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Appropriate Laboratory Utilization Determined by Drug Testing Need

By Ronald Henriquez, PhD, Matthew Ward, PhD, and Alec Saitman, PhD

A key challenge for laboratories is deciding which drug components to include in drug screening panels. Urine drug screening is widely used in healthcare, in workplace settings, and in forensic investigation, and the requirements for drug screening are often unique to the demands and purposes of the testing environment. Urine drug screening by immunoassay is the most common method of testing, because it is fast, inexpensive, and is often sufficiently portable or adaptable to a range of environments. However, beyond these basic premises there are drivers and specific considerations to drug panel component selection and approaches to drug screening in clinical, occupational, and forensic testing.

The origins of drugs of abuse screening in the United States is commonly linked to a policy called the 'War on Drugs,' and a drug testing program unofficially called Operation Golden Flow (1). In 1971, United States President Richard Nixon ordered the military to perform urine drug screening on uniformed service members returning from the Vietnam War, due to a widespread use of heroin. Service members were held in Vietnam if their drug test results were positive. Subsequently in 1988, more formal regulation on workplace drug testing identified 5 drugs or drug-classes for "initial" testing, directing the screening of marijuana, cocaine, opiates, amphetamines, and phencyclidine (PCP), specifically by immunoassay and in a certified laboratory (2). The initial guidelines also specified other requirements, including confirmatory testing and participation in a proficiency/performance testing program. Since that time, many adaptations and evolutions of the basic screening panel have expanded to keep up with contemporary and regional patterns of drug use.

For example, in the early 2000s, an increase in opioid-related deaths attributed to prescribing of semisynthetic opioids such as oxycodone and hydrocodone led to expanded panels for screening in healthcare settings. More recent trends, related to increases in synthetic opioids such as fentanyl, have also altered the landscape of drug testing (3).

Broad legalization of marijuana in many states has also resulted in a significant increase in tetrahydrocannabinol (THC) findings in urine drug screens (4). The changing perception of marijuana legalization and its medical applications has led to increased scrutiny and questions regarding its inclusion in occupational and clinical drug screening. Currently, an updated standard screening panel for drugs of abuse is lacking, and a current consensus guideline for drug screening panel selection does not exist. Additionally, the cutoff values for detection of many drugs may vary by testing location and test environment (5). Therefore, it is necessary to consult the package insert for certain drugs of abuse assays to better understand the basis for interpretation and potential for cross reactivity.

When reviewing the composition of a drug screening panel, it is important to consider the key reasons for testing within your organization, and the test population. It is especially important to keep in mind the distinction between those that are being tested, whether it is a patient, an employee, or a person who is the subject of an investigation, and understanding the utility of these laboratory screening tests for those that will use them, whether it is a

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medical provider, an employer/supervisor, or a forensic investigator. Many of the considerations for drug screening are presented here as perspectives for clinical, workplace, and forensic settings.

Clinical Perspective in Urine Drug Screening Utilization

Clinical Drug Testing Overview

Clinical laboratories typically manage multiple applications for clinical urine drug testing which include outpatient pain management and inpatient-based testing as well as support of maternal/fetal medicine, behavioral medicine, and organ transplant programs. The most common applications are outpatient pain management and inpatient and emergency department-based testing which have distinct differences in the screening portion of these two testing strategies.

For drug testing provided in pain management settings, screening panels are designed to monitor therapeutic compliance, which is to confirm the presence of drugs patients are prescribed and to rule out the presence of drugs that patients are not prescribed. More drug classes are screened for (i.e., opiates, amphetamines, benzodiazepines, etc.) because of high rates of polypharmacy and/or poly drug use, which is one of the reasons for testing. Screening cutoffs tend to be lower to detect therapeutic use of prescribed drugs. Most pain management screens also include automatic reflexive cascades to confirmatory testing for presumptive positives to verify specific drugs and metabolites, expected metabolism patterns, and/or quantitate drug and metabolite concentrations, which may assist interpretation in challenging cases. Many pain management drug screens also include validity tests such as urine creatinine, specific gravity, and pH to verify specimen integrity and check for urine dilution.

Hospital-based urine drug testing has a different set of expectations. Hospital-based urine drug testing typical requires that screening results be available STAT (or within a reasonably short time period from collection). Panels offered for inpatient-based drug testing may include fewer components which focus the panel to only test for the most clinically relevant drug classes. Screening cutoffs may be higher to identify patients with presumptively high concentrations of drug or limit the number of false positive results. Many of these testing algorithms include very little or no automatic reflexing for confirmation. This practice focuses on the fact that confirmation results often cannot be made available in a turnaround time that would change how the patient would be treated or managed.

Table 1. Commonly available urine drug screen components.

Amphetamines	Fentanyl
Barbiturates	Lysergic acid diethylamide (LSD)
Benzodiazepines	Methadone
Buprenorphine	Opiates
Cannabinoids (THC)	Oxycodone
Cocaine metabolite	Phencyclidine (PCP)
Ecstasy (MDMA)	Propoxyphene
Ethanol metabolite	

Clinical Drug Testing Needs

Laboratories providing clinical testing services are balancing the needs of the providers ordering the testing and the financial constraints of performing the testing. Decreasing reimbursement rates by payors for clinical drug testing has led many clinical laboratories to assess the clinical utility of drug screens that they offer. These clinical utility assessments typically reveal some common themes.

Some drug screening components may not be clinically relevant to test in all patient populations; therefore clinical laboratories often need to manage multiple drug screen panels, including "customized" panels, with each including a unique set of drug screen components (see Table 1).

This can lead to drug testing panels within the same laboratory system having varying numbers of drug screening components with outdated reasoning behind their overall composition. Some panels may have misleading laboratory naming conventions (i.e., "Drug 9" when the panel is an inpatient drug screen with 7 components), which can add confusion. Panels within a single laboratory system may also use different screening methodologies or manufactures which can limit the ability for laboratory staff to provide proper interpretation, troubleshooting, or follow-up for unexpected or discrepant results.

Clinical Drug Testing Utilization Opportunities

Clinical review of drug screening panels and testing components can provide opportunities to standardize a clinical laboratory's drug testing program. Specifically for inpatient drug screening, laboratorians can review presumptive positivity data of previously completed testing to determine if some drug components are no longer clinically relevant. This data-driven approach allows laboratories to work directly with their clinical partners to

determine prevalence cutoffs at which drug screening for particular drugs or drug classes can be discontinued.

An example of this is PCP drug screening, which was a component of every drug screen panel before 2019 from Providence Regional Laboratories in Portland, Oregon. A systematic review of all presumptive results from the previous year revealed that only 3 results or 0.08% of the total number of screens performed were positive for PCP, and all 3 results were from proficiency testing samples. Cutoff for consideration of discontinuing component testing was set at 1% presumptive positivity. PCP presumptive positivity was far below this cutoff and was discontinued after review of the data with ordering providers.

Another example of warranted clinical test discontinuation is propoxyphene screening. Propoxyphene is no longer sold in the US as of 2010 (5), and its presence in the US dramatically declined within months of this change. However, many drug screen manufacturers still offer the screening components to US-based laboratories. Like PCP, presumptive positivity data for propoxyphene can rapidly demonstrate the lack of presumptive positivity rates to warrant testing.

Prevalence cutoffs are certainly environment specific, and this should be considered. For example, "zero-tolerance" testing environments such as in some forensic settings may routinely have positive prevalence rates below 1%; however, in those settings, one of the primary purposes of testing is for deterrence.

Provider education is also an important component when making test utilization decisions. Some resistance to removing drug screening components may occur because ordering providers may state that they "do not want to miss any positive results." Many providers may not be aware of community drug prevalence, particularly noting that 1000s of drugs may be in our patient population, but there are limitations to how many drugs can be screened for. Screening for all these drugs in community hospital settings with traditional immunoassays is profoundly impractical if not impossible.

False positivity data may also be useful when making informed utilization decisions. If specific drug screen components yield presumptive positive results that are overwhelmingly confirmed negative by mass spectrometry, the clinical testing may be doing more harm than good. This may be the case for MDMA (ecstasy) specific drug screening. If most of the presumptive positive screening is confirmed negative, those patients may face unnecessary treatment or clinical monitoring which expands the issue to patient safety and hospital resource utilization concerns.

In addition to reviewing drug screening components for their clinical utility, other cosmetic changes to test naming conventions may prove useful. A drug screen called "Drug 9" provides little information about the testing methodology. Anecdotally, the authors have noticed that many drug panels have numbers in the title, which historically translated to the number of components the panel offered. However, many clinical labs make changes to the panel's component number and do not reflect it in the title.

Better approaches to naming drug screening panels revolve around several key strategies. Using the word "Screen" to remind ordering providers of the intent of the testing provides embedded ordering guidance and understanding of future results within the title of the testing. If presumptive positive results are automatically reflexed it may be best to include the phrase "with reflex" or "with confirmation" within the title. Again, this practice provides guidance to ordering providers. If a laboratory system is managing multiple panels designed for different patient populations, it may be useful to describe them—i.e., "inpatient" vs "pain management." If the laboratory system is managing multiple methodologies for drug screenings, naming might indicate "immunoassay" or "mass spectrometry" in the title of the testing.

Forensic/Workplace Perspective in Drug Screening Utilization

Forensic Drug Testing Utilization Overview

Forensic testing aims to provide legally defensible results that may be used for official record or in legal proceedings. Similar to clinical laboratories, those laboratories providing workplace or forensic testing services typically are balancing the needs of the test requestors and the financial constraints of performing the testing. However, most tests offered in these modalities usually are reflexed to confirmatory testing due to the nature of how the results will be used. Depending on their performance this may exclude certain commercial immunoassay offerings from the workflow. This has led to some laboratories opting for more costly mass spectrometry-based methods in the absence of suitable high-throughput immunoassay methods.

Given the wide range of legal ramifications, forensic drug screening may require laboratories to be capable to test for infrequently detected substances despite costs associated. Additionally, given the potential outcomes, workplace-based cutoffs utilized by immunoassays may be insufficient. Lowering screening cutoffs may be required depending on the context of the testing. These limitations are one reason laboratories may choose to implement alternative mass spectrometry technologies, which may also be required if the specimen types are expanded to include other fluids or tissue.

These complex matrices can dramatically impact a laboratory's workflow.

Forensic Drug Testing Utilization Opportunities

Laboratories can maximize resources through reducing mass spectrometry testing volumes by implementing immunoassay screening and improving the laboratory workflow where possible. This is dependent on the volume of specimens received for which immunoassay is acceptable. In the context of military testing, court-ordered rehabilitation, and illicit drug use, it is common to collect urine specimens and use immunoassays to screen prior to confirmatory testing.

In recent years, the use of field expedient tests and urine cups has been adopted and then abandoned in various law enforcement capacities due to their problematic limitations. Interferences from over the counter and prescription medications, poor cross reactivity, and poor visualization designs have led to false readings. This poses a risk for the individuals tested and degrades trust in the legal system in the case of wrongful arrests. The use of field kits would be generally considered outside the purview of a forensic laboratory and serve limited utility within the laboratory without proper evidence including testing by definitive methods.

Workplace Drug Testing Utilization Overview

According to the Drug & Alcohol Testing Industry Association (DATIA), workplace drug testing aims to achieve a safe work environment by deterring employees from abusing alcohol and drugs, preventing the hiring of individuals who use illegal drugs, and identifying early and appropriately referring employees who have drug and/or alcohol problems. This kind of testing yields a high volume of negative results which can be concerning for budgetary constraints. Therefore, workplace drug screening may require careful selection of test panels to minimize overhead of the program. When this is combined with randomized collections, the deterrence effectiveness is maximized with minimum investment in the drug abuse prevention (7).

Additionally, agencies charged with establishing screening cutoffs in workplace testing tend to determine cutoffs to decrease the probability for false positive results. This philosophically defaults to give the employee the benefit of the doubt, and partially accounts for cross reactivity of multiple metabolite compounds. However, since the ultimate use of workplace testing can lead up to dismissal of an employee, presumptive positive results should be confirmed. This practice provides employers a higher level of confidence when implementing corrective measures and prevents false accusation.

Workplace Drug Testing Utilization Opportunities

A review of drug testing results and relevant regional reported clinical/criminal drug use can yield a data-driven selection of test panels to maximize the resources for a deterrence program. Employers that have the freedom to shape their drug-free workplace program can reduce testing costs by eliminating specific analytes with low yield, barring government mandated testing requirements. Workplace drug testing while focused on deterrence can also be used in post-accident investigations and yield potential insurance benefits for an employer. The landscape on use in this area is evolving.

Discussion and Future Directions

Several new initiatives and emerging technologies in drug of abuse testing will shape the future state of drug screening regardless of testing environment. By removing technical barriers and lowering associated costs through automation, smaller screening panels may be replaced with those that are more comprehensive and analytically specific. Ultra-fast liquid chromatography coupled mass spectrometry platforms and automated liquid handlers are currently utilized for this purpose. These systems take advantage of the same concepts of automation that have enabled the widespread and cost-effective use of immunoassays in drug screening. In fact, screening by mass spectrometry has already supplanted immunoassay for many drugs in forensic, clinical, and occupational testing and may offer benefits for newly emerging novel psychoactive substances.

Current practices in drug screening and drug panel selection are influenced by a range of factors. While forensic, workplace, and clinical drug screening are employed for different purposes, there are many commonalities in methods and practices. It is incumbent upon laboratories that employ drug of abuse screens to fully understand the limitations and considerations when assembling and selecting drug screening panels. Due to the changing landscape of drug use patterns, consistent review and revision of panels is also required.

Learning Objectives

After reading this article, the reader will be able to describe the current landscape of drug screening and confirmation testing in different laboratory settings. The reader will be able to list opportunities to standardize and better utilize drug testing to improve patient care and laboratory workflows.

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The Current Landscape of Emerging Cannabinoids

By Andrea R. Terrell, PhD

Hemp and marijuana are nearly genetically identical plants, both derived from the *Cannabis sativa* plant. Marijuana refers to *Cannabis* plants that contain greater than 0.3% delta-9-tetrahydrocannabinol (Δ9-THC), the cannabinoid responsible for the plant's predominant psychoactive effects. Hemp refers to *Cannabis* plants that contain 0.3% or less Δ9-THC. It is believed that marijuana was first cultivated in Asia around 500 BC as an herbal medicine. Traditionally, hemp was used for its fiber to make products like rope, cloth, and paper. In addition to fiber, hemp is now grown for the production of cannabinoids such as cannabidiol (CBD) and cannabigerol (CBG) (1). Δ9-THC, CBD, CBG, and other cannabinoids are being investigated as pharmacological agents, exploiting the cannabinoids' potential analgesic, anti-inflammatory, anticonvulsant, and antioxidant properties.

Cannabis has been part of the American landscape for more than 400 years. It was such an important crop in the American colonies that in 1619, a law passed in Virginia requiring hemp to be grown on every farm. Eventually the hemp plant was replaced with more popular clothing materials such as cotton, but another variety of *cannabis* plant was on the rise—marijuana. In the early 1900s Mexican refugees fleeing violence brought marijuana across the border into the United States. In the 1930s it became popular in the jazz community, followed by adoption by the Beat Generation starting in the 1950s. The 1937 enactment of the Marijuana Tax Act essentially made production and use of the *Cannabis* plant illegal by requiring the purchase of a tax stamp. The stamp could only be purchased after submitting personal information to the government. The act was declared unconstitutional in 1969, but that became moot because in 1970 the Controlled Substances Act (CSA) was passed, placing *Cannabis* in the same Schedule I category as heroin and LSD. In 1996 individual states began defying national laws with California legalizing medical marijuana. Colorado and Washington took the next step and legalized recreational, adult use of marijuana in 2012. As of 2021, all but 11 states have either legalized or decriminalized marijuana (2).

Hemp was unfortunately a casualty of war with the passage of the CSA, which did not distinguish between it and marijuana. This all changed with the passage of the 2018 Farm Bill, which made the cultivation and distribution of hemp and hemp derived products federally legal. The Farm Bill specifies that legal hemp contain no more than 0.3% Δ9-THC by dry weight.

As a result of the patchwork nature of marijuana legalization, but the nationwide legalization of hemp, a new market has presented itself to those willing to operate in a legal grey area. Δ8-THC began appearing on the market in 2020 after an oversupply of hemp-derived CBD caused prices to drop. Using chemistry published ~50 years ago (3), producers began using inexpensive, excess CBD as a precursor for Δ8-THC. The conversion of CBD to Δ8-THC involves purifying CBD from hemp, refluxing CBD in an organic solvent such as toluene

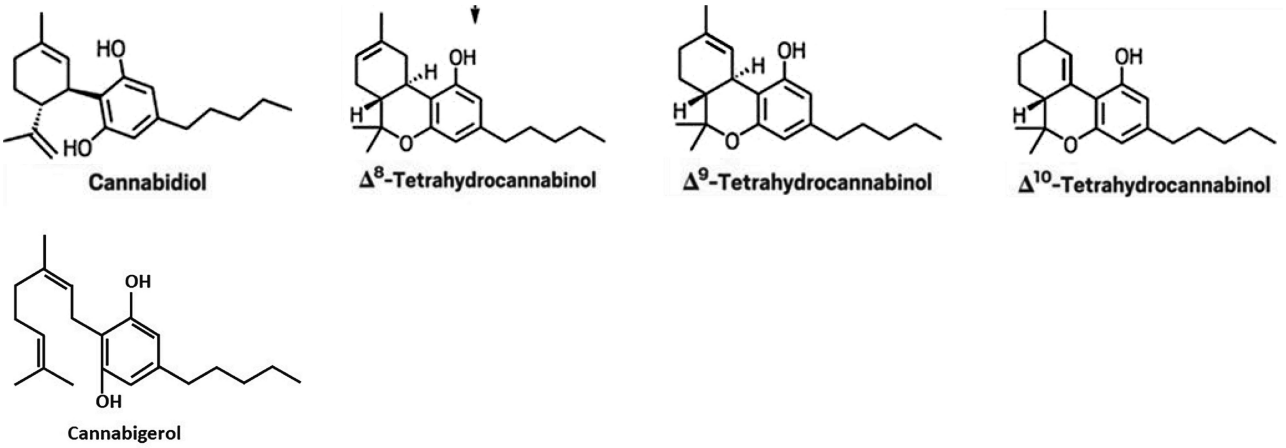

Figure 1. Cannabinoid structures.

or heptane with an acid or metal catalyst, and possibly a strong base to neutralize. The reaction creates Δ8-THC and small amounts of other cannabinoids and other by-products, often uncharacterized. The delta- compounds are only chemically differentiated by the location of a double bond (Figure 1). The conversion was even issued a United States Patent in 2008 (US Patent No.: US 7,399,872 B2).

The synthesized Δ8-THC is then used in edibles like gummies, vape cartridges, tinctures, and even sprayed onto dried hemp flower for smoking. The psychoactive effects of Δ8-THC are reported to be similar, but milder, than the effects of Δ9-THC. Δ8-THC is reported to have sedating effects, similar to *Cannabis indica* varieties.

Δ8-THC is naturally occurring in marijuana plants, albeit at low concentrations. However, the cannabinoid, as it naturally exists in marijuana, is illegal since marijuana is illegal. Δ8-THC derived from hemp is not federally illegal and exploits a loophole in the Farm Bill and in the United States Drug Enforcement Administration (DEA) regulations. The DEA assigns "tetrahydrocannabinols, except for tetrahydrocannabinols in hemp" as Schedule I controlled substances (4).

Although legal federally, many states have enacted their own laws regarding Δ8-THC. Fifteen states prohibit Δ8-THC, and some of these states ban all forms of THC. Alaska allows recreational *cannabis*, but hemp and hemp-derived products (CBD and Δ8-THC) are illegal unless you have authorization from the state. Colorado, also a state with legalized recreational *cannabis*, clarified that converting any cannabinoids from hemp with a chemical process is illegal. Mississippi simply bans all forms of THC. Texas has recently amended their state law, allowing consumable hemp products that do not exceed 0.3% Δ9-THC, but banning all other forms of THC, including Δ8, by including them on the Schedule I controlled substances list. The ban is currently under challenge by retailers operating under the original hemp law where "hemp" means the plant *Cannabis sativa L.* and any part of that plant, including the seeds of the plant and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a Δ9-THC concentration of not more than 0.3 percent on a dry weight basis.

The Food and Drug Administration (FDA) and Centers for Disease Control and Prevention have issued warnings to consumers and retailers about the dangers of Δ8 products. Jointly issued on September 14, 2021, the warning states that the derivative poses "serious health risks" and retailers should provide information about the material's psychoactive qualities. Δ8-THC is not approved for safe use by the FDA, and the FDA linked the compound to over 100 hospitalizations from the start of 2021 (5).

It is not just the compounds themselves that have regulators worried. It is the methods used to clean up the products, leaving unknown by-products in the finished materials. Little is known about the safety and health effects of these by-products. Laboratory testing, even by confirmatory chromatographic methods, may not differentiate the delta-THC variants in patient samples, leading to potential positive results for Δ9-THC in a person who has consumed Δ8-THC. At the product safety level, there are no federal testing requirements for hemp derived products, thus residual chemicals or metals from the synthesis may go undetected.

If regulators ban Δ8-THC, there are other Δ-THC variants that can be produced from hemp derived CBD. It can only be assumed that producers will switch to one of those variants, such as Δ10-THC. Anecdotally, Δ10-THC is reported to have energizing effects, similar to but less potent than

Cannabis sativa varieties of marijuana. Another CBD derived cannabinoid, THC-0-acetate, has begun to be marketed. Anecdotally this compound, which is a precursor to Δ8-THC, has 3 times the potency of Δ9-THC.

As the United States' experiment with *cannabis* legalization continues to expand, we will no doubt continue to see new and innovative approaches to reach an ever-expanding consumer base.

Learning Objectives

After reading this article, the reader will have a greater understanding of the evolution of laws around legalization of hemp and marijuana and the resulting emergence of new cannabinoids.

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Updates from 2021 AACC Annual Scientific Meeting

By Pradip Datta, PhD, DABCC, and Bridgit O. Crews, PhD

In September, the American Association for Clinical Chemistry (AACC) Annual Scientific Meeting and Clinical Lab Expo was held in person in Atlanta, Georgia. In-person attendees were required to provide proof of vaccination and a negative coronavirus test to enter the conference center. Masking was mandatory. Speakers and attendees who were still under travel restrictions were able to participate through virtual formats. There was relatively good attendance of the clinical lab expo with close to 470 exhibitors. Therapeutic drug monitoring (TDM) and toxicology topics were well represented in scientific sessions, roundtables, and poster presentations.

Monday scientific sessions included *Promises and Challenges of Cannabinoids*, which provided attendees with an exceptional overview of cannabinoid pharmacology gathered from over 20 years of research, and shared information on the National Advanced Driving Simulator. Audience members brought up questions regarding the growing prevalence of Δ-tetrahydrocannabinol (THC) derivatives such as Δ-8-THC and shared whether their labs had evaluated the specificity of their methods to differentiate Δ-9-carboxy-tetrahydrocannabinol (THC-COOH) from Δ-8-THC-COOH. Presentations on *Biomarkers of Ethanol Consumption* rounded out Monday toxicology topics, and this hot topic session was also included in the *CLN Daily*.

On Tuesday, speakers from two academic hospital laboratories in Toronto shared details of a novel "drug checking system," which is intended to reduce opioid overdose. The service provides people who use drugs with information on the composition of their drugs. The drug samples are collected at harm reduction sites offering supervised consumption services. Related to this, on Wednesday there was a scientific session on *The Persistent Opioid Epidemic*. Heavy metal testing was covered by three experts in an extended session on lead, mercury, arsenic, and cadmium toxicity, the application of triple quadrupole inductively coupled plasma mass spectrometry (ICP-QQQ-MS), and the utility of chromium and cobalt testing for patients with metal-on-metal implants. The final toxicology sessions presented on Thursday highlighted *Emerging Areas in Drug Monitoring*, discussing antifungals, oral-anticoagulants, and TDM of psychoactive medications.

In addition to scientific sessions, there were more than 30 posters presented in the TDM & Toxicology poster session on Wednesday. An award from the TDM and Toxicology Division went to poster 270, which provided evidence for macrovancomycin in 3 patients with unusual pharmacokinetics and detected by PEG precipitation. A student research award honorable mention also went to poster 264, which evaluated the concordance of umbilical cord drug testing in multiple births. Poster 285 notably demonstrated that while three different immunoassays were able to detect designer benzodiazepines in 35 patient urines, an LC-MS/MS confirmatory method was too selective, failing to detect benzodiazepines in 30 of them. Poster 045 reported that glutaraldehyde, an active ingredient in

adulterant products such as UrinAid and Clear Choice, may produce low results in enzymatic creatinine assays, and poster 266 cautioned that the antibiotic metronidazole may produce false negative results in immunoassays utilizing glucose-6-phosphate dehydrogenase. Poster 286 highlighted a case of acute renal failure in a patient abusing over-the-counter guaifenesin and dextromethorphan. The CALIPER program (Canadian Laboratory Initiative on Pediatric Reference Intervals) presented two posters (243 and 242) on pediatric reference ranges for essential trace elements and heavy metals. Several other posters presented method evaluation for a variety of toxicology applications, including point-of-care testing, a busulfan immunoassay, and laboratory developed testing methods for clozapine. Several posters focused on methods designed to detect fentanyl, norfentanyl, and/or fentanyl analogues.

Educational roundtables also covered toxicology topics, including oral fluid drug testing, umbilical cord and meconium testing, lead testing, and drug screening in clinical practice.

Recordings of the scientific sessions presented at the meeting are available for viewing online by conference registrants through September 30, 2022. Access can also be purchased at www.aacc.org.

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2021 IATDMCT Congress—"Nobody Is Average"

By Kamisha L. Johnson-Davis, PhD, DABCC (CC, TC), FAACC

The 2021 International Association of Therapeutic Drug Monitoring and Clinical Toxicology (IATDMCT) Congress was a hybrid in-person and virtual meeting. The Congress was held in the historic city of Rome, Italy, for the first time, from September 19 to 22nd at the Angelicum Congress Center. The theme of the annual meeting was "Nobody is average" to highlight the importance for individualized drug treatment and efficacy. The Pre-Congress symposium had dual sessions which focused on pharmacometrics-enhanced therapeutic drug monitoring (TDM) and TDM in pediatric patients and neonates. The morning session on pharmacometrics focused on precision dosing and had speakers that discussed population approaches, covariate modeling, and how to develop a basic pharmacokinetic (PK) model. The afternoon session was dedicated to precision dosing, clinical trials design, and individualized treatment with InsightRX and TDMx. The morning pediatric session discussed TDM in children supported with extracorporeal membrane oxygenation (ECMO), biologics in rheumatology, and adverse drug reactions in the pediatric intensive case. The afternoon session highlighted drug monitoring in breast milk, TDM for pediatric hematology, and regimens to improve neonatal pharmacology using PK modeling.

The Congress began with a welcome address from the co-chairs of the Congress Local Organizing Committee, Professors Mario Regazzi and Franco Locatelli, from Italy. The Presidential welcome address was administered by Professor Yusuke Tanigawara, from Japan, followed by the plenary lecture on "Precision dosing: a view from industry," by Drs. Richard W. Peck and Hoffman La Roche.

There was an atmosphere of gratefulness among attendees to see their long-time colleagues and friends for the first time in almost 2 years, due to the COVID-19 pandemic. The Congress program incorporated prominent plenary speakers in therapeutic drug monitoring and clinical toxicology, along with sessions for roundtables, oral and poster session presentations from scientists and physicians from around the world. The topics presented at the congress were proposed from scientific committees of IATDMCT: alternative sampling strategies, anti-infective drugs, clinical toxicology and drugs of misuse, immunosuppressive drugs, pharmacogenetics, pharmacometrics, TDM in oncology, TDM of biologics, TDM in the real world, new psychoactive substances, and a symposium from the young scientist committee.

The prestigious C.E. Pippinger Award was bestowed to Dr. Sal Salamone, from the United States, to acknowledge his outstanding contributions to the field of therapeutic drug monitoring. The Irving Sunshine Award was presented to Professor Eric J. Franssen, from the Netherlands, to recognize his exceptional contributions to clinical toxicology. To recognize young scientists in the field, the Victor Armstrong Young Investigator Award was endowed to Professor Tomoyuki Mizuno, from the United States, to recognize great scientific achievements accomplished early in his career. In addition, the "Best Young Scientist Oral Presentation" was awarded to Jasmine Hughes, from the United States, and the "Best Young Scientist Poster Presentation" was presented to Ranita Kirubakaran, from Australia.

The Congress closed with a plenary session by Professor Manuela Neuman on the clinical importance and pharmacological utility of using biomarkers to diagnose dementia. During the general

assembly, the IATDMCT presidency transitioned from Professor Yusuke Tanigawara to Professor Dario Cattaneo. The 2022 Congress will be held in Prague, Czech Republic, from September 18th to 21st

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- Identify potential analytes (drugs, metabolites, biomarkers) of clinical and/or forensic significance.
- Evaluate methodologies for their utility and limitations relative to the needs of toxicology labs.
- Discuss relevant regulations, such as analytical performance requirements, or the legality of new drugs of abuse.
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