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**Needs and Research Gaps Surrounding
Safe Handling of Synthetic Opioids and
Other Emerging Compounds of Concern
Workshop Report**

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Abstract

With a street drug supply that contains increasingly potent compounds, those involved in the interdiction, analysis, and remediation of these samples continue to face numerous occupational safety challenges. This report synthesizes findings from a multi-community workshop that identified barriers to safe handling, including "hazard fatigue" affecting PPE compliance, a lack of standardized decontamination metrics, and technological lag in field detection of novel compounds and complex mixtures. By analyzing the unique risk profiles of law enforcement, forensic laboratories, first responders, and harm reduction communities, the report identifies critical gaps in research and documentation standards. It concludes with potential opportunities for NIST and other federal partners to address outstanding needs with evidence-based, risk-mitigated protocols that balance operational efficiency with the physical and psychological safety of the workforce.

Keywords

Analytical Chemistry; Drugs; Exposure; Forensic Science; Health and Safety; Law Enforcement; Public Health; Synthetic Opioids.

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Executive Summary

The street drug landscape, especially as it relates to synthetic opioids, has evolved into an ever-changing environment of increasingly potent and complex mixtures. The emergence of nitazenes and orphines – some of which are more potent than fentanyl – has continued to challenge traditional, often static safety guidelines, many of which were developed in the early days of the opioid epidemic. To better identify challenges and gaps in safety protocols amid the dynamic drug landscape, NIST held a cross-community workshop. The workshop brought together frontline personnel from a range of backgrounds including border interdiction, public health, forensic laboratories, industrial hygienists, and researchers to identify gaps and propose possible paths forward.

Key Findings: Four Cross-Community Challenges

- *PPE and Hazard Fatigue* – Overly restrictive universal precautions have led to procedural shortcuts. In high-stakes environments like land borders or dynamic arrests, the time required to don personal protective equipment (PPE) is often viewed as a tactical liability.
- *The Training-to-Practice Gap* – Training remains siloed by profession. Smaller agencies and harm reduction groups often find federal guidelines financially or operationally inaccessible, leading to reduced implementation of safety practices.
- *The Decontamination Dilemma* – There are no nationally recognized clearance standards for synthetic opioids. Agencies are left asking, "How clean is clean enough?" – leading to inconsistent remediation of patrol cars, courtrooms, and public spaces. Who is in charge of decontamination is also often not well understood.
- *Technological Challenges* – Reliance on spectral libraries that are not up-to-date and drug mixtures that often contain active ingredients at low-levels are pushing field detection techniques beyond their capabilities. The need for next-generation detection equipment and data interpretation approaches to maintain pace with the drug supply is clear.

Community-Specific Impacts

Throughout the workshop, it was clear that risks (perceived and real) are not distributed equally across communities. Law enforcement personnel are forced to balance exposure risks in potentially violent scenarios with little time to act while forensic chemists can work in well-controlled laboratories with ample engineering controls and PPE. Personnel involved in drug checking deal with much smaller quantities of drugs than border agents, and canine teams face their own unique threats. Due to the wide range of operational environments, a one-size-fits-all approach to safe handling is unrealistic. Tiered, fit-for-purpose solutions need to be developed.

Potential Paths Forward

- *Establish Vendor-Neutral Test Beds for Field Technologies* – Centralize validation and spectral library curation for field-testing technologies to ensure communities implement fit-for-purpose tools that keep pace with a changing drug supply.

- *Formalize Clearance Metrics* – Define health-based residue limits for post-incident decontamination to provide legal and physical certainty.
- *Increase Communication Across Entities* – Develop infrastructure to enable real-time communication of newly detected compounds, associated safety concerns, and best practices for safe handling across different occupational communities while mitigating alert fatigue.
- *Tiered Safety Guidelines* – Develop a "Good, Better, Best" safety matrix that allows agencies to scale their PPE and engineering controls based on their specific mission and budget.

Conclusion

Occupational safety in the synthetic opioid era is no longer just a PPE requirement; it is a measurement and information challenge. By strengthening metrology-backed standards and interoperable training, we can transition from a reactive defensive posture to a proactive, evidence-based safety architecture.

1. Introduction

Over the last two decades, the street drug landscape has undergone a significant transformation, characterized by the emergence of highly potent synthetic opioids and other psychoactive substances. Higher potency drugs present new exposure dangers and increase the complexity of samples because of the need to heavily dilute or adulterate the drug for consumption. These realities have amplified occupational challenges for the communities tasked with the interdiction, investigation, intervention, and/or identification of these substances in their daily operations.

The National Institute of Standards and Technology (NIST) has been at the forefront of research that addresses safety concerns amplified by the prevalence and potency of synthetic opioids and other emerging substances. Using flow visualization and quantitative analytical techniques, NIST studies have demonstrated that aerosolization of particles occurs during routine activities such as handling drug packaging, sampling drug powder, weighing, and sealing packages. This spread of micrometer-sized particles has inherent implications both for occupational exposure to personnel and contamination of laboratory surfaces [1, 2]. Research at NIST offers a comprehensive perspective on understanding and mitigating drug contamination with practical recommendations for enhancing the safety of those who routinely handle these psychoactive substances in their operational environments. This unique expertise positions NIST to effectively facilitate conversations among communities.

Underscoring the need for a coordinated effort to improve safety within these communities, the Testing, Rapid Analysis, and Narcotic Quality (TRANQ) Research Act of 2023 directed NIST to develop coordinated strategies and voluntary best practices for the safe handling of substances containing xylazine, novel synthetic opioids, or other new psychoactive substances [3]. In response to the TRANQ Research Act, NIST began hosting a series of workshops that brought together representatives from communities that routinely encounter emerging drugs of concern.

In June 2025, NIST organized a one-day in-person workshop titled “*Needs and Research Gaps Surrounding Safe Handling of Synthetic Opioids and Other Emerging Compounds of Concern*”. The workshop brought together representatives from a wide range of occupational communities to:

- Capture the current state of safe handling practices across communities that actively encounter street drugs
- Understand what research is currently being conducted to inform safe handling practices
- Identify research, documentary, policy, and other needs that could assist in the development and deployment of evidence-based best practices

The workshop agenda and list of participants are presented in **Appendix A** and **Appendix B**. The specific goals of the workshop were to capture current research efforts to inform safe handling practices and to identify areas where developing evidence-based practices would be beneficial. This report documents the outcomes of the workshop. The workshop participants collectively

identified overarching common themes across communities despite their unique operational challenges. It was also evident, however, that these operational realities led to divergent approaches to personnel training, personal protective equipment (PPE), and safety protocols. One of the interests of the workshop was to increase awareness of the efforts of different agencies in developing resources for their communities. The development of many of these resources was prompted by the surge of synthetic opioids, particularly fentanyl, in the 2010's.

During the workshop, we reviewed some of the publicly available resources for the safe handling of synthetic opioids. The training materials and informational sheets came from federal, national, state, international, and non-profit organizations, each one tailored to a specific operational mission. While some of these are static resources, developed with fentanyl in mind, others are periodically updated and provide information on the spectrum of emerging substances. The consistent recommendations for safe handling of substances in the new landscape of synthetic opioids include using PPE, employing effective decontamination procedures, ensuring the availability of naloxone, adhering to proper procedures for handling evidence, and instituting routine training and awareness programs. A list of the resources discussed at the workshop is provided in **Appendix C**.

2. Communities Represented

The attendees of the workshop were from a diverse group of agencies, each providing insights from their respective operational perspective. Participants (**Appendix B**) represented a variety of public and private agencies in the United States and Europe that broadly fit into one or more of three key mission spaces: (1) law enforcement and interdiction, (2) public health and safety, and (3) scientific or forensic analysis. Within these mission spaces, ten distinct communities were identified. A brief overview of each is provided below, outlining their operational environments, types of samples encountered, and typical PPE used.

Border Interdiction (Land)

- *Role* – To prevent the introduction of drugs into the street supply through interdiction at a point of entry, including vehicle border crossings, airports, and international mail facilities.
- *Environment* – Personnel operate in both outdoor (ports of entry, i.e., the Southwest border of the United States) and indoor (airports) environments.
- *Types of Samples Encountered* – Highly varied, but often higher purity and larger volumes than other communities. Powders and pills are common, though other concealment methods can lead to a wide range of unusual sample types being encountered. Samples may be encountered on a person, in a vehicle, in mail or packages, or in large shipping containers.
- *Typical PPE* – Gloves, masks may occasionally be used.

Border Interdiction (Maritime)

- *Role* – To prevent the introduction of drugs into the street supply through interdiction in a maritime environment.
- *Environment* – Personnel operate completely at sea and must contend with operational challenges of conducting all work on boats and ships.
- *Types of Samples Encountered* – Often high purity and high amounts of drugs, packaged for trans-border transportation.
- *Typical PPE* – Gloves.

Canine Detection

- *Role* – To use specially-trained dogs to detect and find drugs, typically for interdiction or investigational purposes.
- *Environment* – Canines and their handlers operate in a range of different environments. These can include scenarios in confined spaces like correctional facilities as well as outdoor spaces reflective of law enforcement or border interdiction activities.
- *Types of Samples Encountered* – Highly varied and dependent on the community in which the canine is operating.

- *Typical PPE* – Gloves.

Clandestine Laboratory Response

- *Role* – To safely dismantle and collect evidence from locations where the synthesis, manufacture, or packaging of street drugs is taking or has taken place. This may also include evidence collection from areas where chemical waste from these activities has been disposed of.
- *Environment* – Clandestine laboratories can be located in homes or sheds, in an open environment, or in large commercial buildings.
- *Types of Samples Encountered* – The types and quantities of materials encountered in this community can be quite different from those encountered in other communities. Clandestine laboratories typically contain a range of caustic, toxic chemicals that are used in the synthesis of drugs as well as the drug itself. Depending on the size of the laboratory, these chemicals can be encountered in small or large quantities. Clandestine dismantling chemists will also encounter toxic chemical waste and by-products in these settings.
- *Typical PPE* – Gloves, goggles, masks, and specialized PPE such as protective suits, face shields, and respirators.

Correctional Facilities

- *Role* – To interdict drugs entering or confiscate drugs circulating within correctional institutions.
- *Environment* – Efforts in this space are confined to correctional institutions, primarily focusing on screening people and/or items entering a facility or searches conducted within cells. The environment is highly controlled though it can become volatile.
- *Types of Samples Encountered* – The primary ways in which drugs enter the facilities are through packages and mail, inmate visitors, and staff. Sophisticated concealment methods may be used in each of these entry methods. Paper saturated with small quantities of liquid drugs is a common method of concealment.
- *Typical PPE* – Gloves.

Drug Checking (Harm Reduction)

- *Role* – Drug checking facilities analyze small personal samples from people who use drugs to determine their composition. These analyses are part of a larger harm reduction framework to lower the risk for people who use drugs through education, services, and safe use supplies.
- *Environment* – Personnel operate in non-laboratory environments, typically within the context of larger harm reduction or syringe service program efforts. Common environments include brick-and-mortar facilities, van-based operations, and backpack-based field efforts.

- *Types of Samples Encountered* – Small personal-use samples, usually less than 100 mg. Samples can be powders, pills, plant material, blotter paper, etc. Some sites will also collect and analyze samples from used drug paraphernalia (e.g., syringes, baggies, and cookers).
- *Typical PPE* – Gloves.

First Responder (Paramedic / EMT)

- *Role* – To administer the necessary emergency medical care to those who have been exposed to drugs or who are experiencing a drug overdose.
- *Environment* – Personnel may encounter patients in a range of different environments.
- *Types of Samples Encountered* – While paramedics and emergency medical technicians (EMTs) are not focused on the collection or analysis of drug samples, they may encounter paraphernalia, drug residues, or drug product at a scene or on a patient.
- *Typical PPE* – Gloves and masks.

First Responder (Hazardous Materials)

- *Role* – To respond to and render safe medium- to large-scale spills, including those at clandestine drug labs, unknown chemical spills, or mass casualty exposure incidents.
- *Environment* – Personnel are trained to respond to a wide range of hazardous materials across a variety of operational settings. Scenes could be small, such as an unknown white powder in the back seat of a car, or large, such as an incident at a factory or a mass casualty event.
- *Types of Samples Encountered* – Often powders of an unknown origin; however, a range of other samples and quantities can be encountered.
- *Typical PPE* – Gloves, respirators, sleeves, turnout gear, Self-Contained Breathing Apparatus (SCBA), and Level A multi-threat suits.

Law Enforcement

- *Role* – To find, investigate, and prosecute those who are in possession of drugs. Also, to conduct investigations aimed at stopping or disrupting drug distribution networks.
- *Environment* – There is no single environment in which law enforcement will encounter drugs. The environment is often highly volatile, and concerns regarding personal safety may take precedent over preventing exposure.
- *Types of Samples Encountered* – Highly varied but often street-level drugs packaged for individual distribution. These could include powders, pills, plant materials, liquids, and other forms. In some instances, large amounts of materials may also be encountered.
- *Typical PPE* – Gloves, sometimes masks are also used.

Testing Laboratories (Forensic, Public Health, and Drug Checking)

- *Role* – To provide other communities with confirmatory analysis of samples collected in the field. Labs may analyze drug product, drug residue, or biological samples and produce qualitative and/or quantitative results.
- *Environment* – All handling and analysis is conducted in a laboratory setting, often with extensive engineering controls including fume hoods.
- *Types of Samples Encountered* – Varies depending on type of laboratory and type of testing being conducted. Samples can include drug paraphernalia, paraphernalia residue, drug product, or biological specimens. Samples may be small (trace residues) or large (kilograms).
- *Typical PPE* – Gloves, masks, lab coats, and possibly eye protection.

It is important to recognize that there is also a geographical dependence on the types and quantities of drugs that are encountered by each of these communities, which may mean safety concerns in one region are different than another. Geographical differences exist not only on an international scale but also across neighborhoods within a city.

3. Common Safe Handling Challenges Across Communities

Throughout the workshop, participants were asked to discuss their challenges, concerns, and outstanding questions related to the safe handling of street drugs. While some of the challenges and questions were specific to one community, many were broadly applicable. The safe handling challenges that were cross-community could be grouped into five key topics: 1) understanding unique risks associated with the evolving drug landscape, 2) challenges in following safe handling practices, 3) lack of consistent and timely training, 4) unclear guidelines on decontamination, and 5) the need for improved field-testing techniques so risks could be quickly understood (**Figure 1**).

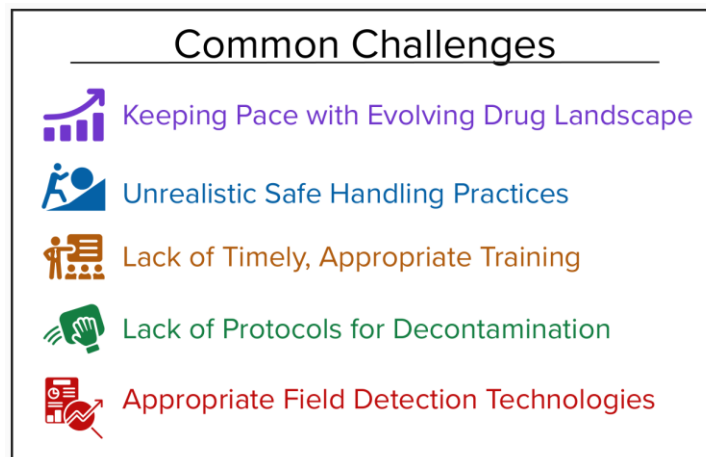


Figure 1. Summary of challenges related to safe handling that were common across occupational communities.

The Evolving Drug Landscape

A primary concern voiced across all occupational communities is the difficulty of assessing the unique risks posed by an increasingly complex drug supply. While the physical forms of these substances (powders, pressed pills, liquids, and syringes) remain largely unchanged, their chemical profiles have shifted dramatically. Throughout the workshop, agencies reported a resurgence of methamphetamine and an influx of new, concerning adulterants like medetomidine. Furthermore, while fentanyl remains a dominant threat, the rapid emergence of high-potency synthetic opioids such as nitazenes [4] and the potential arrival of orphines [5] complicate the existing methods of interdiction as well as personnel training and awareness.

Despite these shifts, basic safety protocols and PPE requirements have remained unchanged. This creates two strategic challenges. First, if every substance is categorized as 'highly hazardous,' the utility of universal precautions diminishes. Second, when a new substance enters the drug supply, how is its presence rapidly and effectively communicated to these communities? This is further complicated when there is little to no available research or data on the toxicity of the compound, as is often the case with novel psychoactive substances (NPS).

Challenges in Following Safe Handling Practices

While gloves remain the foundational defense against exposure across nearly all occupational communities, their use can often be negated by supply availability and operational urgency. Although current toxicological data indicates that the risk of overdose from incidental dermal contact with fentanyl is negligible [6], gloves remain critical to prevent secondary ingestion or mucosal exposure. However, "glove shortages" in the field were cited as a challenge by multiple participants. Beyond gloves, some agencies went further by providing advanced drug PPE kits that include nitrile gloves, masks, Tyvek gloves, coveralls with boots, and cleaning supplies such as water, soap, and wipes. All communities had naloxone readily available for their personnel as part of their emergency response.

Even when PPE is available, the time required to don appropriate PPE can remain a significant hurdle. In law enforcement and interdiction environments, the need to immediately secure a scene—such as during vehicle stops, forceful restraints, or dynamic arrests—often precludes the use of PPE. In these moments, the priority shifts from long-term occupational safety to immediate physical survival, which may make donning gloves, a mask, or other PPE a tactical liability. In addition to time-to-don, participants noted that even when sufficient time existed, PPE was sometimes not worn because it was uncomfortable or caused undue inconvenience in performing their jobs.

There is also a notable perception gap regarding risk across occupational communities. In harm reduction settings, where personnel interact with people who use drugs and only encounter small amounts of drugs, the perceived risk of accidental exposure is often minimal. Conversely, forensic scientists—who operate in controlled settings—may view the same substances through a lens that requires significantly more precaution. Bridging these two perspectives requires a collaborative safety framework that acknowledges varying levels of risk tolerance without compromising the safety of any individual. It also requires further discussion of administrative controls that could serve as a backup when PPE or other controls are unavailable.

A unique and often overlooked hazard that was brought up during the workshop focused on the safety concerns that arise when transitioning from drug analysis to the courtroom. While forensic laboratories often employ multiple layers of PPE and operational controls, the courtroom environment typically lacks any PPE infrastructure. When forensic chemists or law enforcement personnel are required to handle or display evidence to verify seals or appearance, they do so in environments where safe handling may not be possible, potentially introducing undue risks to those in the surrounding environment.

Consistent and Timely Training

The disparity in safe handling practices, especially within an occupational community, is driven by a lack of standardized, cross-agency training. While high-level guidelines exist (**Appendix C**), there is often a lack of related training materials that convert these technical documents into routine, actionable exercises. Across occupational communities, training is often tailored to specific components of a community's mission:

- *Law Enforcement* – Training often focuses on tactical drug identification and responding to incidental exposure.
- *Paramedic or EMT* – Training often focuses on patient care and rapid overdose reversal.
- *Hazardous Materials or Clandestine Laboratory Chemists* – Training often focuses on securing scenes and on the appropriate use of high-level industrial hygiene protocols (Level A/B containment).
- *Harm Reduction* – Training often focuses on communicating drug findings to clients or the public.

A significant safety paradox can often exist in smaller organizations, particularly those focused on harm reduction. While there are numerous guidelines from high-level agencies and organizations for safe handling, they are often perceived as operationally irrelevant (focusing on handling large amounts of material rather than small street-level samples), creating undue challenges in interacting with equipment or other people, or are financially inaccessible. Across communities, there was a general concern that when a safety protocol requires equipment or staffing that a program cannot afford, the result is often abandonment of the guideline rather than a scaled-down, safe alternative.

To address the rapidly evolving drug landscape (e.g., nitazenes and orphines), training likely needs to shift from a static model to a context-sensitive and scalable framework. This framework could incorporate a core training component that presents the main, universal concerns for safe handling, tailored to specific operational constraints of the audience. This could be coupled with additional, regular training courses that focus on new drug threats and modifications to protocols that need to be adapted based on the available data regarding the compound(s). Joint training exercises that span multiple occupational communities could also be considered as ways to help understand different perspectives and better synchronize risk-based responses before agencies meet at high-stress scenes.

Clear Decontamination & Cleaning Protocols

While not all occupational communities deal with decontamination, everyone must clean potentially contaminated items or environments. Clear protocols for decontamination and cleaning were often lacking. A central challenge in this space is the lack of defined acceptable levels or clearance levels for synthetic opioids. Like methamphetamine [7], there are no universally accepted concentration thresholds that define a space as "safe" for public re-entry. Similarly, there are no defined occupational exposure limits to help determine the level of cleaning needed post-exposure. This leads to a critical dialogue regarding the standard of cleanliness required for different environments:

- *Forensic Laboratories* – High-frequency cleaning to prevent cross-contamination of evidence.
- *Operational Spaces* – Cleaning of law enforcement vehicles, interview rooms, and holding cells.

- *Public/Private Spaces* – Residential interior spaces or public restrooms following an overdose.

Without clear, standardized limits, agencies can be left in a state of uncertainty. There also needs to be better education about the differences among cleaning agents, their role, and their effectiveness. For instance, simple soap and water can remove fentanyl from a surface but will not chemically destroy the compound. This could result in the redistribution of the compound over a larger surface area or contamination of the materials used to wipe the water off the surface. Other cleaning agents, such as peracetic acid [8], can chemically break down compounds, rendering them nonhazardous.

While large-scale clandestine laboratory remediations are typically managed by specialized hazardous materials teams or environmental contractors, a responsibility gap can exist for smaller-scale incidents. In many jurisdictions, there is no recognized party or formal procedure for decontaminating a scene following a non-fatal overdose or a non-major spill. This leaves property owners, hotel staff, or transit workers to manage potentially hazardous residues with little to no training or specialized equipment, shifting the burden of risk to the least-prepared individuals. Regardless of the size of the scene, decontamination of non-visible surfaces, such as air handling systems, presents another well-identified yet understudied component that needs to be considered.

Workshop participants also expressed interest in clearer protocols for the decontamination and reuse of high-value PPE, such as SCBA suits. Furthermore, the canine community faces a unique set of challenges. Drug-detection canines are at risk for inhalation exposure, yet field-expedient decontamination procedures for service animals remain underdeveloped. Protecting these valuable assets requires specialized protocols that account for animal physiology and the unique ways they interact with contaminated environments.

Better Field Testing Techniques to Understand Risks

Field testing is a cornerstone of frontline operations, serving as the primary tool for risk assessment, tactical decision-making, and preliminary legal proceedings. However, a significant safety paradox exists – while identifying a substance is critical, the act of sampling itself (particularly opening bags or manipulating powders) can introduce potential exposure concerns. To bridge this gap, some agencies are prioritizing new drug detection and analysis modalities. Key drivers for these changes included use of techniques that do not require opening packaging for handling and techniques that shift the result obtained from detection (“Is a drug present?”) towards identification (“What drug(s) are present?”).

Workshop participants noted a diverse array of technologies currently in use for field detection. These include immunoassay test strips, color tests, vibrational spectroscopy, ion mobility spectrometry, and mass spectrometry. A brief overview of some of the benefits and limitations of each is provided here. More detailed descriptions and information can be found elsewhere [9–11].

- *Immunoassay Test Strips* – Paper-based antibody tests that will produce a positive result for select compound(s) of interest.

- Benefits – Test strips are low-cost and rapid. They have a small form factor and do not require power or a computer. They are specific to a particular compound or class of compounds, which can be helpful when targeted analysis is needed. They are highly sensitive, enabling detection of low-level compounds in complex mixtures.
- Limitations – Test strips require the analyst to open the container to retrieve a small amount of sample, introducing potential exposure risks. Their high specificity can reduce efficacy when broad detection of drugs is desired. False positive results are possible due to cross-reactivity even with benign compounds. Batch-to-batch and vendor-to-vendor inconsistencies are prevalent [12].
- *Fieldable Color Tests* – Small pouches (typically) containing chemicals that create color changes through chemical reactions when a drug sample is added.
 - Benefits – Color tests are low-cost and rapid. They have a small form factor and do not require power or a computer. A wide range of test kits are available for different drug classes.
 - Limitations – Color tests require the user to open the container to retrieve a small amount of sample. Chemical reactions are often based on a particular chemical moiety, making them non-specific and prone to false positives. Most tests rely on visual observation of a color change, which can be difficult to observe in some environments. A recent report has highlighted additional concerns with these tests [13].
- *Vibrational Spectroscopy (Raman, Near-IR [14], and FTIR)* – Instruments that use light, either laser or infrared, to analyze a sample and produce a spectrum that can be compared against a library.
 - Benefits – Systems are typically handheld and can be operated remotely without an auxiliary computer. Some systems are ruggedized for harsh environments. Most systems have large spectral libraries for compound detection. Handheld Raman systems can scan through clear plastic or glass, allowing for identification without opening many types of containers.
 - Limitations – Sensitivity of these techniques is often limited, requiring analysis of bulk materials. Complex mixtures may make data interpretation difficult. Detection of compounds less than 5 % mass fraction of a mixture may not be possible. Updating libraries to include the newest drugs can be difficult.
- *Ion Mobility Spectrometry (IMS) & Fieldable Mass Spectrometry (MS)* – Instruments that measure the collisional cross-section (IMS systems) or mass-to-charge ratio (MS systems) of compounds within a sample after they have been thermally desorbed into the instrument. IMS and MS systems are well suited for trace analysis, enabling the analysis of residue on the outside of drug packaging [15].
 - Benefits – Fieldable systems that enable low-level detection. Systems can be robust enough for use in harsh environments where more sensitive optical

sensors may fail. Systems do not require any chemicals. Many systems are self-contained and can run on battery power.

- Limitations – Libraries can be limited and, depending on the compound, instruments may be prone to false positives from other drugs or benign compounds. Systems can be easily overloaded with samples, which can result in long cleardown times or instrument cleaning. Updating libraries to include the newest drugs can be difficult.

4. Unique Challenges Across Communities

While many of the concerns and challenges were shared across communities and mission-spaces, each community also faced distinct challenges shaped by its operational role, geographical context, and resource availability. The following sections provide brief discussions of additional challenges faced by each represented community.

Border Interdiction (Land and Maritime)

Border agencies are the "first line of defense", often encountering novel substances before they are even identified in clinical or forensic databases. For land interdiction, particularly at ports of entry, the primary challenge is balancing high-throughput screening with officer safety. Sophisticated concealment (e.g., drugs hidden inside machinery or electronics) increases the risk of accidental exposure during physical inspections.

In maritime environments, officers must consider unique environmental challenges – high humidity and high salinity – which can interfere with or damage detection technologies. Unpredictable vessel motion can increase exposure risks when transferring or transporting suspected drug materials. These operational environments also have limited engineering controls (compared to land-based labs), making safe handling more difficult.

Canine Detection and Handling

Canines are highly effective but represent a uniquely vulnerable population that cannot utilize standard PPE. During training, identifying a non-toxic chemical mimic that matches the odor profile of a high-potency synthetic opioid is critical. If a mimic is inaccurate, it risks a false negative in the field; if it is toxic, it introduces unnecessary exposure risks.

Canines face acute risks from inhalation. Their fur and paws can also collect and transfer opioid-containing powder, potentially leading to secondary contamination of their human handler or others who interact with the dog after an event. Effectively removing the particulate to reduce the secondary contamination likelihood remains a major procedural gap.

Clandestine Laboratory Response

Clandestine chemists operate in environments where drugs are not just present but are actively being synthesized, introducing additional chemical risks due to potentially caustic, flammable, and toxic precursors. Response teams need field-screening tools that can identify not just the final drug product, but the precursors and by-products to assess immediate explosive or toxic risks. While bulk chemicals can often be removed quickly, the residual surface contamination poses a long-term threat. Safe reentry limits for these environments are currently undefined.

Correctional Facilities

Correctional settings are unique because they are closed environments where drugs are often distributed in small amounts via mail or visitor contact. Limited research exists on whether staff and canines face a risk of chronic low-level exposure from repeated daily searches of cells and mail. There is also a high demand for passive, airborne sensors that can alert personnel to the presence of aerosolized drugs before they enter a confined space like an inmate cell.

Drug Checking and Harm Reduction

Harm reduction and drug reduction programs generally operate with limited funding and sometimes in legally grey areas. This can present unique or acute challenges in obtaining facilities with engineering controls, training, instrumentation, and resources. There is also limited guidance on best practices for safe handling that are reflective of the realities of working in harm reduction environments. Implementing practices or requiring protocols designed for other operational environments can impose unnecessary financial burdens and strain on staff members.

First Responders (EMT and Hazardous Material Teams)

Though both are "first responders," their primary missions—and thus their risks—diverge sharply. For EMTs and paramedics, the primary risk is inhalation of particulates during patient care. Beyond the physical risk, this community faces significant mental health challenges related to the trauma of recurring synthetic opioid overdoses.

Hazardous material teams noted a unique challenge surrounding maintaining PPE longevity. There is a critical need to understand how repeated decontamination cycles (e.g., using peracetic acid) affect the structural integrity of reusable SCBA suits and masks.

Law Enforcement

For patrol officers, drug encounters are often secondary to a more immediate tactical situation. Accidental exposure is a constant threat during forceful restraints or de-escalation of individuals who may have loose drug powder on their person or clothing. Because street supplies evolve faster than research, law enforcement agencies may struggle to create policies that can protect officers against the next drug threat before it hits the street.

Testing Laboratories (Forensics, Drug Checking, and Public Health)

Chemists face higher risks of direct exposure than some other communities due to the need to either homogenize samples or to obtain net weights (the weight of drug product exclusive of its packaging). They are also required to analyze the actual drug product and cannot rely on trace sampling of the exterior of a package or through-container analyses.

Activities like weighing powders or cutting open layered packaging generate fine particulates that can increase direct or secondary exposure. These particles can remain airborne for prolonged periods, posing an inhalation risk to everyone in the room. To mitigate delayed exposure symptoms, some labs have implemented a cut-off time for evidence handling, ensuring that if a chemist was exposed, symptoms would manifest while they are still on-site with colleagues.

5. Needs and Potential Recommendations

In the breakout sessions, workshop participants were asked to identify perceived needs that, if addressed, would help communities more safely handle synthetic opioids and other emerging substances. Participants were specifically asked three questions:

- What research, related to safe handling and reducing exposure, still needs to be completed?
- Where could standards (documentary, physical, or otherwise) be useful?
- Where could best practices be beneficial to have?

A summary of the main takeaways from these discussions is provided below, broken down into research needs (**Section 5.1**), standards and best practice needs (**Section 5.2**), and other needs (**Section 5.3**).

5.1. Research Needs

From the workshop discussions, four critical pillars were identified in which basic or applied research would help inform approaches to mitigate exposure risks and address outstanding safety questions (**Figure 2**).



Figure 2. Summary of basic and applied research needs that were identified by workshop participants.

Development of Fit-for-Purpose Field-Testing

Frontline personnel require analytical tools that provide accurate, comprehensive drug detection. The ability to accurately identify sample contents allows for informed, risk-based decisions that minimize exposure. Within the context of what is needed to develop fit-for-purpose field techniques, three specific needs were identified.

- *Increase Industry’s Understanding of Operational Requirements* – Participants emphasized that many technologies are not well-suited to their environments and increased engagement with industry early in the development cycle would be beneficial. For sustained adoption, tools must be low-cost, low-maintenance, and require minimal sample manipulation.

- *Address Time Lags Related to Spectral Libraries* – A primary obstacle to accurate detection is the speed at which new compounds enter the supply. Most current technologies rely on spectral libraries that are not updated in real-time or, due to IT security issues, are never updated. Ways to efficiently push updated spectral libraries across a fleet of devices are needed. However, this also introduces the need for a way to rapidly collect high-quality, curated spectra of compounds for which a reference material may not exist. Alternatively, increased research into AI-driven algorithms that can classify unknown substances based on structural similarities – rather than exact library matches – presents another path to address this need.
- *Creation of Independent Method Development and Validation Test Beds* – Stakeholders currently rely on vendor claims, which may not reflect field realities. There is a need for centralized, vendor-neutral test beds to evaluate and validate technology and make the results of such studies digestible by a wide range of communities. These test beds would need to conduct standardized, rigorous testing that incorporates the real-world sample types and operation environments that may be encountered.

Increased Understanding of Occupational Exposure

While existing studies have largely allayed fears of acute overdose from casual dermal contact, significant anxiety remains regarding other exposure routes. Research is needed to quantify the risks of aerosolized particulates that are generated anytime a powdered drug material is handled. Understanding the amount of particulate generated and how these particles drift in various environments is essential for setting occupational exposure limits. Beyond acute incidents, the cumulative effect of chronic, low-level exposure – particularly for forensic chemists and evidence receiving personnel – remains under-researched.

The NIOSH retrospective study (2017–2019) [16] remains a foundational resource, but participants called for ongoing, standardized tracking of "near-miss" incidents to identify emerging patterns in accidental exposure. Rapid characterization of new and emerging drugs is also an urgently needed area of research.

It should be noted that a comprehensive study on research gaps in occupational exposure of illicit opioids was conducted by Basham et al. [17]. The authors reviewed the literature and identified areas of research to support the work of the NIOSH Opioids Research Gaps Working Group. The report summarizes literature from 2010 to 2020. The available literature and research gaps cover the following topic areas: PPE, decontamination and disposal, and engineering controls to prevent exposure. Though the majority of the published literature focused on first responders and law enforcement, the findings and research gaps can be extended to all personnel encountering opioids during routine work-related activities.

Enhancing Canine Safety

Canines are highly effective field detection assets, yet they represent a vulnerable population with unique physiological risks. There is a critical need for validated mimics that produce a

headspace odor profile identical to target narcotics without the toxicity. Research at Florida International University [18] highlights the difficulty of finding mimics that allow canines to "generalize" across a chemical family, such as fentanyl analogs.

Limited data exists regarding a canine's return-to-duty timeline following naloxone administration. Research is still needed to determine if opioid reversal agents have long-term impacts on a canine's olfactory sensitivity. Essler et al. have completed some initial studies on the effect of fentanyl administration and subsequent naloxone administration on the olfactory abilities of canines [19, 20]. They observed that naloxone administration did not affect the canine's ability to subsequently detect target drugs in searches. Admittedly, such studies are difficult to perform and retrospective studies and tracking of incidents could meet the need.

Creating Validated Cleaning and Decontamination Procedures

Research into fentanyl clean-up and decontamination [8, 21–24] has been conducted, but there are still several key questions that need to be addressed.

Existing research [8] has shown that water alone is an insufficient decontaminant and may even spread contamination, as it does not degrade fentanyl itself. Depending on the scenario, this may cause previously uncontaminated surfaces to become contaminated. Chemical breakdown of synthetic opioids is possible with high-efficacy neutralizers, such as peracetic acid or activated hydrogen peroxide, however the use of these compounds on porous substrates (e.g., fabrics and car interiors) remains largely unstudied. Research must also evaluate whether aggressive chemical decontaminants can degrade the integrity of expensive PPE or sensitive electronic instrumentation over time. Standardized studies done in this space are needed to inform appropriate cleaning and decontamination protocols. However, like with detection technologies, protocols that are developed will need to be fit-for-purpose and account for not only the types and amounts of materials to be encountered, but also the operational and financial constraints or certain communities.

Participants also mentioned that increased research into the risks of secondary contamination, particularly the risk of bringing contamination back to one's home, is needed. Development of protocols to minimize the risk of acute and chronic exposure to family members was highlighted.

Other Research Needs

Several other research needs that did not fit into the four categories above were noted. These include:

- Exposure risk studies for specific scenarios, such as the persistence of nitazenes in the air
- Acute and chronic exposure risks to these chemicals for pregnant women
- Ways to rapidly determine metabolites for emerging substances for better exposure monitoring

- Studies that focus on toxicity based on route of exposure
- Identification of combustion products of new and emerging synthetic opioids to inform environmental monitoring and clean-up
- Human factors research, focusing on how to prevent hazard fatigue from introducing procedural errors
- Studies focused on maintaining the mental health of frontline workers, especially those who often interact with people who use drugs and/or people who have overdosed

It should be noted that the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) maintains a list of other important research questions and research needs in their Master Question List for Synthetic Opioids V.2 [25].

5.2. Standards and Best Practice Needs

Documentary standards provide the necessary framework to move from ad-hoc protocols to best practices. The workshop identified a critical need for consensus-based guidelines that are scalable, mission-specific, and updated at the speed of the evolving drug market. These needs centered on research and evaluation of field detection technologies, creation of tiered safe handling and PPE guidelines, canine detection, and decontamination or post-incident cleanup (**Figure 3**).

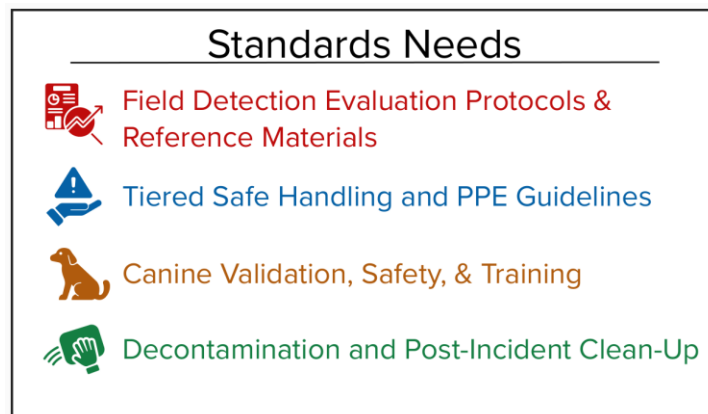


Figure 3. Summary of standards and best practice needs that were identified by workshop participants.

Field Detection Technology Evaluation Protocols and Reference Materials

Agencies often rely on vendor-provided data to make high-consequence procurement decisions. There is a clear need for:

- *Sensitivity and Specificity Thresholds* – Establishing minimum performance requirements for fieldable technologies informed by the types of samples encountered by these communities and by toxicological research. This would ensure that a result is scientifically defensible in a legal or safety context and better ensure that the equipment procured is fit-for-purpose.

- *Validation Protocols* – A standardized methodology for how an agency should validate its equipment in the field. Validations could be conducted by agencies independent of those conducting the actual day-to-day analyses.
- *Complex Reference Mixes* – While individual chemical standards exist, there is a shortage of realistic test materials that accurately mimic the chemical makeup of the street supply. Realistic test materials would enable industry and the community to assess how their equipment handles the "noise" of the current supply.

Tiered Safe Handling and PPE Guidelines

It was clear from the workshop that overly restrictive guidelines can lead to a lack of implementation. To address this challenge, the need for mission-specific, tiered guidelines was highlighted. Specific things that need to be addressed in these guidelines include:

- *Cost-Tiered Approaches* – Guidelines that offer "Good, Better, Best" options based on an agency's budget and specific risk environment (e.g., a rural patrol officer vs. a high-volume forensic lab).
- *Sharps and Evidence Handling* – Specific documentary standards for the safe packaging and transport of high-potency materials when contained within different types of paraphernalia. This is especially true for the unique biological and chemical hazards associated with handling of syringes suspected of containing synthetic opioids.
- *Evidence "Chain of Safety"* – Standardized documentation for how evidence is flagged as hazardous before it enters a courtroom or evidence locker.

Canine Validation, Safety, and Training

The canine community lacks a unified process to certify odor mimics and ensure that the scents used in training translate to the street.

- *Training Aid Verification* – Documentary standards are needed to verify the chemical purity and odor profile of synthetic mimics.
- *Training Aid Handling Guidelines* – Documentary best practices for effective handling of training aid materials to ensure cross-contamination of odor profiles during storage does not occur.
- *Operational Reentry Documentation* – Guidelines that define, based on research, approach return-to-work procedures for canines that have a known or suspected exposure to synthetic opioids in the field.

Decontamination and Post-Incident Clean-Up

Beyond research needed to establish necessary exposure limits and surface concentrations, there is a need for Standard Operating Procedures (SOPs) for daily hygiene.

- *Routine Cleaning Protocols* – Best practices for preventing a buildup of contamination in areas where drugs are routinely analyzed, opened, and stored. Like the tiered PPE approach, these protocols need to be developed to account for different operational, financial, and logistical constraints.
- *Disposal Protocols* – Standardized guidelines for the legal and safe disposal of materials used during field testing (e.g., used test strips and contaminated gloves), especially in circumstances where the samples are collected and analyzed outside of the law enforcement/forensics framework.

5.3. Other Needs

Beyond technical research and formal standards, workshop participants identified four additional critical areas of need to support safe handling practices. These needs focus on breaking down professional silos and ensuring that the right information reaches the right person at the right time.

Risk Communication and Public Awareness

A primary obstacle to effective field operations is misinformation regarding incidental exposure. Inaccurate information concerning the risks of dermal fentanyl exposure has historically led to operational paralysis and unnecessary psychological stress among first responders. There is a need for evidence-based hazard communication that balances necessary caution with scientific reality.

Participants also highlighted the need for a centralized, trusted process to disseminate scientifically sound toxicity data and safe handling protocols to both the public and professional communities.

Collaborative Training and Education

Safety is a cross-community responsibility. The workshop highlighted the high value of inter-agency dialogue. Participants mentioned that it would be beneficial for training to move beyond individual silos. There was an interest in developing joint safe handling exercises where different sectors can share their specific challenges, successes, and tactical maneuvers. To further ensure consistency across communities, the need for a common vocabulary for risk, used by everyone from the crime lab to the courtroom, was highlighted as a way to reduce confusion during multi-agency responses.

Data Interoperability and Reference Materials

The analytical community emphasized that advancing safety can often be limited by a lack of access to shared data. There was a strong desire for increased collaboration between local, state, and federal agencies to share spectral libraries and analytical data for new synthetic

compounds so that agencies could more quickly identify emerging compounds of concern and inform their personnel and/or clientele. The desire to establish formal working groups that would facilitate the rapid exchange of safe handling data, new analytical findings, and the distribution of reference materials was also highlighted.

Real-Time Drug Landscape Information

To maintain situational awareness, frontline personnel need to know what is in the local supply before they encounter it. Participants identified a need for regional drug-checking data and early warning alerts that identify when ultra-potent analogs, like nitazenes, or dangerous adulterants, like medetomidine, enter a specific geographical area. The desire to develop ways to move from snapshot data to longitudinal trend analysis that would allow agencies to predict future safety needs and adjust their PPE procurement and training modules accordingly was also highlighted.

6. Potential NIST Action Items

Given NIST's focus on measurement science and standards development, there are unique opportunities for the agency to assist other communities in addressing some of the above-mentioned research and standards needs. Based on the challenges and barriers identified at the workshop, there are five areas where, given an expansion of efforts and resources, the NIST mission is well aligned to support: development of reference or test materials, creation of technology test beds, advancing contamination and decontamination science, addressing data infrastructure, data science, and reference data needs, and supporting the development of documentary standards.

Standard Reference Materials and Research Grade Test Materials

NIST's longstanding efforts in creating standard reference materials, and more recent efforts to develop research grade test materials, could be leveraged to assist research, development, and validation of analytical devices and canines.

- *Production of "Street-Realistic" Reference Mixes* – Move beyond pure chemical standards to create SRMs that mimic seized drugs. This effort has already been started through the Characterized Authentic Drug Samples (CADS) program but could be expanded to different drug types and different characterizations [26].
- *Trace-Level Detection Standards* – Develop materials for ensuring ongoing performance of trace detection technologies. Similarly, develop materials that could help test and monitor the ability to reliably detect low-concentration synthetic opioids in a matrix.
- *Non-Toxic Canine Mimics* – Work with other governmental and academic partners on the creation of canine mimics that could be used for training and validation purposes.

Establishing Technology Acceleration and Validation Test Beds

NIST could act as a vendor-neutral validator, providing objective, comparable data to the community and working with industry partners to accelerate technology development.

- *Establish a National Field-Testing Validation Center* – A centralized laboratory where fieldable devices (i.e., immunoassays, handheld Raman, FTIR, IMS, etc.) are validated on methods developed for different operational environments. In conjunction, this center could work with industry on research and development challenges with next-generation devices.
- *Standardized Performance Metrics* – Draft a "Uniform Performance Label" for field-testing tech (similar to a nutrition label) that clearly lists a device's sensitivity, specificity, and false-positive rates for specific classes. This would also require the development of the necessary tests to develop the label.

Advancing Decontamination and Surface Science

Leveraging NIST's experience in visualizing and measuring the movement of trace particulates, we could work with other government and industry partners on addressing needs related to preventing exposure and decontamination.

- *Development of "Standard Contaminated Surfaces"* – Create standardized coupons (e.g., pieces of stainless steel, drywall, or car upholstery) contaminated with precise amounts of drugs to test the efficacy of cleaning agents like peracetic acid or pH-buffered bleach.
- *Clearance Level Research* – Assist other agencies with the necessary research to understand and establish exposure levels for different occupations and the public, helping to address the definition of clean.
- *Particulate Drift Modeling* – Use NIST's expertise in particulate visualization and monitoring to simulate how fine drug particulates travel through air handling systems and settle in indoor environments.

Addressing Data Infrastructure, Data Science, and Reference Data Needs

NIST could help address some of the challenges surrounding the reliance on spectral libraries by developing ways to centralize and verify chemical data, develop new algorithms for spectral interpretation, and establish common practices and protocols for producing and transferring spectral data.

- *Centralized Drug Spectra Database* – Create a centralized, freely-available repository that contains spectral data for traditional and emerging drugs collected across a range of different fieldable and laboratory-based tools. By connecting this type of effort to a network of worldwide early warning systems, we could ensure that newly detected compounds are rapidly added to the repository to keep pace with changes in the drug supply.
- *Drug Data Commons* – Create a framework for the storage, sharing, and dissemination of drug data that spans the different operational communities. Using a standardized framework would allow agencies to more quickly share data on newly detected compounds and their associated safety threats.
- *AI/Machine Learning for Unknown Identification* – Develop algorithms that can predict the chemical structure of an unknown compound based on available spectral data.
- *AI/Machine Learning for Toxicity Assessment* – Develop algorithms that can predict the toxicity of a chemical based on its structural similarity to known opioids and other available research and data.

Supporting the Development of Documentary Standards

NIST could work with standards bodies and the community to drive the creation of consensus-based standards to support several needs that were identified. This could be done, in some capacity, through the Organization of Scientific Area Committees (OSAC), which has working

groups specifically focused on forensic drug analysis and canine drug detection. Collaborating with other government agencies and professional entities could drive additional documentary standards development.

References

- [1] Sisco E, Staymates ME, Burns A (2020) An easy to implement approach for laboratories to visualize particle spread during the handling and analysis of drug evidence. *Forensic Chemistry* 18. <https://doi.org/10.1016/j.forc.2020.100232>
- [2] Sisco E, Staymates ME, Watt LM (2020) Net weights: Visualizing and quantifying their contribution to drug background levels in forensic laboratories. *Forensic Chemistry* 20:100259. <https://doi.org/10.1016/j.forc.2020.100259>
- [3] Rep. Collins M [R-G-10 (2023) H.R.1734 - 118th Congress (2023-2024): TRANQ Research Act of 2023. Available at <https://www.congress.gov/bill/118th-congress/house-bill/1734>
- [4] Caprari C, Ferri E, Rossetti P, Gregori A, Citti C, Cannazza G (2025) The emergence of nitazenes: a new chapter in the synthetic opioid crisis. *Archives of Toxicology* 99(10):3877–3896. <https://doi.org/10.1007/s00204-025-04102-3>
- [5] Ujváry I, Christie R, Evans-Brown M, Gallegos A, Jorge R, de Morais J, Sedefov R (2021) DARK Classics in Chemical Neuroscience: Etonitazene and Related Benzimidazoles. *ACS Chemical Neuroscience* 12(7):1072–1092. <https://doi.org/10.1021/acschemneuro.1c00037>
- [6] ACMT and AACT Position Statement: Preventing Occupational Fentanyl and Fentanyl Analog Exposure to Emergency Responders (2022) (American College of Medical Toxicology), 170701. Available at https://www.acmt.net/wp-content/uploads/2022/06/PRS_170701_Preventing-Occupational-Fentanyl-and-Fentanyl-Analog-Exposure-to-Emergency-Responders.pdf
- [7] Kuhn EJ, Walker GS, Whiley H, Wright J, Ross KE (2019) Household Contamination with Methamphetamine: Knowledge and Uncertainties. *International Journal of Environmental Research and Public Health* 16(23):4676. <https://doi.org/10.3390/ijerph16234676>
- [8] Oudejans L, See D, Dodds C, Corlew M, Magnuson M (2021) Decontamination options for indoor surfaces contaminated with realistic fentanyl preparations. *Journal of Environmental Management* 297:113327. <https://doi.org/10.1016/j.jenvman.2021.113327>
- [9] Sisco E (2024) Drug Detection, Analysis, and Monitoring Workshop Report. NIST. Available at <https://www.nist.gov/publications/drug-detection-analysis-and-monitoring-workshop-report>
- [10] Crocombe RA, Giuntini G, Schiering DW, Profeta LTM, Hargreaves MD, Leary PE, Brown CD, Chmura JW (2023) Field-portable detection of fentanyl and its analogs: A review. *Journal of Forensic Sciences* 68(5):1570–1600. <https://doi.org/10.1111/1556-4029.15355>
- [11] Alonzo M, Alder R, Clancy L, Fu S (2022) Portable testing techniques for the analysis of drug materials. *WIREs Forensic Science* 4(6):e1461. <https://doi.org/10.1002/wfs2.1461>
- [12] Halifax JC, Lim L, Ciccarone D, Lynch KL (2024) Testing the test strips: laboratory performance of fentanyl test strips. *Harm Reduction Journal* 21(1):14. <https://doi.org/10.1186/s12954-023-00921-8>
- [13] Miller R, Heaton P, Sturges H (2023) Guilty until Proven Innocent: Field Drug Tests and Wrongful Convictions. (Quattrone Center for the Fair Administration of Justice, University of Pennsylvania). Available at <https://www.law.upenn.edu/institutes/quattronecenter/reports/field-drug-test-study/field-drug-tests-and-wrongful-convictions/>

- [14] Kranenburg RF, Ou F, Sevo P, Petruzzella M, de Ridder R, van Klinken A, Hakkel KD, van Elst DMJ, van Veldhoven R, Pagliano F, van Asten AC, Fiore A (2022) On-site illicit-drug detection with an integrated near-infrared spectral sensor: A proof of concept. *Talanta* 245:123441. <https://doi.org/10.1016/j.talanta.2022.123441>
- [15] Sisco E, Verkouteren J, Staymates J, Lawrence J (2017) Rapid detection of fentanyl, fentanyl analogues, and opioids for on-site or laboratory based drug seizure screening using thermal desorption DART-MS and ion mobility spectrometry. *Forensic Chemistry* 4:108–115. <https://doi.org/10.1016/j.forc.2017.04.001>
- [16] Chiu S, Dowell CH, Hornsby-Myers J, Trout DB (2020) Evaluation of Occupational Exposures to Illicit Drugs During an Emergency Medical Services Response. (National Institute for Occupational Safety and Health), 2018-0067–3312. <https://doi.org/10.26616/NIOSHHE201800673312>
- [17] Basham C, Cerles A, Rush M, Alexander-Scott M, Greenawald L, Chiu S, Broadwater K, Hirst D, Snawder J, Roberts J, Weber A, Knuth M, Casagrande R (2021) Occupational Safety and Health and Illicit Opioids: State of the Research on Protecting Against the Threat of Occupational Exposure. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy* 31(3):315–329. <https://doi.org/10.1177/104829112111039566>
- [18] Dargan R, Hogan KA, Forte L, Bosnich J, Furton KG, DeGreeff LE (2026) Lessons from the development of a canine training aid mimic for the detection of fentanyl: Canines versus instruments. *Forensic Science International* 384:112911. <https://doi.org/10.1016/j.forsciint.2026.112911>
- [19] Essler JL, Smith PG, Berger D, Gregorio E, Pennington MR, McGuire A, Furton KG, Otto CM (2019) A Randomized Cross-Over Trial Comparing the Effect of Intramuscular Versus Intranasal Naloxone Reversal of Intravenous Fentanyl on Odor Detection in Working Dogs. *Animals* 9(6):385. <https://doi.org/10.3390/ani9060385>
- [20] Essler JL, Smith PG, Ruge CE, Darling TA, Barr CA, Otto CM (2022) The first responder exposure to contaminating powder on dog fur during intranasal and intramuscular naloxone administration. *Journal of Veterinary Emergency and Critical Care* 32(1):18–25. <https://doi.org/10.1111/vec.13113>
- [21] Bazley MM, Logan M, Baxter C, Robertson AAB, Blanchfield JT (2020) Decontamination of Fentanyl and Fentanyl Analogues in Field and Laboratory Settings: A Review of Fentanyl Degradation. *Australian Journal of Chemistry* 73(10):868–879. <https://doi.org/10.1071/CH19669>
- [22] Sisco E, Najarro M, Burns A (2018) Quantifying the Effectiveness of Cleaning Agents at Removing Drugs from Laboratory Benches and Floor Tiles. *Forensic Chemistry* 12. <https://doi.org/10.1016/j.forc.2018.11.002>
- [23] Lindén P, Mören L, Qvarnström J, Forsgren N, Engdahl CS, Engqvist M, Henych J, Tengel T, Österlund L, Thors L, Larsson A, Johansson S (2024) Field and laboratory perspectives on fentanyl and carfentanil decontamination. *Scientific Reports* 14(1):25381. <https://doi.org/10.1038/s41598-024-74594-z>
- [24] Reid DJ, Patel KF, Melville AM, Bailey VL, Omberg KM, Lamoureux LR Environmental life cycle of fentanyl: From the cradle to an unknown grave. <https://doi.org/10.1002/jeq2.70016>

- [25] S&T Master Question List for Synthetic Opioids | Homeland Security Available at <https://www.dhs.gov/publication/st-master-question-list-synthetic-opioids>
- [26] Characterized Authentic Drug Samples (CADS) (2024) *NIST*. Available at <https://www.nist.gov/programs-projects/characterized-authentic-drug-samples-cads>

Appendix A. Workshop Agenda

9:00 – 9:10	Opening Remarks & Logistics <i>Ed Sisco, NIST</i>
9:10 – 9:25	Introductions
9:25 – 9:40	Why Are We Here? - NIST Research to Support Safe Handling <i>Matt Staymates & Ed Sisco, NIST</i>
9:40 – 10:00	Review of Current, Publicly Available Resources <i>Monica Joshi, NIST / West Chester University of PA</i>
10:00 – 10:20	Break
10:20 – 12:00	Panel: First-Hand Experiences, Best Practices, and Considerations <i>Law Enforcement – Brent Kluttz, W/B HIDTA</i> <i>Law Enforcement – Kevin Reese / Patrick Skiba, Montgomery County Police</i> <i>Harm Reduction – Yarelix Estrada, Remedy Alliance for the People</i> <i>First Responder – John Zour, Howard Co. Fire and Rescue Services</i> <i>Clandestine Laboratory – Shirley Verschoor, Netherlands Forensic Institute</i> <i>Forensic Lab – Jennifer Watson, Miami Valley Regional Crime Laboratory</i> <i>Corrections – Scott VanGorder, PA Dept. of Corrections</i> <i>Coast Guard – Deborah Hastings, U.S. Coast Guard</i>
12:00 – 1:15	Lunch
1:15 – 2:30	Panel: Industrial Hygiene and Safety Considerations <i>Peter Harnett, Leidos</i> <i>Lukas Oudejans, EPA</i> <i>Kelsey Granger, APHL</i>
2:30 – 2:50	Canine Safety Considerations <i>Lauryn DeGreeff, Florida International University</i>
2:50 – 3:10	Remediation Considerations <i>Lukas Oudejans, EPA</i>
3:10 – 3:30	Break
3:30 – 4:50	Breakout Session: Needs and Next Steps
4:50 – 5:00	Wrap Up
5:00 PM	Conclude

Appendix B. Speakers and Participants

Luis Arroyo West Virginia University	Thinh Bui NIST	Brian Bush NIST	Megan Chambers National Institute of Justice
Melissa Clark AHEC West	Lauryn DeGreeff Florida International University	Lisa Derby NIST	Rae Elkasabany DanceSafe
Yarelis Estrada Remedy Alliance for the People	Alexandra Evans U.S. Postal Inspection Service	Kelsey Granger Association of Public Health Laboratories	Grecia Gratacos U.S. Customs & Border Protection
Peter Harnett Counsel in Occupational & Environmental Health / Leidos	Deborah Hastings U.S. Coast Guard	Monica Joshi NIST	Sydney Ma U.S. Postal Inspection Service
Evy Meeusen Netherlands Forensic Institute	Sara Mikovic U.S. Coast Guard	John O'Brien Montgomery County Police Dept.	Lukas Oudejans U.S. Environmental Protection Agency
Laura Parker U.S. Dept. of Homeland Security	Penelope Pietrowski U.S. Dept. of Homeland Security	Kevin Reese Montgomery County Police Dept.	Jill Robinson Denver Crime Laboratory
Elizabeth Robinson NIST	Jonathan Rosen National Clearinghouse for Worker Safety & Health Training	Julio Santiago U.S. Postal Inspection Service	Frances Scott National Institute of Justice
Sarah Shuda NIST	Edward Sisco NIST	Patrick Skiba Montgomery County Police Dept.	Matthew Staymates NIST
Natalie Underwood U.S. Customs & Border Protection	David (Scott) VanGorder Pennsylvania Dept. of Corrections	Shirley Verschoor Netherlands Forensic Institute	Laura Waters Maryland State Police Forensic Sciences Division
Jennifer Watson Miami Valley Regional Crime Laboratory	Andrea Wiggins U.S. Dept. of Homeland Security	Joseph Wiseman Pennsylvania Dept. of Corrections	Andrea Yarberry NIST
John Zour Howard County Fire & Rescue Services			

Appendix C. Publicly Available Safe Handling Resources Discussed at the Workshop

Agency	Publicly Available Resource
Drug Enforcement Agency (DEA)	Fentanyl Safety Recommendations for First Responders
	Fentanyl: A Briefing Guide For First Responders
	Fentanyl A Real Threat to Law Enforcement
U.S. Customs and Border Protection (CBP)	Fentanyl: The Real Deal
The InterAgency Board (IAB)	Recommendations on Selection and Use of PPE Equipment and Decontamination Products for First Responders Against Exposure Hazards to Synthetic Opioids, Including Fentanyl and Fentanyl Analogues
	IABPUB 2017-04-01 Recommended Best Practices for Minimize Responder Exposure to Synthetic Opioids, IABPUB 2017-01-01 First Responder PPE and Decontamination Recommendations for Fentanyl
U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T)	Master Question List for Synthetic Opioids
Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH)	Fentanyl: Emergency Responders at Risk
	Fentanyl: Emergency Responders Toolkit
U.S. Environmental Protection Agency (EPA)	Fact Sheet for Federal Onsite Coordinators- Fentanyl and Fentanyl Analogs
	Remediation Options for Fentanyl Contaminated Indoor Environments
	Voluntary Guidelines for Methamphetamine and Fentanyl Laboratory Cleanup
Association of Public Health Laboratories (APHL)	Safe Handling Precautions for Fentanyl Safe Handling of Fentanyls in the Laboratory
Justice Institute of British Columbia (JIBC)	Fentanyl Safety for First Responders
United Nations Office on Drugs and Crime (UNODC)	Guidelines for the safe handling of synthetic opioids for law enforcement and customs officers
	United Nations Toolkit on Synthetic Drugs
	Safe Handling and Disposal

Appendix D. List of Symbols, Abbreviations, and Acronyms

ACMT

American College of Medical Toxicology

CBP

Customs and Border Protection

DEA

Drug Enforcement Administration

EMT

emergency medical technician

FTIR

Fourier-transform infrared spectroscopy

HazMat

hazardous materials

IMS

ion mobility spectrometry

NIST

National Institute of Standards and Technology

NPS

novel psychoactive substance

PPE

personal protective equipment

SCBA

self-contained breathing apparatus

USPIS

United States Postal Inspection Service