Evaluation of Exposures and Health Concerns in a Dental Clinic

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Availability of Report

Copies of this report have been sent to the employer and employees at the dental clinic. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

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Introduction

Request

We received a management request for a health hazard evaluation at a dental clinic. The request stated concerns about possible exposure to mercury vapors from amalgam, a metal alloy used for dental fillings.

Workplace

The dental clinic provides dental care services to patients. Services include general dentistry, family dentistry, cosmetic dentistry, restorative dentistry, full-mouth reconstruction, and oral surgery services. At the time of our survey, the clinic employed 17 staff, including three dentists, dental hygienists, dental assistants, administrative staff, and a business administrator.

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

Our Approach

In June 2019, we conducted a site visit to assess possible exposures during routine dental care, assess the ventilation systems in use, and informally interview clinic staff. During our survey in June 2019, we

- Collected full-shift time-weighted average (TWA) samples on dental clinic employees while they performed their regular job duties and analyzed for elemental mercury content.
- Collected full-shift TWA area samples in multiple locations in the dental clinic and analyzed for respirable dust, respirable silica, respirable metals, and volatile organic compound (VOC) concentrations.
    - Full-shift TWA areas samples for VOCs were collected with two different samplers, placed side-by-side.
- Collected instantaneous task-based and area air samples for VOCs during various tasks and procedures.
- Assessed the heating, ventilation, and air-conditioning (HVAC) systems in use.
- Informally interviewed clinic staff to learn about any health concerns potentially related to exposures at work.

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

Our Key Findings

All personal air samples for elemental mercury were below the NIOSH recommended exposure limit (REL) of 50 micrograms per cubic meter of air (µg/m³)

- Full-shift, TWA air samples for elemental mercury ranged from less than 0.1 to 0.5 µg/m³.

All area air samples for respirable dust, respirable silica, and respirable metals were low

- Because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the RELs can be used as points of reference.
- All samples for respirable dust were below the limit of detection with the exception of one air sample collected in Exam Room 5, which measured 17.6 µg/m³ of respirable dust.
    - This sample was well below the Occupational Safety and Health Administration (OSHA) permissible exposure limit of 5,000 µg/m³ (5 milligrams per cubic meter of air [mg/m³]) and the American Conference of Governmental Industrial Hygienists (ACGIH®) threshold limit value (TLV®) of 3,000 µg/m³ (3 mg/m³) for respirable dust.
- All samples for respirable crystalline silica (cristobalite, tridymite, and quartz) were below their respective limits of detection.
- All samples analyzed for respirable metals were below their respective NIOSH RELs.
- Manganese (4.4 µg/m³) had the highest measurement of any metal analyzed. This air sample was collected in Exam Room 6 and was far below the NIOSH REL for manganese of 1,000 µg/m³ (1 mg/m³).

Some VOCs were higher in some locations or during specific tasks or procedures

All air samples for full-shift area air measurements of VOCs were relatively low with the exception of measurements for ethanol, isopropyl alcohol, and acetone. Possible sources of these VOCs included cleaning agents, primer materials, and bonding agents. Ethanol and isopropyl alcohol are chemicals commonly used for cleaning and disinfection procedures. Acetone is a solvent used in some dental restorative primer materials. Ethanol and acetone are sometimes used with dental bonding agents as well. The NIOSH RELs for ethanol, isopropyl alcohol, and acetone are 1,000 ppm (1,000,000 ppb), 400 ppm (400,000 ppb), and 250 ppm (250,000 ppb), respectively. Because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the occupational exposure limits (OELs) can be used as points of reference.

- Full-shift TWA results for ethanol

        - Full-shift TWA results from canister samples from all areas sampled measured 2116.9 parts per billion (ppb) ethanol to measurements above the calibration maximum used by the laboratory performing sample analyses. Samples with measurements above the calibration maximum were not quantifiable and were not reported by the laboratory analyzing the samples.
        - All full-shift TWA thermal desorption tubes had measurements for ethanol above the calibration maximum used by the laboratory analyzing the samples. The calibration maximum for the thermal desorption tubes used to collect VOCs was 139 nanogram (ng) ethanol. This maximum equates to approximately 8.19 parts per million (ppm) ethanol.
    - Full-shift TWA results for isopropyl alcohol
        - All full-shift TWA results from canister samples and thermal desorption tubes had measurements for isopropyl alcohol above the calibration maximum. The calibration maximum for the thermal desorption tubes used to collect VOCs was 165 ng isopropyl alcohol. This maximum equates to approximately 7.46 ppm isopropyl alcohol. The calibration maximum for samples evacuated canisters was approximately 48.5 ppb for isopropyl alcohol.
    - Full-shift TWA results for acetone
        - Full-shift TWA measurements from thermal desorption tubes ranged from 101.1 ppb to 743.0 ppb acetone. All full-shift canister samples had measurements of acetone above the calibration maximum. The calibration maximum for measurements collected using evacuated canisters was approximately 48.5 ppb for acetone. The calibration maximum for the thermal desorption tubes used to collect VOCs was 160 ng acetone. This maximum equates to approximately 7.48 ppm acetone.
    - Full-shift TWA results for other notable VOCs
        - Full-shift TWA measurements from canister samples measured methyl methacrylate at levels ranging from 9.3 ppb to 63.8 ppb and styrene at levels ranging from less than 2.1 ppb to 46.3 ppb. As a point of reference, the NIOSH REL is 100 ppm (100,000 ppb) for methyl methacrylate and 50 ppm (50,000 ppb) styrene. We note that because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the OELs can be used as points of reference.

- The highest instantaneous measurements collected using evacuated canisters during a task were measurements of ethanol and isopropyl alcohol. Ethanol and isopropyl alcohol measurements collected in the breathing zone of an employee while using the sandblaster in the laboratory were above the calibration maximum. The calibration maximum for instantaneous

measurements collected using evacuated canisters was approximately 53.1 ppb for ethanol and 48.5 ppb for isopropyl alcohol.

- The highest instantaneous measurements collected near sources were also measurements of ethanol and isopropyl alcohol. Instantaneous air samples were collected in Exam Room 2 while an employee placed amalgam into a patient's mouth or removed amalgam from a patient's mouth. Some ethanol and isopropyl alcohol measurements were above the laboratory's calibration maximum.
- The second highest instantaneous measurements collected near sources were measurements of acetone collected in Exam Room 2 while an employee placed amalgam into a patient's mouth or removed amalgam from a patient's mouth. Acetone measurements ranged from 156.5 ppb to 193.8 ppb.
- The highest instantaneous measurements collected in general areas were also measurements of ethanol and isopropyl alcohol. Instantaneous air samples were collected in the (1) center of the downstairs laboratory which was no longer in use, (2) center of a downstairs dentist's office, and (3) in a downstairs storage closet used to store electrical equipment and scrubs. Ethanol and isopropyl alcohol measurements were above the calibration maximum used by the laboratory analyzing the samples.
- The second highest instantaneous measurements collected in general areas were measurements of methyl methacrylate (125.5 ppb), collected in the center of the downstairs laboratory, which was no longer in use, and acetone (180.2 ppb), collected in the center of Exam Room 2 at the completion of an amalgam replacement.

The laboratory area was under positive pressure relative to adjacent areas and could serve as a source of air contaminants

- Positive pressure in the laboratory area could lead to entrainment of air and contaminants from the laboratory area in adjacent areas such as the breakroom.
- Although no air sampling results exceeded any occupational exposure limits, the positive pressure differential between the laboratory area and adjacent spaces could cause air and contaminants from the laboratory area to migrate into adjacent spaces in the future.

Some employees reported eye and nose symptoms that were better when away from work.

- Of the 15 clinic staff that were informally interviewed, seven employees reported eye symptoms. One of the seven employees who reported eye symptoms indicated that their symptoms improved while away from work (n=1/7 or 14.3%)
- Six employees reported nasal symptoms, and two of the six employees indicated that their symptoms improved while away from work (n=2/6 or 33.3%). One of the two employees with work-related nasal symptoms indicated that acrylics, such as resins used for temporary crowns or dentures, seemed to cause or worsen their nasal symptoms.

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.

Benefits of Improving Workplace Health and Safety:

- Improved worker health and well-being
- Better workplace morale
- Better employee recruiting and retention
- Improved image and reputation
- Better products, processes, and services
- Could increase overall cost savings

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you 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 groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls here: https://www.cdc.gov/niosh/topics/hierarchy/

We encourage the company 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": https://www.osha.gov/shpguidelines/index.html

Recommendation 1: Reduce risk of entrainment of air from the laboratory into adjacent spaces

Why? The relationship between supply air and exhaust air flow rates can be used to help maintain appropriate pressure relationships. If more air is supplied than exhausted, the space will generally be under positive pressure, which allows contaminants to migrate from the space to adjacent areas. Conversely, exhausting more air than is supplied, maintains the space under negative pressure which helps contain the contaminants in the area where they are generated. The laboratory space under positive pressure relative to adjacent spaces can serve as a source of contaminants that are spread beyond the laboratory. Although all air measurements collected for particulates and vapors were relatively low, there is a potential for future exposures or contaminants generated in the laboratory area to be entrained into adjacent spaces.

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

Ensure the laboratory area is maintained under negative pressure relative to adjacent areas.

- Consult with a ventilation engineer to increase the air flow of the return air to the laboratory space and to ensure the laboratory is maintained under negative pressure relative to adjacent spaces.
- Although there are no specific ASHRAE guidelines for dental clinics, *ANSI/ASHRAE/ASHE Standard 170-2017, Ventilation of Health Care Facilities*, has design parameters for healthcare facilities. ASHRAE recommends laboratory work areas be kept under negative pressure relative to adjacent spaces.

Recommendation 2: Encourage employees to minimize walking through the laboratory area while grinding or sandblasting tasks are being performed

Particulates generated during abrasive tasks in the laboratory area appeared to be efficiently captured by the enclosed abrasive blaster (Micro Cab). However, there can be times when controls designed to capture particulates can fail or not operate optimally, and particulates could be released into the air in the laboratory space. Minimizing foot traffic through the laboratory area during these tasks would minimize risks of possible exposure should the enclosed sandblaster fail to perform optimally.

Recommendation 3: Make N95 filtering-face piece respirators available for voluntary use and train employees on proper use of respiratory protection

Why? We observed employees using surgical masks and triple layer molded face masks. Surgical masks are not respirators and do not protect the wearer from inhaling small particulates. Additionally, they are not designed to eliminate air leakage around the edges. The triple layer molded face masks are designed to absorb liquids, moisture, and microorganisms but do not provide protection against particulates. Both types of masks are designed for potential exposures to blood and body fluids but do not offer protection against particulate, gas, or vapor exposures in the air. Although all measurements for particulates were below established exposure limits, if employees desire to voluntarily use respiratory protection that also provide protection against particulates during particulate generating procedures (e.g., drilling, grinding, and polishing), they should use N95 disposable filtering-face piece respirators.

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

Make N95 disposable filtering-face piece respirators available for voluntary use for protection against particulates when performing tasks that can generate particulates such as drilling, grinding, or polishing.

- Provide training to these employees on how to wear N95 respirators correctly.
- Inform employees that N95 respirators do not protect against exposures to gases or vapors.
- Review and share this respirator training tool available at http://www.cdc.gov/niosh/docs/2010-133/pdfs/2010-133.pdf.

N95 respirators should be available in various sizes, and each potential N95 user should receive a copy of Appendix D of the OSHA Respiratory Protection Standard (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9784). Information about Appendix D and voluntary use of respirators can be found on the OSHA website at https://www.osha.gov/video/respiratory_protection/voluntaryuse_transcript.html.

Recommendation 4: Encourage employees to report any new, persistent, or worsening respiratory symptoms, particularly those with a work-related pattern, to their healthcare providers and, as instructed by their employer, to a designated individual at their workplace

Why? Early recognition of work-related respiratory symptoms can help identify potential occupational exposures and risk factors for disease and help prioritize interventions to prevent work-related lung disease in employees. An individualized management plan (such as assigning an affected employee to a different work location, perhaps at home or a remote site) is sometimes required, depending upon medical findings and recommendations of the individual's healthcare provider.

Supporting Technical Information

Evaluation of Exposures and Health Concerns in a Dental Clinic

HHE Report No. 2019-0134-3375

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Section A: Workplace Information

Workplace

Request basis: Assessment of exposure to mercury vapors from amalgam, a metal alloy used for dental fillings.

Previous issues: None.

Employee Information

At the time of our survey, the clinic employed 17 staff, including three dentists, dental hygienists, dental assistants, administrative staff, and a business administrator.

Process Description

At the time of the survey, the dental clinic provided dental care services to patients including general dentistry, family dentistry, cosmetic dentistry, restorative dentistry, full-mouth reconstruction, and oral surgery services. The clinic had eight examination rooms, a sterilization area, a laboratory space, a consultation office, a break room, administrative areas, a patient waiting area, and a laboratory that was no longer in use in the lower level of the building. While the exposure assessment was conducted, dental staff performed various procedures to include exams, x-rays, cleanings, fluoride treatments, oral cancer screenings, composite procedures, drilling, crown procedures, amalgams, anesthesia, extractions, denture impressions, orthodontics, root canals, sealants, and periodontitis treatments.

Section B: Methods, Results, and Discussion

We focused on these objectives:

- Assess potential for exposure to mercury among dental personnel in the clinic.
- Evaluate air concentrations of respirable dust, respirable silica, respirable metals, and volatile organic compounds (VOCs) in clinic workspaces.
- Assess general exhaust ventilation in the clinic.
- Informally interview employees about their work history, personal protective equipment use, and any work-related symptoms.

Methods: Observations of Workplace and Personal Protective Equipment (PPE)

We observed the workplace while employees performed their job duties and noted use of PPE.

Results: Observation of Work Practices and PPE

Facility Layout

At the time of our survey, the dental clinic was operating in a two-story building. The basement was below-grade and included office space, meeting rooms, and storage areas. The main floor was above-grade and included eight examination rooms, a sterilization area, laboratory space, consultation office, break room, administrative areas, a patient waiting area, and a laboratory that was no longer in use in the lower level of the building. The examination rooms were open to a main hallway that connected to the laboratory space, sterilization area, consultation office, and administrative area. The administrative area was confluent with the patient waiting area. The employee break room was accessible through the laboratory space or administrative area.

Personal Protective Equipment

We observed employees using surgical masks, triple layer molded face masks, and gloves. The triple layer molded face masks are designed to absorb liquids, moisture, and microorganisms.

Methods: Exposure Assessment

Dental personnel can be exposed to various agents such as chemicals, dusts, bio-aerosols, and metals as part of their normal work duties. During this health hazard evaluation, we focused our exposure assessment on mercury, respirable dust, respirable metals, and VOCs.

During June 11–13, 2019, we conducted an exposure assessment survey, which consisted of

(1) observing employees perform various tasks;

(2) collecting personal air samples for elemental mercury; and

(3) collecting area air samples for respirable dust, respirable metals, respirable silica, and VOCs.

We collected full-shift time-weighted average (TWA) personal air samples for elemental mercury on each day of our survey.

- The sampling tube was positioned in the employee's breathing zone, and the tube was connected to a sampling pump pulling air at a flow rate of 100 milliliters per minute (mL/min).
- Samples were collected and analyzed according to NIOSH method 6009 [NIOSH 1994].

We also collected area air samples in 11 locations to include eight examination rooms, the laboratory area, equipment sterilization area, and front office area on each day of our survey. Area air samples were collected using multiple sampling devices to sample for respirable dust, respirable silica, respirable metals, and VOCs.

- Full-shift TWA area samples for respirable dust and respirable silica were collected using a BGI respirable cyclone GK2.69 and analyzed in accordance with NIOSH method 0600 for dust [NIOSH 1998] and NIOSH method 7500 for crystalline silica [NIOSH 2003a].
- Full-shift TWA area samples for respirable metals were also collected using a BGI respirable cyclone GK2.69 and analyzed in accordance with NIOSH method 7303 [NIOSH 2003b]. All respirable cyclone GK2.69s were connected to a sampling pump pulling air through the cyclone at 4.2 liters per minute.
- Full-shift TWA area samples for VOCs were collected using thermal desorption (TD) tubes and evacuated canisters placed side-by-side in different locations in the clinic. TD tubes were connected to a sampling pump pulling air through the TD tube at 25 mL/min and were collected in accordance with NIOSH method 2549 [NIOSH 1996]. For full-shift sampling using TD tubes, we collected two consecutive 3-hour samples and calculated the TWA concentration from the two samples, assuming the total 6-hour monitoring results reflected a full work-shift (8-hour) TWA exposure. Full-shift TWA samples collected using the TD tubes were analyzed using NIOSH method 2549 modified for quantifying compounds listed in NMAM 3900. Method modifications included a longer gas chromatograph column (Rxi-1ms, 60 meters x 0.32 millimeters x 1.0 micrometers, Restek Corporation, Bellefonte, PA) to increase compound separation and calibrating compound response with a gas-phase calibration standard and internal standard loaded onto TD tubes.
- Evacuated canisters were also used to collect instantaneous task-based and source air samples for VOCs. The evacuated canister sampling setup consisted of a 450-mL evacuated canister equipped with either a restricted flow controller set at a 6-hour sampling duration or an instantaneous flow controller designed for a short sampling duration (less than 30 seconds). Full-shift TWA and instantaneous samples collected using the evacuated canisters were analyzed in accordance with NIOSH method 3900 using a gas chromatograph-mass spectrometer equipped with a pre-concentrator [NIOSH 2018].

Results: Exposure Assessment

Personal air sampling for elemental mercury exposure

A summary of personal air sampling results for elemental mercury can be seen in Table C1. All samples were below the NIOSH recommended exposure limit (REL) of 50 micrograms per cubic meter of air (μg/m^3). Concentrations ranged from <0.1 to 0.5 μg/m^3.

Area air sampling for respirable dust and respirable silica

A summary of area air sampling results for respirable dust and respirable silica can be seen in Table C2. All samples for respirable dust were below the limit of detection with the exception of one sample collected in Exam Room 5, which measured 17.6 μg/m^3 of respirable dust. Procedures performed in Exam Room 5 while the sample was collected included a patient exam, nightguard placement, and crown placement. The sample that measured respirable dust in Exam Room 5 was well below the OSHA permissible exposure limit (PEL) of 5,000 μg/m^3 (5 mg/m^3) and the American Conference of Governmental Industrial Hygienists (ACGIH®) threshold limit value (TLV®) of 3,000 μg/m^3 (3 microgram (mg)/m^3) for respirable dust [ACGIH 2020; NIOSH 2007; OSHA 2020]. All samples for respirable crystalline silica (cristobalite, tridymite, and quartz) were below their respective limits of detection. We note here and below, that because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the occupational exposure limits (OELs) can be used as points of reference.

Area air sampling for respirable metals

All samples analyzed for respirable metals were below their respective NIOSH RELs. The highest measurement of any metal analyzed was for manganese (4.4 μg/m^3) collected in Exam Room 6 and was far below the NIOSH REL of 1,000 μg/m^3 (1 mg/m^3) for manganese. Procedures performed in Exam Room 6 while this sample was collected included x-rays, patient exam, periodontitis treatment, sealant, oral cancer screen, cleaning (including polishing), and fluoride treatment.

Area air sampling for volatile organic compounds

All samples for full-shift area measurements of VOCs were relatively low with the exception of measurements for ethanol, isopropyl alcohol, and acetone. Ethanol and isopropyl alcohol are chemicals commonly used for cleaning and disinfection procedures. Acetone is a solvent used in some dental restorative primer materials. Ethanol and acetone are sometimes used with dental bonding agents as well. The NIOSH RELs for ethanol, isopropyl alcohol, and acetone are 1000 ppm (1,000,000 ppb), 400 ppm (400,000 ppb), and 250 ppm (250,000 ppb), respectively [NIOSH 2007]. We note again here, that because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the OELs can be used as points of reference.

Full-shift TWA results from canister samples from all areas sampled measured anywhere from 2116.9 parts per billion (ppb) ethanol to measurements above the calibration maximum used by the laboratory performing sample analyses. Samples that were above the calibration maximum were diluted and re-run

in an attempt to detect quantities below the calibration maximum. The calibration maximum for measurements using evacuated canisters was approximately 53.1 ppb for ethanol. The median dilution factor for samples initially above the calibration maximum was 59. A dilution factor of 59 equates to a theoretical maximum of 3132.9 ppb ethanol (59 x 53.1 ppb = 3132.9 ppb). All full-shift TWA thermal desorption tubes had measurements for ethanol that were above the calibration maximum. The calibration maximum for the thermal desorption tubes used to collect VOCs was 139 ng ethanol. This maximum equates to approximately 8.19 ppm ethanol.

All full-shift TWA results from canister samples and TD tubes had measurements for isopropyl alcohol that were above the calibration maximum. The calibration maximum for the thermal desorption tubes used to collect VOCs was 165 nanogram (ng) isopropyl alcohol. This maximum equates to approximately 7.46 ppm isopropyl alcohol. The calibration maximum for measurements made using evacuated canisters was approximately 48.5 ppb for isopropyl alcohol.

Full-shift TWA measurements from TD tubes ranged from 101.1 ppb to 743.0 ppb acetone. All full-shift canister samples had measurements of acetone that were above the calibration maximum. The calibration maximum for the TD tubes used to collect VOCs was 160 ng acetone. This maximum equates to approximately 7.48 ppm acetone. The calibration maximum for measurements made using evacuated canisters was approximately 48.5 ppb for acetone.

Full-shift TWA measurements from canister samples measured methyl methacrylate at levels ranging from 9.3 ppb to 63.8 ppb and styrene at levels ranging from < 2.1 ppb to 46.3 ppb. Full-shift TWA measurements from TD tubes ranged from 9.8 ppb to 12.8 ppb methyl methacrylate and < 1.9 ppb to < 2.0 ppb styrene. As a point of reference, the NIOSH REL is 100 ppm (100,000 ppb) for methyl methacrylate and 50 ppm (50,000 ppb) for styrene, [NIOSH 2007]. We note here and below, that because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the OELs can be used as points of reference.

The highest instantaneous measurements collected near the breathing zone of an employee during a task were measurements of ethanol and isopropyl alcohol. Ethanol and isopropyl alcohol measurements, collected in the breathing zone of an employee while using the sandblaster in the laboratory, were above the calibration maximum. We note that the calibration maximum for instantaneous measurements using evacuated canisters was approximately 53.1 ppb for ethanol and 48.5 ppb for isopropyl alcohol. The highest instantaneous measurements near sources were also measurements of ethanol and isopropyl alcohol and were collected in Exam Room 2 while an employee placed amalgam into a patient's mouth or removed amalgam from a patient's mouth. Ethanol and isopropyl alcohol measurements, collected near the patient's mouth while an employee placed amalgam into or removed amalgam from a patient's mouth, were also above the calibration maximum.

The second highest instantaneous measurements collected near sources were measurements of acetone collected in Exam Room 2 while an employee placed amalgam into a patient's mouth or removed amalgam from a patient's mouth. Acetone measurements ranged from 156.5 ppb to 193.8 ppb.

The highest instantaneous measurements collected in general areas were also measurements of ethanol and isopropyl alcohol and were collected in (1) the center of the downstairs laboratory, which was no longer in use and closed off from other spaces, (2) the center of the downstairs dentist's office, and (3) a downstairs storage closet used to store electrical equipment and scrubs. Ethanol and isopropyl alcohol measurements were above the calibration maximum. The second highest instantaneous measurements collected in general areas were measurements of methyl methacrylate (125.5 ppb), collected in the center of the downstairs lab which was no longer in use, and acetone (180.2 ppb), collected in the center of Exam Room 2 at the completion of an amalgam replacement.

Methods: Ventilation

We assessed the ventilation systems in place. We conducted visual and physical assessments of all ventilation components at the facility. Physical dimensions of the facility were measured with a Model DISTO E7100i laser-tape measure (Leica Geosystems AG, Heerbrugg, Switzerland). Air flow measurements of supply vents and exhaust outlets were taken using an Accubalance Plus Model 8373 Air Capture Hood (TSI Incorporated, Shoreview, MN).

Results: Ventilation

Ventilation

The examination rooms, consultation office, and laboratory were under positive pressure relative to adjacent spaces.

Methods: Informal Employee Interviews

During June 11–13, 2019, we conducted individual informal interviews with 15 staff to discuss work history, personal protective equipment worn, and health concerns. We also discussed tasks performed and products used. Most interviews lasted approximately five to 10 minutes.

Results: Informal Employee Interviews

Work History

The 15 employees interviewed worked an average of 4.5 days (range: 3.0–5.0 days) and 37.3 hours (range: 24.0–42.5 hours) per week. The average total time worked in the dental industry was 15.5 years (range: <1–43 years). Among the 15 employees interviewed, 12 (80.0%) reported ever working at another dental-related company.

Personal Protective Equipment Worn by Employees

All employees reported wearing scrubs or a white coat while at work. All employees who reported working with patients, performing laboratory tasks, or cleaning rooms reported wearing gloves and goggles/eye protection while doing these tasks; 14 of 15 (93.3%) employees reported wearing a surgical

mask while doing these tasks. One of 15 (6.7%) employees reported wearing an N95 respirator while working with patients. However, we observed that the mask used was a triple layer molded face mask, and this type of face mask does not offer protection against particulate, gas, or vapor exposures in the air.

Work-related Health Symptoms

Overall, seven of 15 (46.7%) interviewed employees reported eye symptoms (such as watery or itchy eyes), and one of these seven (14.3%) employees reported their eye symptoms improved while away from work. No specific products or tasks were reported to cause or irritate the reported eye symptoms. Overall, six of 15 (40.0%) interviewed employees reported nose or sinus symptoms (such as stuffy or runny nose), and two of these six (33.3%) employees reported their nose symptoms improved while away from work. The only product or task reported to cause or irritate these nose symptoms was exposure to acrylics, such as resins used for temporary crowns or dentures.

Discussion

Dental personnel can be exposed to various agents such as chemicals, dusts, bio-aerosols, and metals as part of their normal work duties. We focused our exposure assessment on mercury, respirable dust, respirable metals, and VOCs. We also observed work practices and assessed the ventilation systems in place as well as the use of PPE. Our observations and results from the exposure assessment are further discussed below.

Observation of Work Practices, Processes, and Conditions

We observed employees using surgical masks and triple layer molded face masks. The triple layer molded face masks are designed to absorb liquids, moisture, and microorganisms. Both types of masks are designed for potential exposures to blood and body fluids and are not considered respiratory protection because they do not protect against particulate, gas, or vapor exposures in the air.

Exposure Assessment

All personal air sampling measurements for mercury were well below the NIOSH REL. The highest measurement of 0.5 $\mu g/m^3$ mercury was 100-fold lower than the NIOSH REL of 50 $\mu g/m^3$. Exposure to mercury vapor or dust can potentially occur from various sources such as mixing, handling, or removing amalgam [Warwick et al. 2019].

Because area air samples are not personal air samples collected directly on an employee, the NIOSH RELs are not directly applicable to the results for exposure monitoring purposes. However, area air samples can highlight areas with higher exposure risk, and the NIOSH RELs can be used as points of reference. All area samples for respirable dust, respirable silica, and respirable metals were below their respective RELs. We measured some VOCs that were below their respective exposure limits but are notable because they are associated with respiratory symptoms at levels below their exposure limits. Full-shift TWA measurements from canister samples measured methyl methacrylate at levels ranging from 9.3 ppb to 63.8 ppb and styrene at levels ranging from < 2.1 ppb to 46.3 ppb. Instantaneous measurements collected in the center of the downstairs lab which was no longer in use measured 125.5

ppb methyl methacrylate. We note that exposure to methyl methacrylates or styrene in the air can cause respiratory irritation and work-related asthma at levels below exposure limits [Lindstrom et al. 2002; Jaakkola et al. 2007; Venables and Chan-Yeung 1997; Hayes et al. 1991; Moscato et al. 1987]. Polymers and co-polymers of methyl methacrylate are sometimes used in dental prostheses [WHO 1998]. Styrene is sometimes used as a dental filling component [NCBI 2020].

Because multiple samples for ethanol and isopropyl alcohol from both sampler types were greater than the calibration maximum used by the laboratory performing sample analyses, we cannot interpret whether these samples were lower than the NIOSH REL of 1,000 ppm for ethanol or 400 ppm for isopropyl alcohol. Ethanol and isopropyl alcohol are chemicals commonly used for cleaning and disinfection procedures.

Ventilation Assessment

The examination rooms, consultation office, and laboratory space were under positive pressure relative to adjacent spaces. Positive pressure in the laboratory area could lead to entrainment of air and contaminants from the laboratory area into adjacent areas such as the breakroom. Although there are no specific ASHRAE guidelines for dental clinics, *ANSI/ASHRAE/ASHE Standard 170-2017, Ventilation of Health Care Facilities*, has design parameters for healthcare facilities. ASHRAE recommends that laboratory work areas be kept under negative pressure relative to adjacent spaces [ANSI/ASHRAE/ASHE 2017]. Although all air measurements collected for particulates and vapors were relatively low, there is a potential for future exposures or contaminants generated in the laboratory area to be entrained into adjacent spaces.

Work-related Symptoms or Conditions

Work-related asthma refers to asthma that is brought on by ("occupational asthma") or made worse by ("work-exacerbated asthma" or "work-aggravated asthma") workplace exposures [Tarlo 2016; Tarlo and Lemiere 2014; OSHA 2014; Henneberger et al. 2011; Venables and Chan-Yeung 1997]. It includes asthma due to sensitizers, which cause disease through immune (allergic) mechanisms, and asthma due to irritants, which cause disease through non-immune mechanisms. Symptoms of work-related asthma include episodic shortness of breath, cough, wheeze, and chest tightness. The symptoms may begin early in a work shift, towards the end of a shift, or hours after a shift. They generally, but do not always, improve or remit during periods away from work, such as on weekends or holidays.

Methyl methacrylates and styrene exposure are associated with occupational asthma [Lozewics et al.; Sánchez-Garcia et al.; Hayes et al.; Moscato et al.; Fernandez-Nieto et al.; AOEC 2012]. It is unknown what concentrations of methyl methacrylates or styrene in air can lead to sensitization or asthma, but some individuals are more susceptible to developing these illnesses after exposure than others [Venables and Chan-Yeung 1997]. Persons who become sensitized (develop an immune reaction) to methyl methacrylate or styrene can subsequently react to relatively low concentrations in the air.

Additionally, methyl methacrylates and mercury can cause occupational contact dermatitis in exposed skin [Prajapati et al. 2013; Aalto-Korte et al. 2007; ATSDR 2014]. Dermal exposure can be mitigated with protective barriers such as gloves when handling products that contain methacrylates or mercury.

Symptoms of high exposure to ethanol or isopropyl alcohol include irritation of the eyes, skin, and nose; headache; drowsiness; weakness or dizziness; exhaustion; cough; liver damage; anemia; and reproductive effects [NIOSH 2007]. Symptoms of high exposure to acetone include irritation of the eyes, skin, nose, throat; headache, dizziness, and central nervous system depression [NIOSH 2007].

Should employees develop symptoms consistent with exposure to any of these compounds, they should report new, persistent, or worsening symptoms to their personal healthcare providers, and, as instructed, to a designated individual at their workplace.

Limitations

As described above, because multiple VOC samples were greater than the calibration maximum used by the laboratory performing sample analyses, we cannot interpret whether these samples were lower than the NIOSH REL of 1000 ppm for ethanol or 400 ppm for isopropyl alcohol.

Conclusions

All personal exposure measurements to mercury vapors were well below the NIOSH REL, and all area air samples for respirable dust, respirable silica, and respirable metals were low. Most area VOC samples were also low. We noted positive pressure in the laboratory area that could lead to entrainment of air and contaminants from the laboratory area into adjacent areas such as the breakroom. Although some employees reported eye or nose symptoms, these symptoms in most employees did not appear to be work-related. Among the few reported work-related eye or nose symptoms, exposure to acrylics, such as resins used for temporary crowns or dentures, was noted as causing or irritating nose symptoms. Should employees develop symptoms consistent with exposure, they should report new, persistent, or worsening symptoms to their personal healthcare providers, and, as instructed, to a designated individual at their workplace.

Section C: Tables

Table C1. Full-shift personal exposures to elemental mercury, June 2019.

Analyte	Job Title	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)	Above REL N (%)
Mercury	Administrative	9	5 (56%)	<0.1	0.5	0 (0%)
Mercury	Dental Assistant	21	14 (67%)	<0.1	0.2	0 (0%)
Mercury	Dental Hygienist	5	3 (60%)	<0.1	0.2	0 (0%)
Mercury	Dentist	4	3 (75%)	<0.1	0.1	0 (0%)

N=number of samples; LOD=limit of detection; REL=NIOSH Recommended Exposure Limit.

Table C2. Full-shift area air measurements of respirable silica (cristobalite, quartz, and tridymite) and respirable dust, June 2019.

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 0	Cristobalite	3	0 (0%)	<3.3	<3.3
Exam Room 0	Respirable dust	3	0 (0%)	<13.0	<13.1
Exam Room 0	Quartz	3	0 (0%)	<3.3	<3.3
Exam Room 0	Tridymite	3	0 (0%)	<6.5	<6.6
Exam Room 1	Cristobalite	3	0 (0%)	<3.3	<3.3
Exam Room 1	Respirable dust	3	0 (0%)	<13.0	<13.1
Exam Room 1	Quartz	3	0 (0%)	<3.3	<3.3
Exam Room 1	Tridymite	3	0 (0%)	<6.5	<6.6
Exam Room 2	Cristobalite	3	0 (0%)	<3.3	<3.3
Exam Room 2	Respirable dust	3	0 (0%)	<13.0	<13.1
Exam Room 2	Quartz	3	0 (0%)	<3.3	<3.3
Exam Room 2	Tridymite	3	0 (0%)	<6.5	<6.5
Exam Room 3	Cristobalite	3	0 (0%)	<3.3	<3.5
Exam Room 3	Respirable dust	3	0 (0%)	<13.1	<14.0
Exam Room 3	Quartz	3	0 (0%)	<3.3	<3.5
Exam Room 3	Tridymite	3	0 (0%)	<6.5	<7.0
Exam Room 4	Cristobalite	3	0 (0%)	<3.3	<3.3
Exam Room 4	Respirable dust	3	0 (0%)	<13.0	<13.2
Exam Room 4	Quartz	3	0 (0%)	<3.3	<3.3

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 4	Tridymite	3	0 (0%)	<6.5	<6.6
Exam Room 5	Cristobalite	3	0 (0%)	<3.3	<3.3
Exam Room 5	Respirable dust	3	1 (33%)	<13.1	17.6
Exam Room 5	Quartz	3	0 (0%)	<3.3	<3.3
Exam Room 5	Tridymite	3	0 (0%)	<6.5	<6.6
Exam Room 6	Cristobalite	3	0 (0%)	<3.3	<3.3
Exam Room 6	Respirable dust	3	0 (0%)	<13.1	<13.3
Exam Room 6	Quartz	3	0 (0%)	<3.3	<3.3
Exam Room 6	Tridymite	3	0 (0%)	<6.6	<6.6
Exam Room 7	Cristobalite	3	0 (0%)	<3.2	<3.3
Exam Room 7	Respirable dust	3	0 (0%)	<13.0	<13.3
Exam Room 7	Quartz	3	0 (0%)	<3.2	<3.3
Exam Room 7	Tridymite	3	0 (0%)	<6.5	<6.6
Lab Area	Cristobalite	3	0 (0%)	<3.3	<3.3
Lab Area	Respirable dust	3	0 (0%)	<13.1	<13.3
Lab Area	Quartz	3	0 (0%)	<3.3	<3.3
Lab Area	Tridymite	3	0 (0%)	<6.5	<6.7
Sterilization	Cristobalite	3	0 (0%)	<3.3	<3.3
Sterilization	Respirable dust	3	0 (0%)	<13.1	<13.3
Sterilization	Quartz	3	0 (0%)	<3.3	<3.3
Sterilization	Tridymite	3	0 (0%)	<6.6	<6.6

N=number of samples; LOD=limit of detection.

Table C3. Full-shift area measurements for respirable metals, June 2019.

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 0	Aluminum	3	0 (0%)	<0.46	<0.59
Exam Room 0	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 0	Arsenic	3	0 (0%)	<0.33	<0.39
Exam Room 0	Barium	3	1 (33%)	<0.01	0.02
Exam Room 0	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 0	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 0	Calcium	3	2 (67%)	<=0.79	0.79
Exam Room 0	Chromium	3	3 (100%)	0.32	0.38
Exam Room 0	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 0	Copper	3	0 (0%)	<0.07	<0.20
Exam Room 0	Iron	3	0 (0%)	<0.39	<0.66
Exam Room 0	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 0	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 0	Lithium	3	0 (0%)	<0.03	<0.04
Exam Room 0	Magnesium	3	2 (67%)	<=0.09	0.118
Exam Room 0	Manganese	3	1 (33%)	<=0.01	0.01
Exam Room 0	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 0	Nickel	3	0 (0%)	<0.03	<0.05
Exam Room 0	Phosphorus	3	1 (33%)	<1.31	1.51
Exam Room 0	Potassium	3	3 (100%)	0.48	0.66
Exam Room 0	Selenium	3	0 (0%)	<0.53	<1.32
Exam Room 0	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 0	Strontium	3	1 (33%)	<0.01	0.01
Exam Room 0	Tellurium	3	0 (0%)	<0.04	<0.26
Exam Room 0	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 0	Tin	3	1 (33%)	<=0.04	0.04
Exam Room 0	Titanium	3	0 (0%)	<0.01	<0.01

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 0	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 0	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 0	Zinc	3	1 (33%)	<0.04	0.04
Exam Room 0	Zirconium	3	0 (0%)	<0.01	<0.01
Exam Room 1	Aluminum	3	0 (0%)	<0.46	<0.59
Exam Room 1	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 1	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 1	Barium	3	1 (33%)	<0.01	0.02
Exam Room 1	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 1	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 1	Calcium	3	1 (33%)	<0.65	0.66
Exam Room 1	Chromium	3	2 (67%)	<0.13	0.33
Exam Room 1	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 1	Copper	3	0 (0%)	<0.07	<0.20
Exam Room 1	Iron	3	1 (33%)	<0.39	1.45
Exam Room 1	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 1	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 1	Lithium	3	1 (33%)	<0.03	0.04
Exam Room 1	Magnesium	3	2 (67%)	<=0.09	0.13
Exam Room 1	Manganese	3	1 (33%)	<=0.02	0.02
Exam Room 1	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 1	Nickel	3	0 (0%)	<0.03	<0.05
Exam Room 1	Phosphorus	3	0 (0%)	<1.31	<1.32
Exam Room 1	Potassium	3	3 (100%)	0.32	0.73
Exam Room 1	Selenium	3	0 (0%)	<0.53	<1.32
Exam Room 1	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 1	Strontium	3	0 (0%)	<0.01	<0.01
Exam Room 1	Tellurium	3	1 (33%)	<=0.07	0.07

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 1	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 1	Tin	3	1 (33%)	<=0.06	0.06
Exam Room 1	Titanium	3	1 (33%)	<0.01	0.01
Exam Room 1	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 1	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 1	Zinc	3	1 (33%)	<0.04	0.08
Exam Room 1	Zirconium	3	0 (0%)	<0.01	<0.01
Exam Room 2	Aluminum	3	0 (0%)	<0.46	<0.59
Exam Room 2	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 2	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 2	Barium	3	2 (67%)	<0.01	0.02
Exam Room 2	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 2	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 2	Calcium	3	2 (67%)	<=0.86	0.99
Exam Room 2	Chromium	3	3 (100%)	0.30	0.38
Exam Room 2	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 2	Copper	3	1 (33%)	<0.07	0.20
Exam Room 2	Iron	3	0 (0%)	<0.40	<0.66
Exam Room 2	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 2	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 2	Lithium	3	0 (0%)	<0.03	<0.04
Exam Room 2	Magnesium	3	2 (67%)	<=0.12	0.13
Exam Room 2	Manganese	3	2 (67%)	<=0.02	0.38
Exam Room 2	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 2	Nickel	3	0 (0%)	<0.03	<0.05
Exam Room 2	Phosphorus	3	1 (33%)	<1.31	1.71
Exam Room 2	Potassium	3	3 (100%)	0.51	0.57
Exam Room 2	Selenium	3	0 (0%)	<0.53	<1.32

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 2	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 2	Strontium	3	1 (33%)	<0.01	0.01
Exam Room 2	Tellurium	3	0 (0%)	<0.05	<0.26
Exam Room 2	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 2	Tin	3	0 (0%)	<0.03	<0.20
Exam Room 2	Titanium	3	0 (0%)	<0.01	<0.01
Exam Room 2	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 2	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 2	Zinc	3	1 (33%)	<0.04	0.20
Exam Room 2	Zirconium	3	0 (0%)	<0.01	<0.01
Exam Room 3	Aluminum	3	1 (33%)	<0.59	0.61
Exam Room 3	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 3	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 3	Barium	3	2 (67%)	<0.01	0.07
Exam Room 3	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 3	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 3	Calcium	3	1 (33%)	<0.65	1.06
Exam Room 3	Chromium	3	3 (100%)	0.22	0.42
Exam Room 3	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 3	Copper	3	0 (0%)	<0.07	<0.20
Exam Room 3	Iron	3	0 (0%)	<0.39	<0.66
Exam Room 3	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 3	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 3	Lithium	3	0 (0%)	<0.03	<0.04
Exam Room 3	Magnesium	3	2 (67%)	<=0.11	0.13
Exam Room 3	Manganese	3	1 (33%)	<=0.02	0.02
Exam Room 3	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 3	Nickel	3	1 (33%)	<0.03	0.13

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 3	Phosphorus	3	0 (0%)	<1.31	<1.32
Exam Room 3	Potassium	3	3 (100%)	0.72	1.59
Exam Room 3	Selenium	3	0 (0%)	<0.53	<1.32
Exam Room 3	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 3	Strontium	3	1 (33%)	<0.01	0.01
Exam Room 3	Tellurium	3	0 (0%)	<0.05	<0.26
Exam Room 3	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 3	Tin	3	0 (0%)	<0.03	<0.20
Exam Room 3	Titanium	3	1 (33%)	<0.01	0.01
Exam Room 3	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 3	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 3	Zinc	3	1 (33%)	<0.04	0.09
Exam Room 3	Zirconium	3	1 (33%)	<0.01	0.03
Exam Room 4	Aluminum	3	0 (0%)	<0.46	<0.60
Exam Room 4	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 4	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 4	Barium	3	1 (33%)	<0.01	0.02
Exam Room 4	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 4	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 4	Calcium	3	2 (67%)	<=0.92	0.99
Exam Room 4	Chromium	3	3 (100%)	0.32	0.33
Exam Room 4	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 4	Copper	3	0 (0%)	<0.07	<0.20
Exam Room 4	Iron	3	0 (0%)	<0.39	<0.66
Exam Room 4	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 4	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 4	Lithium	3	0 (0%)	<0.03	<0.04
Exam Room 4	Magnesium	3	2 (67%)	<=0.10	0.14

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 4	Manganese	3	1 (33%)	<=0.07	0.07
Exam Room 4	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 4	Nickel	3	0 (0%)	<0.03	<0.05
Exam Room 4	Phosphorus	3	0 (0%)	<1.31	<1.32
Exam Room 4	Potassium	3	3 (100%)	0.66	0.99
Exam Room 4	Selenium	3	0 (0%)	<0.53	<1.32
Exam Room 4	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 4	Strontium	3	1 (33%)	<0.01	0.01
Exam Room 4	Tellurium	3	0 (0%)	<0.05	<0.26
Exam Room 4	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 4	Tin	3	0 (0%)	<0.03	<0.20
Exam Room 4	Titanium	3	0 (0%)	<0.01	<0.01
Exam Room 4	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 4	Yttrium	3	1 (33%)	<0.01	0.01
Exam Room 4	Zinc	3	2 (67%)	<0.04	0.08
Exam Room 4	Zirconium	3	0 (0%)	<0.01	<0.01
Exam Room 5	Aluminum	3	0 (0%)	<0.46	<0.59
Exam Room 5	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 5	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 5	Barium	3	2 (67%)	<0.01	0.02
Exam Room 5	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 5	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 5	Calcium	3	1 (33%)	<0.66	1.45
Exam Room 5	Chromium	3	3 (100%)	0.24	0.35
Exam Room 5	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 5	Copper	3	0 (0%)	<0.07	<0.20
Exam Room 5	Iron	3	0 (0%)	<0.39	<0.66
Exam Room 5	Lanthanum	3	1 (33%)	<0.01	0.01

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 5	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 5	Lithium	3	0 (0%)	<0.03	<0.04
Exam Room 5	Magnesium	3	2 (67%)	<=0.09	0.13
Exam Room 5	Manganese	3	1 (33%)	<=0.02	0.02
Exam Room 5	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 5	Nickel	3	1 (33%)	<0.03	0.15
Exam Room 5	Phosphorus	3	0 (0%)	<1.31	<1.32
Exam Room 5	Potassium	3	3 (100%)	0.55	1.19
Exam Room 5	Selenium	3	0 (0%)	<0.53	<1.32
Exam Room 5	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 5	Strontium	3	0 (0%)	<0.01	<0.01
Exam Room 5	Tellurium	3	0 (0%)	<0.05	<0.26
Exam Room 5	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 5	Tin	3	0 (0%)	<0.03	<0.20
Exam Room 5	Titanium	3	0 (0%)	<0.01	<0.01
Exam Room 5	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 5	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 5	Zinc	3	3 (100%)	0.05	0.10
Exam Room 5	Zirconium	3	0 (0%)	<0.01	<0.01
Exam Room 6	Aluminum	3	0 (0%)	<0.46	<0.60
Exam Room 6	Antimony	3	0 (0%)	<0.20	<0.33
Exam Room 6	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 6	Barium	3	3 (100%)	0.01	0.02
Exam Room 6	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 6	Cadmium	3	0 (0%)	<0.01	<0.02
Exam Room 6	Calcium	3	2 (67%)	<=0.66	0.80
Exam Room 6	Chromium	3	3 (100%)	0.25	0.49
Exam Room 6	Cobalt	3	0 (0%)	<0.03	<0.03

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 6	Copper	3	2 (67%)	<0.20	2.38
Exam Room 6	Iron	3	0 (0%)	<0.40	<0.66
Exam Room 6	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 6	Lead	3	0 (0%)	<0.13	<0.199
Exam Room 6	Lithium	3	0 (0%)	<0.03	<0.04
Exam Room 6	Magnesium	3	2 (67%)	<=0.11	0.15
Exam Room 6	Manganese	3	2 (67%)	<0.27	4.43
Exam Room 6	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 6	Nickel	3	1 (33%)	<0.03	0.03
Exam Room 6	Phosphorus	3	0 (0%)	<1.32	<1.33
Exam Room 6	Potassium	3	3 (100%)	0.53	1.38
Exam Room 6	Selenium	3	0 (0%)	<0.53	<1.33
Exam Room 6	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 6	Strontium	3	1 (33%)	<0.01	0.01
Exam Room 6	Tellurium	3	0 (0%)	<0.05	<0.27
Exam Room 6	Thallium	3	0 (0%)	<0.13	<0.26
Exam Room 6	Tin	3	0 (0%)	<0.03	<0.20
Exam Room 6	Titanium	3	0 (0%)	<0.01	<0.01
Exam Room 6	Vanadium	3	0 (0%)	<0.26	<0.33
Exam Room 6	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 6	Zinc	3	2 (67%)	<0.04	0.06
Exam Room 6	Zirconium	3	0 (0%)	<0.01	<0.01
Exam Room 7	Aluminum	3	0 (0%)	<0.46	<0.60
Exam Room 7	Antimony	3	1 (33%)	<=0.21	0.21
Exam Room 7	Arsenic	3	0 (0%)	<0.33	<0.40
Exam Room 7	Barium	3	2 (67%)	<0.01	0.04
Exam Room 7	Beryllium	3	0 (0%)	<0.01	<0.01
Exam Room 7	Cadmium	3	1 (33%)	<=0.02	0.02

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Exam Room 7	Calcium	3	2 (67%)	<=1.45	1.59
Exam Room 7	Chromium	3	3 (100%)	0.31	0.39
Exam Room 7	Cobalt	3	0 (0%)	<0.03	<0.03
Exam Room 7	Copper	3	1 (33%)	<0.07	0.45
Exam Room 7	Iron	3	0 (0%)	<0.40	<0.66
Exam Room 7	Lanthanum	3	0 (0%)	<0.01	<0.01
Exam Room 7	Lead	3	0 (0%)	<0.13	<0.20
Exam Room 7	Lithium	3	1 (33%)	<0.03	0.04
Exam Room 7	Magnesium	3	2 (67%)	<=0.12	0.15
Exam Room 7	Manganese	3	2 (67%)	<=0.02	0.80
Exam Room 7	Molybdenum	3	0 (0%)	<0.03	<0.03
Exam Room 7	Nickel	3	0 (0%)	<0.03	<0.05
Exam Room 7	Phosphorus	3	0 (0%)	<1.32	<1.33
Exam Room 7	Potassium	3	3 (100%)	0.49	0.73
Exam Room 7	Selenium	3	0 (0%)	<0.53	<1.31
Exam Room 7	Silver	3	0 (0%)	<0.01	<0.05
Exam Room 7	Strontium	3	1 (33%)	<0.01	0.01
Exam Room 7	Tellurium	3	1 (33%)	<=0.06	0.06
Exam Room 7	Thallium	3	0 (0%)	<0.13	<0.27
Exam Room 7	Tin	3	1 (33%)	<=0.03	0.03
Exam Room 7	Titanium	3	0 (0%)	<0.01	<0.01
Exam Room 7	Vanadium	3	0 (0%)	<0.27	<0.33
Exam Room 7	Yttrium	3	0 (0%)	<0.01	<0.01
Exam Room 7	Zinc	3	3 (100%)	0.05	2.11
Exam Room 7	Zirconium	3	0 (0%)	<0.01	<0.01
Lab Area	Aluminum	3	0 (0%)	<0.46	<0.60
Lab Area	Antimony	3	0 (0%)	<0.20	<0.33
Lab Area	Arsenic	3	0 (0%)	<0.33	<0.40

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Lab Area	Barium	3	3 (100%)	0.01	0.02
Lab Area	Beryllium	3	0 (0%)	<0.01	<0.01
Lab Area	Cadmium	3	0 (0%)	<0.01	<0.02
Lab Area	Calcium	3	1 (33%)	<0.66	0.80
Lab Area	Chromium	3	3 (100%)	0.20	0.41
Lab Area	Cobalt	3	0 (0%)	<0.03	<0.03
Lab Area	Copper	3	0 (0%)	<0.07	<0.20
Lab Area	Iron	3	0 (0%)	<0.40	<0.66
Lab Area	Lanthanum	3	0 (0%)	<0.01	<0.007
Lab Area	Lead	3	0 (0%)	<0.13	<0.20
Lab Area	Lithium	3	0 (0%)	<0.03	<0.04
Lab Area	Magnesium	3	2 (67%)	<=0.11	0.14
Lab Area	Manganese	3	1 (33%)	<=0.09	0.09
Lab Area	Molybdenum	3	0 (0%)	<0.03	<0.03
Lab Area	Nickel	3	0 (0%)	<0.03	<0.05
Lab Area	Phosphorus	3	0 (0%)	<1.32	<1.33
Lab Area	Potassium	3	3 (100%)	0.36	1.19
Lab Area	Selenium	3	0 (0%)	<0.53	<1.33
Lab Area	Silver	3	0 (0%)	<0.01	<0.05
Lab Area	Strontium	3	0 (0%)	<0.01	<0.01
Lab Area	Tellurium	3	1 (33%)	<=0.09	0.09
Lab Area	Thallium	3	0 (0%)	<0.13	<0.26
Lab Area	Tin	3	1 (33%)	<=0.09	0.09
Lab Area	Titanium	3	0 (0%)	<0.01	<0.01
Lab Area	Vanadium	3	0 (0%)	<0.26	<0.33
Lab Area	Yttrium	3	0 (0%)	<0.01	<0.01
Lab Area	Zinc	3	2 (67%)	<0.04	0.06
Lab Area	Zirconium	3	0 (0%)	<0.01	<0.01

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Sterilization	Aluminum	3	0 (0%)	<0.46	<0.60
Sterilization	Antimony	3	0 (0%)	<0.20	<0.33
Sterilization	Arsenic	3	0 (0%)	<0.33	<0.40
Sterilization	Barium	3	2 (67%)	<0.01	0.02
Sterilization	Beryllium	3	0 (0%)	<0.01	<0.01
Sterilization	Cadmium	3	0 (0%)	<0.01	<0.02
Sterilization	Calcium	3	2 (67%)	<=0.86	1.12
Sterilization	Chromium	3	3 (100%)	0.22	0.32
Sterilization	Cobalt	3	0 (0%)	<0.03	<0.03
Sterilization	Copper	3	1 (33%)	<0.07	0.36
Sterilization	Iron	3	0 (0%)	<0.40	<0.66
Sterilization	Lanthanum	3	0 (0%)	<0.01	<0.01
Sterilization	Lead	3	0 (0%)	<0.13	<0.20
Sterilization	Lithium	3	0 (0%)	<0.03	<0.04
Sterilization	Magnesium	3	2 (67%)	<=0.08	0.11
Sterilization	Manganese	3	2 (67%)	<=0.02	0.66
Sterilization	Molybdenum	3	0 (0%)	<0.03	<0.03
Sterilization	Nickel	3	1 (33%)	<0.03	0.07
Sterilization	Phosphorus	3	1 (33%)	<1.32	1.46
Sterilization	Potassium	3	3 (100%)	0.26	0.99
Sterilization	Selenium	3	0 (0%)	<0.53	<1.33
Sterilization	Silver	3	0 (0%)	<0.01	<0.05
Sterilization	Strontium	3	1 (33%)	<0.01	0.01
Sterilization	Tellurium	3	0 (0%)	<0.05	<0.27
Sterilization	Thallium	3	0 (0%)	<0.13	<0.26
Sterilization	Tin	3	0 (0%)	<0.03	<0.20
Sterilization	Titanium	3	0 (0%)	<0.01	<0.01
Sterilization	Vanadium	3	0 (0%)	<0.26	<0.33

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (µg/m³)	Maximum Concentration (µg/m³)
Sterilization	Yttrium	3	0 (0%)	<0.01	<0.01
Sterilization	Zinc	3	1 (33%)	<0.04	0.17
Sterilization	Zirconium	3	0 (0%)	<0.01	<0.01

N=number of samples; LOD=limit of detection.

Table C4. Full-shift canister area measurements of volatile organic compounds, June 2019.

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Administrative	2,3-Butanedione	3	1 (33%)	<2.3	3.0
Administrative	2,3-Hexanedione	3	1 (33%)	<3.5	5.0
Administrative	2,3-Pentanedione	3	0 (0%)	<2.4	<2.5
Administrative	Acetaldehyde	3	0 (0%)	<4.7	<4.8
Administrative	Acetone	3	3 (100%)	101.1	109.9
Administrative	Acetonitrile	3	0 (0%)	<6.3	<6.5
Administrative	Benzene	3	3 (100%)	3.4	3.5
Administrative	Chloroform	3	0 (0%)	<0.1	<0.1
Administrative	D-Limonene	3	3 (100%)	2.6	4.1
Administrative	Ethanol	3	3 (100%)	2116.9	2829.7
Administrative	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Administrative	Isopropyl Alcohol	3	3 (100%)	—	—
Administrative	Methyl Methacrylate	3	3 (100%)	9.5	10.4
Administrative	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Administrative	Styrene	3	1 (33%)	<2.1	6.4
Administrative	Toluene	3	3 (100%)	5.0	5.1
Administrative	alpha-Pinene	3	0 (0%)	<1.5	<1.6
Administrative	m,p-Xylene	3	3 (100%)	2.6	2.7
Administrative	n-Hexane	3	3 (100%)	6.4	24.5
Administrative	o-Xylene	3	1 (33%)	<0.6	2.0
Exam Room 0	2,3-Butanedione	3	0 (0%)	<2.3	<23.6
Exam Room 0	2,3-Hexanedione	3	0 (0%)	<3.4	<35.7
Exam Room 0	2,3-Pentanedione	3	0 (0%)	<2.4	<24.6
Exam Room 0	Acetaldehyde	3	0 (0%)	<4.6	<48.0
Exam Room 0	Acetone	3	3 (100%)	112.2	170.9
Exam Room 0	Acetonitrile	3	0 (0%)	<6.2	<6.5
Exam Room 0	Benzene	3	3 (100%)	3.5	34.3
Exam Room 0	Chloroform	3	0 (0%)	<0.1	<1.1
Exam Room 0	D-Limonene	3	3 (100%)	3.5	52.2
Exam Room 0	Ethanol	3	3 (100%)	2749.0	—
Exam Room 0	Ethylbenzene	3	1 (33%)	<1.4	25.2
Exam Room 0	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 0	Methyl Methacrylate	3	3 (100%)	10.2	63.8

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 0	Methylene Chloride	3	0 (0%)	<0.4	<3.9
Exam Room 0	Styrene	3	3 (100%)	4.6	46.3
Exam Room 0	Toluene	3	2 (67%)	<2.0	48.3
Exam Room 0	alpha-Pinene	3	0 (0%)	<1.5	<15.5
Exam Room 0	m,p-Xylene	3	3 (100%)	2.5	24.8
Exam Room 0	n-Hexane	3	3 (100%)	24.2	31.8
Exam Room 0	o-Xylene	3	2 (67%)	<0.6	18.8
Exam Room 1	2,3-Butanedione	3	0 (0%)	<2.3	<2.3
Exam Room 1	2,3-Hexanedione	3	0 (0%)	<3.5	<3.6
Exam Room 1	2,3-Pentanedione	3	0 (0%)	<2.4	<2.4
Exam Room 1	Acetaldehyde	3	0 (0%)	<4.7	<4.8
Exam Room 1	Acetone	3	3 (100%)	129.0	172.3
Exam Room 1	Acetonitrile	3	0 (0%)	<6.3	<6.5
Exam Room 1	Benzene	3	3 (100%)	3.4	3.6
Exam Room 1	Chloroform	3	1 (33%)	<0.1	1.4
Exam Room 1	D-Limonene	3	3 (100%)	2.8	6.6
Exam Room 1	Ethanol	3	3 (100%)	2899.2	—
Exam Room 1	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Exam Room 1	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 1	Methyl Methacrylate	3	3 (100%)	10.3	11.3
Exam Room 1	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Exam Room 1	Styrene	3	2 (67%)	<2.2	4.6
Exam Room 1	Toluene	3	2 (67%)	<2.0	5.3
Exam Room 1	alpha-Pinene	3	0 (0%)	<1.5	<1.5
Exam Room 1	m,p-Xylene	3	3 (100%)	2.6	2.9
Exam Room 1	n-Hexane	3	3 (100%)	7.0	32.3
Exam Room 1	o-Xylene	3	1 (33%)	<0.6	2.1
Exam Room 2	2,3-Butanedione	3	0 (0%)	<2.3	<2.3
Exam Room 2	2,3-Hexanedione	3	0 (0%)	<3.4	<3.5
Exam Room 2	2,3-Pentanedione	3	0 (0%)	<2.4	<2.4
Exam Room 2	Acetaldehyde	3	0 (0%)	<4.6	<4.8
Exam Room 2	Acetone	3	3 (100%)	119.0	133.3
Exam Room 2	Acetonitrile	3	0 (0%)	<6.3	<6.4
Exam Room 2	Benzene	3	3 (100%)	3.4	6.2

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	Chloroform	3	0 (0%)	<0.1	<0.1
Exam Room 2	D-Limonene	3	3 (100%)	2.7	3.6
Exam Room 2	Ethanol	3	3 (100%)	2598.0	—
Exam Room 2	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Exam Room 2	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 2	Methyl Methacrylate	3	3 (100%)	9.5	10.9
Exam Room 2	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Exam Room 2	Styrene	3	1 (33%)	<2.1	4.6
Exam Room 2	Toluene	3	3 (100%)	4.9	5.0
Exam Room 2	alpha-Pinene	3	0 (0%)	<1.5	<1.5
Exam Room 2	m,p-Xylene	3	3 (100%)	2.6	2.6
Exam Room 2	n-Hexane	3	3 (100%)	6.8	29.1
Exam Room 2	o-Xylene	3	1 (33%)	<0.6	2.0
Exam Room 3	2,3-Butanedione	3	0 (0%)	<2.2	<2.3
Exam Room 3	2,3-Hexanedione	3	1 (33%)	<3.4	5.5
Exam Room 3	2,3-Pentanedione	3	0 (0%)	<2.3	<2.4
Exam Room 3	Acetaldehyde	3	0 (0%)	<4.6	<4.7
Exam Room 3	Acetone	3	3 (100%)	105.6	743.9
Exam Room 3	Acetonitrile	3	0 (0%)	<6.2	<6.4
Exam Room 3	Benzene	3	3 (100%)	3.3	3.6
Exam Room 3	Chloroform	3	0 (0%)	<0.1	<0.1
Exam Room 3	D-Limonene	3	3 (100%)	2.9	6.5
Exam Room 3	Ethanol	3	3 (100%)	2358.8	—
Exam Room 3	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Exam Room 3	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 3	Methyl Methacrylate	3	3 (100%)	10.2	11.0
Exam Room 3	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Exam Room 3	Styrene	3	2 (67%)	<2.1	4.7
Exam Room 3	Toluene	3	2 (67%)	<2.1	5.1
Exam Room 3	alpha-Pinene	3	0 (0%)	<1.5	<1.5
Exam Room 3	m,p-Xylene	3	3 (100%)	2.6	2.7
Exam Room 3	n-Hexane	3	3 (100%)	6.6	30.0
Exam Room 3	o-Xylene	3	1 (33%)	<0.6	2.0
Exam Room 4	2,3-Butanedione	3	0 (0%)	<2.2	<2.4

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 4	2,3-Hexanedione	3	0 (0%)	<3.4	<3.6
Exam Room 4	2,3-Pentanedione	3	0 (0%)	<2.3	<2.5
Exam Room 4	Acetaldehyde	3	0 (0%)	<4.6	<4.8
Exam Room 4	Acetone	3	3 (100%)	111.9	187.2
Exam Room 4	Acetonitrile	3	0 (0%)	<6.2	<6.5
Exam Room 4	Benzene	3	2 (67%)	<1.2	3.4
Exam Room 4	Chloroform	3	0 (0%)	<0.1	<0.1
Exam Room 4	D-Limonene	3	3 (100%)	2.6	6.9
Exam Room 4	Ethanol	3	3 (100%)	2519.1	—
Exam Room 4	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Exam Room 4	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 4	Methyl Methacrylate	3	3 (100%)	9.3	11.1
Exam Room 4	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Exam Room 4	Styrene	3	2 (67%)	<2.1	4.8
Exam Room 4	Toluene	3	2 (67%)	<2.1	5.0
Exam Room 4	alpha-Pinene	3	0 (0%)	<1.5	<1.6
Exam Room 4	m,p-Xylene	3	3 (100%)	2.5	2.6
Exam Room 4	n-Hexane	3	3 (100%)	8.2	38.7
Exam Room 4	o-Xylene	3	1 (33%)	<0.6	2.0
Exam Room 5	2,3-Butanedione	3	0 (0%)	<2.3	<22.7
Exam Room 5	2,3-Hexanedione	3	0 (0%)	<3.5	<34.4
Exam Room 5	2,3-Pentanedione	3	0 (0%)	<2.4	<23.7
Exam Room 5	Acetaldehyde	3	0 (0%)	<4.7	<46.2
Exam Room 5	Acetone	3	3 (100%)	117.8	174.0
Exam Room 5	Acetonitrile	3	0 (0%)	<6.2	<6.4
Exam Room 5	Benzene	3	2 (67%)	<1.2	33.1
Exam Room 5	Chloroform	3	0 (0%)	<0.1	<1.0
Exam Room 5	D-Limonene	3	3 (100%)	2.8	50.3
Exam Room 5	Ethanol	3	3 (100%)	2526.4	—
Exam Room 5	Ethylbenzene	3	0 (0%)	<1.4	<13.7
Exam Room 5	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 5	Methyl Methacrylate	3	3 (100%)	10.4	61.2
Exam Room 5	Methylene Chloride	3	0 (0%)	<0.4	<3.7
Exam Room 5	Styrene	3	1 (33%)	<2.2	21.1

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 5	Toluene	3	3 (100%)	5.0	46.5
Exam Room 5	alpha-Pinene	3	0 (0%)	<1.5	<14.9
Exam Room 5	m,p-Xylene	3	2 (67%)	<=2.6	11.9
Exam Room 5	n-Hexane	3	3 (100%)	8.1	41.4
Exam Room 5	o-Xylene	3	1 (33%)	<0.6	5.7
Exam Room 6	2,3-Butanedione	3	0 (0%)	<2.2	<2.4
Exam Room 6	2,3-Hexanedione	3	0 (0%)	<3.4	<3.7
Exam Room 6	2,3-Pentanedione	3	0 (0%)	<2.3	<2.5
Exam Room 6	Acetaldehyde	3	0 (0%)	<4.5	<4.9
Exam Room 6	Acetone	3	3 (100%)	128.1	174.4
Exam Room 6	Acetonitrile	3	0 (0%)	<6.1	<6.6
Exam Room 6	Benzene	3	2 (67%)	<1.3	3.6
Exam Room 6	Chloroform	3	1 (33%)	<0.1	1.3
Exam Room 6	D-Limonene	3	3 (100%)	3.7	6.7
Exam Room 6	Ethanol	3	3 (100%)	2814.2	—
Exam Room 6	Ethylbenzene	3	0 (0%)	<1.3	<1.5
Exam Room 6	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 6	Methyl Methacrylate	3	3 (100%)	10.4	11.3
Exam Room 6	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Exam Room 6	Styrene	3	2 (67%)	<2.2	4.8
Exam Room 6	Toluene	3	1 (33%)	<2.0	5.3
Exam Room 6	alpha-Pinene	3	0 (0%)	<1.5	<1.6
Exam Room 6	m,p-Xylene	3	3 (100%)	2.5	2.8
Exam Room 6	n-Hexane	3	3 (100%)	8.1	38.8
Exam Room 6	o-Xylene	3	0 (0%)	<0.6	<0.6
Exam Room 7	2,3-Butanedione	3	0 (0%)	<2.3	<2.3
Exam Room 7	2,3-Hexanedione	3	0 (0%)	<3.4	<3.6
Exam Room 7	2,3-Pentanedione	3	0 (0%)	<2.3	<2.5
Exam Room 7	Acetaldehyde	3	0 (0%)	<4.6	<4.8
Exam Room 7	Acetone	3	3 (100%)	117.7	157.9
Exam Room 7	Acetonitrile	3	0 (0%)	<6.2	<6.5
Exam Room 7	Benzene	3	2 (67%)	<1.2	3.5
Exam Room 7	Chloroform	3	0 (0%)	<0.1	<0.1
Exam Room 7	D-Limonene	3	3 (100%)	2.8	6.3

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 7	Ethanol	3	3 (100%)	2664.5	—
Exam Room 7	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Exam Room 7	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 7	Methyl Methacrylate	3	3 (100%)	10.0	11.0
Exam Room 7	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Exam Room 7	Styrene	3	1 (33%)	<2.1	4.7
Exam Room 7	Toluene	3	2 (67%)	<2.0	5.1
Exam Room 7	alpha-Pinene	3	0 (0%)	<1.5	<1.5
Exam Room 7	m,p-Xylene	3	3 (100%)	2.6	2.7
Exam Room 7	n-Hexane	3	3 (100%)	7.8	42.1
Exam Room 7	o-Xylene	3	1 (33%)	<0.6	2.0
Lab Area	2,3-Butanedione	3	0 (0%)	<2.3	<2.3
Lab Area	2,3-Hexanedione	3	0 (0%)	<3.4	<3.5
Lab Area	2,3-Pentanedione	3	0 (0%)	<2.4	<2.4
Lab Area	Acetaldehyde	3	0 (0%)	<4.6	<4.7
Lab Area	Acetone	3	3 (100%)	113.9	140.5
Lab Area	Acetonitrile	3	0 (0%)	<6.2	<6.4
Lab Area	Benzene	3	2 (67%)	<1.2	3.5
Lab Area	Chloroform	3	1 (33%)	<0.1	1.3
Lab Area	D-Limonene	3	3 (100%)	2.8	6.4
Lab Area	Ethanol	3	3 (100%)	2395.9	2791.1
Lab Area	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Lab Area	Isopropyl Alcohol	3	3 (100%)	—	—
Lab Area	Methyl Methacrylate	3	3 (100%)	10.4	10.5
Lab Area	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Lab Area	Styrene	3	2 (67%)	<2.1	4.6
Lab Area	Toluene	3	2 (67%)	<2.0	5.1
Lab Area	alpha-Pinene	3	0 (0%)	<1.5	<1.5
Lab Area	m,p-Xylene	3	3 (100%)	2.6	2.8
Lab Area	n-Hexane	3	3 (100%)	7.3	40.4
Lab Area	o-Xylene	3	1 (33%)	<0.6	2.0
Sterilization	2,3-Butanedione	3	1 (33%)	<2.3	3.0
Sterilization	2,3-Hexanedione	3	0 (0%)	<3.4	<3.5
Sterilization	2,3-Pentanedione	3	0 (0%)	<2.3	<2.4

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Sterilization	Acetaldehyde	3	0 (0%)	<4.6	<4.7
Sterilization	Acetone	3	3 (100%)	115.1	165.0
Sterilization	Acetonitrile	3	0 (0%)	<6.2	<6.4
Sterilization	Benzene	3	2 (67%)	<1.2	3.6
Sterilization	Chloroform	3	2 (67%)	<0.1	1.6
Sterilization	D-Limonene	3	3 (100%)	2.8	8.0
Sterilization	Ethanol	3	3 (100%)	2712.2	—
Sterilization	Ethylbenzene	3	0 (0%)	<1.4	<1.4
Sterilization	Isopropyl Alcohol	3	3 (100%)	—	—
Sterilization	Methyl Methacrylate	3	3 (100%)	9.5	10.7
Sterilization	Methylene Chloride	3	0 (0%)	<0.4	<0.4
Sterilization	Styrene	3	1 (33%)	<2.1	4.7
Sterilization	Toluene	3	2 (67%)	<2.1	5.1
Sterilization	alpha-Pinene	3	0 (0%)	<1.5	<1.5
Sterilization	m,p-Xylene	3	3 (100%)	2.6	3.2
Sterilization	n-Hexane	3	3 (100%)	7.5	62.3
Sterilization	o-Xylene	3	1 (33%)	<0.6	2.4

N=number of samples; LOD=limit of detection; PPB=Parts per billion; "—"indicates measurements above the calibration maximum.

Table C5. Full-shift thermal desorption tube area measurements of volatile organic compounds, June 2019.

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Administrative	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Administrative	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5
Administrative	2,3-Pentanedione	3	0 (0%)	<1.6	<1.6
Administrative	Acetaldehyde	3	0 (0%)	<1.9	<1.9
Administrative	Acetone	3	3 (100%)	—	—
Administrative	Acetonitrile	3	0 (0%)	<1.7	<1.7
Administrative	Benzene	3	0 (0%)	<1.8	<1.9
Administrative	Chloroform	3	0 (0%)	<1.8	<1.9
Administrative	Ethanol	3	3 (100%)	—	—
Administrative	Ethylbenzene	3	0 (0%)	<1.8	<1.9
Administrative	Isopropyl Alcohol	3	3 (100%)	—	—
Administrative	Methyl Methacrylate	3	3 (100%)	9.8	11.6
Administrative	Methylene Chloride	3	0 (0%)	<1.9	<1.9
Administrative	Styrene	3	0 (0%)	<1.9	<1.9
Administrative	Toluene	3	0 (0%)	<1.9	<1.9
Administrative	alpha-Pinene	3	1 (33%)	<=1.7	1.8
Administrative	d-Limonene	3	3 (100%)	6.5	11.9
Administrative	m,p-Xylene	3	0 (0%)	<1.9	<1.9
Administrative	n-Hexane	3	3 (100%)	—	—
Administrative	o-Xylene	3	0 (0%)	<1.9	<1.9
Exam Room 0	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Exam Room 0	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5
Exam Room 0	2,3-Pentanedione	3	0 (0%)	<1.5	<1.6
Exam Room 0	Acetaldehyde	3	0 (0%)	<1.8	<1.9
Exam Room 0	Acetone	3	3 (100%)	—	—
Exam Room 0	Acetonitrile	3	0 (0%)	<1.6	<1.7
Exam Room 0	Benzene	3	0 (0%)	<1.8	<1.9
Exam Room 0	Chloroform	3	0 (0%)	<1.8	<1.9
Exam Room 0	Ethanol	3	3 (100%)	—	—
Exam Room 0	Ethylbenzene	3	0 (0%)	<1.8	<1.9
Exam Room 0	Isopropyl Alcohol	3	0 (0%)	<1.8	<1.8
Exam Room 0	Methyl Methacrylate	3	3 (100%)	8.2	12.5

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 0	Methylene Chloride	3	0 (0%)	<1.8	<1.9
Exam Room 0	Styrene	3	0 (0%)	<1.8	<1.9
Exam Room 0	Toluene	3	0 (0%)	<1.8	<1.9
Exam Room 0	alpha-Pinene	3	2 (67%)	<1.7	2.0
Exam Room 0	d-Limonene	3	3 (100%)	5.8	9.7
Exam Room 0	m,p-Xylene	3	0 (0%)	<1.8	<1.9
Exam Room 0	n-Hexane	3	3 (100%)	—	—
Exam Room 0	o-Xylene	3	0 (0%)	<1.8	<1.9
Exam Room 1	2,3-Butanedione	3	0 (0%)	<1.6	<1.7
Exam Room 1	2,3-Hexanedione	3	0 (0%)	<1.4	<1.4
Exam Room 1	2,3-Pentanedione	3	0 (0%)	<1.5	<1.5
Exam Room 1	Acetaldehyde	3	0 (0%)	<1.8	<1.9
Exam Room 1	Acetone	3	3 (100%)	—	—
Exam Room 1	Acetonitrile	3	0 (0%)	<1.6	<1.7
Exam Room 1	Benzene	3	0 (0%)	<1.8	<1.8
Exam Room 1	Chloroform	3	0 (0%)	<1.7	<1.8
Exam Room 1	Ethanol	3	3 (100%)	—	—
Exam Room 1	Ethylbenzene	3	0 (0%)	<1.7	<1.8
Exam Room 1	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 1	Methyl Methacrylate	3	3 (100%)	8.8	12.8
Exam Room 1	Methylene Chloride	3	0 (0%)	<1.8	<1.9
Exam Room 1	Styrene	3	0 (0%)	<1.8	<1.9
Exam Room 1	Toluene	3	0 (0%)	<1.8	<1.9
Exam Room 1	alpha-Pinene	3	0 (0%)	<1.7	<1.7
Exam Room 1	d-Limonene	3	3 (100%)	5.3	8.3
Exam Room 1	m,p-Xylene	3	0 (0%)	<1.8	<1.9
Exam Room 1	n-Hexane	3	3 (100%)	—	—
Exam Room 1	o-Xylene	3	0 (0%)	<1.8	<1.9
Exam Room 2	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Exam Room 2	2,3-Hexanedione	3	0 (0%)	<1.5	<1.5
Exam Room 2	2,3-Pentanedione	3	0 (0%)	<1.6	<1.6
Exam Room 2	Acetaldehyde	3	0 (0%)	<1.9	<1.9
Exam Room 2	Acetone	3	3 (100%)	—	—
Exam Room 2	Acetonitrile	3	0 (0%)	<1.7	<1.7

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	Benzene	3	0 (0%)	<1.9	<1.9
Exam Room 2	Chloroform	3	0 (0%)	<1.9	<1.9
Exam Room 2	Ethanol	3	3 (100%)	—	—
Exam Room 2	Ethylbenzene	3	0 (0%)	<1.9	<1.9
Exam Room 2	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 2	Methyl Methacrylate	3	3 (100%)	10.9	11.9
Exam Room 2	Methylene Chloride	3	0 (0%)	<1.9	<1.9
Exam Room 2	Styrene	3	0 (0%)	<1.9	<1.9
Exam Room 2	Toluene	3	0 (0%)	<1.9	<1.9
Exam Room 2	alpha-Pinene	3	2 (67%)	<1.8	1.9
Exam Room 2	d-Limonene	3	3 (100%)	7.0	9.4
Exam Room 2	m,p-Xylene	3	0 (0%)	<1.9	<1.9
Exam Room 2	n-Hexane	3	3 (100%)	—	—
Exam Room 2	o-Xylene	3	0 (0%)	<1.9	<1.9
Exam Room 3	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Exam Room 3	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5
Exam Room 3	2,3-Pentanedione	3	0 (0%)	<1.5	<1.7
Exam Room 3	Acetaldehyde	3	0 (0%)	<1.8	<2.0
Exam Room 3	Acetone	3	3 (100%)	—	—
Exam Room 3	Acetonitrile	3	0 (0%)	<1.6	<1.8
Exam Room 3	Benzene	3	0 (0%)	<1.8	<2.0
Exam Room 3	Chloroform	3	0 (0%)	<1.8	<2.0
Exam Room 3	Ethanol	3	3 (100%)	—	—
Exam Room 3	Ethylbenzene	3	0 (0%)	<1.8	<2.0
Exam Room 3	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 3	Methyl Methacrylate	3	3 (100%)	9.9	11.0
Exam Room 3	Methylene Chloride	3	0 (0%)	<1.8	<2.0
Exam Room 3	Styrene	3	0 (0%)	<1.8	<2.0
Exam Room 3	Toluene	3	0 (0%)	<1.8	<2.0
Exam Room 3	alpha-Pinene	3	1 (33%)	<1.7	1.9
Exam Room 3	d-Limonene	3	3 (100%)	6.9	9.9
Exam Room 3	m,p-Xylene	3	0 (0%)	<1.8	<2.0
Exam Room 3	n-Hexane	3	3 (100%)	—	—
Exam Room 3	o-Xylene	3	0 (0%)	<1.8	<2.0

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 4	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Exam Room 4	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5
Exam Room 4	2,3-Pentanedione	3	0 (0%)	<1.5	<1.6
Exam Room 4	Acetaldehyde	3	0 (0%)	<1.8	<1.9
Exam Room 4	Acetone	3	0 (0%)	<1.9	<2.0
Exam Room 4	Acetonitrile	3	0 (0%)	<1.6	<1.7
Exam Room 4	Benzene	3	0 (0%)	<1.8	<1.9
Exam Room 4	Chloroform	3	0 (0%)	<1.8	<1.9
Exam Room 4	Ethanol	3	3 (100%)	—	—
Exam Room 4	Ethylbenzene	3	0 (0%)	<1.8	<1.9
Exam Room 4	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 4	Methyl Methacrylate	3	3 (100%)	11.2	12.0
Exam Room 4	Methylene Chloride	3	0 (0%)	<1.8	<1.9
Exam Room 4	Styrene	3	0 (0%)	<1.8	<1.9
Exam Room 4	Toluene	3	1 (33%)	<1.8	3.7
Exam Room 4	alpha-Pinene	3	1 (33%)	<1.7	2.1
Exam Room 4	d-Limonene	3	3 (100%)	7.5	10.0
Exam Room 4	m,p-Xylene	3	0 (0%)	<1.8	<1.9
Exam Room 4	n-Hexane	3	3 (100%)	0.9	—
Exam Room 4	o-Xylene	3	0 (0%)	<1.8	<1.9
Exam Room 5	2,3-Butanedione	3	0 (0%)	<1.7	<1.9
Exam Room 5	2,3-Hexanedione	3	0 (0%)	<1.4	<1.6
Exam Room 5	2,3-Pentanedione	3	0 (0%)	<1.6	<1.7
Exam Room 5	Acetaldehyde	3	0 (0%)	<1.9	<2.0
Exam Room 5	Acetone	3	3 (100%)	—	—
Exam Room 5	Acetonitrile	3	0 (0%)	<1.7	<1.8
Exam Room 5	Benzene	3	0 (0%)	<1.9	<2.0
Exam Room 5	Chloroform	3	0 (0%)	<1.8	<2.0
Exam Room 5	Ethanol	3	3 (100%)	—	—
Exam Room 5	Ethylbenzene	3	0 (0%)	<1.8	<2.0
Exam Room 5	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 5	Methyl Methacrylate	3	3 (100%)	10.0	10.8
Exam Room 5	Methylene Chloride	3	0 (0%)	<1.9	<2.1
Exam Room 5	Styrene	3	0 (0%)	<1.9	<2.0

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 5	Toluene	3	1 (33%)	<1.9	7.1
Exam Room 5	alpha-Pinene	3	0 (0%)	<1.7	<1.9
Exam Room 5	d-Limonene	3	3 (100%)	6.8	10.5
Exam Room 5	m,p-Xylene	3	0 (0%)	<1.9	<2.1
Exam Room 5	n-Hexane	3	3 (100%)	8.0	—
Exam Room 5	o-Xylene	3	0 (0%)	<1.9	<2.0
Exam Room 6	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Exam Room 6	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5
Exam Room 6	2,3-Pentanedione	3	0 (0%)	<1.6	<1.6
Exam Room 6	Acetaldehyde	3	0 (0%)	<1.9	<2.0
Exam Room 6	Acetone	3	3 (100%)	—	—
Exam Room 6	Acetonitrile	3	0 (0%)	<1.7	<1.8
Exam Room 6	Benzene	3	0 (0%)	<1.9	<1.9
Exam Room 6	Chloroform	3	0 (0%)	<1.8	<1.9
Exam Room 6	Ethanol	3	3 (100%)	—	—
Exam Room 6	Ethylbenzene	3	0 (0%)	<1.8	<1.9
Exam Room 6	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 6	Methyl Methacrylate	3	3 (100%)	10.4	12.6
Exam Room 6	Methylene Chloride	3	0 (0%)	<1.9	<2.0
Exam Room 6	Styrene	3	0 (0%)	<1.9	<1.9
Exam Room 6	Toluene	3	0 (0%)	<1.9	<2.0
Exam Room 6	alpha-Pinene	3	2 (67%)	<=1.8	1.8
Exam Room 6	d-Limonene	3	3 (100%)	6.5	9.9
Exam Room 6	m,p-Xylene	3	0 (0%)	<1.9	<2.0
Exam Room 6	n-Hexane	3	3 (100%)	7.5	>7.5
Exam Room 6	o-Xylene	3	0 (0%)	<1.9	<1.9
Exam Room 7	2,3-Butanedione	3	0 (0%)	<1.8	<1.8
Exam Room 7	2,3-Hexanedione	3	0 (0%)	<1.5	<1.5
Exam Room 7	2,3-Pentanedione	3	0 (0%)	<1.6	<1.6
Exam Room 7	Acetaldehyde	3	0 (0%)	<1.9	<2.0
Exam Room 7	Acetone	3	3 (100%)	—	—
Exam Room 7	Acetonitrile	3	0 (0%)	<1.7	<1.8
Exam Room 7	Benzene	3	0 (0%)	<1.9	<1.9
Exam Room 7	Chloroform	3	0 (0%)	<1.9	<1.9

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 7	Ethanol	3	3 (100%)	—	—
Exam Room 7	Ethylbenzene	3	0 (0%)	<1.9	<1.9
Exam Room 7	Isopropyl Alcohol	3	3 (100%)	—	—
Exam Room 7	Methyl Methacrylate	3	3 (100%)	10.0	11.8
Exam Room 7	Methylene Chloride	3	0 (0%)	<1.9	<2.0
Exam Room 7	Styrene	3	0 (0%)	<1.9	<1.9
Exam Room 7	Toluene	3	0 (0%)	<1.9	<2.0
Exam Room 7	alpha-Pinene	3	1 (33%)	<1.8	1.8
Exam Room 7	d-Limonene	3	3 (100%)	6.7	9.9
Exam Room 7	m,p-Xylene	3	0 (0%)	<1.9	<2.0
Exam Room 7	n-Hexane	3	3 (100%)	7.7	—
Exam Room 7	o-Xylene	3	0 (0%)	<1.9	<1.9
Lab Area	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Lab Area	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5
Lab Area	2,3-Pentanedione	3	0 (0%)	<1.6	<1.6
Lab Area	Acetaldehyde	3	0 (0%)	<1.9	<2.0
Lab Area	Acetone	3	3 (100%)	—	—
Lab Area	Acetonitrile	3	0 (0%)	<1.7	<1.8
Lab Area	Benzene	3	0 (0%)	<1.9	<1.9
Lab Area	Chloroform	3	0 (0%)	<1.8	<1.9
Lab Area	Ethanol	3	3 (100%)	—	—
Lab Area	Ethylbenzene	3	0 (0%)	<1.8	<1.9
Lab Area	Isopropyl Alcohol	3	3 (100%)	—	—
Lab Area	Methyl Methacrylate	3	3 (100%)	11.4	11.9
Lab Area	Methylene Chloride	3	0 (0%)	<1.9	<2.0
Lab Area	Styrene	3	0 (0%)	<1.9	<1.9
Lab Area	Toluene	3	0 (0%)	<1.9	<2.0
Lab Area	alpha-Pinene	3	2 (67%)	<1.7	1.9
Lab Area	d-Limonene	3	3 (100%)	6.8	10.6
Lab Area	m,p-Xylene	3	0 (0%)	<1.9	<2.0
Lab Area	n-Hexane	3	3 (100%)	7.3	—
Lab Area	o-Xylene	3	0 (0%)	<1.9	<1.9
Sterilization	2,3-Butanedione	3	0 (0%)	<1.7	<1.8
Sterilization	2,3-Hexanedione	3	0 (0%)	<1.4	<1.5

Work Area	Analyte	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Sterilization	2,3-Pentanedione	3	0 (0%)	<1.6	<1.6
Sterilization	Acetaldehyde	3	0 (0%)	<1.9	<1.9
Sterilization	Acetone	3	3 (100%)	—	—
Sterilization	Acetonitrile	3	0 (0%)	<1.7	<1.7
Sterilization	Benzene	3	0 (0%)	<1.9	<1.9
Sterilization	Chloroform	3	0 (0%)	<1.8	<1.9
Sterilization	Ethanol	3	3 (100%)	—	—
Sterilization	Ethylbenzene	3	0 (0%)	<1.8	<1.9
Sterilization	Isopropyl Alcohol	3	3 (100%)	—	—
Sterilization	Methyl Methacrylate	3	3 (100%)	9.8	>9.8
Sterilization	Methylene Chloride	3	0 (0%)	<1.9	<1.9
Sterilization	Styrene	3	0 (0%)	<1.9	<1.9
Sterilization	Toluene	3	0 (0%)	<1.9	<1.9
Sterilization	alpha-Pinene	3	0 (0%)	<1.7	<1.8
Sterilization	d-Limonene	3	3 (100%)	6.7	11.7
Sterilization	m,p-Xylene	3	0 (0%)	<1.9	<1.9
Sterilization	n-Hexane	3	3 (100%)	7.4	—
Sterilization	o-Xylene	3	0 (0%)	<1.9	<1.9

N=number of samples; LOD=limit of detection; PPB=parts per billion. "—" indicates measurements above the calibration maximum.

Table C6. Instantaneous canister measurements of volatile organic compounds collected in the breathing zone of an employee while using aluminum oxide in the enclosed sandblaster in the lab area, June 2019.

Analyte	N	Above LOD, N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
2,3-Butanedione	2	0 (0%)	<0.7	<0.7
2,3-Hexanedione	2	1 (50%)	<1.1	1.8
2,3-Pentanedione	2	0 (0%)	<0.7	<0.8
Acetaldehyde	2	2 (100%)	17.9	18.3
Acetone	2	2 (100%)	96.7	98.4
Acetonitrile	2	0 (0%)	<1.9	<2.0
Benzene	2	1 (50%)	<0.4	1.1
Chloroform	2	2 (100%)	1.4	1.5
D-Limonene	2	2 (100%)	5.1	7.3
Ethanol	2	2 (100%)	—	—
Ethylbenzene	2	0 (0%)	<0.4	<0.4
Isopropyl Alcohol	2	2 (100%)	—	—
Methyl Methacrylate	2	2 (100%)	10.9	12.2
Methylene Chloride	2	1 (50%)	<0.1	0.4
Styrene	2	1 (50%)	<0.7	1.6
Toluene	2	0 (0%)	<0.6	<0.6
alpha-Pinene	2	0 (0%)	<0.5	<0.5
m,p-Xylene	2	2 (100%)	1.0	1.0
n-Hexane	2	2 (100%)	1.5	1.5
o-Xylene	2	0 (0%)	<0.2	<0.2

N=number of samples; LOD=limit of detection; PPB=parts per billion. "—" indicates measurements above the calibration maximum.

Table C7. Instantaneous canister measurements of sources of volatile organic compounds during specific tasks, June 2019.

Work Area	Analyte	Source Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	2,3-Butanedione	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.6	<0.6
Exam Room 2	2,3-Butanedione	Collected above patient's head during removal of amalgam	1	0 (0%)	<0.7	<0.7
Exam Room 2	2,3-Butanedione	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.8	<0.8
Exam Room 2	2,3-Hexanedione	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.9	<0.9
Exam Room 2	2,3-Hexanedione	Collected above patient's head during removal of amalgam	1	0 (0%)	<1.0	<1.0
Exam Room 2	2,3-Hexanedione	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<1.2	<1.2
Exam Room 2	2,3-Pentanedione	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.6	<0.6
Exam Room 2	2,3-Pentanedione	Collected above patient's head during removal of amalgam	1	0 (0%)	<0.7	<0.7
Exam Room 2	2,3-Pentanedione	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.9	<0.9
Exam Room 2	Acetaldehyde	Collected above patient's head during placement of amalgam	1	1 (100%)	21.9	21.9
Exam Room 2	Acetaldehyde	Collected above patient's head during removal of amalgam	1	1 (100%)	23.7	23.7
Exam Room 2	Acetaldehyde	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	28.9	28.9
Exam Room 2	Acetone	Collected above patient's head during placement of amalgam	1	1 (100%)	156.5	156.5
Exam Room 2	Acetone	Collected above patient's head during removal of amalgam	1	1 (100%)	181.0	181.0
Exam Room 2	Acetone	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	193.8	193.8
Exam Room 2	Acetonitrile	Collected above patient's head during placement of amalgam	1	0 (0%)	<1.7	<1.7
Exam Room 2	Acetonitrile	Collected above patient's head during removal of amalgam	1	0 (0%)	<1.8	<1.8
Exam Room 2	Acetonitrile	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<2.3	<2.3

Work Area	Analyte	Source Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	Benzene	Collected above patient's head during placement of amalgam	1	1 (100%)	1.0	1.0
Exam Room 2	Benzene	Collected above patient's head during removal of amalgam	1	1 (100%)	1.1	1.1
Exam Room 2	Benzene	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	3.0	3.0
Exam Room 2	Chloroform	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.0	<0.0
Exam Room 2	Chloroform	Collected above patient's head during removal of amalgam	1	1 (100%)	0.9	0.9
Exam Room 2	Chloroform	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.0	<0.0
Exam Room 2	D-Limonene	Collected above patient's head during placement of amalgam	1	1 (100%)	5.8	5.8
Exam Room 2	D-Limonene	Collected above patient's head during removal of amalgam	1	1 (100%)	7.3	7.3
Exam Room 2	D-Limonene	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	6.9	6.9
Exam Room 2	Ethanol	Collected above patient's head during placement of amalgam	1	1 (100%)	—	—
Exam Room 2	Ethanol	Collected above patient's head during removal of amalgam	1	1 (100%)	—	—
Exam Room 2	Ethanol	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	—	—
Exam Room 2	Ethylbenzene	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.4	<0.4
Exam Room 2	Ethylbenzene	Collected above patient's head during removal of amalgam	1	0 (0%)	<0.4	<0.4
Exam Room 2	Ethylbenzene	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.5	<0.5
Exam Room 2	Isopropyl Alcohol	Collected above patient's head during placement of amalgam	1	1 (100%)	—	—
Exam Room 2	Isopropyl Alcohol	Collected above patient's head during removal of amalgam	1	1 (100%)	—	—
Exam Room 2	Isopropyl Alcohol	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	—	—

Work Area	Analyte	Source Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	Methyl Methacrylate	Collected above patient's head during placement of amalgam	1	1 (100%)	9.4	9.4
Exam Room 2	Methyl Methacrylate	Collected above patient's head during removal of amalgam	1	1 (100%)	10.0	10.0
Exam Room 2	Methyl Methacrylate	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	9.9	9.9
Exam Room 2	Methylene Chloride	Collected above patient's head during placement of amalgam	1	1 (100%)	0.4	0.4
Exam Room 2	Methylene Chloride	Collected above patient's head during removal of amalgam	1	0 (0%)	<0.1	<0.1
Exam Room 2	Methylene Chloride	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.1	<0.1
Exam Room 2	Styrene	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.6	<0.6
Exam Room 2	Styrene	Collected above patient's head during removal of amalgam	1	1 (100%)	3.4	3.4
Exam Room 2	Styrene	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	1.8	1.8
Exam Room 2	Toluene	Collected above patient's head during placement of amalgam	1	1 (100%)	1.8	1.8
Exam Room 2	Toluene	Collected above patient's head during removal of amalgam	1	1 (100%)	0.7	0.7
Exam Room 2	Toluene	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.7	<0.7
Exam Room 2	alpha-Pinene	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.4	<0.4
Exam Room 2	alpha-Pinene	Collected above patient's head during removal of amalgam	1	0 (0%)	<0.4	<0.4
Exam Room 2	alpha-Pinene	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.5	<0.5
Exam Room 2	m,p-Xylene	Collected above patient's head during placement of amalgam	1	1 (100%)	0.9	0.9
Exam Room 2	m,p-Xylene	Collected above patient's head during removal of amalgam	1	1 (100%)	0.9	0.9
Exam Room 2	m,p-Xylene	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	1.1	1.1

Work Area	Analyte	Source Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	n-Hexane	Collected above patient's head during placement of amalgam	1	1 (100%)	26.7	26.7
Exam Room 2	n-Hexane	Collected above patient's head during removal of amalgam	1	1 (100%)	28.6	28.6
Exam Room 2	n-Hexane	Collected above dentist's shoulder during removal of amalgam	1	1 (100%)	29.1	29.1
Exam Room 2	o-Xylene	Collected above patient's head during placement of amalgam	1	0 (0%)	<0.2	<0.2
Exam Room 2	o-Xylene	Collected above patient's head during removal of amalgam	1	0 (0%)	<0.2	<0.2
Exam Room 2	o-Xylene	Collected above dentist's shoulder during removal of amalgam	1	0 (0%)	<0.2	<0.2

N=number of samples; LOD=limit of detection; PPB=parts per billion. "—" indicates measurements above the calibration maximum.

Table C8. Instantaneous canister measurements of volatile organic compounds by work area, June 2019

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Downstairs	2,3-Butanedione	Sample collected in center of the room in old lab area	1	0 (0%)	<0.6	<0.6
Downstairs	2,3-Butanedione	Sample collected in center of the office downstairs	1	0 (0%)	<0.6	<0.6
Downstairs	2,3-Butanedione	Sample collected in closet with electrical equipment and scrubs jacket	1	0 (0%)	<0.6	<0.6
Downstairs	2,3-Hexanedione	Sample collected in center of the room in old lab area	1	0 (0%)	<0.9	<0.9
Downstairs	2,3-Hexanedione	Sample collected in center of the office downstairs	1	0 (0%)	<0.9	<0.9
Downstairs	2,3-Hexanedione	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	1.7	1.7
Downstairs	2,3-Pentanedione	Sample collected in center of the room in old lab area	1	0 (0%)	<0.6	<0.6
Downstairs	2,3-Pentanedione	Sample collected in center of the office downstairs	1	0 (0%)	<0.6	<0.6
Downstairs	2,3-Pentanedione	Sample collected in closet with electrical equipment and scrubs jacket	1	0 (0%)	<0.6	<0.6
Downstairs	Acetaldehyde	Sample collected in center of the room in old lab area	1	1 (100%)	22.1	22.1
Downstairs	Acetaldehyde	Sample collected in center of the office downstairs	1	1 (100%)	25.1	25.1
Downstairs	Acetaldehyde	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	47.9	47.9
Downstairs	Acetone	Sample collected in center of the room in old lab area	1	1 (100%)	97.4	97.4
Downstairs	Acetone	Sample collected in center of the office downstairs	1	1 (100%)	97.9	97.9
Downstairs	Acetone	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	88.5	88.5
Downstairs	Acetonitrile	Sample collected in center of the room in old lab area	1	0 (0%)	<1.6	<1.6
Downstairs	Acetonitrile	Sample collected in center of the office downstairs	1	0 (0%)	<1.6	<1.6
Downstairs	Acetonitrile	Sample collected in closet with electrical equipment and scrubs jacket	1	0 (0%)	<1.6	<1.6

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Downstairs	Benzene	Sample collected in center of the room in old lab area	1	1 (100%)	1.0	1.0
Downstairs	Benzene	Sample collected in center of the office downstairs	1	1 (100%)	1.0	1.0
Downstairs	Benzene	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	0.9	0.9
Downstairs	Chloroform	Sample collected in center of the room in old lab area	1	1 (100%)	0.6	0.6
Downstairs	Chloroform	Sample collected in center of the office downstairs	1	1 (100%)	0.7	0.7
Downstairs	Chloroform	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	0.7	0.7
Downstairs	D-Limonene	Sample collected in center of the room in old lab area	1	1 (100%)	33.7	33.7
Downstairs	D-Limonene	Sample collected in center of the office downstairs	1	1 (100%)	18.9	18.9
Downstairs	D-Limonene	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	15.7	15.7
Downstairs	Ethanol	Sample collected in center of the room in old lab area	1	1 (100%)	—	—
Downstairs	Ethanol	Sample collected in center of the office downstairs	1	1 (100%)	—	—
Downstairs	Ethanol	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	—	—
Downstairs	Ethylbenzene	Sample collected in center of the room in old lab area	1	0 (0%)	<0.4	<0.4
Downstairs	Ethylbenzene	Sample collected in center of the office downstairs	1	0 (0%)	<0.4	<0.4
Downstairs	Ethylbenzene	Sample collected in closet with electrical equipment and scrubs jacket	1	0 (0%)	<0.4	<0.4
Downstairs	Isopropyl Alcohol	Sample collected in center of the room in old lab area	1	1 (100%)	—	—
Downstairs	Isopropyl Alcohol	Sample collected in center of the office downstairs	1	1 (100%)	—	—
Downstairs	Isopropyl Alcohol	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	—	—

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Downstairs	Methyl Methacrylate	Sample collected in center of the room in old lab area	1	1 (100%)	125.5	125.5
Downstairs	Methyl Methacrylate	Sample collected in center of the office downstairs	1	1 (100%)	24.8	24.8
Downstairs	Methyl Methacrylate	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	22.5	22.5
Downstairs	Methylene Chloride	Sample collected in center of the room in old lab area	1	1 (100%)	0.4	0.4
Downstairs	Methylene Chloride	Sample collected in center of the office downstairs	1	1 (100%)	0.4	0.4
Downstairs	Methylene Chloride	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	0.5	0.5
Downstairs	Styrene	Sample collected in center of the room in old lab area	1	1 (100%)	1.7	1.7
Downstairs	Styrene	Sample collected in center of the office downstairs	1	1 (100%)	1.6	1.6
Downstairs	Styrene	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	1.6	1.6
Downstairs	Toluene	Sample collected in center of the room in old lab area	1	1 (100%)	2.7	2.7
Downstairs	Toluene	Sample collected in center of the office downstairs	1	1 (100%)	0.9	0.9
Downstairs	Toluene	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	2.1	2.1
Downstairs	alpha-Pinene	Sample collected in center of the room in old lab area	1	0 (0%)	<0.4	<0.4
Downstairs	alpha-Pinene	Sample collected in center of the office downstairs	1	0 (0%)	<0.4	<0.4
Downstairs	alpha-Pinene	Sample collected in closet with electrical equipment and scrubs jacket	1	0 (0%)	<0.4	<0.4
Downstairs	m,p-Xylene	Sample collected in center of the room in old lab area	1	1 (100%)	1.0	1.0
Downstairs	m,p-Xylene	Sample collected in center of the office downstairs	1	1 (100%)	0.9	0.9
Downstairs	m,p-Xylene	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	1.1	1.1
Downstairs	n-Hexane	Sample collected in center of the room in old lab area	1	1 (100%)	10.9	10.9

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Downstairs	n-Hexane	Sample collected in center of the office downstairs	1	1 (100%)	8.5	8.5
Downstairs	n-Hexane	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	7.8	7.8
Downstairs	o-Xylene	Sample collected in center of the room in old lab area	1	1 (100%)	0.6	0.6
Downstairs	o-Xylene	Sample collected in center of the office downstairs	1	0 (0%)	<0.1	<0.1
Downstairs	o-Xylene	Sample collected in closet with electrical equipment and scrubs jacket	1	1 (100%)	0.7	0.7
Exam Room 2	2,3-Butanedione	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.7	<0.7
Exam Room 2	2,3-Hexanedione	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<1.0	<1.0
Exam Room 2	2,3-Pentanedione	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.7	<0.7
Exam Room 2	Acetaldehyde	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	26.4	26.4
Exam Room 2	Acetone	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	180.2	180.2
Exam Room 2	Acetonitrile	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<1.9	<1.9
Exam Room 2	Benzene	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	1.1	1.1
Exam Room 2	Chloroform	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.0	<0.0
Exam Room 2	D-Limonene	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	6.9	6.9

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Exam Room 2	Ethanol	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	—	—
Exam Room 2	Ethylbenzene	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.4	<0.4
Exam Room 2	Isopropyl Alcohol	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	—	—
Exam Room 2	Methyl Methacrylate	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	9.7	9.7
Exam Room 2	Methylene Chloride	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.1	<0.1
Exam Room 2	Styrene	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	1.6	1.6
Exam Room 2	Toluene	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.6	<0.6
Exam Room 2	alpha-Pinene	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.5	<0.5
Exam Room 2	m,p-Xylene	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	1.0	1.0
Exam Room 2	n-Hexane	Sample collected in center of exam room at completion of amalgam replacement	1	1 (100%)	27.3	27.3
Exam Room 2	o-Xylene	Sample collected in center of exam room at completion of amalgam replacement	1	0 (0%)	<0.2	<0.2
Lab Area	2,3-Butanedione	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	2.3	2.3

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Lab Area	2,3-Hexanedione	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	3.3	3.3
Lab Area	2,3-Pentanedione	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<1.2	<1.2
Lab Area	Acetaldehyde	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<2.3	<2.3
Lab Area	Acetone	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	276.5	276.5
Lab Area	Acetonitrile	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<3.0	<3.0
Lab Area	Benzene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	1.7	1.7
Lab Area	Chloroform	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	0.8	0.8
Lab Area	D-Limonene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	5.1	5.1
Lab Area	Ethanol	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	—	—
Lab Area	Ethylbenzene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<0.7	<0.7
Lab Area	Isopropyl Alcohol	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	—	—
Lab Area	Methyl Methacrylate	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	9.9	9.9

Work Area	Analyte	Area Description	N	Above LOD N (%)	Minimum Concentration (PPB)	Maximum Concentration (PPB)
Lab Area	Methylene Chloride	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<0.2	<0.2
Lab Area	Styrene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<1.0	<1.0
Lab Area	Toluene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	2.6	2.6
Lab Area	alpha-Pinene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<0.7	<0.7
Lab Area	m,p-Xylene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	1.4	1.4
Lab Area	n-Hexane	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	1 (100%)	3.1	3.1
Lab Area	o-Xylene	Sample collected in lab area during abrasive procedure with enclosed sandblaster	1	0 (0%)	<0.3	<0.3

N=number of samples; LOD=limit of detection; PPB=parts per billion. "—" indicates measurements above the calibration maximum.

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 pre-existing 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 (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, and 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 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 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, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Other set of OELs commonly used and cited in the United States include 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 2020].

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 http://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.

Section E: References

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