



Evaluation of a Cluster of Unexplained Illnesses Among Employees in an Office Building Following Overnight Building Renovation

HHE Report No. 2019-0240-3410

May 2025



Authors: Nancy Clark Burton, PhD, MPH, MS, CIH

Marrisa Alexander Scott, DVM, MS, MPH

Sarah M. Hatcher, PhD

Analytical Support: Jennifer Roberts, Bureau Veritas North America, Inc.

Desktop Publisher: Shawna Watts

Editor: Cheryl Hamilton

Industrial Hygiene Field Assistance: Kevin Moore

Logistics: Donnie Booher, Kevin Moore

Medical Field Assistance: Erin Blau

Keywords: North American Industry Classification System (NAICS) 921190 (Other General Government Support), Kentucky, Indoor Environmental Quality, IEQ, Renovation, Glue, Volatile Organic Compounds, VOCs, Fragrances, Cyclohexanone, Limonene, Ethanol

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Availability of Report

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Recommended Citation

NIOSH [2024]. Evaluation of a cluster of unexplained illnesses among employees in an office building following overnight building renovation. By Burton NC, Alexander-Scott M, Hatcher S. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Health Hazard Evaluation Report 2019-0240-3410, <https://www.cdc.gov/niosh/hhe/reports/pdfs/2019-0240-3410.pdf>.

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Introduction

Request

A state epidemiologist requested technical assistance from the Health Hazard Evaluation Program concerning a cluster of unexplained illnesses among employees who worked in a state office building undergoing renovation.

Workplace

Employees worked at an office building leased by five state agencies and several private tenants. The single-story building was about 55,000 square feet. Part of the building was undergoing renovation at the time of our evaluation. The area under renovation was about 12,000 square feet.

Employees included in the evaluation worked in the offices of two state agencies in the building. Thirty-four employees worked in the office adjacent to the renovation space (Agency A) and two worked in another office in the building (Agency B). All employees primarily did office work. Agency A employees met with clients and helped process applications for social services benefits such as Medicaid and Supplemental Nutrition Assistance Program (SNAP). Agency B employees provided services related to driver license testing.

To learn more about the workplace, go to [Section A in the Supporting Technical Information](#)

Our Approach

We visited the building from August 26 through August 28, 2019, and completed the following activities:

- Held voluntary, confidential medical interviews with Agency A and Agency B employees who worked in the building. During interviews, we discussed job tenure, job tasks, work activities, health symptoms, and relevant medical history.
- Reviewed medical records of employees who sought care for their symptoms on or after August 1, 2019—the day of the building renovation.
- Inspected the rooftop heating, ventilation, air conditioning (HVAC) units, and ductwork serving the two agencies' offices.
- Used smoke tubes to visually observe air flow patterns in the building.
- Reviewed safety data sheets for products used in the renovation area.
- Reviewed a consultant's report concerning indoor environmental quality for Agency A.
- Collected bulk samples of materials for content analyses from the area being renovated, the employee entrance to Agency A (Yellow Room), above Agency B's office ceiling, and the garage.

To learn more about our methods, go to [Section B in the Supporting Technical Information](#)

Our Key Findings

Employees reported health symptoms that were potentially related to building renovation activities

- Most employees (91%) working in the building during or right after the overnight renovation (July 31–August 2) reported at least one health symptom that improved when away from work.
- Most employees (81%) present in the building during or right after the overnight renovation reported a potential renovation-related illness, defined as two or more symptoms that began during or after the overnight renovation.

Issues with indoor environmental quality were identified throughout the building

- We found some of the HVAC units were not providing air into the Agency A office spaces, and other HVAC units were not providing cooling.
- When the local fire department investigated, they identified open gaps at the top of the walls separating the renovation area from the hallway shared with the offices. We did not observe air movement around the sealed doorways leading into the hallways.
- We observed fragrance products in use throughout the office areas.
- We found that the glue from the renovation area and fragrance containers in the offices were releasing volatile organic compounds, which can impact human health.
- The consultant’s air quality report identified several water-stained ceiling tiles (some with active mold growth). These were replaced before the National Institute for Occupational Safety and Health (NIOSH) site visit. We observed mold growth on the wall over the mop sink in Agency A. This was also identified in the consultant’s report.
- We detected a musty smell in the main hallway at the front of the building. This area has the potential for mold growth because the air-conditioned hallway connected with the unconditioned renovation area. This could cause moisture to collect on the wall surfaces.

Lead paint was detected in the Yellow Room leading into Agency A office space

- The yellow paint flakes and dust we observed in Agency A hallways contained lead.

To learn more about our results, go to [Section B in the Supporting Technical Information](#)

Our Recommendations

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

Potential Benefits of Improving Workplace Health and Safety:

- | | |
|--|--|
| ↑ Improved worker health and well-being | ↑ Enhanced image and reputation |
| ↑ Better workplace morale | ↑ Superior products, processes, and services |
| ↑ Easier employee recruiting and retention | ↑ 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 is a way of determining which actions will best control exposures. In most cases, the preferred approach is to eliminate hazards or to replace the hazard with something less hazardous (i.e., substitution). Installing engineering controls to isolate people from the hazard is the next step in the hierarchy. Until such controls are in place, or if they are not effective or practical, administrative controls and personal protective equipment might be needed. Read more about the hierarchy of controls at <https://www.cdc.gov/niosh/hierarchy-of-controls/about/index.html>.



We encourage the 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* at <https://www.osha.gov/safety-management>.

Recommendation 1: Prevent odors from migrating into the office areas and reduce odor sources

Why? Odors, especially when thought of as harmful, can make asthma symptoms worse. Workers with preexisting health conditions can develop breathing issues when exposed to contaminants such as volatile organic compounds and odors in the air. Identifying symptoms early can reduce their severity and lead to the right treatment if needed.

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



Seal all gaps at the top of the walls that separate the renovation area from the hallway and office areas.



Follow the recommendations for maintaining indoor air quality during renovation projects outlined in a NIOSH Workplace Solution document.

- Use the information from this NIOSH publication during construction and renovation projects: [Maintaining acceptable indoor environmental quality \(IEQ\) during construction and renovation projects \(cdc.gov\)](https://www.cdc.gov/niosh/publications/maintaining-acceptable-indoor-environmental-quality-ieu-during-construction-and-renovation-projects).
- Schedule renovation work during periods of low building occupancy and low occupancy adjacent to the work areas whenever possible.
- Isolate work areas from occupied areas using physical barriers, negative pressurization of the renovation area relative to occupied areas, and local exhaust ventilation with high-efficiency particulate air (HEPA) filtration where dust generation is expected. If local exhaust is not feasible, portable air cleaning devices could be used.



Establish a “fragrance-free” office policy to limit odors for employees who may be sensitive to strong odors and scents.



Encourage employees to continue reporting potential work-related health concerns to their supervisors. If needed, employees should seek care for work-related medical concerns from a healthcare provider knowledgeable in occupational 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 someone in your geographic area.

Recommendation 2: Maintain the ventilation system according to ASHRAE standards and follow the manufacturer’s maintenance recommendations to ensure the system operates properly and provides acceptable indoor air quality

Why? Poor ventilation in buildings is a common problem and often caused by a lack of proper attention to the building's ventilation systems. These systems include all the equipment used to ventilate, heat, and cool the building; to move the air around the building (ductwork); and to filter and clean the air. These systems require maintenance and care to operate properly and provide acceptable indoor air quality. The ventilation systems can have a large impact on how pollutants are distributed in and removed from spaces.

Although no comprehensive regulatory standards specific to indoor environmental quality have been established, guidelines have been developed by organizations and agencies, including ASHRAE, NIOSH, and the U.S. Environmental Protection Agency (EPA). These resources are available from the EPA indoor air quality topic page at <https://www.epa.gov/indoor-air-quality-iaq>.

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



Inspect and repair HVAC units with issues identified during the site visit.

- Repair the HVAC unit serving the Agency A conference room, kitchen, and Room 120 to supply cooling.
- Examine and repair the HVAC units serving Agency A and Rooms 134 and 135, to find the cause for lack of airflow through the supply grilles.

Recommendation 3: Correct mold and dampness issues

Why? Damp building conditions promote the growth of mold, bacteria, and other microbial agents. Moisture can also attract cockroaches, rodents, and dust mites. Dampness can add to the breakdown of building materials and furniture, which can result in negative health effects.

Employees reported skin, eye, respiratory, and other symptoms including headaches, fatigue, difficulty concentrating, and memory issues that improved when away from the building.

- Mold was seen on the wall over the mop sink in the janitor’s closet in Agency A.
- Stained and potentially moldy ceiling tiles were observed in Agency A and replaced.

A musty smell was detected in the main building hallway.

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



Fix and replace the wallboard over the mop sink in the janitor’s closet. Also surrounding the area with metal will help prevent splashing and prevent further water damage.

- Monitor the repaired area to ensure repair and remediation actions are effective.
- Find information about remediating mold-damaged building materials in the U.S. Environmental Protection Agency document titled [Mold Remediation in Schools and Commercial Buildings \(EPA 402-K-01-001, September 2008\)](#).



Visually inspect for water intrusion and damage in the building on a regular basis. Quickly repair any issues found.

- If dampness or mold is not seen during visual inspections but is suspected because of musty odors or continued health complaints, consider other methods (such as infrared camera or borescope) to look for hidden problems.

Recommendation 4: Address other health and safety issues we identified during our evaluation

Why? A workplace can have multiple health hazards that cause worker illness or injury. Similar to the ones identified above, these hazards can potentially cause serious health symptoms, lower morale and quality of life for your employees, and possibly increased costs to your business. We saw the following potential issues at your workplace:

- Lead in the yellow paint throughout the Yellow Room.
- Buildup of dust and dirt in the halls of Agency A.

Although they were not the focus of our evaluation, these hazards could cause harm to your workers’ health and safety and should be addressed.

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



Hire a licensed professional to conduct lead remediation for the Yellow Room before it is used again.

- Do not allow employees to access the Yellow Room until remediation is completed.



Upgrade the vacuum cleaners to more efficient HEPA models to reduce dust and dirt in the office areas.

- Carpets can trap dust contains environmental contaminants such as lead or mold that can trigger allergies.

Supporting Technical Information

Evaluation of a Cluster of Unexplained Illnesses
Among Employees in an Office Building Following
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HHE Report No. 2019-0240-3410

May 2025

Section A: Workplace Information

Building

Total size: 55,000 square feet

Renovation area: 12,000 square feet

Floors: One

Built: approximately 1951

Ventilation: 30 individual heating, ventilating, and air-conditioning (HVAC) units (six units for renovation area)

Tenants: Five state agencies, massage therapists, a school of performing arts, mental healthcare providers, nonprofit organizations, estheticians, contact lenses company, branding/marketing company, and office suites available for rent by the day, week, or month.

Employee Information

- At the time of our evaluation, 36 employees worked in the two agencies' offices. Thirty-five employees participated in interviews. Twenty-six employees were interviewed in person and nine employees were interviewed by phone.
- All interviewed employees worked full time (40 hour per week).
- The median age among interviewed employees was 47 years (interquartile range [IQR] = 40–55 years).
- Interviewed employees (n = 35) reported working in the building a median of 5 years (IQR = 1 year, 9 months–10 years) and for their current agency for a median of 6 years (IQR = 2–13 years).
- All employees primarily performed office work. Agency A employees met with clients, assisted them with social services benefits, and processed applications for programs like Medicaid and SNAP. This involved performing computer-based tasks, interviewing clients, answering phones, and doing general office or clerical tasks. Agency B employees provided services related to driver license testing including conducting road tests, scheduling, answering phones, and doing general office or clerical tasks.

History of Issue at Workplace

In August 2019, a state epidemiologist requested technical assistance from the Health Hazard Evaluation Program concerning a cluster of unexplained illnesses in a state office building undergoing renovation. On August 1, 2019, employees reported a strong, unusual odor and then health symptoms following overnight renovation work in the building. Symptoms included nausea, odd or metallic taste, vision problems, respiratory issues, throat irritation, shortness of breath, and chest tightness. Several employees of Agency A sought care at a nearby urgent care office. After receiving a call from the urgent care physician, poison control alerted the state health department, who initiated an investigation.

After receiving the request for technical assistance from the state health department, we spoke with employee representatives, management representatives, building owners, and renovation workers who performed and oversaw the renovation activities during the evening of July 31. We learned that the plumbing renovation began on July 11 and ended on August 6. The renovation plan consisted of preparing the space for a medical practice, which included plumbing and HVAC system changes. The plan also included remodeling the interior to add offices, waiting areas, an employee break area, and patient rooms.

The renovation company performed concrete cutting during the day on July 11 and the evening of July 12. During July 15–16, a diesel-powered excavator was used to move concrete. Exhaust fans were used for ventilation in the renovation area. On the evening of July 29, plumbing work was performed, and the diesel-powered excavator was driven out of the building.

The main renovation event of concern for this evaluation occurred on the evening of July 31. According to renovation worker and state employee accounts, renovation began sometime between 5:30–7:30 p.m. that evening. The renovation worker finished plumbing work and used gas-powered equipment to cut concrete for approximately 10 minutes. Renovation work finished at approximately 11:30 p.m., and an inspection was scheduled for the next day.

The following morning, August 1, before the inspection, the renovation worker used polyvinyl chloride (PVC) glues—Oatey PVC regular clear cement (Oatey Co., Cleveland, Ohio) and Uni-Weld medium clear cement (United Elchem Industries, Cleveland, Ohio)—to glue plumbing caps and traps. On August 6, the site was back-filled with gravel carried into the space using wheelbarrows; no gas- or diesel-powered equipment was used.

According to employee accounts and email records, employees first complained of odors and feeling ill following renovation performed July 15–16. As a result, the building owners provided air freshener pods and Zep Air & Fabric Odor Eliminator spray (Zep Inc., Emerson, Georgia) to neutralize renovation odors. Owners also hung plastic draping door frames to help prevent renovation-related odors and associated chemicals from drifting from the renovation site to the adjacent hallway and Agency A's office.

Interviewed employees reported that upon entering the building the morning of August 1, they smelled an offensive odor and soon developed a variety of health symptoms. To neutralize the odor, Zep was sprayed throughout the hallways and common areas, except the lobby of Agency A, at approximately 9:00 a.m. Approximately one third of employees who were in the Agency A office on August 1 left the office at or before noon because of the odor and their health symptoms. Agency B employees stayed in their office.

Employees from Agency A also reported issues when they returned to the office on August 6. The local fire department received a report of individuals being taken to the hospital due to unknown exposures. They conducted direct-reading air monitoring for carbon monoxide, combustible gas, hydrogen sulfide, and oxygen concentrations. All measurements were within the normal range. They conducted a walkthrough of the building and noted that the sheet rock walls in the renovation area did not extend all the way to the ceiling.

Section B: Methods, Results, and Discussion

Methods: Employee Health

We reviewed available medical records for employees who sought medical care for their symptoms during August 1–August 8, 2019. Through these records, we obtained a list of symptoms experienced by employees following the overnight renovation.

We invited all employees working in Agency A and Agency B office spaces adjacent to the renovation area with the shared hallway to participate in voluntary, confidential medical interviews. Employees who could not be interviewed in person during our site visit were interviewed by phone during August 29–September 6, 2019.

Interview topics included job tenure, work activities, time spent in the building during July 31–August 9, self-reported symptoms on or after July 31, and relevant medical conditions. Interviewed employees were also asked to describe building odors following the overnight renovation. For these questions, employees were provided a floorplan of the Agency A office and asked to identify areas where they smelled odors on or after July 31. We divided the Agency A office area into quadrants and asked where the employees worked within the office area to determine their location in conjunction with the renovation area.

Among employees who were in the office after 5:00 p.m. on July 31, or any time on August 1 or 2, we used these definitions:

- Work-related symptoms as self-reported symptoms that improved when the employee was away from work.
- Potential renovation-related illness as the self-report of two or more of the following symptoms with onset during July 31–August 2: ear pain, visual changes (including blurry vision), chest tightness, cough, shortness of breath (dyspnea), wheezing, diarrhea, nausea, vomiting, sore throat, vertigo, eye irritation, or headache.

We described demographics and work characteristics of interview participants using frequencies and percentages or medians and IQRs (the range between the 25th and 75th percentiles). We estimated the prevalence of work-related symptoms and of potential renovation-related illnesses. Among Agency A employees, we compared the prevalence of potential renovation-related illness among employees working in Quadrants 1 and 3 with employees working in Quadrants 2 and 4 using a prevalence ratio (PR) and 95% confidence interval (CI).

We also compared the prevalence of potential renovation-related illness among employees with underlying health conditions, and specifically atopy (defined as self-report of a medical diagnosis of asthma, hay fever, or eczema) with employees without underlying health conditions or atopy.

Results: Employee Health

Medical Record Review

We reviewed medical records for 11 employees who sought medical care for one or more of the following symptoms during July 31–August 8, 2019: ear pain, visual changes/blurry vision, chest tightness, cough, shortness of breath (dyspnea), wheezing, diarrhea, nausea, vomiting, sore throat, rib pain, vertigo/dizziness, eye irritation, headache, and muscle weakness.

Employee Interviews

We interviewed 35 of the 36 state employees who worked in the building offices. Interviewed employees primarily worked for two state agencies (Agency A and Agency B). Among the 35 interviewed employees, the median age was 47 years (IQR = 40–55 years). Among the 35 employees, 7 (20%) interviewed employees were male and 28 (80%) interviewed employees were female.

Interviewed employees reported working for their current agency a median of 6 years (IQR = 2–13 years; range = 3 months–27 years) and in the building for a median of 5 years (IQR = 1 year, 9 months–10 years; range = 2 months–32 years). All interviewed employees reported working full-time.

Among 35 interviewed employees, 32 (91%) reported being in the office after 5:00 p.m. on July 31 or any time August 1–2 and were considered potentially exposed to unknown substances from the overnight renovation on July 31. Of these 32 employees, 30 (94%) reported first smelling an odor after 5: p.m. on July 31 or August 1.

Twenty-seven (84%) employees reported smelling an odor immediately upon entering the office on August 1. Employees described the odor as smelling like renovation (n = 25), machinery/equipment (n = 14), glue (n = 4), chemical(s) (n = 3), or another scent (n = 2). Notably, a handwritten note on a sign informing clients that the office was closed stated that the air quality concerns were “due to renovation plumbing glue,” which may have influenced employees’ odor descriptions (Figure B1).

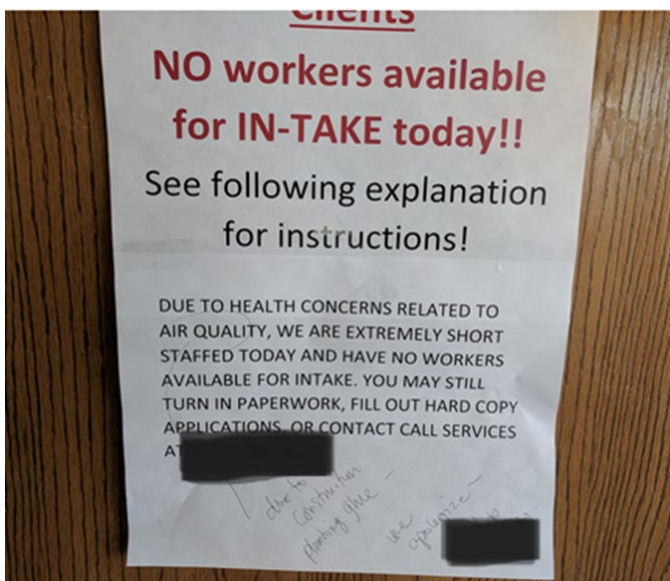


Figure B1. Sign placed on the entrance to the office of Agency A when employees vacated the office. Photo by NIOSH.

Among 32 employees who were considered potentially exposed, the median number of reported symptoms that started on or after July 31 was 3 (IQR = 2–6). Of the 32 employees, 29 (91%) reported at least one work-related symptom (Table C1). The most common work-related symptoms among these 32 employees, with onset between 5:00 p.m. on July 31 and any time on August 2 were headache (69%), nausea (50%), eye irritation (47%), cough (41%), and sore throat (41%).

Of the 32 interviewed employees, 26 (81%) who were potentially exposed reported symptoms that met the definition of a potential renovation-related illness (Table C2). Among these 26 employees, the most frequently reported symptoms were headache (88%), nausea (77%), eye irritation (62%), cough (58%), sore throat (58%), and vertigo/dizziness (50%).

Quadrants 1 and 3 were located closest to the renovation area, while Quadrants 2 and 4 were further away, although still in the same shared space (Figure B2). Among the 17 employees working in Quadrants 1 and 3, 94% (n = 16) met the definition of experiencing a potential renovation-related illness, compared with 77% (n = 10) of the 13 employees working in Quadrants 2 and 4. This indicated that those closer to the renovation area had a 22% greater prevalence of potential renovation-related illness than those further away; however, this difference was not significant (PR: 1.22; 95% CI: 0.89, 1.69).

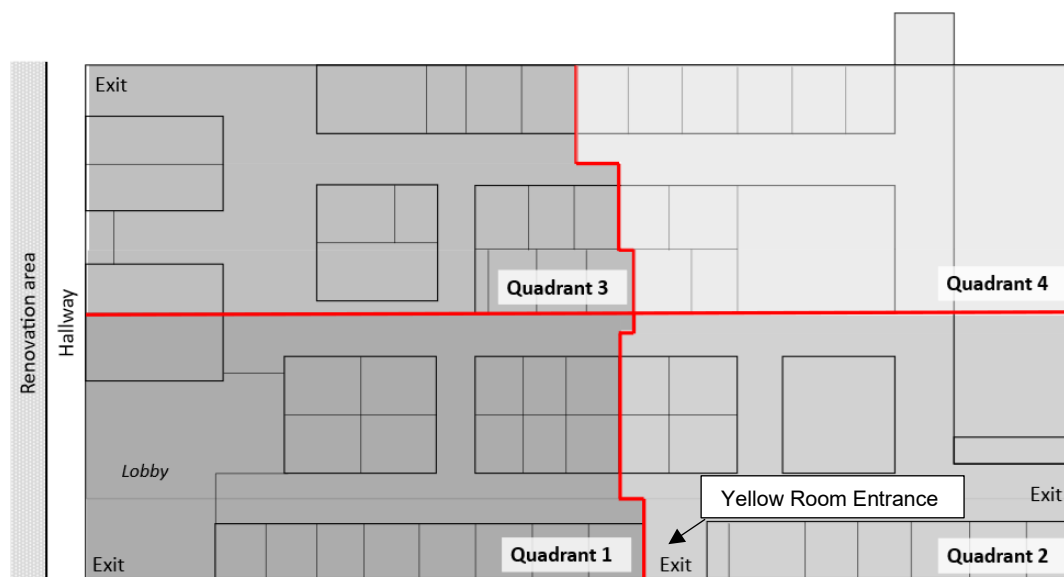


Figure B2. Agency A office layout, divided into four quadrants and the location of the Yellow Room entrance labeled. Figure by NIOSH.

Employees with underlying medical conditions, specifically atopy, had a similar prevalence of potential renovation-related illness compared with employees without underlying medical conditions, including atopy (results not shown).

Methods: Review of Prior Indoor Air Quality Consultant Report

An indoor environmental quality (IEQ) assessment was performed by an environmental consultant on August 14, 2019, at the request of state management for the Agency A office. The consultant performed a visual inspection, collected airborne and surface mold samples, and measured temperature (°F), relative humidity (RH), and carbon dioxide, in and outside the building. We reviewed the assessment report to identify previously known problems and recommendations.

Results: Review of Prior Indoor Air Quality Consultant Report

The consultant's report identified the following: the presence of stained ceiling tiles with some active mold growth throughout the office, water-stained and moldy wallboard in the janitor's closet, missing ceiling tiles, water-stained carpet, and a musty smell in the Agency A office hallways.

The consultant conducted mold spore sampling and found that the total mold spore counts inside were lower than outdoors. However, they also found that the counts of some specific types of mold (*Aspergillus/ Penicillium* spores) were higher indoors in the lobby and office corridors than outdoors. This can indicate potential mold growth indoors. They collected additional swab samples for mold spores and identified mold growing on some of the ceiling tiles and in the janitor's closet.

The indoor temperatures in the office areas ranged 72.6°F to 75.9°F. The temperature for the front lobby was 86.6°F. The temperature outside the building ranged 91.1°F to 95.2°F. RH levels in the building ranged 33% to 52%. RH levels outside the building ranged 37% to 52%.

The consultant recommended replacing the missing and stained ceiling tiles, identifying and repairing the sources of water intrusion, repairing and remediating the janitor's sink area, adding air cleaners to the office corridors to remove mold spores, steam cleaning the carpets, and cleaning all nonporous surfaces.

At the time of the NIOSH site visit, the owner of the building had identified and replaced all 17 stained ceiling tiles and the missing ceiling tiles in the Agency A office space, had a contractor steam clean the carpets in the Agency A space and adjacent hallway, repaired two leaking roof drains, and hired a contractor to paint and clean the office walls.

Methods: On-site Building Evaluation

We conducted a visual inspection of the renovation area, Agency A and Agency B areas, and the other offices in the occupied portion of the building adjacent to the renovation area. We inspected several of the rooftop HVAC units and ductwork that serviced Agency A and Agency B areas. We also visually observed air flow patterns using smoke tubes at the entrances to Agency A and Agency B offices, the supply and exhaust grilles in these offices and shared spaces, bathrooms, and the doorways and walls between the renovation area and hallway adjacent to the occupied spaces.

Results: On-site Building Evaluation

The HVAC units we checked were clean and had no standing water inside the units. The HVAC units that served Agency A were powered off but were turned on during the site visit. We found that the HVAC unit that served the Agency A conference room, kitchen, and Room 120 was working but was

not providing cooling. At the time of the site visit, air did not flow from the doorways or walls in the renovation area into the adjacent hallway where these areas were sealed with plastic (Figures B3 and B4). We were not able to see the areas near the top of the walls that the fire department had determined were not sealed.



Figure B3. Renovation area showing sealed door (back), which was the main entrance to the area, and a sheet rock wall, which was part of the hallway across from Agency A offices. Photo by NIOSH.



Figure B4. Plumbing work in the renovation area completed overnight before the reported incident. Photo by NIOSH.

However, we found that air flowed from the hallway into the Agency A storage space. The HVAC supplies and exhausts were working in the Agency A employee offices and bathrooms but were not working in Rooms 134 and 135. We also found that untreated air entered the Agency A office from the Yellow room (Figure B5). We detected a musty smell when entering the front of the building in the main hallway. This area had a potential for mold growth due to the juncture of the air-conditioned hallway and the unconditioned renovation area, which can result in condensation on the wall surfaces.



Figure B5. Yellow Room leading into Agency A offices. Photo by NIOSH.

We found several fragrance sources in the workspace (air fresheners, oil infusers, etc.). The use of some products with fragrance can affect the health of employees with chemical sensitivities, allergies, asthma, or chronic headaches, such as migraines.

We inspected the janitorial closet for Agency A and observed mold growing on the wallboard around the mop sink where water splashes (Figure B6). We also observed the vacuum currently being used in Agency A had worn bristles and may not be very effective in picking up dirt.

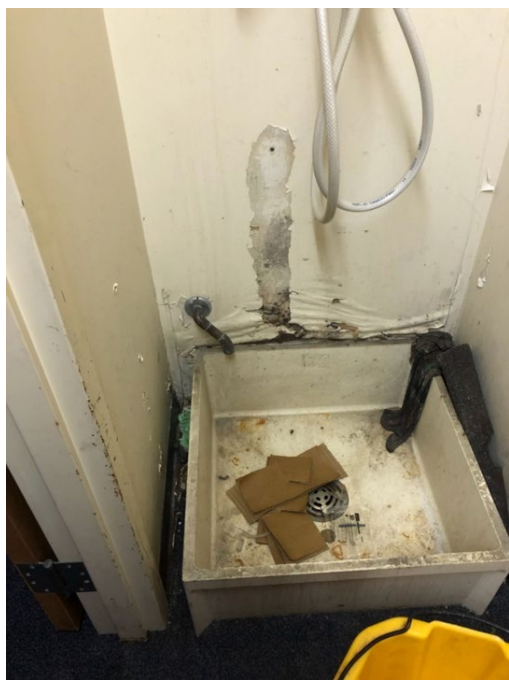


Figure B6. Water damage and mold growth on the wall above the mop sink in the Agency A janitor's closet. Photo by NIOSH.

Methods: Environmental Samples

We collected two paint chip samples from the Yellow Room in Agency A's portion of the building. The Yellow Room samples were analyzed for lead contamination using inductively coupled plasma according to NIOSH Method 7303 [NIOSH 2024].

We also collected bulk samples of material above the ceiling in Agency B's office and above the ceiling of the garage. The ceiling material samples were analyzed by polarized light microscopy for identification of asbestos fibers [EPA 1993].

We collected containers of two types of cement glue (Oatey PVC regular clear cement and Uni-Weld medium clear cement) and the Zep Air & Odor Eliminator spray (used in the renovation project). A head space analysis was conducted for volatile organic compounds (VOCs) from the containers. A thermal desorption tube was used to collect an air sample over each container for 2 minutes at 100 milliliters per minute at room temperature. The thermal desorption tubes were analyzed according to NIOSH Method 2549 [NIOSH 2024].

Results: Environmental Samples

The two paint samples contained lead at the following concentrations: One sample had 530 micrograms of lead per gram of dust and the other had 270 micrograms of lead per gram of dust. During the walk-through of the building, we saw yellow paint flakes on the rug at the entrance of the Agency A office space from the Yellow Room. This indicated that paint and other material in the Yellow Room had

been transferred to the office space when the Yellow Room was used as an office entrance. The two ceiling material samples contained fiberglass insulation but did not contain asbestos.

The results of headspace analyses revealed several VOCs that corresponded to chemicals listed on the safety data sheets (SDSs). We found cyclohexanone, tetrahydrofuran, methyl ethyl ketone, and acetone in the headspace analysis of Oatey PVC cement. The SDS listed methyl ethyl ketone, cyclohexanone, tetrahydrofuran, acetone, and polyvinyl chloride as major components. We found cyclohexane, phenol, tetrahydrofuran, and methyl ethyl ketone in the headspace analysis of Uni-Weld cement. The SDS listed tetrahydrofuran, 3-propanol, methyl ethyl ketone, polyvinyl chloride, cyclohexanone, and colloidal silicon dioxide as the main chemicals in the mixture.

The SDSs for these two products recommended the products be used with good general ventilation, defined as at least 10 air changes per hour and local exhaust ventilation as needed. The SDS for Zep Odor Eliminator indicated that the product contained ethanol. We found limonene, ethanol, isopropanol, beta-pinene, and dimethyl benzaldehyde in the headspace analysis.

Discussion

We found that unplanned pathways existed for odors to travel into the occupied areas of the building from the renovation area. The fire department findings indicated that some areas near the top of the walls were not sealed and could serve as a conduit for odors to move into other building areas. The renovation area doors and openings were sealed with plastic, and we did not observe any airflow into the adjacent spaces. However, some of the plastic sheeting had been added after the exposure incident.

We found that a majority of employees in the building after 5:00 p.m. on July 31, or any time on August 1 or 2, reported experiencing at least one work-related symptom that improved when away from work. Their symptoms were consistent with a potential renovation-related illness. The prevalence of a potential renovation-related illness did not differ between employees working in areas close and more distant from the renovation. Odors can worsen chronic respiratory problems such as asthma, and it is thought that odors can affect the physiological and psychological responses of individuals with asthma [Beach et al. 1997; Jaen and Dalton 2014]. However, in this case, we also found that the prevalence of potential renovation-related illness did not differ between employees with and without underlying health conditions, including atopy.

Many chemicals or compounds have a very low odor threshold, which means people can smell them at very low levels. During our site visit and tour of the renovation area, we found two open containers of PVC glue. These were likely used during the renovation work that took place during the late evening of July 31 and early morning of August 1. VOCs are a large class of chemicals that contain carbon and have a sufficiently high vapor pressure to allow some of the compound to exist as a gas at room temperature. The compounds detected from the open containers fall into this class. These chemical compounds are commonly used for tasks such as cleaning, painting, printing, degreasing, thinning, and extraction. Low VOC compounds are recommended for building renovations [NIOSH 2019].

Inhalation and dermal exposure are both important routes of exposure to VOCs in the workplace [Cone 1986]. VOCs may cause minimal to mild irritation of the respiratory system [Rosenberg et al. 1997]. This irritation is usually restricted to the upper airways, mucous membranes, and eyes, and it

generally resolves quickly without long-term effects [Rosenberg et al. 1997]. In sufficient concentrations, most VOCs can cause acute, nonspecific central nervous system depression. The symptoms of significant acute solvent exposure include headache, nausea and vomiting, dizziness, slurred speech, impaired balance, poor concentration, disorientation, and confusion. These symptoms go away quickly upon cessation of exposure [Guidotti 2010, Chapter 10].

It is possible that the symptoms reported by interviewed employees were associated with the odor in the office on August 1. Odors result from the presence of organic or inorganic compounds that trigger the sense of smell. These odors can be pleasant or unpleasant. The presence of odors can cause some people to suspect harmful exposures. However, odors in a building do not always mean that occupants are exposed to harmful levels of chemicals. Odors can lead to health symptoms when the odor is caused by an irritant in the odor mixture at levels that cause health symptoms [Schiffman and Williams 2005]. However, even in the absence of an irritant, odors—particularly malodors—can lead to health symptoms. In other words, the odor itself can cause health symptoms, particularly when it is perceived as unpleasant or harmful.

Reported symptoms in association with malodors are nonspecific and include eye, nose, and throat irritation, headache, nausea, diarrhea, sore throat, cough, chest tightness, nasal congestion, shortness of breath, and alterations in mood [Schiffman and Williams 2005]. In addition, individuals with preexisting conditions such as asthma reported more health issues than individuals without health issues when exposed to perfume and flowers [Claeson et al. 2016; Weinberg et al. 2017; Wolkoff and Nielsen 2017]. The health effects reported among interviewed employees could be associated with all these mechanisms and may have been exacerbated by the air deodorizers used to mask the odor.

We found some evidence of mold growth during our site visit. Mold was also identified during the consultant's inspection. Microbial agents found in indoor air that are important to health include pollen and plant spores coming from outdoors; bacteria, fungi, algae, and protozoa from both indoors and outdoors; and microbes and allergens spread from person to person, and from person to the environment (including pet dander) [WHO 2009]. Dampness and inadequate ventilation lead to the growth of microbes and degrade building materials [WHO 2009].

Many buildings have episodes of water or moisture intrusion. The key to preventing microbial growth is to identify the source of moisture and eliminate it [NIOSH 2012]. Moisture intrusion, along with nutrient sources such as building materials or furnishings, allows mold and other microbes to grow indoors, so it is important to keep the building interior and furnishings dry [NIOSH 2012]. Remediation of microbial contamination may improve IEQ conditions even though a specific cause-effect relationship is not determined.

NIOSH investigators routinely recommend remediating observed water intrusion, dampness, and microbial contamination, and correcting situations that are favorable for microbial growth and bioaerosol dissemination [NIOSH 2012]. Comprehensive reviews of previous scientific studies have evaluated the development of health effects associated with exposures from damp indoor conditions. The findings show associations with upper and lower respiratory symptoms, asthma development and exacerbation, hypersensitivity pneumonitis, respiratory infections, allergic rhinitis, bronchitis, and eczema [Mendell et al. 2011; WHO 2009].

The paint in the Yellow Room contained lead. Inorganic lead is a naturally occurring, soft metal that has been mined and used in industry since ancient times. It comes in many forms (e.g., lead acetate, lead chloride, lead chromate, lead nitrate, lead oxide, lead phosphate, and lead sulfate). Lead is considered toxic to all organ systems and serves no useful purpose in the body. Neither NIOSH nor OSHA has established surface contamination limits for lead in the workplace.

Currently, the U.S. Environmental Protection Agency limits lead on surfaces in public buildings and child-occupied housing to less than 10 micrograms of lead per square foot [EPA 2020]. OSHA's substance-specific standard for lead requires that all surfaces be maintained as free as practicable of accumulations of lead [29 CFR 1910.1025(h)(1)]. Employers of workplaces that have lead present must regularly and effectively clean surfaces in locations such as change areas, storage facilities, and breakrooms or eating areas to ensure they are as free as practicable from lead contamination [OSHA 2003].

Limitations

This evaluation is subject to several limitations. The evaluation was cross-sectional in design, so we were unable to determine if there was a causal relationship between exposure to the renovation odor and employees' health symptoms. Environmental sampling and observations can only document conditions in the locations evaluated and on the days the evaluation occurred. As a result, we were unable to measure any potential exposures that may have been present on August 1, 2019. Agency A's office area was unoccupied during our evaluation, so the environmental observations may not be representative of conditions in the past or on other days when the building is occupied. Not all relevant medical records for employees who reported symptoms were available for review.

Employees' interview responses were based on self-report and occurred about 3–4 weeks after the incident, which may have resulted in decreased recall. Inaccuracies in recall of symptoms and their timing could have led to misclassification when determining whether an employee's reported symptoms met the definition of a potential renovation-related illness. Because most interviewed employees working in the building reported they detected an odor and experienced at least one symptom, no clear unexposed group existed. The absence of an unexposed group limited our ability to evaluate factors that may have increased the prevalence of experiencing health symptoms or a potential renovation-related illness.

Conclusions

We identified potential issues related to IEQ that could explain the health symptoms that occurred after the plumbing renovations in the renovation area. These issues included the use of glues and fragrance products that may cause odor complaints, gaps at the ceiling level that allow airflow into occupied areas, and nonfunctional ventilation units in the Agency A office area. Lead-containing paint flakes and dust were also being unintentionally tracked into the Agency A office area through an employee entrance.

Section C: Tables

Table C1. Prevalence of work-related symptoms* among interviewed employees who worked in the building July 31, 2019, after 5:00 p.m., or any time August 1–2, with symptom onset July 31–August 2 (n = 32)

Symptom	Employees who reported work-related symptoms*
	No. (%)
Any symptom	29 (91)
Headache	22 (69)
Nausea	16 (50)
Eye irritation	15 (47)
Cough	13 (41)
Sore throat	13 (41)
Vertigo/dizziness	12 (38)
Shortness of breath	11 (34)
Odd taste	10 (31)
Wheeze	9 (28)
Metallic taste	9 (28)
Chest tightness	6 (19)
Nasal congestion	6 (19)
Nose irritation	5 (16)
Mental fog	5 (16)
Diarrhea	2 (6)
Fatigue	2 (6)
Vision problems / blurry vision	2 (6)
Ear pain	0 (0)
Other†	6 (19)

* Work-related symptoms are self-reported symptoms that improved when the employee was away from work.

† Other symptoms include rash, other taste in mouth, vomiting, nosebleed, sensation of high blood pressure, and irritable mood.

Table C2. Prevalence of self-reported symptoms among interviewed employees who worked in the building July 31, 2019, after 5:00 p.m., or any time August 1–2, reporting symptoms meeting the definition of a potential renovation-related illness* (n = 26)

Symptom	Employees who met the definition of potential renovation-related illness*
	No. (%)
Headache	23 (88)
Nausea	20 (77)
Eye irritation	16 (62)
Cough	15 (58)
Sore throat	15 (58)
Vertigo/dizziness	13 (50)
Shortness of breath	11 (42)
Chest tightness	11 (42)
Wheezing	9 (35)
Diarrhea	4 (15)
Vision problems / blurry vision	3 (12)
Vomiting	2 (8)
Ear pain	0 (0)

* A potential renovation-related illness was defined as the self-report of two or more of the following symptoms with onset during July 31–August 2: ear pain, visual changes (including blurry vision), chest tightness, cough, shortness of breath (dyspnea), wheezing, diarrhea, nausea, vomiting, sore throat, vertigo, eye irritation, or headache.

Section D: References

Methods

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Discussion

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HHE Report No. 2019-0240-3410

