HealthHazard® Evaluation Program

Evaluation of Workplace Exposures in a School Ceramics and Visual Arts Studio

HHE Report No. 2023-0069-3420

August 2025

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Authors: **M. Colleen O'Connor, MPH**

Jessica L. Rinsky, PhD, MPH

Analytical Support: Bureau Veritas North America, Inc.

Desktop Publisher: Shawna Watts

Editor: Cheryl Hamilton

Industrial Hygiene Field Assistance: Kevin L. Dunn

Logistics: Donald Booher

Keywords: North American Industry Classification System (NAICS) 611110 (Elementary and Secondary Schools), North Carolina, Art Studios, Sculpture, Ceramics, Ventilation, Respirable Crystalline Silica, Respirable Dust

The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 [29 USC 669a(6)]. The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations [42 CFR Part 85].

Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date.

Availability of Report

Recommended Citation

NIOSH [2025]. Evaluation of workplace exposures in a school ceramics and visual arts studio. By O'Connor MC, Rinsky JL. Cincinnati, OH: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Health Hazard Evaluation Report 2023-0069-3420, https://www.cdc.gov/niosh/hhe/reports/pdfs/2023-0069-3420.pdf.

Table of Contents

Main Report

Supporting Technical Information

This page left intentionally blank

Introduction

Request

Management of a school requested a health hazard evaluation of their ceramics and visual arts studio, referred to as the art studio hereafter. They were interested in an assessment of potential exposures related to ceramics, including exposure to respiratory hazards such as respirable crystalline silica.

Workplace

At the time of our visit, the school served children pre-Kindergarten through 12th grade. Two teachers used the art studio for their classes, which included ceramics, drawing, oil painting, printmaking, and photography classes. The ceramics classes were open to high school students and included hand building and wheel throwing techniques. The art studio was about 1,015 square feet, with a 10-foot ceiling, and was located on the first floor of a two-story building. The second floor of the building was only accessible by an outdoor staircase. The art studio included a main studio room, storage closet, small office used as storage, and photography dark room. A portion of the main studio room was designated as a lounge area where students socialized between classes and during lunch periods. A kiln room, which housed two electric kilns, was accessible through a back hallway.

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

Our Approach

We visited the school during December 2023, to learn more about the art studio space, potential hazards, and health concerns associated with the art studio. We completed the following activities during our visit:

- Observed a ceramics class, including set-up, and clean-up procedures.
- Collected air samples for respirable dust, respirable crystalline silica, and respirable metals.
- Tested surfaces throughout the art studio for metals.
- Assessed the ventilation system throughout the art studio space.

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

Our Key Findings

Metals were present on all surfaces tested

- All surfaces tested positive for at least one of the metals it was tested for. Surfaces included benchtop and tabletop spaces used as clay workstations and near the dedicated clay sink, a windowsill, the top of a washer/dryer unit, the teacher's desk, and a bathroom door handle.
- Some samples, while positive, had results close to the lower detectable limits of the laboratory tests. This means we cannot be certain about the quantity of metals present on those surfaces.
- No occupational exposure limits for metals on surfaces exist to compare to our results. However, the presence of metals on surfaces indicated the need to improve cleaning protocols and practice good hand hygiene before eating, drinking, or other activities.

Respirable dust, respirable crystalline silica, and respirable metals were not present in any of the air samples collected

- We found no respirable dust, respirable crystalline silica, or respirable metals in the samples. These results mean that either none of the dust was present in the air or that the amount present was too small to be detected by the laboratory.

The art studio space was not set up to meet the needs of its occupants

- The ventilation system in the art studio was not sufficient for the space, leaving areas of the room without adequate airflow.
- Back hallway and office spaces were being used as storage; however, objects were not necessarily stored securely and could pose a hazard if they were to fall.
- Cluttered spaces may allow for moisture to get trapped and create conditions that encourage mold and mildew growth.
- Egress (exits) from the dark room and back office were limited due to storage along the hallway. This could be dangerous in case of an emergency evacuation.
- Some chemicals and materials had been placed into secondary containers without proper labeling or were not being stored per manufacturers' recommendations.

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

Our Recommendations

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

Potential Benefits of Improving Workplace Health and Safety:

- ↑ Improved worker health and well-being
- ↑ Better workplace morale
- ↑ Easier employee recruiting and retention
- ↑ Enhanced image and reputation
- ↑ Superior products, processes, and services
- ↑ Increased 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 practical, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/hierarchy-of-controls/about/index.html.

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

Recommendation 1: Improve housekeeping and clean-up procedures

Why? Metals such as lead, cadmium, or nickel are found in many visual art materials including clay, glaze, and paint. Certain metals can be toxic to all organ systems and serve no useful purpose in the body. Other metals may be found at lower levels in the body, but at elevated levels, they can be toxic. Overexposure or unnecessary exposure to some metals can cause nonspecific symptoms and, over time, can cause or worsen some chronic conditions such as high blood pressure. When metals are on surfaces, there is also potential for people to carry those metals out of the workplace.

We found that at least one metal was present on all the surfaces we tested in the art studio. The presence of metals on surfaces indicated that additional steps can be taken to improve housekeeping and clean-up procedures to reduce the concentration of metals on surfaces. This is especially important for frequently touched surfaces.

While most of the furniture and surfaces within the art classroom were easily cleaned using wet cleaning methods, the cloth furniture and carpeting we observed at the front of the classroom can be challenging to keep clean because of their porous nature.

Providing adequate storage space for materials would allow for easier cleanup and minimize the risk of harm from falling objects or slip and trip hazards. In addition, ensuring that all hazardous materials are correctly labeled and stored per manufacturers' recommendations will minimize accidental exposures.

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

Develop and implement a cleaning protocol that minimizes metals and clay residue on work surfaces.

- Use clean cloths, sponges, or paper towels dampened with water to clean surfaces where clay has been worked.
- Ensure that cleaning materials, if reusable (for example, cloths and sponges), are adequately cleaned after each use to minimize the risk of leaving metals and other contaminants on classroom surfaces. Launder cloths in the washer and dryer located in the classroom space, and clean sponges in the sink.
- Wipe work surfaces a second time with clean, wet cloths to remove remaining clay residue.

Minimize upholstered furnishings and carpeting.

- Upholstered furnishings and carpeting are harder to clean than nonporous materials and can accumulate clay dust.
- Use furniture that is easy to clean using wet methods, if possible.

Ensure adequate storage for all classroom materials.

- Having adequate storage for all supplies needed for visual art classes will allow materials to be stored without creating slip, trip and fall hazards, and will maintain adequate exits from all areas of the space.
- Minimizing overcrowding of materials will allow better airflow throughout the classroom and will reduce the likelihood of moisture becoming trapped, leading to mold and mildew growth.

Store materials safely and appropriately.

- Make sure to properly store materials, based on the material type, in a way that reduces the risk of physical hazards.
- Ensure all areas follow fire safety codes for safe egress.

- Follow best practices for chemical storage.
    - Follow manufacturers' recommendations for storage.
    - Try to store chemicals in their original containers. If it is necessary to transfer materials to other secondary containers, make sure those containers are well labeled and appropriate for the chemical they contain.
    - Follow all guidelines about hazardous materials storage from the North Carolina Department of Public Safety (https://www.ncdps.gov/our-organization/emergency-management/hazardous-materials/hazardous-materials-storage).

Recommendation 2: Evaluate the art classroom ventilation system

Why? Properly designed, installed, and maintained heating, ventilating, and air-conditioning (HVAC) systems can help reduce indoor contaminants, and maintain comfort parameters (temperature, humidity) at recommended levels. This will reduce potential exposures and associated symptoms for those who occupy the building. Improvements to the ventilation system performance will ensure that school resources are used efficiently and conditions within the art studio space are optimized.

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

Consult with a licensed professional ventilation engineer to assess the art studio ventilation system.

- The licensed professional ventilation engineer should have experience in the design of HVAC systems for educational environments including multiuse areas (such as classrooms, dining and kitchen areas, gymnasiums, and offices) and be familiar with the type of system in the art studio.
- Work with this professional to assess local exhaust ventilation for the kilns and determine best practices for ventilating the kiln room when kilns are on.

Recommendation 3: Follow best practices for multiuse spaces to ensure employee safety in the art studio

Why? Employee safety is key to a healthy, productive, and enjoyable work environment. An art studio may have multiple hazards that can cause worker illness or injury. Identifying potential hazards and providing adequate control measures to address the hazards will provide a safer work environment.

We were told, and we observed, that employees and students used the art classroom as an eating space during lunch and other times. Employees and students primarily sat in the lounge area at the front of the room but also sat at the large table in the main classroom space where classes occur.

In discussions, employees and management raised questions about whether the exposures we evaluated could be associated with negative health effects. Applying best practices, for example, not eating in the workspace, can help reduce unnecessary exposures, and the risk of potentially related symptoms or conditions among employees.

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

Install eyewash stations that are easy to access in case of an emergency. For example, put one in the main art classroom, the photography dark room, or wherever chemicals are being used.

- If installing an additional eyewash station inside the art studio is not possible, consider converting one of the studio sinks to an eyewash station.

Develop standard operating procedures for any personal protective equipment that is used.

- Standard operating procedures should include: (1) a description of what personal protective equipment is available to employees; (2) when using protective equipment is required or should be considered; and (3) proper training for protective equipment use, maintenance, and storage.

Prohibit eating and drinking in areas where ceramic or chemical use occurs.

- Identify alternative spaces that are safe for eating and drinking.
- Encourage both employees and students to use the alternative spaces.

If medical concerns arise related to exposures at work, encourage employees to seek care from a healthcare provider who is knowledgeable in occupational and environmental medicine.

- The American College of Occupational and Environmental Medicine (https://acoem.org/Find-a-Provider) and the Association of Occupational and Environmental Clinics (http://www.aoec.org/index.htm) maintain databases of providers to help locate an occupational medicine clinician in your geographic area.

Supporting Technical Information

Evaluation of Workplace Exposures in a School Ceramics and Visual Arts Studio

HHE Report No. 2023-0069-3420

August 2025

Section A: Workplace Information

Building

The school served children pre-Kindergarten through 12th grade. Ceramics classes were taught within the school's multiuse art studio. The ceramics classes included hand building and wheel throwing techniques. The art studio also held classes like drawing, oil painting, printmaking, and photography. The main studio room was approximately 1,015 square feet (ft^2), with a 10 ft ceiling, and located on the first floor of a two-story building. The second floor was only accessible via an outdoor staircase. The art studio also included a storage closet, a small office used as storage, and a photography dark room. The main studio space contained two sinks, one of which was dedicated solely to clay and ceramics. A portion of the main studio room was designated as a lounge area where students socialized between classes and during lunch periods. A kiln room was accessible through a back hallway. It housed two electric kilns. An eyewash station was located in the back hallway next to the classroom door along with two single occupant restrooms. The building had heat and air conditioning; however, doors and windows were often open throughout the day. A technology classroom was also on the first floor of the building.

Employee Information

- Two teachers primarily occupied and taught in the art studio. They were responsible for teaching the ceramics and visual arts classes. Both taught other classes on campus.
- Our observations focused on the ceramics teacher's class periods.

Process Description

The school day was from 8:30 a.m. to 3:15 p.m., with each class lasting 70 minutes. The school offered various ceramics classes throughout the year; however, not every class was offered year-round. During our visit in December 2023, a hand building techniques ceramics class was being offered. During the class, students worked on their individual projects around the classroom while the ceramics teacher observed and provided feedback. The ceramics classes primarily used premixed clays and glazes, but once per term the teacher prepared plaster for the plaster sculpture class. The teacher completed this task outdoors. Glazes were either painted on with brushes or the pieces were dipped into the glazes using tongs. Students and teachers were responsible for cleaning the classroom after each class session; janitorial staff did not clean the space. During free periods, students were able to come into the art studio and worked on individual projects. At least one teacher was present during the free periods to assist students, as needed.

Section B: Methods, Results, and Discussion

Methods: Observation of Work Processes, Practices, and Conditions

We observed the following activities during our site visit:

- Ceramics class
- Cleaning processes
- Workplace conditions

In addition to observing classroom activities, we took air flow measurements with a hot wire anemometer to do a basic evaluation of the ventilation system throughout the space. We toured the classroom and the storage areas they used. Finally, we talked with the teachers about safety procedures in place and any use of personal protective equipment (PPE).

Results: Observation of Work Processes, Practices, and Conditions

Cleaning

Students and teachers were responsible for cleaning up the classroom after each class period. We observed the clean-up procedures after the ceramic hand building class. Cleaning methods varied from person to person. However, most people used the sponges they had used to work the clay to clean up the tabletops and workboards. Many of the workstations had a clay residue left behind after cleaning was completed.

Storage

At one end of the main art studio were storage rooms, an office, and a hallway that were over-filled with materials and supplies. The conditions created potential hazards such as risk of materials falling from overfilled overhead storage, and provided conditions in which moisture could become trapped and potentially lead to mold growth and dust collection. Hallways also had materials stored in a way that created narrow passageways that could be a fire hazard. Additionally, in some instances chemicals were stored in secondary containers without clear labels or were not stored according to the manufacturer's best practices.

Safety

Due to the variety of classes offered, as well as the different types of materials and chemicals used, the school had installed an eyewash station. The eyewash station was located in the back hallway between the art classroom and the computer lab.

We observed that employees and students ate and drank in the art classroom throughout the day. Primarily, food was eaten in the lounge area at the front of the classroom, however, the large table in the main classroom was also used. Bathrooms and a sink in the classroom were available for handwashing, but no policies or signage existed encouraging occupants to wash their hands before eating or drinking in the art studio space.

Ventilation

The first floor of the building had a single air return vent located in the back hallway across from the kiln room. We confirmed through basic air flow measurements that the ventilation system was working. We observed noticeable air flow through the return. However, measurements showed that air movement decreased as we moved farther away from the return vent. There were no other return vents located throughout the art studio.

A louver was placed at the bottom of the door leading to the back hallway to allow airflow even when the door was closed. The supply vents located throughout the art studio had low to no measurable airflow, making it unclear where the supply air was originating. We were informed and confirmed through observation that many doors and windows were open throughout the school day to increase airflow, which potentially decreased the efficiency of the ventilation system of the first floor. The second floor of the building had a separate ventilation system from the first floor.

The kiln room contained two electric kilns, however, only one was operational at the time of our visit. The local exhaust ventilation control for the functioning kiln did not work. Employees reported that when the kiln was firing, the space could become extremely warm, and doors and windows often needed to be opened.

Personal Protective Equipment

Finally, we discussed the use of PPE like nitrile gloves and N95® filtering facepiece respirators with the employees. While these items were said to be available for employees for voluntary use during activities like glaze or plaster mixing, it was unclear where the PPE was located. We also observed no clear guidance for proper PPE usage.

Methods: Exposure Assessment

Air Sampling

During our visit in December 2023, we collected air samples for respirable dust and respirable crystalline silica (RCS) from the breathing zone of one teacher and from one location in the classroom. We used three-piece, 37-millimeter diameter cassettes with 5-micrometer (µm) pore size polyvinyl chloride filters. We used a Mesa Labs Model GK 2.69 high flow personal sampling cyclone at a flow rate of 4.20 liters per minute.

- We analyzed each sample for respirable dust and RCS using NIOSH Methods 0600 [NIOSH 1998] and 7500 [NIOSH 2003].
- We collected samples for the duration of the teacher's time in the classroom, which was approximately 4 hours.

We collected an area air sample for total metals in one location around the classroom. We used a 37-millimeter diameter cassette with Solu-CAP and an 0.8 µm MCE filter. Samples were collected at a flow rate of 4.0 liters per minute.

- We analyzed the sample for respirable metals using NIOSH Method 7306 [NIOSH 2015].

- We collected the sample for the duration of the teacher's time in the classroom, which was approximately 4 hours.

Direct Reading Instruments

To characterize any airborne particulate that occurred during ceramics classes and related activities, we used the TSI Personal Aerosol Monitor (SidePak™) photometer that measures total mass concentrations in milligrams per cubic meter (mg/m^3) with a particle size ranging 100–10,000 nanometers. The data collected show inhalable particle mass concentrations in real time. These instruments were placed on the center island and on the benchtop next to the wall of windows, both of which were used as clay workstations during class periods. Note that windows near direct reading instruments were closed for the duration of the sampling.

Surface Wipe Sampling

We collected surface wipe samples for metals in eight locations in and around the classroom. We used Environmental Express® GhostWipe® Moist Wipes on a 10 by 10-centimeter area each.

Results: Exposure Assessment

Air Sampling

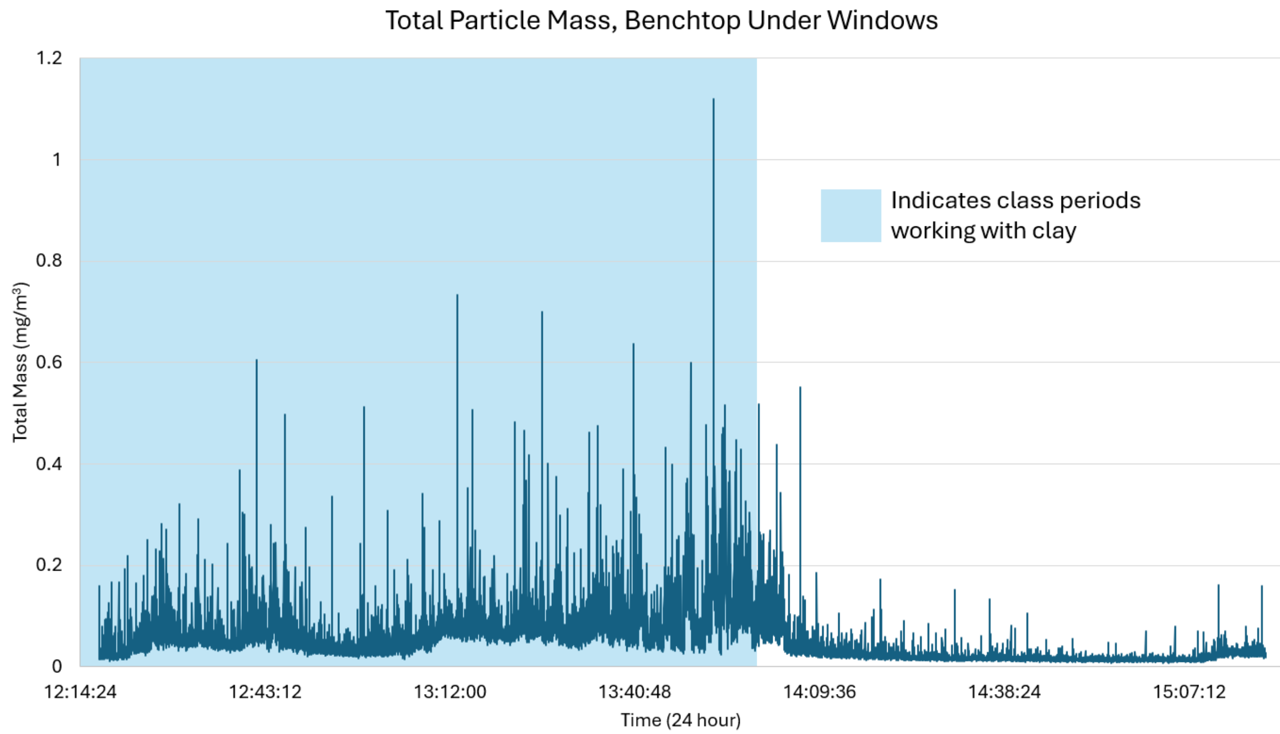
No RCS or respirable dust was detected in the personal sample. The results and the corresponding permissible exposure limits (PELs) set by the Occupational Safety and Health Administration (OSHA) are shown in Tables C1 and C2 in Section C of this report. The PELs correspond to an exposure over an 8-hour workday.

Additional area air samples were collected on the center island table. This was located in the middle of the art studio and was where students worked on ceramics projects throughout the course of the day. These samples were analyzed for RCS, respirable dust, and metals. No RCS, respirable dust, or metals were detected in the area samples.

Direct Reading Instruments

Afternoon classes, which included the ceramics class and an independent project period, were associated with higher concentrations of airborne particulate. Both activities involved clay-based projects. Clean-up for the clay projects took about 30 minutes, which was followed by a student-led oil painting class. We noted no clearly defined spikes in particle mass concentration, but total mass dropped below 0.2 mg/m^3 after clay-related activities ended, just before the oil painting class began. During clay-based class periods and clean-up, students and the teacher continually moved around the classroom and activity was generally higher. During the oil painting class, the activity was much lower. This can be seen in the Figure B1 graphs, with the classes involving clay work in the shaded area.

(A)



(B)

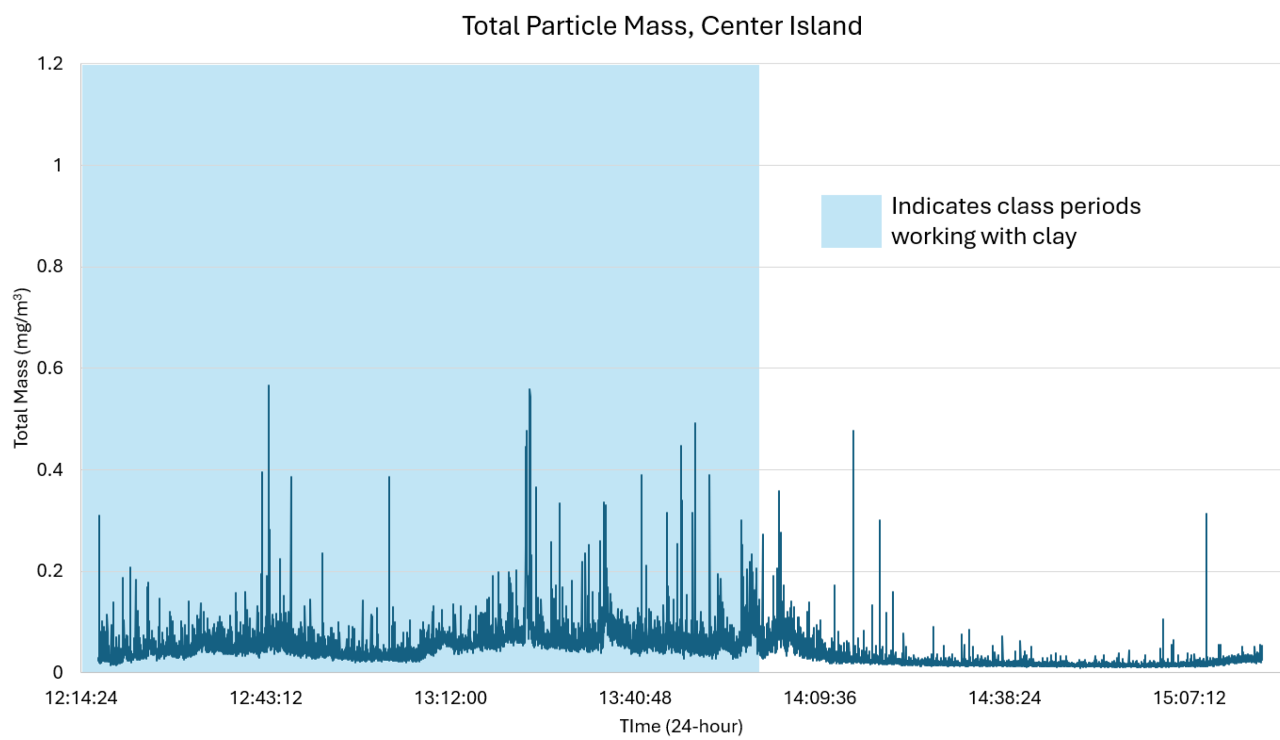


Figure B1. Total particle mass (mg/m^3) as measured during a 3-hour period on the (A) benchtop under the window, and (B) center island.

Surface Wipe Sampling

Every surface sampled came back positive for at least one of the metals tested. A positive result, designated in Table C3 by a "+," indicates the sample collected returned a result for the metal tested. The values are above the limit of detection but may not be above the limit of quantitation. This means that for some samples, while the metal was detected, it was too low for the lab to quantify it accurately.

Occupational exposure limits for surface contamination with metals do not exist, but the recommendation per OSHA is to have surface contamination be "as free as practicable" to minimize the potential for ingestion or skin absorption after contact with contaminated surfaces [AIHA 2020; OSHA 1992, 1995, 2006]. OSHA provides some additional guidance here with regard to specific contaminants: https://www.osha.gov/surface-contamination/standards. AIHA provides additional context and guidance regarding metals on surfaces here: https://publications.aiha.org/202010-conquering-toxic-metals.

Discussion

Cleaning Procedures

Our surface sampling results showed metals were present on surfaces throughout the art studio. This contamination may come from various sources including clay, glazes, pigments, tools, or other activities done in the art studio. While there are no available occupational exposure limits for surface sampling to compare to our results, OSHA guidance suggests keeping surface contamination "as free as practicable." The presence of the elements on each surface does not necessarily indicate that meaningful levels of exposure are occurring. However, the results imply that clean-up procedures, as observed during our December 2023 visit, did not completely remove residual clays, glazes, and other materials at the end of class periods.

Our results also indicated the potential for exposure by other routes such as dermal or ingestion. For example, surface contamination on a table also used for food consumption poses the risk of unintentionally ingesting metals and other contaminants that could be harmful to the body. In addition, there is a potential that clothing will become contaminated, which could lead to the transport of the contaminant outside the space. Further, non-process related activities such as sweeping could generate airborne contaminants. Using clean cloths, clean sponges, or paper towels, rather than the materials used to work on the clay, should reduce the amount of surface contamination from metals found in the products used during classes. If items used to clean up are the same as those used to work with clay, they need to be fully rinsed out in clean water. These findings support the importance of minimizing eating and drinking in the spaces where ceramics materials and other chemicals are used.

Storage

We found potential hazards related to the storage of chemicals and materials in the art studio space. We acknowledge that storing materials in a shared art space used for many activities can be challenging. However, proper labeling and storage of chemicals and materials will help minimize hazards. Multiple safety guides for art studios, including ceramic studios, offer guidance in proper handling, labeling, and storage of materials. The U.S. Environmental Protection Agency's *Environmental Health & Safety in the Arts: A Guide for K–12 Schools, Colleges and Artisans*, provides guidance for proper management of waste and residuals from art studios. It can be found here: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1003I69.TXT.

Airborne Particulate and Ventilation

All air samples revealed no detectable levels for RCS, respirable dust, and respirable metals, suggesting low to no inhalation exposure to these materials. Activities that occurred during the class periods where clay work was being done generated a higher number of airborne particulate than when those activities were not occurring. However, the direct reading instruments used cannot differentiate the types of particles detected, so we do not know the specific makeup of the particles. Therefore, the increases in particle concentration could be linked to several things, including increased human activity in the classroom or outdoor activities since the doors and windows in the classroom were open [Liu et al. 2022].

Although general air quality was not the focus of this health hazard evaluation, our HVAC inspection indicated that its single return vent and the frequent opening of doors and windows may prevent it from meeting the needs of the space and functioning as designed. One of the most common issues found in many nonindustrial health hazard evaluations, like schools, is ventilation systems that are either not properly designed or maintained for the space. A well-designed ventilation system can help reduce exposures to any contaminants generated during ceramics and other art classes. Guidance on ventilation systems and indoor air quality can be found in the ANSI/ASHRAE Standard 62.1-2022, *Ventilation for Acceptable Indoor Air Quality*.

Limitations

This evaluation was cross-sectional, meaning we assessed hazards at one point in time. Cross-sectional evaluations provide useful information that can inform recommendations for improving workplace safety and health. However, cross-sectional evaluations are not able to document changes in hazards over time. It is possible that levels of exposure to the hazards evaluated here may differ when activities are performed that we did not observe during our visit. Although the levels of various hazards can vary over time, the recommendations we have provided are still relevant to reducing exposures.

Conclusions

Nondetectable levels of RCS, dust, and metals in air samples indicate that employees are unlikely to be exposed to hazardous levels of these exposures in air while spending time in the space. However, opportunities to improve employee health and safety exist by reducing metals on surfaces through improved cleaning; reducing potential safety hazards by improving the labeling and storage of materials; improving employee comfort through assessment of the ventilation system; and improving PPE selection, use, and storage.

Attribution Statement

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

Section C: Tables

Table C1. Personal air sampling for **RCS** in December 2023

Job/Activity	Sample time (minutes)	Total volume (liters)	Concentration (μg/m^3)*
Ceramics teacher	188	780	Not detected
OSHA Permisible Exposure Limit			50
OSHA Action Level			25

* μg/m^3 = micrograms per cubic meter

Table C2. Personal air sampling for **respirable dust** in December 2023

Job/Activity	Sample time (minutes)	Total volume (liters)	Concentration (mg/m^3)*
Ceramics teacher	188	780	Not detected
OSHA Permisible Exposure Limit			5

* mg/m^3 = milligrams per cubic meter

Table C3. Elements, including metals, found in surface samples in and around art studio

Analyte	Benchtop by wall/windows (clay workstation)	Island benchtop (clay workstation)	Benchtop by wall/windows next to clay sink	Gray tabletop where classes began (clay workstation)	Top of dryer	Windowsill in lounge/common space	Teacher's desk at back of classroom	Bathroom door handle (closer to kiln room)
Aluminum	+	+	+	+	+	+	+	+
Antimony	–	–	–	–	–	–	(+)	–
Barium	+	+	+	+	+	+	+	+
Beryllium	+	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Cadmium	+	(+)	(+)	(+)	+	(+)	(+)	+
Calcium	+	+	+	+	+	+	+	+
Chromium	(+)	–	(+)	(+)	+	–	+	(+)
Cobalt	+	(+)	–	–	+	–	+	(+)
Copper	+	+	(+)	+	+	+	+	+
Iron	(+)	–	(+)	(+)	+	(+)	–	(+)
Lanthanum	(+)	(+)	–	(+)	+	–	–	(+)
Lead	–	–	(+)	–	+	(+)	–	(+)
Lithium	+	(+)	(+)	(+)	+	(+)	(+)	(+)
Magnesium	–	(+)	–	–	+	–	–	(+)
Manganese	+	+	+	+	+	+	+	+
Molybdenum	–	–	–	–	–	–	(+)	–
Nickel	(+)	–	(+)	–	+	–	+	+
Phosphorus	–	–	–	(+)	(+)	(+)	(+)	(+)
Potassium	(+)	(+)	+	(+)	+	(+)	(+)	+
Silver	–	(+)	–	–	+	(+)	–	+
Strontium	+	+	+	+	+	+	+	+
Tin	–	–	–	–	(+)	–	–	–
Titanium	(+)	(+)	+	(+)	+	+	+	+
Vanadium	+	(+)	(+)	+	+	(+)	(+)	+
Yttrium	+	+	+	+	+	(+)	(+)	+
Zinc	(+)	(+)	(+)	–	(+)	(+)	(+)	+
Zirconium	–	–	–	–	(+)	–	–	–

+ indicates element present on surface at or above the limit of quantification.

() indicates element present on surface above limit of detection but below limit of quantification.

Section D: Occupational Exposure Limits

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

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

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

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

- OSHA, an agency of the U.S. Department of Labor, publishes PELs [29 CFR 1910 for general industry; 29 CFR 1926 for construction industry; and 29 CFR 1917 for maritime industry]. These legal limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2007]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States includes the threshold limit values or TLVs, which are recommended by the American Conference of Governmental Industrial Hygienists (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 2024].

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

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

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

Respirable Crystalline Silica

Silica, or silicon dioxide, occurs in a crystalline or non-crystalline (amorphous) form. In crystalline silica, the silicon dioxide molecules are oriented in a fixed pattern versus the random arrangement of the amorphous form. The more common crystalline forms in workplace environments are quartz and cristobalite, and to a lesser extent, tridymite. Occupational exposures to RCS (quartz and cristobalite) have been associated with silicosis, lung cancer, pulmonary tuberculosis disease and other airway diseases, kidney disease, and autoimmune disorders.

Silicosis is an irreversible but preventable fibrotic disease of the lung caused by the deposition of fine crystalline silica particles in the lungs. Silicosis is caused by the inhalation and deposition of crystalline silica particles that are 10 μm or less in diameter. Particles 10 μm and smaller are considered respirable particles and have the potential to reach the lower portions of the human lung (alveolar region). Although particle sizes 10 μm and smaller are considered respirable, some of these particles can be deposited before they reach the alveolar region [Hinds 1999].

Symptoms of silicosis usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and nonspecific chest illnesses. Silicosis usually occurs after years of exposure (chronic) but may appear in a shorter period of time (acute) if exposure concentrations are very high. Acute silicosis is typically associated with a history of high exposures from tasks that produce small particles of airborne dust with a high silica content [NIOSH 1986]. Even though the carcinogenicity of crystalline silica in humans has been strongly debated in the scientific community, the International Agency for Research on Cancer (IARC) in 1996 concluded that there was "sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources" [IARC 1997]. Several other serious diseases from occupational exposure to crystalline silica include lung cancer and noncancerous disorders such as immunologic disorders and autoimmune diseases, rheumatoid arthritis, renal diseases, and increased risk of developing tuberculosis disease after exposure to the infectious agent [NIOSH 2002].

When proper practices are not followed or controls are not maintained, RCS exposures can exceed the OSHA PEL, NIOSH REL, or the ACGIH TLV. The OSHA PEL and NIOSH REL for RCS are both 50 micrograms per cubic meter ($\mu g/m^3$) [NIOSH 2007; OSHA 2016]. The ACGIH TLV for quartz is 25 $\mu g/m^3$ as an 8-hour TWA [ACGIH 2024]. The OSHA action level for RCS is 25 $\mu g/m^3$ [OSHA 2016].

Section E: References

ACGIH [2024]. 2024 TLVs and BEIs: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, https://www.acgih.org/science/tlv-bei-guidelines/.

AIHA [2020]. Conquering toxic metals. American Industrial Hygiene Association. Synergist (Akron), October, https://synergist.aiha.org/202010-conquering-toxic-metals.

ANSI/ASHRAE [2022]. Standard 62.1-2022. Ventilation for acceptable indoor air quality. Washington, DC: American National Standards Institute. Atlanta, GA: ASHRAE, https://www.ashrae.org/.

CFR [2025]. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register, https://www.ecfr.gov.

Hinds WC [1999]. Aerosol technology: properties, behavior, and measurement of airborne particles. 2nd ed. New York: John Wiley & Sons, Inc.

IARC [1997]. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Silica, some silicates, coal dust and para-aramid fibrils. Vol. 68. Lyons, France: World Health Organization, International Agency for Research on Cancer, https://publications.iarc.fr/86.

Liu Y, Ma H, Zhang N, Li Q [2022]. A systematic literature review on indoor PM2.5 concentrations and personal exposures in urban residential buildings. Heliyon *8*(8):e10174, https://doi.org/10.1016/j.heliyon.2022.e10174.

NIOSH [1986]. Occupational respiratory diseases. Merchant JA, Boehlecke BA, Taylor G, PicketHarner M. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 1986-102, https://www.cdc.gov/niosh/docs/86-102/default.html.

NIOSH [1998]. Particulates not otherwise regulated, respirable: Method 0600. NIOSH Manual of Analytical Methods (NMAM™) Fourth Edition. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113, https://www.cdc.gov/niosh/docs/2003-154/pdfs/0600.pdf.

NIOSH [2002]. NIOSH hazard review: health effects of occupational exposure to respirable crystalline silica. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2002-129, https://www.cdc.gov/niosh/docs/2002-129/default.html.

NIOSH [2003]. Silica, Crystalline, by XED (filter redeposition): Method 7500. NIOSH Manual of Analytical Methods (NMAM™) Fourth Edition. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication, https://www.cdc.gov/niosh/docs/2003-154/pdfs/7500.pdf.

NIOSH [2007]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2005-149, http://www.cdc.gov/niosh/npg/.

NIOSH [2015]. ELEMENTS by Cellulosic Internal Capsule Sampler: Method 7306. NIOSH Manual of Analytical Methods (NMAM™) Fifth Edition. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication, https://www.cdc.gov/niosh/docs/2014-151/pdfs/methods/7306.pdf.

NIOSH [2025]. NIOSH manual of analytical methods (NMAM). 5th ed. O'Connor PF, Ashley K, eds. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2014-151, http://www.cdc.gov/niosh/nmam.

OSHA [1992]. 29 CFR 1910.1027 Cadmium. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1027.

OSHA [1995]. 29 CFR 1910.1025 Lead. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1025.

OSHA [2006]. 29 CFR 1910.1026 Chromium (VI). Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1026.

OSHA [2016]. 29 CFR 1926.1153 Silica. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, https://www.osha.gov/lawsregs/regulations/standardnumber/1926/1926.1153.

This page intentionally left blank

National Institute for Occupational Safety and Health

Promoting productive workplaces through safety and health research

HHE Report No. 2023-0069-3420