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A snapshot of drug background levels on surfaces in a forensic laboratory

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HIGHLIGHTS

- Surface concentration of drugs in a forensic lab was measured using LC/MS/MS and TD-DART-MS.
- Concentrations were highest in the drug chemistry section.
- Balances contained highest concentrations, showing the difficulty in cleaning them.
- Data can help address data integrity, safety and the effects of procedural changes.

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ABSTRACT

While background studies have been commonplace in many occupational fields for a long time, attempts to understand the chemical background in forensics labs has been largely understudied. Such studies can help define the efficiency of cleaning procedures and the integrity of collected data, which is becoming increasingly important due to improving sensitivity of instrumentation and the prevalence with which potent drugs of abuse, such as the opioids, are being seen. The results from this study provide a snapshot of the drug background levels on surfaces in a laboratory system comprised of a central laboratory and two satellite laboratories. Samples were collected from work surfaces by swiping with meta-aramid wipes, and extracted for analysis by LC/MS/MS, for quantitation, and TD-DART-MS, for non-targeted screening. Surfaces were sampled from within the drug unit (where drug evidence is processed) and the evidence receiving unit (where drug cases are handled) in all laboratories as well as the report writing area, the toxicology unit and the crime scene unit in the central laboratory. Results showed that the background was restricted primarily to the benches, balances, and instrumentation within the drug unit – with approximately an order of magnitude higher concentrations observed on the balances, compared to the benches. Higher levels were also observed in analyst specific surfaces when compared to general use surfaces within the drug unit – which corresponded to where bulk evidence handling was completed. Background in the evidence receiving and report writing sections was minimal. Comparison of the main laboratory to the satellite laboratories showed similarities amongst frequently encountered drugs like cocaine, but noticeable differences in opioids which could be attributed to differences in the make-up of exhibits each laboratory receives. Understanding the background levels of drugs in a forensic laboratory environment is crucial to improving cleaning protocols, helping define detection limits for highly sensitive analyses, and providing additional results to the broader community that has been establishing background levels in other environments.

1. Introduction

Characterizing the chemical background of an operational environment is a common practice in a number of occupational fields, from environmental [1–3] to pharmaceutical [4–6] to electronics manufacturing [7]. These and other fields attempt to understand and quantify the background of compounds of interest for many reasons, including occupational or public health [8], quality control [9], and remediation [10]. Background sampling can be performed by a number of different methods including surface sampling [8,11] done by wiping a surface with a collection wipe, air sampling [12], or water sampling [13].

To help establish a baseline background level, it is important to understand what the background is comprised of and how much there

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is. A non-targeted screening analysis is a useful tool to identify what compounds of interest might be present. Following this with a targeted quantitative analysis can provide both confirmation of the compounds identified and their concentration or mass per unit area. Once this baseline is established, repeated sampling can help answer questions relating to persistence or temporal changes. If mitigation strategies are implemented, routine sampling can also be used to evaluate the effectiveness of these processes.

Several studies have investigated the levels of illicit drugs in various environments. Most of these studies have focused on detection of drugs in waste waters and surface water for a variety of purposes – from understanding the health effects [14,15] to estimating drug usage [16] to examining the potential investigative value of such an analysis [17]. In addition to wastewater and surface water, work has been completed to measure the level of illicit drugs in the air of cities across the world [18–20]. This type of analysis has shown that pg m^{-3} to ng m^{-3} levels of cocaine were observed in most cities while heroin and cannabinol could be detected less frequently [19].

Given that illicit drugs can be detected in the air, it is reasonable to assume that environmental surface background also exists – either as residual powder or as condensed aerosols from smoking. Work by Smith and McGrath [21] looked at detection of cocaine off of surfaces that people contact on a daily basis (*i.e.* fuel pumps, shopping carts, and door handles) and found that upwards of 75% off all the surfaces tested were found to contain detectable levels of cocaine. While no attempts were made to quantify the level of cocaine off of these surfaces, Jenkins [22] investigated the level of cocaine on US currency and found that levels can, at times, exceed 1 mg $bill^{-1}$, but were commonly in the range of tens to hundreds of micrograms per bill. Other work has investigated the surface levels of methamphetamine in clandestine laboratories and found hundreds of micrograms per square meter [23]. Removal efficiencies off of household surfaces has also been studied [24].

While surface levels of drugs in forensic laboratories has not been discussed in the literature, this question has been examined in the context of police stations. Doran et al. have completed substantial studies investigating the levels of drugs, and persistence of those drugs, in police stations throughout Australia [25,26]. The work by Doran et al. highlighted increased prevalence of illicit drugs in police stations, relative to public spaces, which was attributed to the handling of drug evidence at the stations. In most instances, the level of drugs detected was low (< 50 ng) but several surfaces did contain micrograms of material. Given that forensic laboratories also handle bulk amounts of illicit drugs on a regular basis, it is reasonable to assume that handling of drug evidence will potentially contribute to an elevated background level, compared to public spaces. Opening and handling of bulk quantities of drugs can lead to aerosolized release of this material, typically in the form of particulate, throughout the laboratory. Like any other particulate trace, there is a reasonable expectation that this residue will be transferred throughout the laboratory via touch, direct transfer, and/or suspension of particulate in the air.

Additionally, forensic laboratories are currently being faced with increasing backlogs [27,28] and decreasing budgets to tackle such backlogs. This dichotomy is especially significant in drug chemistry units which are constantly being presented with new and increasingly potent compounds (*i.e.* fentanyl analogs). To tackle this issue, laboratories are implementing, or considering implementing, analytical tools [29] (such as direct analysis in real time mass spectrometry, DART-MS [30–32]) that allow for rapid screening, presumptive testing, and/or triaging. Because these analytical tools typically employ high throughput analysis with minimal to no sample preparation it is crucial to understand background levels of analytes of interest to minimize the likelihood of reporting a false detection. Additionally, as emerging analytical instrumentation becomes increasingly sensitive [31,32], the background level of the chemicals of interest in the analysis chain must be considered. Establishing background levels of compounds of interest in a forensic laboratory can provide drug analysts and laboratory quality managers with valuable information to make informed decisions on a range of topics such as workflow processes, adequate personal protective equipment (PPE), cleaning protocols, and occupational safety hazards.

This study provides a snapshot of the drug background levels in a three-laboratory system (a central laboratory and two satellite laboratories) in order to get a rough understanding of what expected drug background levels may be. Interpretation of these levels from a data quality and occupational health perspective are the focus of ongoing collaborative work. Wipe samples were collected across the drug chemistry unit, evidence receiving unit, toxicology unit, crime scene unit, and report writing section of the central laboratory as well as the drug chemistry unit and evidence receiving of the two satellite laboratories. Samples were analyzed using liquid chromatography-tandem mass spectrometry (LC/MS/MS) for quantitation of 18 drugs and thermal desorption direct analysis in real time mass spectrometry (TD-DART-MS) for non-targeted screening analysis. A total of 60 samples were measured from the central laboratory and an additional 50 samples from the two satellite labs. Surface concentrations of drugs were highest and most diverse within the drug unit, where a total of 15 of the 18 targeted drugs were detected at concentration ranges from 1 pg cm^{-2} to 97 ng cm^{-2}. Within the drug unit, balances were found to contain the highest surface concentrations that were typically close to an order of magnitude higher than the benches. Levels observed in the evidence receiving and other units were substantially lower than within the drug unit, and some noticeable differences were observed between the drug units across the three laboratories.

2. Materials and methods

2.1. Sample collection and extraction

Samples were collected from various locations throughout the laboratory, targeting both areas common to the typical workflow for the analysis of drug evidence and areas where drug cases are not analyzed. At all three laboratories samples were collected from the drug unit and the evidence receiving unit. In addition, samples were also collected from the report writing area (for drug analysts), toxicology unit, and crime scene unit at the central laboratory. Within the drug unit, samples were taken from both general-use surfaces/items, such as chemical hoods and instruments, and analyst-specific surfaces/items, such as balances and benches assigned to individual analysts to process their casework. Additionally, surfaces/items such as benches, storage bins, and door handles in the other units were sampled. All surfaces that were sampled were non-porous. For benches and hoods, the entirety of the surface was sampled (surface area was not controlled but was measured). For balances, the enclosure (pan and surrounding area) in addition to the control panel were sampled. A total of 60 samples were collected from the central laboratory with the majority of the samples collected from the drug unit. An additional 50 samples were collected from the two satellite labs and focused solely on the drug and evidence receiving units. The entirety of the surface was sampled with a single wipe and the surface area determined by photographing the surface sampled and calculating the area using Adobe (San Jose, CA, USA).

Samples were collected with meta-aramid wipes (DSA Detection, North Andover, MA), which are dry wipes commonly used for particle collection in trace contraband detection. The particle collection efficiency of this material off non-porous surfaces has been previously measured at approximately 30% collection, demonstrating that it was an adequate substrate for the collection of trace residues off a variety of surfaces [33]. Potential differences in collection efficiency within the surfaces was not accounted for in the measurement. Samples were collected on the top half of the wipe by wiping in a unilateral direction using two to three fingers to apply firm force (7 N–10 N) and help guide the maximum collection of trace residues into the desired area of the