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Assessing Impaired Driving Through Comprehensive Forensic Toxicology

A Multistate Approach

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About

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National Alliance to Stop Impaired Driving
A Coalition Established by RESPONSIBILITY.ORG

The National Alliance to Stop Impaired Driving (NASID) is a coalition established and led by Responsibility.org to eliminate all forms of impaired driving, especially multiple substance impaired driving, through effective and proven measures such as DUI system reform, DUI detection and improved use of data and technology. To learn more visit NASID.org.

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Project Background

Driving under the influence of drugs (DUID) and alcohol (DUI) impaired driving are both public safety and public health concerns in the United States (US). Obtaining accurate data about the extent and nature of the DUID problem (alcohol, drugs, and polysubstance combinations) is difficult due to a lack of consistent toxicology testing, absence of centralized reporting and the continual emergence of new drugs and adulterants in the drug supply. This is particularly challenging when toxicology laboratories have stop-limit testing polices for when a sample has reached a particular blood alcohol concentration (BAC), which only addresses alcohol without examining all potential impairment contributors. The recent rise in fentanyl and methamphetamine use in general is also most likely reflected in the driving population. The use of illicit substances, prescription medications and/or over-the-counter medications has continued to rise over the last decade, and in turn has resulted in the potential for more drivers to be on the road while using any of the aforementioned substances. According to the results of the 2013-2014 National Roadside Survey of Alcohol and Drug Use by Drivers, approximately 22% of randomly stopped drivers tested positive for drugs in oral fluid or blood specimens (1). While the simple detection of a drug in these matrices does not imply impairment, illegal substances without medicinal use were detected in up to 15% of drivers during the nighttime hours of the weekend. Recent data demonstrated that 55.8% of the injured or killed drivers, passengers, pedestrians and cyclists tested positive for one or more drugs (including alcohol) (2). In 2021, traffic fatalities increased by 10% compared to 2020, and traffic fatality counts were the highest since 2005 (3). Statistical projections for the first quarter of 2024 show a marginal decrease (3%) compared to 2023 (4). Increasingly, drug impaired driving is becoming a concern for US law enforcement and traffic safety agencies. Applying a comprehensive and systematic approach to detection, investigation and analytical confirmation of drug involvement is key to successful prosecution and deterrence of all forms of impairment (5, 6).

Beginning in 2004, the National Safety Council's Alcohol, Drugs and Impairment Division (NSC-ADID) started an initiative to standardize toxicology laboratory testing practices for DUID cases by surveying the testing scope and analytical cutoffs being used for blood and urine drug testing (7). In 2007, the first set of recommendations were published, which represented a list of drugs which ought to be tested for in suspected impaired driving cases (8). Since the first publication, a total of four iterations of recommendations for toxicological investigation of drug impaired driving have been published based on input from laboratories surveyed across the US (7, 9, 10) with the 2017 recommendations being cited by the Academy Standards Board (ASB) as the basis for their standards for forensic toxicology testing in impaired driving investigations (11). The Tier I scope (Table 1) represents drugs most frequently encountered in impaired driving and traffic fatalities and represents the minimum scope of testing that should be pursued in all suspected impaired driving cases. Currently 35 drugs and/or metabolites are represented in the scope. The Tier II scope (Table 2) represents drugs less frequently encountered or drugs that may have more of a regional prevalence and are considered optional for testing. Data compiled through a survey of laboratories (n=65) for compliance in terms of Tier I testing scope and cutoff per the NSC-ADID's recommendations showed a mean compliance of 82%, suggesting progress has been made in the goal of standardizing the scope of forensic toxicology testing.

Limitations associated with data collected as part of the Fatality Analysis Reporting System (FARS) have long been acknowledged. Further, the practice of stop-limit testing where the determination of whether or not to perform drug testing based on an administratively set alcohol concentration (usually .08 -.10 g/100mL) or only confirming the "most important" drug or highest schedule drug was reported by 45% of laboratories (n=65). In unpublished data collected as part of an ongoing evaluation of this practice, 47 of 75 (62%) cases analyzed from Wisconsin, where drug testing was not pursued based on a blood alcohol concentration greater or equal to 0.08 g/100mL, were positive for at least one Tier I drug, Tier II drug, or combination in addition to alcohol.

Project Background Continued

Table 1. Tier I Drugs

DRE category; cannabis
THC
Carboxy-THC
11-OH-THC

DRE category; CNS stimulants
Methamphetamine
Amphetamine
MDMA
MDA
Cocaine
Benzoylecgonine
Cocaethylene

DRE category; narcotic analgesics
Codeine
6-Acetylmorphine
Buprenorphine
Norbuprenorphine
Fentanyl
Hydrocodone
Hydromorphone
Methadone
Morphine
Oxycodone
Oxymorphone
Tramadol
O-desmethyltramadol

DRE category; CNS depressants
Carisoprodol
Meprobamate
Zolpidem
Alprazolam
Alpha-Hydroxyalprazolam
Clonazepam
7-Aminoclonazepam
Lorazepam
Diazepam
Nordiazepam
Oxazepam
Temazepam

DRE
Drug Recognition Expert

THC
Delta-9-tetrahydrocannabinol

Carboxy THC
11-Nor-9-carboxy-tetrahydrocannabinol

11-OH-THC
11-hydroxy-tetrahydrocannabinol

CNS
Central Nervous System

Project Background Continued

Table 2. Tier II Drugs

DRE category; cannabis
Synthetic cannabinoids

DRE category; CNS stimulants
Cathinones
Methylphenidate
Mitragynine

DRE category; CNS depressants
A-typical antipsychotics
Barbiturates
Carbamazepine
Chlordiazepoxide
Chlorpheniramine
Cyclobenzaprine
Diphenhydramine
Doxylamine
Gabapentin
Gamma-hydroxybutyrate
Hydroxyzine
Lamotrigine
Mirtazapine
Novel benzodiazepines
Phenytoin
Pregabalin
Secobarbital
Topiramate
Tricyclic antidepressants
Valproic acid
Zopiclone

DRE category; narcotic analgesics
Fentanyl analogs
Novel opioids
Tapentadol

DRE category; dissociative drugs
Dextromethorphan
Ketamine
PCP

DRE category; inhalants
Inhalant class

DRE category; hallucinogens
Hallucinogens

Project Goal

Previous research investigating DUID data in the state of Pennsylvania showed that 56% of the cases were cases in which only a Tier I and/or Tier II drug was identified with an additional 24% comprising of drugs and alcohol. Drugs classified as Tier II drugs, such as diphenhydramine (7.4%), gabapentin (4.3%), and hydroxyzine (3.5%) were detected with greater frequency than some Tier I drugs like benzoylecgonine (6.9%), alprazolam (3.5%) and cocaine (3.4%). Additional Tier II drugs detected with some frequency were 8-aminoclonazepam (3.1%), fluorofentanyl (2.8%) and trazodone (2.7%). These data are consistent with national trends and show the shift in the use of these illicit substances, which quickly outpaces the rate at which laboratories can update methods to include trending drugs. Having real-time information would allow laboratories to make data-supported and informed decisions about what drugs to include in the DUID testing scope and how to best prioritize resources to maximize drug detection.

To better characterize drug impaired driving and provide timely reporting on impaired driving trends across the US, the goal of this research was to comprehensively test blood samples collected and submitted for analysis for both Tier I and Tier II drugs and other emergent substances, including novel psychoactive substances (NPS), in suspected DUID cases. Data collected as part of the research was also circulated to the states submitting samples to allow laboratories to assess the impacts of stop-limit testing practices and provide a clear understanding of missed drugs in the laboratory's testing process thereby influencing future data decisions. Data may also be leveraged for potential support of further funding of laboratories to pursue testing methods with a greater scope.

Project Methods

Samples from five states/agencies who agreed to participate in the project (Missouri, Montana, Ohio, Wisconsin, and from NMS Labs (samples from Pennsylvania)) were de-identified prior to transfer to Center for Forensic Science Research and Education (CFSRE) for analysis. In addition to the samples, the blood alcohol results from the original testing laboratory were provided. Samples from Pennsylvania came with data for THC and its metabolites.

The types of samples submitted by each state varied. Samples submitted from Missouri, Montana, Ohio, and Pennsylvania were sent at random, regardless of the original laboratory's testing results. Samples sent from Wisconsin were cases where the BAC was greater than 0.10 g/100 mL and had received no drug testing per laboratory policy.

The retention policy varied by state and can be found in Table 3 on the following page.

Project Methods Continued

Table 3. Laboratory Sample Retention Policy

Laboratory	Retention Length	Earliest Date of Sample Receipt	Latest Date of Sample Receipt
Missouri State Highway Patrol	1-2 months	2/8/2023	9/27/2023
Montana Department of Justice, Forensic Science Division	1 year	1/3/2022	8/29/2022
Montgomery County Coroner's Office	1 year	3/7/2022	10/6/2022
NMS Labs (Pennsylvania)	6 weeks	6/3/2022	1/5/2024
Wisconsin State Laboratory of Hygiene	6 months	1/1/2023	7/14/2023

Several of the states (e.g., Montana and Wisconsin) have stop-limit testing practices in place when the alcohol concentration of the sample is above a certain threshold. Analysis of these specimens provided additional insights into polydrug consumption where both alcohol and drugs may have contributed to impairment.

Samples were analyzed on a Sciex TripleTOF 5600+ coupled to the Shimadzu Nexera UHPLC, a high-resolution mass spectrometer that allows for comprehensive testing. Included in the data processing method are all Tier I drugs and most Tier II drugs, including many NPS. Notable drug or drug class exceptions from the method include barbiturates, valproic acid, GHB and inhalants. A targeted assay was used for the detection of cannabinoids for all states except Pennsylvania (cannabinoid results provided with the sample). Included in the scope of analysis was delta-9 THC and the hydroxy and carboxy metabolites. Screening for synthetic cannabinoids was only performed in samples originating from Pennsylvania. Further, all samples were analyzed for gabapentin, a trending medicinal drug that was not included in the scope of the other methods.

Project Results

For the project, a total of 1,025 samples were analyzed. The geographic distribution of the samples included 516 samples from Pennsylvania, 193 from Missouri, 116 from Ohio, 100 from Montana, and 100 from Wisconsin. Related to the general findings, in 27 (2.6%) cases there were no drugs or alcohol detected, 709 (69%) were ethanol positive and 738 (71%) were drug positive (data for alcohol and drugs is not mutually exclusive as reported here). Further evaluation of the data, excluding negative samples (n=27), showed that 45% of the samples analyzed were positive for both drugs and alcohol (Figure 1).

Alchohol and Drug Data (n=998)

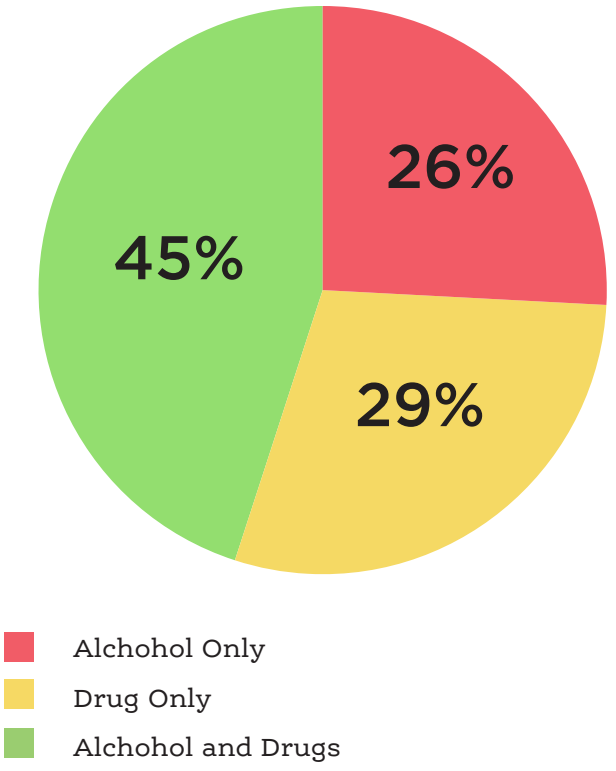


Figure 1. Percent of drug and alcohol findings in positive samples.

Alcohol testing is routinely performed in toxicology testing and almost every suspected impaired driving case is tested for alcohol, at a minimum. Ethanol was identified in 709 cases. The average ethanol concentration was 0.166±0.074 g/100mL (median 0.163 g/100mL) with a range of 0.011-0.42 g/100 mL. The distribution of blood alcohol concentrations from the aggregate data is provided in Figure 2. The greatest number of cases had blood alcohol ranges between 0.101 and 0.201 g/100 mL. It should be noted that the distribution of alcohol concentrations is likely skewed as some states were only sending cases where alcohol concentrations were in excess of 0.100 g/100 mL and no drug testing had been performed.

Distribution of BACs

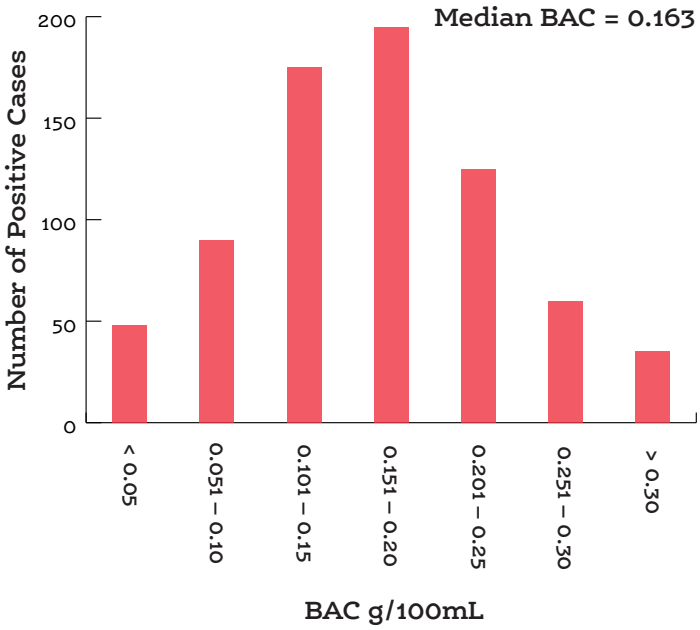


Figure 2. Distribution of blood alcohol concentration (BAC) results in positive cases.

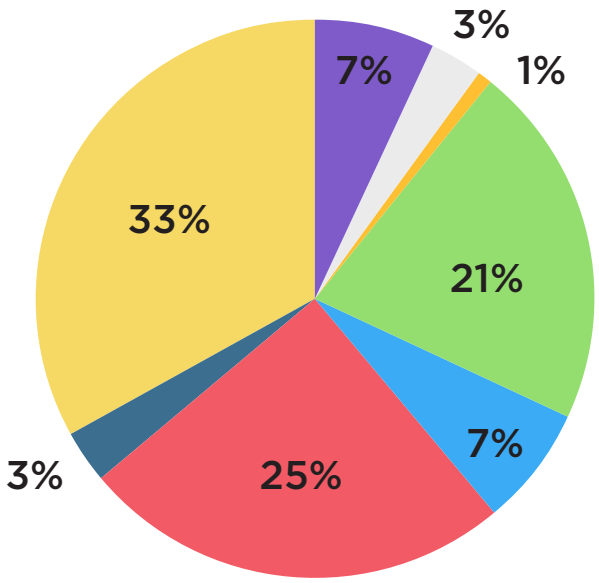
Project Results Continued

Figure 3 shows the positivity distribution of all data collected. The majority of samples (n=335, 33%) were positive for both ethanol and a Tier I drug, followed by samples positive for ethanol only (n=260, 26%). There were 69 (7%) samples positive for both Tier I drugs and Tier II drugs (no ethanol), and 37 (3%) samples positive for ethanol and Tier II drugs. There were 27 (3%) samples where no drugs were detected and seven (1%) samples that were only positive for Tier II drugs.

- None Detected
- Tier II Only
- Tier I Only
- Tier I and II
- Ethanol Only
- Ethanol and Tier II
- Ethanol and Tier I
- Ethanol and Tier I, and Tier II

Percent Positivity Data (n=1,025)

Figure 3. Percent of drug findings in all samples.



Project Results Continued

Summary tables (Table 4 and Table 5) illustrating the results for Tier I and Tier II testing from all states are shown below. After ethanol and Delta-9 tetrahydrocannabinol (THC), methamphetamine was the next most frequently detected drug, followed by amphetamine and fentanyl. Of the 35 drugs that are included in the Tier I scope recommendations, 28 were identified in the samples. Tier I drugs not included in Table 1, but identified in samples were: 3,4-Methylenedioxyamphetamine (MDA), oxazepam, and norbuprenorphine. All three of these drugs were only detected in a single instance.

Table 4. Tier I results for all states (n=1,025 cases).

Drug	No. of Positive Cases	Percent Positivity
Ethanol	709	69%
THC (Carboxy-THC)	391 (579)	38% (56%)
Methamphetamine	101	9.8%
Amphetamine	80	7.8%
Fentanyl	47	4.5%
Benzoylecgonine	37	3.6%
Cocaine	36	3.5%
Alprazolam	23	2.2%
Cocaethylene	19	1.8%
Nordiazepam	19	1.8%
7-aminoclonazolam	17	1.6%
Diazepam	17	1.6%
Oxycodone	12	1.1%
Zolpidem	10	0.97%
Clonazepam	9	0.87%
Methadone	8	0.78%
Tramadol	8	0.78%
Hydrocodone	6	0.58%
Lorazepam	5	0.48%
Buprenorphine	3	0.29%
MDMA	3	0.29%
Morphine	2	0.19%
O-desmethyltramadol	2	0.19%
Temazepam	2	0.19%

Project Results Continued

With respect to Tier II drugs, gabapentin was the most frequently detected drug followed by diphenhydramine and cyclobenzaprine. There was a total of 33 different Tier II drugs detected across all states. With respect to NPS, there were limited instances of their Tier II drugs detection in the samples that were tested. Clonazolam, MDMB-4en-PINACA, eutylone, 2-fluoro-2-oxo PCE, N-pyrrolidino etonitazene, and 9-carboxy hexahydrocannabinol (HHC) were all found in one case each. Similar to Table 4, only Tier II drugs identified in more than one case were included in Table 5.

Table 5. Tier II results for all states (n=1,025 cases).

Drug	No. of Positive Cases	Percent Positivity
Gabapentin	34	3.3%
Diphenhydramine	31	3.0%
Cyclobenzaprine	27	2.6%
Trazodone (mCPP)	25 (11)	2.4% (1.0%)
Hydroxyzine	22	2.1%
Dextro /levo methorphan	14	1.3%
Doxylamine	12	1.1%
Lamotrigine	12	1.1%
Quetiapine	11	1.0%
Fluorofentanyl	9	0.88%
Mitragynine	7	0.68%
Bromazolam	7	0.68%
Amitriptyline	6	0.58%
Nortriptyline	6	0.58%
8-aminoclonazolam	5	0.48%
Mirtazapine	4	0.39%
Ketamine	4	0.39%
Carbamazepine	3	0.29%
Aripiprazole	3	0.29%
Chlordiazepoxide	2	0.19%
Chlorpheniramine	2	0.19%
Phencyclidine	2	0.19%
Ziprasidone	2	0.19%

Project Results Continued

As part of the evaluation of data, the different class combinations for drugs in Tier I were evaluated (Table 6). Cannabinoids found in combination with ethanol was the most frequent drug combination identified in 363 cases (35%), followed by cannabinoids and CNS stimulants identified in 99 cases (9.6%). CNS stimulants combined with ethanol was the third most common drug combination identified in 73 cases (7.1%).

Table 6. Drug combinations by Tier I drug classes (n=1,025 cases).

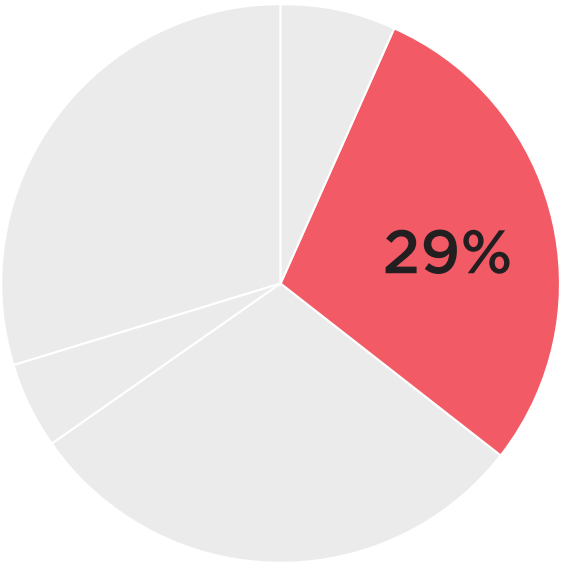
Drug Combination	No. of Cases	Percent Positivity
Cannabinoids and Ethanol	363	35%
Cannabinoids and CNS Stimulants	99	9.6%
CNS Stimulants and Ethanol	73	7.1%
Cannabinoids and Narcotic Analgesics	49	4.7%
Cannabinoids and CNS Depressants	46	4.4%
CNS depressants and Ethanol	37	3.6%
Narcotic Analgesics and Ethanol	28	2.7%
Narcotic Analgesics and CNS Stimulants	28	2.7%
Cannabinoids and Low Dose Benzodiazepines	27	2.6%
Low Dose Benzodiazepines and Ethanol	21	2.0%
CNS Stimulants and CNS Depressants	19	1.8%
Narcotic Analgesics and CNS Depressants	19	1.8%
Cannabinoids and High Dose Benzodiazepines	15	1.4%
CNS Stimulants and Low Dose Benzodiazepines	13	1.2%
High Dose Benzodiazepines and Ethanol	12	1.1%
Narcotic Analgesics and Low Dose Benzodiazepines	12	1.1%
CNS Stimulants and High Dose Benzodiazepines	6	0.58%
Narcotic Analgesics and High Dose Benzodiazepines	5	0.48%

Stop Limit Testing

While alcohol testing is routinely performed on suspected impaired driving cases, there are practices that preclude drug testing in some instances. Reviewing cases that were positive for drugs or alcohol, 29% of the cases in this data set were positive for drugs only (Figure 4).

Drug Only Positivity (n=998)

Figure 4. Percent of drug findings in positive samples



Stop Limit Testing Continued

Stop limit testing is a commonly used practice across toxicology laboratories, where further drug testing is precluded in samples where a specified blood alcohol concentration (BAC) has been observed. In a recent survey of 80 forensic toxicology laboratories by the NSC-ADID, 51% reported making an administrative decision to stop testing if a BAC result is at or above a certain concentration (12). The two most common BAC thresholds reported were 0.08 g/100mL and 0.10 g/100mL (71% of respondents, n=39). The rationale for this practice includes a lack of enhanced penalties for combined drug and alcohol use, the impairment can be explained by the BAC, limited resources and/or budget and agency request. Drug positivity for Tier I, Tier II or combination was evaluated at four BAC thresholds (<0.08 g/100mL, ≥0.08 g/100mL, ≥0.10 g/100mL and ≥0.15 g/100mL). Data from that evaluation is provided in Table 7.

Stop Limit Thresholds

Table 7. Drug Positivity for a Tier I, Tier II, and/or Combination at Various BAC Thresholds

	<0.08 g/100 mL	≥0.08 g/100mL	≥0.10 g/100 mL	≥0.15 g/100 mL
Pennsylvania (n=516)	5.2%	26%	15%	16%
Missouri (n=193)	11%	45%	39%	27%
Ohio (n=116)	5.1%	33%	31%	26%
Wisconsin (n=100)	N/A	72%	70%	44%
Montana (n=100)	5.0%	54%	48%	34%

Discussion

Of the 1,025 samples that were analyzed as part of the project, the totality of results is consistent with data that was collected in 2020-2021 with the most frequently identified drugs being THC, methamphetamine, amphetamine and fentanyl (13). Gabapentin continues to trend as one of the most frequently encountered Tier II drugs. Diphenhydramine (Benadryl) positivity steadily increased over the project period making it one of the most frequently detected Tier II drugs in the data set. With respect to NPS drugs, there were incidents where NPS, particularly NPS benzodiazepines were detected. In some cases, these NPS benzodiazepines were the only identification, however, in others they are identified with other Tier I drugs. With respect to the findings, those provided herein support continuing the Tier I scope recommendations, as these are the most frequently encountered drugs in suspected impaired driving cases.

Stop limit testing is a frequent practice among toxicology laboratories. Up to 72% of cases have drug positive results when ethanol is present at a concentration of greater than 0.08 g/100mL. Limiting testing based on alcohol results precludes information of drug involvement in several cases leading to underreporting of drug contributions to impaired driving.

Conclusions

Drug impaired driving is a significant public health problem in the US, impacting roadway users, laboratories, safety advocates, and policy makers, and it spans multiple demographics including investigators, prosecutors, traffic safety advocates and all road users, not just impaired drivers. As cited in “The Road to Zero: A Vision for Achieving Zero Roadway Deaths by 2050” report, traffic safety requires a multifaceted approach (14). Critical to improving traffic safety is comprehensive data that identifies behaviors like impaired driving that compromise safe roadways. Data generated from samples that have been uniformly and comprehensively tested for the most prevalent drugs, in addition to alcohol, supports and promotes a safety culture.

The benefits of having greater standardization in testing include more consistent data, greater likelihood of detection of drugs in impaired drivers, and early detection of emerging compounds, as well as a more complete understanding of the scope and severity of drug impaired driving. More consistent practices also help ensure prosecution for impaired driving is standardized and more equitable, provides better support for the DRE program and results in higher quality consolidated data for epidemiological and public health studies. The data provided as part of this research underscores the high likelihood of detecting both alcohol and drugs in suspected impaired driving investigations. Understanding the true extent of impaired driving supports campaigns designed to raise awareness and educate the public about the risks of drugged driving, inform laboratories about drug positivity and drug trends, highlight the number of drug positive cases missed when practices like stop-limit testing are used, and allows the creation of proactive policies based on near-real time data not restricted by the current limitations of FARS drug-use data.

The data collected as part of this research initiative fills gaps in knowledge of both the extent and nature of impaired driving. Fully investigating the frequency of drug positivity in suspected impaired driving cases using a standardized approach will help provide objective data that can be aggregated and leveraged to accurately characterize the scope of the problem. An understanding of how drugs and alcohol interact with one another, resulting in impairment that is greater than the sum of its parts, is important from a driver education and criminal prosecution perspective. Without looking into the relative prevalence of these compounds in DUID casework, we cannot fully know their contributions to the problem. By characterizing a more comprehensive list of potentially impairing substances detected in the DUID population, we can improve the quality of statistics, which can be used to inform public policy and support initiatives like those outlined in the Road to Zero initiative.

References

1. Berning, A., Compton, R. and Wochinger, K. (2015) Results of the 2013–2014 National Roadside Survey of Alcohol and Drug Use by Drivers. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812118-roadside_survey_2014.pdf (24 April 2020).

2. Thomas, F.D., Darrah, J., Graham, L., Berning, A., Blomberg, R., Finstad, K., et al. (2022) Alcohol and Drug Prevalence Among Seriously or Fatally Injured Road Users. National Highway Traffic Safety Administration.

3. Stewart, T. (2023) Overview of Motor Vehicle Traffic Crashes in 2021. National Highway Traffic Safety Administration.

4. Crash Stats: Early Estimate of Motor Vehicle Traffic Fatalities for the First Quarter of 2024 (2024) National Highway Traffic Safety Administration.

5. Hayes, C. (2013) Efforts Continue to Address Drugged Driving, But Is It Enough? Police Chief Magazine, July 1, 2013. https://www.policechiefmagazine.org/efforts-continue-to-address-drugged-driving-but-is-it-enough/ (5 May 2020).

6. Jones, A.W., Morland, J.G. and Liu, R.H. (2020) Alcohol, Drugs, and Impaired Driving: Forensic Science and Law Enforcement Issues. CRC Press. https://www.routledge.com/Alcohol-Drugs-and-Impaired-Driving-Forensic-Science-and-Law-Enforcement/Jones-Morland-Liu/p/book/9780367251628 (5 May 2020).

7. D'Orazio, A.L., Scott, K.S., Mohr, A.L.A. and Logan, B.K. (2016) Updates for Recommendations for Drug Testing in DUID & Traffic Fatality Investigations. https://www.forensicscienceeducation.org/wp-content/uploads/2016/04/Full-Survey-Report.pdf (5 May 2020).

8. Farrell, L.J., Kerrigan, S. and Logan, B.K. (2007) Recommendations for toxicological investigation of drug impaired driving. Journal of Forensic Sciences, 52, 1214–1218.

9. Logan, B.K., Lowrie, K.J., Turri, J.L., Yeakel, J.K., Limoges, J.F., Miles, A.K., et al. (2013) Recommendations for toxicological investigation of drug-impaired driving and motor vehicle fatalities. Journal of Analytical Toxicology, 37, 552–558.

10. Logan, B.K., D'Orazio, A.L., Mohr, A.L.A., Limoges, J.F., Miles, A.K., Scarneo, C.E., et al. (2018) Recommendations for Toxicological Investigation of Drug-Impaired Driving and Motor Vehicle Fatalities-2017 Update. Journal of Analytical Toxicology, 42, 63–68.

11. AAFS Standards Board (2019) Standard for the Analytical Scope and Sensitivity of Forensic Toxicology Testing in Impaired Driving Investigations. http://www.asbstandardsboard.org/wp-content/uploads/2019/09/120_Std_Ballot01.pdf (5 May 2020).

12. D'Orazio, A.L., Mohr, A.L.A. and Logan, B.K. Updates for Recommendations for Drug Testing in DUID & Traffic Fatality Investigations 2024: Toxicology Laboratory Survey. https://www.cfsre.org/images/Presentations/2024_Survey_Report.pdf (28 August 2024).

13. Mohr, A.L.A. and Logan, B.K. (2023) Assessment of the Contribution to Drug Impaired Driving from Emerging and Undertested Drugs. https://www.ojp.gov/pdffiles1/nij/grants/307336.pdf.

14. Ecola, L., Popper, S.W., Silberglitt, R. and Fraade-Blanar, L. (2018) The Road to Zero: A Vision for Achieving Zero Roadway Deaths by 2050. RAND Corporation, Santa Monica, CA. https://www.nsc.org/getmedia/485b0d61-e657-44e7-84f2-1a4206a7ea33/rtz-report.pdf.aspx (27 December 2023)

Appendix A – Individual State Data

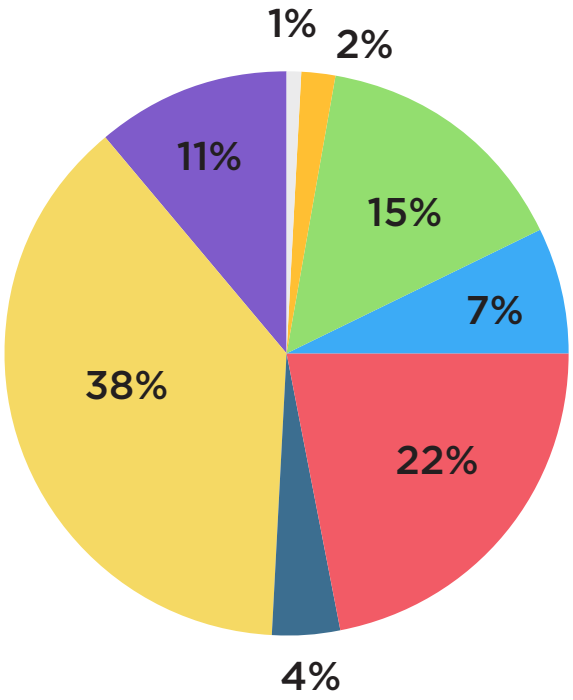
Missouri

A total of 193 samples from Missouri were analyzed for this research. The distribution of positive findings for Missouri data is shown in Figure A1.

- None Detected
- Tier II Only
- Tier I Only
- Tier I and II
- Ethanol Only
- Ethanol and Tier II
- Ethanol and Tier I
- Ethanol and Tier I, and Tier II

MO Percent Positivity Data (n=193)

Figure A1. Overall positivity distribution for Missouri.



Appendix A – Individual State Data

Missouri, Continued

Results related to drug findings for Tier I and Tier II drugs are shown in Table A1. Ethanol was identified in 146 cases in total. The average ethanol concentration was 0.152±0.075 g/100mL (median 0.156 g/100mL) with a range of 0.011-0.42 g/100 mL. Delta-9 tetrahydrocannabinol (THC) was identified in 74 cases, carboxy-THC was identified in 131 cases and hydroxy-THC was found in 41 cases. Out of the 35 drugs in the Tier I recommended testing scope, there were 17 Tier I drugs detected in the Missouri data set. Of interest with respect to Tier II findings was the detection of 8-aminoclonazolam, an NPS benzodiazepine. In both of these cases, 8-aminoclonazolam was identified with fentanyl and THC.

Table A1. Tier I and Tier II Drug Findings in Missouri (n=193).

Tier I Drugs

Drug	Positivity
Ethanol	75%
THC (Carboxy-THC)	38% (67%)
Methamphetamine (Amphetamine)	12% (10%)
Fentanyl	6.2%
Cocaine (Benzoylecgonine)	4.6% (4.6%)
Cocaethylene	4.1%
Diazepam (Nordiazepam)	3.6%
Alprazolam	2.5%
Oxycodone	2.0%
Clonazepam (7-aminoclonazepam)	1.0% (1.5%)
-	-
-	-
-	-

Tier II Drugs

Drug	Positivity
Diphenhydramine	4.1%
Hydroxyzine	2.5%
Trazodone	2.5%
Mitragynine	2.0%
Gabapentin	2.0%
Fluorofentanyl	2.0%
Oxycodone	1.5%
8-aminoclonazolam	1.0%
Cyclobenzaprine	1.0%
Dextro/levo methorphan	1.0%
Doxylamine	1.0%
Lamotrigine	1.0%
Quetiapine	1.0%

Appendix A – Individual State Data

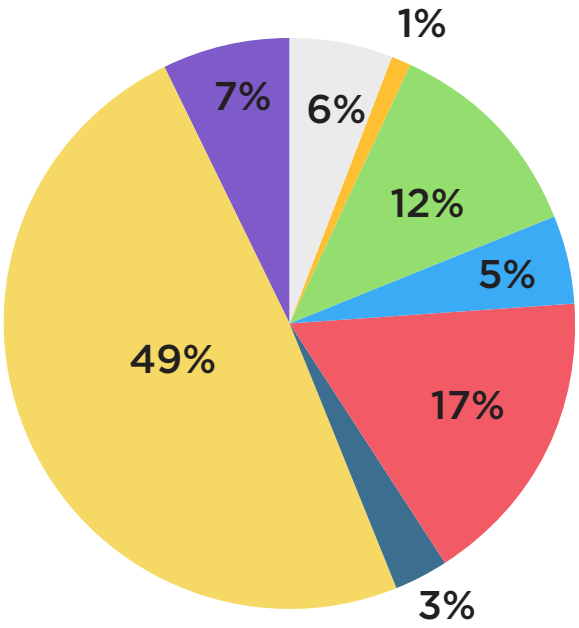
Montana

A total of 100 samples from Montana were analyzed for this research. The distribution of positive findings for Montana data is shown in Figure A2.

None Detected
Tier II Only
Tier I Only
Tier I and II
Ethanol Only
Ethanol and Tier II
Ethanol and Tier I
Ethanol and Tier I, and Tier II

MT Percent Positivity Data (n=100)

Figure A2. Overall positivity distribution for Montana.



Appendix A – Individual State Data

Montana, Continued

Results related to drug findings for Tier I and Tier II drugs are shown in Table A2. Ethanol was identified in 76 cases in total. The average ethanol concentration was 0.182±0.079 g/100mL (median 0.163 g/100mL) with a range of 0.03-0.35 g/100 mL. THC was identified in 24 cases, carboxy-THC was identified in 66 cases and hydroxy-THC was found in five cases. Methamphetamine and amphetamine were the most frequently encountered drugs after ethanol and THC. A total of 16 different Tier II drugs were identified in the Montana data set, with cyclobenzaprine, trazodone and lamotrigine being the most commonly detected drugs.

Table A2. Tier I and Tier II Drug Findings in Montana (n=100).

Tier I Drugs		Tier II Drugs	
Drug	**Positivity**	**Drug**	**Positivity**
Ethanol	76%	Cyclobenzaprine	4.0%
THC (Carboxy-THC)	24% (66%)	Trazodone	3.0%
Methamphetamine (Amphetamine)	12% (12%)	Lamotrigine	3.0%
Nordiazepam	4.0%	Doxylamine	2.0%
Fentanyl	2.0%	Gabapentin	2.0%
Tramadol	2.0%	Aripiprazole	2.0%
Alprazolam	1.0%	8-aminoclonazolam	1.0%
Diazepam	1.0%	Amitriptyline	1.0%
Hydrocodone	1.0%	Chlordiazepoxide	1.0%
Zolpidem	1.0%	Dextro/levo methorphan	1.0%
Oxycodone	1.0%	Diphenhydramine	1.0%
-	-	Mitragynine	1.0%
-	-	Olanzapine	1.0%
-	-	Nortriptyline	1.0%

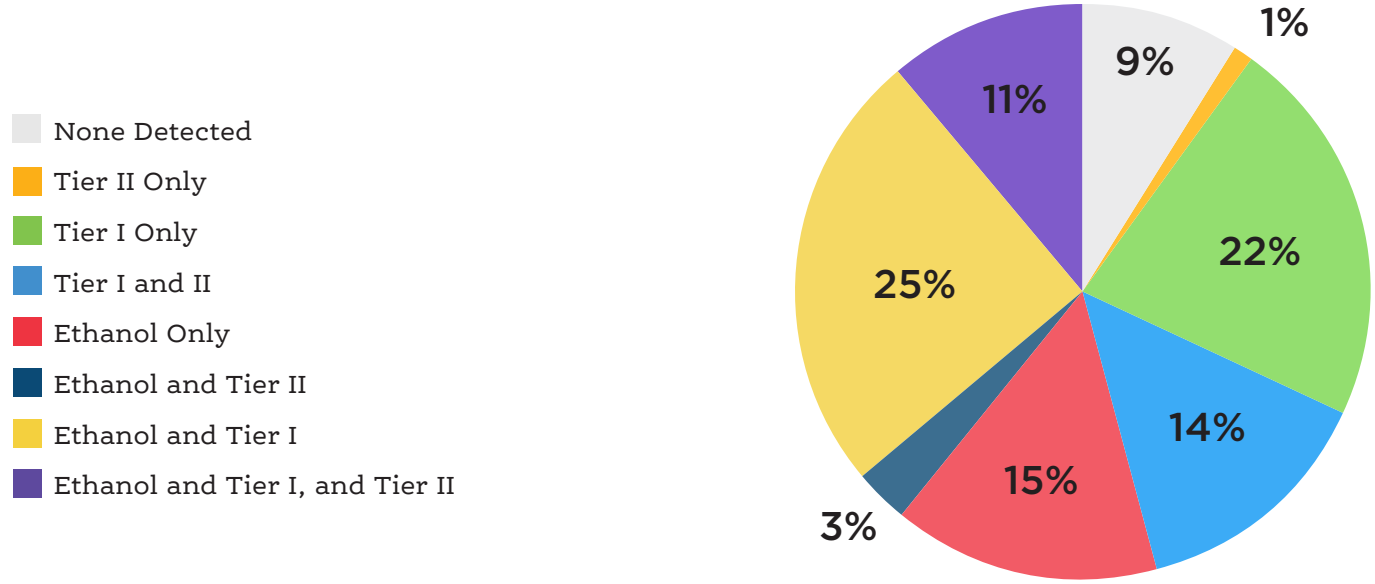
Appendix A – Individual State Data

Ohio

A total of 116 samples from Ohio were analyzed for this research. The distribution of positive findings for Ohio data is shown in Figure A3.

OH Percent Positivity Data (n=116)

Figure A3. Overall positivity distribution for Ohio.



Appendix A – Individual State Data

Ohio, Continued

Results related to drug findings for Tier I and Tier II drugs are shown in Table A3. Ethanol was identified in 63 cases in total. The average ethanol concentration was 0.179±0.075 g/100mL (median 0.163 g/100mL) with a range of 0.014-0.379 g/100 mL. Consistent with the other state findings, the most frequently encountered drug was THC. After THC and ethanol, methamphetamine, amphetamine and fentanyl were the next most frequently encountered drugs. Out of the 35 drugs in the Tier I recommended scope, there were 20 detected in the Ohio data set. Hydroxyzine and diphenhydramine were the most commonly encountered Tier II drugs followed by dextro/levo methorphan and quetiapine.

Table A3. Tier I and Tier II Drug Findings in Ohio (n=116).

Tier I Drugs

Drug	Positivity
THC (Carboxy-THC)	12% (62%)
Ethanol	54%
Methamphetamine (Amphetamine)	15% (12%)
Fentanyl	10%
Cocaine (Benzoylecgonine)	5.1% (4.3%)
Alprazolam	5.1%
Diazepam (Nordiazepam)	4.3% (3.4%)
Cocaethylene	2.5%
Clonazepam (7-aminoclonazepam)	0.86% (2.5%)
Zolpidem	1.7%
-	-

Tier II Drugs

Drug	Positivity
Hydroxyzine	5.1%
Diphenhydramine	5.1%
Dextro/levo methorphan	4.3%
Quetiapine	4.3%
Gabapentin	3.4%
Cyclobenzaprine	3.4%
Fluorofentanyl	2.5%
Amitriptyline	1.7%
Trazodone	1.7%
Clonazolam (8-aminoclonazolam)	0.86% (1.7%)
Bromazolam	1.7%

Appendix A – Individual State Data

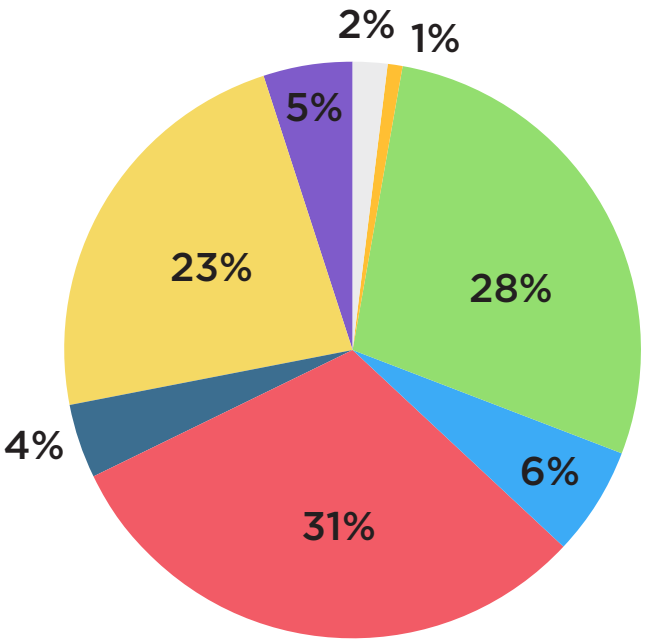
Pennsylvania

A total of 516 samples from Pennsylvania were analyzed for this research. The distribution of positive findings for Pennsylvania data is shown in Figure A4.

- None Detected
- Tier II Only
- Tier I Only
- Tier I and II
- Ethanol Only
- Ethanol and Tier II
- Ethanol and Tier I
- Ethanol and Tier I, and Tier II

PA Percent Positivity Data (n=516)

Figure A4. Overall positivity distribution for Pennsylvania.



Appendix A – Individual State Data

Pennsylvania, Continued

Results related to drug findings for Tier I and Tier II drugs are shown in Table A4. Ethanol was identified in 323 cases in total. The average ethanol concentration was 0.162±0.075 g/100mL (median 0.16 g/100mL) with a range of 0.012-0.371 g/100 mL. THC was identified in 253 cases. The average THC concentration was 9.5±10.7 ng/mL (median 5.35 ng/mL) with a range of 0.5-64 ng/mL. After ethanol and THC, methamphetamine was the most frequently detected drug, followed by amphetamine and benzoylecgonine, an inactive metabolite of cocaine. Out of the 35 drugs in the Tier I scope recommendations, there were 27 Tier I drugs detected in the Pennsylvania data set. Gabapentin was the most commonly detected Tier II drug followed by diphenhydramine and cyclobenzaprine. There were four instances were an NPS drug was detected in the Tier II category: mitragynine (Kratom), MDMB-4en-PINACA, N-pyrrolidino etonitazene and tianeptine.

Table A4. Tier I and Tier II Drug Findings in Pennsylvania (n=516).

Tier I Drugs		Tier II Drugs	
Drug	**Positivity**	**Drug**	**Positivity**
Ethanol	62%	Gabapentin	3.6%
THC (Carboxy-THC)	49% (48%)	Diphenhydramine	2.9%
Methamphetamine	7.9%	Cyclobenzaprine	2.7%
Amphetamine	5.8%	Trazodone	2.3%
Benzoylecgonine	4.2%	Hydroxyzine	1.9%
Cocaine	4.0%	Dextro/levo methorphan	1.1%
Fentanyl	3.6%	Doxylamine	1.1%
Alprazolam	2.1%	-	-
7-aminoclonazepam	1.9%	-	-
Oxycodone	1.3%	-	-
Clonazepam	1.1%	-	-

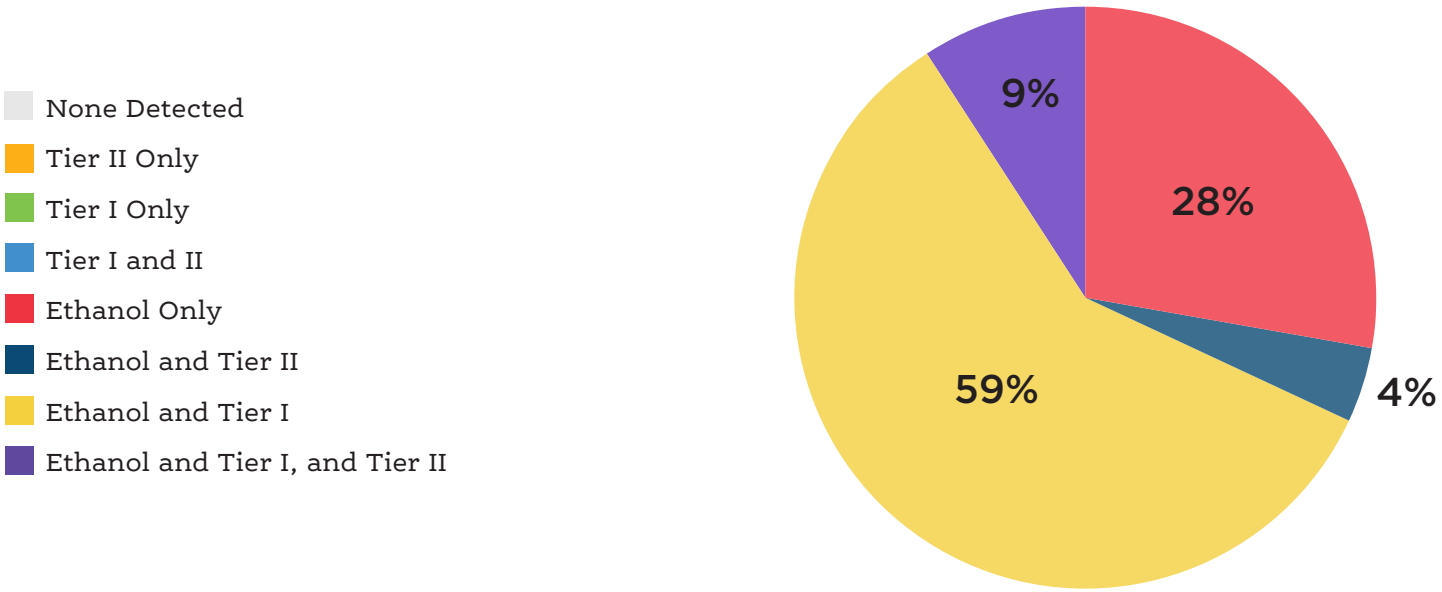
Appendix A – Individual State Data

Wisconsin

A total of 100 samples from Wisconsin were analyzed as part of this research. The distribution of positive findings for Wisconsin data is shown in Figure A5.

WI Percent Positivity Data (n=100)

Figure A5. Overall positivity distribution for Wisconsin.



Appendix A – Individual State Data

Wisconsin, Continued

Results related to drug findings for Tier I and Tier II drugs are shown in Table A5. Only samples where the BAC was greater than 0.10 g/100mL were submitted. The average ethanol concentration was 0.179±0.056 g/100mL (median 0.162 g/100mL) with a range of 0.094-0.332 g/100 mL. After THC and ethanol, methamphetamine was the most frequently detected drug, followed by amphetamine, fentanyl and cocaethylene, an active metabolite formed by the coingestion of cocaine and ethanol. Trazodone was the most commonly identified Tier II drug.

Figure A5. Overall positivity distribution for Wisconsin.

Tier I Drugs

Drug	Positivity
Ethanol	100%
THC (Carboxy-THC)	26%(62%)
Methamphetamine (Amphetamine)	5.0%(4.0%)
Cocaethylene	2.0%
Fentanyl	2.0%
Benzoylecgonine	1.0%
Methadone	1.0%
Zolpidem	1.0%
MDMA	1.0%
-	-
-	-
-	-

Tier II Drugs

Drug	Positivity
Trazodone	3.0%
Cyclobenzaprine	2.0%
Lamotrigine	2.0%
Diphenhydramine	1.0%
Doxylamine	1.0%
Gabapentin	1.0%
Hydroxyzine	1.0%
Mirtazapine	1.0%
Mitragynine	1.0%
Quetiapine	1.0%
Nortriptyline	1.0%
Aripiprazole	1.0%