



COLLEGE of AMERICAN
PATHOLOGISTS

Drug Testing: Today and Tomorrow

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Introduction: Michael A. Peat, Ph.D.

- Editor-in-Chief of the *Journal of Forensic Sciences*, the official journal of the American Academy of Forensic Sciences (AAFS)
- Consultant to the United States Anti-Doping Agency
- Faculty Member for the American College of Occupational and Environmental Medicine
- Assistant Commissioner of the Forensic Drug Testing Accreditation Program for the College of American Pathologists
- Ph.D. from the University of Utah Department of Biochemical Pharmacology and Toxicology



Michael A. Peat, Ph.D.
Editor-in-Chief, Journal of Forensic Sciences

Objectives

- Share evolution within the US and the major testing programs
- Show data of effectiveness in reducing drug use
- Discuss up-to-date issues with drug use and cheating
- Expand application in other areas like Pain Management and Forensic Toxicology

Topics

- **Urine, Oral Fluid, and Hair Drug Testing**
- Professional Health Monitoring Programs
- Athletic Drug Testing
- What does tomorrow bring?
- Pain Management Programs
- Forensic Toxicology
- Future Challenges

Drug Effects and Detection Periods

Drug Effects	Detection Period
Intoxication	minutes to hours
Impairment	minutes to hours
Under influence	minutes to hours
Sample	Detection Period
Blood (plasma)	minutes to days
Breath	minutes to ?
Oral fluid	minutes to days
Urine	hours to days
Sweat patch	weeks
Hair	days to months
Nails	days to months

Workplace Drug Testing in the US: History

- **Started in the 1980s and is almost routinely performed for pre-employment purposes**
- **Department of Transportation (DOT) and others introduced rules for drug testing in the early 1990s and added alcohol testing rules in the late 1990s**

Workplace Drug Testing in the US: Today

- Program began with 5 drug classes and 7 drugs, now includes 7 classes and 14 drugs
- Regulated testing includes pre-employment, probable cause, random and return to duty testing
- Almost 10 million people covered by this regulated testing – commercial drivers the largest proportion; also covers airline and railroad employees
- Primarily use urine but oral fluid has been approved by Substance Abuse and Mental Health Services Administration (SAMHSA); awaiting DOT rules for its implementation

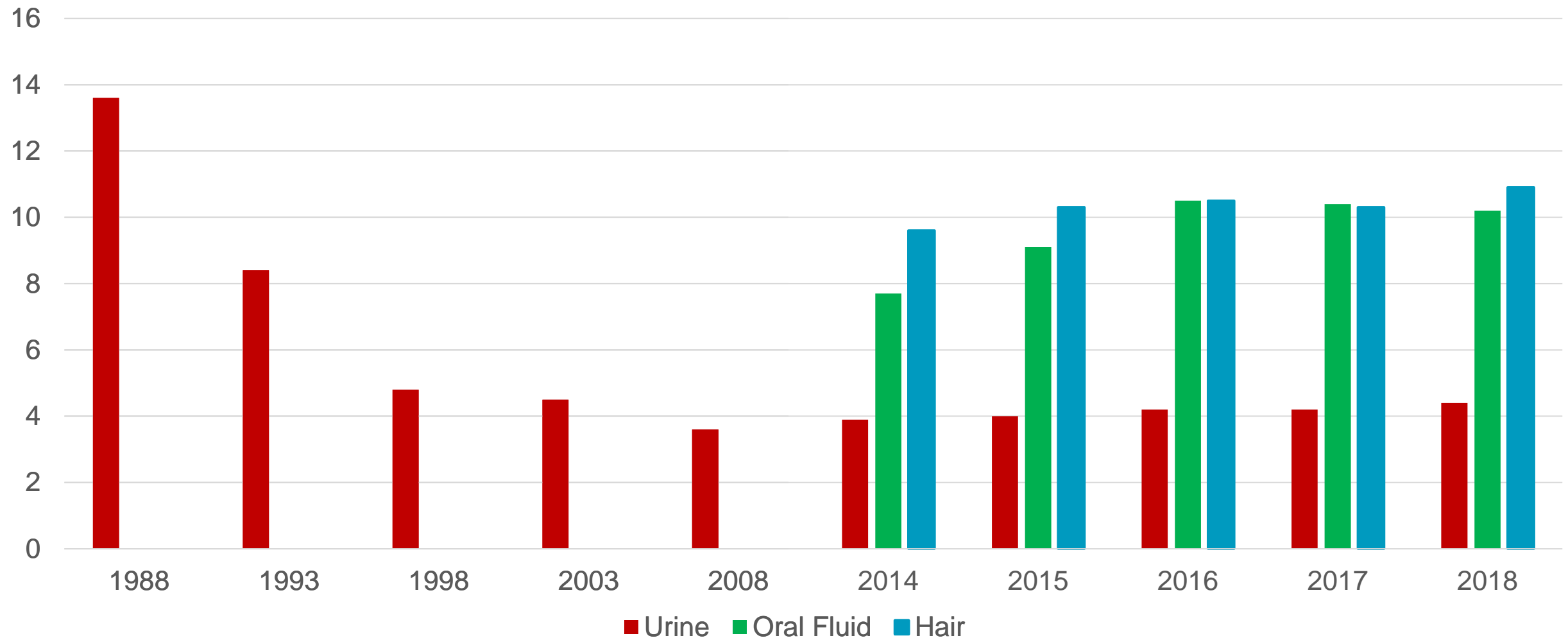
Screening and Confirmation Cut-Offs

Screening Cut-Offs (ng/ml)	
Marijuana Metabolites (TCHA)	50
Cocaine Metabolites	150
Codeine/Morphine	2000
Hydrocodone/Hydromorphone	300
Oxycodone/Oxymorphone	100
6-Acetylmorphine	10
Phencyclidine	25
Amphetamines/Methamphetamine	500
MDMA/MDA	500

Confirmation Cut-Offs (ng/ml)	
THCA	15
Benzoylecognine	100
Codeine	2000
Morphine	2000
Hydrocodone	100
Hydromorphone	100
Oxycodone	100
Oxymorphone	100
6-Acetylmorphine	10
Phencyclidine	25
Amphetamine	250
Methamphetamine	250
MDMA	250
MDA	250

Percent Positives

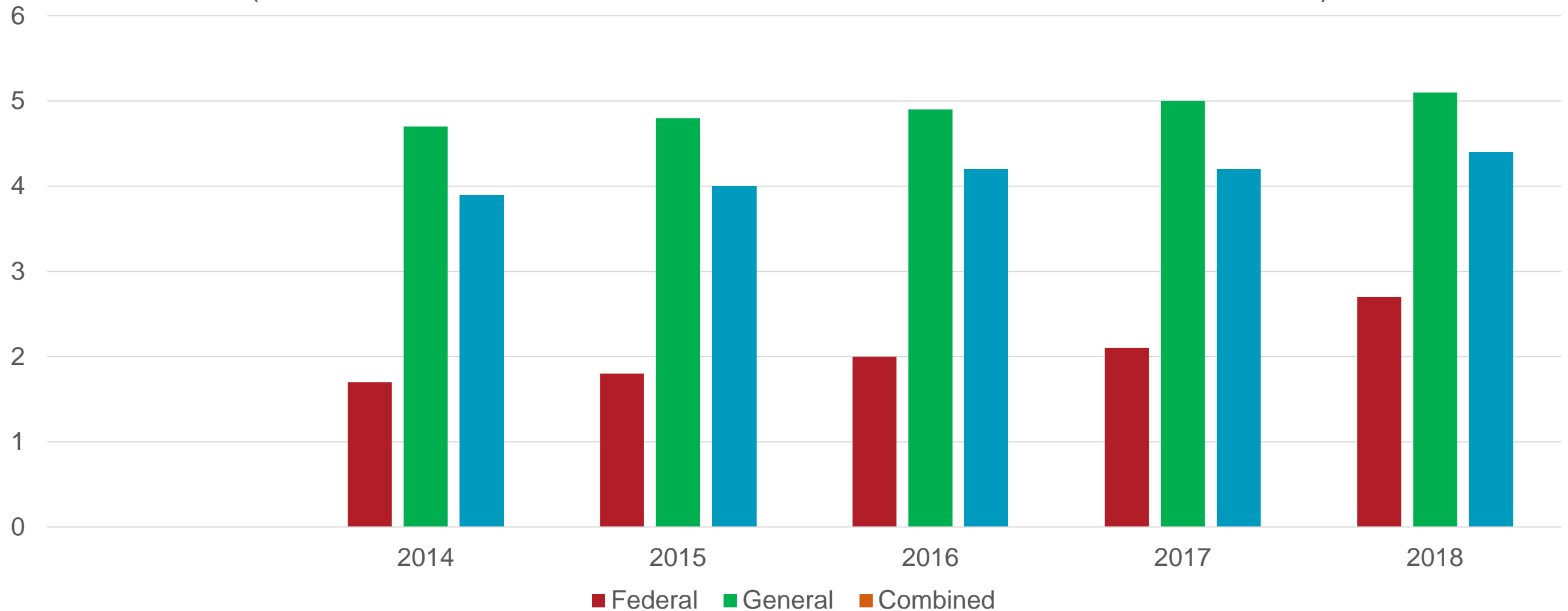
Positive Rates (as % of total tested): Urine, Oral Fluid and Hair
(General U.S. Workforce for Oral Fluid and Hair. Combined U.S. Workforce for Urine)
(Nearly 9 million urine tests from January to December 2018)



Source: Quest Diagnostics Drug Index 2018

Percent of Positives (cont.)

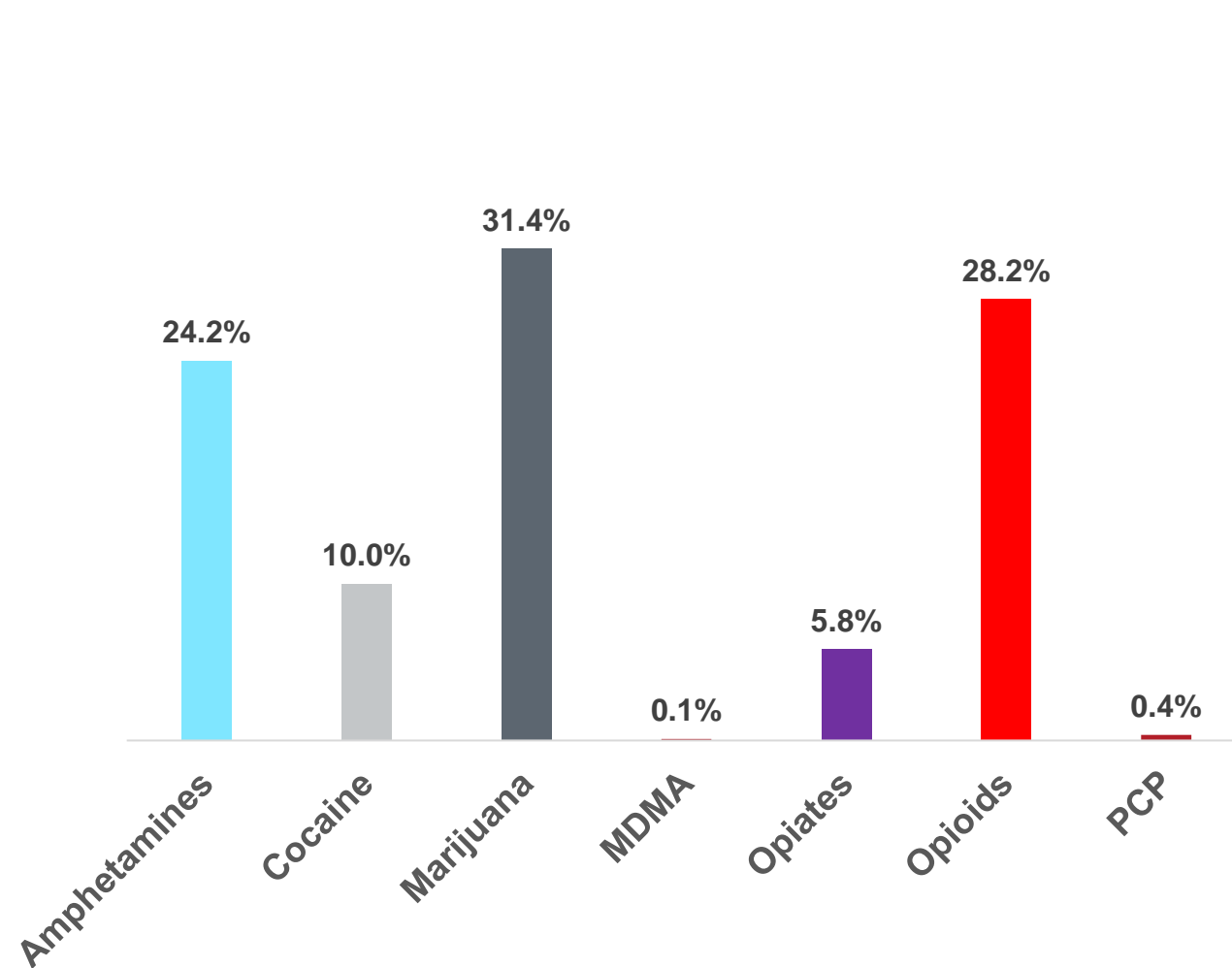
Positive Rates (as a %) by Workforce: Federal, General, Combined
(More than 2.4 million Federal tests and more than 6.5 million General tests)



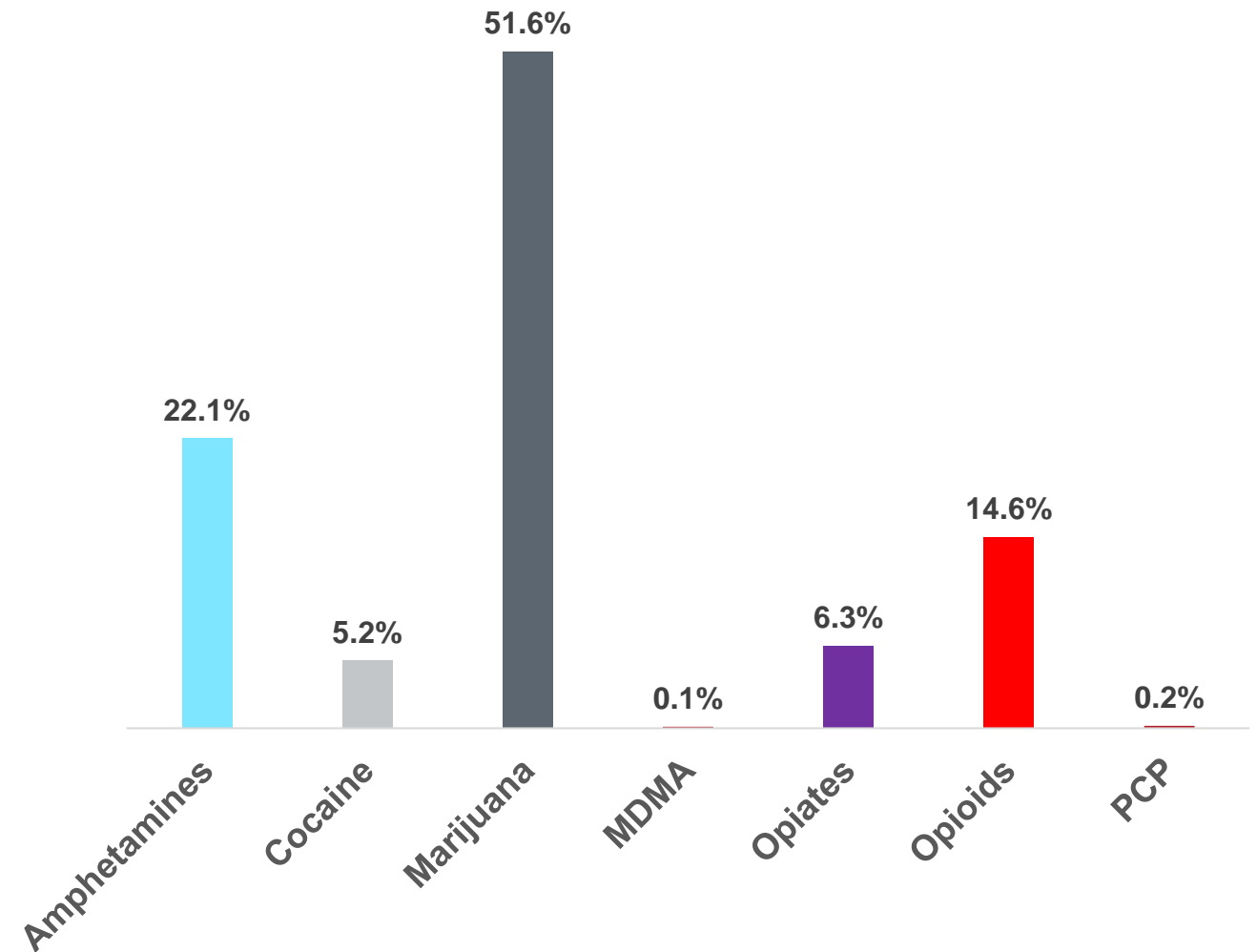
Source: Quest Diagnostics Drug Index 2018

Percent of Positives: Federal vs General Workforce

2018: Percent of Positives by Drug - Federal Workforce
(More than 2.4 million tests from January to December 2018)



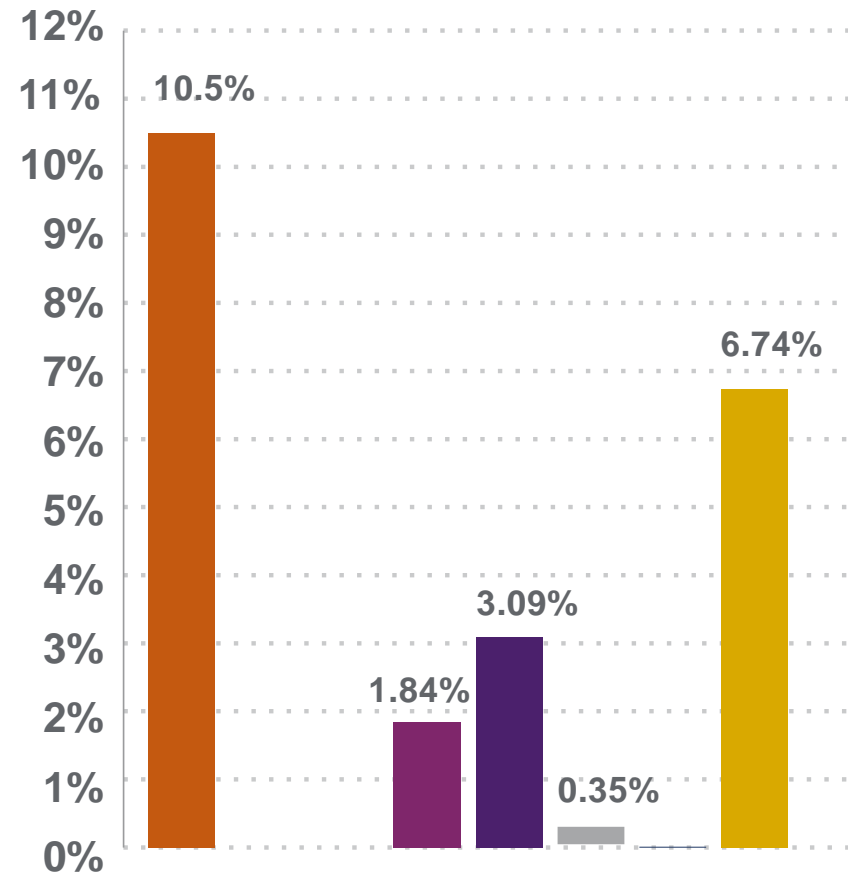
2018: Percent of Positives by Drug - General Workforce
(More than 6.5 million tests from January to December 2018)



Specimen Positivity: Workplace Drug Testing

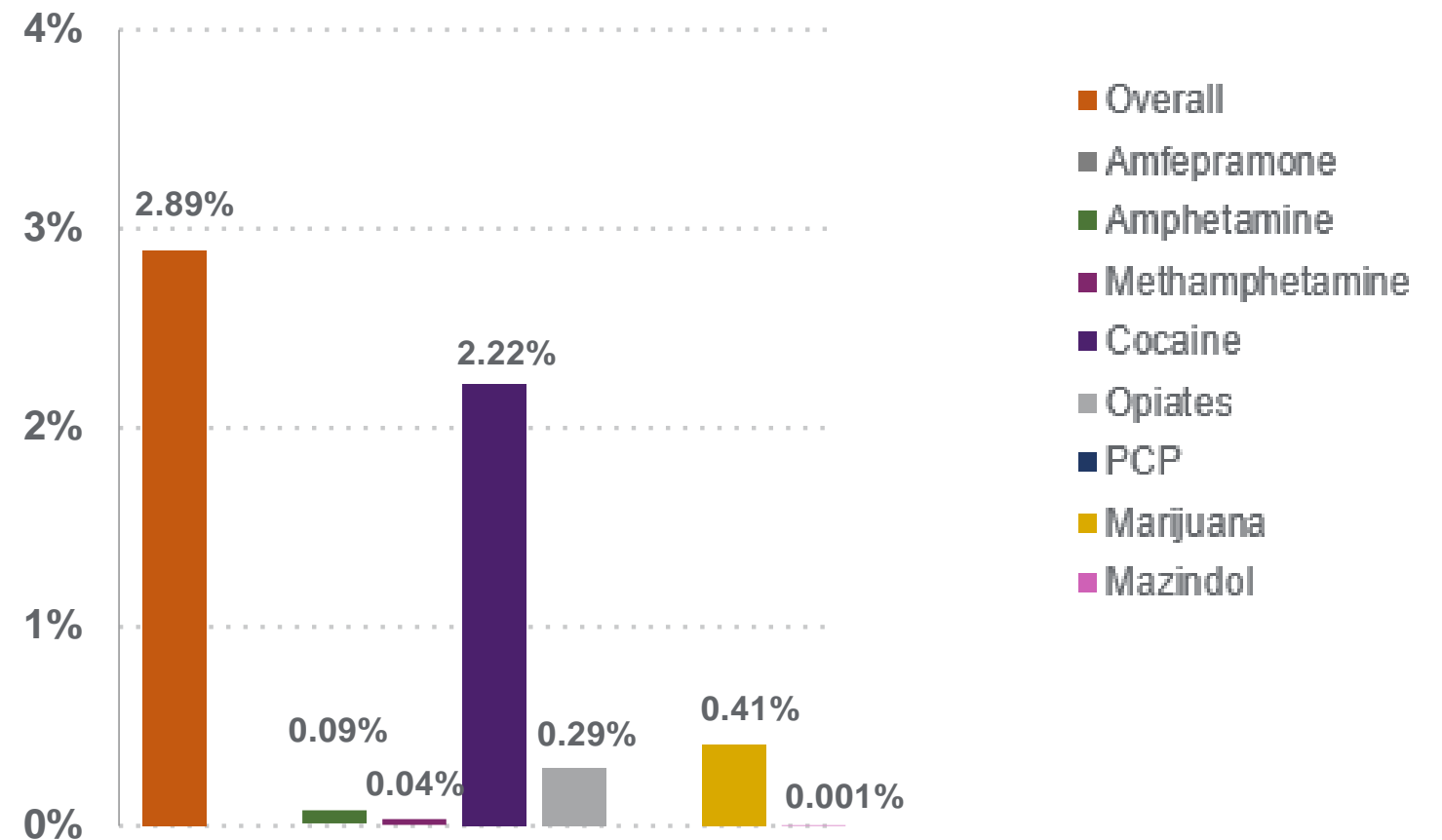
United States: Quest Diagnostics

More than 500,000 specimens



Brazil: Quest Diagnostics

More than 1.7 million specimens



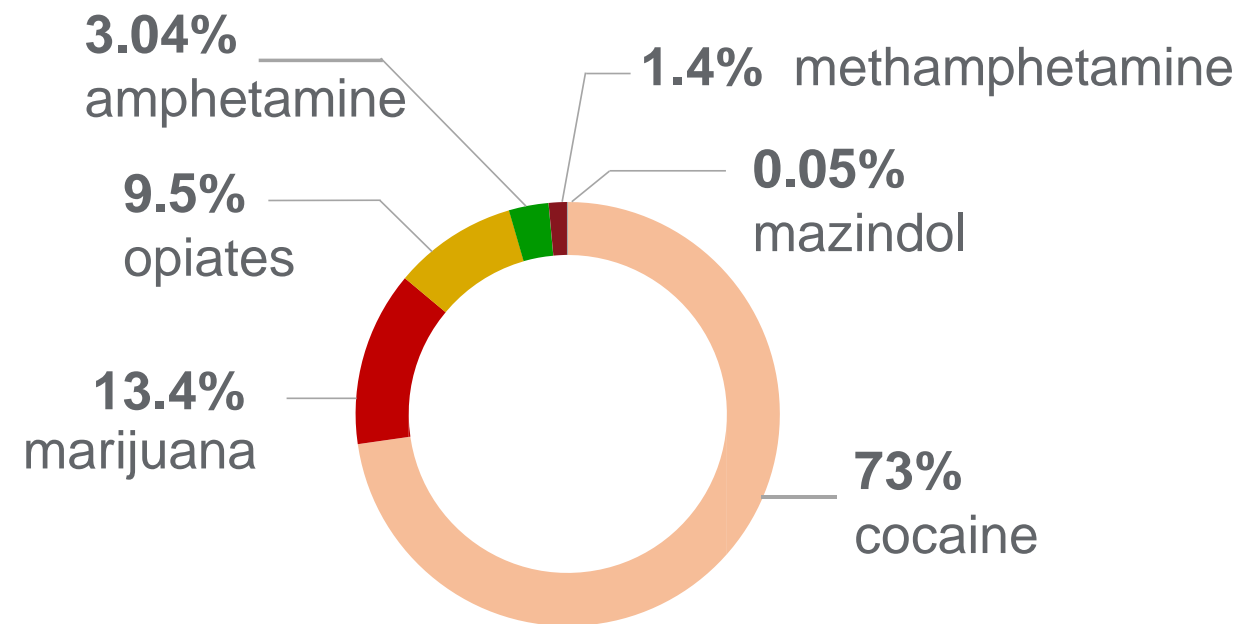
- Overall
- Amfepramone
- Amphetamine
- Methamphetamine
- Cocaine
- Opiates
- PCP
- Marijuana
- Mazindol

Source: Quest Diagnostics March 2016 – March 2019

Findings from Brazil Drug Testing

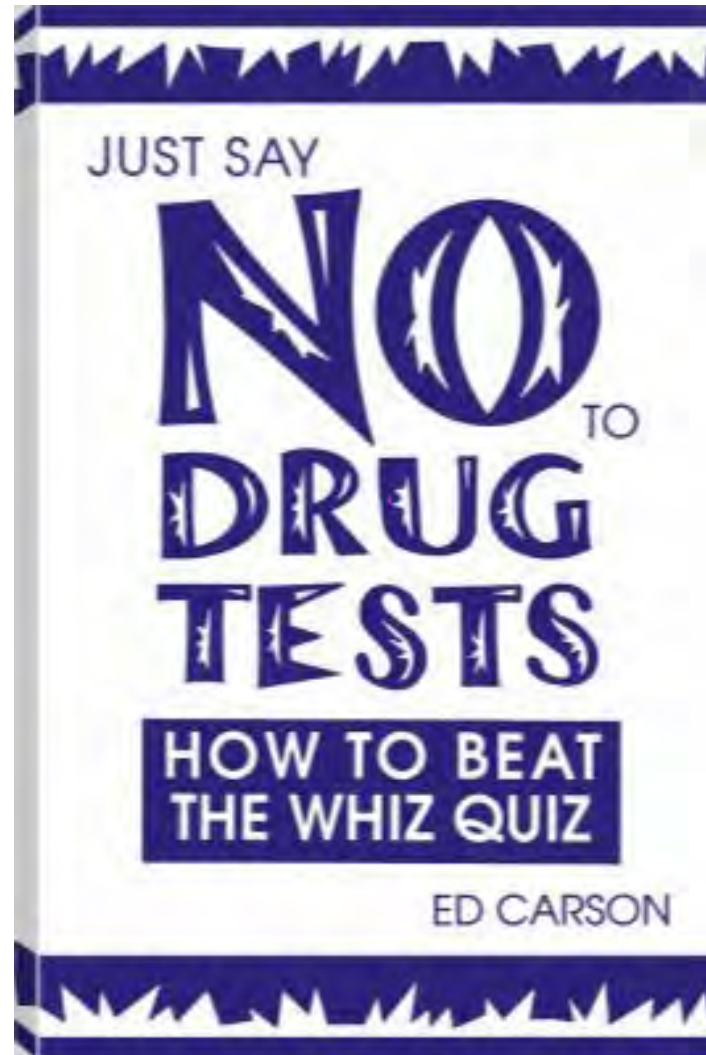
Substance abuse issues are more 'occupational' in nature

Analysis by Quest Diagnostics showed cocaine ranks as the most commonly detected drug in toxicology tests for Brazilian drivers renewing their licenses from March 2016 to March 2019. **Of those test results confirmed positive, the following substances were detected:**

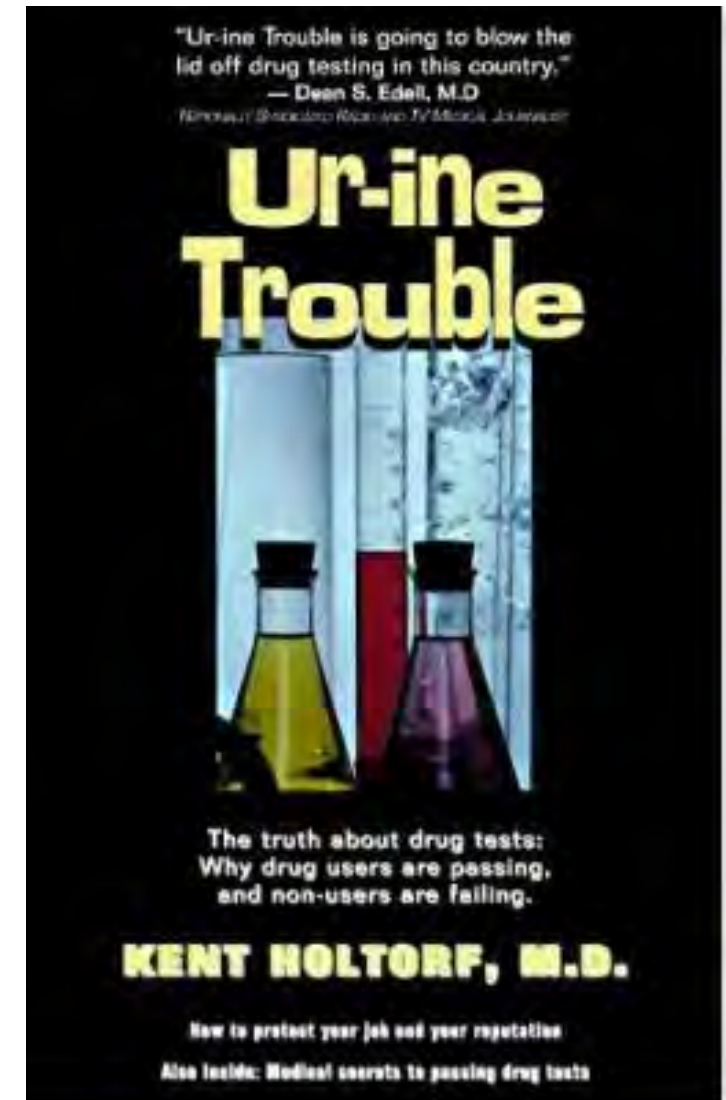
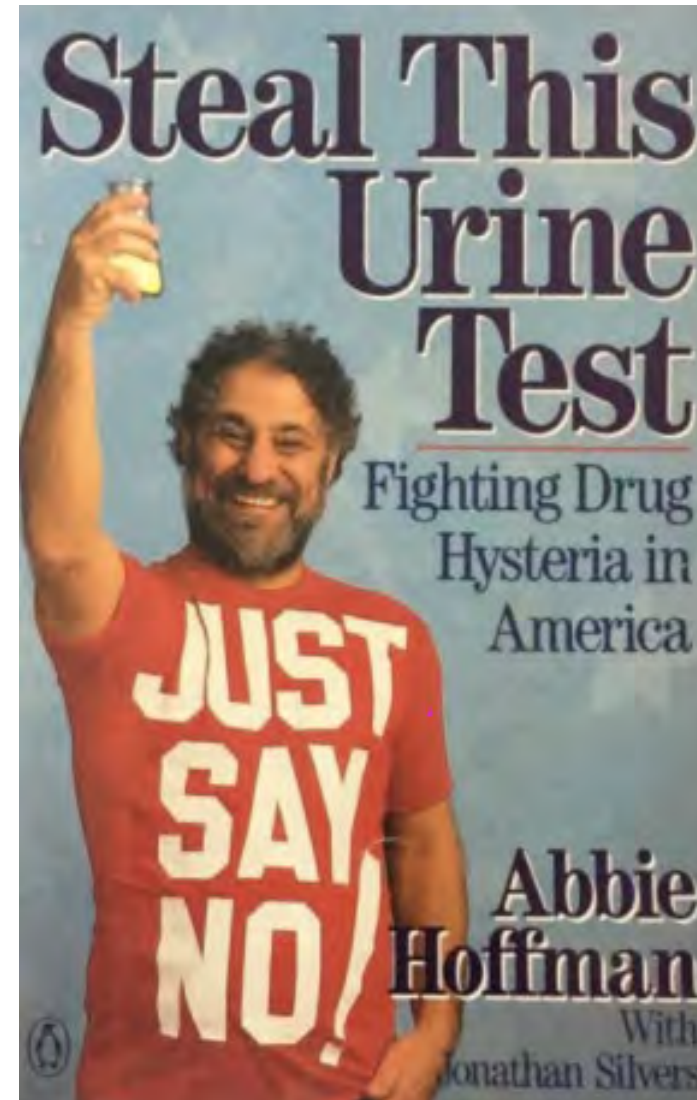


Source: Quest Diagnostics; more than 50,000 positive test results

Various Publications

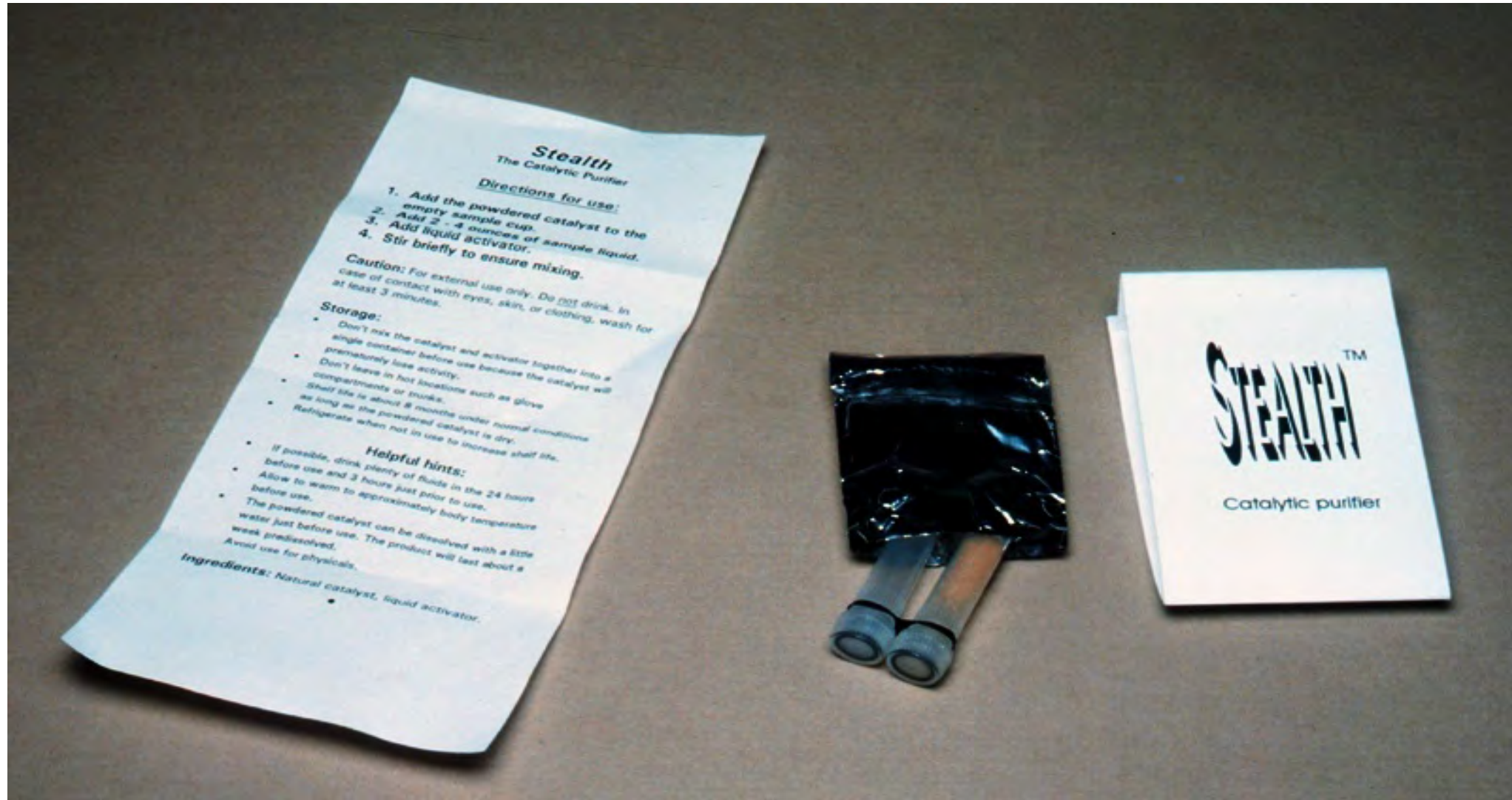


Source: Google search on book titles



Substitution and Adulteration Testing

- **Required for regulated programs and commonly included in other programs**
 - **Substitution: Less than 2 mg/dl creatinine and specific gravity equal to or less than 1.0010**
 - **DOT has a criteria for creatinine between 2 and 5 mg/dl**
 - **Adulterated**
 - **presence of oxidizing agents, household chemicals, and other substances**
 - **pH less than 4 and greater than 11**
 - **invalid specimens**
 - **inconsistent creatine and specific gravity readings**
 - **Suspect adulterant to be present but cannot confirm it**



Oral Fluid and Hair versus Urine

- **Pros:**

- Less invasive collection – directly observed
- Multiple sampling for hair – drug use history by segmentation, although latest data may challenge this
- Easier shipment and storage
- More resistant to adulteration and substitution



- **Cons:**

- Variations in detection windows
- Less is known about the science – dose vs concentration studies
- More sensitive procedures needed – however, advanced MS technology more than capable today
- Proficiency Testing Programs – difficult to establish for hair

Image sources: Urine & Oral <https://freedomscreeindr.com/wp/faqs/oral-fluid-vs-urinalysis/>
Hair: https://animal.ifas.ufl.edu/brooks_equine_genetics_lab/research/lab/basics.shtml

Oral Fluid: Laboratory Testing

- **Important Points to Be Made:**
 - Same approach as urine testing – immunoassay initial test followed by confirmation using mass spectrometric procedures
 - Latter may include LCMS, GCMS, LCMSMS, UltraHPLCMSMS, TOFSIMS, etc.
 - Chain of Custody and QC protocols similar to urine testing
 - No specimen validity testing required
 - THC included and not THC metabolite
 - To be certified for oral fluid testing, labs. must demonstrate competency through satisfactory performance testing and inspection

SAMHSA Oral Fluid: Screening and Confirmation Cut-Offs

Screening Cut-Offs (ng/ml)	
Marijuana (TCH)	4
Cocaine/Benzoyllecgonine	15
Codeine/Morphine	30
Hydrocodone/Hydromorphone	30
Oxycodone/Oxymorphone	30
6-Acetylmorphine	4
Phencyclidine	10
Amphetamines/Methamphetamine	50
MDMA/MDA	50

Confirmation Cut-Offs (ng/ml)	
Marijuana (TCH)	2
Cocaine	8
Benzoyllecgonine	8
Codeine	15
Morphine	15
Hydrocodone	15
Hydromorphone	15
Oxycodone	15
Oxymorphone	15
6-Acetylmorphine	2
Phencyclidine	10
Amphetamine	25
Methamphetamine	25
MDMA	25
MDA	25

Oral Fluid: Pharmacology

- **Incorporation into oral fluid:**
 - **Passive diffusion from plasma – dependent upon oral fluid pH (ionized/non-ionized at oral fluid pH), solubility in lipid membranes and degree of plasma protein binding**
 - **Only free non-protein bound and non-ionized drug can cross membranes into oral fluid**
 - **From the buccal cavity – oral use, smoking, inhalation and insufflation**

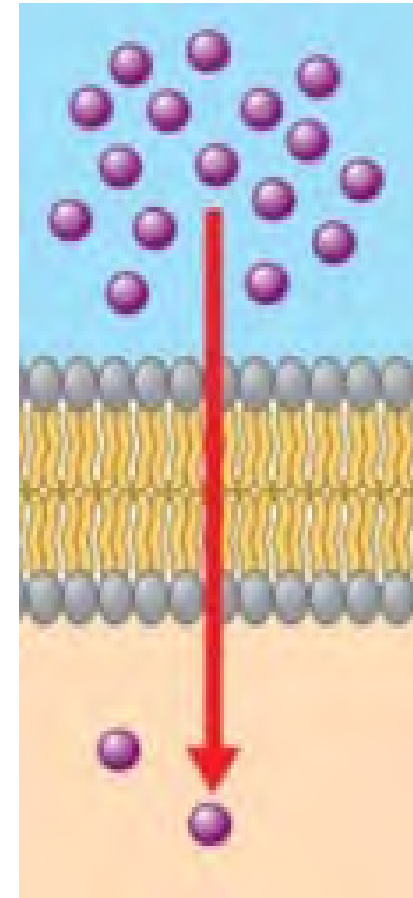


Image source: excerpt from <https://www.slideshare.net/umersm2012/passage-of-drug-molecules-across-cell-membrane-and-its-distribution>

Oral Fluid: Marijuana (THC and THCA) Detection

- **THC and THCA in oral fluid:**
 - THC trapped in buccal cavity can be detected for the first 12 to 18 hours, maybe as long as 24 to 30 hours. THC and THCA are heavily plasma protein bound – limited transfer to oral fluid from blood.
 - THCA can be detected by sensitive MSMS technologies (similar to those used in hair testing) and detection window is longer, especially for heavy users
 - HHS decided to require THC testing at 4 ng/ml for the screening test and 2 ng/ml for the confirmation test
- **Passive exposure**
 - Under extreme conditions it is possible that detectable amounts of THC may be detected. However, as with urine the concentrations remain below the cut-offs.

Hair Testing: Screening Cut-Offs

Lab A: Screening Cut-offs (pg/mg hair)

Marijuana (THC)	1
Amphetamines	300
Cocaine/Metabolites	300
Opiates	300
Opiates/Opioids	500
PCP	300

Lab B: Screening Cut-offs (pg/mg hair)

Marijuana (THC)	2
Amphetamines	500
Cocaine/Metabolites	500
Opiates, Hydrocodone and Hydromorphone	200
Oxycodone/Oxymorphone	200
PCP	300

Hair Testing: Confirmation Cut-Offs

Lab A: Confirmation Cut-offs (pg/mg)

Marijuana (THCA)	0.1
Amphetamines (includes amphetamine, methamphetamine, MDMA and MDA)	300
Cocaine/Metabolites (includes benzoylecgonine, cocaine, cocaethylene, and norcocaine)	300
Opiates/Opioids (includes morphine, codeine, MAM, hydrocodone, hydromorphone, oxycodone, and oxymorphone)	300
PCP	300
Marijuana (THCA)	0.1

Lab B: Confirmation Cut-offs (pg/mg)

Marijuana (THC)	2
Amphetamines	500
Cocaine/Metabolites	500
Opiates, Hydrocodone and Hydromorphone	200
Oxycodone/Oxymorphone	200
PCP	300

Hair Testing: Pharmacology

- Incorporated by several different pathways:
 - Passive diffusion into the follicle base
 - Embedded into hair as bands during growth – amount of drug deposited proportional to blood concentration and the distance of band from surface can estimate time of use
 - Via secretions of the apocrine sweat glands and the sebaceous glands – adsorbed into the shaft during and after its formation

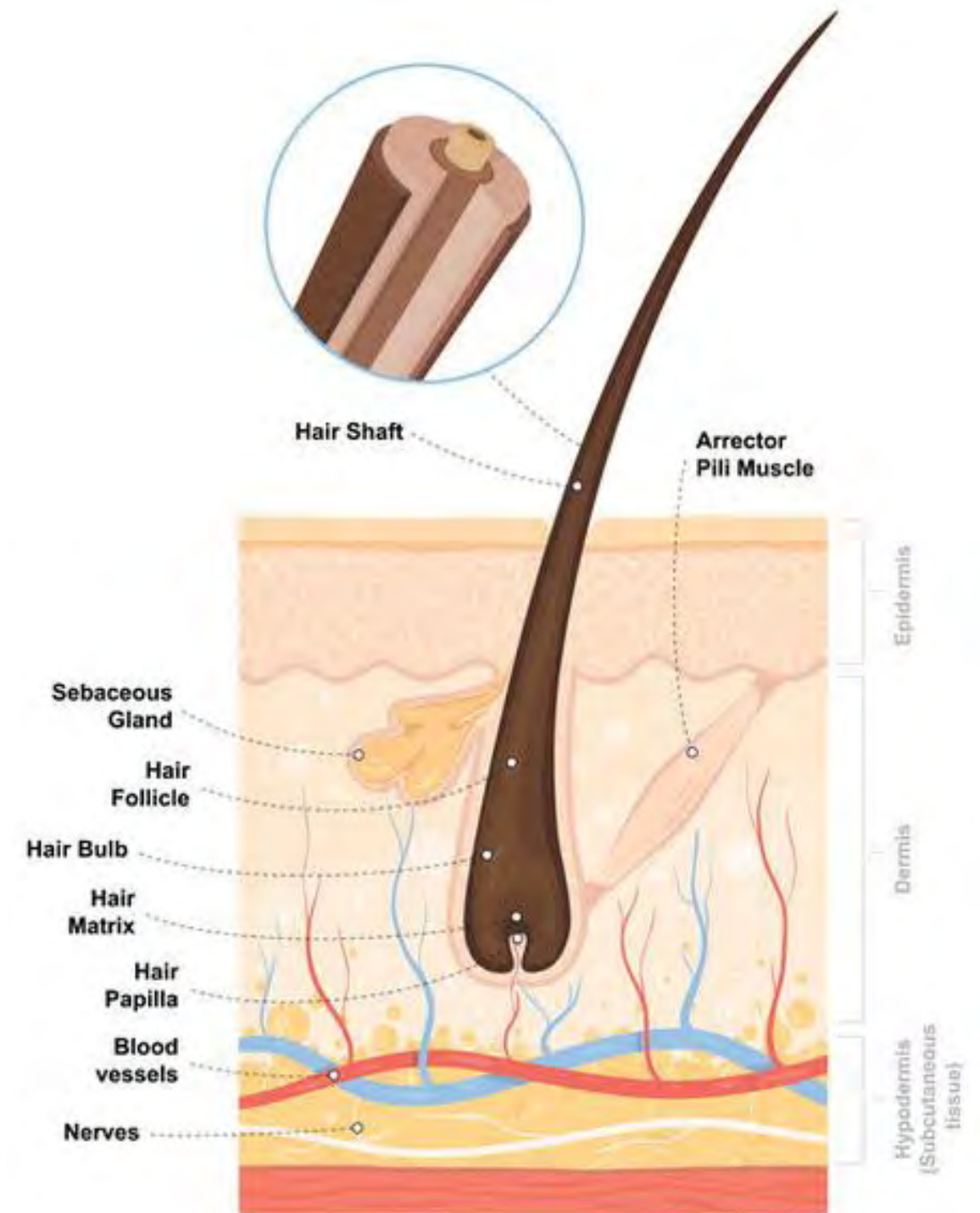


Image source: <https://hairmax.co.uk/blogs/news/the-anatomy-of-the-hair-follicle>

Hair Testing: Talking Points

- **Same approach as urine testing – immunoassay initial test followed by confirmation using mass spectrometric procedures**
- **Latter will include LCMS, GCMS, LCMSMS, UltraHPLCMSMS, TOFSIMS, etc.**
- **Chain of Custody and QC protocols similar to urine testing**
- **Proficiency Testing programs difficult to develop**
- **Laboratory Certification Program available through the College of American Pathologists (CAP)**

Hair Testing: Talking Points – External Contamination

- **Significant discussion on external contamination and wash procedures:**
 - **No consensus on procedure to be used – various solvents and chemicals used, enzymatic procedures also**
 - **Important to test washes to ensure no drugs are detected**
 - **Some reports that surface contaminants move into the hair during the wash**
 - **Detection of drug metabolites – important to overcome claims of external contamination**

Hair Testing: Further Talking Points

- **Adsorption from deposition by sweat etc. and absorption from blood/serum, sebaceous fluid**
- **Segmentation (ability to approximate time of use by dividing strand into segments) called into question because of diffusion along the shaft as hair grows**
- **Detailed dose to concentration studies not available – how much must the user use?**
- **Not suitable for reasonable cause or post-accident testing because of time lag between drug use and incorporation into hair shaft**

Positive Prevalence in Hair and Urine**

Drug(s)	Hair	Urine	% Difference
Overall	12.6%	7.6%	66%
Amphetamine	5.9%	2.1%	179%
Methamphetamine	5.9%	1.8%	222%
Cocaine	4.8%	0.65%	635%
Marijuana	3.4%	3.4%	0
Opiates	0.23%	0.52%	-56%
PCP	0.049%	0.048%	1%

** ~193,000 paired specimens 2004-2009 at Quest laboratories
(pre-employment 73%; random 12%; other 15%)

Comparison of Positives: Urine vs. Hair**

	Urine Positive/ Hair Negative	Urine Negative/ Hair Positive	Urine and Hair both Positive
Overall	18.4%	51.0%	30.6%
Amphetamine	9.6%	67.6%	22.7%
Methamphetamine	5.9%	70.8%	23.4%
Cocaine	2.1%	86.7%	11.2%
Marijuana	30.8%	30.5%	38.7%
Opiates	64.6%	19.8%	15.7%
PCP	29.9%	30.6%	38.7%

**** ~30,000 non-negative paired specimens 2004-2009 at Quest laboratories**

Topics

- Urine, Oral Fluid, and Hair Drug Testing
- **Professional Health Monitoring Programs**
- Athletic Drug Testing
- What does tomorrow bring?
- Pain Management Programs
- Forensic Toxicology
- Future Challenges

Acknowledgement:

I would like to thank Dr. Donna Smith (Quality Assurance Officer, RecoveryTrek, Norfolk, Virginia) for her assistance in preparing this Section of the Presentation.

Professional Health Monitoring Programs (PHMP) in the US

- **Monitoring programs administered by each State, where participants sign a “contract” with their State Board program agreeing to abstinence from all drugs/controlled substances and alcohol**
 - They are monitored via testing for 1-5 years, depending on their agreement with the State Board
 - Typically, physicians, nurses, pharmacists, and other health care professionals who have had their licenses revoked, suspended, or surrendered because of substance abuse
- **Cut-offs, both screening and confirmation, are generally much lower than what is used in workplace testing**
 - Frequently the confirmation cut-off is the laboratory’s limit of quantitation

PHMP in the US (cont.)

- **The standard for testing is urine testing**
 - Participants are typically tested once-twice per week in the first months; less frequently during the latter years
 - Laboratory-based testing using the workplace forensic standard of immunoassay screening and GC or LC Mass Spectrometry for confirmation
 - Custody and control forms are used to document each specimen collection and test
 - Cut-offs are generally lower than the workplace cut-offs
- **Most PHMPs include hair or oral fluid testing as adjuncts to their urine drug testing programs**
 - The drugs included on hair and oral fluid panels are less extensive than what is available for urine testing

PHMP in the US (cont.)

- **Wide range of panels used – 10 drug to 35 plus drugs**
 - Testing program may change weekly
 - A participant may have a urine screen one week using a drug panel of 14 drugs and the following week be tested using one with 26 drugs
- **Almost all PHMPs include a urine panel option with ethanol glucuronide/ethanol sulfate alcohol biomarker testing**
 - Cut-off levels are very low (250 or 500 ng/ml) and aimed at detecting even incidental or unknowing ingestion of alcohol
- **Some also do PEth blood testing, using either whole blood (venipuncture draw) or dried blood spot (finger prick applied to treated card)**

Typical drugs included in urine testing panels

- **Amphetamines and MDMA:**

 - Methamphetamine and amphetamine

 - MDMA, MDA and MDEA

 - Phentermine

 - Phemmetrazine

- **Barbiturates:**

 - Secobarbital, phenobarbital and others as requested

- **Benzodiazepines**

 - Diazepam, nordiazepam, oxazepam, temazepam,

 - alprazolam, alpha-hydroxyalprazolam, temazepam,

 - lorazepam, clonazepam, 7-aminoclonazepam and

 - others as requested

- **Opiates**

 - Morphine, Codeine and 6-acetylmorphine

- **Opioids**

 - Hydrocodone, hydromorphone, oxycodone, oxymorphone

- **Cocaine and benzoylecgonine**

- **PCP**

- **THC acid metabolite**

- **Fentanyls**

 - Fentanyl and norfentanyl

 - Sufentanil and norsufentail

- **Others**

 - Tramadol and meperidine (pethidine)

 - Zolpidem

- **Other expanded panels available upon request at most labs**

Alcohol Biomarkers: Ethanol Glucuronide (EtG) and Ethanol Sulfate (EtS)

SAMHSA Interpretation Guidelines:

- 1000 ng/mL ("high" positive)
 - heavy drinking prior 48 hrs.
 - light drinking same day
- 500-1000 ng/mL ("low" positive)
 - previous heavy drinking (1-3 days)
 - recent light drinking (prior 24 hours)
 - "intense" extraneous exposure (last 24 hours)
- 100-500 ng/mL ("very low" positive)
 - previous heavy drinking (1-3 days)
 - previous light drinking (12-36 hours)
 - recent extraneous exposure

Source: SAMHSA Advisory 2012

Topics

- Urine, Oral Fluid, and Hair Drug Testing
- Professional Health Monitoring Programs
- **Athletic Drug Testing**
- What does tomorrow bring?
- Pain Management Programs
- Forensic Toxicology
- Future Challenges

Athletic Testing: WADA and USADA* List

- **International Olympic Committee (IOC) list includes:**
 - **Stimulants: 40 and other subjects with similar chemical structure or similar pharmacologic effects**
 - **Narcotics: 10 (does not include codeine)**
 - **Cannabinoids**
 - **Anabolic Agents (including but not limited):**
 - **Exogenous: 38 and their analogs**
 - **Endogenous: 5 and their analogs**
 - **Other anabolic agents: clenbuterol and zeranol**
 - **Peptide Hormones: EPO, hGH, IGF-1, hCG, LH (males only), insulin and corticotrophins**
 - **Beta-2 Agonists: some sports only and include salbutamol (aka albuterol)**
 - **Masking Agents**
 - **Glucocorticosteroids**
 - **Enhancement of oxygen transfer**

*World Anti-Doping Agency (WADA) and United States Anti-Doping Agency
Reference: www.wada-ama.org and www.usantidoping.org

Athletic Testing: WADA and USADA List (cont.)

- Both WADA and USADA have websites for athletes
- Some Federations have their own specifically banned substance(s), for example the list for shooting includes propranolol
- Complex analytical protocols and performing labs must be certified by WADA
- Observed collections in all events

2020 full list can be found at <https://www.wada-ama.org/en/content/what-is-prohibited> (accessed August 6, 2020)

Reference: www.wada-ama.org and www.usantidoping.org

Topics

- Urine, Oral Fluid, and Hair Drug Testing
- Professional Health Monitoring Programs
- Athletic Drug Testing
- **What does tomorrow bring?**
- Pain Management Programs
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Areas not covered in this review of “workplace” drug testing

- **Parole and probation testing**
 - Point of collection testing and generally no confirmation
 - Sweat patch testing in some jurisdictions
- **Student testing – high school and college sports teams**
 - Mostly urine based and not widespread
 - Generally does not include performance enhancing drugs
- **Driving under the influence of drugs**
 - Performed in crime labs after a traffic stop and if drugs are suspected
 - Variety of state laws cover this topic
- **Rehabilitation programs**
 - Often similar to probation or PHMP testing – great variation in approach used

Current and Future Challenges

- **Other specimens for drug testing**
 - Nails – being used today in some programs, for example commercial driver testing in Brazil
 - Breath – work done by the Karolinska Institute and others show that this is feasible. Practical applications still unknown as it uses MS
- **Designer drugs**
 - Amphetamines, Cannabinomimetics, “Bath Salts”, Fentanyl, Opioids, Tramadol – like, and ones unknown
 - Need for sophisticated MSMS and ability to “screen” specimens – for example, UHPLCHRMS.
- **Accreditation – regulatory oversight**
 - Only increase as drug testing increases

What does the COVID-19 pandemic do to funding and ability to test?

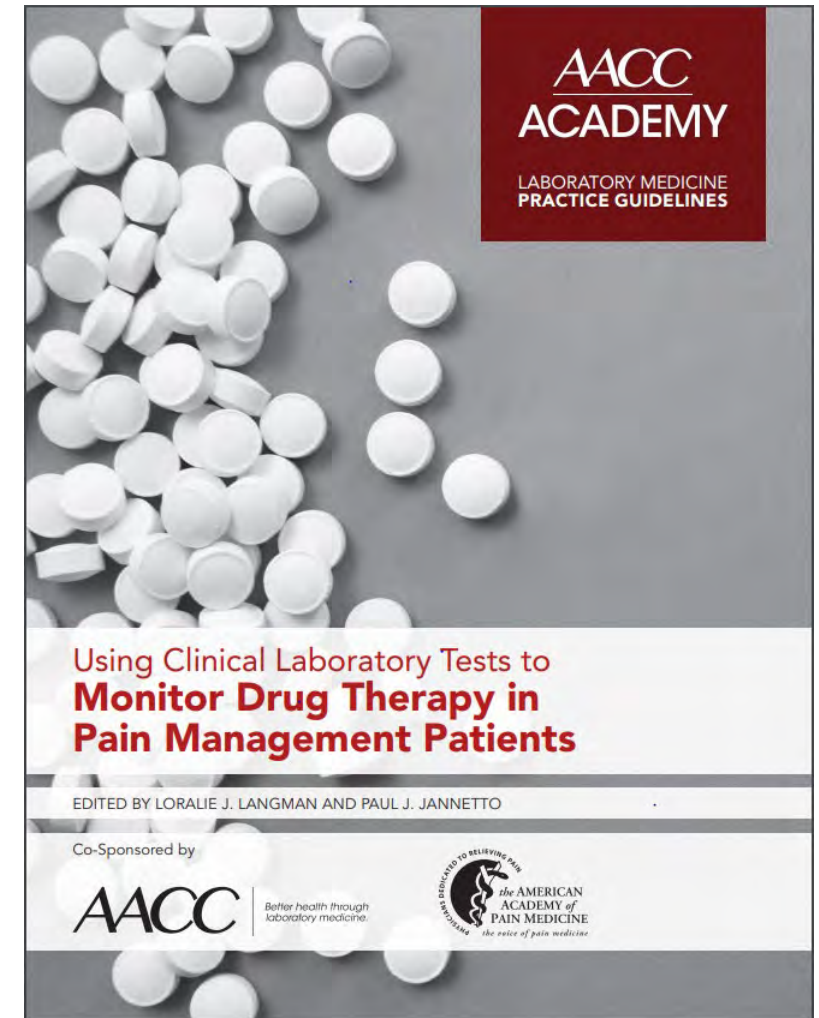
Topics

- Urine, Oral Fluid, and Hair Drug Testing
- Professional Health Monitoring Programs
- Athletic Drug Testing
- What does tomorrow bring?
- **Pain Management Programs**
- Forensic Toxicology
- What does tomorrow bring?

Pain Management

- Clinical medicine and urine (or oral fluid) drug testing plays an important part in a pain management program and is a growing area
- Following link is to some Guidelines published by AACC in 2018:

Langman L, et al. Laboratory Medicine Practice Guidelines: Using Clinical Laboratory Tests to Monitor Drug Therapy in Pain Management Patients: <https://www.aacc.org/-/media/Files/Science-and-Practice/Practice-Guidelines/Pain-Management/LMPGPain-Management20171220.pdf> (source of image)



Pain Management Guidelines

- **To test or not to test, and when?**
 - Effective at detecting drug use
 - Testing not necessarily an indicator of outcomes
 - Should be random
 - Frequency based on patient risk
- **Which substances to test for?**
 - Tier I: Routine monitoring – five drug classes (amphetamines, benzodiazepines, cannabinoids, cocaine and opioids)
 - Tier II: High risk patients – includes a number of others, for example alcohol, antidepressants, dissociative anesthetics, muscle relaxants and other narcotics
 - Tier III: As clinically indicated

Source: www.arup.com

Pain Management Guidelines

- **Which specimen to test?**
 - Urine preferred
 - Oral fluid is being used
- **Specimen validity testing?**
 - Temperature and pH check at collection
 - Laboratory performs at least creatinine, specific gravity and have a more extensive panel available if needed
- **What do different lab methods mean?**
 - Generally use immunoassay screens and mass spec. confirmations.
 - In the US testing methods can affect billing codes

Source: www.arup.com

Pain Management Guidelines

- **How to test?**
 - Immunoassay screens a must
 - Confirmation preferable if results are inconsistent with patient history
- **Are quantitative results necessary?**
 - Not necessarily
 - If done, should not be used to evaluate dosage
 - Maybe useful in complex cases
- **Interpretation**
 - Consultation needs to be available

Example of Urine Testing Panel

- Amphetamines
- Barbiturates
- Benzodizepines
- Burprenorphine
- Carisprodol
- Cocaine
- Ethanol glucuronide
- Fentanyl
- MDMA
- Meperidine
- Methadone
- Opiates and opioids
- PCP
- Propoxyphene
- Tapentadol
- Tramadol
- Cannabinoids
- Zolpidem

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- **Forensic Toxicology**
- Future Challenges

Forensic Toxicology

- **Classically defined as toxicology testing to assist the medical examiner, forensic pathologist, or other personnel in determining the cause of death**
- **Today it is essentially toxicology testing for forensic or legal purposes**
 - Includes driving while impaired, drug facilitated sexual assault and medico-legal investigations
- **Testing panels are often extensive and vary by geography**
 - Common drugs include a wide range of drugs of abuse, therapeutic agents, and over the counter drugs
 - In some areas or cases can include metals, pesticides, volatiles and organic solvents
- **In the US today focus is on standardization**

American Standards Board (ASB)

- **Subsidiary of American Academy of Forensic Sciences**
- **Accredited by the American National Sciences Institute**
- **Standards developed in three steps**
 - Preparation by committees of experts
 - Consensus body comment and review – often this is repeated
 - Final preparation of standard by ASB
- **Standards being developed by either ASB or NIST in all areas of forensic science**
- **Some overlap with European Union initiatives and ISO standards**
- **In forensic toxicology ASB has published the following standards:**
 - **Standard Practices for Method Validation in Forensic Toxicology (2019)**
 - **Measurement Traceability in Forensic Toxicology (2018)**

Reference: www.asbstandard.org

American Standards Board (ASB) – cont.

- **The OSAC Toxicology Sub-committee and ASB Toxicology Consensus Body encourage all interested parties to provide comments on recirculated versions of three toxicology standards:**
 - **ASB Standard 119, *Standard for the Analytical Scope and Sensitivity of Forensic Toxicological Testing of Blood in Medicolegal Death Investigations*, First Edition (Comment Deadline, September 7, 2020)**
 - **ASB Standard 120, *Standard for the Analytical Scope and Sensitivity of Forensic Toxicological Testing of Blood in Impaired Driving Investigations*, First Edition (Comment Deadline, September 7, 2020)**
 - **ASB Standard 121, *Standard for the Analytical Scope and Sensitivity of Forensic Toxicological Testing of Urine in Drug-Facilitated Crime Investigations*, First Edition (Comment Deadline, September 7, 2020)**

Reference: www.asbstandard.org

American Board of Forensic Toxicology: Accreditation Program

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- SECTION L: SAFETY

Topics

- Urine, Oral Fluid, and Hair Drug Testing
- Professional Health Monitoring Programs
- Athletic Drug Testing
- What does tomorrow bring?
- Pain Management Programs
- Forensic Toxicology
- **Future Challenges**

Current and Future Challenges

- **Pain Management**

- Interpretation – if testing is only a confirmation of using program why cannot POCT replace lab testing? Development of dosing algorithms for urine date not feasible today. However, ones using oral fluid concentrations maybe more practical?

- **Driving while impaired**

- Breath testing for drugs – is that practical?
- Cannabis breathalyzer – will it detect THC, THC metabolites or cannabinoids – if it doesn't detect THC what value does it have?
- Oral fluid roadside testing for drugs – more practical – probably not as inclusive as a lab testing program

Current and Future Challenges

- **Forensic toxicology**
 - Use of more high-powered MS protocols
 - Regulatory oversight, especially in countries where DWI, Sexual Assaults, etc., specimens analyzed in traditional forensic toxicology labs.

Current and Future Challenges

- **Has technology exceeded our ability to interpret the data?**
 - What does a 1 ng/ml THC and a 20 ng/ml THCA concentration in blood mean? Is it indicative of impairment?
 - A 22 year old is found dead in his college dorm. The forensic toxicology examination showed the presence of trace amounts of ketamine. The pathology examination showed no life-threatening medical conditions. What is the cause of death?
- **Therapeutic use of psychedelics**
 - MDMA for PTSD and ketamine for depression (How to Change Your Mind, Michael Pollan, Penguin Press, 2018)

What does the COVID-19 pandemic do to funding and ability to test?

Summary

- Review workplace drug testing and data to show impact
- Understand choice of panels and related considerations
- Share changes in technology and regulatory oversight
- Discuss future challenges including unknowns like COVID

Thank you for your participation and interest.



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