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NSTSCE

National Surface Transportation Safety Center for Excellence

Estimating the Prevalence of Synthetic Cannabinoid Use Among Commercial Motor Vehicle Drivers

Developing a Pilot Test to Collect Data on Substance Use

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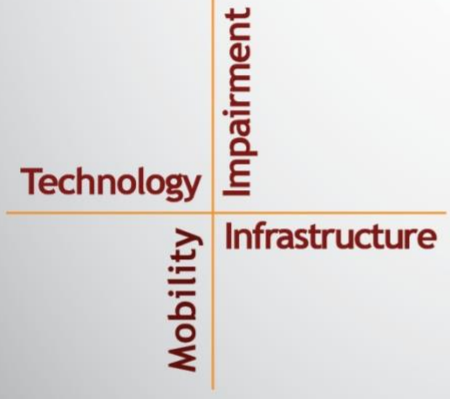

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EXECUTIVE SUMMARY

Synthetic cannabinoids (SCs) have potential for potent adverse effects on users, including effects potentially detrimental to driving performance. However, current Department of Transportation drug testing requirements do not include SCs. The extent to which commercial motor vehicle (CMV) drivers are using SCs and the magnitude of SC-impaired driving remains unclear. Following an investigation, the National Transportation Safety Board (NTSB) further investigation into the prevalence of SCs among CMV drivers. A goal of this study was to investigate the feasibility of collecting drug use information, including drug use information about SCs, from CMV drivers. Specifically, there were two objectives of this study:

1. Develop an effective method for estimating the prevalence of synthetic substances/designer drugs in CMV drivers.
2. Establish preliminary prevalence data on alcohol, synthetics, illicit drugs, prescription medications, and over-the-counter drugs among CMV drivers.

Methods

The study included data collection from an initial focus group followed by anonymous questionnaire and drug test data collection. Eligible participants in both study portions needed to have a valid Class A commercial driver's license (CDL), be currently employed as a CMV driver, and read and speak English comfortably.

Focus Group

The goal of the focus group was to gather information to aid participant recruitment and refine study questionnaires. Drivers in the focus group were compensated for their participation. The focus group included seven CMV drivers and lasted 2 hours. During the semi-structured discussion, participants were asked their thoughts and opinions on various aspects of CMV driver recruitment and to provide feedback on the drug history questionnaire. The summarized results from the focus group were used to identify new CMV driver recruitment strategies and improve the drug history questionnaire. These revised strategies and data collection tools were implemented in the anonymous data collection portion.

Questionnaire and Drug Testing

The second data collection task included the collection of questionnaire and drug test data from a sample of CMV drivers (n = 202). CMV drivers were recruited at multiple public rest areas, gas stations, and several industrial parks in the Southeast region of the United States, all located along several major corridors in the Southeast known for heavy CMV traffic. Participation in the questionnaire and urine drug testing study was anonymous and confidential. Participants were not asked to show identification, state their names, or sign any documents for participation. The drug history questionnaire collected information on the participant's knowledge and history of personal over-the-counter, prescription, and illegal drug use and was linked to the urine sample with an anonymous subject ID number.

The collected urine samples were tested by Redwood Toxicology Laboratory for tampering and presence of alcohol, antidepressants, anticonvulsants, barbiturates, benzodiazepines,

narcotics/opiates, PCP, sedative/hypnotic agents, stimulants (e.g., amphetamine, cocaine, methamphetamine), tetrahydrocannabinol (THC; marijuana), and 37 SC compounds and their metabolites. Urine samples were first screened for these substances at a screening-level cutoff threshold; samples that met the screening-level cutoff threshold then underwent confirmation testing. Screening-level cutoff thresholds are generally less sensitive or equivalent to the confirmation testing cutoff threshold. If a sample met or exceeded the lab's confirmation testing cutoff threshold for a particular substance, the sample was marked as having a positive test result for the substance.

Data Analysis

Questionnaire and drug test result data were summarized using summary statistics, tables, and figures to describe self-reported usage behaviors for all substances, knowledge of driving-related issues for a subset of substances, and frequency of positive tests for specific substances, compounds, and metabolites. Two drivers were removed from these analyses due to irregular survey responses. A power analysis of questionnaire and drug test results for SC use was used to determine the appropriate sample size for future studies exploring SC use and driving safety in CMV drivers.

Results

The drug history questionnaire included data from 206 drivers. The most reported substance was tobacco, with 62 drivers reporting use in the past year (32.80%). The following substances were not reported as used within the past year by any of the participating drivers: benzodiazepines, barbiturates, heroin, ketamine, LSD, PCP, Rohypnol, and SCs. The number of drivers who believed the substance was still in their system during their most recent driving trip included 55 drivers reporting *yes* for tobacco, 21 drivers reporting *yes* for over-the-counter medications, and four drivers believing marijuana was still in their system. Drivers were asked if they believed they were impaired by the substance on their most recent driving trip. Four substances had *yes* responses to this question. Marijuana impairment was self-reported by slightly under 1% of driver respondents (two drivers).

Two thirds of respondents (66.31%) believed using prescription pain medications as prescribed was very likely to affect safe driving ability. More than half of respondents chose *very likely* for morphine/codeine, methadone/buprenorphine, sleep aids, barbiturates, and medical cannabis. Over 76% of respondents believed using prescription pain medication as prescribed was somewhat or very likely to lead to arrest for drug-impaired driving. Methadone/buprenorphine (74.38% somewhat or very likely) was viewed similarly by respondents. Due to a survey software error, medical marijuana/cannabis was not included in the analysis of likelihood of arrest.

Urine samples were tested for 84 substances. The urine test data included 202 drivers. Of these samples, 35 included at least one positive result (17.33%), 165 had no positive results (81.68%), and two tests had been diluted (0.99%). There were 18 substances found within the urine samples. The total number of positive results for all drivers and substances was 46, as drivers may have had multiple substances with a positive result. Alcohol was detected in 3.96% of driver

samples. THC was also found in 3.96% of driver samples. Citalopram, an SSRI, was detected in nearly 3% of driver samples. No driver samples were found to have detectable levels of SCs.

As the drug history questionnaire and urine test results showed no SC use in the driver sample, the power analysis relied on assumptions of detectable use in larger study sample sizes. The sample size estimations provide a starting point in planning for future studies.

Discussion

This study utilized self-report survey data and urine tests to estimate prevalence of substance use and gain understanding of drivers' opinions on substance use while driving, with a study emphasis on understanding use of SCs in this population. Due to the anonymous nature of data collection, the study provided a unique opportunity to understand current substance usage behaviors in drivers (without relying on medical screening data or post-crash drug testing) and build on previous studies in the field by Camden et al. (2014, 2015) and Hickman et al. (2020). The study used voluntary sampling to obtain drug history and urine test data. Although participation was completely voluntary, the final sample was representative of current estimated truck driver population demographics (Zippia, 2022).

High prevalence of tobacco use in the current sample mirrored findings from previous studies of CMV drivers (Kagabo et al., 2020; Sorensen et al., 2009; Thiese at al., 2015). Use of controlled or illegal substances was infrequently observed. A positive marijuana metabolite result in the urine test was detected for eight drivers (3.96% of sample). Three positive results in the urine test showed the presence of opiates oxycodone, hydrocodone, or hydromorphone above the relevant cutoff levels. Almost 4% of driver samples tested positive for alcohol, with concentrations ranging from 0.039 to 0.140g/dL. Two drivers reported using over-the-counter sleep aids and three drivers reported using prescription sleep aids within 4 hours of their most recent drive. It is important to note the following regulations and recommendations regarding substance use while operating a CMV. Federal regulations disqualify CMV drivers from operating a CMV if using marijuana (49 CFR Part 40, at 40.151(e)) and set the CMV driver BAC limit while operating a commercial vehicle to 0.04% (FMCSA, 2019). In addition, FMCSA (2017) requires drivers to have a prescription if taking any "controlled substance or prescription medication." Due to increased risk of crash involvement, the American College of Occupational and Environmental Medicine does not recommend opioid use by those in safety-sensitive careers, such as commercial vehicle operators (Hegmann et al., 2014). The Centers for Disease Control and Prevention (2017) have recommended not taking sleep aids before driving due to the potential for driver drowsiness while operating a vehicle.

In the current study, all participants self-reported no use of SCs and the drug test data revealed zero positive SC results. This may be because detecting SC use through urine tests can be difficult. SC compositions and ingredients evolve frequently, and current tests may not be fully up-to-date in detecting current SC ingredients (Castellanos & Thornton, 2012; Every-Palmer, 2010; Trecki et al., 2015). For some users, this is part of the appeal—users may prefer a substance that is not detected in a traditional urine test. However, the tests developed by Redwood Toxicology used in this study monitor multiple metabolites for each SC to detect changes in SC components and structure. At the time of project proposal and study planning, urine testing was the best available method to accurately test for SCs. While urine testing has

limitations in testing for other substances (e.g., urine tests detect presence of metabolites in the urine, not impairment), subject matter experts consulted during the study agreed that urine testing was the best method to capture use of SCs in the target population.

This study was the first of its kind to specifically pilot test methods to collect SC use data in the CDL population. Results showed the anonymous data collection is possible and rates of positive drug use are higher than previously identified through standard driver drug testing. Although the results from the pilot test are promising, it is important to consider that driver participation was voluntary. Thus, it is possible that the sample was biased towards drivers who did not use any medications, illegal substances, or SCs. Formal data on participation refusal was not recorded; however, informal records suggest that approximately 1 out of 4 drivers agreed to participate. The most common reason for refusal was a lack of time. Most drivers have tight delivery schedules, and many drivers indicated that they did not have 15 minutes to spare. The second most common reason for refusal was a concern of data confidentiality.

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LIST OF ABBREVIATIONS AND SYMBOLS

CDL	commercial driver's license
CMV	commercial motor vehicle
DOT	Department of Transportation
FMCSA	Federal Motor Carrier Safety Administration
NTSB	National Transportation Safety Board
SC	synthetic cannabinoid
THC	tetrahydrocannabinol
VTTI	Virginia Tech Transportation Institute

CHAPTER 1. INTRODUCTION

On September 26, 2014, a truck-tractor semitrailer fatally struck a medium-size passenger bus that was carrying members of a college softball team. Four passengers on the bus were killed and another 13 passengers were injured. Prior to the crash, the driver of the truck-tractor departed the left lane and continued through the median, traveling more than 1,100 feet without evidence of braking or steering (Figure 1, Figure 2, Figure 3). The driver, who had a history of using synthetic cannabinoids (SCs), had a pipe in the cab of the truck-tractor containing 5-fluoro-AMB, a known SC. A post-crash investigation by the National Transportation Safety Board (NTSB, 2015) identified the primary cause of this crash to be SC use that impaired the tractor-trailer driver. Although post-crash drug screenings did detect possible signs of 5-fluoro-AMB, it was not able to confirm either the presence or absence of 5-fluoro-AMB.

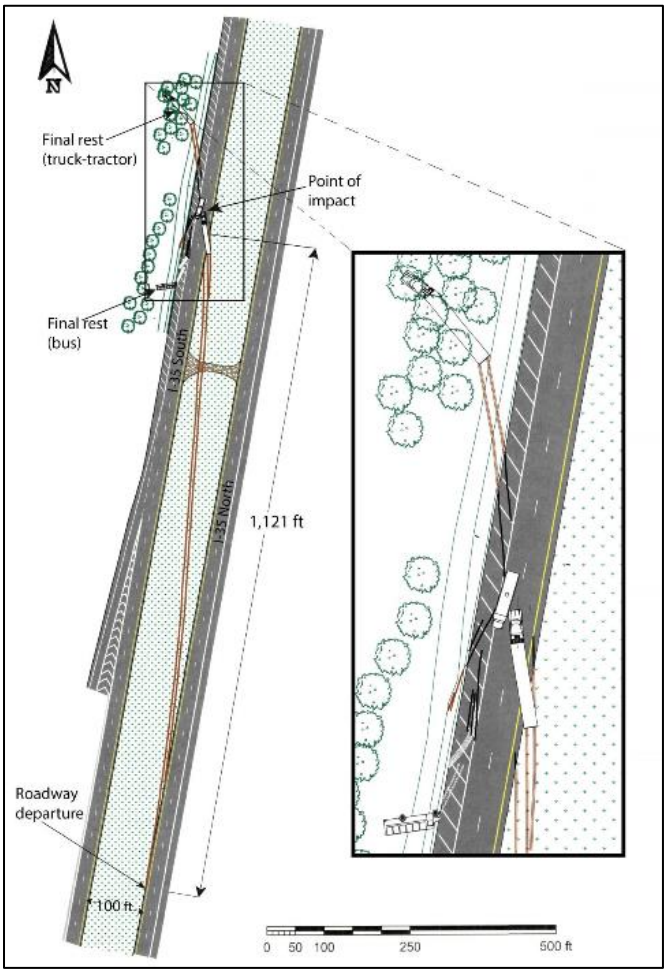

Figure 1. Diagram. Map of the crash (NTSB, 2015).

Figure 2. Photo. The tractor-trailer post crash (NTSB, 2015).

Figure 3. Photos. The passenger bus hit by the tractor-trailer (NTSB, 2015).

SCs were originally developed as pharmacological research tools to investigate new therapeutic methods using the endocannabinoid system. As such, SCs affect the same brain receptors as Δ9-tetrahydrocannabinol (THC), the primary psychoactive ingredient in cannabis. Most SCs are developed in clandestine laboratories as designer illicit drugs that may be overtly marketed as herbal blends, incenses, and air fresheners. Similar to THC, these SCs were designed to interact with CB1 and CB2 cannabinoid receptors. However, while THC is a partial agonist at both receptors, SCs may be full agonists and selective for one receptor type. This increases the potency and potential adverse effects of SCs. The effects would be particularly detrimental to driving performance. Further, adverse effects of SCs have been shown to include psychosis, seizures, anxiety, sedation, drug dependence, auditory and visual hallucinations, paranoid delusions, attention impairment, suicidal ideation, and nonresponsiveness (Seely et al., 2012; Spaderna et al., 2013).

While SCs mimic the effects of THC, most are structurally different from natural cannabinoids and cannot be detected using standard drug testing procedures. New SCs are constantly being developed, which further complicates detection and criminalization of these substances. This is of concern specifically for individuals who are regularly screened for drug use (e.g., commercial motor vehicle [CMV] drivers). For example, Wish et al. (2013) tested 1,064 drug test samples from individuals in the Maryland, District of Columbia (D.C.), and Virginia parole and probation systems. These individuals are regularly tested for illegal drug use. Wish et al. found that 39% of the young men in the D.C. parole and probation system tested negative for traditional drugs but were positive for an SC. Similar estimates, although lower, were found in Virginia and Maryland.

These detection challenges have profound implications for CMV drivers. Title 49 CFR 40.85 specifies that Department of Transportation (DOT) drug tests should examine: (a) marijuana metabolites, (b) cocaine metabolites, (c) amphetamines, (d) opiate metabolites, and (e) PCP. This does not allow for testing of drugs that are not on the list, such as SCs. Indeed, SCs would not be detected using current DOT testing procedures. The extent to which CMV drivers are exploiting SCs for their inability to be detected using DOT tests and the magnitude of SC-impaired driving remains unclear. Further, the NTSB (2015) report highlights how little is known about the full effect of SCs on traffic safety. The report recommended the Federal Motor Carrier Safety Administration (FMCSA) "determine the prevalence of commercial motor vehicle driver use of impairing substances, particularly synthetic cannabinoids, and develop a plan to reduce the use of such substances" (NTSB, 2015, H-15-38). However, the prevalence rate of SC use among CMV drivers, including 5-fluoro-AMB, is unknown. Following their investigation, the NTSB recommended further investigation into the prevalence of SCs among CMV drivers.

OBJECTIVE

The goal of this study was to investigate the feasibility of collecting drug use information, including drug use information about SCs, from CMV drivers. Specifically, there were two objectives of this study:

1. Develop an effective method for estimating the prevalence of synthetic substances in CMV drivers.

2. Establish preliminary prevalence data on alcohol, synthetics, illicit drugs, prescription medications, and over-the-counter drugs among CMV drivers.

Primary consideration was given to the best procedure for testing SCs. Multiple SC families were examined, and the team worked with a leading toxicology lab to ensure newly emerging SCs were included for testing to the extent possible.

CHAPTER 2. METHODS

The study consisted of two separate data collection tasks. The first data collection task consisted of a focus group with CMV drivers. The focus group was designed to gather information to aid participant recruitment for the second data collection task. The second data collection task included the collection of questionnaire and drug test data from a sample of CMV drivers.

FOCUS GROUP

Researchers conducted a 2-hour focus group with seven CMV drivers to assist methodology development for the second data collection task.

Participant Recruitment

The Virginia Tech Transportation Institute (VTTI) recruited participants from an existing database of individuals interested in participating in studies. A researcher called individuals from the database and gave them a brief overview of the study. Interested participants were screened for eligibility by the research team. Participants had to possess a valid Class A commercial driver's license (CDL), be currently employed as a CMV driver, and be comfortable speaking and reading English. If they were eligible, they were offered onsite (at VTTI) or remote participation options.

Data Collection

Due to COVID-19 safety protocols, the focus group was held virtually over Zoom. Participants who came to VTTI were escorted to individual rooms with a laptop to participate safely in the meeting. Via Zoom, a researcher conducted the semi-structured focus group to collect participating drivers' opinions on possible recruitment strategies and on the anonymous questionnaire to be used in the second data collection task. During the focus group, participants were given an overview of the purpose of the study and were then asked about their thoughts and opinions on various recruitment methods for CMV drivers, such as recruitment locations and presentation of this research opportunity to drivers. Participants were also asked to offer any other recruitment ideas that had not been discussed. Participants reviewed the drug history questionnaire that participating CMV drivers would complete. The focus group participants were not asked to fill out the questionnaire but simply to give their feedback on the clarity of the questions and layout of the questionnaire. Video and audio from the focus group was recorded to allow for further review. At the completion of the focus group, each participant was compensated $300.

Data Analysis

Researchers summarized results from the focus group to identify new strategies to successfully recruit CMV drivers for the second data collection task. Suggestions from participants on the drug history questionnaire were used to improve ease of completion and clarity of the document. These recommendations were incorporated into the procedures discussed below.

QUESTIONNAIRE AND DRUG TESTING

Two different procedures were used to recruit CMV drivers for the questionnaire and drug testing portion of the study. The first recruitment method required interested drivers to approach researchers and inquire about the study. Two members of the research team set up a tent, table, chairs, VTTI signage, and posters describing the study at multiple public rest areas and gas stations along several major freight corridors in the Southeast region of the United States. These corridors are traversed by CMV drivers from across the United States. These locations were selected based on the amount of available parking for CMVs, estimated daily flow of CMVs at the location, and space available for researchers to safely set up the information table and talk with interested drivers. Interested participants approached the recruitment table and discussed participation with a member of the research team (see brief recruitment script in CHAPTER 1.1.APPENDIX A). If the driver decided to participate, a researcher obtained verbal consent to ask the screening questions to determine eligibility. Drivers needed to have a valid Class A CDL, be currently employed as a CMV driver, and read and speak English comfortably.

The second recruitment method included the research team providing CMV drivers with all the material and information to participate in the study without requiring any driver to make a decision on the spot. This allowed the potential participant time to review the information, complete their work-related tasks, and make a decision about participating later in the day. Recruitment via this method took place at multiple public rest areas, a gas station, and several industrial parks in the Southeast region of the United States. These locations were along several major corridors in the Southeast known for heavy CMV traffic. A member of the research team offered CMV drivers a packet that included a brief recruitment script (CHAPTER 1.1.APPENDIX A), a participant information sheet (CHAPTER 4.APPENDIX B), a paper version of the drug history survey (CHAPTER 4.4.APPENDIX C), and a urine sample collection kit with instructions on how to collect and return the urine sample to researchers for $50 compensation (0). Drivers were also instructed to speak with a researcher should they have any questions. Researchers maintained a table, chairs, and VTTI recruitment signage.

Participation in the questionnaire and drug testing study was anonymous and confidential. Participants were not asked to show identification, state their names, or sign any documents for participation.

Data Collection

Drivers who elected to participate completed the drug history questionnaire (CHAPTER 4.4.APPENDIX C) via paper survey or tablet. The drug history questionnaire collected information on the participant's knowledge and history of over-the-counter, prescription, and illegal drug use. In addition, participants were given a paper bag with a urine sample collection kit that they could take to the restroom to collect a urine sample and then discretely return to researchers in the paper bag. Survey responses were linked to the urine sample with an anonymous subject ID number. Once the participant returned the bag containing the urine sample, a researcher gave them $50 cash for compensation. Full participation took approximately 15 minutes to complete.

The collected urine samples were packaged adhering to the guidelines for shipping biological specimens through a postal service. Specimens were packed and sent within 7 days of collection to Redwood Toxicology Laboratory for testing. The toxicology lab tested each sample for tampering and presence of alcohol, antidepressants, anticonvulsants, barbiturates, benzodiazepines, narcotics/opiates, PCP, sedative/hypnotic agents, stimulants (e.g., amphetamine, cocaine, methamphetamine), and THC (marijuana; CHAPTER 1.1.APPENDIX A). In addition, each sample was tested for 37 SC compounds and their metabolites (0). Urine samples were first screened for these substances at or above a screening-level cutoff threshold; samples that met the screening-level cutoff threshold then underwent confirmation testing. Screening-level cutoff thresholds are generally less sensitive or equivalent to the confirmation testing cutoff threshold. Redwood Toxicology Laboratory (n.d.) uses "chromatography-mass spectrometry (GC-MS), liquid chromatography-tandem mass spectrometry (LC-MS/MS) and/or gas chromatography-flame ionization detector (GC-FID)" to detect the substances during confirmation testing. If a sample met or exceeded the lab's cutoff threshold for a particular substance, the sample was marked as having a positive test result for the substance. The screening plus follow-up confirmation testing and associated cutoff thresholds are chosen to maximize accuracy and efficiency in detecting true positives while limiting the number of false positives. The confirmation testing cutoff thresholds used in this study are included in APPENDIX E. Negative results did not mean that these drugs were not present in the sample, only that they were not detected in amounts as high or higher than the associated confirmation testing cutoff threshold.

Data Analysis

Data collected in the questionnaire were summarized using summary statistics, tables, and figures. The methods captured proportion of drivers reporting substance use, use frequency and usage behaviors of each substance, and knowledge of driving-related issues for a subset of substances. Drug test data were analyzed in a similar way. The data were summarized to calculate number of tests with any positive result and frequency of positive tests for specific substances, compounds, and metabolites. Analysis options were reduced based on the low frequency of substance use in the data.

The questionnaire and drug test data were used together to identify potential biased responders. From the questionnaire data, the total number of reported used substances by each driver was calculated. Two calculations were performed for each driver: one considered substances reportedly used within the previous 2 days, and another considered substances used within the past year. Based on the response distributions, 95% of drivers reported less than two substances used within the past 48 hours, and 99% of drivers reported less than four substances used within the past 48 hours. The drug test results were further evaluated for the drivers who fell in the upper 5% and 1% of reported substance use. Drug test results revealed inconsistent substance use in the upper 5% of drivers and no identified substance use in the upper 1% of drivers. Based on the conflicting questionnaire response and drug test results, the two drivers in the upper 1% were removed from additional analysis.

Questionnaire and drug test data on SC use in the driver sample were incorporated into a power analysis to determine the appropriate sample size for future studies exploring SC use and driving safety in CMV drivers. Power analyses with sample size estimation are performed to estimate the

minimum sample size needed to detect a significant difference in the study groups if the difference is real. Power analyses require estimates or inputs for several assumptions. These assumptions include (a) the Type I error rate (alpha, usually set at 0.05); (b) the minimum power desired (a value of 0.80 is standard); (c) an estimated baseline value for one study group and an estimated value or range of values for the second study group or effect size; (d) the analysis method; and (e) whether the alternative hypothesis will be one-sided or two-sided.

The power analysis assumed a future study could use two potential methods. One option would assess rates of safety outcomes (crashes, safety-critical events, or violations) for SC users and non-users. The data, counts of safety outcomes measured over a period of time, would be analyzed using a Poisson regression model. For the power analysis, a two-sample Poisson rate approach was selected, assuming a power value of 0.80. Due to privacy concerns, it may be difficult to match safety outcomes to a driver's self-reported or drug-tested SC use. A second option would add questions on past crash or violation involvement to the questionnaire to collect self-reported safety outcome data. To analyze these data, SC users and non-users would be compared for proportion of drivers who had experienced a crash or violation. For the power analysis, a two-sample proportion with power value of 0.80 was selected.

CHAPTER 3. RESULTS

The study collected questionnaire data and urine sample data from 208 participants. Two participants were excluded from analyses due to inconsistencies in their data, so the final analysis data set included 206 participants. Questionnaires with missing values were not wholly excluded from the analysis data set, so counts and frequencies of responses may not add up to 206 in all tables.

Formal data on participation refusal during recruitment was not recorded; however, informal records suggest that approximately 1 out of 4 drivers agreed to participate. The most common reason for refusal was a lack of time. Most drivers have tight delivery schedules, and many drivers indicated that they did not have 15 minutes to spare. The second most common reason for refusal was a concern of data confidentiality and privacy. However, the research team identified factors (e.g., specific locations, time of day, and weather conditions) that were often present when a driver declined participation and revised recruitment strategies to improve driver recruitment.

DRIVER DEMOGRAPHICS

The participant sample consisted of 189 males (92.65%) and 15 females (7.35%), with two non-response values. The distribution of race is presented in Table 1, and Table 2 includes the proportion of participants who are of Hispanic, Latino, or Spanish origin. The participant average age was 45.14 years (n = 205, SD = 12.90, range of 21 to 77 years old) and the average body mass index (BMI), calculated from participant reported height and weight, was 31.45 (n = 205, SD = 6.25, range of 18.13 to 54.52 BMI score).

Table 1. Race of participants, with counts and percentages of total sample.

Participant Race	Frequency	Percent
American Indian or Native American	6	2.93
Asian	10	4.88
Black or African American	39	19.02
More than one	7	3.41
Native Hawaiian or Other Pacific Islander	2	0.98
Other Race (specify)	11	5.37
Unknown	1	0.49
White	129	62.93

Table 2. Hispanic, Latino, and Spanish representation in the participant sample.

Are you of Hispanic, Latino, or Spanish origin?	Frequency	Percent
No	177	87.19
Yes	26	12.81

DRIVER SELF-REPORT SUBSTANCE USE

In the questionnaire, participants were asked about several substances. The substances are listed in Table 3. The current section will present the response distribution to the driver self-report substance use questions.

Table 3. List of substances included in questionnaire.

List of Substances		
ADHD Medication	GHB	Muscle relaxant
Amphetamines	Heroin	Over-the-counter medicines
Antidepressants	Ketamine	Over-the-counter sleep aids
Barbiturates	LSD	PCP
Benzodiazepines	Marijuana	Prescription pain medications
Cocaine	Medicinal marijuana/cannabis	Rohypnol
Cough Medicine	Methadone or buprenorphine	Sleep aids
Dietary/appetite suppressant	Methamphetamine	Synthetic cannabinoids
Ecstasy	Morphine or codeine	Tobacco

The number of drivers reporting use of each substance is included in Table 4. Drivers were asked "when is the last time you used this substance?" and given five response options (included in the table). The most reported substance was tobacco, with 62 drivers reporting use in the past year (32.80%). Over-the-counter medications had been used by 25 drivers within the past 24 hours (12.14%). Cough medicine was used by a third of drivers in the past year (32.98%). The following substances were reported not used within the past year by any of the participating drivers: benzodiazepines, barbiturates, heroin, ketamine, LSD, PCP, Rohypnol, and SCs.

Table 4. Counts of participants reporting substance use by use timeline.

Substance	Number of Responses	Past 24 Hours	Past 2 Days	Past Month	Over a Month	Beyond a Year/Never
ADHD Medication	183	0	0	1	2	180
Amphetamines	159	1	0	0	0	158
Antidepressants	170	8	2	1	0	159
Barbiturates	166	0	0	0	0	166
Benzodiazepines	169	0	1	0	0	168
Cocaine	183	0	1	1	0	181
Cough Medicine	188	4	1	12	45	126
Dietary/appetite suppressant	159	1	0	0	1	157
Ecstasy	188	0	0	1	0	187
GHB	187	0	0	1	0	186
Heroin	184	0	0	0	0	184
Ketamine	184	0	0	0	0	184
LSD	184	0	0	0	0	184

Substance	Number of Responses	Past 24 Hours	Past 2 Days	Past Month	Over a Month	Beyond a Year/Never
Marijuana	187	4	0	3	0	180
Medicinal marijuana/cannabis	169	3	0	2	0	164
Methadone or buprenorphine	182	1	0	0	1	180
Methamphetamine	186	0	0	1	0	185
Morphine or codeine	184	2	1	3	6	172
Muscle relaxant	159	1	0	1	2	155
Over-the-counter medicines	206	25	12	12	22	135
Over-the-counter sleep aids	206	6	4	7	17	172
PCP	185	0	0	0	0	185
Prescription pain medications	180	1	0	3	3	173
Rohypnol	185	0	0	0	0	185
Sleep aids	160	3	0	0	1	156
Synthetic cannabinoids	186	0	0	0	0	186
Tobacco	189	62	4	4	5	114

The substances included in Table 5 and Table 6 were reported at a frequency, or were of particular interest to the study, to be further reviewed for differences in driver demographics. Table 5 lists the substances with average age of users. The table includes a breakdown by substance use timeline, with drivers reporting use within the past month as one group, drivers reporting use in over a month as a second group, and drivers reporting use beyond a year or never as a third group. In Table 6, the proportion and number of male participants is listed by substance and substance use timeline groups.

Table 5. Average age for users of substance by substance use timeline.

Substance	Average Age for Users Within Month (24 hours, 2 days, last month)	Average Age for Users Over 1 Month	Average Age for Users Beyond a Year/Never
Antidepressants	44.64 (*SD* = 8.50)	-	45.39 (*SD* = 12.89)
Cough Medicine	45.88 (*SD* = 12.47)	41.50 (*SD* = 12.51)	45.97 (*SD* = 12.42)
Marijuana	37.86 (*SD* = 14.99)	-	44.98 (*SD* = 12.33)
Medicinal marijuana/cannabis	35.40 (*SD* = 10.53)	-	45.54 (*SD* = 12.64)
Morphine codeine	45.50 (*SD* = 14.24)	40.83 (*SD* = 13.08)	45.54 (*SD* = 12.63)
Over-the-counter medicines	45.46 (*SD* = 12.35)	42.82 (*SD* = 13.12)	45.40 (*SD* = 13.11)
Over-the-counter sleep aids	48.18 (*SD* = 15.06)	39.65 (*SD* = 11.91)	45.38 (*SD* = 12.69)
Prescription Pain Medication	49.75 (*SD* = 9.00)	48.33 (*SD* = 24.85)	45.29 (*SD* = 12.67)
Synthetic Cannabinoids	-	-	45.00 (*SD* = 12.44)
Tobacco	42.88 (*SD* = 12.58)	41.40 (*SD* = 18.65)	46.83 (*SD* = 12.59)

Table 6. Gender of users of substance by substance use timeline, reported as percentage and number of users identifying as male.

Substance	% Male for Users Within Month (24 hours, 2 days, last month)	% Male for Users Over 1 Month	% Male for Users Beyond a Year/Never
Antidepressants	81.82% (9)	-	92.99% (146)
Cough Medicine	100.00% (17)	90.91% (40)	92.00% (115)
Marijuana	100.00% (7)	-	92.13% (164)
Medicinal marijuana/cannabis	100.00% (5)	-	91.98% (149)
Morphine codeine	100.00% (6)	100.00% (6)	92.35% (157)
Over-the-counter medicines	97.87% (46)	81.82% (18)	92.59% (125)
Over-the-counter sleep aids	88.24% (15)	94.12% (16)	92.94% (158)
Prescription Pain Medication	100.00% (4)	100.00% (3)	92.40% (158)
Synthetic Cannabinoids	-	-	92.39% (170)
Tobacco	86.96% (60)	100.00% (4)	95.61% (109)

Drivers were asked if they had used the substance within 4 hours of their most recent trip. The number of drivers reporting *yes* for each substance is included in Table 19Table 7. Over 31% of drivers (59 drivers) reported using tobacco within 4 hours of their last trip. Over-the-counter medications were used within 4 hours of the last trip by 17 drivers (9.04% of respondents). Use of antidepressants within 4 hours of the last trip was reported by eight drivers (3.88% of respondents). The following substances did not have any reports of use within 4 hours of the last trip: ADHD medication, benzodiazepines, cocaine, ecstasy, GHB, heroin, ketamine, LSD, methadone or buprenorphine, methamphetamine, PCP, Rohypnol, and SCs.

Table 7. Counts of participants reporting substance use within 4 hours of their most recent trip.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0	205
Amphetamines	206	2	204
Antidepressants	206	8	198
Barbiturates	206	1	205
Benzodiazepines	206	0	206
Cocaine	206	0	206
Cough Medicine	206	3	205
Dietary/appetite suppressant	206	2	204
Ecstasy	206	0	206
GHB	206	0	206
Heroin	206	0	206

Substance	Number of Responses	Yes	No
Ketamine	206	0	206
LSD	206	0	206
Marijuana	206	1	205
Medicinal marijuana/cannabis	206	1	205
Methadone or buprenorphine	206	0	206
Methamphetamine	206	0	206
Morphine or codeine	206	2	204
Muscle relaxant	206	3	203
Over-the-counter medicines	188	17	171
Over-the-counter sleep aids	188	2	186
PCP	206	0	206
Prescription pain medications	206	1	205
Rohypnol	206	0	206
Sleep aids	206	3	203
Synthetic cannabinoids	206	0	206
Tobacco	189	59	130

The number of drivers who believed the substance was still in their system during their most recent driving trip is included in Table 8. Echoing previous questions, tobacco was reported as *yes* (still present) by 55 drivers. Over-the-counter medications were believed to still be in their system by 21 drivers. Four drivers believed marijuana was still in their system during their most recent driving trip.

Table 8. Counts of participants reporting substance was still present in their system on most recent driving trip.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0	205
Amphetamines	206	1	205
Antidepressants	206	9	197
Barbiturates	206	1	205
Benzodiazepines	206	0	206
Cocaine	205	0	205
Cough Medicine	206	1	205
Dietary/appetite suppressant	205	0	205
Ecstasy	206	0	206
GHB	206	0	206
Heroin	206	0	206
Ketamine	205	0	205
LSD	205	0	205
Marijuana	206	4	202
Medicinal marijuana/cannabis	205	2	203
Methadone or buprenorphine	205	0	205
Methamphetamine	205	0	205

Substance	Number of Responses	Yes	No
Morphine or codeine	206	1	205
Muscle relaxant	206	0	206
Over-the-counter medicines	205	21	184
Over-the-counter sleep aids	205	2	203
PCP	205	0	205
Prescription pain medications	206	1	205
Rohypnol	206	0	206
Sleep aids	206	0	206
Synthetic cannabinoids	205	0	205
Tobacco	189	55	134

Drivers were asked if they believed they were impaired by the substance on their most recent driving trip. For each substance, the number of drivers responding *yes* to this question is included in Table 9. Four substances had *yes* responses to this question. Marijuana impairment was self-reported by slightly under 1% of driver respondents (two drivers).

Table 9. Counts of participants reporting belief they were impaired by this substance on most recent driving trip.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0	205
Amphetamines	206	0	206
Antidepressants	206	0	206
Barbiturates	206	1	205
Benzodiazepines	206	0	206
Cocaine	205	0	205
Cough Medicine	206	0	206
Dietary/appetite suppressant	205	0	205
Ecstasy	206	0	206
GHB	206	0	206
Heroin	206	0	206
Ketamine	205	0	205
LSD	205	0	205
Marijuana	206	2	204
Medicinal marijuana/cannabis	205	0	205
Methadone or buprenorphine	205	0	205
Methamphetamine	205	0	205
Morphine or codeine	205	0	205
Muscle relaxant	206	0	206
Over-the-counter medicines	205	0	205
Over-the-counter sleep aids	205	1	204
PCP	205	0	205
Prescription pain medications	206	0	206
Rohypnol	206	0	206

Substance	Number of Responses	Yes	No
Sleep aids	206	0	206
Synthetic cannabinoids	205	0	205
Tobacco	189	7	182

The prescription substances had follow-up questions for participants. Drivers were asked if a substance was prescribed for their use (Table 10). Results are presented in Table 10Table 22. Prescribed medications included antidepressants (12 drivers; 5.83% of respondents), prescription pain medications (three drivers; 1.46% of respondents), morphine or codeine (two drivers; 0.97% of respondents), ADHD medications (one driver; 0.49% of respondents), and muscle relaxants (one driver; 0.49% of respondents). No participants reported prescriptions for amphetamines, barbiturates, benzodiazepines, dietary/appetite suppressants, medicinal marijuana/cannabis, methadone or buprenorphine, or sleep aids. In a follow-up question, drivers were asked if they take more of the substance than prescribed. All drivers, except one driver, reported they did not take more of the substance than prescribed. One driver reported being unsure if they took more amphetamines than prescribed. However, no drivers reported being prescribed amphetamines in the previous question.

Table 10. Counts of participants reporting prescription for substance.

Substance	Number of Responses	Yes	No
ADHD Medication	205	1	204
Amphetamines	206	0	206
Antidepressants	206	12	194
Barbiturates	206	0	206
Benzodiazepines	206	0	206
Dietary/appetite suppressant	205	0	205
Medicinal marijuana/cannabis	205	0	205
Methadone or buprenorphine	205	0	205
Morphine or codeine	206	2	204
Muscle relaxant	206	1	205
Prescription pain medications	206	3	203
Sleep aids	206	0	206

Drivers were asked if they believe taking the substance as prescribed could affect a person's ability to drive safely (Table 11). Response options included *very unlikely*, *somewhat unlikely*, *somewhat likely*, and *very likely*. Two thirds of respondents (66.31%) believed using prescription pain medications as prescribed was very likely to affect safe driving ability. More than half of respondents chose *very likely* for morphine/codeine, methadone/buprenorphine, sleep aids, barbiturates, and medical marijuana/cannabis. Dietary/appetite suppressants were reported as slightly or very unlikely to affect safe driving ability by 54.55% of respondents.

Table 11. Proportion of participants reporting belief substance used as prescribed could affect a person's ability to drive safely.

Substance	Number of Responses	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
ADHD Medication	178	20.22	19.66	19.66	40.45
Amphetamines	168	17.86	11.90	22.62	47.62
Antidepressants	172	24.42	20.35	22.67	32.56
Barbiturates	168	12.69	10.71	14.29	61.31
Benzodiazepines	166	14.46	12.05	24.70	48.80
Dietary/appetite suppressant	165	33.94	20.61	18.79	26.67
Medicinal marijuana/cannabis	173	12.72	13.87	15.03	58.38
Methadone or buprenorphine	176	13.64	9.66	14.20	62.50
Morphine or codeine	190	20.00	7.89	17.37	54.74
Muscle relaxant	171	25.73	19.88	15.79	38.60
Prescription pain medications	187	13.90	9.09	10.70	66.31
Sleep aids	169	15.98	11.83	18.34	53.85

Drivers were also asked if they believed the person taking the substance as prescribed could be arrested for impaired driving. Response options included *very unlikely*, *somewhat unlikely*, *somewhat likely*, and *very likely*. The results are included in Table 12. Due to a survey software error, medical marijuana/cannabis rating distributions were not included below. Over 76% of respondents believed using prescription pain medication as prescribed was somewhat or very likely to lead to arrest for impaired driving. Methadone/buprenorphine (74.38% somewhat or very likely) was viewed similarly by respondents. Dietary/appetite suppressants were the only substance with fewer than 50% of respondents believing that substance use could lead to arrest for impaired driving.

Table 12. Proportion of participants reporting belief using substance as prescribed could lead to arrest for impaired driving.

Substance	Number of Responses	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
ADHD Medication	155	22.58	21.94	17.42	38.06
Amphetamines	149	19.46	14.09	19.46	46.98
Antidepressants	151	29.80	19.21	19.21	31.79
Barbiturates	145	15.17	14.48	18.62	51.72
Benzodiazepines	144	15.28	16.67	22.22	45.83
Dietary/appetite suppressant	146	38.36	19.86	13.01	28.38
Medicinal marijuana/cannabis	44	-	-	-	-
Methadone or buprenorphine	160	14.38	11.25	16.88	57.50
Morphine or codeine	167	16.77	14.37	17.96	50.90
Muscle relaxant	151	20.53	17.22	19.21	43.05
Prescription pain medications	165	13.33	10.30	13.94	62.42
Sleep aids	149	24.83	14.09	15.44	45.64

The last survey question asked drivers if they had ever taken the substance with alcohol. Responses to the *yes*/*no* question are included in Table 13. Over 8% of drivers reported having taken morphine or codeine with alcohol. The use of medicinal marijuana/cannabis with alcohol was reported by 3.73% of respondents. Similarly, prescription pain medication had been taken with alcohol by 2.72% of respondents.

Table 13. Proportion of participants reporting use of substance with alcohol.

Substance	Number of Responses	Yes	No
ADHD Medication	144	1	143
Amphetamines	125	0	125
Antidepressants	133	4	129
Barbiturates	126	0	126
Benzodiazepines	125	3	122
Dietary/appetite suppressant	123	0	123
Medicinal marijuana/cannabis	132	5	127
Methadone or buprenorphine	145	0	145
Morphine or codeine	137	11	126
Muscle relaxant	125	2	123
Prescription pain medications	147	4	143
Sleep aids	122	0	122

DRUG TEST DATA

Drivers were tested for 84 substances from a provided urine sample. The urine test data included 202 drivers, excluding the two drivers with erroneous questionnaire responses. Of these samples, 35 included at least one positive result (17.33%), 165 had no positive results (81.68%), and two tests had been tampered with (0.99%; shown in Figure 4).

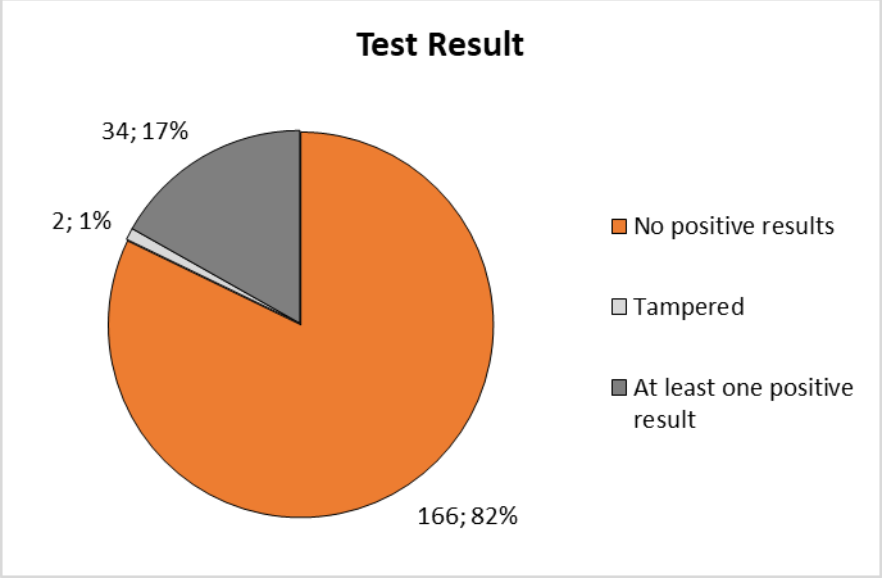

Figure 4. Pie chart. Proportion of participant tests by positive or negative result.

The substances included in Table 14 had a positive test result. The table lists the substance test name with the number of positive results in the participant sample. There were 18 substances with a positive result. The total number of positive results for all drivers and substances was 46, as drivers may have had multiple substances with a positive result. Also included in the table is a breakdown by individual substances of the proportion of all positive results. Alcohol was detected in nearly 4% of driver samples, representing 17.39% of all positive test results. The test results included the concentration of alcohol for tests with a positive alcohol result. Concentrations ranged from 0.039 to 0.140g/dL, with an average concentration of 0.091g/dL (*SD* = 0.033). Marijuana metabolites were found in 3.96% of driver samples, representing 17.02% of all positive test results. Citalopram, the SSRI, was detected in nearly 3% of driver samples and made up approximately 13% of all positive test results. No driver samples were found to have detectable levels of SCs.

Table 14. List of substances with positive test result.

Tested Substance	Number of Positive Results	Proportion of All Positive Results	Proportion of Drivers
Alcohol	8	17.02%	3.96%
Antidep_Bupropion	2	4.26%	0.99%
Antidep_Trazodone	2	4.26%	0.99%
Antidep_Venlafaxine	2	4.26%	0.99%
Barb_Barbiturates	1	2.13%	0.50%
Benzo_Nordiazepam	1	2.13%	0.50%
Benzo_Oxazepam	1	2.13%	0.50%
Benzo_Tempazepam	1	2.13%	0.50%
Coc_Cocaine	2	4.26%	0.99%
MiscNarc_Tramadol	1	2.13%	0.50%
Opiates_Hydrocodone	1	2.13%	0.50%
Opiates_Hydromorphone	1	2.13%	0.50%
Oxy_Oxycodone	1	2.13%	0.50%
SSRI_Citalopram	6	12.77%	2.97%
SSRI_Fluoxetine	2	4.26%	0.99%
SSRI_Sertraline	4	8.51%	1.98%
THC_THC	8	17.02%	3.96%
TCAs_Amitriptyline	3	6.38%	1.49%

Questionnaire data from drivers with a positive test result were further examined to determine if the survey responses matched the test result data. A direct comparison of survey responses and positive test results could not be made for each substance. This was for two reasons: (a) the language used to describe certain substances did not match the drug test details (e.g., the term “antidepressants” appeared in the survey, which could include SSRIs or other substances in the drug test results) and (b) certain substances have multiple uses that may not be reflected in the drivers survey responses (e.g., a driver may using a substance as a prescribed sleep aid when the substance is mainly used to treat other disorders). Table 15 presents the number of all positive drug tests for drivers reporting substance use in the questionnaire. Use reported beyond a year or never was excluded from the table below. For the eight drivers with a positive THC result, three

reported using marijuana and medicinal marijuana in the past 24 hours. The remaining five drivers reported use of beyond a year or never for these substances.

Table 15. Counts of positive drug tests in participants reporting substance use by use timeline.

Substance from Questionnaire	Number of Positive Drug Tests for Drivers Reporting Use in Past 24 Hours	Number of Positive Drug Tests for Drivers Reporting Use in Past 2 Days	Number of Positive Drug Tests for Drivers Reporting Use in Past Month	Number of Positive Drug Tests for Drivers Reporting Use in Over a Month
ADHD Medication	0	0	0	1
Amphetamines	1	0	0	0
Antidepressants	8	2	0	0
Barbiturates	0	0	0	0
Benzodiazepines	0	1	0	0
Cocaine	0	1	0	0
Cough Medicine	0	0	1	12
Dietary/appetite suppressant	1	0	0	0
Ecstasy	0	0	0	0
GHB	0	0	0	0
Heroin	0	0	0	0
Ketamine	0	0	0	0
LSD	0	0	0	0
Marijuana	3	0	0	0
Medicinal marijuana/cannabis	3	0	0	0
Methadone or buprenorphine	0	0	0	0
Methamphetamine	0	0	0	0
Morphine or codeine	1	0	1	1
Muscle relaxant	0	0	1	2
Over-the-counter medicines	7	1	0	3
Over-the-counter sleep aids	1	1	0	5
PCP	0	0	0	0
Prescription pain medications	1	0	1	1
Rohypnol	0	0	0	0
Sleep aids	0	0	0	0
Synthetic cannabinoids	0	0	0	0
Tobacco	19	1	1	1

POWER ANALYSIS FOR FUTURE STUDIES OF SCS

To better understand future study needs, the questionnaire data and test data results were used to perform a power analysis. The goal of the power analysis was to determine the necessary minimum sample size to capture sufficient numbers of SC users for an assessment of safety performance for current users and non-users. The power analyses and sample size estimations were performed for two future analysis approaches. The first approach would focus on differences in crash rates in the user and non-user groups. The formal statistical analysis would likely be a Poisson regression model, which is frequently used to assess rates of safety events in studies of driving safety. The second approach would compare safety event involvement in the user and non-user groups. In this approach, the proportion of drivers who reported previous involvement in a safety event would be calculated for each group. A formal statistical analysis might use a logistic regression model to assess the likelihood of safety event involvement based on user group status.

Assumptions for the first approach power analysis were as follows: the data would follow a two-sample Poisson rate distribution (two-sample indicates an SC user group and non-user group), a minimum power of 0.80, an alpha or Type I error rate of 0.05, an expected difference in user crash rate ranging from 1.5 times to 2.5 times the non-user crash rate, and a one-sided analysis (alternative hypothesis states user group has a significantly higher crash rate compared to non-user group). A plot showing the interaction of group sample size and comparison rates on power is shown in Figure 5.

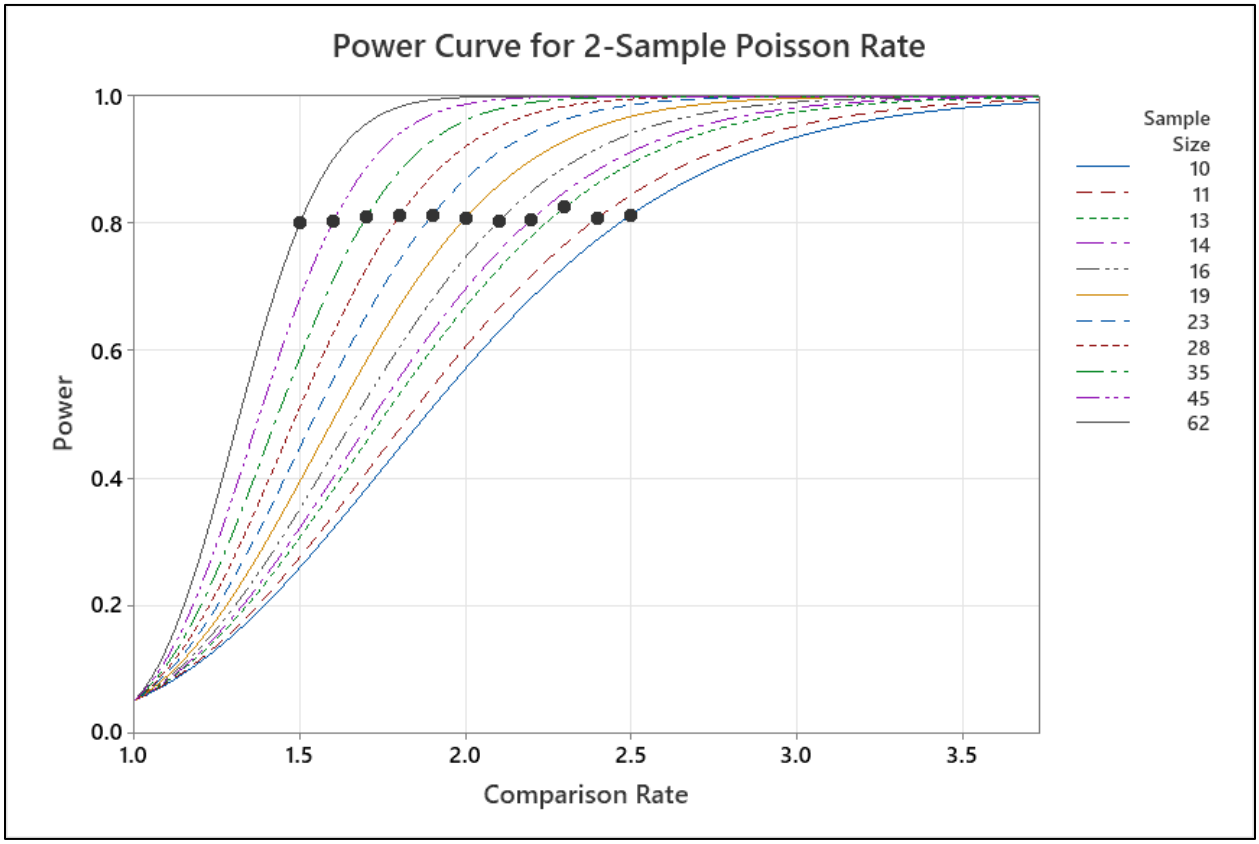

Figure 5. Graph. Power curve for two-sample Poisson rate power analysis.

Based on the questionnaire findings of zero reported users in just over 200 drivers (supported by the test data), SC users are expected to make up less than 0.05% of study participants. For the power analysis, we assumed the actual user rate to be approximately 1 in 500 drivers. Table 16 presents the minimum group sample size requirement to achieve a power of 0.80 and the actual power at the minimum group sample size. To meet the target power, the SC user group will need to equal the minimum group sample size. The table also includes the expected total sample size needed, assuming the study participant SC user to non-user ratio is 1:499 (or 0.002% of study participants). If users have a safety outcome rate twice that of non-users (comparison rate = 2), the total sample size should be at approximately 9,500 drivers.

Table 16. Power analysis results for two-sample Poisson rate power analysis, with minimum user and non-user group sample sizes, over multiple comparison rate values.

Comparison Rate	Minimum Sample Size per Group	Target Power at Minimum Sample Size per Group	Actual Power at Minimum Sample Size per Group	Synthetic Cannabinoid User Group Sample Size	Non-User Group Sample Size	Total Sample Size
1.5	62	0.80	0.80	62	30,938	31,000
1.6	45	0.80	0.80	45	22,455	22,500
1.7	35	0.80	0.81	35	17,465	17,500
1.8	28	0.80	0.81	28	13,972	14,000
1.9	23	0.80	0.81	23	11,477	11,500
2.0	19	0.80	0.81	19	9,481	9,500
2.1	16	0.80	0.80	16	7,984	8,000
2.2	14	0.80	0.81	14	6,986	7,000
2.3	13	0.80	0.83	13	6,487	6,500
2.4	11	0.80	0.81	11	5,489	5,500
2.5	10	0.80	0.81	10	4,990	5,000

The second approach would examine the proportion of drivers reporting involvement in a safety event by user group. Assumptions for this power analysis were as follows: the data would compare proportions from two samples (two-sample indicates an SC user group and non-user group), a minimum power of 0.80, an alpha or Type I error rate of 0.05, an expected proportion of non-user drivers involved in a safety event to be 1%, and a one-sided analysis (alternative hypothesis states user group has a significantly higher proportion of safety event involvement compared to non-user group). The interaction of group sample size and proportion of drivers involved in a safety event on power is shown in Figure 6.

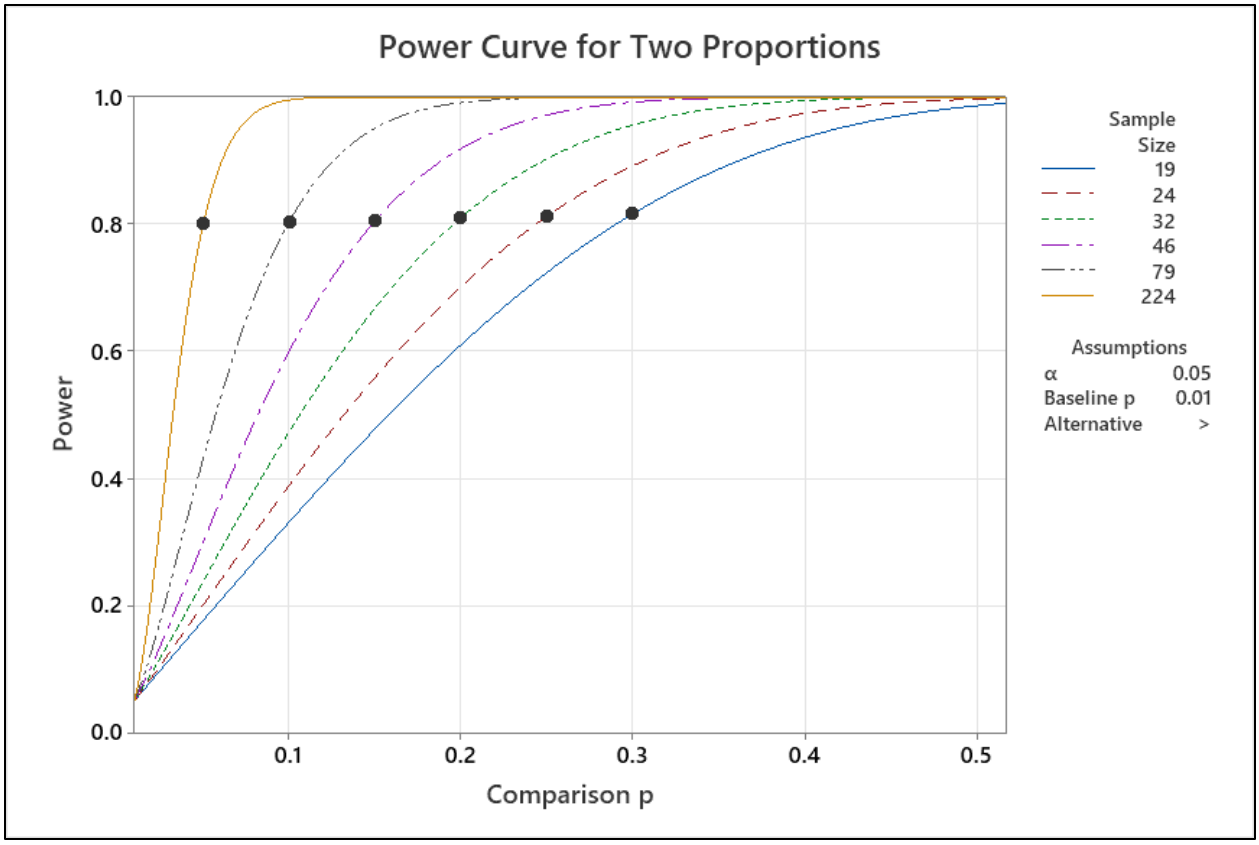

Figure 6. Graph. Power curve for two-sample proportion power analysis.

The power analysis results were used in conjunction with the current study's proportion of users to determine a total sample size for a future study. The study analysis would compare crash involvement in users and non-users. Table 17 lists the minimum sample size per group at different comparison proportions. However, as we expect users to be less than 0.05% of a driver sample, a larger sample of drivers is needed to meet minimum user representation. The table includes sample size calculations for the user group, non-user group, and total sample size. If the non-user group has 1% of drivers involved in a safety event, the user group has a comparison *p* of 0.25 (25% involved in a safety outcome), and the user group makes up 0.005% of the sample, the total sample size needed is 16,000 drivers. This sample would include 24 users and 11,975 non-users.

Table 17. Power analysis results for two-sample proportion power analysis, with minimum user and non-user group sample sizes, over multiple comparison rate values.

Comparison *p*	Minimum Sample Size per Group	Target Power at Minimum Sample Size per Group	Actual Power at Minimum Sample Size per Group	Synthetic Cannabinoid User Group Sample Size	Non-User Group Sample Size	Total Sample Size
0.05	224	0.80	0.80	224	111,776	112,000
0.10	79	0.80	0.80	79	39,421	39,500
0.15	46	0.80	0.80	46	22,954	23,000
0.20	32	0.80	0.81	32	15,968	16,000
0.25	24	0.80	0.81	24	11,976	12,000
0.30	19	0.80	0.82	19	9,481	9,500

As seen in each of the sample size estimation tables (Table 16 and Table 17), the range for total sample size varied widely depending on expectations for safety behavior in the SC user group. However, the sample size estimations should provide a starting point in planning for future studies.

CHAPTER 4. DISCUSSION

The current study used multiple data collection methods to better understand use of substances by commercial drivers, with a study emphasis on understanding use of SCs in this population. The study employed self-report survey data and urine tests to estimate prevalence of substance use and gain understanding of drivers' opinions on substance use while driving. Due to the anonymous nature of data collection, the study provided a unique opportunity to understand current substance usage behaviors in drivers (without relying on medical screening data or post-crash drug testing) and to build on previous studies in the field by Camden et al. (2014, 2015) and Hickman et al. (2020).

IMPACT OF SAMPLING METHOD ON OBTAINING A REPRESENTATIVE SAMPLE

Participants were recruited at over 10 sites, using two recruitment styles: one where the researchers approached drivers and one where drivers needed to approach researchers. Although participation was completely voluntary, the final sample was representative of truck driver population demographics. The current study included 93% males and 7% females, with an average age of 45 years (*SD* = 13). Thiese at al. (2015) included a driver sample of 96% males and 4% females, with an average age of 46 years (*SD* = 10). The U.S. Census Bureau (2021) reported 93% of drivers/sales workers and truck drivers were males and the average age was 46 years old. The current study included a wide representation of BMI values in the driver sample. Slightly less than 25% of drivers were morbidly obese (compared to 26.6% of drivers in Thiese at al., 2015). Participants were recruited from sites in Virginia, but the recruiting researchers noted participants self-reporting being from Virginia and states outside Virginia.

The breakdown of participant race in the current sample mirrors the breakdown for "professional truck drivers" from Zippia (2022). Drivers in the current study included 62.9% white (compared to 64.2% in Zippia data), 19.0% Black or African American (13.7% in Zippia data), 4.9% Asian (3.1% in Zippia data), 2.9% American Indian or Native American (0.9% in Zippia data), and 1.0% Native Hawaiian or Pacific Islander (not listed in Zippia data), with drivers also reporting multiple, other, or unknown race. Zippia reported 16.0% Hispanic or Latino representation, and the current study included 12.8% Hispanic, Latino, or Spanish origin.

SUBSTANCE USE IN SAMPLE

The questionnaire data provided an opportunity for drivers to self-report substance use from the past year. Low use counts in many substances limited statistical analysis options. Seven substances had no reported use within the year (barbiturates, heroin, ketamine, LSD, PCP, Rohypnol, and SCs). Benzodiazepines, methamphetamine, GHB, ecstasy, and amphetamines were each reported used by one driver (with responses ranging between the past day or over the year).

The most frequently reported substance was tobacco, with 39.68% of the sample reporting use within the year. Within the past 24 hours, tobacco (32.80% of sample) and over-the-counter medications (12.14% of sample) were reported by the largest number of drivers. Although 55 drivers reported believing tobacco was in their system during their most recent drive, seven drivers believed they were *impaired* by the substance. Thiese et al. (2015) surveyed nearly 800

drivers and found 49.6% reported tobacco use. Kagabo et al. (2020) interviewed 37 drivers, of whom 68.8% reported smoking cigarettes daily. A study of tobacco use in over-the-road drivers and pick-up/delivery drivers showed usage in 54.9% and 33.9% of drivers by job role, respectively (Sorensen et al., 2009). However, in Hickman et al. (2020), medical examination report data from 13,724 drivers showed 4.84% with confirmed tobacco use and an additional seven drivers with potential tobacco use. The medical examination report data showed much lower rates of tobacco use among CMV drivers compared to the current study, Thiese at al., and Sorensen et al. (2009). When asked about effects of smoking, most drivers did not report negative effects of smoking but did report positive effects, such as smoking cigarettes to reduce their stress and as a method to stay awake while driving (Kagabo et al., 2020).

More than 16% of drivers reported using an over-the-counter sleep aid within the past month. While it is unknown which sleep aids participants in this study used, common over-the-counter sleep aids include melatonin, diphenhydramine, and doxylamine. Three drivers reported using prescription sleep aids within the past 24 hours. Two drivers reported using over-the-counter sleep aids and three drivers reported using prescription sleep aids within 4 hours of their most recent drive. No drivers reported having a prescription for sleep aids. However, FMCSA (2017) requires drivers have a prescription if taking any "controlled substance or prescription medication" (para. 1). Over 60% of drivers felt an arrest for impaired driving could result from using sleep aids as prescribed (reported as feeling somewhat or very likely). The Centers for Disease Control and Prevention (2017) have recommended not taking sleep aids before driving due to the potential for driver drowsiness while operating a vehicle. Hansen et al. (2015) found an increased risk of crashes in new users of sleep aids compared to non-users. In the current study, 72% of drivers believed sleep aids could affect a person's ability to drive safely (somewhat likely or highly likely). Truck drivers can have unpredictable, inconsistent sleep schedules and need to rest in less-than-ideal places, such as brightly lit, busy rest stops (Rojas, 2019). Sleep aids may help drivers get better rest in these situations, but they need to be used safely and according to the medication guidelines on driving and operating heavy machinery.

Four drivers reported believing marijuana was still in their system during their most recent drive, and two drivers reported this same belief for medicinal marijuana or cannabis. Nearly 4% of drivers had a positive marijuana metabolite result in the urine test (eight drivers, 3.96% of sample). According to FMCSA (2020) regulations, CMV drivers are not qualified to operate a CMV if using marijuana, "even if…recommended by a licensed medical practitioner." Studies assessing driving performance and marijuana use have shown mixed safety-related results (Krueger et al., 2011). The impact of legalized cannabis and prescription marijuana on driving performance in the truck driver population needs further assessment.

Twelve drivers reported using morphine or codeine within the past month, and seven drivers reported using prescription pain medicine within the past month. None of the drivers who reported using these medications within the 4 hours before their last trip felt the medications impaired their driving. Three drivers reported having a prescription for morphine or codeine, and two drivers reported a prescription for pain medicine. Three positive results in the urine confirmation test showed the presence of oxycodone, hydrocodone, or hydromorphone at or above the cutoff levels for those specific opiates. Of all survey respondents, 72% of drivers felt morphine or codeine could affect a driver's ability to drive safely (somewhat likely or very likely), and 77% felt this to be true for prescription pain medication. Over 75% of drivers

believed (somewhat likely or highly likely) that using prescription pain medications as prescribed could lead to an arrest for drug-impaired driving. An analysis of Fatality Analysis Reporting System (FARS) data found truck drivers positive for opioid analgesics to be at 2.80 times the risk of being at-fault or having shared fault in a fatal crash (Reguly et al., 2014). A 2013 study of Canadian drivers found increased odds of road trauma for drivers prescribed opioids, with odds ratios ranging from 1.21 to 1.42 depending on opioid dose value (Gomes et al., 2013). Due to increased risk of crash involvement, the American College of Occupational and Environmental Medicine does not recommend opioid use by those in safety-sensitive careers, such as commercial vehicle operators (Hegmann et al., 2014).

Although drivers were not asked about alcohol use in the survey, the urine test did screen for alcohol. Almost 4% of driver samples tested positive for alcohol, with concentrations ranging from 0.039 to 0.140g/dL. FMCSA (2019) has set a national BAC limit while operating a commercial vehicle to 0.04%—drivers at or above this limit are considered driving under the influence. The drivers in the current study who tested positive for alcohol had alcohol concentrations close to or over the FMCSA limit. It is important to note drivers could be on a rest break at the time of participation in the study. In a survey with 11,129 responses, Hickman et al. (2020) found 30.10% of CMV drivers reported consuming one alcoholic drink per week and 0.35% consuming two drinks per week. The remaining 69.55% reported not consuming alcohol. Hickman et al. (2020) also tracked driver risk of crash or violation involvement based on responses to the survey data; results were mixed in terms of increased and decreased risks of involvement in crashes or violations when comparing drivers who consumed alcohol and drivers who did not consume alcohol (analyses stratified by age). Thiese et al. (2015) found self-reported alcohol use in commercial drivers was associated with a significantly increased risk of being involved in a crash in the driver's lifetime.

IMPACT OF SCS IN SAMPLE

In the current study, all participants self-reported no use of SCs, and the drug test data revealed zero positive SC results. A 2011 study of college students found 8% reported SC use (Hu et al., 2011). In a sample of marijuana and tobacco users, 24% of respondents reported SC use in the past month (Gunderson et al., 2014). However, a comparison between these results and CMV drivers is difficult as CMV drivers may be less likely to use SCs compared to college students or the general population. A review of the literature revealed SC use was often described through analysis of self-report survey data or in post-mortem case studies (Labay et al., 2016). This may be because detecting SC use through urine tests can be difficult. SC compositions and ingredients evolve frequently, and current tests may not be fully up to date in detecting current SC ingredients (Castellanos & Thornton, 2012; Every-Palmer, 2010; Trecki et al., 2015). For some users, this is part of the appeal; users may prefer a substance that is not detected in a traditional urine test. A study by Lindigkeit et al. (2009) examined SC composition in Germany before and after a national prohibition on a common SC component. The samples were collected 4 weeks apart, and the after sample showed a new, non-regulated component had already been introduced to SCs. However, the tests developed by Redwood Toxicology used in this study monitor multiple metabolites for each SC to detect changes in SC components and structure.

LIMITATIONS

Although there are limitations to collecting survey data from a voluntary response sample, the use of an anonymous survey in addition to just urine tests gave the best possible chance at estimating SC use in truck drivers. The following limitations were noted.

- Self-report survey data from a voluntary response sample can have limitations. The sample includes only drivers willing to share information on substance use (even with anonymized data and compensation).
- The research team did not have a way to verify the accuracy of many survey questions beyond the urine analysis results.
- As previously mentioned, detecting SC use in urine tests is difficult due to constantly evolving compounds. This leads to the following question: Was the lack of positive SC results in the urine test data accurate (no users in our sample), or was SC use not detected in the tests?
- Due to the confidential nature of the data collection, the results lack contextual information around substance use. For example, drivers reporting alcohol use may not mean they were illegally operating their CMVs while under the influence of alcohol. Drivers could have been on an extended rest break, which some drivers reported in conversation.
- Low counts of reported substance use reduced the number of analysis options. However, as this study was designed as a pilot test, this limitation was to be expected.
- Urine tests only detect the presence of a substance (or its metabolites) in urine; they do not test for actual impairment. Many substances can be detectable in urine for days or weeks after use. Further, urine samples can be diluted/adulterated/substituted, and observing data collection violated participant privacy. While urine tests have these limitations, toxicology subject matter experts consulted during the study believed urine testing was the best method to capture use of SCs in the target population.
- A negative urine test result indicates the substance or its metabolites did not meet the test cutoff threshold. This test outcome can be due to non-use of the substance, or it may mean the tested drugs were not present in the urine at the specified level. It is important to note that substance users can have negative urine test results if the presence of the substance or its metabolites in the urine did not meet the test cutoff threshold.

FUTURE RESEARCH AND CONCLUSIONS

This study was the first of its kind to specifically pilot test methods to collect SC use data in the CDL population. Results showed the anonymous data collection is possible, and rates of positive drug use are higher than previously identified through standard driver drug testing. One possible follow-up study could compare drug test rates in the current study to the FMCSA Drug and Alcohol Clearinghouse, which collects data on all drug and alcohol violations by CDL holders. In addition, the current effort can serve as a pilot test for a larger future study. Potential follow-up study designs included above assumed SC users to be less than 0.05% of a truck driver sample, and a sample of approximately 9,500 to 16,000 drivers is needed to be sufficient for meaningful analysis of both SC users and non-users. Given the effects of substance use on driver well-being and safe driving, it is important to assess prevalence of substance use (illicit and licit)

among the CMV population. Future studies could further examine medication use to investigate its positive and negative effects on crashes. The survey could be expanded by asking drivers the reasons they use each specific substance. Future studies might compare safety event rates or safety event involvement for SC users and non-users. Findings could be used to develop educational and outreach materials to educate CMV drivers on the potential effects of substance use on the ability to drive safely.

APPENDIX A. BRIEF RECRUITMENT SCRIPT

Hi, my name is [insert researchers name], and I am a researcher with the Virginia Tech Transportation Institute. Thank you for agreeing to learn more about the following research opportunity sponsored by the National Surface Transportation Safety Center for Excellence. We are conducting this study to learn more about risk factors, health, and traffic safety among commercial truck drivers. This will include collecting information on drug use, perceptions of risk, and other health-related items. We would like to ask you several questions about your current and past substance use and collect a urine sample. We would like to point out that we will not be asking for any identifying information and nothing you share with us, nor the results of your drug test, will be shared with anyone outside of Virginia Tech Transportation Institute, including the police. All study data will be anonymous and confidential. You are free to not answer any study questions and may withdraw from the study without penalty at any time. If you choose to participate in the study, you will receive a $50 gift card for completing this questionnaire and providing a urine sample. Do you have any questions about participating in the study?

{Answer any questions.}

If you have any additional questions, please do not hesitate to ask.

Before we begin, I need to ask a couple of questions to confirm your eligibility to participate:

1. *Do you have a valid Class A Commercial Driver's License?*
2. *Are you over the age of 18 years?*
3. *Are you currently employed as a commercial truck driver?*
4. *Are you currently working within two hours of your shift?*

{If no to any of these questions, then kindly dismiss from the study. If yes, then proceed with providing participant with the information sheet and obtaining verbal consent}

APPENDIX B. PARTICIPANT INFORMATION SHEET

Title of research study: Understanding Risk Factors and Health among CMV Drivers

Protocol Number 20-217

Principal Investigator: Matthew Camden; ***mcamden@vtti.vt.edu***; 540-231-1503

Key Information: The following is a short summary of this study to help you decide whether or not to be a part of this study. More detailed information is listed later on in this form.

We invite you to take part in this research study because you a current commercial motor vehicle driver.

What should I know about being in a research study?

- Someone will explain this research to you
- Whether or not you take part is up to you
- You can choose not to take part
- You can agree to take part and later change your mind
- Your decision will not be held against you
- You can ask all the questions you want before you decide

What should I know about this research study?

The purpose of this study is to investigate risk factors, health, and traffic safety among CMV drivers. This will include collecting information on drug use, perceptions of risk, and other health-related items. We expect your participation in this research study to last no more than 20 minutes. You will be asked to complete an anonymous survey and provide an anonymous urine sample. No information will be collected to identify you (more detailed information about the study procedures can be found under "***What happens if I say yes, I want to be in this research?***"). All data gathered in this study is completely anonymous and will be treated confidentiality. The risks associated with completing the questionnaire are no greater than those involved in completing any other paperwork (more detailed information about the risks of this study can be found under "***Is there any way being in this study could be bad for me? (Detailed Risks)***"). You will be compensated $50 for your time and effort. There are no benefits to you from your taking part in this research.

Detailed Information: The following is more detailed information about this study in addition to the information listed above.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at:

Matthew Camden, 540-231-1503, mcamden@vtti.vt.edu

This research has been reviewed and approved by the Virginia Tech Institutional Review Board (IRB). You may communicate with them at 540-231-3732 or irb@vt.edu if:

- You have questions about your rights as a research subject
- Your questions, concerns, or complaints are not being answered by the research team
- You cannot reach the research team
- You want to talk to someone besides the research team to provide feedback about this research

How many people will be studied?

We plan to include 225 people in this research study.

What happens if I say yes, I want to be in this research?

If you are willing to participate in the study, you will be asked to complete the following activities:

1. Indicate your willingness to participate by providing verbal consent
2. Answer a short questionnaire about your current and past substance use. The questionnaire will not ask for any information that would personally identify you.
3. After completing the questionnaire, the researcher will give you a sterile plastic container in an opaque Ziploc bag and you will be directed to the on-site restroom to provide a urine sample.
4. Place the container with the sample in the Ziploc bag and return it to the researchers to receive your compensation. No information will be collected to identify you.

What happens if I say yes, but I change my mind later?

You can leave the research study at any time; it will not be held against you. If you decide to leave the research session, you only need to inform one of the investigators. You may request that your data be withdrawn from the analyses.

Is there any way being in this study could be bad for me? (Detailed Risks)

All data gathered in this study is completely anonymous and will be treated confidentiality. Coding (i.e., Participant 1 = #0001) will be used so no identifying information will be collected and no link will exist between your identity, the questionnaire, and the urine sample you provide.

The risks associated with completing the questionnaire are no greater than those involved in completing any other paperwork. You are free not to answer any question without penalty and to withdraw at any time. The risk associated with providing the urine specimen is no greater than those associated with providing a similar specimen at a doctor's office.

What happens to the information collected for the research?

We will make every effort to limit the use and disclosure of your personal information, including research study and medical records, only to people who have a need to review this information.

We cannot promise complete confidentiality. Organizations that may inspect and copy your information include the IRB, Human Research Protection Program, and other authorized representatives of Virginia Tech. If identifiers are removed from your private information or samples that are collected during this research, that information or those samples could be used for future research studies or distributed to another investigator for future research studies without your additional informed consent. Please note that no identifiable information will be collected in this research task.

Drug use data includes your responses to the questionnaire and your drug test results. The urine drug test will provide detailed reports of substances within your system. Some urine tests only provide binary (i.e., yes vs. no) estimates of drug usage. However, our test will show the specific concentrations of a number of drugs. This includes THC, amphetamines, cocaine, opiates, barbiturates, benzodiazepines, methamphetamine, PCP, and a number of other common drugs. The samples will be sent to an independent toxicology laboratory for analysis. Since we are not collecting any identifying data, the laboratory also will not have any information on your identity. Only a non-identifying subject code generated by the research team will be used to link your responses today with the drug test results.

We expect the data from this study to be useful for the next 5 years. Drug test results will be provided to the research team from the testing laboratory. The research team will retain these results for 5 years, along with the remainder of the study data. However, the research laboratory will not store test results past the duration of data collection. Following drug analysis, all urine samples will be destroyed. The data may be used by future VTTI research teams with the approval of an IRB.

You will not have access to your study data. This includes results from analysis of your urine sample. You are free to choose not to answer any questions without penalty

Can I be removed from the research without my OK?

The person in charge of the research study or a member of the research team can remove you from the research study without your approval. A possible reason for removal includes behaving in a manner that is unsafe or makes others feel unsafe.

What else do I need to know?

This research is being funded by the National Surface Transportation Safety Center for Excellence.

If you agree to take part in this research study, you will receive $50 cash for completing the questionnaire and providing a urine sample.

APPENDIX C. DRUG HISTORY QUESTIONNAIRE

General Questionnaire

1. **What is your age (in years)? _____**

2. **Are you a male or female?** ☐ Male ☐ Female

3. **Are you Hispanic or Latino?** ☐ Yes ☐ No

4. **To which racial group would you say you belong?**

☐ White
☐ Black or African American
☐ Asian
☐ American Indian or Native American
☐ Native Hawaiian or Other Pacific Islander
☐ More than one
☐ Unknown
☐ Other Race (specify) _____

5. **What is your current height?** _____(ft) _____(inches)

6. **What is your current weight?** _____(lbs)

B. Drug Use Questionnaire

Drug Use Questionnaire								
Substance	Part A					Part B	Part C	
	Past 24 Hours	Past 2 Days	Past Month	Over a Month	Beyond a year/ Never	Did you take this drug within 4 hours of your most recent trip?	Do you believe this drug was present in your system on your most recent driving trip?	Do you believe you were impaired by this drug on your most recent trip?
1. Cough medicines (like Robitussin, Vicks 44, etc.)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 2	☐ Yes ☐ No	☐ Yes ☐ No
2. Over-the-counter sleep aids (like Unisom, ZzzQuil)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 3	☐ Yes ☐ No	☐ Yes ☐ No
3. Other over-the-counter medicines: Specify below:	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 4	☐ Yes ☐ No	☐ Yes ☐ No
4. Tobacco (like cigarettes, cigars, chewing tobacco)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 5	☐ Yes ☐ No	☐ Yes ☐ No
5. Marijuana (like pot, hash, weed)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 6	☐ Yes ☐ No	☐ Yes ☐ No
6. Cocaine (like crack or coke)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 7	☐ Yes ☐ No	☐ Yes ☐ No
7. Heroin	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 8	☐ Yes ☐ No	☐ Yes ☐ No

8. LSD (acid)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 9	☐ Yes ☐ No	☐ Yes ☐ No
9. Ecstasy (like "E," MDMA, "X")	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 10	☐ Yes ☐ No	☐ Yes ☐ No
10. Methamphetamine (like speed, crank, crystal meth)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 11	☐ Yes ☐ No	☐ Yes ☐ No
11. GHB (like Liquid Ecstasy, Liquid G)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 12	☐ Yes ☐ No	☐ Yes ☐ No
12. PCP (like Angel Dust)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 13	☐ Yes ☐ No	☐ Yes ☐ No
13. Rohypnol (Roofies)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 14	☐ Yes ☐ No	☐ Yes ☐ No
14. Ketamine (Special K)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Go to # 15	☐ Yes ☐ No	☐ Yes ☐ No
15. Synthetic Cannabinoids (like K2 Spice, Haze)	☐ Go to Part B	☐	☐	☐	☐	☐ Yes ☐ No Done	☐ Yes ☐ No	☐ Yes ☐ No

C. Prescription Drug Questionnaire

Prescription Drug Questionnaire												ID Num:	
The following is a list of medications/drugs people may use. Please indicate the last time you used that particular medication/drug. This is for research purposes only. All your responses are **completely anonymous.**						Part A			Part B		Part C		
						A	B	C	D	E	F	G	H
						Did you take this drug within 4 hours of your most recent trip?	Do you believe this drug was present in your system on your most recent driving trip?	Do you believe you were impaired by this drug on your most recent trip?	Was this drug prescribed for your use?	Did you take more of this drug than prescribed?	How likely do you think it is that taking this drug **as prescribed** could affect a person's ability to **drive safely**?	How likely do you think it is that a person taking this drug **as prescribed** could be **arrested** for impaired driving?	Have you ever taken this medication with alcohol?
Drug	Past 24 Hours	Past 2 Days	Past Month	Over a Month	Beyond a year/ Never						1- Very likely 2- Somewhat likely 3- Somewhat unlikely 4- Very unlikely	1- Very likely 2- Somewhat Likely 3- Somewhat unlikely 4- Very unlikely	
1. Morphine or codeine (like Tylenol with codeine)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #2	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
2. Methadone or buprenorphine (like Subutex, Suboxone)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #3	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
3. Other prescription pain medications (like oxycontin/ oxycodone, percocet, opana/ oxymorphone, vicodin/ hydrocodone	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #4	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
4. ADHD medications (like Ritalin, Aderall, Concerta)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #5	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No			☐ Yes ☐ No

										☐ Unsure			
5. Other amphetamines (like Benzedrine, Dexedrine)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #6	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
6. Prescription dietary/ appetite suppressant (like Tenuate, phentermine)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #7	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
7. Sleep aids (like Ambien, Lunesta)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #8	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
8. Muscle relaxants (like Soma, Flexiril)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #9	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
9. Antidepressants (like Prozac, Zoloft, Wellbutrin, Lexapro, Effexot)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #10	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
10. Benzodiazepines (like Xanax/Alprazolam, Valium/Diazepam, Antivan/Lorazepam	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #11	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No
11. Barbiturates (Phenobarbital)	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Go to #12	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No

12. Medicinal marijuana/ cannabis	☐ Go to Part A	☐ Go to Part B	☐	☐ Go to Part C	☐ Done	☐ Yes ☐ No Go to Part B	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No Go to Part C	☐ Yes ☐ No ☐ Unsure			☐ Yes ☐ No

APPENDIX D. URINE COLLECTION SAMPLE INSTRUCTIONS

Inside the paper bag is a sealed plastic cup with a plastic bag and smaller plastic collection tube inside.

1) Open sealed cup.
2) Remove smaller collection tube and plastic bag from larger sealed cup.
3) Use larger cup to collect urine and transfer to smaller collection tube (The tube does not need to be full to the top with urine. Half-full is enough for a urine sample).
4) Close collection tube and throw away larger cup.
5) Place collection tube with urine sample and plastic bag back into paper bag. Be sure not to throw out the plastic bag. We need it back.
6) Return sample to researcher.

APPENDIX E. REDWOOD TOXICOLOGY COMPREHENSIVE DRUG TESTING PANEL WITH COMPREHENSIVE TEST CUTOFF LEVELS

Drug	Drug Classification (if applicable)	Confirmation Test Cutoff Threshold
Alcohol (Ethanol)	-	0.02 g/dL
Amitriptyline	Antidepressants	25 ng/mL
Escitalopram	Antidepressants	150 ng/mL
Sertraline	Antidepressants	150 ng/mL
Bupropion Metabolite	Antidepressants	250 ng/mL
Fluoxetine	Antidepressants	150 ng/mL
Trazodone/Nefazodone and/or Metabolite	Antidepressants	Qualitative
Citalopram	Antidepressants	150 ng/mL
Imipramine	Antidepressants	25 ng/mL
Venlafaxine	Antidepressants	100 ng/mL
Desipramine	Antidepressants	25 ng/mL
Maprotiline	Antidepressants	100 ng/mL
Doxepin	Antidepressants	25 ng/mL
Paroxetine	Antidepressants	150 ng/mL
Carbamazepine	Antidepressants	100 ng/mL
Oxcarbazepine	Anticonvulsants	100 ng/mL
Amobarbital	Anticonvulsants	200 ng/mL
Butalbital	Barbiturates	200 ng/mL
Phenobarbital	Barbiturates	200 ng/mL
Butabarbital	Barbiturates	200 ng/mL
Pentobarbital	Barbiturates	200 ng/mL
Secobarbital	Barbiturates	200 ng/mL
Alprazolam	Benzodiazepines	50 ng/mL
Lorazepam	Benzodiazepines	50 ng/mL
Temazepam	Benzodiazepines	50 ng/mL
Clonazepam	Benzodiazepines	50 ng/mL
Midazolam	Benzodiazepines	50 ng/mL
Triazolam	Benzodiazepines	50 ng/mL
Flunitrazepam	Benzodiazepines	50 ng/mL
Nordiazepam	Benzodiazepines	50 ng/mL
Flurazepam	Benzodiazepines	50 ng/mL
Oxazepam	Benzodiazepines	50 ng/mL
Buprenorphine	Narcotics/Opiates	0.5 ng/mL
Ketamine	Narcotics/Opiates	5 ng/mL
Oxymorphone	Narcotics/Opiates	50 ng/mL
Butorphanol	Narcotics/Opiates	5 ng/mL
Meperidine Metabolite	Narcotics/Opiates	25 ng/mL
Pentazocine	Narcotics/Opiates	250 ng/mL
Codeine	Narcotics/Opiates	100 ng/mL
Methadone	Narcotics/Opiates	100 ng/ml

Drug	Drug Classification (if applicable)	Confirmation Test Cutoff Threshold
Propoxyphene	Narcotics/Opiates	200 ng/mL
Fentanyl	Narcotics/Opiates	5 ng/mL
Morphine	Narcotics/Opiates	100 ng/mL
Tramadol	Narcotics/Opiates	100 ng/mL
Hydrocodone	Narcotics/Opiates	100 ng/mL
Nalbuphine	Narcotics/Opiates	250 ng/mL
Hydromorphone	Narcotics/Opiates	100 ng/mL
Oxycodone	Narcotics/Opiates	50 ng/mL
Phencyclidine (PCP)	-	25 ng/mL
Carisoprodol	Sedative/Hypnotic Agents	200 ng/mL
Meprobamate	Sedative/Hypnotic Agents	200 ng/mL
Zolpidem	Sedative/Hypnotic Agents	10 ng/mL
Amphetamine	Stimulants	250 ng/mL
Methylenedioxyamphetamine (MDA)	Stimulants	250 ng/mL
Methylphenidate	Stimulants	Qualitative
Cocaine	Stimulants	100 ng/mL
Methylenedioxymethamphetamine (MDMA)	Stimulants	250 ng/mL
Methamphetamine	Stimulants	250 ng/mL
Methylenedioxyethylamphetamine (MDEA)	Stimulants	250 ng/mL
THC/THC-COOH (Marijuana)	-	5 ng/mL

APPENDIX F. REDWOOD TOXICOLOGY SCs PANEL

Drug	Drug Classification (if applicable)	Confirmation Test Cutoff Threshold
5-fluoro-AB-PINACA	SC	Qualitative
5-fluoro-ADBICA	SC	Qualitative
5-fluoro-ADB-PINACA	SC	Qualitative
5-fluoro-AKB-48	SC	Qualitative
5-fluoro-AMB1	SC	Qualitative
5-fluoro-PB-22	SC	Qualitative
AB-CHMINACA1	SC	Qualitative
AB-FUBINACA	SC	Qualitative
AB-PINACA	SC	Qualitative
ADBICA	SC	Qualitative
ADB-PINACA	SC	Qualitative
AKB-84	SC	Qualitative
AM-1248	SC	Qualitative
AM-2201	SC	Qualitative
AM-694	SC	Qualitative
BB-22	SC	Qualitative
FDU-PB-221	SC	Qualitative
FUB-1441	SC	Qualitative
FUB-AMB1	SC	Qualitative
FUB-PB-221	SC	Qualitative
JWH-018	SC	Qualitative
JWH-019	SC	Qualitative
JWH-073	SC	Qualitative
JWH-081	SC	Qualitative
JWH-122	SC	Qualitative
JWH-200	SC	Qualitative
JWH-203	SC	Qualitative
JWH-210	SC	Qualitative
JWH-250	SC	Qualitative
JWH-398	SC	Qualitative
MAM-2201	SC	Qualitative
PB-22	SC	Qualitative
RCS-4	SC	Qualitative
RCS-8	SC	Qualitative
THJ-22011	SC	Qualitative
UR-144	SC	Qualitative
XLR-11	SC	Qualitative

APPENDIX G. QUESTIONNAIRE RESULTS WITH DRIVER COUNTS

Table 18. Proportion of participants reporting substance use by use timeline.

Substance	Number of Responses	Past 24 Hours	Past 2 Days	Past Month	Over a Month	Beyond a Year/Never
ADHD Medication	183	0	0	0.55	1.09	98.36
Amphetamines	159	0.63	0	0	0	99.37
Antidepressants	170	4.71	1.18	0.59	0	93.53
Barbiturates	166	0	0	0	0	100.00
Benzodiazepines	169	0	0.59	0	0	99.41
Cocaine	183	0	0.55	0.55	0	98.91
Cough Medicine	188	2.13	0.53	6.38	23.94	67.02
Dietary/appetite suppressant	159	0.63	0	0	0.63	98.74
Ecstasy	188	0	0	0.53	0	99.47
GHB	187	0	0	0.53	0	99.47
Heroin	184	0	0	0	0	100.00
Ketamine	184	0	0	0	0	100.00
LSD	184	0	0	0	0	100.00
Marijuana	187	2.14	0	1.60	0	96.26
Medicinal marijuana/cannabis	169	1.78	0	1.18	0	97.04
Methadone or buprenorphine	182	0.55	0	0	0.55	98.90
Methamphetamine	186	0	0	0.54	0	99.46
Morphine or codeine	184	1.09	0.54	1.63	3.26	93.48
Muscle relaxant	159	0.63	0	0.63	1.26	97.48
Over-the-counter medicines	206	12.14	5.83	5.83	10.68	65.53
Over-the-counter sleep aids	206	2.91	1.94	3.40	8.25	83.50
PCP	185	0	0	0	0	100.00
Prescription pain medications	180	0.56	0	1.67	1.67	96.11
Rohypnol	185	0	0	0	0	100.00
Sleep aids	160	1.88	0	0	0.63	97.50
Synthetic cannabinoids	186	0	0	0	0	100.00
Tobacco	189	32.80	2.12	2.12	2.65	60.32

Table 19. Proportion of participants reporting substance use within 4 hours of their most recent trip.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0	100.00
Amphetamines	206	0.97	99.03
Antidepressants	206	3.88	96.12
Barbiturates	206	0.49	99.51
Benzodiazepines	206	0	100.00
Cocaine	206	0	100.00
Cough Medicine	206	1.46	98.54

Substance	Number of Responses	Yes	No
Dietary/appetite suppressant	206	0.97	99.03
Ecstasy	206	0	100.00
GHB	206	0	100.00
Heroin	206	0	100.00
Ketamine	206	0	100.00
LSD	206	0	100.00
Marijuana	206	0.49	99.51
Medicinal marijuana/cannabis	206	0.49	99.51
Methadone or buprenorphine	206	0	100.00
Methamphetamine	206	0	100.00
Morphine or codeine	206	0.97	99.03
Muscle relaxant	206	1.46	98.54
Over-the-counter medicines	188	9.04	90.96
Over-the-counter sleep aids	188	1.06	98.94
PCP	206	0	100.00
Prescription pain medications	206	0.49	99.51
Rohypnol	206	0	100.00
Sleep aids	206	1.46	98.54
Synthetic cannabinoids	206	0	100.00
Tobacco	189	31.22	68.78

Table 20. Proportion of participants reporting belief substance was present in their system on most recent driving trip.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0	100.00
Amphetamines	206	0.49	99.51
Antidepressants	206	4.37	95.63
Barbiturates	206	0.49	99.51
Benzodiazepines	206	0	100.00
Cocaine	205	0	100.00
Cough Medicine	206	0.49	99.51
Dietary/appetite suppressant	205	0	100.00
Ecstasy	206	0	100.00
GHB	206	0	100.00
Heroin	206	0	100.00
Ketamine	205	0	100.00
LSD	205	0	100.00
Marijuana	206	1.94	98.06
Medicinal marijuana/cannabis	206	0.98	99.02
Methadone or buprenorphine	205	0	100.00
Methamphetamine	205	0	100.00
Morphine or codeine	206	0.49	99.51
Muscle relaxant	206	0	100.00
Over-the-counter medicines	205	10.24	89.76
Over-the-counter sleep aids	205	0.98	99.02

Substance	Number of Responses	Yes	No
PCP	206	0	100.00
Prescription pain medications	206	0.49	99.51
Rohypnol	206	0	100.00
Sleep aids	206	0	100.00
Synthetic cannabinoids	205	0	100.00
Tobacco	189	29.10	70.90

Table 21. Proportion of participants reporting belief they were impaired by this substance on most recent driving trip.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0	100.00
Amphetamines	206	0	100.00
Antidepressants	206	0	100.00
Barbiturates	206	0.49	99.51
Benzodiazepines	206	0	100.00
Cocaine	205	0	100.00
Cough Medicine	206	0	100.00
Dietary/appetite suppressant	205	0	100.00
Ecstasy	206	0	100.00
GHB	206	0	100.00
Heroin	206	0	100.00
Ketamine	205	0	100.00
LSD	205	0	100.00
Marijuana	206	0.97	99.03
Medicinal marijuana/cannabis	205	0	100.00
Methadone or buprenorphine	205	0	100.00
Methamphetamine	205	0	100.00
Morphine or codeine	206	0	100.00
Muscle relaxant	206	0	100.00
Over-the-counter medicines	205	0	100.00
Over-the-counter sleep aids	205	0.49	99.51
PCP	205	0	100.00
Prescription pain medications	206	0	100.00
Rohypnol	206	0	100.00
Sleep aids	206	0	100.00
Synthetic cannabinoids	205	0	100.00
Tobacco	189	3.70	96.30

Table 22. Proportion of participants reporting prescription for substance.

Substance	Number of Responses	Yes	No
ADHD Medication	205	0.49	99.51
Amphetamines	206	0	100.00
Antidepressants	206	5.83	94.17
Barbiturates	206	0	100.00
Benzodiazepines	206	0	100.00
Dietary/appetite suppressant	205	0	100.00
Medicinal marijuana/cannabis	205	0	100.00

Substance	Number of Responses	Yes	No
Methadone or buprenorphine	205	0	100.00
Morphine or codeine	206	0.97	99.03
Muscle relaxant	206	0.49	99.51
Prescription pain medications	206	1.46	98.54
Sleep aids	206	0	100.00

Table 23. Counts of participants reporting taking more of the substance than prescribed.

Substance	Number of Responses	Yes	No	Unsure
ADHD Medication	205	0	205	0
Amphetamines	206	0	205	1
Antidepressants	206	0	206	0
Barbiturates	206	0	206	0
Benzodiazepines	206	0	206	0
Dietary/appetite suppressant	205	0	205	0
Medicinal marijuana/cannabis	205	0	205	0
Methadone or buprenorphine	205	0	205	0
Morphine or codeine	206	0	206	0
Muscle relaxant	206	0	206	0
Prescription pain medications	206	0	206	0
Sleep aids	206	0	206	0

Table 24. Counts of participants reporting belief substance used as prescribed could affect a person's ability to drive safely.

Substance	Number of Responses	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
ADHD Medication	178	36	35	35	72
Amphetamines	168	30	20	38	80
Antidepressants	172	42	35	39	56
Barbiturates	168	23	18	24	103
Benzodiazepines	166	24	20	41	81
Dietary/appetite suppressant	165	56	34	31	44
Medicinal marijuana/cannabis	173	22	24	26	101
Methadone or buprenorphine	176	24	17	25	110
Morphine or codeine	190	38	15	33	104
Muscle relaxant	171	44	34	27	66
Prescription pain medications	187	26	17	20	124
Sleep aids	169	27	20	31	91

Table 25. Counts of participants reporting belief using substance as prescribed could lead to arrest for impaired driving.

Substance	Number of Responses	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
ADHD Medication	155	35	34	27	59
Amphetamines	149	29	21	29	70
Antidepressants	151	45	29	29	48
Barbiturates	145	22	21	27	75
Benzodiazepines	144	22	24	32	66
Dietary/appetite suppressant	146	56	29	19	42
Medicinal marijuana/cannabis	44 *(survey response errors present)*	1	-	-	1
Methadone or buprenorphine	160	23	18	27	92
Morphine or codeine	167	28	24	30	85
Muscle relaxant	151	31	26	29	65
Prescription pain medications	165	22	17	23	103
Sleep aids	149	37	21	23	68

Table 26. Counts of participants reporting use of substance with alcohol.

Substance	Number of Responses	No	Yes
ADHD Medication	144	143	1
Amphetamines	125	125	0
Antidepressants	133	129	4
Barbiturates	126	126	0
Benzodiazepines	125	122	3
Dietary/appetite suppressant	123	123	0
Medicinal marijuana/cannabis	132	127	5
Methadone or buprenorphine	145	145	0
Morphine or codeine	137	126	11
Muscle relaxant	125	123	2
Prescription pain medications	147	143	4
Sleep aids	122	122	0

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