0.4%	0 0.0%	0 0.0%	0 0.0%	11 1.4%	0 0.0%	0 0.0%	12
Sedatives	0 0.0%	4 1.7%	0 0.0%	2 2.6%	1 8.3%	20 2.6%	0 0.0%	0 0.0%	27
Stimulants	0 0.0%	2 0.8%	0 0.0%	2 2.6%	0 0.0%	21 2.8%	0 0.0%	0 0.0%	25
Other	0 0.0%	2 0.8%	0 0.0%	0 0.0%	0 0.0%	1 0.1%	0 0.0%	0 0.0%	3
More than 1 Class	0 0.0%	6 2.5%	0 0.0%	1 1.3%	0 0.0%	21 2.8%	2 7.1%	0 0.0%	30
Negative	22 100.0%	201 83.1%	8 88.9%	67 87.0%	10 83.3%	633 82.8%	25 89.3%	16 100.0	982
Total	22 100.0%	242 100.0%	9 100.0%	77 100.0%	12 100.0%	765 100.0%	28 100.0%	16 100.0	1171

*Because some drivers did not report race/ethnicity, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 6A. Race/Ethnicity in Oral Fluid by Drug Category

	Race/Ethnicity								
Class	Asian	Black or African American	Hawaiian or other Pacific Islander	Hispanic	Native American or Alaska Native	White	More than one race	Other	Total
Case									
Illegal	6 5.6%	40 7.7%	7 18.4%	23 12.2%	3 10.7%	222 10.7%	13 16.7%	7 15.6%	321
Medications only	4 3.7%	18 3.5%	2 5.3%	9 4.8%	4 14.3%	126 6.0%	5 6.4%	5 11.1%	173
Negative	98 90.7%	460 88.8%	29 76.3%	157 83.1%	21 75%	1737 83.3%	60 76.9%	33 73.3%	2595
Total	108 100.0%	518 100.0%	38 100.0%	189 100.0%	28 100.0%	2085 100.0%	78 100.0%	45 100.0	3089
Control									
Illegal	5 3.5%	114 9.2%	5 9.1%	38 9.8%	4 8.5%	350 8.5%	15 13.0%	11 15.5%	542
Medications only	3 2.1%	42 3.4%	1 1.8%	14 3.6%	1 2.1%	271 6.6%	5 4.4%	3 4.2%	340
Negative	134 94.4%	1079 87.4%	49 89.1%	336 86.6%	42 89.4%	3494 84.9%	95 82.6%	57 80.3%	5286
Total	142 100.0%	1235 100.0%	55 100.0%	388 100.0%	47 100.0%	4115 100.0%	115 100.0%	71 100.0	6168

*Because some drivers did not report race/ethnicity, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 6B. Race/Ethnicity in Blood by Drug Category

	Race/Ethnicity								
Class	Asian	Black or African American	Hawaiian or other Pacific Islander	Hispanic	Native American or Alaska Native	White	More than one race	Other	Total
Case									
Illegal	0 0.0%	9 8.7%	0 0.0%	5 13.2%	0 0.0%	39 9.8%	2 22.2%	2 25.0%	57
Medications only	0 0.0%	4 3.9%	1 14.3%	2 5.3%	1 16.7%	40 10.1%	2 22.2%	0 0.0%	50
Negative	13 100.0%	91 87.5%	6 85.7%	31 81.6%	5 83.3%	319 80.2%	5 55.6%	6 75.0%	476
Total	13 100.0%	104 100.0%	7 100.0%	38 100.0%	6 100.0%	398 100.0%	9 100.0%	8 100.0	583
Control									
Illegal	0 0.0%	31 12.8%	1 11.1%	6 7.8%	1 8.3%	67 8.8%	2 7.1%	0 0.0%	108
Medications only	0 0.0%	10 4.1%	0 0.0%	4 5.2%	1 8.3%	65 8.5%	1 3.6%	0 0.0%	81
Negative	22 100.0%	201 83.1%	8 88.9%	67 87.0%	10 83.3%	633 82.8%	25 89.3%	16 100.0	982
Total	22 100.0%	242 100.0%	9 100.0%	77 100.0%	12 100.0%	765 100.0%	28 100.0%	16 100.0	1171

*Because some drivers did not report race/ethnicity, the total counts in these tables do not match exactly the numbers of perfect oral-fluid-based matches and blood-based matches in the report.

Table 7. BAC by Drug Class

	Case					Control				
Class	BAC .08+	BAC between .05 and .08	BAC between zero and .05	BAC zero	Total	BAC .08+	BAC between .05 and .08	BAC between zero and .05	BAC zero	Total
Oral Fluid										
Marijuana	14 15.1%	2 10.0%	10 20.0%	164 5.6%	190	4 18.2%	3 11.1%	12 9.4%	301 5.0%	320
Antidepressants	1 1.1%	0 0.0%	0 0.0%	20 0.7%	21	0 0.0%	0 0.0%	0 0.0%	50 0.8%	50
Narcotic Analgesics	0 0.0%	0 0.0%	1 2.0%	54 1.8%	55	2 9.1%	0 0.0%	5 3.9%	118 2.0%	125
Sedatives	1 1.1%	1 5.0%	0 0.0%	43 1.5%	45	0 0.0%	1 3.7%	4 3.1%	87 1.5%	92
Stimulants	5 5.4%	0 0.0%	1 2.0%	74 2.5%	80	1 4.6%	3 11.1%	4 3.1%	150 2.5%	158
Other	0 0.0%	0 0.0%	0 0.0%	12 0.4%	12	0 0.0%	0 0.0%	0 0.0%	12 0.2%	12
More than 1 Class	4 4.3%	4 20.0%	6 12.0%	78 2.7%	92	0 0.0%	2 7.4%	6 4.7%	124 2.1%	132
Negative	68 73.1%	13 65.0%	32 64.0%	2487 84.8%	2600	15 68.2%	18 66.7%	97 75.8%	5171 86.0%	5301
Total	93 100.0%	20 100.0%	50 100.0%	2932 100.0%	3095	22 100.0%	27 100.0%	128 100.0%	6013 100.0%	6190
Blood										
Marijuana	2 2	0 0	1 1	24 24	27 27	1 50.0%	0 0.0%	1 4.2%	71 6.2%	73
Antidepressants	28.6% 0	0.0% 0	16.7% 0	4.2% 13	13	0 0.0%	0 0.0%	0 0.0%	20 1.7%	20
Narcotic Analgesics	0.0% 0	0.0% 0	0.0% 0	2.3% 6	6	0 0.0%	0 0.0%	1 4.2%	11 1.0%	12
Sedatives	0.0% 2	0.0% 0	0.0% 0	1.1% 14	16	0 0.0%	0 0.0%	0 0.0%	27 2.4%	27
Stimulants	28.6% 0	0.0% 0	0.0% 0	2.4% 19	19	0 0.0%	0 0.0%	0 0.0%	25 2.2%	25
Other	0.0% 0	0.0% 0	0.0% 0	3.3% 5	5	0 0.0%	0 0.0%	0 0.0%	3 0.3%	3
More than 1 Class	0.0% 0	0.0% 0	0.0% 1	0.9% 23	24	0 0.0%	0 0.0%	2 8.3%	28 2.4%	30
Negative	0.0% 3	0.0% 2	16.7% 4	4.0% 469	478	1 50.0%	2 100.0%	20 83.3%	963 83.9%	986
Total	42.9% 7	100.0% 2	66.7% 6	81.9% 573	588	2 100.0%	2 100.0%	24 100.0%	1148 100.0%	1176

Table 8. BAC by Drug Category

	Case					Control				
Class	BAC .08+	BAC between .05 and .08	BAC between zero and .05	BAC zero	Total	BAC .08+	BAC between .05 and .08	BAC between zero and .05	BAC zero	Total
Oral Fluid										
Illegal	22 23.7%	6 30.0%	15 30.0%	279 9.5%	322	5 22.7%	8 29.6%	20 15.6%	513 8.5%	546
Medications only	3 3.2%	1 5.0%	3 6.0%	166 5.7%	173	2 9.1%	1 3.7%	11 8.6%	329 5.5%	343
Negative	68 73.1%	13 65.0%	32 64.0%	2487 84.8%	2600	15 68.2%	18 66.7%	97 75.8%	5171 86.0%	5301
Total	93 100.0%	20 100.0%	50 100.0%	2932 100.0%	3095	22 100.0%	27 100.0%	128 100.0%	6013 100.0%	6190
Blood										
Illegal	2 28.6%	0 0.0%	2 33.3%	55 9.6%	59	1 50.0%	0 0.0%	3 12.5%	105 9.2%	109
Medications only	2 28.6%	0 0.0%	0 0.0%	49 8.6%	51	0 0.0%	0 0.0%	1 4.2%	80 7.0%	81
Negative	3 42.9%	2 100.0%	4 66.7%	469 81.9%	478	1 50.0%	2 100.0%	20 83.3%	963 83.9%	986
Total	7 100.0%	2 100.0%	6 100.0%	573 100.0%	588	2 100.0%	2 100.0%	24 100.0%	1148 100.0%	1176

Appendix R: Odds Ratios by Drug Class or Drug Category

Table 1. Marijuana

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.885	0.808	0.970	0.872	0.795	0.957
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.338	2.013	2.716	2.452	2.106	2.854
35 – 64	0.735	0.663	0.816	0.757	0.681	0.841
65+	1.211	1.002	1.464	1.245	1.028	1.506
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.857	0.758	0.969	0.858	0.758	0.971
Hispanic	0.894	0.739	1.081	0.900	0.743	1.091
Other	1.387	1.175	1.638	1.373	1.161	1.625
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.893	0.627	1.270
BAC ≥ 0.05				6.245	4.170	9.351
Drug (Ref: Negative)	-	-	-	-	-	-
Marijuana	1.046	0.863	1.266	1.003	0.825	1.218
Drugs Other Than Marijuana	1.037	0.872	1.234	1.023	0.859	1.219
Multi-drug User	1.330	0.978	1.808	6.245	4.170	9.351

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

Table 2. Antidepressants

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.883	0.806	0.968	0.870	0.793	0.953
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.337	2.012	2.714	2.449	2.104	2.851
35 – 64	0.736	0.663	0.816	0.758	0.683	0.842
65+	1.217	1.007	1.471	1.253	1.035	1.515
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.856	0.758	0.967	0.856	0.757	0.969
Hispanic	0.892	0.737	1.079	0.898	0.741	1.089
Other	1.388	1.175	1.639	1.373	1.160	1.624
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.889	0.625	1.265
BAC ≥ 0.05				6.229	4.160	9.328
Drug (Ref: Negative)	-	-	-	-	-	-
Antidepressant	0.868	0.570	1.321	0.864	0.564	1.325
Drugs Other Than Antidepressant	1.053	0.915	1.211	1.024	0.889	1.180
Multi-drug User	1.379	1.005	1.894	1.352	0.980	1.866

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

Table 3. Narcotic Analgesic

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.885	0.808	0.970	0.871	0.794	0.955
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.343	2.017	2.721	2.459	2.112	2.862
35 – 64	0.734	0.662	0.814	0.756	0.681	0.839
65+	1.206	0.998	1.458	1.240	1.025	1.500
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.857	0.759	0.969	0.857	0.758	0.970
Hispanic	0.894	0.739	1.082	0.900	0.742	1.091
Other	1.390	1.177	1.641	1.377	1.164	1.628
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.891	0.626	1.268
BAC ≥ 0.05				6.283	4.196	9.408
Drug (Ref: Negative)	-	-	-	-	-	-
Narcotic-Analgesic	1.135	0.852	1.513	1.166	0.873	1.555
Drugs Other Than Narcotic-Analgesic	1.024	0.885	1.185	0.988	0.852	1.145
Multi-drug User	1.283	0.928	1.775	1.236	0.890	1.718

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

Table 4. Sedatives

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.887	0.810	0.972	0.873	0.796	0.957
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.346	2.020	2.725	2.457	2.111	2.860
35 – 64	0.733	0.661	0.812	0.756	0.681	0.839
65+	1.205	0.997	1.456	1.242	1.027	1.502
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.858	0.760	0.970	0.858	0.758	0.971
Hispanic	0.894	0.739	1.081	0.899	0.742	1.090
Other	1.389	1.176	1.640	1.374	1.161	1.625
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.894	0.628	1.271
BAC ≥ 0.05				6.213	4.148	9.306
Drug (Ref: Negative)	-	-	-	-	-	-
Sedative	1.274	0.929	1.746	1.189	0.863	1.639
Drugs Other Than Sedative	1.013	0.877	1.169	0.993	0.858	1.148
Multi-drug User	1.240	0.898	1.713	1.240	0.894	1.721

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

Table 5. Stimulants

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.883	0.806	0.967	0.869	0.793	0.953
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.342	2.016	2.720	2.455	2.109	2.857
35 – 64	0.736	0.664	0.816	0.758	0.683	0.842
65+	1.208	1.000	1.459	1.243	1.028	1.504
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.856	0.757	0.967	0.856	0.756	0.968
Hispanic	0.892	0.737	1.079	0.898	0.741	1.088
Other	1.387	1.175	1.638	1.372	1.160	1.623
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.891	0.626	1.268
BAC ≥ 0.05				6.248	4.172	9.357
Drug (Ref: Negative)	-	-	-	-	-	-
Stimulant	0.940	0.723	1.222	0.915	0.701	1.194
Drugs Other Than Stimulant	1.069	0.921	1.241	1.042	0.896	1.212
Multi-drug User	1.374	1.002	1.883	1.353	0.983	1.864

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

Table 6. Illegal

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.885	0.808	0.970	0.872	0.795	0.956
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.339	2.013	2.717	2.453	2.107	2.856
35 – 64	0.735	0.663	0.815	0.757	0.681	0.840
65+	1.210	1.000	1.463	1.242	1.026	1.504
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.857	0.759	0.969	0.858	0.758	0.970
Hispanic	0.894	0.739	1.082	0.900	0.742	1.091
Other	1.388	1.175	1.638	1.373	1.161	1.625
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.893	0.628	1.270
BAC ≥ 0.05				6.250	4.174	9.359
Drug (Ref: Negative)	-	-	-	-	-	-
Illegal	1.039	0.879	1.228	0.999	0.843	1.184
Drugs Other Than Illegal	1.044	0.850	1.283	1.039	0.844	1.279
Multi-drug User	1.330	0.978	1.809	1.312	0.960	1.792

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

Table 7. Medication

Effect	Model A (Not adjusted for alcohol) OR	95%LCI	95%UCI	Model B (Adjusted for alcohol) OR	95%LCI	95%UCI
Gender (Ref: Female)	-	-	-	-	-	-
Male	0.885	0.808	0.969	0.872	0.795	0.956
Age (Ref: 21-34)	-	-	-	-	-	-
16 – 20	2.337	2.012	2.715	2.452	2.106	2.854
35 – 64	0.736	0.663	0.816	0.757	0.682	0.841
65+	1.212	1.002	1.465	1.245	1.029	1.507
Race/Ethnicity (Ref: White)	-	-	-	-	-	-
Black or African American	0.857	0.758	0.969	0.857	0.758	0.970
Hispanic	0.894	0.739	1.081	0.900	0.742	1.091
Other	1.387	1.175	1.638	1.373	1.161	1.624
BAC (Ref: Zero)				-	-	-
0 < BAC < 0.05				0.892	0.627	1.270
BAC ≥ 0.05				6.245	4.170	9.351
Drug (Ref: Negative)	-	-	-	-	-	-
Medication	1.029	0.835	1.267	1.023	0.829	1.262
Drugs Other Than Medication	1.049	0.887	1.240	1.009	0.851	1.196
Multi-drug User	1.341	0.967	1.861	1.302	0.935	1.813

Note: OR, 95%LCI, and 95%UCI denote Odds Ratio and the lower and upper 95% confidence interval, respectively.

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