Toxicology 101

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Overview

- What is forensic toxicology?
- Sub-disciplines
- Role of the toxicologist
- Laboratory methodology
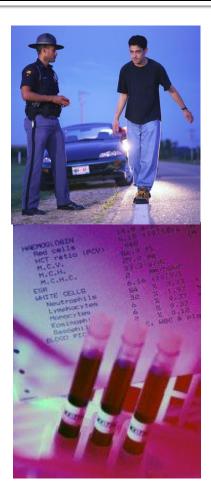- Interpretation
- Challenges

Toothbrush Defense

Forensic Toxicology

Drugs and Poisons in Biological Samples

Three sub-disciplines:

- **Human performance toxicology**
- Postmortem forensic toxicology
- Forensic urine drug testing

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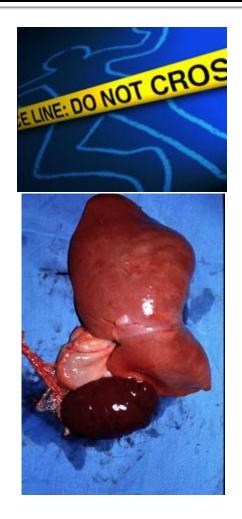- Postmortem forensic toxicology
- **Forensic urine drug testing**

What is Human Performance Toxicology?

- "Behavioral toxicology"
- How drugs influence human performance or behavior
- Improve performance (e.g. athletics)
- Decrease performance (e.g. criminal context)
  - Impaired driving
  - Drug-facilitated sexual assault
  - Other criminal acts while under the influence of a drug
  - (Death investigation)

Role of the Toxicologist

- Test
- Interpret
- Testify

- B.S. Chemistry, biology or related science
- M.S. or Ph.D. in Chemistry, FS or related science

Toxicology Testing

Alcohol

- Gas chromatography-Flame Ionization Detection (GC-FID)
- Headspace GC
- Standardized methodology
- Well established and accepted

Drugs

- Two-step process
  - Screening (often "immunoassay")
  - Confirmation e.g. GC-MS
- Many procedures (many drugs)
- Well established and accepted

Drug Testing – Step I Presumptive Screen

- Antibody-based test (immunoassay)
- <u>Defined "cutoffs"</u>
- Know what these are
- Know what drugs are included in the screen
- Limited scope
- Used to determine what additional tests are necessary
- Rapid (hours)
- False positives & negatives possible
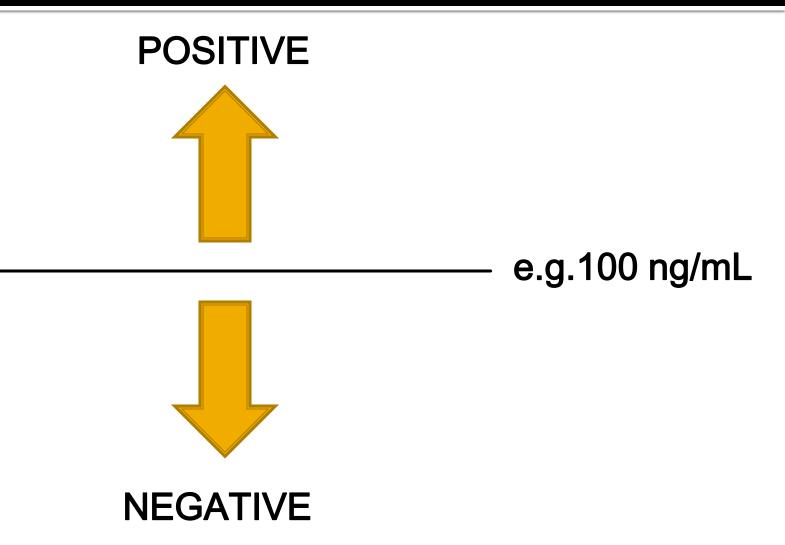- Not forensically defensible without confirmation

Cutoff Concentration

POSITIVE

e.g.100 ng/mL

Cutoff Concentration

POSITIVE

NEGATIVE

e.g.100 ng/mL

Drug Testing – Part II Confirmation

- Gas chromatography-mass spectrometry (GC-MS) or similar
- Sensitive and specific
- Separate and identify
- Used for qualitative and quantitative testing
- Forensically defensible
- Typically report drugs if they are detectable and/or meet specific criteria – rather than an administrative cutoff
- Broad scope (hundreds of drugs)
- Requires separation of the drug from the matrix (blood)
- Labor intensive
- Expensive

Analytical Issues

- Methodology widely accepted
- Extensive scientific literature
- Results may vary between laboratories
  - Sample storage/degradation (biological matrix)
  - Scope of testing
  - Cutoffs vary between labs
  - Equipment/resources in the laboratory
  - Limits of detection/analytical capabilities
  - Policies/procedures regarding testing protocols
  - Non reportable data

Why does it take so long?

- Complex biological matrices
- Isolate the substances prior to analysis
- Purification process (extraction) is labor intensive
- Specific procedures for _isolation_ each drug or class of drug
- Specific procedures for _analysis_ each drug or class of drug
- Results subject to technical/administrative review

Impaired Driving

Alcohol
- Notably the <u>most prevalent</u> drug in impaired driving
- Effects, properties and pharmacokinetics are <u>well understood</u>
- Produce <u>predictable effects</u> in a <u>dose-dependent manner</u>
- Per-se approach

Drugs
- Prevalence not well understood (likely <u>underestimated</u>)
- <u>Many drugs</u> involved (hundreds)
- Scientific literature less mature
- Effects are <u>less predictable</u>
- May require proof of impairment

Toxicology Challenges and Misconceptions in Impaired Driving

- What level of [DRUG] is equivalent to a .o8 BAC?
- *Any* level of [DRUG] indicates impairment
- Quantitative vs. Qualitative toxicology reports (Do you *need* a NUMBER?)
- Can we interpret based upon lab report alone?
- Polypharmacy issues – multiple drug/alcohol combinations
- Training needs
  - New methods for new drugs
  - Interpretive testimony
- Why is the report NEGATIVE?

Are Drugs Important?

- **10 million** people reported driving after illicit drug use (SAMHSA, 2007)
- Drugs (other than alcohol) found in 17.8% fatally injured drivers (NHTSA)
- Drugs detected in 10 to 22% of drivers involved in crashes, often in combination with alcohol
- Drugs detected in up to 40% of injured drivers requiring medical treatment
- Drug use among drivers arrested for motor vehicle offenses is 15-50%
- Driving under the influence of drugs (DUID) is highly significant

SAMHSA – Substance Abuse and Mental Health Services Administration
NHTSA – National Highway Traffic Safety Administration

Impaired Driving Constants

- DUID inherently more complex (scientifically and legally) than alcohol-related DWI
- Fewer studies than for alcohol
- Requires toxicologists with specialized training to *interpret* effects
- Drug *impairment* is determined on a case-by-case basis
- DUID represents a significant number of DWIs
- More difficult to prosecute than alcohol-impaired driving
- Under-reported, under-recognized
- Drugs are constant factor in traffic crashes
- Full impact – not yet known

Impaired Driving Variables

- Statutory schemes vary state to state:
- May require the drug to render a driver *incapable of driving safely*
- May require the drug to *impair a driver's ability to operate a vehicle safely* or require a driver to be "*under the influence*", "*impaired*" *or otherwise affected by an intoxicating drug*
- **"Per-se"** or "**zero tolerance**" drug laws which make it a criminal offense to have a specified drug or metabolite in the body while operating a motor vehicle
- Laboratory policies and procedures vary
- Particularly SOPs, quantitative vs. qualitative services, analytic capability/instrumentation, resources, training
- All these SCIENTIFIC and LEGAL **variables** may influence how we **interpret** a case

Drugs Used

Drug Impaired Driving

Drugs most commonly associated with impaired driving:

- **Cannabinoids**/Marijuana
- **CNS Depressants**
  Sedative-hypnotics, muscle relaxants, antidepressants, antihistamines, anticonvulsants, antipsychotics, anxiolytics
- **CNS Stimulants**
  Cocaine, methamphetamine
- **Narcotic Analgesics**
  Morphine, codeine, hydrocodone (Vicodin), oxycodone (Oxycontin), methadone

Top Ten List

1. THC & metabolite (Carboxy-THC)
2. Cocaine and metabolite (Benzoylecgonine)
3. Methamphetamine
4. Diazepam and metabolite (Nordiazepam)
5. Carisoprodol and metabolite (Meprobamate)
6. Hydrocodone
7. Morphine
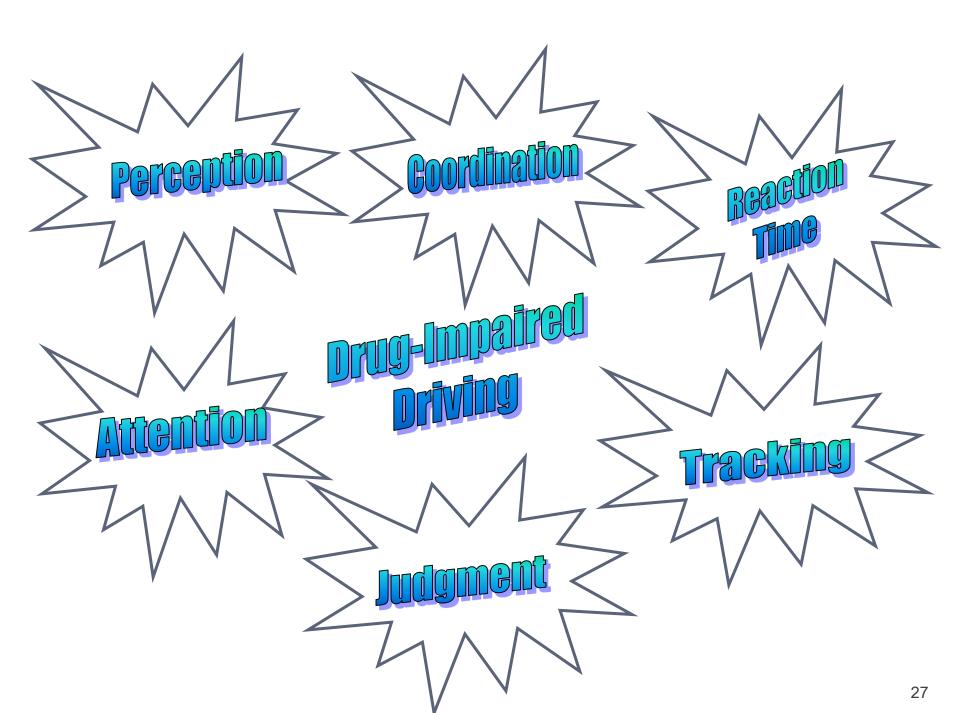8. Alprazolam
9. Zolpidem
10. Methadone

Which Drugs Can Impair Driving?

1. Any drug that can affect the brain's perception, collection, processing, storage or critical evaluation processes

2. Any drug that affects communication of the brain's commands to muscles or organ systems that execute them

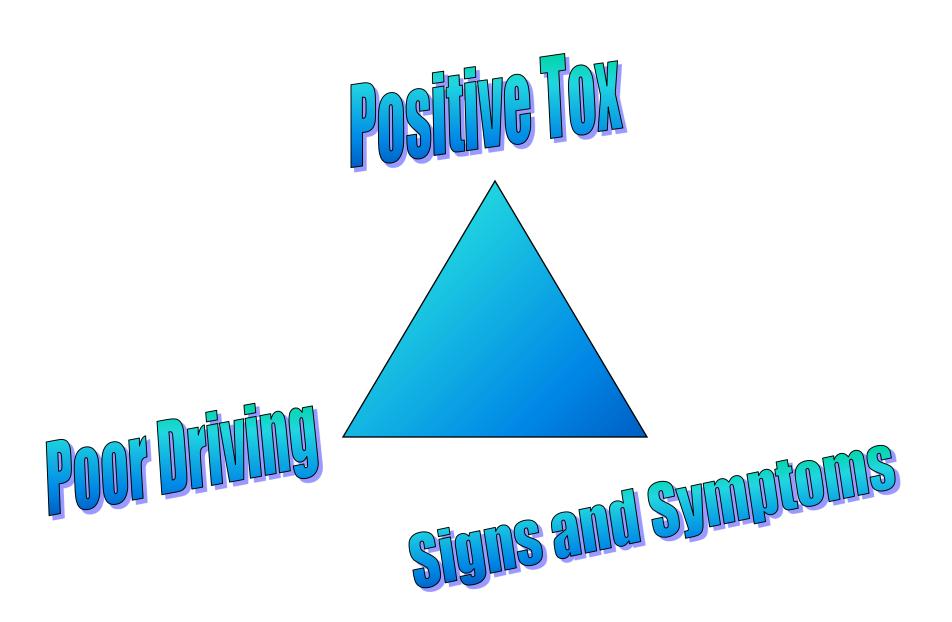*For the most part, drugs that affect the central nervous system (CNS)*

Drug Toxicology Challenges

- More complex
- Often in combination with other drugs and/or alcohol (additive or synergistic effects)
- Scientific literature is complex
- May require a toxicologist to interpret the results and provide an opinion
- These complex issues must be explained to the court using every day language

Perception

Coordination

Reaction
Time

Drug-Impaired
Driving

Attention

Tracking

Judgment

Is this driver impaired?

- Impairment is based on knowledge of the drug(s), intended effects, side effects and toxic effects
- The toxicologist can rarely give an opinion based upon the drug report alone
- The opinion may depend on the context of the case and information gathered by the investigator (situation, environment, observations, performance on field sobriety tests, other evaluations, driving pattern etc.)

Positive Tox

Poor Driving

Signs and Symptoms

Drug Interpretation Issues

- Multiple drug use
- Tolerance (chronic vs. naïve)
- Health
- Metabolism
- Individual sensitivity/response
- Withdrawal
- Put in context of case e.g. environmental factors
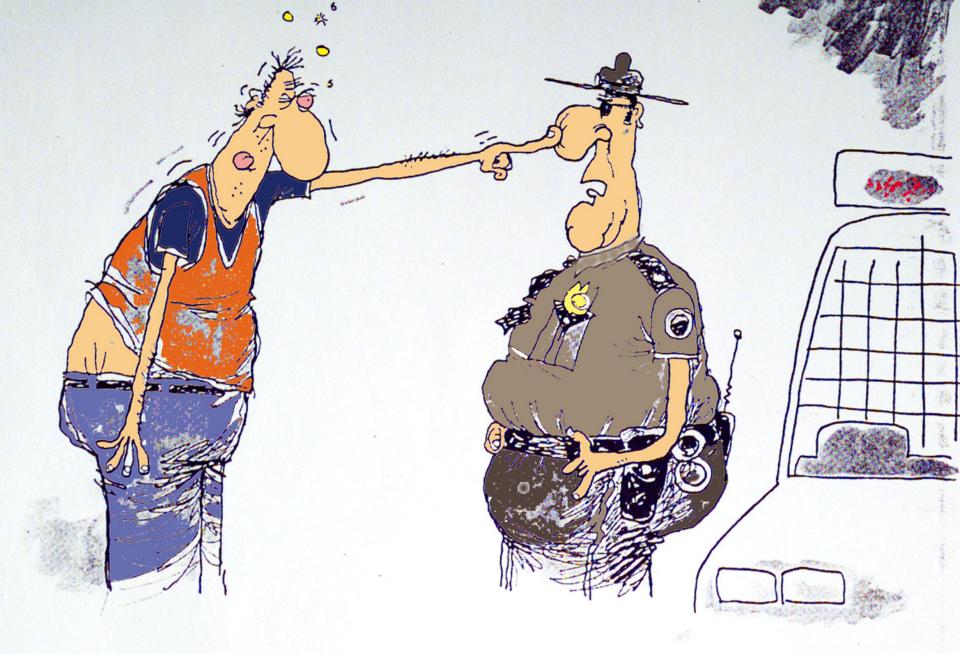- Other factors (distraction, injuries, disease etc)

Signs and Symptoms: Depressants

- Confusion
- Poor divided attention
- Sedation
- Droopy eyelids
- Slowed reaction times
- Memory effects
- HGN

- Poor balance
- Poor coordination
- Unsteadiness
- Slurred speech
- Disorientation
- Low b.p.
- Low pulse

"Once more, only this time touch your nose."

Drug Evaluation and Classification

- Systematic, standardized, post-arrest procedure for Drug Evaluation and Classification (DEC)
- Performed by a trained and certified police officer
- Formally and scientifically validated for drugs
- DEC Certified officers are Drug Recognition Experts (DREs)
- 12-step evaluation of behavior, appearance, psychophysical tests, vital signs, eye measurements
- DRE documents drug signs and symptoms – provides opinion as to which class of drug is responsible for impairment. These can be interpreted by a Toxicologist in a DUID case
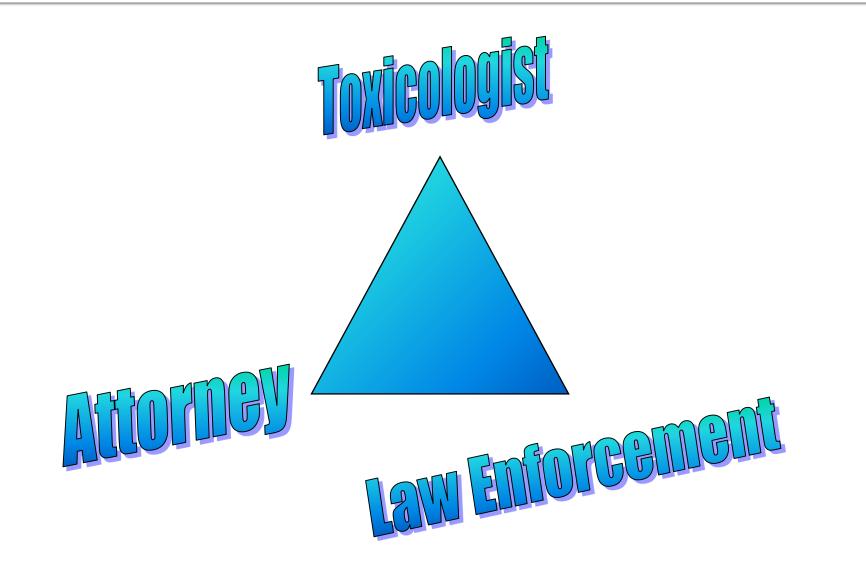- **DRE provides the court with additional information**
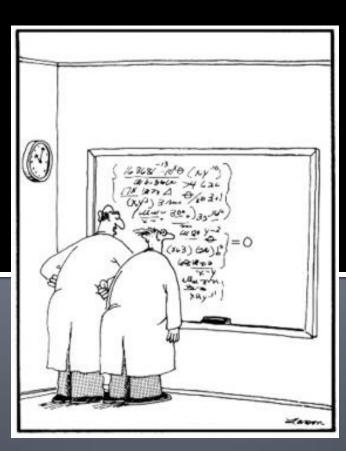
Driving Behavior - Depressants -

- Weaving
- Extreme lane of travel
- Striking other vehicles
- Striking fixed objects
- Slow speed
- Hit and run
- Wrong way driving

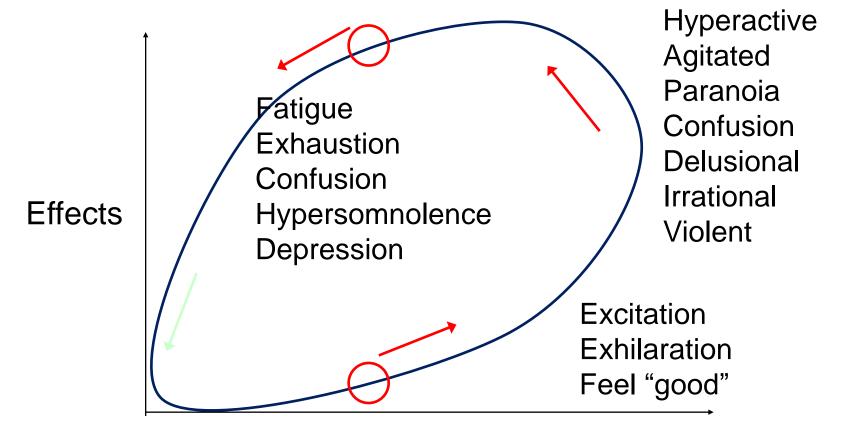# Interpretation Requires Information From Many Sources:

Toxicologist

Attorney

Law Enforcement

What does the number actually mean???

Toxicology Blood Ranges

Drug	Concentration Range
Carboxy-THC	6 – 282 ng/mL
THC	2 – 23 ng/mL
BE	0.01 – 10 mg/L
Cocaine	0.005 – 0.64 mg/L
Methamphetamine	0.05 – 14 mg/L
Amphetamine	0.01 – 0.19 mg/L
Diazepam	0.03 – 5 mg/L
Nordiazepam	0.03 – 3.2 mg/L

Definition of Statistics: *The science of producing unreliable facts from reliable figures*

Example: Methamphetamine High vs Low

Effects

Fatigue
Exhaustion
Confusion
Hypersomnolence
Depression

Hyperactive
Agitated
Paranoia
Confusion
Delusional
Irrational
Violent

Excitation
Exhilaration
Feel "good"

Concentration

Use of Quantitative Results

- Provides valuable information from an interpretive standpoint
- Must be used responsibly
- Should not be interpreted in isolation
- Toxicologist should be prepared to discuss interpretive limitations

The Scientific Literature

- Empirical Considerations
- Epidemiological Studies
- Case Reports
- Laboratory Studies
- Simulator Studies
- On-the-road driving studies

Limitations

- Often not real-world doses
- Often not real driving
- Less complex tasks
- Small populations
- Drug combinations

Hot Tamale Defense

- Vehicle swerves into oncoming traffic
- Speech slurred, watery eyes, HGN present
- Unsteady on his feet, staggering
- Falls over during OLS, WAT
- Stated that he swerved "To pick up a tamale"
- BAC 0.00%
- Toxicology:
  Morphine 0.05 mg/L,
  Meprobamate 20 mg/L
  Carisoprodol 2 mg/L
  Oxycodone 0.13 mg/L
  Hydrocodone 0.06 mg/L
  Diazepam 0.3 mg/L
  Nordiazepam 0.3 mg/L
  Gabapentin, present.

Recommendations for Toxicological Investigation of Drug Impaired Driving

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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, amphetamine, 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

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[3]Washington State Patrol, Forensic Laboratory Services Bureau, 2203 Airport Way S., Suite 360, Seattle, WA 98134.

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Additional Resources

- Drug Toxicology for Prosecutors American Prosecutors Research Institute, 2004.
  http://www.ndaa-apri.org/pdf/drug_toxicology_for_prosecutors_04.pdf

- Drugs and Human Performance Fact Sheets, DOT HS 809 725, National Highway and Traffic Safety Administration, 2004
  http://www.nhtsa.gov/people/injury/research/job185drugs/index.htm

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