Recommendations for Toxicological Investigation of Drug-Impaired Driving and Motor Vehicle Fatalities

Amanda L. D'Orazio, M.S., D-ABFT-FT

3/28/2024

1

Project Background

- **In 2004, a group convened to identify problems with the current system of prosecuting impaired driving cases, from the point of detection through adjudication**
  - Toxicologists, Drug Recognition Experts (DREs), prosecuting attorneys
  - Identified lack of consistency of practice among laboratories
- **Beginning in 2004, the National Safety Council (NSC) began documenting analytical practices of toxicology laboratories in driving under the influence of drugs (DUID) cases**
  - Looked at screening and confirmation scope as well as cutoffs
  - Recommendations were published in 2007
    - Most frequently encountered analytes in DUID investigations
    - Minimum menu of drugs which should be tested for
    - Based on availability of immunoassay screening technology and standard instrumentation available to most laboratories

2

2007 Recommendations

J Forensic Sci, September 2007, Vol. 52, No. 5
doi: 10.1111/j.1556-4029.2007.00516.x
Available online at: www.blackwell-synergy.com

Laurel J. Farrell,[1] B.A.; Sarah Kerrigan,[2] Ph.D.; and Barry K. Logan,[3] Ph.D.

Recommendations for Toxicological Investigation of Drug Impaired Driving*

ABSTRACT: Investigation of a suspected alcohol or drug impaired driving (DUID) case ideally contains several key elements, including a trained officer documenting observations of driving and subject behavior, and collection of a biological specimen for comprehensive toxicology testing. There is currently no common standard of practice among forensic toxicology laboratories in the United States as to which drugs should be tested for, and at what analytical cutoff. Having some uniformity of practice among laboratories would ensure that drugs most frequently associated with driving impairment were consistently evaluated, that appropriate methods were used to screen and confirm the presence of drugs, and that more accurate data were collected on the extent of drug use among drivers. A survey of United States laboratories actively involved in providing analytical support to the Drug Evaluation and Classification Program identified marijuana, benzodiazepines, cocaine, prescription and illicit opiates, muscle relaxants, amphetamines, CNS depressants, and sleep aids used as hypnotics, as being the most frequently encountered drugs in these cases. This manuscript presents recommendations as to what specific members of these drug classes should at a minimum be tested for in the investigation of suspected DUID cases. Additionally we include recommendations for analytical cutoffs for screening and confirmation of drugs in blood and urine. Adopting these guidelines would ensure that the most common drugs would be detected, that laboratories could compare epidemiological findings between jurisdictions, and that aggregate national statistics on alcohol and drug use in drivers involved in fatal injury collisions were representative of the true rates of drug use in the driving population.

KEYWORDS: forensic science, drug, impaired, impaired performance, automobile driving, driving under the influence of drugs

Toxicologists in the United States have been discussing the need for better standardization in the scope and analytical cutoffs used in drug testing performed in drug impaired driving investigations. In May 2004, a group representing toxicologists, Drug Recognition Experts (DREs) and prosecuting attorneys active in the area of driving under the influence of drugs (DUID) was convened under the auspices of the National Safety Council's Committee on Alcohol and Other Drugs (COAD), and its subcommittee on Drugs: Pharmacology and Toxicology. The panel was charged with identifying problems with the current system of prosecuting impaired driving cases, from the point of detection through adjudication. The discussions were wide ranging, however the lack of consistency of practice among laboratories was one of the major limitations identified. Tasks were assigned to the major stakeholder groups attending. The Joint Drugs and Driving Committee of the Society of Forensic Toxicologists (SOFT) and the American Academy of Forensic Sciences (AAFS) and the COAD were assigned responsibility for surveying practices among laboratories performing toxicology in support of state DRE programs and more generally for toxicological investigations of drug impaired driving cases (1).

Laboratories engaged in performing toxicological testing in support of DRE programs were identified and surveyed with respect to their analytical practices. At a follow up meeting in October 2005, survey results were presented and there was discussion of development of recommendations for laboratories performing this testing to follow in order to ensure the greatest chance of detecting drugs most likely to be encountered in blood and urine in impaired driving cases. Subsequently the authors of this manuscript (LJF, SK, and BKL) developed the following recommendations for a minimum menu of drugs which should be tested for based on drugs most frequently encountered in DUID investigations (2–5), together with recommended cutoff targets for screening and confirmation in blood and urine, based on the availability of immunoassay screening technology and standard instrumentation available to most laboratories working in this field.

Survey of Current Practice

Current practice in toxicology laboratories supporting DRE programs was determined by a survey of all participating labs that could be identified. The survey included questions on scope and analytical cutoffs of services provided, as well as statistics on the frequency of drugs identified in DUID casework. The survey conducted in 2004–2005 was the third survey of this type with prior surveys having been conducted in 1996 and 1999. Completed surveys were received from 42 laboratories in 24 states. This survey response represented 71% of identified laboratories and 66% of the states with active DRE Programs at the time of the survey. Respondents represented city, county, state, and privately funded laboratories serving wide ranging populations (100,000 to >5,000,000). The survey results disclosed significant variability between laboratories in terms of scope and analytical cutoffs used in testing performed in DUID cases.

One-hundred percent of survey respondents used an immunoassay to perform presumptive drug screening on blood or urine specimens. Forty-one percent of the responding laboratories added

[1]Colorado Bureau of Investigation, 690 Kipling St., Suite 4000, Denver, CO 80215.
[2]College of Criminal Justice, Sam Houston State University, Huntsville, TX 77341.
[3]Washington State Patrol, Forensic Laboratory Services Bureau, 2203 Airport Way S., Suite 360, Seattle, WA 98134.
*Presented at the 58th Annual Meeting of the American Academy of Forensic Sciences, Seattle, WA, February 2006. The opinions expressed in this article are those of the authors and do not represent an official position of any of the professional organizations or government agencies identified in the article.
Received 7 Nov. 2006; and in revised form 30 Mar. 2007; accepted 8 April 2007; published 3 Aug. 2007.

1214

Initial Survey

- **Survey sent to laboratories to gather information**
  - Questions related to analytical scope and cutoffs and most frequently encountered drugs in driving under the influence of drugs (DUID) casework
  - 3 surveys: 1996, 1999, 2004-2005
    - 42 laboratories in 24 states
      - City, county, state, and private laboratories
      - 66% were states with an active DRE program

Initial Survey Findings

Screening	Confirmation
• **100% of laboratories used immunoassay to screen blood and urine specimens**	• **100% of laboratories performed confirmatory analysis by gas chromatography/mass spectrometry (GC/MS)**

• **41% of laboratories had one or more additional techniques to increase scope for screening**
  • High performance liquid chromatography (HPLC)
  • Gas chromatography (GC) with various detectors
  • Liquid chromatography/mass spectrometry (LC/MS)
	• **22% used additional techniques**
	  • LC/MS
	  • HPLC
	  • GC with various detectors

NMS LABS

5

Initial Survey Findings

Great variability among laboratories

- **Screening and confirmation cutoffs varied by as much as two orders of magnitude**
- **28% of laboratories reported analytical services for both blood and urine**
- **No difference between urine and blood screening and confirmation levels**
  - *Deemed inappropriate due to drug/metabolite concentrations found in those matrices due to therapeutic use or misuse
- **Differences in screening and confirmation cutoffs within the same jurisdiction**
  - *Not a good public policy – the same sample might test either positive or negative depending on which laboratory it was sent to
- **Findings indicated a need for more uniformity amongst laboratories performing testing on DUID casework**

NMS LABS

6

Initial Survey Findings

Top 10 most frequently encountered drugs

- **Top 5 drugs**
  - Cannabis
  - Benzodiazepines & Cocaine
  - Hydrocodone
  - Morphine/Codeine
  - Methamphetamine & Carisoprodol/Meprobamate

TABLE 3—*Survey data—most frequently encountered drugs. Labs (n = 40) were requested to list the 10 drugs most often identified. The drugs and their frequency of mention are listed in the table.*

Drug	Frequency
Cannabis	39
Benzodiazepines*	37
Cocaine	37
Hydrocodone	30
Morphine/Codeine	28
Methamphetamine	26
Carisoprodol/Meprobamate	26
Oxycodone	16
Methadone	12
Antidepressants†	11
Zolpidem	10
Phencylcidine (PCP)	8
Butalbital/Barbiturates‡	7
Diphenhydramine	6
3,4-Methylenedioxymethamphetamine	5
Propoxyphene	5
Ephedrine/Pseudoephedrine	2
Cyclobenzaprine	1
Dextromethorphan	1
Gamma-hydroxybutyrate	1
Ketamine	1
Phenothiazines	1
Tramadol	1

*Diazepam = 28, Alprazolam = 27, Oxazepam/Nordiazepam = 7, Clonazepam = 4, Lorazepam = 3, Temazepam = 1, and benzodiazepines with no specific information = 2.
†Venlafaxine = 2, Amitriptyline = 1, Fluoxetine = 1, Citalopram = 1, and antidepressants with no specific information = 6.
‡Butalbital = 5, Barbiturates with no specific information = 2.

7

2007 Recommendations

- **44 drugs listed in scope for both blood and urine specimens**
  - Not an exhaustive list
  - Acknowledgement of regional variability of drug trends
  - Does not include drugs where immunoassays are not commercially available
    - GHB, hallucinogens, inhalants
- **Cutoffs based on analytical methodology and good laboratory practice rather than pharmacology or the probability of impairment**

Blood	Urine
Interpreted by comparison with other populations	**Easy to collect**
Ratios of parent to metabolite can differentiate acute from recent or chronic use	**Can test positive for drugs long after impairing effects have dissipated**
Difficult to collect • Requires a phlebotomist or medical staff • Delay in collection	**No verified correlation between urine drug concentrations and effects**

8

2012 Survey / 2013 Recommendations

Journal of Analytical Toxicology 2013;37:552–558
doi:10.1093/jat/bkt059 Advance Access publication August 13, 2013

Special Issue

Recommendations for Toxicological Investigation of Drug-Impaired Driving and Motor Vehicle Fatalities

Barry K. Logan[1,2,*], Kayla J. Lowrie[1], Jennifer L. Turri[1], Jillian K. Yeakel[1], Jennifer F. Limoges[3], Amy K. Miles[4], Colleen E. Scarneo[5], Sarah Kerrigan[6] and Laurel J. Farrell[7]

[1]Center for Forensic Science Research and Education, Fredric Rieders Family Renaissance Foundation, Willow Grove, PA, USA, [2]NMS Labs, Willow Grove, PA, USA, [3]New York State Police Forensic Investigation Center, Albany, NY, USA, [4]Wisconsin State Laboratory of Hygiene, Madison, WI, USA, [5]New Hampshire Department of Safety, Division of State Police Forensic Laboratory, Concord, NH, USA, [6]Sam Houston State University, Huntsville, TX, USA, and [7]Toxicologist/Consultant, Longmont, CO, USA

*Author to whom correspondence should be addressed. Email: barry.logan@frfoundation.org

This report describes the review and update of a set of minimum recommendations for the toxicological investigation of suspected alcohol and drug-impaired driving cases and motor vehicle fatalities involving drugs or alcohol. The recommendations have the goal of ensuring that a consistent set of data regarding the most frequently encountered drugs linked to driving impairment is collected for practical application in the investigation of those cases and to allow epidemiological monitoring and the development of evidence-based public policy on this important public safety issue. The recommendations are based on a survey of practices in US laboratories performing this kind of analysis, consideration of existing epidemiological crash and arrest data and practical considerations of widely available technology platforms in laboratories performing this work. The final recommendations were derived from a consensus meeting of experts recruited from survey respondents and the membership of the National Safety Council's Alcohol, Drug and Impairment Division (formerly known as the Committee on Alcohol and Other Drugs, CADD).

Introduction

Increasing attention is being paid to the issue of drug impaired driving in the USA and around the world. Between 2006 and 2009, the European Union funded the Driving Under the Influence of Drugs (DRUID) project, a collaboration of 57 institutions in 19 countries, amassing convincing findings from over 50 epidemiological, behavioral, roadside survey and technology evaluation studies concerning the relationship between drug use and driving impairment (1). Many of the findings from DRUID and its predecessors are now being addressed in Europe in the form of policy and legislative reform, including the expansion of roadside oral fluid testing, drug categorization for consumer and dispenser education and zero-tolerance laws for illicit drug use. In the USA, a National Roadside Survey of drug and alcohol use by drivers was conducted in 2007 (2). The survey included the collection of blood and oral fluid samples from 5,000 subjects, which were analyzed for the presence of drugs. This study brought the high incidence of potentially impairing drug use in the driving population to the attention of the public and policy makers. A follow-up, case-controlled crash risk study is in progress. A 2006 report on drug use in fatally injured drivers in Washington State (3) demonstrated high positivity rates for drug use in fatally injured drivers. This study found central nervous system (CNS)-active drugs in 39% of fatally injured drivers. CNS depressants including carisoprodol, diazepam, hydrocodone, diphenhydramine, amitriptyline and others were detected in 14.1% of cases. Cannabinoids were present in 12.7% of cases, and CNS stimulants, including cocaine and amphetamines, in 9.7% of cases. Logan and Barnes (4) described rates of drug and alcohol use by suspects in vehicular assault and vehicular homicide cases, demonstrating that 65.4% of suspects were positive for alcohol use, while 50.1% were positive for drug use. Moreover, of the alcohol-positive cases, 51.3% were additionally positive for drug use. Other evidence that the prevalence of drug use in drivers is significantly under-reported when alcohol use is involved was shown by Limoges *et al.* in 2009. In that report, DUI cases in which only alcohol testing was requested, but on which drug testing was subsequently performed, 40% of the alcohol-positive drivers were presumptively positive for drugs (5). In 2012, the National Highway Traffic Safety Administration (NHTSA) issued a report proposing guidelines for standardization in the evaluation of both therapeutic and abused drugs to allow better informed prescribing practices and public education (6).

Other groups have also called for more attention to the drugged driving issue, in particular demanding better practices and standardization of analytical toxicology procedures. In 2010 and again in 2012, the National Governors Highway Safety Association (NGHSA) called for the evaluation of the feasibility of establishing national standards for various controlled substances involved in drug-impaired driving (7). In 2010, the US Office of National Drug Control Policy (ONDCP) issued its national strategy for drug demand reduction, and for the first time included drug-impaired driving as part of that strategy. In 2012, the ONDCP made a similar recommendation in its National Drug Control Strategy (8) calling for the development of standardized screening methodologies for drug testing laboratories to use in impaired driving investigations. In addition, the ONDCP plan calls for the implementation of oral fluid testing as a tool to aid impaired driving enforcement. In November 2012, the National Transportation Safety Board (NTSB), an independent federal agency charged by Congress with investigating every civil aviation accident in the USA and significant accidents in other modes of transportation including railroad, highway and marine, called on NHTSA to support the development of standard practices for drug testing in transportation accident investigations (9). NHTSA itself has identified a weakness in the key epidemiological tool it uses to track alcohol and drug involvement in traffic fatalities: The Fatality Accident Reporting System (FARS) reflects the fact that drug-use data are either not generated or not reported in ~70% of traffic fatalities (10). The data have further limitations based on the fact that among those states

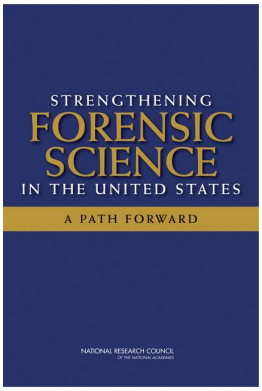
Increasing DUID Prevalence Prompts 2012 Survey

- **The issue of drug impaired driving in the U.S. became the focus of top safety organizations who called for standardization which prompted another survey with updated recommendations**

National Roadside Survey	Highlighted the high incidence of potentially impairing drug use in the driving population
National Highway Traffic Safety Administration (NHTSA)	Issued a report proposing guidelines for standardization in evaluating drugs
National Governors Highway Safety Association (NGHSA)	Called for the evaluation of the feasibility of establishing national standards for controlled substances in drug-impaired driving
US Office of National Drug Control Policy (ONDCP)	• Issued national strategy for drug demand reduction including drug-impaired driving • Called for the development of standardized screening methodologies for drug testing laboratories • Called for implementation of oral fluid testing as a tool to aid in impaired driving performance
National Transportation Safety Board (NTSB)	Called on NHTSA to support the development of standard practices for drug testing in transportation accident investigations

Increasing DUID Prevalence Prompts 2012 Survey

- **Laboratories highlighted prevalence of drug use in driving cases**
  - Under-reporting of drugs when alcohol is detected
  - Other drugs present when alcohol tested positive
- **The 2009 National Academy of Sciences (NAS) Report**
  - Called for better standardization of approaches to forensic analysis and consensus-based standards



11

2012 Survey Findings

- **Questions related to:**
  - Laboratory type
  - Turnaround time and workload data
  - Matrices tested and screening and confirmation procedures
  - Staffing and training
  - Materials needed
  - Compliance with previous iteration of recommendations (scope and sensitivity)
- **Survey via SurveyMonkey® completed by 96 laboratories**
  - State, county, city, private, and academic laboratories

12

2012 Survey Findings

Top 20 most frequently encountered drugs

- **Top 5 drugs (previous survey)**
  - Cannabis
  - Benzodiazepines & Cocaine
  - Hydrocodone
  - Morphine/Codeine
  - Methamphetamine & Carisoprodol/Meprobamate

Table I
Frequency of drug appearing in top 20 most prevalent drugs in oversampled laboratories ($N = 13$)

Compound	Number of laboratories reporting this compound/class in their top 20
THC and metabolites	13
Alprazolam/alpha-hydroxyalprazolam	13
Diazepam/nordiazepam	13
Cocaine and metabolites	13
Morphine	13
Oxycodone	12
Hydrocodone	12
Carisoprodol/meprobamate	11
Zolpidem	11
Methamphetamine	9
Clonazepam/7-aminoclonazepam	9
Amphetamine	9
Methadone	9
Lorazepam	9
Codeine	7
Diphenhydramine	6
Tramadol	6
phencyclidine (PCP)	5
Hydromorphone	5
Citalopram	4
Temazepam	3
Oxazepam	2
Trazodone	2
Oxymorphone	2
Butalbital	2
Dihydrocodeine	2
Pseudoephedrine	2
6-Acetylmorphine	2
Fentanyl	2
3,4-methylenedioxymethamohetamine (MDMA)	2
Fluoxetine/norfluoxetine	1
Venlafaxine/norvenlafaxine	1
Gabapentin	1
Cyclobenzaprine	1
Amitriptyline	1
Topiramate	1

13

Assessing Compliance with 2007 Recommendations

2012 Survey Findings

- **~30% of laboratories not in compliance (blood) disagreed with some aspect with the recommendation**
- **~18% of laboratories not in compliance (urine) disagreed with some aspect with the recommendation**
- **Reasons for not meeting recommendations (blood and urine):**
  - Deficiencies in staffing, appropriate instrument technology, instrument capacity, method validation
  - Qualitative analysis only or quantitative analysis in select blood cases
  - DUID law in their jurisdiction covers only scheduled substances (hard to justify expenditure of resources on more extensive testing)

14

2013 Recommendations

Established Tier I and Tier II

Tier I	Tier II

• **Drugs most prevalent in US driving populations**
• **Strongest evidence of impairment**
• **Detected by the use of commercially available immunoassays**
• **Minimum acceptable scope for DUID testing (33 compounds)**
  • Blood, urine, and oral fluid
	• **Drugs less frequently encountered**
	  • Regional rather than national significance
	  • Beyond routine analytical capabilities of some laboratories
	• **Associated with the potential for impairment**
	• **Includes synthetic cannabinoids, CNS stimulants and depressants, narcotic analgesics, dissociative drugs, hallucinogens, and inhalants**

NMS LABS

15

2013 Recommendations

- **Acknowledgement of widespread practice of omitting drug testing if the blood alcohol testing exceeds 0.08g/100mL in blood, or g/210L in breath**
  - Known as “stop-limit” testing
  - Creates blind spot in knowledge of combined drug and alcohol use
- **Laboratories must offer confirmatory testing for all compounds included in screening scope**
  - Only report test results for confirmed compounds
  - Should not report presumptive screening-positive test result
    - Identity another laboratory that can perform confirmatory testing if testing is not available at original laboratory

NMS LABS

16

2013 Recommendations

Matrices

Blood

- Preferred specimen
- Concentrations can be evaluated within context (therapeutic, toxic, recreational use)

Urine

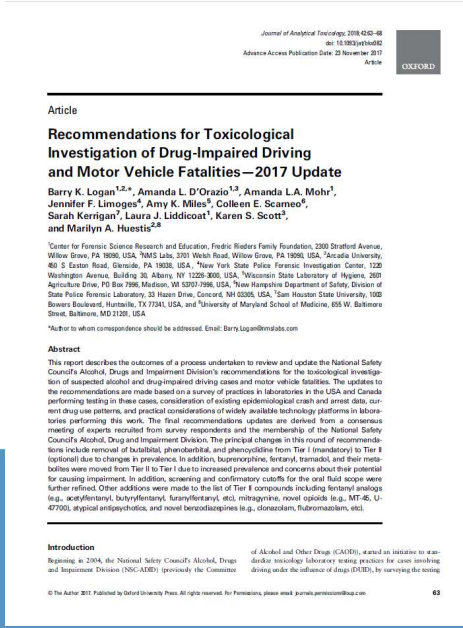
- Demonstrates prior drug use or exposure
- No verified correlation between urine drug concentrations and effects
- Can test positive for drugs long after impairing effects have dissipated

Oral Fluid

- Collection – easy and low cost
- Obtain proximate to the time of driving
- Preliminary on-site test results available for probable cause or evaluation
- Best suited to per se states or impairment noted from observations or sobriety tests
- Positive result can be used to identify recent drug use

17

2016 Survey / 2017 Recommendations



Journal of Analytical Toxicology, 2018;42:63–68
doi: 10.1093/jat/bkx012
Advance Access Publication Date: 23 November 2017
Article

Article

Recommendations for Toxicological Investigation of Drug-Impaired Driving and Motor Vehicle Fatalities—2017 Update

Barry K. Logan[1,2,*], Amanda L. D'Orazio[1,3], Amanda L.A. Mohr[1], Jennifer F. Limoges[4], Amy K. Miles[5], Colleen E. Scarneo[6], Sarah Kerrigan[7], Laura J. Liddicoat[1], Karen S. Scott[3], and Marilyn A. Huestis[2,8]

[1]Center for Forensic Science Research and Education, Fredric Rieders Family Foundation, 2300 Stratford Avenue, Willow Grove, PA 19090, USA, [2]NMS Labs, 3701 Welsh Road, Willow Grove, PA 19090, USA, [3]Arcadia University, 450 S Easton Road, Glenside, PA 19038, USA, [4]New York State Police Forensic Investigation Center, 1220 Washington Avenue, Building 30, Albany, NY 12226-3000, USA, [5]Wisconsin State Laboratory of Hygiene, 2601 Agriculture Drive, PO Box 7996, Madison, WI 53707-7996, USA, [6]New Hampshire Department of Safety, Division of State Police Forensic Laboratory, 33 Hazen Drive, Concord, NH 03305, USA, [7]Sam Houston State University, 1003 Bowers Boulevard, Huntsville, TX 77341, USA, and [8]University of Maryland School of Medicine, 655 W. Baltimore Street, Baltimore, MD 21201, USA

*Author to whom correspondence should be addressed. Email: Barry.Logan@nmslabs.com

Abstract

This report describes the outcomes of a process undertaken to review and update the National Safety Council's Alcohol, Drugs and Impairment Division's recommendations for the toxicological investigation of suspected alcohol and drug-impaired driving cases and motor vehicle fatalities. The updates to the recommendations are made based on a survey of practices in laboratories in the USA and Canada performing testing in these cases, consideration of existing epidemiological crash and arrest data, current drug use patterns, and practical considerations of widely available technology platforms in laboratories performing this work. The final recommendations updates are derived from a consensus meeting of experts recruited from survey respondents and the membership of the National Safety Council's Alcohol, Drug and Impairment Division. The principal changes in this round of recommendations include removal of butalbital, phenobarbital, and phencyclidine from Tier I (mandatory) to Tier II (optional) due to changes in prevalence. In addition, buprenorphine, fentanyl, tramadol, and their metabolites were moved from Tier II to Tier I due to increased prevalence and concerns about their potential for causing impairment. In addition, screening and confirmatory cutoffs for the oral fluid scope were further refined. Other additions were made to the list of Tier II compounds including fentanyl analogs (e.g., acetylfentanyl, butyrylfentanyl, furanylfentanyl, etc), mitragynine, novel opioids (e.g., MT-45, U-47700), atypical antipsychotics, and novel benzodiazepines (e.g., clonazolam, flubromazolam, etc).

Introduction

Beginning in 2004, the National Safety Council's Alcohol, Drugs and Impairment Division (NSC-ADD) (previously the Committee of Alcohol and Other Drugs (CAOD)), started an initiative to standardize toxicology laboratory testing practices for cases involving driving under the influence of drugs (DUID), by surveying the testing

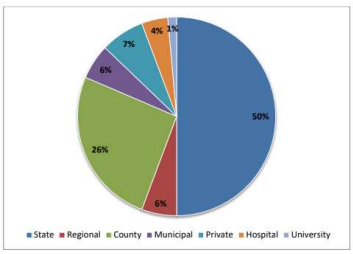
18

NHTSA Prompts 2016 Survey

- **NHTSA requested another review of the recommendations**
  - Changes available in technology since the 2013 recommendations
  - Increased popularity and rapidly changing landscape of novel psychoactive substances (NPS)

2016 Survey Findings

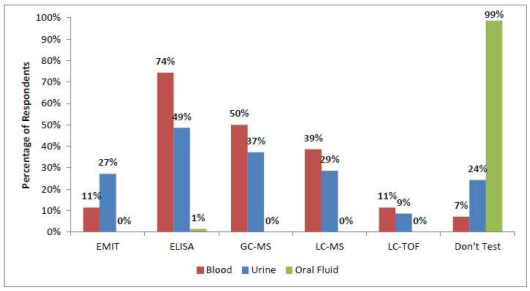
- **Survey via SurveyMonkey® completed by 70 laboratories**
- **Specimens tested:**
  - 90% test blood samples
  - 68% test urine
  - 1% test oral fluid



2016 Survey Findings

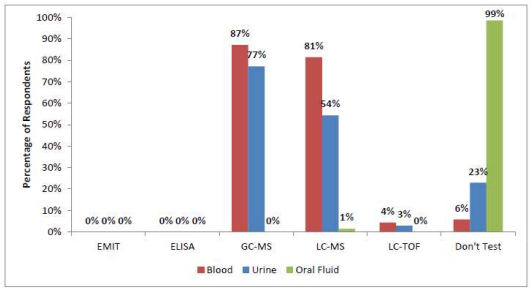
Screening Methods

- **Top three methods**
- Blood
  - 74% ELISA, 50% GC/MS, 39% LC-MS-MS
- Urine
  - 49% ELISA, 37% GC/MS, 29% LC-MS-MS



Confirmation Methods

- **Top three methods**
- Blood
  - 87% GC/MS, 81% LC-MS-MS, 4% LC-TOF
- Urine
  - 77% GC/MS, 54% LC-MS-MS, 3% LC-TOF



21

2016 Survey Findings

- **Compliance with 2013 recommendations**
  - 17% of laboratories met or exceeded all recommendations
  - 52% are partially in compliance and actively developing or validating methods to meet remaining recommendations
  - 20% do not believe the recommendations for some compounds are relevant for their laboratory (low prevalence)
- **Trends (2007 and 2013 recommendations)**
  - Cutoff limits that did not change had about the same or increased compliance
  - Cutoff limits that had been lowered showed lower rates of compliance
    - Laboratories needed more time to meet compliance through revalidation
  - Reasons for lack of compliance:
    - Lack of staffing, instrument capacity, instrument technology, analyst time for method validation, budget, cutoffs not relevant for their laboratory
- **Tier II testing**
  - 81% test for some compounds

22

2016 Survey Findings

Top 10 most frequently detected drugs

- **Top 5 consistent with initial survey and 2012 survey**
  - Alprazolam/alpha-hydroxyalprazolam
  - THC and metabolites
  - Oxycodone
  - Morphine
  - Methamphetamine & Cocaine/metabolites

Table I. Number of laboratories reporting this compound/class in their 10 most frequently detected ($n = 70$)

Compound	Frequency
Alprazolam/alpha-hydroxyalprazolam	65
THC and metabolites	63
Oxycodone	57
Morphine	48
Methamphetamine	46
Cocaine and metabolites	46
Clonazepam/7-aminoclonazepam	41
Diazepam/Nordiazepam	40
Amphetamine	36
Hydrocodone	36
Diphenhydramine	22
Zolpidem	18
Fentanyl	18
Lorazepam	18
Methadone	16
Codeine	15
Carisoprodol/Meprobamate	14
6-Acetylmorphine	13
Citalopram	9
Tramadol	9
Hydromorphone	9
Gabapentin	5
Trazodone	4
Oxazepam	3
Fluoxetine/Norfluoxetine	3
Phencyclidine (PCP)	3
Temazepam	3
Cyclobenzaprine	2
Dihydrocodeine	2
Oxymorphone	2
MDMA	1
Amitriptyline	1
Butalbital	1
Topiramate	1

23

Consensus Meeting

- **Subset of survey participants invited to review the results of the 2016 survey and the 2013 recommendations**
  - Selected based on geographic location, agency type, and workload to provide diversity of experience and perspective
  - Provided additional detail on screening and confirmation cutoffs used in their laboratory
  - Used peer-reviewed literature to assist with promotion/demotion of analytes to Tier I and Tier II scope
  - Performed a line-by-line review of the 2013 recommendations using a modified Delphi method

24

2017 Recommendations

Tier I and Tier II

Promotions

- **Buprenorphine and metabolite, fentanyl, tramadol and metabolite – Tier II to Tier I due to increased prevalence and potential for impairment**

Demotions

- **Butalbital and phenobarbital – Tier I to Tier II due to low prevalence**
- **Phencyclidine (PCP) – Tier I to Tier II due to low/regional prevalence**

Removals from Tier II

- **Meperidine and propoxyphene – due to discontinued availability in the U.S.**
- **Due to low prevalence**
  - Modafinil, citalopram, clonidine, doxepin, fluoxetine, olanzapine, paroxetine, phenazepam, quetiapine, risperidone, sertraline, trazodone, triazolam, venlafaxine, zaleplon, LSD, psilocybin

Additions to Tier II

- **Increased prevalence and potential for impairment**
  - Fentanyl analogs, mitragynine, novel opioids, atypical antipsychotics, novel benzodiazepines
- **Tricyclic antidepressants added as a class**

25

2017 Recommendations

Changes to cutoffs

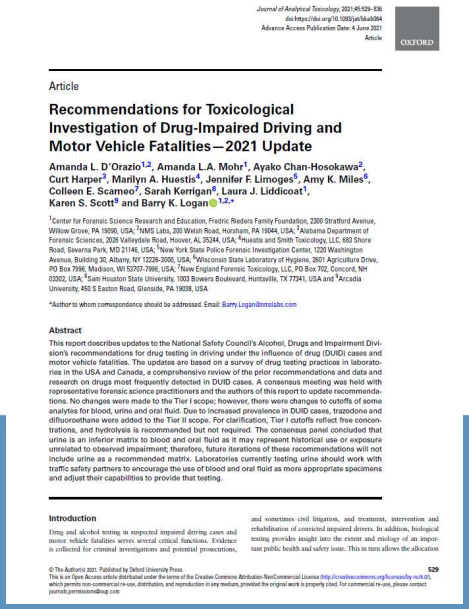
- **Blood**
  - Screening cutoffs for low dose benzodiazepines changed to 10 ng/mL and 50 ng/mL for high dose
  - Cutoff for oxymorphone was eliminated – screening for oxycodone for ELISA
- **Urine**
  - Cutoff established for carboxy-THC and zolpidem – screening using ELISA
  - Cutoff removed for MDMA/MDA – screening for amphetamine/methamphetamine using ELISA
- **Oral fluid**
  - Cutoffs improved based on 1 laboratory's validated testing

Matrices

- **Urine is best suited to demonstrate historical drug use or exposure**
  - Less reliable specimen in the context of impaired driving
  - Inferior to blood and oral fluid
  - Should be interpreted caution

26

2020 Survey / 2021 Recommendations



Journal of Analytical Toxicology, 2021;45:529–536
doi:https://doi.org/10.1093/jat/bkaa064
Advance Access Publication Date: 4 June 2021
Article

OXFORD

Article

Recommendations for Toxicological Investigation of Drug-Impaired Driving and Motor Vehicle Fatalities—2021 Update

Amanda L. D'Orazio[1,2], Amanda L.A. Mohr[1], Ayako Chan-Hosokawa[2], Curt Harper[3], Marilyn A. Huestis[4], Jennifer F. Limoges[5], Amy K. Miles[6], Colleen E. Scarneo[7], Sarah Kerrigan[8], Laura J. Liddicoat[1], Karen S. Scott[9] and Barry K. Logan[1,2,*]

[1]Center for Forensic Science Research and Education, Fredric Rieders Family Foundation, 2390 Stratford Avenue, Willow Grove, PA 19090, USA; [2]NMS Labs, 200 Welsh Road, Horsham, PA 19044, USA; [3]Alabama Department of Forensic Sciences, 2026 Valleydale Road, Hoover, AL 35244, USA; [4]Huestis and Smith Toxicology, LLC, 683 Shore Road, Severna Park, MD 21146, USA; [5]New York State Police Forensic Investigation Center, 1220 Washington Avenue, Building 30, Albany, NY 12226-3000, USA; [6]Wisconsin State Laboratory of Hygiene, 2601 Agriculture Drive, PO Box 7996, Madison, WI 53707-7996, USA; [7]New England Forensic Toxicology, LLC, PO Box 702, Concord, NH 03302, USA; [8]Sam Houston State University, 1003 Bowers Boulevard, Huntsville, TX 77341, USA and [9]Arcadia University, 450 S Easton Road, Glenside, PA 19038, USA

*Author to whom correspondence should be addressed. Email: Barry.Logan@nmslabs.com

Abstract

This report describes updates to the National Safety Council's Alcohol, Drugs and Impairment Division's recommendations for drug testing in driving under the influence of drug (DUID) cases and motor vehicle fatalities. The updates are based on a survey of drug testing practices in laboratories in the USA and Canada, a comprehensive review of the prior recommendations and data and research on drugs most frequently detected in DUID cases. A consensus meeting was held with representative forensic science practitioners and the authors of this report to update recommendations. No changes were made to the Tier I scope; however, there were changes to cutoffs of some analytes for blood, urine and oral fluid. Due to increased prevalence in DUID cases, trazodone and difluoroethane were added to the Tier II scope. For clarification, Tier I cutoffs reflect free concentrations, and hydrolysis is recommended but not required. The consensus panel concluded that urine is an inferior matrix to blood and oral fluid as it may represent historical use or exposure unrelated to observed impairment; therefore, future iterations of these recommendations will not include urine as a recommended matrix. Laboratories currently testing urine should work with traffic safety partners to encourage the use of blood and oral fluid as more appropriate specimens and adjust their capabilities to provide that testing.

Introduction

Drug and alcohol testing in suspected impaired driving cases and motor vehicle fatalities serves several critical functions. Evidence is collected for criminal investigations and potential prosecutions, and sometimes civil litigation, and treatment, intervention and rehabilitation of convicted impaired drivers. In addition, biological testing provides insight into the extent and etiology of an important public health and safety issue. This in turn allows the allocation

2020 Survey

- **What prompted this review?**
  - Drug trends continuing to evolve in impaired driving cases
  - Changes available in technology (widespread availability, more sensitivity)
- **The American Academy of Forensic Sciences Standards Board (ASB) used the 2017 recommendations as the basis for Standard 120 "Standard for the Analytical Scope and Sensitivity of Forensic Toxicology Blood Testing in Impaired Driving Investigations"**

ANSI/ASB Standard 120, First Edition
2021

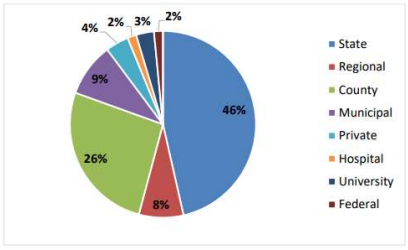
Standard for the Analytical Scope and Sensitivity of Forensic Toxicological Testing of Blood in Impaired Driving Investigations

ASB ACADEMY STANDARDS BOARD

ANSI

2020 Survey Findings

- **Survey via SurveyMonkey® completed by 65 laboratories**
- **Specimens tested**
  - 89% test blood samples
  - 63% test urine
  - 3% test oral fluid

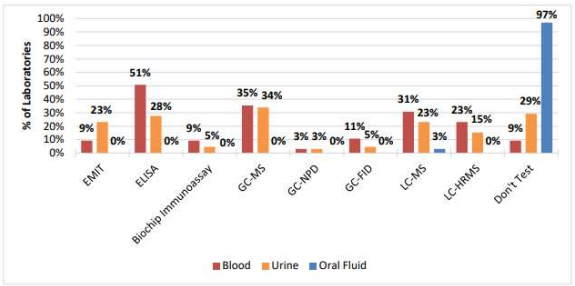


29

2020 Survey Findings

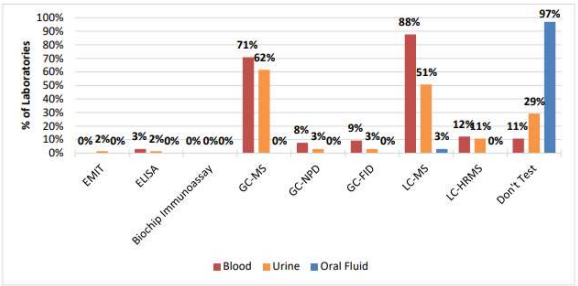
Screening Methods

- **Top three methods**
- Blood
  - 51% ELISA, 35% GC/MS, 31% LC-MS-MS
- Urine
  - 34% GC/MS, 28% ELISA, 23% LC-MS-MS and EMIT



Confirmation Methods

- **Top three methods**
- Blood
  - 88% LC-MS-MS, 71% GC/MS, 12% LC-HRMS
- Urine
  - 62% GC/MS, 51% LC-MS-MS, 11% LC-HRMS



30

2020 Survey Findings

- **Compliance with 2017 recommendations**
  - 12% of laboratories met or exceeded all recommendations
  - 40% are partially in compliance and actively developing or validating methods to meet remaining recommendations
  - 19% do not believe the recommendations for some compounds are relevant for their laboratory (low prevalence)
  - 44% were close to meeting the recommendations; however, method validation was not a high management priority
- **Trends (2013 and 2017 recommendations)**
  - Cutoff limits that did not change had about the same or increased compliance
  - Cutoff limits that had been lowered showed lower rates of compliance
    - Laboratories needed more time to meet compliance through revalidation
  - Reasons for lack of compliance:
    - Lack of staffing, instrument capacity, instrument technology, analyst time for method validation, budget, cutoffs not relevant for their laboratory
- **Tier II testing**
  - 91% test for some compounds

NMS LABS

2020 Survey Findings

Top 15 most frequently detected drugs

- **Top 5 mostly consistent with previous surveys**
  - Most notable: Fentanyl
    - 26% of laboratories in 2016 survey
    - 70% of laboratories in 2020 survey

Table I. Number of Laboratories Reporting This Drug/Drug Class in Their 15 Most Frequently Detected Drugs ($n = 64$)

Compound	Frequency
Δ^9-THC and metabolites[a]	62
Alprazolam/alpha-hydroxyalprazolam[a]	57
Cocaine and metabolites[a]	57
Methamphetamine[a]	56
Diazepam/nordiazepam[a]	48
Clonazepam/7-aminoclonazepam[a]	45
Fentanyl[a]	45
Amphetamine[a]	43
Hydrocodone[a]	34
Morphine[a]	34
Oxycodone[a]	34
Diphenhydramine[b]	30
Lorazepam[a]	26
Zolpidem[a]	23
Methadone[a]	22
Gabapentin[b]	21
Codeine[a]	18
Buprenorphine/norbuprenorphine[a]	15
Tramadol/O-desmethyltramadol[a]	14
Phencyclidine (PCP)[b]	12
6-Acetylmorphine[a]	11
Fentanyl analogs[b]	11
Oxazepam[a]	11
Temazepam[a]	10
Citalopram	9
3,4-MDMA[a]	8
Carisoprodol/meprobamate[a]	8
Cyclobenzaprine[b]	8
Dextromethorphan[b]	8
Hydromorphone[a]	6
Novel benzodiazepines[b]	6
Trazodone	6
Mitragynine[b]	4
Doxylamine[b]	3
Novel opioids[b]	3
Oxymorphone[a]	3
Tricyclic antidepressants[b]	3
Etizolam	2
Heroin	2
Inhalants[b]	2
Ketamine[b]	2
Midazolam	2
Phenylpropanolamine	2
Pseudoephedrine	2
Sertraline	2
Barbiturates[b]	1
Cathinones[b]	1
Chlorpheniramine[b]	1
Ethanol	1
Flualprazolam	1
Guaifenesin	1
Hydroxyzine[b]	1
Lamotrigine[b]	1
Methylphenidate[b]	1
Olanzapine	1
Phentermine	1
Synthetic cannabinoids[b]	1
Valproic acid[b]	1
Venlafaxine	1

[a]Tier I compounds.
[b]Tier II compounds.

NMS LABS

Consensus Meeting

- **Subset of survey participants invited to review the results of the 2020 survey and the 2017 recommendations**
  - Selected based on geographic location, agency type, workload, and matrices tested to provide diversity of experience and perspective
  - Performed a line-by-line review of the 2017 recommendations using a modified Delphi method

2021 Recommendations

Tier I and Tier II

Tier I

- **No changes to scope (no promotions/demotions)**
- **Screening and confirmation cutoffs for carisoprodol raised to 1000 ng/mL**
- **Screening cutoff for meprobamate removed in blood and urine**
- **Confirmation cutoff for norbuprenorphine raised to 1 ng/mL in blood**
- **Confirmation cutoff for fentanyl raised to 1 ng/mL in urine**
- **Compounds should have cross-reactivity at or above 80% of the target ELISA compound**
- **Changes to several oral fluid cutoffs**

Tier II

- **Trazodone added due to increased prevalence (previously removed from the 2013 recommendations due to decreased prevalence)**
- **Difluoroethane (DFE) added due to increased prevalence**

Matrices

- **Urine**
  - Demonstrates prior drug use or exposure
  - No verified correlation between urine drug concentrations and effects
  - Last iteration containing urine cutoffs
- **Blood and oral fluid are the preferred matrices for testing**

Trends

35

Trends

Caseload

- Increase reported per laboratory for both drug and alcohol cases

Compliance with Tier I

- Cutoffs that did not change saw an increase in compliance or remained about the same
- Lack of staffing, training, time, money, and laboratory space provide challenges for compliance

Compliance	2013 Recommendations		2017 Recommendations	
	Blood	Urine	Blood	Urine
Met or exceeded recommendations	17%	18%	12%	10%
Did not agree with some recommendations	20%	32%	19%	22%
In process of making changes to meet recommendations	52%	36%	40%	29%
Close to meeting recommendations but not priority	-	-	44%	45%

Instrument Technology

Blood Samples			
Top 3 Screening Methods		Top 3 Confirming Methods	
2016	2020	2016	2020
ELISA - 74%	ELISA - 51%	GC-MS - 87%	LC-MS - 88%
GC-MS - 50%	GC-MS - 35%	LC-MS - 81%	GC-MS - 71%
LC-MS - 39%	LC-MS - 31%	LC-TOF - 4%	LC-HRMS - 12%

Urine Samples			
Top 3 Screening Methods		Top 3 Confirming Methods	
2016	2020	2016	2020
ELISA - 49%	GC-MS - 34%	GC-MS - 77%	GC-MS - 62%
GC-MS - 37%	ELISA - 28%	LC-MS - 54%	LC-MS - 51%
LC-MS - 29%	EMIT, LC-HRMS - 23%	LC-TOF - 3%	LC-HRMS - 11%

Tier II Testing

- In 2016, 81% of laboratories
- In 2020, 91% of laboratories

Tier I Scope

- Top drugs consistently detected year after year
  - All in Tier I or Tier II scope

36

2024 Survey and Recommendations

37

What Could Happen Next?

My opinions/predictions after involvement with 2 iterations

- **Tier I**
  - 2021 Recommendations – last iteration to include urine as a matrix
  - Continue to enhance oral fluid cutoffs
  - Demotion of carisoprodol and meprobamate to Tier II?
  - Promotion of gabapentin from Tier II?
- **Tier II**
  - Removal of some compounds after reviewing Top 15 most frequently detected drugs?
  - Continue to include NPS as a class
  - Call out specific hallucinogens?
- **Survey is currently open – is your laboratory participating?**

38

NMS LABS

Work at NMS Labs

39

Tier I Testing

Testing	Compliance – Blood

• **Matrices for testing**
  • Blood, urine, oral fluid
  • Vitreous fluid (confirm findings, ex. 6-MAM and ethanol)
• **Screening technologies**
  • Blood – ELISA, LC-HRMS
  • Urine – EMIT, LC-HRMS
  • Oral fluid – LC-MS
• **Confirmation technologies**
  • Blood – GC-MS, LC-MS
  • Urine – GC-MS, LC-MS
  • Oral fluid – LC-MS
	• **Screening – mostly compliant**
	  • Above the cutoff for some low-dose benzodiazepines
	  • Ex. clonazepam and 7-aminoclonazepam
	  • Basic panel via ELISA – detected together eliciting a combined positive response so setting each at 10 ng/mL is not a priority at this time
	  • Expanded panel via LC-HRMS – able to detect
	  • Above the cutoff for morphine
	• **Confirmation – mostly compliant**
	  • Above the cutoff for meprobamate

NMS LABS

40

Tier II Testing

- **All compounds available for testing at NMS Labs**
  - Not all within DUID/DRE panel but can be tested for upon request

Table III. Recommended Tier II Drugs/Drug Classes

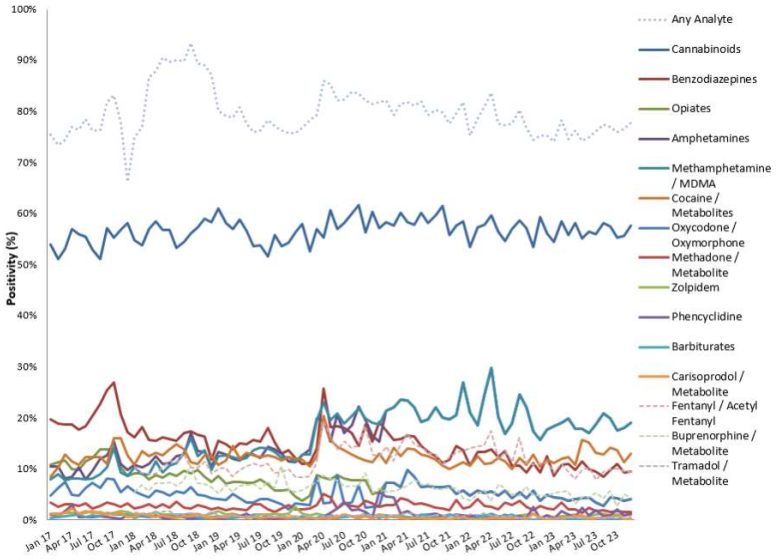
DRE category; cannabis	Novel benzodiazepines
Synthetic cannabinoids	Phenytoin
DRE category; CNS stimulants	Pregabalin
Cathinones	Secobarbital
Methylphenidate	Topiramate
Mitragynine	Trazodone
DRE category; CNS depressants	Tricyclic antidepressants
Atypical antipsychotics	Valproic acid
Barbiturates	Zopiclone
Carbamazepine	DRE category; narcotic analgesics
Chlordiazepoxide	Fentanyl analogs
Chlorpheniramine	Novel opioids
Cyclobenzaprine	Tapentadol
Diphenhydramine	DRE category; dissociative drugs
Doxylamine	Dextromethorphan
Gabapentin	Ketamine
Gamma-hydroxybutyrate	PCP
Hydroxyzine	DRE category; inhalants
Lamotrigine	Difluoroethane
Mirtazapine	Inhalant class
	DRE category; hallucinogens
	Hallucinogens

41

Drug Positivity

2017-2023

- **Top dotted line = any analyte**
  - 66-93%, average = 76%
- **#1 drug detected = cannabinoids**
  - Consistent with top drugs detected on DUID survey

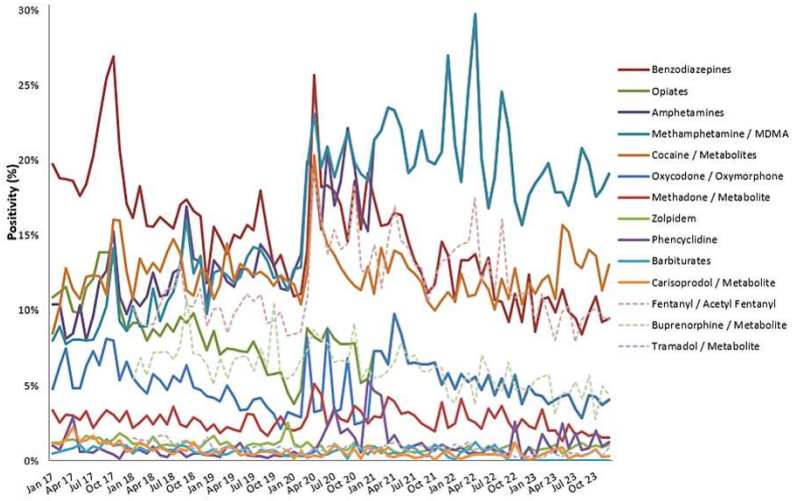


42

Drug Positivity

2017-2023

- **Other top drugs**
  - Methamphetamine/MDMA, Amphetamines
  - Cocaine/metabolites
  - Benzodiazepines
  - Fentanyl/Acetyl fentanyl
- **Consistent with top drugs detected on DUID survey**



43

44

Thank you!

Any questions, please email me at

Amanda.Dorazio@NMSLabs.com

NMS Labs
200 Welsh Road
Horsham, PA 19044

nmslabs.com company/nms-labs nmslabs nms_labs

45