Health Hazard Evaluation Program

Evaluation of Occupational Exposures to Illicit Drugs at a Police Department Crime Laboratory

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Introduction

Request

Management at a police department crime laboratory requested an evaluation due to concerns about potential occupational exposure to illicit drugs among employees working in the forensic chemistry unit.

Workplace

The police department crime laboratory provides forensic and crime scene services to support law enforcement and criminal investigations in the city, county, and to federal agencies. The crime laboratory is organized into specialized units, including crime scene, firearms, forensic biology, forensic chemistry, forensic imaging, computer forensics, latent print, quality assurance, and trace evidence units. Employees of the laboratories performed forensic analyses on a wide variety of evidence. We focused our evaluation on employees who routinely handled or analyzed evidence that may contain controlled substances and those who worked in areas of the laboratory where suspected illicit drugs were present.

We conducted site visits in May and July 2024. At the time of our visits, six forensic scientists worked in the forensic chemistry unit and two worked in the trace evidence unit. The trace evidence unit is the part of the forensic chemistry unit that tests for trace evidence such as explosives, residues, and paint.

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

We visited the crime laboratory twice to learn about potential health concerns and to measure exposures. During our site visits, we completed the following activities:

- Observed laboratory work processes, practices, and conditions.
- Measured forensic scientists' exposures to cocaine, fentanyl, heroin, and methamphetamine in air, on hands, and on surfaces in the forensic chemistry laboratory and in office areas.
    - We compared fentanyl exposures in air to the American Conference of Governmental Industrial Hygienists (ACGIH®) occupational exposure limit of 0.1 micrograms per cubic meter of air.
    - Cocaine, heroin, and methamphetamine have no occupational exposure limits set by the federal government or consensus organizations.
- Assessed the fume hoods and the airflow between laboratory areas and hallways.
- Held confidential medical interviews with 7 forensic scientists.
- Tested 7 forensic scientists' urine for cocaine, fentanyl, heroin, methamphetamine, and several metabolites (breakdown products) of these drugs.

- Reviewed relevant records including safety and health program documents, exposure and injury reports, laboratory surface sampling results completed prior to our visits, and facility information.

To learn more about our methods, go to **Section B in the Supporting Technical Information**

Our Key Findings

One forensic scientist was overexposed to fentanyl in the air. Forensic scientists were also exposed to cocaine and methamphetamine in the air.

- One forensic scientist had a full-shift time-weighted average exposure of 0.15 micrograms of fentanyl per cubic meter of air on the first of 2 days of air sampling. This exposure exceeds the occupational exposure limit set by ACGIH of 0.1 micrograms per cubic meter of air.
  - This employee completed preliminary analysis of evidence described as "thousands" of tablets that were suspected to contain fentanyl during air sampling.
  - Laboratory area air samples had detectable fentanyl concentrations.
  - Two other employees who had documented completing a case identified preliminarily as containing fentanyl did not have fentanyl in their personal air samples.
- Of six employees participating in personal air sampling, all four employees who had documented completing or assisting on evidence containing cocaine had cocaine detected in their personal air samples. One employee working in the forensic chemistry laboratory who did not work on or assist with evidence identified as containing cocaine had cocaine detected in one of their personal air samples.
- Of six employees participating in personal air sampling, all six employees working in the forensic chemistry laboratory had methamphetamine in their personal air samples on both days of the site visit. All employees worked on or assisted in analyzing evidence that was preliminarily identified as containing methamphetamine.

Cocaine, fentanyl, and methamphetamine were found on hands of forensic scientists and on surfaces in and outside of the laboratory. Heroin was found on surfaces in the laboratory.

- Of seven employees participating in handwipe samples on 2 days of sampling, cocaine (7 of 12 samples), fentanyl (2 of 12 samples), and methamphetamine (6 of 12 samples) were found on handwipe samples collected before working in the laboratory. Cocaine (11 of 12 samples), fentanyl (1 of 12 samples), and methamphetamine (11 of 12 samples) were found on handwipe samples after working in the laboratory.
  - On average, levels of cocaine and methamphetamine found on hands were higher after working in the laboratory compared to before. However, this was not always the case.

- Cocaine was found on all 20 surface samples inside and outside of the laboratory. Methamphetamine was found on all 15 surface samples collected inside of the laboratory. Fentanyl (11/15) and heroin (8/15) were found on some surfaces inside of the laboratory.
    - No surface samples exceeded the surface limit set by ACGIH for fentanyl of 1 microgram per 100 square centimeters.
    - Ten surface samples, all collected in the laboratory, exceeded 0.1 micrograms per 100 square centimeters for methamphetamine. This is the standard for methamphetamine contamination in remediated spaces adopted by most states with such standards.
- Cocaine and methamphetamine were found on a surface sample collected from the vestibule sink handle.

Methamphetamine was found in some employees' urine samples

- Three employees had detectable levels of methamphetamine in their pre-shift urine samples. All measured concentrations were low, well below levels typically associated with clinical or forensic drug testing thresholds.
    - Post-shift samples from these employees showed lower methamphetamine concentrations than their pre-shift samples; in some cases, levels were not detectable post-shift. This pattern may reflect a carryover effect from prior casework exposures.
    - All measured levels were below drug testing thresholds used in clinical or forensic settings.
    - Biomonitoring results only capture recent exposure and do not provide information on long-term or cumulative exposure.
- Methamphetamine was one of the most frequently handled substances reported by employees during the 2 weeks prior to sampling.

To learn more about our results, go to Section B in the Supporting Technical Information

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Potential Benefits of Improving Workplace Health and Safety:	
↑ Improved worker health and well-being	↑ Enhanced image and reputation
↑ Better workplace morale	↑ Superior products, processes, and services
↑ Easier employee recruiting and retention	↑ Increase overall cost savings

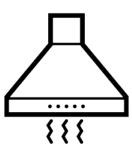
The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions employers can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls is a way of determining which actions will best control exposures. In most cases, the preferred approach is to eliminate hazards or to replace the hazard with something less hazardous (i.e., substitution). Installing engineering controls to isolate people from the hazard is the next step in the hierarchy. Until such controls are in place, or if they are not effective or practical, administrative controls and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/hierarchy-of-controls/about/index.html.

We encourage the laboratory to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in *Recommended Practices for Safety and Health Programs* at https://www.osha.gov/safety-management.

Recommendation 1: Reduce employees' exposures to cocaine, fentanyl, heroin, and methamphetamine

Why? One forensic scientist's air sample exceeded the recommended occupational exposure limit for fentanyl. We have no indication that exposures to cocaine, fentanyl, heroin, methamphetamine at this crime laboratory have impacted employees' health. However, following sound occupational health practice, we recommend reducing workplace exposures to illicit drugs to as low as possible.

How? At your workplace, we recommend these specific actions:



Improve the performance of existing ventilated workspaces.

- Work with the servicer of your laboratory or benchtop hoods to ensure that laboratory or benchtop hoods meet design and performance specifications outlined in the American National Standards Institute and American Society of Safety Professionals (ANSI/ASSP) Z9.5-2022: Laboratory Ventilation standard [ANSI/ASSP 2022].
    - If the average face velocity falls outside of the standard's specifications or if low or no airflow is detected at the hood face, the hood fan should be evaluated and serviced as needed. More information can be found in ANSI/ASHRAE Standard 110.
- Continue requiring forensic scientists to use a laboratory or benchtop hood for the handling of controlled substances, specifically for activities that involve transferring loose material like weighing powder, opening bulk evidence, and handling bulk evidence.
- If necessary, test and balance the laboratory building ventilation systems after adjustments to ensure laboratory spaces remain negatively pressurized relative to exterior areas, such as hallways.

Continue practices that were implemented to reduce exposure to controlled substances and their movement outside of the laboratory.

- Continue working with law enforcement partners to address concerns about inconsistent packaging.
- Continue to implement policies to minimize taking net weights (weighing material without packaging) only when necessary. This may require working with partners in the court system to address modification of policies.
- If not done so already, maintain a cleaning schedule that includes regularly cleaning keyboards and mice and any other commonly touched surfaces in the laboratory using effective cleaning methods to reduce presence of drugs on these surfaces.
    - The U.S. Environmental Protection Agency has evaluated cleaning methods for fentanyl removal efficacy: Research to Inform Decontamination Strategies, Methods, and Related Technical Challenges for Remediation of a Fentanyl-Contaminated Site.
    - The National Institute for Standards and Technology evaluated the effectiveness of cleaning agents for removal efficacy for the four drugs evaluated in this HHE: Quantifying the effectiveness of cleaning agents at removing drugs from laboratory benches and floor tiles.
    - For electronics, determine appropriate cleaning methods according to manufacturer recommendations.
- Encourage employees to wash their hands with soap and water before eating, drinking or smoking, and before leaving the laboratory for the day.
- Regularly clean surfaces outside of the laboratory to keep surfaces free of controlled substances.
- Implement a regular cleaning schedule for surfaces that are infrequently cleaned, such as sink handles, chairs, and horizontal surfaces in the laboratory.

Consider implementing quantitative fit testing for respirators that are required for use during evidence analysis

- Continue providing employees with N95® or P100® respirators for use when handling bulk samples.
- Ensure N95 respirators and surgical masks are stored properly to prevent contamination from controlled substances.
- If respirator use is required during work, develop a written respiratory protection program specifically for the crime laboratory. Ensure employees are medically cleared, fit tested, and trained to use the specific respirator required according to the OSHA Respiratory Protection Standard (29 CFR 1910.134).

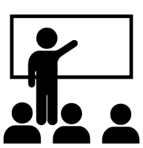
Recommendation 2: Provide annual training on laboratory best practices to prevent exposure and improve recognition of symptoms of controlled substance exposure

Why? Training on health and safety policies is essential for creating a safe and supportive work environment where employees understand how to identify risks, prevent accidents, and respond effectively to emergencies. Training, as part of ongoing communication, fosters a culture of care and responsibility, helping to reduce injuries, illness, and workplace stress. By prioritizing employee well-being, organizations build trust, strengthen team morale, and demonstrate a genuine commitment to the people who make their success possible.

How? At your workplace, we recommend these specific actions:

Update the safety manual and other standard operating procedures to reflect changes implemented to reduce exposure to controlled substances.

- Remove any discrepancies that may cause confusion. Examples include discrepancies in policies on the following topics:
    - Glove use in the laboratory
    - Respirator use
- Consider creating a safety manual specifically for forensic scientists who analyze evidence that may contain controlled substances as some hazards and recommended practices may differ compared to other units.



Train employees to recognize signs and symptoms of controlled substance exposures.

- Signs and symptoms include but are not limited to
    - For stimulants: agitation, a fast heart rate, loss of appetite, hyperactivity, dilated pupils, flushed skin, excessive sweating, increased movement, dry mouth, and teeth grinding.
    - For opioids: respiratory depression, dry mouth, drowsiness, constipation, neurologic effects (such as sedation, relaxation, difficulty in concentration, and mental slowness), tiredness, lightheadedness, mild disorientation, heaviness of limbs, and itching.

Train employees on proper handwashing methods.

- Instruct employees to wash hands after every case, before eating or drinking, and when leaving the laboratory.
- More information on handwashing is available on the CDC website.

Recommendation 3: Improve communication between employees and laboratory management regarding health and safety policies and practices

Why? Ongoing communication regarding health and safety policies and any upcoming changes increases employee engagement on the topic. Explicit safety and health commitment from laboratory and unit management may increase employee compliance with health and safety policies.

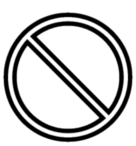
How? At your workplace, we recommend these specific actions:

Continue supporting the health and safety committee that includes employee representatives to provide continuous feedback on health and safety issues during work

- Conduct meetings before, during, and after implementation of changes in policy and work processes.
- Evaluate if implemented or suggested controls introduce new hazards or exposures.
- Discuss how employee concerns are addressed.

Encourage employees to report symptoms associated with work to managers and healthcare providers

Provide an anonymous way for employees to report health and safety concerns at work



Given the type of work employees perform, policies on workplace drug testing for controlled substances should consider the likelihood of low-level occupational exposure

Supporting Technical Information

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Section A: Workplace Information

Building

The police department crime laboratory, opened in 2012, is a 60,000-square-foot purpose-built laboratory. The crime laboratory was designed to enhance forensic investigations by consolidating all forensic units in the city and county into a single facility. The building includes dedicated spaces for forensic analysis, evidence handling, report writing, and administrative offices. The forensic chemistry unit analyzes evidence for controlled substances. The forensic chemistry unit also includes a trace evidence unit that analyzes trace residues on evidence such as gunshot, explosive, fire debris, and paint. The forensic chemistry laboratory sits next door to the trace laboratory.

Employee Information

At the time of our evaluation, the crime laboratory employed

- six forensic scientists in the forensic chemistry unit
- two forensic scientists in the trace unit (one of whom was cross-training in forensic drug analysis)

Although the trace unit is administratively housed within the forensic chemistry unit, it has distinct functions and workflows. For the purposes of this evaluation, we evaluated forensic chemistry and trace unit employees together when referring to employees handling or potentially exposed to controlled substances.

The forensic scientists were not represented by any unions.

Each forensic scientist has a designated workspace within the laboratory for analysis and an individual cubicle or office outside of the laboratory for report writing and administrative tasks.

History of Issue at the Workplace

Occupational exposure to illicit drugs has been an ongoing concern at the laboratory due to ever-changing drug trends. Laboratory management had concerns regarding employee exposure which prompted increased scrutiny of laboratory safety practices and ultimately led to the request for this evaluation.

Process Description

The forensic chemistry laboratory primarily analyzed suspected seized drugs. Law enforcement agencies submit packaged evidence. Forensic scientists are responsible for retrieving evidence from the evidence storage area, processing, and analyzing the materials. The exact nature of the substances is unknown upon receipt, requiring cautious handling. This forensic chemistry laboratory conducts presumptive analysis first to inform the trial court of the preliminary results, including the identity, weight, and presence or absence of controlled substances.

Each case is assigned to a forensic scientist. Each case may consist of one or more pieces of evidence. Forensic scientists use their professional judgment and experience to determine the techniques used for presumptive analysis. Presumptive analysis techniques may include colorimetric, microcrystalline, or visual evaluation methods. For this laboratory, most of the caseload (approximately 80%) consisted of presumptive analysis. After presumptive analysis, the evidence was returned to the evidence storage area.

If a case goes to trial, the evidence is retrieved from the evidence storage area and final (confirmatory) analysis is conducted on the submitted evidence. Confirmatory analysis generally consisted of analytical techniques including spectroscopy, chromatography, mass spectrometry, or a combination of these techniques.

Sample processing and weighing were conducted within the main laboratory space. Each forensic scientist typically preferred using a specific fume hood for their work. Laboratory benches were arranged with desks and computers along the periphery. Report writing and administrative tasks occurred in cubicles and offices located outside the laboratory.

Section B: Methods, Results, and Discussion

Our objectives were as follows:

- Evaluate the potential routes and extent of work-related exposure to methamphetamine, cocaine, fentanyl, and heroin among employees in the crime laboratory's forensic chemistry and trace evidence units.
- Evaluate the prevalence of work-related symptoms among employees in the forensic chemistry unit, including the trace evidence unit, which is organizationally part of forensic chemistry but has distinct functions.
- Identify and evaluate controls to protect employees who work in or enter the laboratories from exposure to controlled substances.

Methods: Document Review

We reviewed multiple documents provided by the police department crime laboratory to assess existing workplace safety policies, laboratory procedures, and historical exposure concerns. These included General Laboratory Safety and Operational Policies:

- Forensic Chemistry Policies and Procedures (2024)
- Crime Laboratory Safety Manual (2023)
- Respiratory Protection Standard (2013)
- Job Safety Analysis for Chemistry Unit (undated)
- Fume Hood Certification Records (2023)
- MAXAIR® CAPR® Information Sheet (2023), a loose-fitting powered air-purifying respirator (PAPR) that the forensic chemistry unit was in the process of acquiring

Exposure and Injury Reports

- Timeline of Biomonitoring Events – Documenting prior instances of positive drug tests among employees for 4th quarter 2022 to 1st quarter 2024 and surface sampling results (undated)
- Crime Lab Injury Reports – Summarizing reported occupational injuries and illnesses among forensic scientists for May 1, 2013, to May 31, 2023

Workplace Safety Changes

- Chemistry Safety Changes Timeline – Outlines modifications to laboratory procedures and safety controls following previous exposure incidents for 4th quarter 2022 to 2nd quarter 2024

We reviewed these documents to assess whether existing policies aligned with observed laboratory practices, evaluate engineering and administrative controls, and identify gaps in exposure prevention measures.

Results: Document Review

The “Laboratory Safety and Personal Protective (PPE) Equipment” section of the Forensic Chemistry Policies and Procedures described the required trainings, safety controls, laboratory practices, and PPE for scientists and laboratory visitors. The manual specifies that all sample analyses should be conducted within a fume or benchtop hood. Use of N95® or P100® respirators is required when handling evidence weighing more than 100 grams (bulk sized), when net weights must be obtained, or when packaging is deemed inadequate. The manual includes specific cleaning protocols, detailing the surfaces and equipment to be cleaned and the cleaning agents to be used. Dry cleaning methods are prohibited in the laboratory. PPE required in the laboratory included eye protection, gloves, and lab coats. Lab coats are required at all times in the forensic chemistry laboratory, but only when analyzing evidence in the trace laboratory. Washing of lab coats was to occur every week by a forensic scientist using the facility’s in-house laundry equipment. The policies and procedures outlined in this document align with the Chemistry Safety Changes Timeline.

The Chemistry Safety Changes Timeline described the modifications to laboratory safety protocols and controls implemented in response to previous concerns about exposure risks beginning in the fourth quarter of 2022. These changes included increased use of fume hoods for weighing procedures, always requiring gloves in the laboratory, and additional training on PPE use. Some of the newly implemented controls to prevent and reduce exposure to controlled substances, such as mandatory glove use at all times in the laboratory, conflicted with guidance in the Laboratory Safety Manual but aligned with the Forensic Chemistry Policies and Procedures. In addition to discussing the timeline for when two forensic scientists had promotion-related positive tests for cocaine over a 2-year period, the Timeline of Biomonitoring Events presented results of surface sampling conducted using a direct-reading instrument on various surfaces in the forensic chemistry laboratory by chemistry personnel or management in the 4^{th} quarter of 2023. Methamphetamine was detected in a laboratory fume hood; laboratory management stated that this surface was identified as not being correctly cleaned. Information on the detection limit of the direct-reading instrument was not provided in this document. Beginning in the first quarter of 2023, the policy for weighing changed from measuring net weights for all evidence to using estimated net weights to reduce the need to remove evidence items from packaging or using gross weight whenever possible. In the first quarter of 2024, this was amended to weighing and sampling only occurring in hoods. There were no documented updates to the laboratory’s routine exposure monitoring program or formalized procedures for decontamination of work surfaces.

The Laboratory Safety Manual for the crime laboratory stated the roles and responsibilities for safety manager and for laboratory employees. Due to the variability of the evidence, “forensic laboratory personnel are frequently faced with new hazards” and must “be careful in assessing the risks involved in their work.” This manual is meant to provide general information to assist forensic scientists in protecting themselves from these hazards. Scientists are encouraged to report all potentially hazardous situations in the laboratory to a supervisor who will liaise with the safety officer. The Safety Manual prohibits “smoking, eating, chewing gum, drinking or the application of make-up” in laboratory analytical areas, or sections of the laboratory where analytical work is performed. “Gloved individuals must refrain from touching doorknobs, drawer handles, or other common-use items that may later be touched by another person.” Employees are also instructed to frequently wash hands when “handling materials and items contaminated with body fluids" and "upon removal of gloves" for at least 20 seconds.

The Safety Manual also outlined available laboratory PPE, including eye protection, gloves, lab coats, and "facemasks." Lab coats are only specified to be worn while performing analysis in the laboratory or when working with hazardous materials. It is unclear if facemasks refer to filtering facepiece respirators. Hygiene and housekeeping instructions are provided, with the manual specifying that each specific unit's policies will address their cleaning requirements.

The Safety Manual section discussing fume hood maintenance specified that hoods should be maintained at 60 to 100 feet per minute (fpm) at a "reasonable sash height." Fume hood certification was up-to-date and occurred annually according to management representatives. However, these records and measurements from fume hoods showed that airflow velocities varied between hoods and hoods were not evaluated for containment ability according to recommendations by the American National Standards Institute and the American Society of Safety Professionals (ANSI/ASSP) [ANSI/ASSP 2022]. The two main ducted hoods in the chemistry lab had average face velocities of 158 and 193 fpm, which are higher than the maximum face velocity recommended by ANSI/ASSP of 120 fpm. The ductless fume hoods were not yet installed when these fume hoods were last certified.

The Respiratory Protection Standard defined the types of respirators that can be used by local government employees and is not specific to crime laboratory employees. This standard was developed by the city to assist city departments to develop their own written respiratory protection program and does not outline specific respiratory protection requirements for the crime laboratory. This standard requires that departments, as part of a respiratory protection program, identify respiratory hazards; identify respirators selected for use; conduct medical evaluations for employees required to wear respiratory protection; conduct (qualitative) fit testing; identify procedures for use, maintenance, and care of respirators; provide training; and program evaluation and recordkeeping. This standard also provides the information required in the OSHA Respiratory Protection Standard Appendix D to provide to employees who voluntarily use respirators. Crime laboratory management was in the process of acquiring the MAXAIR CAPR, a type of PAPR, for use when handling bulk evidence as an alternative to using N95 and P100 respirators.

The Job Safety Analysis document described job tasks required of forensic scientists, identified potential hazards, and outlined controls and required PPE. The document ends with recommendations; however, it is unclear who is responsible for implementing recommendations and when or if they were implemented.

The Crime Lab Injury Reports from 2013 to 2023 did not document any acute illnesses or injuries explicitly linked to drug exposure. However, forensic scientists reported experiencing headaches, nasal irritation, and dizziness after handling suspected bulk drug samples in informal conversations during our initial visit. There was no documented follow-up to evaluate whether these symptoms were associated with workplace exposures.

Methods: Observations of Work Processes, Practices, and Conditions

We conducted observations in the forensic chemistry laboratory focused on three key areas:

- Workplace conditions and work practices
- Fume hood performance and usage
- Employee use of PPE

We evaluated fume hood face velocities by using the reading on the face velocity monitor on the fume hood, using the grid method (dividing fume hood into grids, measuring the air velocity reading in each grid using a TSI® VelociCalc® air velocity meter, and calculating the average of these readings), or by reviewing documents provided for fume hood performance certification.

Results: Observations of Work Processes, Practices, and Conditions

Workplace Conditions and Work Practices

Each forensic scientist was assigned an individual workstation, which consisted of a laboratory benchtop, a computer, a monitor, a keyboard (covered or uncovered), and a mouse. Forensic scientists had access to sampling tools, colorimetric drug tests, and microscopes for analysis. Management representatives stated that they had worked to reduce the need for equipment entering and exiting the laboratory and were working toward decreasing the amount of paper entering and exiting. We observed that paper for notetaking was being taken in and out of the laboratory.

As part of standard protocols, forensic scientists retrieved evidence from secure storage areas before beginning lab work and transported items to their workstations for processing. Forensic scientists unpackaged evidence, prepared samples for analysis, and weighed substances to determine a gross weight.

At the time of our evaluation, laboratory procedures encouraged forensic scientists to not measure net weight, opting for estimated net weight or gross weight depending on the packaging. The laboratory had created a catalog of the weights of commonly used packaging that forensic scientists were to use when estimating net weights based on gross weights. However, depending on the nature of the controlled substance, net weight determination was sometimes required. When net weights were required, they were measured in fume hoods. We observed forensic scientists taking gross weights of larger evidence packages and net weights for smaller amounts of evidence. We observed several instances where evidence handling could result in aerosolization of powdered substances. These instances included tablet crushing within hoods (releasing visible powder), powder dispersal during evidence re-sealing outside of hoods, and transport of open containers across the laboratory space.

Forensic scientists used cleaners consisting of OxiClean™ and distilled water or a methanol solution to wipe down benchtops and equipment. We observed most forensic scientists clean surfaces and tools between cases with either solution.

At the time of our visit, the forensic chemistry laboratory maintained naloxone kits for emergency opioid exposures. Some employees reported that they had not received hands-on training on naloxone administration.

Fume Hood Performance and Use

Fume hoods, ducted and ductless, were present in the forensic chemistry laboratory. Each hood had a set of reagents and a balance. Forensic scientists were expected to conduct drug sample handling and weighing within these hoods. Some employees cited workflow limitations and challenges using the fume hoods effectively as reasons for inconsistent use during evidence processing.

On-site airflow measurements indicated that some fume hoods may operate outside of recommended airflow parameters. Specifically

- Two ducted fume hoods were available for forensic scientists to use. ANSI/ASSP recommends that the average face velocity of a hood be sufficient to capture and contain the hazardous chemical emissions generated within the hood. Hoods with a face velocity range of 60–120 fpm may be acceptable depending on the containment capability and design of the hood.
    - During the first site visit, ductless fume hoods were inside ducted hoods but not turned on to shield against the ducted fume hoods' high air flow, which had previously hindered their usability. Forensic scientists were using ductless hoods inside ducted hoods for analysis. The average face velocity measured at the ductless hoods inside the ducted hoods was
      20 and 40 fpm, respectively. The face velocity measured for the ducted hoods exceeded 300 fpm.
    - During the second site visit, one of the ducted hoods was on and in use without the ductless hood inside. This ducted hood had a measured average face velocity of 195 fpm. At this average face velocity, the flow could be turbulent and reduce the containment effectiveness of the hood, as well as prevent its use when handling powders and smaller items. The second of these ducted hoods was not in use due to the inability to handle powdered evidence because of the high air movement.
- Three ductless hoods were placed on benchtops for use. Two Sentry Air Systems ductless fume hoods had a face velocity of 90–120 fpm on the setting that was typically used by forensic scientists. The newly acquired Air Science Purair® ductless fume hood had a measured average face velocity of 23 fpm, which was below the face velocity range recommended by ANSI/ASSP [ANSI/ASSP 2022].
- One ducted fume hood was used for solvent and waste storage and not used by forensic scientists for evidence handling and analysis. This fume hood had a measured average face velocity of 95 fpm, which is within the general range recommended by ANSI/ASSP.

Records from the most recent fume hood certification confirmed that airflow was measured and recorded, but it was unclear whether corrective actions were taken for hoods with face velocities that fell outside of ANSI/ASSP general recommendations. Containment was not evaluated. The Sentry Air System ductless fume hoods were certified at a higher face velocity than we measured; these ductless fume hoods have a variable speed controller; the setting used for certification was unclear

We witnessed some forensic scientists in awkward positions or using reagents outside of the ductless fume hoods because these hoods had small, fixed openings. We observed forensic scientists having difficulty maneuvering larger evidence packages into the small opening of the ductless fume hoods. We also observed a forensic scientist bump into the hood face several times while working. Forensic scientists noted difficulty in taring balances and weighing powders because of interference from air movement within the hoods. During use of a ductless fume hood, we observed a forensic scientist turn off the hood's airflow during the weighing process.

Laboratory Airflow

We assessed airflow patterns between laboratory spaces and surrounding areas using ventilation smoke to visualize air movement. Ideally, air should flow into the laboratory from adjacent common areas to help contain airborne contaminants. The vestibule has two doorways, one leading to the forensic chemistry laboratory and the other leading to the instrument room. We observed that air flowed from the hallway into the vestibule and from the vestibule into the crime laboratory and the instrument room. The door between the forensic chemistry laboratory and instrument room usually remained open, but when closed, the forensic chemistry laboratory is slightly positively pressured compared to the instrument room, meaning the air flowed from the crime laboratory into the instrument room. The current configuration is acceptable to keep controlled substances from migrating outside of the laboratory area.

Employee Use of Personal Protective Equipment

Forensic scientists were observed donning PPE in vestibules before entering the lab. Lab coats were required within the forensic chemistry laboratory. Observations showed variation in sleeve design, with some coats having cuffed sleeves and others not. Management and employee representatives stated that lab coats were laundered every other week in the laboratory laundry located in the basement of the building. We did not observe this process. Lab coats hanging on hooks in the vestibule appeared clean. Glove changing practices varied. While most forensic scientists changed gloves between cases, some did not change gloves between handling different items within a single case. All forensic scientists consistently wore eye protection during drug-related casework, though some individuals with prescription glasses needed side shields.

During our site visit, we observed most forensic scientists wearing surgical masks when in the laboratory. When handling powders over 100 grams, forensic scientists wore N95 filtering facepiece respirators or half-facepiece elastomeric respirators with a P100 filter. Management had qualitatively fit tested employees for the respirators they were wearing. Forensic scientists were fit tested for half-facepiece elastomeric respirators when they failed the fit test for an N95 respirator. We observed boxes of surgical masks and N95 respirators sitting in an opened box on an unoccupied bench in the lab. At the time of our site visit, the laboratory was in the process of updating its respiratory protection program. Between our initial and second site visits, laboratory management began implementing several changes, including the acquisition of two ductless fume hoods, one of which was installed during the second site visit, and a no-hose PAPR for use by forensic scientists conducting analysis. The PAPR system was not yet in use during our site visit.

Methods: Exposure Assessment

Personal Air Sampling and Casework Records

We took personal breathing zone air samples for six of eight forensic scientists in the forensic chemistry and trace units over 2 days during our second visit. We sampled for cocaine, fentanyl, heroin, and methamphetamine using 25-millimeter glass fiber filters in conductive cassettes attached to pumps drawing air at 2 liters per minute. A series of one to three samples comprised an employee's full shift. We calculated a time-weighted average (TWA) concentration using the employee's individual sample data for each of the four target drugs.

All samples (air, handwipe, and surface) were shipped cold to the analytical laboratory. At the laboratory, the samples were extracted in the cassette to prevent wall losses using a water and methanol mixture. The samples were analyzed via ultrahigh performance liquid chromatography with triple quadrupole mass spectroscopy detection. The laboratory reporting limit was 1 nanogram (ng) per sample for each of the four drugs analyzed for both air and wipe samples. Below this amount, the drug was either not detected at all or too little drug was in the sample to be precisely quantified, even by very sensitive analytical methods. These samples are referred to as "not quantifiable" or NQ.

Full-shift fentanyl exposures were compared with a Threshold Limit Value (TLV®) of 0.1 microgram (μg) per cubic meter or 0.0001 milligrams per cubic meter established by ACGIH [ACGIH 2025].

After the site visit, management provided a list of the presumptive or final results for the illicit drugs in cases analyzed during the site visit. We reviewed casework information and, when possible, compared it to the results of the air and handwipe samples collected during our site visit.

Handwipe Sampling

We took pre-shift and post-shift handwipe samples for seven of eight forensic scientists for cocaine, fentanyl, heroin, and methamphetamine. Prior to entering the laboratory to work, we instructed employees to wash their hands with soap and water thoroughly for 20 seconds after which we took the pre-shift handwipe sample to determine pre-laboratory work amounts. Employees were asked to wash hands as they normally would during their work shift. Post-shift handwipe samples were taken when the employee ended work in the laboratory and before they washed their hands for the last time before leaving work. We sampled the palm sides of each employee's hands using a swab wetted with methanol. To calculate the concentration of an analyte, we divided the result amount by the average hand surface area corresponding to the forensic scientist's sex (287 cm^2 for females and 350 cm^2 for males) [Anthropology Research Project 1989].

The fraction of the total amount of each analyte on hands that was removed (recovery) during wipe sampling has not been characterized. We are not aware of occupational standards or guidelines regarding limits on handwipes for cocaine, fentanyl, heroin, and methamphetamine.

Biomonitoring

To assess potential systemic exposure, urine samples were collected from seven employees before and after their shifts. Each participant provided up to

- One pre-shift sample on the first day
- Two post-shift samples (one after the first shift and one after the second shift)

Urine samples were analyzed for cocaine (and its metabolite benzoylecgonine), fentanyl (and its metabolite norfentanyl), heroin (and its metabolites 6-acetylmorphine, morphine, and hydromorphone), and methamphetamine. Analysis was performed using liquid chromatography-tandem mass spectrometry (LC-MS/MS), a highly sensitive method for detecting trace levels of controlled substances. To account for variations in hydration, all results were creatinine-adjusted and reported in nanograms per milliliter (ng/mL).

There are no established workplace exposure limits for these substances in urine. The biomonitoring results were not used for drug testing purposes and were interpreted as indicators of potential occupational exposure. This evaluation did not follow the protocols required for regulated or non-regulated workplace drug testing and was not designed to support the use of results in such programs.

Area Air Sampling

We took area air samples in the forensic chemistry laboratory and office over 2 days during our second visit. We sampled for cocaine, fentanyl, heroin, and methamphetamine using 25-millimeter glass fiber filters in conductive cassettes attached to pumps drawing air at 2 liters per minute using the same analytical method described for personal air sampling. A series of two to three samples comprised full shift for an area. We calculated a TWA concentration for each set of samples.

Surface Sampling

We sampled a total of 20 surfaces in spaces inside and outside of the laboratory for cocaine, fentanyl, heroin, and methamphetamine using swabs wetted with methanol. This included four laboratory workstation keyboards, three work benches, two instrument room keyboards, two laboratory vent covers, one instrument room mouse, one laboratory fume hood surface, one laboratory door handle, one back of chair in the laboratory, one vestibule sink faucet handle, one bathroom door handle, one office door handle, one office desk, and one drinking fountain handle. The sample area was 100-square centimeters (cm^2) using a template on most surfaces. On surfaces where we did not use a template, including computer keyboards, computer mice, and faucet handles, we sampled an area of approximately 100 cm^2. We calculated the concentration of all surface samples using an area of 100 cm^2.

Average surface recovery for the materials comprising laboratory benchtops, office desktops, and scale plates exceeded 70% using the swabs [Bureau Veritas North America 2018]. For other surfaces, like keyboards and the chair, the recovery ranges for these materials have not been characterized. There are no occupational standards regarding limits on surfaces for cocaine, heroin, and methamphetamine set by the federal government or consensus organization. However, some companies and states have developed surface contamination limits. ACGIH has adopted a fentanyl Threshold Limit Value Surface Limit (TLV-SL) of 1 microgram per 100 square centimeters (1 μg/100 cm^2) [ACGIH 2025]. Some states have developed guidelines for remediation of contaminated spaces such as clandestine drug labs. The U.S. Environmental Protection Agency (EPA) has developed methamphetamine laboratory cleanup guidelines. According to the EPA, 21 states have developed recommended or required standards for methamphetamine remediation as of August 2021. The state standards range from 0.05 to 1.5 μg per 100 cm^2, the most common being 0.1 μg methamphetamine per 100 cm^2 [EPA 2021]. California law provides limits for the clean-up of properties contaminated by illegal methamphetamine and/or fentanyl laboratories [California Legislature 2019]. The California law states that (1) property contaminated by illegal methamphetamine laboratory activity is safe for human occupancy if the level of methamphetamine on an indoor surface is ≤ 1.5 μg per 100 cm^2 and (2) property contaminated by illegal fentanyl laboratory activity is safe for human occupancy if the level of fentanyl on an indoor surface is "below the detection level." The law does not specify the detection level.

Results: Exposure Assessment

Air Sampling and Casework Records

Six of eight employees participated in air sampling during our second site visit. A full-shift sample was comprised of one to three consecutive samples on the sampling day, depending on the duration of lab work (range: 85–353 minutes). Sampling began when employees entered the laboratory for the first time that day and ended when employees left the laboratory for the last time that day.

Results of full-shift TWA exposures are presented in Table C1. One employee on day one had a full-shift fentanyl exposure of 0.15 μg/m^3, which exceeded the TLV of 0.1 μg/m^3. Casework records indicate that this employee had completed a case consisting of a large number of fentanyl tablets the next day. It is unclear when analysis for this case began.

The other analytes (cocaine, heroin, and methamphetamine) do not have established occupational exposure limits. Of the six employees, three handled cocaine-containing evidence, four handled fentanyl-containing evidence, and four handled methamphetamine-containing evidence. No employees had heroin detected in their personal air samples, and there were no identified cases involving heroin handled during the days of our site visit. One employee who was in training did not handle their own evidence but assisted a forensic scientist during their analysis.

We looked at the relationships between confirmed substances in employees' casework on both days and the results of their personal air samples. One employee who did not work on casework containing cocaine on either day had cocaine in their personal air sample (day 1). Only employees who did not work or assist on casework in the lab had no cocaine detected in their air samples.

However, two employees who worked on casework containing fentanyl did not have fentanyl in their personal air samples. The casework that was identified during presumptive testing as containing fentanyl consisted of tablets and powders (under 2 grams). The powders identified as containing fentanyl in preliminary testing also usually contained fentanyl analogues, substances that are chemically similar to fentanyl but have different structures. The method used for air sampling of fentanyl does not include fentanyl analogues, so exposure to fentanyl analogues in air was not quantified. Other than the employee in training, all employees who worked on casework containing methamphetamine had methamphetamine in their personal air samples.

Handwipe Sampling

Table C2 shows 12 handwipe sampling results taken before and after six employees worked in the forensic chemistry lab and one employee worked in the trace lab. Before working in the laboratory, more than half of the employees had cocaine and methamphetamine on their hands, even after washing their hands. One employee who did not work in the forensic chemistry lab had no drugs found on their hands before and after their work in the laboratory. This result is not included in the discussion of handwipe sampling results below.

All employees who worked in the laboratory analyzing evidence for controlled substances had cocaine and methamphetamine on their hands after they finished work in the lab and before they washed their hands. Most post-shift handwipe samples collected had higher amounts of an analyte compared to the corresponding pre-shift handwipe sample. Of the 11 sets of handwipe samples collected from employees who handled controlled substances evidence, all 11 post-shift samples had cocaine (range: 0.0038–0.15 ng/cm^2) compared to 7 for pre-shift hand wipe samples (range: NQ–0.078 ng/cm^2). All 11 post-shift samples had methamphetamine (range: 0.0056–0.42 ng/cm^2), and 6 pre-shift handwipe samples had a quantifiable amount of methamphetamine (range: NQ–0.090 ng/cm^2). Few employees had fentanyl found on their hands before (n = 2) and after (n = 1) work in the lab; there was not a clear pattern of fentanyl levels on hands. The employee with a personal air sample above the ACGIH TLV for fentanyl was the only employee with fentanyl found on their hands after work on the first day of sampling (0.011 ng/cm^2). This is the highest concentration of fentanyl found on all handwipe samples. No handwipe samples had heroin detected above the reporting limit of 1 ng per sample.

Biomonitoring

Table C3 shows biomonitoring sample results for the four drugs and their metabolites. All seven participating employees provided at least two urine samples, resulting in a total of 19 urine samples collected and analyzed. No employees had detectable levels of cocaine, heroin, fentanyl, or their metabolites in their pre-shift urine samples. Three employees had detectable levels of methamphetamine in their pre-shift urine samples, with concentrations ranging from 0.53 to 3.79 ng/mL. One employee had a detectable level of methamphetamine in their post-shift urine sample of 1.35 ng/mL.

Table C4 shows the estimated half-life and urine detection window of the analytes in urine testing based on values typically cited for conventional analytical methods for traditional workplace drug testing. However, for this evaluation, highly sensitive LC-MS/MS methods were used, allowing for lower limits of detection and longer potential detection windows than those reported for traditional drug testing. Therefore, the presence of a drug or metabolite in urine may reflect exposure that occurred days prior, particularly at low concentrations.

Area Air Sampling

Table C5 shows the area air sampling results for the four drugs. Area air samples for the forensic chemistry laboratory found cocaine at the same concentration on both days (0.0031 µg/m^3), fentanyl on the first day (0.0029 µg/m^3), and methamphetamine on both days (0.036 and 0.095 µg/m^3). Area air samples collected in the office did not have any of the drugs present.

Surface Sampling

Table C6 shows surface wipe sampling concentration results collected during the evaluation. For instrument and laboratory workstation keyboards (covered and uncovered), all six surface samples had cocaine (range: 0.46–5.4 μg/100 cm^2), fentanyl (range: 0.040–0.23 μg/100 cm^2), heroin (range: 0.0043–0.073 μg/100 cm^2), and methamphetamine (range: 0.30–18 μg/100 cm^2). A surface sample collected on an instrument room mouse found cocaine (3.6 μg/100 cm^2), fentanyl (0.099 μg/100 cm^2), heroin (0.022 μg/100 cm^2), and methamphetamine (1.2 μg/100 cm^2).

Of the three samples taken from lab benches, all three had cocaine (range: 0.0073–1.4 μg/100 cm^2) and methamphetamine (range: 0.0014–0.097 μg/100 cm^2), two had fentanyl (range: NQ–0.0066 μg/100 cm^2), and one had heroin (range: NQ–0.0020 μg/100 cm^2). A sample taken from vestibule sink faucet handles had cocaine (0.0083 μg/100 cm^2) and methamphetamine (0.0047 μg/100 cm^2).

Other laboratory surfaces we sampled had lower amounts of the drugs than the keyboards, mouse, benches, and faucet handles, and included the laboratory fume hood surface, door handle, ventilation supply and return covers, and the back of a roller chair used in the lab by forensic scientists. The samples taken on common area surfaces outside of the lab (e.g., office door handle, restroom push handle, drinking fountain handle, and office desk) had lower amounts of only cocaine (all four samples, range: 0.0011–0.0051 μg/100 cm^2) and methamphetamine (two samples, range: NQ–0.0022 μg/100 cm^2).

Ten surface samples exceeded the remediation guideline most commonly adopted by states for methamphetamine of 0.1 μg per 100 cm^2 [EPA 2021]. These standards are not occupational standards but can he helpful in the absence of occupational standards. Several states have adopted a health-based remediation standard calculated by California's Department of Toxic Substances Control of 1.5 μg per 100 cm^2 for methamphetamine [EPA 2021]. Two samples taken from laboratory keyboards, one uncovered and one covered, exceeded this health-based remediation standard. None of the surface samples exceeded the TLV-SL of 1 μg fentanyl per 100 cm^2 set by ACGIH. However, 11 of our 20 samples were above the detection limit of our method and therefore exceeded fentanyl surface limits as cited by the state of California in the Methamphetamine or Fentanyl Contaminated Property Cleanup Act [California Legislature 2019].

Methods: Employee Health Assessment

Confidential Medical Interviews

During our site visit in July 2024, we invited all employees working in the forensic chemistry and trace units to participate in confidential medical interviews. The interviews were conducted in a private setting and included structured questions about:

- Demographics, work history, and training related to handling illicit drugs
- Use of PPE such as gloves, respirators, and lab coats
- Perceived health effects or symptoms associated with workplace exposures
- Workplace hygiene practices and decontamination procedures

Each interview lasted approximately 20–30 minutes and was conducted by NIOSH staff. Employees were encouraged to share any concerns about workplace safety, health effects, or drug handling procedures. The interview questions did not include a question to assess non-occupational exposures to illicit drugs.

Results were aggregated to identify common symptoms, exposure trends, and potential safety gaps. We summarized continuous variables using medians and ranges, and categorical variables using counts and percentages.

Results: Employee Health Assessment

Confidential Medical Interviews

Seven of eight employees working in the forensic chemistry and trace units participated in confidential medical interviews. The median age of interviewed employees was 40 years (range: 27–49 years), with five female and two male participants. The median length of time working in the forensic sciences was 6 years (range: 1–15 years), and the median time with the local forensic laboratory was 3 years (range: 1–15 years). All employees reported working 40–45 hours per week.

Among the seven employees interviewed, the median number of samples handled in the 2 weeks prior was 90 (range: 0–140) (Table C7); the lower end of the range reflects one employee who was still in training and had not yet independently processed a case. Four employees reported handling bulk drug samples during this period. Across all seven participants, the median number of bulk drugs handled in the past 2 weeks was 12 (range: 0–20). All but the employee in training reported processing samples under a fume hood, with a median of 60 cases handled in the past 2 weeks (range: 0–140). However, employees noted that while laboratory policy requires all evidence processing to occur under a fume hood, the hoods were turned off during weighing procedures, potentially increasing exposure risk. Regarding specific drug exposures, five employees (71%) reported handling fentanyl, while four employees (57%) reported handling methamphetamine, cocaine, and heroin in the past 2 weeks. One employee (14%) reported handling other controlled substances, such as oxycodone. Among the three employees with detectable methamphetamine in their urine, all had reported handling methamphetamine-containing evidence during this period.

When asked about their PPE use in the prior 2 weeks, all seven employees reported always wearing nitrile gloves, lab coats, and safety glasses when handling evidence (Table C8). Reported respirator use varied, with three employees sometimes wearing an N95 respirator, one employee using a half-face respirator. The four employees reporting respirator use in the past 2 weeks also reported handling bulk drug samples in the same period. Employees who did not wear fitted respirators reported sometimes using unfitted N95 or KN95 masks.

Glove changing practices differed among employees. Three employees reported changing gloves at least after every case, including one employee who reported changing gloves after handling each individual item. Two others reported changing gloves several times a day, but not after every case (Table C8). This could contribute to contamination and is a deviation from written policies requiring scientists to change gloves at least between cases. Similarly, handwashing practices varied. Three employees reported washing hands every time after removing gloves, while two reported sometimes washing hands but not after every glove change.

All employees reported never eating, drinking, or storing food in the lab or vault room in the past 2 weeks (Table C8). Six employees reported always washing hands before eating or drinking at work, while one reported doing so only sometimes.

When asked about lab coat laundering frequency, four employees reported that their lab coats were laundered weekly, one reported every 2 weeks, and one reported that their lab coat was never laundered (data not shown). Employees reported different methods for storing their coats, including hanging them on coat racks, placing them on the backs of chairs, or keeping them in office spaces instead of designated lab coat storage areas.

Among the seven employees interviewed, five (71%) had been medically cleared for respirator use and six (86%) had undergone fit testing in the past 12 months (Table C9). This suggests there is one employee who may not be medically cleared but has been fit tested for a respirator. Only three employees (43%) reported wearing a fit-tested respirator in the past 2 weeks. Employees stated that fit testing was conducted using qualitative methods administered by a workplace safety administrator. If an individual failed the qualitative fit test, they were referred for quantitative testing, which provides a numerical assessment of fit.

Five employees reported participating in laboratory cleaning (Table C10), with common cleaning activities including wiping down shared equipment (n = 4), fume hoods (n = 4), and lab benches (n = 2). Cleaning solutions varied, with employees reporting the use of methanol (n = 2), bleach (n = 2), peroxide (n = 1), and OxiClean™ (n = 1). No employees reported using dry sweeping, a practice that could increase airborne contaminant exposure.

Employees were asked whether they had ever experienced any symptoms they felt were related to handling cases or samples at work (Table C11). Five employees reported experiencing dizziness while handling cases or samples at work, while four employees reported experiencing headaches. No employees reported experiencing shortness of breath, nausea, confusion, pinpoint pupils, or other symptoms associated with opioid or stimulant exposure. For reference, a summary of the known health effects associated with high-level exposures to cocaine, fentanyl, heroin, and methamphetamine is provided in Table C12.

Employees expressed concerns about frequent changes in laboratory policies, noting that guidelines for handling drugs were unclear and needed to be standardized. Three employees reported that additional training was needed on exposure risks, including when to report asymptomatic exposure incidents (data not shown). Some employees also requested additional clarification of respiratory protection policies, including when to replace respirators and filters.

Several employees raised concerns about the availability and use of naloxone in the laboratory, stating that training on naloxone administration had been inconsistent (data not shown). Some employees were unsure how to properly use certain naloxone kits while others noted that expired naloxone kits had not been promptly replaced.

At the conclusion of the interviews, employees also raised concerns about solvent exposure in addition to bulk drug exposure. Some employees noted that casework involving highly volatile substances, such as phencyclidine (PCP), should be handled with additional precautions beyond those currently in place. Others expressed concerns about the inconsistent packaging of controlled substances submitted for analysis and the potential for unexpected exposure to potent drugs like fentanyl.

Discussion

This evaluation identified multiple indicators of potential occupational exposure to controlled substances among forensic scientists in the forensic chemistry and trace units of the crime laboratory. Cocaine, fentanyl, and methamphetamine were detected in both personal breathing zone and laboratory area air samples, pre- and post-shift handwipe samples, and on surfaces. While heroin was not detected in personal and area air samples or handwipe samples, it was identified on surfaces, indicating a potential risk of dermal or ingestion exposure through contaminated surfaces. In one notable instance, a forensic scientist who analyzed thousands of tablets presumptively identified to contain fentanyl had airborne exposures exceeding the ACGIH TLV of 0.1 $\mu g/m^3$, suggesting inadequate engineering controls during high-volume or high-risk casework.

Despite these findings, none of the interviewed forensic scientists reported acute symptoms typically associated with exposure to these substances, such as confusion or respiratory distress. However, four employees reported headaches, especially when handling strong-smelling or powdered evidence. These non-specific symptoms align with reports from other NIOSH HHEs of forensic laboratories, where staff similarly described intermittent headaches, dizziness, nausea, or chest tightness while working with suspected PCP, opioids, or cocaine—even when PPE was worn or fume hoods were in use [NIOSH 2011, 2020]. Such symptoms may result from low-level chemical exposures, sensitivity to solvents, or inconsistencies in ventilation and PPE use. Though not definitive evidence of exposure, when coupled with objective environmental sampling data, these symptoms highlight gaps in exposure control effectiveness.

Biomonitoring results provide further support for potential exposure. Methamphetamine was detected in the urine of three employees. While urine testing only captures recent exposure and cannot distinguish between occupational and non-occupational sources, its detection alongside environmental data suggests systemic absorption may be occurring through inhalation, mucous membrane contact, or inadvertent ingestion.

Although detectable methamphetamine in pre-shift urine samples could reflect non-occupational exposure, several lines of evidence suggest otherwise. All detected levels were well below drug testing thresholds typically used in clinical or forensic settings. For context, the Substance Abuse and Mental Health Services Administration (SAMSHA) sets an initial screening cutoff for methamphetamine at 500 ng/mL, with confirmatory testing at 250 ng/mL [SAMHSA 2010]. In our evaluation, the highest measured concentration was 3.79 ng/mL—almost two orders of magnitude lower than these thresholds—making illicit use less likely. Case history further supports plausible workplace exposure: two employees were engaged in work tasks with possible exposure to illicit drugs on the day prior to sampling. These scenarios, along with positive environmental findings (e.g., handwipe and surface contamination), support the possibility of carryover exposure. This pattern is consistent with findings from a prior HHE evaluating cannabis exposure among law enforcement officers, where cannabinoids were detected in urine even after apparent exposure ended [NIOSH 2020]. Similarly, internal methamphetamine detection may reflect residual low-level absorption across multiple shifts, possibly through inhalation, dermal contact, or inadvertent ingestion.

Hair testing was not conducted as part of this evaluation. Although hair analysis can capture longer-term exposures, it is less suitable for acute or recent exposure assessment in occupational settings due to limitations in differentiating systemic absorption from external contamination [Cuypers and Flanagan 2018]. In this context, urine testing and environmental sampling were more appropriate tools to assess exposure during the period of interest.

Work practice observations revealed that exposure controls were inconsistently applied. Although laboratory policy requires sample processing under a chemical hood, some employees reported disabling hoods during weighing procedures due to turbulent airflow, which may reduce capture efficiency and compromise analytical accuracy. Not all employees had equal access to functioning chemical hoods and several hoods were found to have face velocities higher than the ANSI/ASSP maximum recommendation of 120 fpm [ANSI/ASSP 2022]. Typically, face velocity measurements are used as a survey and maintenance tool to assess a hood's performance; updated ANSI/ASSP recommendations state that an adequate face velocity is necessary but should not be the only performance indicator used to evaluate a hood's containment. Other factors, such as hood design, laboratory layout, cross-drafts, and traffic could also modify hood performance. Based on records, it is unknown if hoods had been evaluated for containment ability. This variability likely contributed to observed airborne contamination and reflects similar challenges documented in other forensic laboratory evaluations [NIOSH 2011, 2020]. ANSI/ASSP recommend tracer gas containment testing to evaluate hood containment when the hood is commissioned, or when significant changes are made to the laboratory or ventilation system [ANSI/ASSP 2022].

The practice of performing both presumptive and final analyses (when needed) on the same sample, although more efficient, may increase opportunities for exposure due to repeated handling of bulk evidence. This differs from practices observed in other laboratories, where analysts typically handle evidence only once or have more delineated roles in case processing. Establishing protocols that minimize repeated sample handling could reduce unnecessary exposures.

Cleaning practices varied by employee and laboratory location. While many staff used methanol, bleach, OxiClean™, or hydrogen peroxide, the frequency, thoroughness, and method of application were inconsistent. Importantly, interior packaging—often handled during sample prep—has been shown to strongly correlate with drug content [Sisco et al. 2018], while outer packaging is less predictive and may be overlooked as a contamination source. As a result, staff may unintentionally expose themselves during initial evidence handling. Cocaine and methamphetamine were present in handwipe and surface samples throughout laboratory and non-laboratory areas. Heroin and fentanyl were present in surface samples throughout laboratory areas. Compared to the results from Sisco et al. [2018] evaluating background levels on surfaces in a forensic laboratory, surface sample results in this evaluation found higher prevalence of samples containing cocaine in the laboratory (100% versus 95%), fentanyl (73% versus 62%), and methamphetamine (100% versus 77%). The median results for these drugs from surface samples taken in the laboratory in this evaluation were also higher than in Sisco et al. [2018]. While some of these differences could be attributed to the difference in distribution of surface samples taken or from regional and temporal differences in drug evidence, this does suggest that consistent and thorough cleaning practices could lower the amount of drugs on surfaces within the laboratory. Our own surface sampling confirmed the presence of cocaine and methamphetamine in non-laboratory areas at this forensic laboratory. In a 2011 HHE, similar contamination was observed in office locations near a police department drug vault [NIOSH 2011].

Pre-shift handwipe samples were positive for cocaine and methamphetamine in more than half of the participants, despite handwashing prior to sample collection. These results are consistent with results from previous HHEs in forensic settings and suggest persistent contamination of surfaces and clothing [NIOSH 2020]. Improper glove use, infrequent laundering of lab coats, and inconsistent lab coat storage (e.g., hanging coats on office chairs) may contribute to these findings. Storing used coats in office or break areas, rather than near lab exits or in designated storage locations, increases the potential for contamination to spread beyond the lab.

Respirator use and program implementation may warrant further evaluation. Although most employees were medically cleared and had undergone fit testing within the past year, only three reported using a fit-tested respirator during the 2 weeks prior to our visit. The four employees who reported respirator use (N95 and half-facepiece elastomeric respirators) also reported working on bulk drug samples in the 2 weeks prior to our visit. However, self-reported data also revealed a potential gap in the respiratory protection program: more employees reported being fit tested than reported receiving medical clearance. According to the OSHA Respiratory Protection Standard [29 CFR 1910.134], a medical evaluation must be completed before fit testing is conducted. This discrepancy may reflect recall error or incomplete documentation, but it also raises the possibility that fit testing occurred before proper medical clearance in some cases. Ensuring that all required elements of the respiratory protection program are completed and documented in the correct order is critical for regulatory compliance and employee safety.

Most employees had received qualitative fit testing, which relies on the wearer's sensory detection of test agents (such as saccharin or Bitrex®) to assess the fit of the respirator. While qualitative fit testing meets the OSHA standard for negative pressure respirators, it is subjective and less precise than quantitative fit testing, which measures the actual amount of leakage into the respirator and provides a numerical fit factor. In this workplace, quantitative fit testing was only performed when an employee failed qualitative testing, potentially delaying the identification of poor respirator fit.

Employees also expressed uncertainty regarding when and which type of respirator should be used, how to properly store respirators, and when to replace filters or cartridges (data not shown). Improper storage and infrequent cartridge changes were common, and some employees were unaware of how long their respirator cartridges had been in use. These findings mirror concerns raised in previous HHEs of forensic laboratories, where respirator programs were present but inconsistently implemented [NIOSH 2020]. Taken together, these observations highlight the need for clear, scenario-based respiratory protection guidance, routine refresher training, and expanded use of quantitative fit testing, especially in high-risk environments where employees may be exposed to potent substances such as fentanyl.

Developing scenario-based protocols—tailored to the type and quantity of evidence—would help standardize PPE selection, engineering control use, and decontamination practices. For example, sampling large quantities of suspected opioids should always occur under a chemical hood or in a ventilated enclosure. Low-hazard evidence, such as residue testing, may be appropriate for benchtop analysis under specific conditions. These types of policies, reinforced by routine training and accessible job aids, would enhance both safety and consistency in practice.

In summary, while the laboratory has implemented commendable improvements—including increased fume hood availability and an expanded respiratory protection program—continued gaps in work practices, environmental contamination, and biomonitoring suggest that exposure controls are not yet fully effective. A combination of clearer protocols, improved training, and ongoing exposure monitoring can reduce risk and protect forensic staff from unintended drug exposures.

Limitations

This evaluation had several limitations. First, our assessment was based on the second site visit with sampling conducted over 2 days, which may not fully represent the range of work activities, exposures, and safety practices over longer periods. Workload, drug types handled, and adherence to protective measures may vary depending on case volume, staffing levels, and specific forensic assignments.

Second, biomonitoring results only capture recent exposure and do not provide information on long-term or cumulative exposure. The absence of detectable drugs in urine does not necessarily mean that no exposure occurred, as certain substances may have been present at levels below the detection limit or metabolized before sample collection. Additionally, external sources of exposure outside the workplace cannot be ruled out for substances detected in urine samples.

Third, while our air and surface sampling results provide insight into potential routes of exposure, they do not quantify actual inhalation or dermal absorption. Surface contamination does not always indicate that employees are being exposed at levels sufficient to result in measurable biological absorption.

Fourth, self-reported data from confidential medical interviews are subject to recall and reporting bias and personal perception. Employees may have underreported or overreported symptoms, PPE use, or adherence to safety practices based on their understanding, past experiences, or concerns about job-related consequences. Additionally, our sample size was small, limiting the ability to identify trends or draw broader conclusions.

Fifth, symptoms that were reported were non-specific so the presence of symptoms might not have been associated with or indicated that exposure occurred.

Lastly, our evaluation focused on workplace conditions at the time of our visit, and subsequent changes to policies, procedures, or engineering controls may have affected exposure risks after our assessment. Future evaluations, including longitudinal monitoring of workplace exposure and ongoing biomonitoring efforts, would provide a more comprehensive assessment of occupational health risks in forensic laboratories.

Conclusions

Our evaluation identified potential occupational exposures to controlled substances among forensic scientists in the forensic chemistry and trace units, with one employee's air sampling result exceeding the ACGIH TLV for fentanyl and surface and air sampling detecting cocaine, fentanyl, and methamphetamine contamination in laboratory work areas. While biomonitoring results did not indicate widespread systemic absorption, methamphetamine was detected in the urine of three employees. In addition to one post-shift sample, two pre-shift samples may also reflect residual workplace exposure, particularly when considering the low levels detected, the high sensitivity of the assay, and the extended detection window of methamphetamine. Observations revealed inconsistent fume hood use, respirator practices, and decontamination procedures, which may contribute to exposure risks. Some employees reported headaches and dizziness, and concerns were raised about solvent exposure, evolving policies, and the need for improved training on exposure risks and naloxone use. Proactive steps were already taken by the laboratory, including enhanced respiratory protection measures, increased PPE training, and improved naloxone availability. Continued efforts to strengthen engineering controls, PPE compliance, and standardized protocols will further enhance workplace safety and reduce exposure risks.

Attribution Statement

N95 is a certification mark of the U.S. Department of Health and Human Services (HHS) registered in the United States and several international jurisdictions.

P100 is a certification mark of the U.S. Department of Health and Human Services (HHS) registered in the United States.

Section C: Tables

Table C1. Personal breathing zone air sample results for illicit drugs from participating forensic scientists (n = 6)

Participant	Day	Average airflow (liters/minute)	Sample time (minutes)	Air volume (liters)	Cocaine TWA (µg/m³)	Fentanyl TWA (µg/m³)	Heroin TWA (µg/m³)	Methamphetamine TWA (µg/m³)
2	1	2.02	85	172	NQ	NQ	NQ	NQ
3	1	1.97	353	696	0.026	NQ	NQ	0.046
3	2	1.98	343	678	0.0080	NQ	NQ	0.26
4	1	1.98	281	556	0.0025	0.15*	NQ	0.092
4	2	2.03	96	195	NQ	0.0015	NQ	0.0089
5	1	1.98	286	565	0.010	0.0049	NQ	0.048
5	2	2.01	243	489	0.014	NQ	NQ	0.12
6	1	2.01	297	597	0.0028	0.0026	NQ	0.015
6	2	2.00	241	483	NQ	NQ	NQ	0.018
7	1	2.00	294	587	0.0034	NQ	NQ	0.11
7	2	2.03	256	519	0.016	NQ	NQ	0.022
				ACGIH TLV	None	0.1	None	None

TWA = time-weighted average

µg/m³ = micrograms per cubic meter

NQ = not quantifiable. This value was under the laboratory's reportable limit of 0.001 µg per sample.

ACGIH TLV = American Conference of Governmental Industrial Hygienists Threshold Limit Value

* Exceeds ACGIH TLV of 0.1 µg/m³ inhalable particulate matter for fentanyl

Table C2. Pre- and post-shift handwipe sample results (n = 12) for illicit drugs among participating forensic scientists (n = 7)

Participant	Day	Cocaine (ng/cm²)		Fentanyl (ng/cm²)		Heroin (ng/cm²)		Methamphetamine (ng/cm²)	
		Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift
1	1	NQ	0.0080	NQ	NQ	NQ	NQ	NQ	0.0056
2	1	NQ	NQ	NQ	NQ	NQ	NQ	NQ	NQ
3	1	NQ	0.013	NQ	NQ	NQ	NQ	NQ	0.025
3	2	0.078	0.0038	0.0038	NQ	NQ	NQ	0.090	0.047
4	1	NQ	0.012	NQ	0.011	NQ	NQ	NQ	0.42
4	2	0.0080	0.0094	0.0052	NQ	NQ	NQ	0.045	0.039
5	1	0.033	0.15	NQ	NQ	NQ	NQ	0.028	0.12
5	2	0.0094	0.044	NQ	NQ	NQ	NQ	0.0038	0.39
6	1	NQ	0.025	NQ	NQ	NQ	NQ	NQ	0.0063
6	2	0.0073	0.0073	NQ	NQ	NQ	NQ	0.0063	0.0063
7	1	0.0043	0.013	NQ	NQ	NQ	NQ	NQ	0.029
7	2	0.013	0.013	NQ	NQ	NQ	NQ	0.011	0.027

ng/cm^2 = nanograms per square centimeter

NQ = not quantifiable. This value was below the reporting limit of 1 nanogram per wipe sample.

Table C3. Pre- and post-shift urine sample results (n = 12) for illicit drugs and their metabolites among participating forensic scientists (n = 7)

Participant	Day	Cocaine (ng/mL)		Benzoylecgonine (ng/mL)		Fentanyl (ng/mL)		Norfentanyl (ng/mL)		Heroin (ng/mL)		6-Acetylmorphine (ng/mL)		Morphine (ng/mL)		Hydromorphone (ng/mL)		Methamphetamine (ng/mL)	
		Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift	Pre-shift	Post-shift
	LOD	0.002		0.078		0.002		0.002		0.078		0.002		0.098		0.098		0.002	
	LOQ	0.039		0.313		0.313		0.078		0.313		0.078		0.195		0.098		0.156	
1	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.68	ND
1	2		ND		ND		ND		ND		ND		ND		ND		ND		ND
2	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	2		ND		ND		ND		ND		ND		ND		ND		ND		ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.79	1.35
3	2		ND		ND		ND		ND		ND		ND		ND		ND		ND
4	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.53	ND
5	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	2		ND		ND		ND		ND		ND		ND		ND		ND		ND
7	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	2		ND		ND		ND		ND		ND		ND		ND		ND		ND

ng/mL = nanogram per milliliter

ND = not detected

LOD = limit of detection

LOQ = limit of quantitation

Table C4. Estimated half-life and urine detection window of analytes included in urine testing

Analyte	Urine half-life	Urine detection window
Cocaine	45–90 minutes*†	45 minutes‡
Benzoylecgonine	7.5 hours†	2–5 days†§
Fentanyl	3–12 hours†‡	1–4 days†‡
Norfentanyl	5.2–27.4 hours¶	3–4 days‡
Heroin**	2–6 minutes†‡	—
6-acetylmorphine	30 minutes†	2 hours–1 day†§
Morphine	2–3 hours*†	1–3 days†§
Hydromorphone	1.5–3.8 hours†	2–4 days†§
Methamphetamine	8–17 hours*†	1–2 days†§

* Bateman et al. 2014

† Swotinsky 2015

‡ Baselt 2008

§ Dasgupta 2017

¶ Bird 2025

** Estimates of urine detection windows for heroin are not available because heroin is essentially completely metabolized into the listed metabolites and not excreted as heroin in the urine.

Table C5. Area air sample results for illicit drugs

Location	Day	Average airflow (liters/minute)	Sample time (minutes)	Air volume (liters)	Cocaine TWA (µg/m^3)	Fentanyl TWA (µg/m^3)	Heroin TWA (µg/m^3)	Methamphetamine TWA (µg/m^3)
Forensic laboratory	1	1.99	361	719	0.0031	0.0029	NQ	0.036
Forensic laboratory	2	2.02	388	783	0.0031	NQ	NQ	0.095
Office	1	1.99	356	709	NQ	NQ	NQ	NQ
Office	2	2.01	240	483	NQ	NQ	NQ	NQ

TWA = time-weighted average

µg/m^3 = micrograms per cubic meter

NQ = not quantifiable. This value was under the laboratory's reportable limit of 1 nanogram (0.001 µg) per sample.

Table C6. Surface wipe sample results for illicit drugs

Location	Day	Inside or outside of laboratory	Cocaine (µg/100 cm²)	Fentanyl (µg/100 cm²)	Heroin (µg/100 cm²)	Methamphetamine (µg/100 cm²)
Laboratory keyboard (covered)*	2	Inside	5.4	0.21	0.038	18
Instrument room GC/MS keyboard*	2	Inside	1.8	0.084	0.0043	0.76
Instrument room GC/MS keyboard*	2	Inside	1.2	0.040	0.0082	0.30
Laboratory keyboard (uncovered)*	2	Inside	0.58	0.11	0.0047	1.6
Laboratory keyboard (covered)*	2	Inside	0.56	0.23	0.073	1.3
Laboratory keyboard (covered)*	2	Inside	0.46	0.092	0.037	1.2
Instrument room GC/MS mouse*	2	Inside	3.6	0.099	0.022	1.2
Laboratory workstation bench	2	Inside	1.4	0.0041	0.0020	0.097
Laboratory workstation bench	2	Inside	0.10	0.0066	NQ	0.052
Laboratory workstation bench	1	Inside	0.0073	NQ	NQ	0.0014
Laboratory fume hood surface	1	Inside	0.12	0.033	NQ	0.11
Laboratory interior door handle	1	Inside	0.099	0.0086	NQ	0.11
Laboratory ceiling supply vent cover	2	Inside	0.051	NQ	NQ	0.99
Laboratory back of chair	2	Inside	0.017	NQ	NQ	0.0093
Vestibule sink faucet handles*	2	Neither	0.0083	NQ	NQ	0.0047
Laboratory ceiling return vent cover	2	Inside	0.0053	NQ	NQ	0.016
Office door handle (inside and outside)	1	Outside	0.0051	NQ	NQ	0.0022
Women's bathroom exterior push handle	1	Outside	0.0033	NQ	NQ	NQ
Drinking fountain handle	2	Outside	0.0024	NQ	NQ	0.0011
Office desk	1	Outside	0.0011	NQ	NQ	NQ
TLV-SL			None	1	None	None

ng/100 cm² = nanograms per 100 square centimeters

NQ = not quantifiable. This value was below the reporting limit of 1 nanogram per wipe sample.

GC/MS = gas chromatography/mass spectrometer

TLV-SL = threshold limit value-surface limit

* A 100 cm² template was not used for this sample. The area was estimated to be 100 cm².

Table C7. Confidential medical interview (n = 7) results showing frequency, location, and potential exposure from drug samples in the 2 weeks prior to sample collection

Number of samples handled in the past 2 weeks, median (range)	90 (0–140)
Number of bulk drugs handled in the past 2 weeks, median (range)	12 (0–20)
Number of samples processed under a fume hood, median (range)	60 (0–140)
Processed samples under a fume hood, no. (%)	6 (86)
Potential exposure to the following drugs, no. (%)	
Methamphetamine	4 (57)
Cocaine	4 (57)
Heroin	4 (57)
Fentanyl	5 (71)
Other drugs	1 (14)

Table C8. Confidential medical interview (n = 7) results showing frequency of PPE use and hygiene practices in the 2 weeks prior to sample collection

Practice	Frequency		
	Always	Sometimes	Never
Wear laboratory coat	7	0	0
Wear nitrile gloves	7	0	0
Wear eye protection	7	0	0
Wear N95 respirator	0	3	0
Wear half-face respirator	0	1	0
Change gloves after every case*	3	2	0
Washed hands after every case	2	0	0
Wash hands after removing gloves	3	2	0
Wash hands before leaving laboratory	7	0	0
Wash hands before eating/drinking at work	6	1	0
Eating, drinking, or storing food in lab or vault room	0	0	7

* One “always” respondent reported changing gloves after each item; two “sometimes” respondents changed gloves several times daily, but not necessarily after every case

Table C9. Description of respirator use and fit testing by employees (n = 7)

	Number of employees (%)
Medically cleared for respiratory use in the past 12 months	5 (71)
Fit tested in the past 12 months	6 (86)
Wore a fit-tested respirator in the past 2 weeks	3 (43)

Table C10. Description of cleaning practices by employees (n = 7)

Task	Number of employees (%)
Cleaned shared equipment	4 (57)
Cleaned fume hoods	4 (57)
Cleaned lab benches	2 (29)
Used methanol for cleaning	2 (29)
Used bleach for cleaning	2 (29)
Used peroxide for cleaning	1 (14)
Used OxiClean™ for cleaning	1 (14)

Table C11. Health effects and concerns felt to be related to handling cases or samples at work by employees (n = 7)

Symptom or concern	Number of employees (%)
Experienced dizziness	5 (71)
Experienced headaches	4 (57)
Reported symptoms of opioid or stimulant exposure*	4 (57)
Concerned about solvent exposure	2 (29)
Concerned about respirator fit and use	2 (29)
Requested additional training on exposure risks	1 (14)

* Symptoms of opioid or stimulant exposure refer to health effects known to be associated with these substances (e.g., dizziness, headache, pinpoint pupils, agitation, etc.), as outlined in Table C12.

Table C12. Summary from selected literature – health effects of severe cocaine, fentanyl, heroin, and methamphetamine toxicity*

Controlled substance	Health effects
Cocaine	Dilated pupils, sweating, agitation, anxiety, elevated heart rate and blood pressure, heart arrhythmias, stroke, seizures, and high body temperature
Fentanyl	Lethargy or other indications of central nervous system depression, shallow or slow breathing, miosis or pinpoint pupils, slow heart rate, low blood pressure, low body temperature
Heroin	Lethargy or other indications of central nervous system depression, shallow or slow breathing, miosis or pinpoint pupils, slow heart rate, low blood pressure, low body temperature
Methamphetamine	Dilated pupils, sweating, agitation, anxiety, hallucinations, elevated heart rate and blood pressure, heart arrhythmias, stroke, seizures, high body temperatures, and electrolyte abnormalities (e.g., low potassium or sodium or elevated blood glucose)

* Bateman et al. 2014

Section D: Occupational Exposure Limits

NIOSH investigators refer to mandatory (legally enforceable) and recommended occupational exposure limits (OELs) for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects.

However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a preexisting medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- OSHA, an agency of the U.S. Department of Labor, publishes permissible exposure limits [29 CFR 1910 for general industry; 29 CFR 1926 for construction industry; and 29 CFR 1917 for maritime industry] called PELs. These legal limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2007]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States includes the threshold limit values or TLVs, which are recommended by ACGIH. The ACGIH TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2025].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA (Public Law 91-596) requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions.

Occupational Exposure Limit for Fentanyl in Air

In the United States, governmental organizations have not set OELs for fentanyl in air. ACGIH has set a TLV that is a TWA for fentanyl as inhalable particulate matter of 0.0001 milligrams per cubic meter (mg/m^3) ($0.1 \mu g/m^3$ or $100 ng/m^3$). Additionally, ACGIH has set a TLV that is a STEL (15-minute TLV-STEL) of $0.0002 mg/m^3$ ($0.2 \mu g/m^3$ or $200 ng/m^3$) [ACGIH 2025]. A pharmaceutical industry limit that has been cited for pharmaceutical employees is the same as the ACGIH TLV of $0.0001 mg/m^3$ [Van Nimmen et al. 2006].

Occupational Exposure Limit for Fentanyl on Surfaces

ACGIH has set a TLV for fentanyl on surfaces of 1 microgram per 100 square centimeters ($1 \mu g/100 cm^2$) [ACGIH 2025].

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