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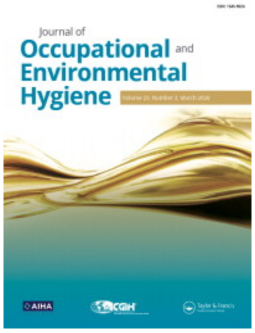

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Occupational exposures to illicit drugs in forensic science divisions

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ABSTRACT

Forensic scientists from local, county, state, and federal law enforcement agencies analyze evidence daily in which unknown substances suspected of containing illicit drugs are handled, weighed, and chemically processed. To address concerns about potential occupational exposures to opioids like fentanyl and other illicit substances, the National Institute for Occupational Safety and Health (NIOSH) conducted a multi-site exposure assessment among forensic laboratory personnel. NIOSH evaluated personal and area air samples, hand-wipe samples, area surface samples, and personal biomonitoring urine samples for cocaine, fentanyl, heroin, methamphetamine, and other metabolites. Thirteen of the 91 personal air, time-weighted average (TWA) samples collected exceeded the American Conference of Governmental Industrial Hygienists (ACGIH)® Threshold Limit Value (TLV)® for fentanyl of 100 ng/m^3 (8 h TWA), with exceedances observed at 4 of 11 sites. The ACGIH Surface Limit (TLV-SL) of 10 ng/cm^2 for fentanyl was exceeded for 8 of 86 surface wipes taken in laboratories at 3 of 11 sites. Commonly touched surfaces found to be above the TLV-SL included laboratory scales, keyboards, return air vents, the top of a light fixture, and inside a laboratory hood. Similarly, there were detectable concentrations in air and surface samples for cocaine and methamphetamine. Eight of 11 sites had at least one person with some detectable level of an illicit drug or metabolite in a urine sample. Based on the results of the current study, safety thresholds for fentanyl were exceeded. For other illicit drugs such as methamphetamine, cocaine, or heroin, thresholds have not been established to protect these workers. Due to the unpredictable nature of the evidence being handled, prudent occupational safety calls for minimizing exposure to chronic low doses of illicit drugs, as the health effects are unknown. To minimize exposure risk, best practices were identified from the literature and provided to each laboratory. Since potential health hazards have not been clearly established for chronic low-dose exposures, more research could lead to a better understanding of the potential health effects, if any, on workers.

KEYWORDS
Biomonitoring; laboratory; fentanyl; methamphetamine; cocaine; safety

Introduction

Public safety workers, including first responders, law enforcement officers, and workers supporting law enforcement services, are routinely involved in searches, investigative work, and evidence handling that could involve exposure to illicit drugs. Forensic scientists from local, county, state, and federal law enforcement agencies analyze evidence daily in which unknown substances are removed from packaging, weighed, and chemically processed to verify chemical composition for legal proceedings. In response to growing concerns about occupational exposures to opioids like fentanyl and heroin and other illicit drugs such as cocaine and methamphetamine, the National Institute for Occupational Safety and Health (NIOSH) conducted several Health Hazard Evaluations (HHEs) at the request of public safety employees such as fire fighters, first responders, law enforcement, and forensic scientists (NIOSH 2011; Chiu et al. 2018a, 2018b,

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2018c, 2020a, 2020b, 2025). These evaluations revealed detectable levels of cocaine, fentanyl, heroin, and methamphetamine in workplace personal air samples, end-of-shift handwipes, and surface samples from laboratory benchtops and keyboards (NIOSH 2020a, 2020b). First responders, educational staff, hotel staff, airline flight crews, public transit workers, librarians, food service workers, and others may encounter opioids and be at risk for adverse health effects from occupational exposures (Basham et al. 2021). However, there is limited data on illicit drugs being detected in occupational settings (Adams et al. 2023). A recent study assessed fentanyl and methamphetamine in the air and on surfaces of transit vehicles also found detectable levels (Beaudreau et al. 2025). The purpose of the current study was to provide a review of potential hazards in forensic departments nationwide, including regional differences, and to identify best practices from the literature for these facilities to reduce potential exposures.

Recently, the American Conference of Governmental Industrial Hygienists (ACGIH) adopted fentanyl Threshold Limit Values (TLVs) of 100 ng/m^3 (8 h time-weighted average [TWA]) and 200 ng/m^3 (15 min Short-Term Exposure Limit [STEL]) in air in addition to a Surface Limit (SL) of 10 ng/cm^2 (ACGIH 2024). Fentanyl is a potent synthetic opioid analgesic that is rapidly absorbed after inhalation and produces almost immediate effects, such as respiratory depression, that can be incapacitating and lethal in a matter of minutes (ACGIH 2024). The TLV-TWA value for fentanyl is recommended to protect workers against central nervous system impairment and respiratory depression. The TLV-TWA and SL were derived using the lowest transdermal dose rate of 12.5 micrograms (μg) per hour for therapeutic effects (ACGIH 2024). Currently, no other ACGIH-TLV standards, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), or NIOSH Recommended Exposure Limits (RELs) in air exist for other illicit drugs. Additionally, there are no Biological Exposure Indices (BEIs) or other health-based occupational biomonitoring guidelines for cocaine, methamphetamine, heroin, or fentanyl. Existing urine thresholds in the literature are derived from workplace drug testing and clinical toxicology and are intended to detect recent drug use or impairment, not to define safe or unsafe exposure levels (DHHS 2025). According to the 2022 National Forensic Laboratory Information System (NFLIS) Drug Annual Report, a total of 1,181,750 drug reports were submitted by state and local forensic laboratories in the United States (USDEA 2022c). Methamphetamine was the most frequently identified drug (29% of the reports) in 2022, followed by cocaine (14%), fentanyl (14%), cannabis/tetrahydrocannabinol (THC) (12%), and heroin (3%). Nationally, reports for fentanyl dramatically increased from 2019 at 6.5% to 2022 at 14% (USDEA 2019, 2022c).

There is an insufficient body of literature characterizing occupational exposures to illicit drugs, with uncertainty about the potential health effects from low-dose chronic exposures. The purpose of the current study was to address critical gaps in the understanding of occupational exposure to illicit drugs among forensic scientists and to better inform best practices in reducing exposures. When handling evidence, forensic scientists are potentially releasing illicit drugs into the air and on surrounding surfaces. Therefore, it is important to characterize the levels of contamination and to analyze which of these drugs are being metabolized by workers. The current study focused on assessing occupational exposures to cocaine, fentanyl, heroin, and methamphetamine in personal air samples as well as dermal wipe and urine samples. Previous HHEs determined potential exposures were occurring and illustrated the need to evaluate laboratory practices, what controls were available, and to observe the use of controls to better inform best practices. Reducing exposures is particularly important as more toxic and dangerous illicit drugs are emerging (USDEA 2022a, 2022b). The high potency of the newer fentanyl analogs, large volumes of distribution, and potential active metabolites have raised concerns about the management of people who are occupationally exposed to illicit drugs (Leen and Juurlink 2019). While the current study is short-term and cross-sectional in design, it provides valuable information to inform future prospective studies and potential exposure-reducing interventions.

Methods

General

The current study investigated the exposures of forensic scientists to illicit drugs by a convenience sample of law enforcement forensic science divisions across the U.S. The primary focus was on the evaluation of exposures to employees who routinely handled and/or analyzed suspected illicit drug evidence in law enforcement forensic divisions. Recruitment occurred between May 2022 and January 2025 by utilizing the cooperation of the Association of Public Health Laboratories (APHL), American Academy of Forensic Science (AAFS), the American Society of Crime

Laboratory Directors (ASCLD), and regional forensic organizations. Forensic laboratories that responded to the recruitment flyer and forensic scientists at those laboratories who were willing to participate were included in the study. Two forensic laboratories were willing to participate but were unable to be included due to the early termination of the project. One laboratory consented to the current study in addition to being a part of an HHE, and all data from that site that was included in the current study was collected according to this research protocol. Over the course of 2 days, investigators collected personal and area air samples, personal handwipe samples, area surface samples, and performed personal biomonitoring for cocaine, fentanyl, heroin, methamphetamine, and metabolites in urine. In light of rapidly changing laws and public attitudes of cannabis/THC, it was excluded from the current study. Participants were informed that the urine sampling was for research purposes only, did not meet the standards for regulated or non-regulated workplace drug testing programs, and did not enable urine sampling results to be incorporated into workplace drug testing programs. Informal qualitative observations of the forensic scientists were recorded by NIOSH scientists at intermittent time frames over the course of 2 days. Activities of the forensic scientist, appearance and presumptive identity of the illicit drug in question, and the personal protective equipment (PPE) worn were recorded.

Participants completed questionnaires to provide information on the use of controls, current PPE practices, and potential health-related symptoms. The questionnaires were developed by an epidemiologist and industrial hygienists and are based on questions previously developed and utilized for former Health Hazard Evaluation (HHE) studies (NIOSH 2020a, 2020b, 2023). All participants provided written consent. Each forensic crime laboratory location, referred to as sites throughout the paper, accepted an invitation to voluntarily participate in NIOSH's "Occupational Exposure to Illicit Drugs in Forensic Science Divisions" study. The study protocol was reviewed and approved by the NIOSH Institutional Review Board (45 C.F.R. Part 46).

Air sampling

Filter-based personal breathing zone (PBZ) and area samples were collected to assess the airborne concentration of cocaine, fentanyl, heroin, or methamphetamine. Air sample collection was performed using a 25-mm cassette with a 5 µm pore size nylon filter attached to an Airchek Touch sampling pump (SKC Inc., Eighty-Four, PA, USA) operating at the specified flow rate of 2 liters per minute, and filters were analyzed by the NIOSH contract laboratory (BVNA 2025a). Given that the inhalable size fraction was not specifically sampled, the inhalable fraction may have been underestimated when compared to the inhalable TLV-TWA (Martin and Zalk 1998). All sampling pump calibrations were verified before and after each day of sampling to ensure the proper flow within 5% of specified rate. The sample mass of cocaine, fentanyl, heroin, and methamphetamine was measured using ultrahigh performance liquid chromatography with triple quadrupole mass spectrometry (LC-QqQ MS) detection (Bijlsma et al. 2009; GOA 2020; BVNA 2025a). Per BVNA, a sampling time of 120 min was established based on their internal stability testing, as exceeding this limit could affect the percent recovery for some analytes (BVNA 2018). Based on the reported mass collected on the filter and the sample specific air volume, concentrations were calculated and reported in ng/m^3. The BVNA reporting limit was 1 ng per sample for each of the four drugs analyzed. An air sample with a sampling time of 120 min that was below 1 ng would yield a full shift reporting limit of $<$4 ng/m^3.

PBZ samples were collected using a task-based sampling approach to characterize potential exposures and were only collected when an individual was in the laboratory. The time a participant spent in the laboratory varied from 1.5 h to 9.9 h each sampling day, with the filter being changed up to five times. A TWA concentration was calculated using the employee's individual sample data for each of the four target drugs. In the instances where only a representative exposure sample period was collected ($<$8 h), the remaining sample time was averaged assuming zero exposure (OSHA 2023). TWAs were calculated when at least one value was above the detectable reporting limit of 1 ng during an individual's shift.

Office area air samples were collected within the indoor office area, away from the laboratory, during 2 days of sampling. Laboratory area air samples were taken adjacent to working scientists and were collected on both days. All area samples were evaluated for the levels of cocaine, fentanyl, heroin, and methamphetamine for an average of 6 h. Since a representative exposure sample period was typically collected ($<$8 h), the remaining sample time was averaged assuming zero exposure (OSHA 2023). Field blanks were neither connected to a pump nor had their plugs removed but were otherwise treated as all other samples and sent for analysis as blind samples.

Wipe sampling

Handwipe samples were collected using OpiAlert wipes from Bureau Veritas North America (BVNA, Lake Zurich, IL). Pre-shift dermal wipes were collected after the urine specimen was collected and hand washing was performed. Post-shift wipes were collected prior to urine collection. Individuals were told to behave as they normally do when leaving the lab and entering a common area, which could include washing hands, prior to the post-shift dermal wipe. The wipe was dipped in methanol and swabbed by the researcher over the palm-side of both hands horizontally and vertically until the entire palm-side surface was wiped. Area wipes were collected using a 10 centimeter (cm) by 10 cm square template as described in the OpiAlert kit, when feasible (BVNA 2025b). In some instances, such as samples involving door handles (~100 cm^2), areas were estimated. High-touch surface areas were targeted inside and outside of the laboratory, and areas where individual laboratories had specific concerns. Area wipe samples were collected in laboratory areas such as lab keyboards, benchtops, scales, supply vents, tops of light fixtures, arms of chairs, phone handles, balances, scanners, evidence shelves, and exterior door handles. Area wipe samples were also collected in non-laboratory areas such as office desktops, keyboards, bathroom exterior door handles, and office exterior door handles. Samples were collected mid-shift when employees were not present at that location. After collection, dermal and area wipe samples were placed in glass amber vials and frozen prior to shipment. Samples were shipped with ice packs to the contract lab for analysis. Wipe sample masses of cocaine, fentanyl, heroin, and methamphetamine were measured using ultrahigh performance liquid chromatography with triple quadrupole mass spectrometry (LC-QqQ MS) detection (Bijlsma et al. 2009; GOA 2020; BVNA 2025b). The laboratory reporting limit was 1 ng per sample for each of the four drugs analyzed with surface and handwipe samples. The laboratory reporting limit is the lowest mass of the chemical that the laboratory can reliably detect and report. Wipe samples with values below the reporting limit are referred to as "Not Reported" or NR. Surface wipe samples were typically 100 cm^2, yielding a reporting limit of $<$ 0.01 ng/cm^2. Dermal handwipe area was calculated based on an anthropometric survey by Gordon et al. (1989), and surface areas were estimated to be 350 cm^2 for men and 287 cm^2 for women, yielding a reporting limit of $<$0.003 ng/cm^2. Field blank wipes were dipped in methanol, treated as all other wipes, and sent for analysis as blind samples.

Urine collection

Participants provided spot urine specimens at the beginning of the work shift on the first day and the end of their work shift on two consecutive sampling days for a total of three samples per participant. Employees collected their urine in a 120 milliliter (mL) sterilized urine cup, with a minimum of 15 mL of urine for each collection. From each sample, NIOSH researchers immediately aliquoted 8 mL, which was frozen and sent on dry ice to the University of California, San Francisco (UCSF) Clinical Toxicology and Environmental Biomonitoring Lab for analysis.

The UCSF laboratory utilized liquid chromatography-tandem mass spectrometry (LC-MS/MS) to measure the concentration of cocaine, benzoylecgonine (a cocaine metabolite), fentanyl, norfentanyl (a fentanyl metabolite), heroin, 6-acetylmorphine (a heroin metabolite), morphine (a heroin metabolite), hydromorphone (a heroin metabolite), and methamphetamine (UCSF 2022; USDEA 2022b). The laboratory established limits of quantification (LOQ) and limits of detection (LOD) for the urine concentrations (Tables S1 and S2). Values below the LOD were reported as not detected (ND). Field blank samples were aliquoted in the field and sent for analysis as blind samples. Aside from field blanks, the lab routinely employs double (solvent blank), matrix blank, and quality controls (low and high) in each batch run. The lab employed a set of 15 internal standards in all its comprehensive drug panels.

Statistical analysis

For air, handwipe, and surface samples below the reporting limit and urine samples below the LOD, a multiple order value imputation method was employed to assign values to non-detects (Pleil 2016). In brief, this procedure plotted the natural logarithm of all detected values against their corresponding Z-scores in a Quantile-Quantile plot, fitted a linear regression, and used its equation to imputed non-detectable values from their Z-scores. The Wilcoxon signed-rank test was employed to compare paired pre- and post-shift concentrations in dermal wipes and urine samples. The Mann-Whitney U test was used to compare PBZ and office area TWA air, PBZ and laboratory area TWA air, and office and laboratory area TWA air values. Spearman's correlation coefficient was calculated to determine whether there was a correlation between post-shift dermal values, PBZ TWA air values, and post-shift urine values of the analytes and corresponding metabolites. All descriptive statistics and the imputation procedure were conducted in R version 4.4.3, using the *tidyverse* (v2.0.0) and *marlod* (v0.2.1) packages (Chen 2025). Statistical tests were two-sided at the 0.05 significance level.

Results

Observations

Forty-eight participants were recruited from 11 forensic crime laboratories (nine in the Midwest, one in the West, and one in the South) from five states; labs were visited between September 2023 and November 2024. Additional site visits in diverse geographical areas were planned but were unable to be completed. Laboratories ranged from older to newer facilities with characteristics ranging from benchtops at standing level to sitting level, from one ventilation fume hood for the entire laboratory to one fume hood per forensic chemist, and from well-designed spaces to converted spaces not originally designed for analytical chemistry. Typically, at these laboratories, suspected illicit drug evidence collected by law enforcement submitting agencies would be brought to the facility evidence receiving area. Packaged evidence would then be logged in by receiving personnel and suspected illicit drugs would be assigned to a forensic scientist for analysis. The drug chemistry section analyzed evidence for the presence of controlled substances. The specific types of analyses performed would be dictated by the evidence being evaluated. Forensic scientists followed a general protocol when analyzing suspected controlled substances. Weights, counts, and descriptions were obtained and documented. Weighing practices include taking net weights (weighing the material without packaging), gross weights (weighing the material with the packaging), or a combination of the two. The visual exam (macroscopic or microscopic) could include, but was not limited to, the following observations: color, size, shape, markings (inscriptions, writing, sharpness, size, location), hardness, consistency, edges, and scoring. Next, the analyst might perform a literature search or conduct color tests or other preliminary testing. The sample would then be prepared for analysis and confirmed using the appropriate instrumentation, such as gas chromatography-mass spectrometry (GC-MS) or gas chromatography-infrared spectroscopy (GC-IR). Throughout the process, notes were recorded on their laboratory computer. Upon completion of an analysis, the forensic scientists would repackage the evidence and return it to the drug storage area. A report would then be prepared with the analysis results.

At each laboratory, observations included a variety of analyses of several types of materials including white powder (thought to be cocaine) being transferred to a weighing dish, moved into a scale, and poured into a bag; suspected fentanyl and heroin in pill, liquid, and powder forms; cocaine/crack mini baggies; and bulk cases with large quantities of suspected crystal methamphetamine (∼15 lb). Each laboratory had its own ventilation controls, practices for handling evidence, and policies and procedures on the use of PPE. Some forensic scientists preferred to work on fresh sheets of paper, while others preferred to work directly on the benchtop. Forensic scientists continuously made case notes and documented actions throughout the drug analysis process on their computer in the laboratory. Forensic scientists also summarized their methods and the results of their analyses in final reports. These reports were written on a computer either in the controlled substances unit laboratory or in an office area outside of the laboratory. When handling evidence, scientists would typically wear nitrile gloves, although two scientists preferred wearing latex. Gloves were usually observed to be changed several times a day by most forensic scientists but occasionally more often if there was visible contamination. Generally, forensic scientists took notes on laboratory computers with gloves on. However, when there was no open evidence, and the scientist was working on the computer, it was observed that no gloves were usually worn. The frequency of cleaning of work surfaces, including benchtops, keyboards, and computer mice, was often carried out at the discretion of the forensic scientist. It was observed that the laboratory benchtop would be cleaned several times a day, most often with methanol, ethanol, or hydrogen peroxide. Additionally, cleaning would occur if any obvious contamination on keyboards, scales, or fume hoods were present.

Other PPE, such as laboratory coats, safety glasses, and N95 respirators, were typically available to forensic scientists to use at their discretion but often not required by management. Often, a vestibule area, if available, was utilized to store N95 respirators and safety glasses for those who elected to wear them and to store fresh lab coats. Some scientists utilized the vestibule area to wash their hands when leaving the laboratory. Forensic scientists elected to wear lab coats (81% of participants), safety glasses (31% of participants), and gloves (98% of participants) while handling evidence. The location where participants stored their lab coats during and at the end of the day varied between facilities. Often, lab coats were stored on the back of the laboratory chair or in the vestibule, leaving the laboratory. Clean lab coats were typically available to the scientists, and lab coats were not observed to be worn outside of the laboratory. Of the 48 participants, only two individuals were observed using respiratory protection. One participant was wearing respiratory protection per the facility's protocol, and the other at their personal discretion. Four scientists were observed using surgical masks per the facility's protocol. For ventilation controls, some facilities had open local exhaust ventilation or 'snorkels' above the open benchtop, and some facilities had ventilation hoods available for use at the scientists' discretion. Ventilation hoods and snorkels appeared to be in good working order at the time of our visit, and ventilation hoods were certified within the year.

Best practices were provided to laboratories based on observations, data collected at each site visit, and existing literature. It was suggested to all laboratories to process and handle illicit drugs in enclosures, either in existing available fume hoods (n [laboratories] = 11) or add desktop ductless fume hoods ($n = 10$). Best practices provided to laboratories also included wearing PPE ($n = 11$) such as nitrile gloves, laboratory coats, safety glasses and respiratory protection if handling powders; minimizing taking net weights (weighing the material without packaging) ($n = 9$); cleaning regularly and periodic deep cleaning with appropriate cleaning solutions ($n = 11$) and symptom checking and reporting ($n = 10$) (Table S3). Examples of best practices provided to laboratories for forensic labs handling illicit drugs are in the Supplemental Information.

Questionnaire

All 48 participants completed a questionnaire about demographics, work, and work practices. A summary of the questions asked of participants is in Table 1, with additional questions in Tables S4 and S5. The median age of the participants was 38 years (range: 25 to 60 years). The forensic scientists had been working in the field of analyzing illicit drugs for a median of 10 years (range: 1.5 to 35 years). Changing gloves after every case was reported by 23 participants (48%), several times a day by 14 participants (29%), or some other timeframe by 11 participants (23%). Additionally, hands were reported to be washed sometimes but not after every glove removal by 33 participants (69%), after every glove removal by three participants (6%), never after glove removal by one participant (2%), or some other timeframe by 11 participants (23%). Each forensic scientist analyzed an average of 12 samples each day (range: 0 to 85 samples). Five participants reported an incident of exposure in the past 2 weeks; however, no one reported the incidents to their supervisor. Over 2 days, participants (Day 1 [$n = 47$] + Day 2 [$n = 45$] = 92) reported handling methamphetamine [number of participants, % of participants (67, 73%)], cocaine (69, 75%), heroin (13, 14%), fentanyl (69, 75%), and other illicit drugs (41, 45%). Fourteen participants reported experiencing symptoms or health effects at any time during their employment as a forensic scientist that they felt were related to handling cases/samples at work; however, only two went to a doctor to be evaluated.

Air sampling

A total of 383 filter-based air samples were collected to characterize potential exposures during the 2 days of sampling for cocaine, fentanyl, heroin, and methamphetamine (250 PBZ samples and 133 area samples). The 250 PBZ samples were utilized to generate 91 8 hr TWA values, and the 133 area samples were utilized to generate 44 8 hr TWA values for comparison for all four illicit drugs. Of the 31 field blank air samples collected, 30 blanks were less than the reporting limit for all analytes and one blank had detectable levels of fentanyl. To account for possible contamination at that specific site, the detectable level of fentanyl was subtracted from all the air samples collected on that day.

Of the 91 PBZ 8 hr TWAs, 89 TWAs (98%) had detectable quantities of methamphetamine, 79 TWAs (87%) had detectable quantities of cocaine, 47 TWAs (52%) had detectable quantities of fentanyl, and eight TWAs (9%) had detectable quantities of heroin. The ACGIH TLV-TWA (100 ng/m^3) air concentration for fentanyl was exceeded in 13 of 91 PBZ TWA values at four sites within the Midwest and West. These TWA exceedances ranged from 147 to 8,645 ng/m^3. An additional eight PBZ TWA values were at least half of the TLV-TWA (>50 ng/m^3).

Of the 44 area samples, 23 TWA values were collected within the laboratories, and 21 TWA values

Table 1. Questionnaire summary of personal protective equipment (PPE) use and cleaning practices ($n = 48$).

Question	Number of participants, % of participants
Generally, do you regularly wear any of the following personal protective equipment?	Gloves, nitrile/latex/etc. (47, 97.9%), Gloves, chemical resistant (3, 6.3%), Safety glasses/goggles (15, 31.3%), N95 (9, 18.8%), Respirator, half-face (3, 6.3%), Laboratory coat (39, 81.3%), Other (19, 39.6%)
During the past 2 weeks, how often did you change your gloves?	After every case (23, 47.9%), Several times a day but not after every case (14, 29.2%), Once a day (0, 0.0%), Other (11, 22.9%)
During the last 2 weeks, how often did you wash your hands after removing your gloves?	Every time (3, 6.3%), Sometimes but not after every glove removal (33, 68.8%), Never (1, 2.1%), Other (11, 22.9%)
During the last 2 weeks, how often did you change your lab coat? (i.e., used a new disposable lab coat or a newly laundered lab coat)	Several times a day (0, 0.0%), Once a day (3, 6.4%), Once a week (10, 21.3%), Every 2 weeks (8, 17.0%), Once a month (10, 21.3%), Other (16, 34.0%)
During the last 2 weeks, why did you wear eye protection?	Personal preference (6, 21.4%), Required for specific job duties (20, 71.4%), Other (6, 21.4%)
Over the past 2 weeks, how often have you been in the lab or handling drug evidence without any PPE?	Never (40, 83.3%), 1-2 times (4, 8.3%), 3-5 times (0, 0.0%), More than 5 times (4, 8.3%)
If yes, why were you in the lab without PPE?	Not handing samples or performing an experiment (7, 87.5%), Quickly doing some work (1, 12.5%)
Over the past 2 weeks, how often did you wash your hands immediately before or after leaving the lab/vault room?	Always (21, 43.8%), Sometimes (25, 52.1%), Never (2, 4.2%)
Over the past 2 weeks, how often did you wash your hands immediately before eating or drinking at work?	Always (31, 64.6%), Sometimes (17, 35.4%), Never (0, 0.0%)
What parts of the laboratory/vault room did you clean?	Lab bench (40, 93.0%), Common areas in the lab (26, 60.5%), Shared equipment (28, 65.1%), Hood (25, 58.1%), Vault room (3, 7.0%), Other (4, 9.3%)
How often did you clean the lab bench?	After every item (14, 35.0%), After every case (9, 22.5%), Several times a day but not after every case (13, 32.5%), Once a day (3, 7.5%), Several times a week (0, 0.0%), Weekly (0, 0.0%), Less often than weekly (1, 2.5%)
What type(s) of cleaning activities did you do in the laboratory?	Dry sweep floors (7, 18.4%), Clean surfaces with dry cloth (6, 15.8%), Clean surfaces with wet cloth/paper towel (36, 94.7%), Remove biohazard or other hazardous waste from the lab (11, 28.9%), Other (3, 7.9%)
What type(s) of cleaning solutions did you use in the laboratory?	Water (8, 18.6%), Disinfectant wipes (8, 18.6%), Bleach (3, 7.0%), Lysol (1, 2.3%), Ethanol (6, 14.0%), Methanol (29, 67.4%), Other (23, 53.5%)
In the past 2 weeks, have you had direct skin, respiratory, or mucous membrane exposure (e.g., eye or mouth) to suspected illicit drugs at work?	Yes (5, 10.4%), No (43, 89.6%)
Did you report this incident?	Yes (0, 0.0%), No (5, 100.0%)

were collected within the offices. Of the 23 laboratory area TWA values, 22 TWAs (96%) had detectable quantities of methamphetamine, 11 TWAs (48%) had detectable quantities of cocaine, seven TWAs (30%) had detectable quantities of fentanyl, and one TWA (4%) had detectable quantities of heroin. While the TLV-TWA is intended solely for PBZ sampling, when comparing the TLV-TWA to area samples, the TLV-TWA air concentration for fentanyl was exceeded in two of the 23 area laboratory TWA values (159 ng/m^3 and 257 ng/m^3), and these two sites also had individuals that exceeded the PBZ TLV-TWA. Of all the office areas, TWA values ($n = 21$), 10 TWAs (48%) had detectable quantities of methamphetamine, one TWA (5%) had detectable quantities of cocaine, one TWA (5%) had detectable quantities of fentanyl, and none had detectable quantities of heroin (Figure 1). No area TWA concentrations collected from offices were above the TLV-TWA for fentanyl. Median and range concentrations are presented in Table 2. Tables S1 and S2 contain the raw data. PBZ air samples and laboratory area air samples, and PBZ air samples and office area air samples were significantly different for all analytes except heroin due to the large number of samples below the level of detection. Laboratory and office area air samples were significantly different for cocaine and methamphetamine, but not fentanyl or heroin (Figure 1).

Dermal and surface wipe sampling

A total of 306 wipe samples were collected during the 2 days of sampling, including personal pre- and post-shift dermal samples (184 total, 92 pre-shift and 92 post-shift) and surface wipes (122 total). All samples were analyzed for cocaine, fentanyl, heroin, and methamphetamine. Twenty-five wipe blank samples were collected and measured below the reporting limit of 1 ng, except for three samples. To account for possible contamination, positive blanks for fentanyl and cocaine were subtracted from all of the wipe samples collected from that specific site.

Illicit drugs were detected in 34 out of 47 dermal wipe samples (72%) pre-shift Day 1, and 28 out of 45 samples (62%) pre-shift Day 2. For dermal wipe post-shift samples, illicit drugs were detected in 44 out of 47 samples (94%) Day 1 and 43 out of 45 samples (96%) Day 2. Illicit drug results for post-shift dermal wipe samples were overall greater than pre-shift dermal wipes. Pre-shift median values for cocaine, fentanyl, and methamphetamine were 0.00645 ng/cm^2, 0.00212 ng/cm^2, and 0.00383 ng/cm^2, respectively, and post-shift median values for cocaine, fentanyl, and methamphetamine were 0.0951 ng/cm^2, 0.0135 ng/cm^2, and 0.0827 ng/cm^2, respectively. Heroin pre-shift and post-shift medians were NR. Median and range values for pre- and post-shift dermal handwipes are presented in Table 2. There was a significant statistical difference between the pre-shift dermal wipes and the post-shift dermal wipes for all four drugs ($p < 0.01$) (Table 2).

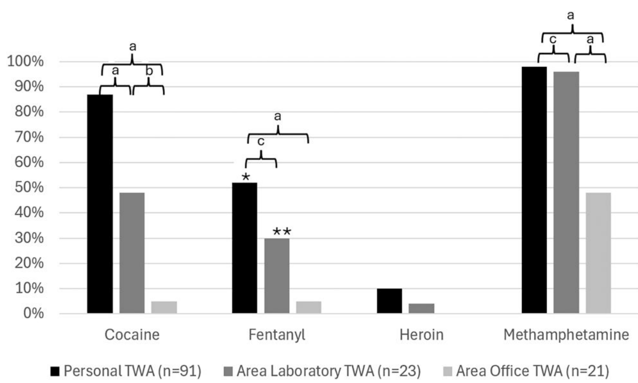

Figure 1. Percentage of samples with detectable results in 8-hr Time Weighted Average (TWA) air samples.
*13 of the 91 samples were above the TLV-TWA of 100 ng/m^3 for fentanyl; **2 of the 23 samples were above the TLV-TWA of 100 ng/m^3 for fentanyl; a: $p < 0.001$, b: $p < 0.01$, c: $p < 0.05$.

Fentanyl was above the TLV-SL of 10 ng/cm^2 for eight of the 86 surface wipes taken in the laboratories. Locations above TLV-SL include laboratory scales (46.1 ng/cm^2 and 51.4 ng/cm^2), laboratory keyboards (12.1 ng/cm^2 and 10.3 ng/cm^2), laboratory return air vents (48.0 ng/cm^2 and 22.8 ng/cm^2), the top of a light fixture in a laboratory (24.8 ng/cm^2) and inside a laboratory hood (13.0 ng/cm^2). The TLV-SL was not exceeded in the 36 wipes taken from areas outside of the laboratory. Fentanyl was detected in public area surface wipes including an evidence in-processing keyboard (0.933 ng/cm^2), evidence in-processing desktop (0.0120 ng/cm^2), an office desktop (0.265 ng/cm^2), hallway drinking water fountain buttons (0.118 ng/cm^2), office keyboards (0.0865 ng/cm^2, 0.0300 ng/cm^2, 0.0305 ng/cm^2, and 0.0230 ng/cm^2), office door handle (0.0460 ng/cm^2), and breakroom countertops (0.0320 ng/cm^2 and 0.0120 ng/cm^2).

Cocaine [median, range (5.97 ng/cm^2, NR – 559 ng/cm^2)] and methamphetamine (3.96 ng/cm^2, NR – 481 ng/cm^2) were detected in all but one of the laboratory surface samples. However, in the non-laboratory surface samples, cocaine (0.0360 ng/cm^2, NR – 1.47 ng/cm^2) and methamphetamine (0.0195 ng/cm^2, NR – 0.965 ng/cm^2) were also detected in more than 50% of the samples. Heroin was detected in 27 surface wipes taken from the laboratory (NR, NR – 13.5 ng/cm^2) and from two samples outside of the laboratory, including an office desktop (0.0210 ng/cm^2) and an office keyboard (0.256 ng/cm^2). Surface sample results are summarized in Table 3.

Table 2. Median and range values in air samples, dermal hand wipes, and urine samples for cocaine, fentanyl, heroin, and methamphetamine (and urine metabolites).

	Air TWA (ng/m^3)$^\beta$			Dermal (ng/cm^2)		Urine (ng/mL)	
	Personal ($n = 91$)	Laboratory Area ($n = 23$)	Office Area ($n = 21$)	Pre-shift ($n = 92$)	Post-shift ($n = 92$)	Pre-shift ($n = 45$)	Post-shift ($n = 84$)
Cocaine	17.7 (NR – 52,562) [13%]	NR (NR – 86.9) [55%]	NR (NR – 93.0) [95%]	0.00645 (NR – 0.557)**[38%]	0.0951 (NR – 8.88)**[7%]	ND (ND – 0.665) [86%]	ND (ND – 14.6) [89%]
Benzoylecgonine	–	–	–	–	–	ND (ND – 1.35) [89%]	ND (ND – 67.6) [89%]
Fentanyl	2.51 (NR – 8645) [48%]	NR (NR – 257) [73%]	NR (NR – 4.56) [95%]	0.00212 (NR – 0.334)** [77%]	0.0135 (NR – 7.48)** [36%]	ND (ND – 0.428) [98%]	ND (ND – 3.16) [95%]
Norfentanyl	–	–	–	–	–	ND [100%]	ND (ND – 1.24) [96%]
Heroin	NR (NR – 11.7) [91%]	NR (NR – 3.49) [95%]	NR (NR – NR) [100%]	NR (NR – 0.00418)*[98%]	NR (NR – 0.0254)*[86%]	ND [100%]	ND [100%]
Methamphetamine	33.6 (NR – 1710) [2%]	12.9 (NR – 505) [5%]	NR (NR – 13.6) [52%]	0.00383 (NR – 0.352)** [46%]	0.0827 (NR – 10.8)** [7%]	ND (ND – 3.79) [86%]	ND (ND – 11.35) [89%]

Median (minimum – maximum) [%n as ND or NR].
*$p < 0.01$.
**$p < 0.001$, comparison between pre-shift and post-shift values, Wilcoxon signed rank test.
β: Statistical differences for Air TWA are reflected in Figure 1; – No sample (Norfentanyl and Benzoylecgonine are metabolites and are only present in urine.).
6-acetylmorphine, morphine, hydromorphone were NR.
TWA – Time Weighted Average, ND – Not Detected; NR – Not Reported.

Table 3. Median and range values in surface samples collected inside and outside of the laboratory for cocaine, fentanyl, heroin, and methamphetamine.

	Cocaine	Fentanyl	Heroin	Methamphetamine
Laboratory surfaces, ng/cm^2, median (range) [%n as NR]				
Benchtop/desktop (n = 17)	7.44 (0.0730–215) [0%]	0.140 (NR – 6.80) [12%]	NR (NR – 0.180) [82%]	5.60 (0.0140–481) [0%]
Keyboards (n = 21)	8.30 (0.235–61.0) [0%]	0.367 (NR – 12.1) [5%]	0.00550 (NR – 0.731) [48%]	7.58 (0.250–180)0%]
Supply vent (n = 11)	0.0380 (NR – 1.50) [9%]	NR (NR – 0.459) [64%]	NR (NR – 0.257) [82%]	0.220 (NR – 40.0) [9%]
Return vent (n = 9)	6.10 (0.0530–559) [0%]	0.256 (NR – 48.0) [11%]	0.0700 (NR – 13.5) [33%]	5.03 (0.164 – 120) [0%]
Scale (n = 4)	40.6 (10.1–101) [0%]	25.4 (0.360–51.4)0%]	0.0975 (NR – 0.320) [25%]	28.9 (2.47–75.4) [0%]
Hood interior (n = 3)	11.0 (1.17–43.0) [0%]	8.70 (0.334–13.0) [0%]	NR (NR – 0.310) [67%]	4.8 (1.05–10.0) [0%]
Door handles (n = 3)	0.688 (0.175–0.990) [0%]	0.0860 (0.0100–0.647) [0%]	NR [100%]	1.05 (0.250–1.14) [0%]
Evidence storage area (n = 3)	6.43 (1.30–19.6) [0%]	0.0260 (NR – 0.219) [33%]	NR [100%]	0.839 (0.470–0.859) [0%]
Unused area/dust collection (n = 3)	3.50 (0.205–15.6) [0%]	3.60 (0.240–24.8) [0%]	NR (NR – 0.0790) [67%]	1.40 (0.0310–10.3) [0%]
FTIR (n = 2)	115 (41.0–189) [0%]	0.472 (0.0320–0.911) [0%]	NR [100%]	138 (58.0–217) [0%]
Different forensic department (n = 2)	0.115 (NR – 0.230) [50%]	NR [100%]	NR [100%]	0.00600 (NR – 0.0120) [50%]
Other miscellaneous measured surfaces in laboratory (ng/cm^2)				
Work phone	0.0460	NR	NR	0.0760
Arm of chair	22.1	4.08	0.555	3.70
Back of chair	0.172	NR	NR	0.0930
Phone cradle	16.7	6.84	0.155	5.69
GCMS mouse	35.6	0.985	0.220	12.3
Refrigerator handle	13.5	3.52	0.0160	21.5
Bottom of shoes	55.0	1.30	0.0170	47.0
Ceiling vent not on	0.0390	NR	NR	0.0510
Non-laboratory surfaces, ng/cm^2, median (range) [%n as NR]				
Keyboard (n = 10)	0.165 (0.00700–1.47) [0%]	0.0120 (NR – 0.933) [50%]	NR (NR – 0.256) [90%]	0.0330 (NR – 0.965) [20%]
Desktop (n = 9)	0.0210 (NR – 1.45) [11%]	NR (NR – 0.265) [89%]	NR (NR – 0.0210) [89%]	0.0110 (NR – 0.254) [44%]
Handles (drinking fountain, doorknobs, sinks) (n = 10)	0.0500 (NR – 0.955) [10%]	NR (NR – 0.118) [80%]	NR [100%]	0.0350 (NR – 0.880) [20%]
Food/break area (n = 7)	0.0160 (NR – 0.330) [29%]	NR (NR – 0.0320) [57%]	NR [100%]	NR (NR – 0.120) [71%]

Median (minimum–maximum) [%n as ND or NR].
FTIR: Fourier transform infrared spectrometer; GCMS: Gas chromatograph mass spectrometer; ng/cm^2: nanograms per centimeter squared.
NR: Not reported.

Urine sampling

Of 48 participants, urine samples from 47 individuals were collected to characterize potential exposures during the 2 days of sampling. One participant declined to provide urine, and three participants' samples were unable to be analyzed due to contract termination. Typically, three samples were collected per participant (one pre-shift sample on Day 1 and post-shift samples for Days 1 and 2). Three participants only participated on 1 day of sampling with a pre- and post-shift sample. A total of 138 urine samples were collected, and 129 samples were analyzed for cocaine, benzoylecgonine (a cocaine metabolite), fentanyl, norfentanyl (a fentanyl metabolite), heroin, 6-acetylmorphine (a heroin metabolite), morphine (a heroin metabolite), hydromorphone (a heroin metabolite), and methamphetamine.

The majority of urine samples did not contain detectable amounts of the analytes ($n = 103$, 80%). Of the 129 analyzed samples, 45 samples (35%) were pre-shift, 43 samples (33%) were post-shift Day 1, and 41 samples (32%) were post-shift Day 2. Of 11 sites, eight sites had at least one person with some detectable level of an illicit drug or metabolite ($n = 19$) in any urine sample. Cocaine was detected in six (14%) pre-shift samples and nine post-shift samples (11%), and benzoylecgonine was detected in five (11%) pre-shift samples and in nine (11%) post-shift samples. Fentanyl was detected in one (2%) pre-shift sample and four (5%) post-shift samples, and norfentanyl was detected in three post-shift samples (4%). Methamphetamine was detected in six (14%) pre-shift samples and nine (11%) post-shift samples. Heroin, 6-acetylmorphine, morphine, and hydromorphone were not detected in any samples. Median and range values for cocaine, benzoylecgonine, fentanyl, norfentanyl, and methamphetamine can be seen in Table 2. There were no statistical differences for any of the drugs or their metabolites between the Day 1 pre-shift compared to the Day 1 post-shift, Day 2 post-shift, or all post-shift values (p-values, Table S6). Tables S3 and S4 contain the raw data.

Statistical analysis

Based on Spearman correlation analysis, post-shift dermal wipe samples were significantly correlated with 8 hr personal air TWA samples for all analytes ($p < 0.01$), except in the case of heroin due to the large number of samples below the reportable level. Levels in post-shift dermal samples were significantly correlated with post-shift urine samples for cocaine ($p < 0.05$), fentanyl ($p < 0.01$), and norfentanyl ($p < 0.01$). Levels in air TWA samples for fentanyl ($p < 0.001$) and norfentanyl ($p < 0.01$) were significantly correlated with levels in post-shift urine samples. Results of the Spearman correlation coefficients are presented in Table 4.

Discussion

All four drugs—cocaine, fentanyl, heroin, and methamphetamine—were detected in both personal air samples and dermal hand wipes. All four drugs were also found in area air samples and on work surfaces collected inside the laboratory. Only one of 48 participants had no detectable levels of any of the four drugs in their air sample. Additionally, low levels of cocaine, fentanyl, and methamphetamine were found in samples collected outside the laboratory from air samples and surfaces such as office keyboards and desktops. Participants had biological evidence and indications of exposure to cocaine, fentanyl, and methamphetamine in their urine. Participants were possibly exposed via inhalation, contact with mucous membranes, through accidental ingestion, or dermal absorption (Salocks et al. 2014). These data demonstrate that chronic low levels of occupational exposures to illicit drugs are occurring in forensic laboratories, and in some instances, these exposures were over the TLV. Ten of the TWA air samples collected from participants exceeded the fentanyl TLV-TWA, with three participants exceeding the TLV-TWA on both days of sampling. The measured exposures that exceeded the TLV were 1.4 to 86 times the TLV-TWA. While no air sample was taken for 15 min and therefore cannot be directly compared to the TLV-STEL, 10 TWA values (8 h) exceeded the TLV-STEL, and in one instance were six times over this value. There are currently no published occupational exposure limits (OELs) for cocaine, heroin, or methamphetamine. While no immediately dangerous to life or health (IDLH) values exist for any of these drugs, a single, high-concentration exposure could potentially pose an IDLH risk (Oelhaf and Azadfard 2023; Richards and Laurin 2023; Richards and Le 2023; Ramos-Matos et al. 2025).

Eight laboratory surfaces, including two keyboards, two scales, a hood, two return air vents, and the top of a light fixture, had contamination at or above the TLV-SL (10 ng/cm^2–48 ng/cm^2). No samples of high-touch surfaces outside of the laboratory (e.g., the office keyboard) exceeded the TLV-SL. The surface samples that were found to have detectable exposures in the return air vents within the laboratory may indicate that these return vents are rarely cleaned, and that contaminated air could be circulated through the ventilation system. However, no samples were collected within the air duct. Of the 11 supply air vent wipe samples collected, four were found to have detectable concentrations under 1 ng/cm^2. Of the 36 non-laboratory surface wipe samples, 11 had low detectable levels of fentanyl (<1 ng/cm^2), four of which were on office keyboards. This suggests that high-touch surfaces and areas outside of the laboratory were kept relatively clean. However, some trace levels of illicit drugs still contaminated non-laboratory areas. Similar trends for surface contamination were seen with cocaine, heroin, and methamphetamine.

The maximum acceptable amount of methamphetamine present on a surface differs between each state. Several states have established guidelines or regulations, but more have not set any remediation standards or regulations for methamphetamine contamination (Kuhn et al. 2019). As of 2021, 21 states had developed recommended or required standards for methamphetamine remediation that range from 0.5 to 15 ng/cm^2, with the most common being 1 ng/cm^2 (USEPA 2021b). In the current study, 40 of 86 lab surface samples exceeded 1 ng/cm^2 for methamphetamine, and all methamphetamine samples ($n = 36$) collected outside of the laboratory were below 1 ng/cm^2 (Kuhn et al. 2019).

Of the 10 participants whose personal sampling values exceeded the TLV-TWA air concentration for fentanyl, three of these individuals also had detectable post-shift fentanyl urine values, and all but one of the post-shift dermal results for those individuals also had detectable levels of fentanyl. Cocaine and methamphetamine were also found in air, urine, and dermal samples. Eleven of the 48 participants had detectable quantities of illicit drugs in their post-shift urine samples that were higher than the corresponding pre-shift value. Therefore, ongoing exposures at work likely contributed to urinary levels. Personal air and post-shift dermal sampling for cocaine, fentanyl, and methamphetamine were significantly associated with each other. Post-shift dermal samples for cocaine, fentanyl, and norfentanyl, and personal air samples for fentanyl and norfentanyl were significantly associated with urine values. This could suggest a relationship between (1) work practices like glove use and handwashing, and (2) dermal exposure or the opportunity for hand to mucous membrane transfer that could influence internal dose.

Table 4. Spearman correlation coefficients for personal air TWA samples, dermal samples, and urine samples.

		Spearman correlation coefficient, p (*p*-value)	
Parameter	Drug	Post-Shift Dermal	Personal Air TWA
Personal air TWA	Cocaine	**0.294 ($p < 0.01$)**	
	Fentanyl	**0.668 ($p < 0.001$)**	
	Heroin	−0.00964 ($p = 0.9$)	
	Methamphetamine	**0.367 ($p < 0.001$)**	
Post-shift urine	Cocaine	**0.273 ($p < 0.05$)**	0.0928 ($p = 0.4$)
	Benzoylecgonine[a]	0.149 ($p = 0.2$)	0.116 ($p = 0.3$)
	Fentanyl	**0.322 ($p < 0.01$)**	**0.372 ($p < 0.001$)**
	Norfentanyl[b]	**0.292 ($p < 0.01$)**	**0.314 ($p < 0.01$)**
	Heroin		
	Methamphetamine	0.139 ($p = 0.2$)	0.122 ($p = 0.3$)

Bold values indicate $p < 0.05$.
[a]Benzoylecgonine urine compared with cocaine dermal and air.
[b]Norfentanyl urine compared with fentanyl dermal and air.

Biological monitoring is a useful tool to determine if potential exposures have been taken into the body and is an index of an individual's uptake of a chemical by all exposure routes (inhalation, ingestion, and dermal or mucous membrane absorption; percutaneous exposure is unlikely in this setting) (USEPA 2025). However, attributing drugs and metabolites in urine to one or several individual work practices was not possible in the current study, considering the variable casework across employees and the variation in ventilation and other controls between the different sites. Internal doses for individuals within a workgroup may be different for a variety of reasons, including physiological makeup and health status of the worker or particle size distributions of the drugs analyzed (ACGIH 2024).

Pre-shift dermal wipe ($n = 34$) and pre-shift urine samples ($n = 10$) on Day 1 revealed low levels of cocaine, fentanyl, and methamphetamine. As there were low levels of illicit drugs detected in high-touch areas outside of the laboratory, it was reasonable to see some low-level detection of cocaine, fentanyl, and methamphetamine in pre-shift hand wipes. Additionally, the office area also had some low levels of illicit drugs on surfaces and in the air. The limited lower values in the office area demonstrated that containment of these illicit drugs was primarily maintained within the lab. All pre-shift handwipes were at levels below 0.6 ng/cm^2 for all analytes. As sensitive assays for the detection of illicit drugs in urine were being utilized, it was expected to see a high number of positive results and longer detection windows than traditional methods. For example, benzoylecgonine with traditional analytical methods has a urine detection window of 2 to 4 days, but utilizing more sensitive analytical methods, it could have a detection window of 17 to 22 days. (Dasgupta 2016; Nickley et al. 2017). It was also reasonable to see low-level detection results in pre-shift urine samples, as forensic scientists potentially had worked previous days when they may have been exposed to the illicit drugs. When comparing the current study's urine results to federal workplace drug testing guidelines, one participant could have tested positive for fentanyl and norfentanyl (Table S1) (DHHS 2025). This participant had detectable levels of cocaine and benzoylecgonine in their pre-shift urine samples and cocaine, benzoylecgonine, fentanyl, norfentanyl, and methamphetamine in their post-shift urine samples. This participant also had detectable levels of cocaine, fentanyl (above the air TLV), and methamphetamine in their personal air samples and in their pre- and post-shift dermal samples. This information is suggestive of an occupational exposure.

Post-shift dermal wipes were significantly correlated with air TWA samples (for cocaine, fentanyl, and methamphetamine) and with urine samples (for cocaine, fentanyl, and norfentanyl) and may provide forensic laboratories with a lower-cost option to evaluate contamination and help reduce workplace exposures. In a study evaluating opioid exposures in pharmaceutical production workers, fentanyl levels in pre-shift urine samples reflected dermal exposure to the compound during the previous day (Van Nimmen et al. 2010). When comparing air, dermal, and urine sampling, dermal sampling is the easiest to perform and is the least invasive to the participant. Dermal sampling can also evaluate the contamination outside of the laboratory, potentially differentiate exposure by specific tasks, and assist in the evaluation of PPE use (OSHA 2014).

In a systematic review, Adams et al. (2023) determined that there have been a limited number of studies that have evaluated occupational fentanyl exposures and even fewer that have performed air, dermal, or urine sampling other than HHEs. Current research includes case studies of unintentional releases of illicit drugs creating occupational exposures for a pharmacist (Feldman and Weston 2022) and law enforcement officers (Chiu et al. 2019), other observational or qualitative studies with occupations in law enforcement (Attaway et al. 2021), and medicolegal death investigators and autopsy technicians (Chiu et al. 2020). An exposure assessment for fentanyl and methamphetamine on transit vehicles found detectable levels in the air and on surfaces, but at levels much lower than seen in the current study (Beaudreau et al. 2025). A study of pharmaceutical production workers found similar results to the current study, with several instances of employees exceeding air TLV-TWA for fentanyl, along with detection in dermal and urine samples (Van Nimmen et al. 2006).

There are many references for best practice considerations for handling illicit drugs, including NIOSH recommendations to emergency responders that can be applied to handling illicit drugs in forensic laboratories (Moss et al. 2018; Sisco et al. 2019, 2020; Basham et al. 2021; Oudejans 2021; Oudejans et al. 2021; USEPA 2021a; Oudejans 2022; NIOSH 2024). Best practices to consider were provided to each laboratory based on existing literature and observations. For example, all laboratories can consider processing and handling illicit drugs in enclosures such as available fume hoods or adding desktop ductless fume hoods (Plog et al. 2002). They may also minimize taking net weights (weighing the material without packaging) to reduce aerosolizing particulates (Sisco et al. 2020), clean regularly with periodic deep cleaning with appropriate cleaning solutions (Oudejans 2021; USEPA 2021a; Oudejans 2022), and ensure wearing of appropriate PPE (Basham et al. 2021). Symptom recognition and reporting were suggested to 10 laboratories to be mindful of potential symptoms in themselves and their coworkers. Each laboratory should evaluate and implement these considerations based on its unique operations, facility layout, and staffing to develop necessary health and safety protocols. By employing suggested best practices, laboratory contamination could possibly be reduced, and the minimal contamination outside of the laboratory into the common and office areas could be eliminated.

Limitations

There are several limitations to the current study. A national perspective could not be captured to represent all geographical areas appropriately because of the early termination of the project. Due to participant workload, scheduling, or willingness to participate, some aspects of the sampling (air, urine, or dermal) could not be completed for every participant. While specific surface area sampling, like keyboards and desktops inside and outside of the laboratory, was attempted at each location, it was not always feasible, depending on the workload of the scientists, timing of sampling, and the goal of being unobtrusive to workflow at the facility. Additionally, creatinine or specific gravity was not measured in urine, and therefore, there was no correction for the hydration status of the worker. Lastly, the current study was a cross-sectional evaluation of illicit drug exposures in these facilities and may not necessarily be reflective of exposure levels over time.

Conclusions

Prudent occupational health practice calls for minimizing exposure to illicit drugs because of the known hazards at higher levels of exposure and the unpredictable nature and origin of the evidence being handled. Uncertainty about the potential health effects from low-dose chronic exposures to these illicit drugs remains. It was demonstrated in the current study that safety thresholds for fentanyl were exceeded. However, thresholds for other illicit drugs, such as methamphetamine and cocaine, have not been established to protect these workers. There is evidence that forensic scientists are potentially inhaling, ingesting, or absorbing illicit drugs due to exposures at the workplace, and potential health hazards have not been clearly established. More work on low-dose exposure assessment could help fill these research gaps in forensic divisions.

Disclaimer

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