HHE Health Hazard® Evaluation Program

Evaluation of Indoor Environmental Quality and Health Concerns Among Employees of a Public Elementary School

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October 2021

Centers for Disease Control and Prevention
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Disclaimer

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Availability of Report

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

Recommended Citation

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Introduction

Request

Employees from a public elementary school requested a confidential health hazard evaluation because they thought that they might be experiencing a greater burden of general and reproductive medical conditions than was typical. Employees were concerned that these medical conditions were related to something in their work environment, specifically mold or other causes of poor indoor environmental quality at the school.

Workplace

At the time of our visit, the single-story, public elementary school (one of three in the county) served about 500 children in prekindergarten, kindergarten, and Grades 1–5. About 67 employees worked at the school.

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

Our Approach

In September 2019 we visited the school. During our visit we completed the following activities:

- Visually inspected every room in the school and their associated heating, ventilation, and air-conditioning (HVAC) systems.
- Evaluated every room in the school using the Dampness and Mold Assessment Tool developed by the National Institute for Occupational Safety and Health (NIOSH).
- Measured temperature, relative humidity, carbon monoxide, and carbon dioxide levels in eight occupied classrooms, the teachers' lounge, and outside the school.
- Interviewed employees about their work and their health. Information collected included job tenure, job tasks, and the occurrence and timing of medical symptoms, diagnoses, and concerns.

We sent a letter summarizing our findings from the site visit and recommendations in October 2019.

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

Our Key Findings

We found no evidence of active mold growth in the school

- We observed evidence of past roof leaks but found no visible mold, or wet/damp areas inside the school.

- We observed a leaking hose bibb near the crawlspace on the outside of the building. The crawlspace had some water intrusion, but no mold growth.
- We found two HVAC system condensate drains in the courtyard that did not drain into their respective drainpipes.

The unit ventilators original to the building were approaching the end of their expected service life

- Mold was not observed on or in the unit ventilators we checked.
- Some classroom unit ventilators were partially or completely blocked by books, classroom supplies, or furniture (Figure 1).
- Some classrooms had exhaust fans to help move air though the classroom. These fans were in various states of operation (e.g., functioning, partially functioning, not functioning at all). Some had been recently repaired.
- Carbon dioxide levels were well above outdoor levels in seven of the eight classrooms we measured. This means that the HVAC systems did not provide enough outdoor air to meet guidelines for acceptable ventilation.
- Temperature or relative humidity levels exceeded professional guidelines in two of the eight classrooms we measured. This means that the HVAC systems were unable to condition the air to meet guidelines for comfort parameters.

Figure 1. A classroom unit ventilator is partially blocked by furniture and classroom supplies. The window above it is open. Photo by NIOSH.

- Some areas of the school that were not designed for prolonged occupancy (for example, storage rooms) were being used as classrooms. Areas with inadequate or no HVAC systems cannot meet professional guidelines for acceptable ventilation or comfort parameters.

Some symptoms were more common among school employees than among other comparable working populations

- Employees reported experiencing frequent, work-related stuffy or runny nose or sinus congestion and headaches. Frequent, work-related refers to symptoms that occur at least weekly and improve when away from work.

- The percentage of school employees reporting these symptoms was similar to what employees working in buildings with known indoor environmental quality complaints reported in previous studies.
- The percentage of school employees reporting these symptoms was elevated compared with what employees working in buildings without known indoor environmental quality complaints reported in previous studies.
- Although we cannot directly link these common and nonspecific symptoms with working in the school, these symptoms can be related to poor ventilation.

- Employees reported experiencing migraines or severe headaches during the previous three months.
  - The percentage of school employees reporting these symptoms was elevated compared with what was observed among U.S. teachers and paraprofessionals and with the U.S. female population. However, the percentage of employees reporting migraines and severe headaches that qualified as work-related, was lower. Work-related symptoms were those that improved away from work.
  - No specific indoor environmental exposure has been linked with migraines and severe headaches. Previous studies provide limited evidence to indicate a relationship between uncomfortable indoor environment and migraines and severe headaches, mainly as a trigger among those who already experience these headaches. Noise and stress are also known triggers of migraines and severe headaches.
- Figure B5 in the Supporting Technical Information provides a visual display of these results.

Reproductive medical conditions were not more common among school employees compared with the U.S. population or a previous study of U.S. teachers

- A similar or lower proportion of school employees experienced endometriosis, uterine fibroids, hysterectomy, infertility, and miscarriage compared with the general U.S. population and other populations of employed women.
- We found no evidence that the reproductive medical conditions examined are related to working in the school.
- Figures B6–B7 in the Supporting Technical Information provides a visual display of these results.

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	↑ May increase overall cost savings

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later.

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/shpguidelines/index.html.

Recommendation 1: Prioritize the renovation or replacement of classroom ventilation systems

Why? Properly designed, installed, and maintained HVAC systems can prevent outdoor contaminants from entering the school via the outdoor air intakes of the ventilation system(s) and reduce indoor contaminants. Maintaining comfort parameters (temperature, humidity) at recommended levels has been shown to help resolve or improve symptoms among building occupants.

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

Consult with a licensed professional mechanical engineer to conduct a comprehensive assessment of the school's ventilation systems.

- The licensed professional mechanical 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 buildings ventilated by both forced-air and unit ventilator-type systems.
    - ANSI/ASHRAE Standard 62.1-2019 "Ventilation for Acceptable Indoor Air Quality" recommends a minimum ventilation rate of an outdoor air supply rate of 10 cubic feet per minute per person for classrooms. However, adequate ventilation rates can depend on occupancy, room size, outdoor air provided, and other building-related sources.

- ANSI/ASHRAE Standard 55-2020 "Thermal Environmental Conditions for Human Occupancy" reports human comfort to temperature and humidity levels and establishes a range of temperatures and humidity levels that are considered comfortable by 80% or more of the test subjects. The standard recommends:
    - 68.5 degrees Fahrenheit to 76 degrees Fahrenheit in the winter, and 75 degrees Fahrenheit to 80.5 degrees Fahrenheit in the summer (assuming low air movement and 50% relative humidity) and,
    - Relative humidity be kept at or below 65% in all seasons.

Ensure existing classroom unit ventilators work as designed.

- Do not block airflow around unit ventilators or supply air ducts.
- Reassess the existing preventive maintenance program. Regular inspections and proper maintenance will keep equipment functioning as designed, prolong service life, and save money over the life of the equipment.
- Audit classroom usage (e.g., activities, numbers of occupants) to understand demands on the space. Avoid using rooms not designed for occupants as classrooms or other occupied spaces.
- Keep windows closed to reduce the entrance of unfiltered, unconditioned air.

Recommendation 2: Start an indoor environmental quality management program

Why? This is a proactive approach that can help address the indoor environmental quality issues that have evolved over the past several years and prevent them from recurring. Good indoor environmental quality contributes to a favorable environment for students, performance of teachers and staff, and a sense of comfort, health, and well-being for all building occupants. The U.S. Environmental Protection Agency (EPA) provides guidance on indoor environmental quality in schools, found at *Creating Healthy Indoor Air Quality in Schools* at https://www.epa.gov/iaq-schools.

Additional guidance can be found in the NIOSH/EPA document *Building Air Quality: A Guide for Building Owners and Facility Managers*. This document is available at https://www.epa.gov/sites/production/files/2014-08/documents/iaq.pdf.

A companion NIOSH/EPA guide, *Building Air Quality Action Plan*, discusses how to develop and assess an indoor environmental quality management program and is available at http://www.cdc.gov/niosh/docs/98-123/pdfs/98-123.pdf.

Although no comprehensive regulatory standards specific to indoor environmental quality have been established, guidelines have been developed by organizations and agencies, including ANSI/ASHRAE, NIOSH, and EPA. These resources are available from the NIOSH indoor environmental quality topic page at http://www.cdc.gov/niosh/topics/indoorenv/.

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

Designate an indoor environmental quality manager or administrator with clearly defined responsibilities, authority, and resources to lead the program.

- The indoor environmental quality manager would be responsible for the following tasks:
    - Understand the building's structure and function and be able to communicate effectively with employees.
    - Proactively identify and manage projects that might affect indoor environmental quality (e.g., redecoration, renovation, relocation of personnel).
    - Oversee the activities of occupants and contractors that affect indoor environmental quality (e.g., housekeeping, pest control, maintenance, food preparation).
    - Educate building occupants and contractors about their responsibilities in relation to indoor environmental quality.
    - Encourage employees to report signs of moisture intrusion to the facilities maintenance staff.
    - Speak for all employees and assist with communication. All staff should be made aware of the designee and how to submit concerns for investigation.
    - Maintain and ensure effective and timely communication with occupants regarding indoor environmental quality.

Incorporate the following components of an effective indoor environmental quality management program:

- A formal system (preferably anonymous) for reporting building concerns.
    - A mechanism to let staff know when and how the problem is addressed.
    - A plan for clear communication to all employees about the existence of the program and how to submit a concern.
- A fragrance-free workplace policy. Ensure the policy addresses perfumes and other scented personal care products, air fresheners, and potpourri.
    - The American Lung Association publishes a sample fragrance-free school policy: http://action.lung.org/site/DocServer/fragrance-free-policy-sample-updated.pdf.

Recommendation 3: Improve communication to address employee concerns in the workplace

Why? We found that communication between the school administration and employees could be improved. Good communication is a key component to a strong health and safety program. It is important that school administration clearly communicate about hazards in the workplace and address concerns about potential hazards reported by employees.

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

Communicate with employees about reported hazards and the steps being taken to address those concerns.

Encourage employees to report concerns about work-related symptoms or medical issues to their supervisor or another designee.

Encourage employees to seek evaluation and care (if needed) from a healthcare provider who is knowledgeable in occupational medicine for work-related medical concerns.

- The American College of Occupational and Environmental Medicine maintains a database of providers to help locate someone in your geographic area: https://acoem.org/Find-a-Provider.
- It may be useful to provide the physician with a copy of this report.

Recommendation 4: Create a pest management plan

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 the school district. Although not the focus of our evaluation; employees reported and, we observed several indications of rodent infestation.

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

Hire a licensed exterminator to investigate the entire building for pests.

Consult existing resources to inform and implement your integrated pest management plan.

- For example, the Michigan Department of Agriculture and Rural Development provides resources for Integrated Pest Management Plans at https://www.michigan.gov/mdard/0,4610,7-125-1566_2405_37164---,00.html.

Reevaluate food storage, consumption practices, and housekeeping after food consumption in classrooms.

Supporting Technical Information

Evaluation of Indoor Environmental Quality and Health Concerns Among Employees of a Public Elementary School

HHE Report No. 2019-0156-3382

October 2021

Section A: Workplace Information

Building

The single-story, public elementary school was built in 1954. Two additions were made, one in the 1960s and another in the 1990s. The school serves approximately 500 students in prekindergarten, kindergarten, and grades 1 through 5.

Employee Information

Number of employees at time of evaluation: 67

Median age: 39 years (range: 20–65 years)

Median tenure working at the school: 4 years (range: < 1–32 years)

Median hours/week spent in school: 40 hours (range: 3–55 hours/week)

Background

In 2015, employees saw evidence of water intrusion in the school. Employees also noted that multiple employees had or were experiencing migraines, thyroid disorders, and various reproductive medical conditions. They became concerned that these medical conditions could be associated with poor indoor environmental quality (IEQ) in their workplace.

Employees reported their concerns to school administrators in 2015. The same year, a new roof was installed; however, reports of water leaks inside the school continued. In 2016, the school administration contracted an environmental consultant to evaluate indoor air quality (IAQ). The consultant performed four evaluations between October 2015 and March 2019. Employees submitted this health hazard evaluation request after two employees suffered strokes, leading to increased concern about employees' safety and health at work.

Section B: Methods, Results, and Discussion

Our objectives were to determine if the school had mold or other IEQ issues and if the medical and reproductive conditions of concern could be associated with the building.

Methods: Review of Prior Indoor Air Quality Consultant Reports

Four IAQ assessments were performed by an environmental consultant on behalf of school administrators and one IAQ assessment was performed by a different environmental consultant on behalf of the teachers' union. We reviewed each assessment report to identify known problems and previously provided recommendations.

Results: Review of Prior Indoor Air Quality Consultant Reports

Prior Investigations Requested by School Administration

October 2015

In response to employee concerns about the potential for mold growth in Rm 412 after a roof leak, school administration hired a consultant. The consultant performed a visual inspection, collected airborne mold samples, and measured temperature (°F), relative humidity (RH), carbon dioxide (CO_2), and carbon monoxide (CO) levels in Rm 412 and other locations in and outside the building. The consultant reported the following:

- Multiple classrooms had materials and furniture blocking the front and tops of unit ventilators.
- Mold levels in the building ranged from 3,800 structures per cubic meter of air (sm^3) to 14,000 sm^3. The mold level in Rm 412 was 14,000 sm^3. The mold level outside the building was 28,000 sm^3. No growth or amplification sites of mold were found within the area of concern in the building.
- CO_2 levels in the building ranged from 646 parts per million (ppm) (in Rm 113) to 1,318 ppm (in Rm 414); the CO_2 level in Rm 412 was 1,303 ppm. The CO_2 level outside the building was 406 ppm.
- All CO levels were below instrument detection limits (≈1 ppm).
- Temperatures in the building ranged from 70.3°F (in Rm 412) to 73.9°F (in Rm 103). The temperature outside the building was 70°F. RH levels in the building ranged from 33.9% (in Rm 113) to 42.7% (in Rm 414). Outdoor RH was not reported. The temperature was 70.3°F and RH was 38.6% in Rm 412.

October 2016

In response to employee concerns about mold growth in carpets due to lingering moisture from cleaning performed during the summer, school administration hired a consultant. The consultant performed a visual inspection, collected airborne and surface mold samples, and measured temperature, RH, CO_2, and CO levels in several locations in and outside the building. The consultant reported the following:

- Multiple classrooms had materials and furniture blocking the front and tops of unit ventilators.
- Mold levels in the building ranged from 2,100 sm^3 (in the Library) to 43,000 sm^3 (in Rm 322). The mold level outside the building was 41,000 sm^3. Surface samples collected inside the building did not identify obvious signs of fungal growth or a reservoir.
- CO_2 levels in the building ranged from 525 ppm (in Rm 321) to 2,685 ppm (in Rm 416). The CO_2 level outside the building was 410 ppm. CO_2 measurements were made in occupied areas, to the extent possible. CO levels were reported to be "very low" inside and 2 ppm outside.
- Temperatures in the building ranged from 72.0°F (in Rm 319) to 77.7°F (in Rm 202). The temperature outside the building was 76.0°F. RH levels in the building ranged from 42.3% (in Rm 107) to 57.2% (in Rm 314). The RH level outside the building was 54.3%.

January 2019

In response to reports that employees were "…experiencing health concerns…" associated with Rm 410, school administration hired a consultant. The consultant performed a visual inspection, collected airborne mold samples, and measured temperature, RH, CO_2, and CO levels in Rm 410 and other locations in and outside the building. In addition, they measured volatile organic compounds, hydrogen sulfide, hydrocarbons, and percent oxygen levels. The consultant reported the following:

- Materials and furniture blocked the front and tops of the unit ventilator in Rm 410. In addition, there was a strong odor coming from under the sink, and a faint paint odor in the closet in Rm 410.
- Mold levels in the building ranged from 90 sm^3 (in Rm 410) to 200 sm^3 (in Rm 101). No mold was detected outside.
- Temperatures ranged from 67.5°F (in Rm 410) to 70.4°F (in the hall outside Rm 410). The temperature outside the building was –8°F. RH levels in the building ranged from 8.2% (in the hall outside Rm 410) to 11.8% (in Rm 410). The RH level outside the building was 0.5%.
- CO_2 levels ranged from 410 to 487 ppm in room 410. The CO_2 level outside the building was 371 ppm. CO levels were low or below instrument detection limits (≈1 ppm) in all sampling locations inside and outside the building.
- Volatile organic compound sampling detected trace levels (described by the consultant as "…thousands of times less than Occupational Safety and Health Administration (OSHA) permissible exposure limits") of ethanol and ethyl acetate ("…possibly from perfume or nail polish").
- All hydrogen sulfide and hydrocarbon levels were below instrument detection limits (≈1 ppm).
- Percent oxygen measurements were 20.9% in all sampling locations inside and outside the building. All oxygen levels recorded were within established guidelines.
- "…these measurements were taken on a non-school day so do not represent measurements during occupied times."

March 2019

In response to employee concerns about IAQ in the school, school administration hired a consultant. The consultant performed a visual inspection, collected airborne and bulk mold samples, airborne polychlorinated biphenyls samples, bulk water samples for lead and copper, and measured CO_2 levels, focusing on the 400 wing of the building and outside the building. The consultant reported the following:

- Multiple classrooms had materials and furniture blocking the front and tops of unit ventilators.
- Mold levels in the building ranged from 210 sm^3 (in 300 hallway) to 2,300 sm^3 (in Rm 410). The mold level outside the building was 3,600 sm^3. The bulk sample of insulation (from Rm 411) was reported as "not mold."
- CO_2 levels were not recorded, but real-time measurements were "…at times…" above 2,000 ppm in Rm 410, Rm 412, and in "associated hallways during occupied times."
- Lead and copper concentrations in water samples collected from drinking fountains were reported (by the laboratory) as below applicable EPA and State Action Levels.
- Polychlorinated biphenyls levels in the air in the building were reported as not detected.

Prior Investigation Requested by Employees

May 2019

Employees hired a consultant to provide a second opinion about IAQ at the school. The employee consultant met with representatives of school employees, staff, and the school administration consultant. They reviewed past administration-initiated IAQ reports and performed a visual inspection of the building.

The consultant performed no sampling but encouraged administration to conduct (1) a health effects survey of employees, (2) an "enhanced" visual inspection of the school, including the tunnel system (crawlspace), (3) additional mold sampling, and (4) a detailed review of cleaning products and procedures.

Methods: On-site Building Evaluation

Visual Inspection

We inspected every room including classrooms, multipurpose areas, library, lunchroom, kitchen, gymnasium, and the administrative offices. We also inspected areas in the school not readily accessible to teachers or students, such as storage areas, the roof, and the crawlspace (referred to as tunnels in the consultants' reports). We visually inspected ventilation systems and at least one of the three types of unit ventilators in the school.

Environmental Measurements

We used TSI® Q-Traks to record temperature, RH, CO, and CO_2 measurements in eight classrooms, the teacher's lounge, and outside the building. We selected classrooms based on past complaints and past IAQ investigations. Measurements made in these classrooms were collected over the course of the school day (eight or more hours). Measurements made in other locations and outside the building were

spot measurements. We compared these measurements with ANSI/ASHRAE guidelines when applicable.

NIOSH Dampness and Mold Assessment Tool

We evaluated every room in the school using the NIOSH Dampness and Mold Assessment Tool (https://www.cdc.gov/niosh/docs/2019-114/pdfs/2019-114.pdf?id=10.26616/NIOSHPUB2019114). The tool refers users to the EPA document Mold Remediation in School and Commercial Buildings (www.epa.gov/mold/mold-remediation-schools-and-commercial-buildings-guide).

Results: On-site Building Evaluation

Visual Inspection

Lack of adequate space is an issue at the school, so some storage rooms had been converted to classroom use. We also observed classrooms crowded both with students and furniture.

Though we found signs of a lack of maintenance, we also observed recent maintenance including upgrades, repairs, and improvements to several HVAC units throughout the school. We observed evidence of past roof leaks. However, we found no evidence of current moisture or mold in any of the classrooms. We did see several stained ceiling tiles throughout the building but none of these stained surfaces were wet at the time of our visit.

The crawlspace had some water intrusion, but no mold growth. We observed a leaking hose bibb near the crawlspace on the outside the building, a potential source of the water in the crawlspace. We found two condensate drains in the courtyard that did not drain into their respective drainpipes. The school's membrane-style flat roof had been replaced in 2015 and appeared in good condition, with little standing water and no debris that could potentially clog roof drains.

We saw scented air fresheners in use in a few locations. These can be a potential source of irritation, odor, and allergic reactions to some employees.

Heating, Ventilating, and Air-Conditioning

We inspected inside at least one of each type of unit ventilator in the building. A unit ventilator, also called a fan coil unit, is a simple ventilation system. Hot water from a central boiler was piped to each unit ventilator. A fan inside each unit ventilator circulated classroom air across the hot water lines to provide heating. As such, many of the unit ventilators could only provide heating and were unable to cool the air or control humidity.

In most classrooms, a unit ventilator was located on the exterior wall beneath an operable window, a design common in older schools (Figure B1). In some classrooms, the unit ventilator was in the ceiling (Figure B2).

Some (but not all) unit ventilators also had an outdoor air intake that could allow outdoor air to be mixed with recirculated room air. These units were paired with an exhaust fan to help move air though the classroom. Not all of these fans functioned. Consistent with the prior IAQ consultant reports, we found multiple classrooms had teaching supplies and/or furniture partially blocking unit ventilator air intakes and/or exhausts. In addition to affecting ventilation, the clutter on and around unit ventilators may also hinder housekeeping and maintenance activities.

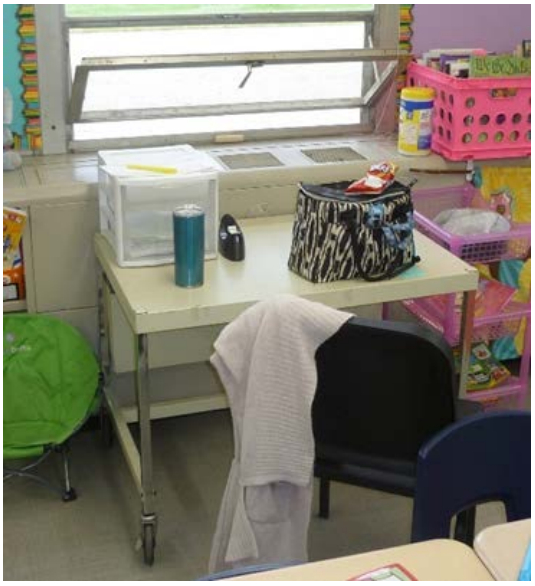

Figure B1. A typical classroom unit ventilator. Photo by NIOSH.

The interiors of unit ventilators that we randomly checked were clean and had no visible evidence of microbial contamination. Some of the classroom unit ventilators had damaged or missing foam seals on the covers. Seals ensure the unit ventilator circulates air only after it has been drawn through the filter. The air filters in these units were also the correct size, properly installed, and appeared in good condition (Figure B3).

Figure B2. Typical classroom ceiling-mounted unit ventilator. Photo by NIOSH.

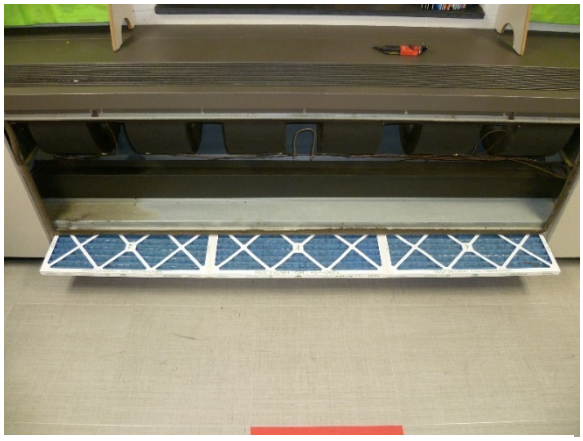

Figure B3. Classroom unit ventilator with access panel removed. Photo by NIOSH.

Maintenance personnel reported that all the ventilation systems in the school used minimum efficiency reporting value (MERV) 8 air filters, an air filter type often used in nonindustrial workplaces such as offices and schools. The air filters in the rooftop HVAC units were replaced twice per year, while those in the classroom unit ventilators were replaced three times per year, or as needed.

Environmental Measurements

The results of environmental monitoring are presented in Table C1.

Carbon Monoxide

During our visit, CO concentrations in the building ranged from not detected to 1 ppm, well below the most restrictive occupational exposure levels (OELs) (data not shown).

Carbon Dioxide

During our visit, CO_2 concentrations in the classrooms ranged from 419 to 2,566 ppm. The maximum CO_2 concentration was well above the outdoor level.

Temperature and Relative Humidity

During our visit, temperature and RH measurements ranged from 67°F to 80°F and 33% to 57% RH. Temperature and RH measurements inside the building were outside (either above or below) ANSI/ASHRAE guidelines.

NIOSH Dampness and Mold Assessment Tool

We used the tool to evaluate every room in the building. We assessed for mold growth and water damage using the following tool guidelines:

a. Damage or Stains – This refers to any water-related damage or stains identified per component. Damage could include peeling paint, efflorescence, rust, warping, and deteriorated or crumbling building materials. Stains could include discoloration caused by possible water leaks, flooding or condensation.

b. Visible Mold – Mold can include patches or spots that are colored differently than the underlying material (typically gray, brown, or black). Mold can appear fuzzy and can have a musty or earthy odor.

c. Wet or Damp – Wet or damp conditions could include visible signs of moisture, such as water beads or condensation, humidity, water leaks, or flooding.

We then scored each room. Scoring is based on the size of all affected areas combined. Individual sizes of each affected area are added together to obtain a combined size. The possible scores are as follows:

0 = No problem areas identified.

1 = The combined area of damage is the size of a standard sheet of paper (8½" × 11") or smaller.

2 = The combined area of damage is greater than the size of a standard sheet of paper (8½" × 11") and less than the size of a standard interior door (32" × 80").

3 = The combined area of damage is greater than the size of a standard interior door (32" × 80").

A score of 3 for Damage or Stains, Visible Mold, or Wet or Damp should trigger immediate attention to identify problem sources and to remediate. Likewise, a score of 3 for Mold Odor should trigger attention to identify areas of hidden mold. For example: a score of 1-0-0 means:

- 1 = The combined area of damage/stain observed is the size of a standard sheet of paper or smaller.

- 0 = No visible mold growth.
- 0 = No wetness or dampness.

Scores should also be used for comparison of rooms/areas over time to see if remediation works or if problems get worse.

Though we found signs of past water intrusion, we found no evidence of current water intrusion or mold growth in any of the rooms of the school. Figure B4 shows the results of our assessment. None of the scores were greater than 2.

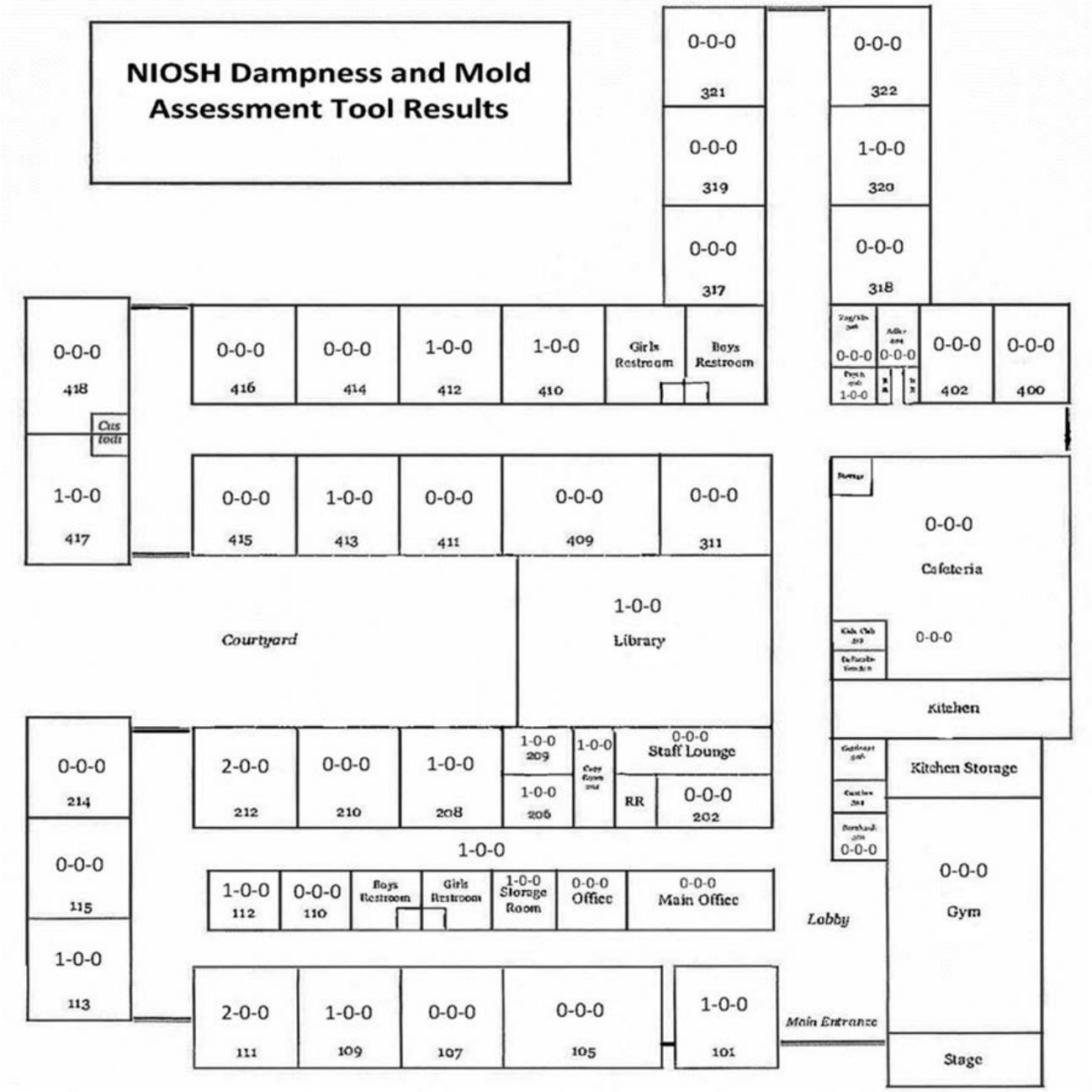

Figure B4. NIOSH dampness and mold assessment results

Methods: Employee Interviews

During our site visit, we invited all current school employees to participate in voluntary, confidential medical interviews. Employees who were on leave or not available during our visit were invited to participate in a phone interview. We used the structured interviews to collect information from employees about employment history at the school, other jobs outside of the school, demographics, respiratory and general medical symptoms and conditions, reproductive medical history, and health and safety concerns related to their work. Employees who reported the following medical conditions were invited to sign a medical record release form to allow NIOSH staff to request their medical records if needed to confirm a diagnosis: migraines and severe headaches, stroke, thyroid conditions or cancer, infertility, uterine fibroids, and hysterectomy.

We limited the analysis of chronic (i.e., stroke and thyroid disorders) and reproductive medical conditions to female employees who participated in an interview and who had worked at least one week during the previous school year. Male employees were excluded from analysis of stroke, thyroid disorders, and infertility because the risk of these conditions is known to differ by sex and there was a small number of male employees (< 5). Male employees were excluded from analyses of other reproductive conditions because they are not at risk for experiencing the conditions.

In the following sections we describe the information collected about symptoms and conditions in detail. Using this information, we estimated the percentage of participating employees experiencing a symptom or condition, referred to as prevalence.

General and Respiratory Symptoms

We asked employees about the frequency of the following symptoms and whether the symptom improves, stays the same, or worsens when away from work.

- Dry, itching, or irritated eyes
- Stuffy or runny nose, or sinus congestion
- Sore or dry throat
- Headache
- Chest tightness
- Wheezing
- Cough
- Shortness of breath
- Dizziness or lightheadedness
- Nausea, upset stomach, or gastrointestinal (GI) upset

Using a similar approach as previous studies [Brightman et al. 2008; Malkin et al. 1996], we classified the symptom as frequent if a person experienced the symptom daily or weekly. We classified the symptoms

as work-related if a person reported that the symptom improved when away from work. We estimated the prevalence of frequent, work-related symptoms among interview participants.

Migraines or Severe Headaches

We asked interviewees if they ever had a migraine. If the interviewee reported ever experiencing a migraine, we asked follow-up questions to understand when they first experienced migraines, frequency of migraines, if the migraine symptoms improve when away from work, whether a medical professional had provided a diagnosis, and whether any known triggers exist. We then asked the same set of questions about severe headaches, which we defined as a headache bad enough to disrupt daily activities that was not a migraine.

We estimated the prevalence of migraines or severe headaches within the previous three months. Concentrating on the previous three months allowed for comparison with existing U.S. population statistics, limited the potential for inaccurate recall of older events, and captured the first three weeks of the school year. We also examined the proportion of persons experiencing migraine or severe headache in the past three months who reported the symptoms got better when away from work.

Stroke and Thyroid Disorders

We asked interviewees if a medical professional had ever told them that they had a stroke, a thyroid problem, or thyroid cancer. If an interviewee reported one of these conditions, we asked follow-up questions about details and timing of the diagnosis. We estimated the lifetime prevalence of stroke and individual types of thyroid disorders and the prevalence of each condition diagnosed after beginning work at the school.

Reproductive Medical Conditions

We asked female employees questions about their menstrual and reproductive history to assess the prevalence of the following conditions.

Endometriosis

We asked interviewees if a medical professional had ever told them they had endometriosis. We asked those reporting a diagnosis when their symptoms began. From this information, we estimated the lifetime prevalence of endometriosis and the prevalence of endometriosis with symptoms starting after beginning work at the school.

Uterine Fibroids

We asked interviewees if a medical professional had ever told them they had uterine fibroids. We asked those reporting a diagnosis when their symptoms began. From this information, we estimated the lifetime prevalence of uterine fibroids and the prevalence of uterine fibroids with symptoms starting after beginning work at the school.

Hysterectomy

We asked interviewees if they had ever had a hysterectomy. We asked those reporting a hysterectomy when it occurred and why it was performed. From this information, we estimated the prevalence of hysterectomy and the prevalence of hysterectomy occurring after beginning work at the school. We also examined the reasons for hysterectomy to identify any patterns.

Infertility

Infertility is defined as a female having unprotected sexual intercourse with a male partner for 1 year or more without becoming pregnant [CDC 2014b]. We estimated the prevalence of infertility as the number of female employees reporting infertility divided by the total number of female employees of reproductive age (15–44 years old); estimating infertility in this way allowed us to compare the prevalence of infertility among female employees to the prevalence in the U.S. population. We estimated the lifetime prevalence of infertility and the prevalence of infertility that occurred for the first time after beginning work at the school.

Miscarriage

We asked interviewees about their pregnancy history. For each pregnancy we asked their age at the beginning of pregnancy, whether they were working at the school during the pregnancy, gestational age in weeks at the end of the pregnancy, and how the pregnancy ended (e.g., live birth, miscarriage). We estimated the prevalence of miscarriages as the number of reported miscarriages divided by the total number of reported pregnancies occurring while the mother was working at the school.

Employee Concerns

We asked interviewees the following questions:

- Is there something in your workplace that you think is causing health problems? If yes, please tell me more about it.
- Is there anything else you would like me to know that I haven't asked you about?

We examined the answers to these open-ended questions and describe the themes observed in employees' answers.

Statistical Analysis and Data Visualization

For each prevalence estimate described above, we estimated the Clopper-Pearson exact 95% confidence interval (CI). For miscarriage, we estimated the prevalence and 95% CI using generalized estimating equations to account for nonindependence of miscarriages experienced by the same woman. CIs are provided to show precision; the smaller the number of people included in the analysis, the wider the interval and the less precision we have. Because the occurrence of some conditions increases with increasing age, we attempted to either present estimates by age group or adjust for age; however, there were too few employees in each age group to provide stable estimates, so those results are not reported here.

We identified previous studies and published estimates of the prevalence of each condition described above in the general U.S. population and other working populations as available. We qualitatively compared the prevalence of each condition to the prevalence found in other populations to determine whether the prevalence among school employees was less than, similar to, or greater than the prevalence in comparable populations.

To visualize these analyses, we created stock graphs showing the results from the employee interviews and how they compare with the U.S. population or relevant populations of employed U.S. women, when available.

Results: Employee Interviews

Among 67 employees of the school, 65 participated in an interview and are included in analysis of general symptoms. For analysis of health outcomes that take time to develop (i.e., stroke, thyroid disorders, reproductive health outcomes) we included the 58 female employees who participated in an interview and worked at the school for at least one week prior to the 2019–2020 school year.

Among the 65 participating employees,

- > 90% identified as female;
- > 90% identified as non-Hispanic white;
- 54% (n = 35) were teachers, 23% (n = 15) were paraprofessionals, and 23% (n = 15) were administrators, school assistants, interventionists, or specialists;
- 17% (n = 11) reported working another job outside of the school, including jobs in the service, education, recreation, and sales industries;
- median age was 39 years (range: 20–65 years old); and,
- median time working at the school was 4 years (range: < 1–32 years) for a median 40 hours/week (range: 3–55 hours/week) during the school year.

General and Respiratory Symptoms

The percentage of frequent, work-related symptoms reported by school employees is shown in Table C2. Frequent, work-related headache was the most common symptom followed by stuffy or runny nose, or sinus congestion. The percentage of school employees reporting these two symptoms was similar to the percentage of office workers in buildings with IEQ complaints, and greater than the percentage of office workers in buildings with no known IEQ complaints. The prevalence of other symptoms among school employees was low, and similar to what has been reported by office workers in buildings with no known IEQ complaints.

Migraines and Severe Headaches

Approximately 40% (95% CI: 28%, 53%) of school employees reported a migraine or severe headache during the previous three months (Table C3). This estimate was elevated compared with what has been reported among female U.S. teachers and paraprofessionals participating in a national study (24%) [CDC 2018a] and women in the general U.S. population (28%) [Smitherman et al. 2013]. However, only 19% (95% CI: 10%, 31%) of female school employees met the criteria for potentially work-related migraines or severe headaches (meaning the migraine or severe headache improved when away from the school environment).

Strokes and Thyroid Conditions

No strokes were reported among participating employees. We are aware of reports of two strokes occurring among former employees of the school but are not able to assess medical outcomes among former employees accurately.

Six of 58 current employees who worked at the school prior to the 2019–2020 school year reported a diagnosis of a thyroid condition (10%). Conditions reported included various types of hyper- and

hypothyroidism; no employee reported a diagnosis of thyroid cancer. The lifetime prevalence of thyroid conditions reported by employees was similar to the prevalence of thyroid disorders in the U.S. population (1%–12% depending on the population) [American Thyroid Association, no date; Institute of Medicine 2003]. Only three employees reported that symptoms of their thyroid disorder began after starting work at the school.

Reproductive Medical Conditions

The prevalence of the reproductive medical conditions evaluated are shown in Table C4. The prevalence of these conditions among participating employees was similar to the lifetime prevalence among U.S. women and populations of employed women. In addition, many symptoms of these conditions began prior to employment at the school.

Employee Concerns

Approximately 46% of participating employees said they thought there was something in their workplace that is causing health problems; 25% said they did not think there was something in their workplace causing health problems; and 28% said they weren't sure. The most mentioned environmental concerns were poor ventilation (67%), evidence of water intrusion (48%), mice (34%), poor cleanliness (33%), and odors (16%). Approximately 45% of employees were concerned about medical conditions either they had experienced or had seen coworkers' experience; specific medical conditions mentioned included those evaluated here. In addition, employees described a stressful work environment due to concerns about workplace health and safety, poor communication between school administration and staff and between staff, an inability to take bathroom breaks when needed, and general pressures of serving as an educator.

Data Visualization

Figures B5–B7 show the percentage of participating school employees experiencing selected general and respiratory symptoms, migraines and severe headaches, and reproductive medical conditions compared with other populations. Figure B5, Graphs A–B show the percentage of participating school employees (n = 65) reporting frequent, work-related stuffy or runny nose, or sinus congestion and frequent, work-related headache compared with observations from other studies of workers in buildings with and without IEQ complaints. Graph C shows the percentage of participating school employees (n = 64) reporting any migraine or severe headache and work-related migraine or severe headache during the previous three months compared with the percentage of the U.S. female population and U.S. female teachers and paraprofessionals experiencing at least one migraine or severe headache during a 3-month period. Figure B6, Graphs D–G show the percentage of participating school employees (n = 57) reporting ever receiving a diagnosis of endometriosis, uterine fibroids, and hysterectomy, and the percentage of participating school employees (n = 56) experiencing infertility compared with the percentage of the U.S. female population experiencing these medical conditions or procedures. Finally, Figure B7, Graph H shows the percentage of pregnancies experienced while employed at the school (n = 35) ending in miscarriage among participating school employees compared with the percentage of pregnancies ending in miscarriage in the U.S. female population and in a previous study of U.S. teachers. Estimates shown in Figures B5–B7 also appear in Tables C2–C4 along with citations for the comparison estimates.

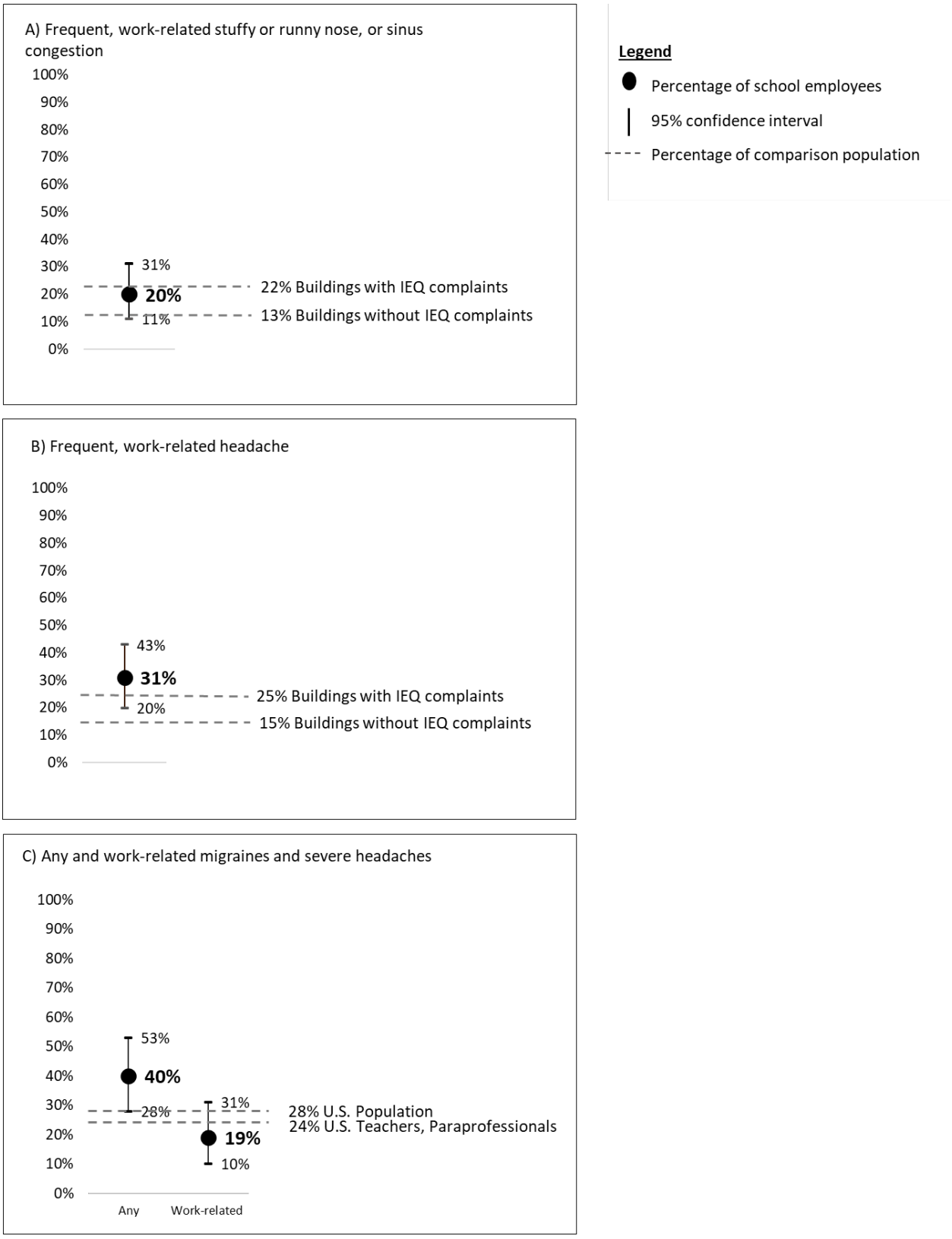

Figure B5. Graphs (A–C) show the percentage of participating school employees who experienced the following symptoms or conditions as compared with other populations: (A) frequent, work-related stuffy or runny nose, or sinus congestion, (B) frequent work-related headache, and (C) any migraine or severe headache and work-related migraine or severe headache during the previous three months.

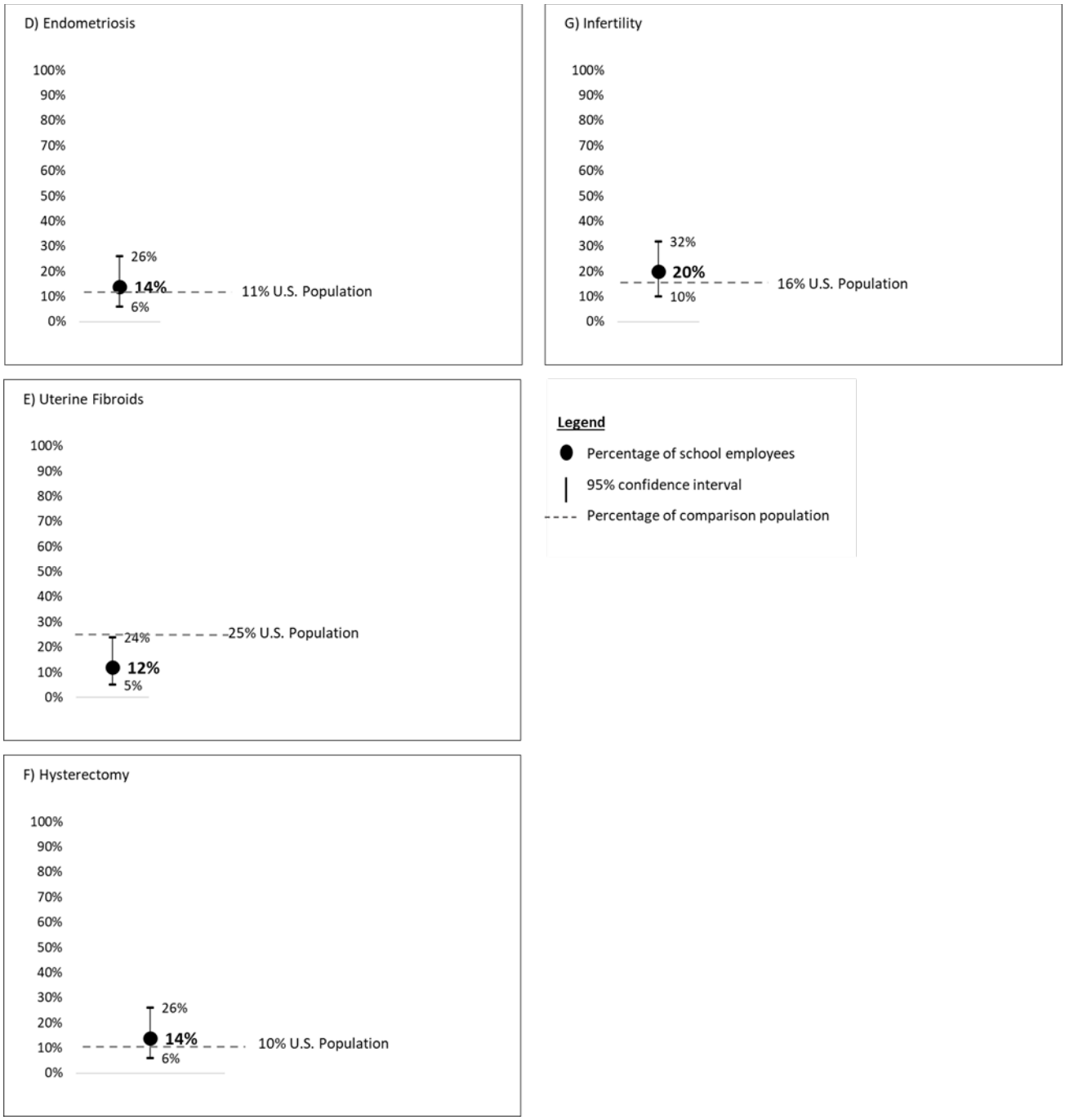

Figure B6. Graphs (D–G) show the percentage of participating school employees who reported the following diagnoses or conditions as compared with other populations: (D) endometriosis, (E) uterine fibroids; (F) hysterectomy; and (G) infertility.

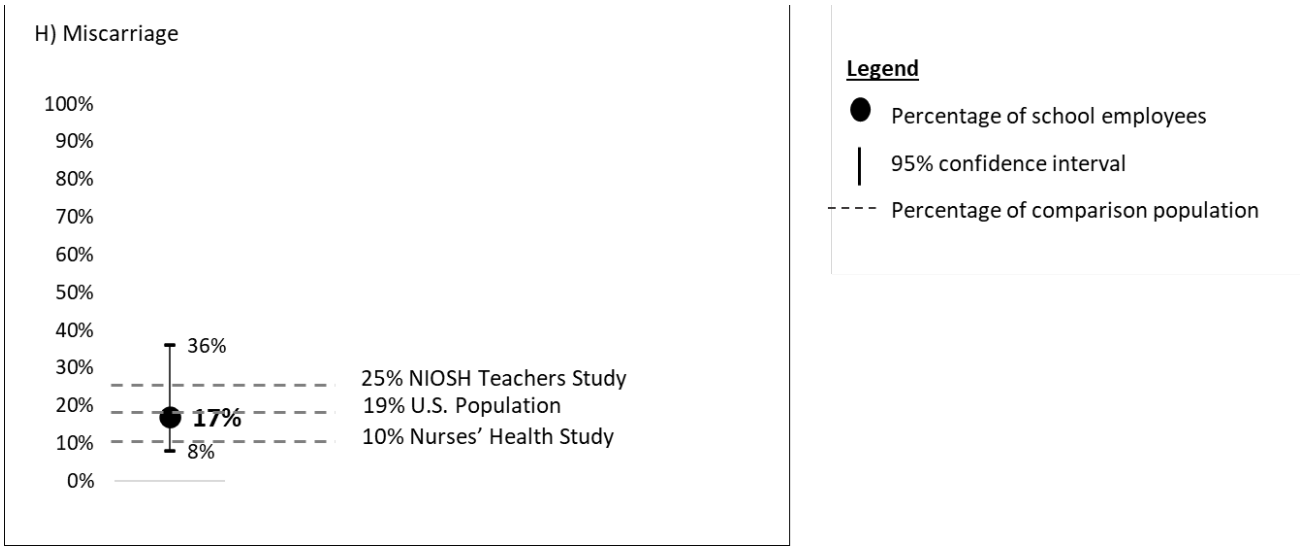

Figure B7. Graph H shows the percentage of pregnancies occurring while employed at the school reported to have ended in miscarriage compared with other populations.

Discussion

We identified indicators of poor IEQ at the school during this evaluation. Classrooms, offices, and other spaces lacked appropriate ventilation to keep environmental parameters such as temperature and RH, in recommended ranges. Although we did not find mold present in the building, we did see evidence of past water intrusion. These IEQ deficiencies could be related to general symptoms (e.g., nasal irritation, headache) experienced by staff. Although employees were concerned about an excess of medical conditions including reproductive conditions, we did not find an excess among school employees compared with the U.S. population or other employed populations. In addition, we did not identify specific exposures that are known to cause these medical conditions.

Indoor Environmental Quality

Our observations and recommendations about IEQ are consistent with the findings and recommendations provided by consultants hired by school administrators and employees. Below we provide context for our findings and recommendations to address IEQ at the school.

Heating, Ventilating, and Air-Conditioning

Even when new, some unit ventilators would be unable to meet ANSI/ASHRAE guidelines for temperature and RH control. Increased occupancy rates are an added challenge to these systems.

The amount of air required to be delivered to a given space by a ventilation system is based primarily on the number of people occupying the space, the type and amount of equipment used in the space, and the overall size of the space [ANSI/ASHRAE 2019].

One of the most common deficiencies we have found over many years of health hazard evaluations in nonindustrial indoor environments is the inadequate design, improper operation and/or maintenance of ventilation systems and other building components [Rosenstock 1996]. NIOSH investigators have found that correcting HVAC problems often reduces reported symptoms. Most studies of ventilation rates and building occupant symptoms have shown that rates below 20 cubic feet per minute per person

are associated with one or more health symptoms [Seppänen et al. 1999]. Moreover, higher ventilation rates have been associated with decreases in the prevalence of symptoms [Seppänen et al. 1999].

An analysis of the published scientific literature showed that nonspecific symptoms such as headache, fatigue, and mucous membrane irritation increase as ventilation rates decrease [Fisk et al. 2009]. Studies in schools and office buildings have found a decrease in illness-related absences with increased ventilation rates [Mendell et al. 2011; Milton et al. 2000; Shendell et al. 2004]. Thus, improving HVAC operation and maintenance and increasing ventilation rates can improve symptoms without ever identifying any specific cause-effect relationships. We believe similar benefits would occur if ventilation is improved at this school. Additionally, improvements to ventilation are a key element of preventing the spread of viruses such as SARS-CoV-2, the virus that causes COVID-19.

Environmental Measurements

Carbon Monoxide

During our visit, CO levels were well below the most restrictive occupational exposure level.

CO is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials (e.g., gasoline, wood, coal). Exposure to CO limits the ability of the blood to carry oxygen to the tissues by binding with hemoglobin to form carboxyhemoglobin (COHb) [ACGIH 2001; NIOSH 1972, 1977, 1979, 2010; Proctor et al. 1988]. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea. These initial symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. Coma or death may occur if high exposures continue.

Carbon Dioxide

During our visit, the maximum CO_2 levels were well above outdoor levels in seven of the eight classrooms we measured. Elevated indoor CO_2 levels could indicate potentially inadequate ventilation.

Outdoor air is delivered through the ventilation system and is necessary to dilute indoor air pollutants. Office machines, building materials, furnishings, cleaning products, and the building occupants themselves are potential sources of indoor air pollutants. CO_2 is a normal constituent of exhaled breath and is not considered a building air pollutant. However, CO_2 concentrations can be used as an easily measured surrogate for ventilation rates. It can be used as an indicator of whether enough outdoor air is being introduced into an occupied space for acceptable odor control and comfort. As the level of CO_2 increases, the level of indoor contaminants may also be increasing. Recent studies have shown that the health effects associated with elevated CO_2 levels are varied and may be associated with other factors [Fisk et al. 2019; Mishra et al. 2021; Persily and de Jonge 2017].

Temperature and Relative Humidity

During our visit, temperature and RH measurements inside the building exceeded ANSI/ASHRAE guidelines indicating inadequate thermal and humidity control.

The ANSI/ASHRAE Standard 55-2020, Thermal Environmental Conditions for Human Occupancy, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable [ANSI/ASHRAE 2020]. Assuming slow air movement and 50% RH, the operative temperatures recommended by ANSI/ASHRAE range from 68.5°F to 76°F in the winter, and from

75°F to 80.5°F in the summer. The difference between the two is largely due to seasonal clothing selection.

ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality, requires that RH levels be designed to be limited to 65% or less for mechanical systems with dehumidification capability [ANSI/ASHRAE 2019]. For other mechanical system types or where spaces are not served by mechanical systems, Standard 62.1 has no humidity limitations. Excessive humidity can promote the growth of microorganisms and dust mites. The standard does not specify a lower humidity limit but notes that nonthermal comfort factors such as skin drying, irritation of mucus membranes, dry eyes, and static electricity may place limits on acceptability of very low humidity environments. Some employees reported these symptoms.

Mold

Exposure to microbes is not unique to the indoor environment. No environment, indoors or out, is completely free from microbes, not even a surgical operating room. Microbes present in indoor air that are relevant 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 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 to 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].

Although we did not find evidence of current water intrusion and related microbial growth, it is important that measures are taken to prevent water intrusion in the future to protect the health and safety of those spending time in the building [NIOSH 2012]. No exposure guidelines for mold in air exist, so it is not possible to distinguish between "safe" and "unsafe" levels of exposure. Healthy individuals are usually not vulnerable to infections from airborne mold exposure. However, people with weakened immune systems (those with diabetes, on chronic systemic steroid therapy, with cancer or acquired immune deficiency syndrome, among others) may be more vulnerable to infections by molds. Nevertheless, the potential for health problems is an important reason to prevent indoor mold growth and to remediate any indoor mold contamination. Moisture intrusion, along with nutrient sources such as building materials or furnishings, allows mold to grow indoors, so it is important to keep the building interior and furnishings dry. By preventing water intrusion and thereby microbial growth, the potential for exposure to mold or other microbes in the school environment will be limited.

No airborne exposure standards specific to the nonindustrial indoor environment exist. Likewise, no exposure guidelines for mold (or other microbes) in air exist, so it is not possible to distinguish between "safe" and "unsafe" levels of exposure. Therefore, measuring indoor environmental contaminants, such

as mold or volatile organic compounds, has seldom proved helpful in determining the cause of symptoms. For this reason, we do not recommend sampling for mold and encourage redirecting resources toward improving ventilation systems.

Health Concerns

The percentage of employees experiencing frequent, work-related headache, stuffy or runny nose or sinus congestion, or sore or dry throat was similar to the percentage of employees in buildings with known IEQ problems reporting these symptoms in previous evaluations [Brightman et al. 2008, Malkin et al. 1996]. These symptoms are nonspecific, meaning they can be caused by many things, and are common. For example, 86%–95% of the general population have one or more of these symptoms during any given 2- to 4-week period, and the average adult reports a minimum of one symptom every 4–6 days [Barsky and Borus 1995]. Further, the average adult has two to three upper respiratory infections per year, also causing these nonspecific symptoms [Benninger et al. 2003].

Water intrusion with resultant microbial growth and lack of adequate ventilation are both associated with many of the symptoms reported by employees [Brightman et al. 2008, Malkin et al. 1996]. During our visit, ventilation deficiencies were almost ubiquitous throughout the school. While past water damage was isolated and limited and we did not see visible mold growth. Therefore, it is more likely that poor ventilation may be contributing to the occurrence of these nonspecific symptoms compared with dampness, water damage, and mold growth. Low indoor RH is more likely in winter. Health complaints associated with indoor dryness include skin irritation; drying of the mucous membranes of the nose, mouth, and throat; nosebleeds; eye irritation; sore throat; and minor respiratory difficulties [Arundel et al. 1986; Berglund 1998].

We also found an elevated prevalence of migraines and severe headaches during the previous three months compared with U.S. studies of teachers and paraprofessionals and the general U.S. population [CDC 2018a; Smitherman et al. 2013]. However, only half of those migraines and severe headaches qualified as potentially work-related, meaning the migraines or severe headaches improved when employees were away from the school, indicating that something in the school environment may not fully explain this excess.

Migraines and severe headaches are common in the United States, especially among women between the ages of 18 and 44 years [Lipton et al. 2001; Smitherman et al. 2013]. Approximately one in every four women will experience a migraine during their lifetime, and these symptoms can be disabling and burdensome, often interfering with productivity [Bigal et al. 2004; Moens et al. 2007; Smitherman et al. 2013; Tietjen et al. 2012]. Migraines and severe headaches have a range of triggers that include foods and beverages, weather changes, hormonal changes (e.g., pregnancy, menstruation), and environmental factors [Friedman et al. 2009]. Factors in indoor environments (e.g., poor ventilation, out-of-comfort lighting, loud noise, odors) may serve as triggers in people who suffer from migraines or severe headaches [Tietjen et al. 2012]. In addition, previous work has shown that stress in the workplace may also trigger migraines and severe headaches in those who suffer from them [Tietjen et al. 2012]. Because migraines and severe headaches are common and can have many triggers [Smitherman et al. 2013], a link to any specific exposure at the school cannot be made with certainty. However, improving

ventilation, reducing odors by implementing a fragrance-free workplace policy, and addressing stressors in the work environment can help reduce migraine and severe headache triggers.

Many employees originally became concerned about health and safety of school staff following reports that two employees suffered strokes. Neither person reported to have experienced a stroke was still working at the school and therefore we were unable to investigate these reports further. We found no evidence of an excess of thyroid disease, infertility, endometriosis, uterine fibroids, hysterectomy, and miscarriages among current staff compared with the U.S. population and other working populations of women. We also did not identify any known causes of these conditions in the school environment. Information about the epidemiology of each of the reproductive conditions is provided in Section D. Many of these conditions are distressing, often occur without an obvious reason and are not openly discussed. Once people begin to discuss their experiences, the number of people experiencing a condition can seem overwhelming, even when occurring at a similar rate as in the U.S. population. When this happens at work, people may search for a cause of their conditions or symptoms in the work environment. However, care must be taken when attributing common symptoms or conditions to specific exposures because the occurrence of these conditions may not be related to a common, workplace cause.

With few exceptions, concentrations of frequently measured chemical substances in the indoor work environment fell well below the recommended OELs published by NIOSH [NIOSH 2010], ACGIH [ACGIH 2021], and the American Industrial Hygiene Association (AIHA) [AIHA 2010], as well as the mandatory PELs set by OSHA [29 CFR 1910 (general industry)]. ANSI/ASHRAE has published recommended building ventilation and thermal comfort guidelines [ANSI/ASHRAE 2019, 2020]. ACGIH and AIHA have also developed a manual of guidelines for approaching investigations of building-related symptoms that might be caused by airborne living organisms or their effluents [ACGIH 1999; AIHA 2008]. Other resources that provide guidance for establishing acceptable IEQ are available through EPA at https://www.epa.gov/indoor-air-quality-iaq and https://www.epa.gov/iaq-schools as well as the joint EPA/NIOSH document *Building Air Quality: A Guide for Building Owners and Facility Managers*.

Limitations

This evaluation is subject to several limitations. Industrial hygiene sampling can only document exposures and conditions in the locations evaluated and on the days the evaluation occurred. These results may not be representative of conditions in the past, during other days, or on other work sites. In addition, we were only able to document symptoms, conditions, and concerns reported to us during our interviews of current employees. We were not able to include former employees in our evaluation. We were told of a small number of employees who left work due to illness and we considered that information as part of our evaluation. However, if substantial numbers of employees left work because they were ill, this could affect our results. Additionally, many of the conditions and symptoms employees expressed concern about are complicated to diagnose and sensitive topics to discuss, making them difficult to measure both within employees and in the general population. This means that some people will be misclassified as having a condition when they don't, or as not having a condition when they do. If this misclassification is not systematic, it should not change our conclusions. Finally,

although many of the conditions we examined are common, the population of school employees is small. Because of the small number of people experiencing each condition, we were not able to adjust for characteristics that relate to a person's risk of a disease (e.g., age). This limited our ability to identify appropriate estimates from other populations for comparison.

Conclusions

Many of the symptoms reported by employees, such as headaches and nasal irritation, are common in the general population but are also associated with inadequate ventilation. In addition, it is also possible that inadequate ventilation combined with stressors in the work environment may trigger migraines or severe headaches among employees who experience these conditions. We found no evidence that other reported medical problems were occurring more frequently among school employees compared with other similar populations, or that these medical problems could be related to the school. Improvements to the school ventilation system, using building areas for their designed use, and improved communication between school administrators and staff should result in improved safety and health of employees.

Section C: Tables

Table C1. Carbon dioxide, temperature, and relative humidity measurements

Location	Carbon dioxide (in ppm)			Temperature* (in Fahrenheit)			Relative humidity† (in percent)		
	Low	High	Average	Low	High	Average	Low	High	Average
Rm 111	523	2,566	1,637	67	80	75	33	51	42
Rm 112	431	1,704	783	75	80	78	51	55	53
Rm 202	419	879	541	75	79	77	46	56	51
Rm 311	459	1,880	1,331	74	78	76	33	53	49
Rm 320	407	1,430	624	73	78	76	51	64	54
Rm 400	431	1,582	933	73	77	75	41	56	48
Rm 410	397	1,118	567	72	79	75	51	67	56
Rm 411	422	1,635	597	74	81	78	48	58	54
Lounge	373	1,089	576	75	81	78	40	56	45
Outside	363	406	378	68	79	74	37	72	54

* ANSI/ASHRAE recommends indoor temperatures of 68.5°F to 76°F in the winter, and 75°F to 80.5°F in the summer.

† ANSI/ASHRAE recommends indoor relative humidity be maintained at or below 65%.

Table C2. Percentage of school employees participating in an interview (n = 65) experiencing frequent, work-related symptoms compared with previous studies of office workers in buildings with and without indoor environmental quality (IEQ) complaints

Frequent, work-related symptom*	School employees		Comparison groups working populations in buildings	
	No.	Percent (95% CI)	With IEQ complaints†	Without IEQ complaints‡
Headache§	20	31% (20%, 43%)	25%	15%
Stuffy or runny nose, or sinus congestion	13	20% (11%, 31%)	22%	13%
Sore or dry throat	7	11% (4%, 21%)	16%	7%
Dry, itching, or irritated eyes	5	8% (3%, 17%)	30%	19%
Cough	3	5% (1%, 13%)	9%	5%
Dizziness or lightheadedness	3	5% (1%, 13%)	8%	3%
Chest tightness	3	5% (1%, 13%)	6%	2%
Shortness of breath	1	2% (0%, 9%)	5%	2%
Nausea, upset stomach, or GI upset	1	2% (0%, 9%)	5%	3%
Wheezing	1	2% (0%, 9%)	4%	2%

* Unrelated to an acute illness such as a cold or gastrointestinal infection. Frequent, work-related means a symptom that occurs at least weekly and gets better when away from work.

† Malkin et al. 1996

‡ Brightman et al. 2008

§ Excludes migraines and severe headaches.

Table C3. Percentage of school employees (n = 64) reporting a migraine or severe headache during the previous three months compared with published estimates from studies of employed women and the U.S. population

Symptom	School employees				Comparison groups	
	Total		Work-related*		Employed population of U.S. teachers and paraprofessionals†	U.S. population‡
	No.	Percent (95% CI)	No.	Percent (95% CI)	Percent	Percent
Migraines and severe headaches	25	40% (28%, 53%)	12	19% (10%, 31%)	24%	28%

* Work-related means the occurrence of migraine or severe headache improved when away from work.

† CDC 2018a

‡ Smitherman et al. 2013

Table C4. Percentage of female school employees reporting a reproductive medical condition compared with previous studies of women in the U.S. population and other employed populations

Self-reported reproductive medical condition	School employees						Comparison groups	
	Lifetime			Symptoms began after employment at the school			U.S. female population*	Employed women†
	No. interviewed	No.	Percent (95% CI)	No. interviewed	No.	Percent (95% CI)	Percent	Percent
Endometriosis	57	8	14% (6%, 26%)	51	3	6% (1%, 16%)	10%	—
Uterine fibroids	57	7	12% (5%, 24%)	53	4	8% (2%, 18%)	9%–25%	—
Hysterectomy‡	57	8	14% (6%, 26%)	56	7	13% (5%, 24%)	10%	—
Infertility§	56	11	20% (10%, 32%)	51	6	12% (4%, 24%)	6%–16%	16%
Pregnancy outcome	—	—	—	No. pregnancies	No.	Percent (95% CI)	—	—
Miscarriage	—	—	—	35	6	17% (8%, 36%)	19%	25%

* Endometriosis estimate [Eisenberg et al. 2018]; uterine fibroids estimates [Marsh et al. 2018; Stewart et al. 2017; Yu et al. 2018]; hysterectomy estimate [Brett et al. 1997], infertility estimates [CDC 2014a,b; Gleason et al. 2019]; miscarriage estimate [Rossen et al. 2018].

† Infertility estimate [Katon et al. 2014]; miscarriage estimate [Lawson et al. 2012; Grajewski et al. 2015].

‡ Reasons for hysterectomy reported by school employees included uterine fibroids, heavy periods, other complications.

§ Infertility is defined as having unprotected sex with a male partner for 1 year or more without becoming pregnant [CDC 2014b]. Reasons for infertility reported by school employees included endometriosis, polycystic ovary syndrome (PCOS), and not ovulating regularly. Some employees reported more than one reason.

Section D: Epidemiology of Selected Reproductive Outcomes

Endometriosis

Endometriosis is a condition where tissue that normally lines the uterus grows outside the uterus [CDC 2018b; Office of Women's Health 2019a]. When this tissue grows outside the uterus, it can cause pain (typically in the abdomen, lower back, or pelvic area), pain during urination or intercourse, heavy periods, fatigue, and constipation [Eisenberg et al. 2018; Office of Women's Health 2019a]. Endometriosis can also cause infertility; for some women, having trouble getting pregnant may be the first sign of the condition.

Endometriosis is thought to affect more than 6.5 million women (11% of women) in the United States between the ages of 15 and 44 years old [Office of Women's Health 2019a]. Depending on the population, up to 16% of women may have endometriosis [Fuldeore and Soliman 2017]. However, the true prevalence of endometriosis in the United States may be higher because the diagnosis can be complicated to make and is at times overlooked [Eisenberg et al. 2018; Giudice and Kao 2004].

The cause of endometriosis is not well understood [Office of Women's Health 2019a]. However, women who have never had children, menstrual periods that last more than 7 days, short menstrual cycles (27 days or fewer), a family member with endometriosis, or a health problem that blocks the normal flow of menstrual blood from the body may be more likely to develop endometriosis. Researchers have examined associations between exposure to environmental chemicals and endometriosis; specifically, estrogen-like compounds have been suggested as a potential cause [Giudice and Kao 2004]. However, there is no definitive evidence linking chemical exposure to risk of endometriosis.

More information about endometriosis can be found at: https://www.womenshealth.gov/a-z-topics/endometriosis.

Uterine Fibroids

Uterine fibroids are tumors made up of muscle cells that grow in the wall of the uterus [Office of Women's Health 2019b; Stewart et al. 2017]. Not all women with fibroids have symptoms [Office of Women's Health 2019b; Stewart et al. 2017]. Women who do have symptoms may experience pain and heavy menstrual bleeding, feeling "full" in the lower abdomen, frequent urination or incontinence, constipation, pain during intercourse, and lower back pain. Fibroids can also result in reproductive problems such as infertility, miscarriage, or early labor.

Uterine fibroids are the most common noncancerous tumors in women of childbearing age and are common in the United States [Office of Women's Health 2019b; Stewart et al. 2017]. Approximately 20%–80% of women develop fibroids by the time they are 50 years old; fibroids occur most commonly in women in their 40s and 50s. The prevalence is difficult to estimate because many women may have fibroids but no symptoms.

The cause of fibroids is unknown. The risk of fibroids increases with increasing age until a woman reaches her 60s, when risk declines because of menopause [Stewart et al. 2017]. Fibroids are more common among Black women than White women. In addition, having a family history of fibroids,

being overweight, or eating a diet rich in red meat and ham are factors associated with a higher risk of fibroids [Office of Women's Health 2019b; Stewart et al. 2017]. Some reproductive factors (e.g., giving birth, time since last birth), use of some contraceptives, and smoking are associated with a reduced risk of fibroids [Stewart et al. 2017].

Researchers have examined associations between exposure to endocrine-disrupting chemicals, or chemicals that mimic or interfere with the body's hormones known as the endocrine system, and fibroids [Katz et al. 2016; NIEHS 2021]. However, there is no definitive evidence linking chemical exposure to risk of fibroids.

More information about uterine fibroids can be found at: https://www.cdc.gov/reproductivehealth/womensrh/healthconcerns.html#Fibroids%20.

Hysterectomy

Hysterectomy is the surgical removal of the uterus; sometimes the cervix, ovaries, and fallopian tubes are also removed [CDC 2020; Whiteman et al. 2008]. Hysterectomies are very common—1 of 3 women in the United States has had a hysterectomy by age 60.

Hysterectomies are performed to relieve symptoms associated with gynecologic conditions, for example, endometriosis or uterine fibroids, or to treat conditions including uterine prolapse (when the uterus drops into the vagina); cancer of the uterus, cervix, or ovaries; vaginal bleeding that persists despite treatment; or chronic pelvic pain [Medline 2021].

More information about hysterectomy can be found at: https://www.cdc.gov/reproductivehealth/womensrh/index.htm and https://medlineplus.gov/hysterectomy.html.

Infertility

Infertility means not being able to get pregnant after 1 year of trying [CDC 2014b, 2020]. For clinical purposes, if a woman is 35 years old or older, infertility may be based on 6 months of trying to become pregnant. Women who can get pregnant but are unable to stay pregnant may also be considered infertile. Infertility can occur because of factors affecting either the male or female partner, or both partners.

Previous studies in the United States have found that between 6% and 18% of couples experience infertility (do not achieve pregnancy within 12 months of trying) [CDC 2014b; Gleason 2019; Thoma 2013]; the estimates vary based on study methodology and the population studied. About 10% of women (6.1 million) in the United States aged 15–44 years have difficulty getting pregnant or staying pregnant [CDC 2020].

Age is one of the most important factors affecting fertility [CDC 2014b]. Among women who have not given birth, the percentage experiencing infertility increases with increasing age, from 7%–9% among those 15–34 years old to 25% among those 35–39 years old, and 30% among those 40–44 years old [CDC 2014b]. Older men may also contribute to infertility through reductions in the quality and quantity of sperm produced.

Other factors that can affect fertility include genetic abnormalities, acute and chronic diseases, treatments for certain conditions, behavioral factors, and exposure to environmental, occupational, and infectious

agents. Some known hazards that can affect fertility or disrupt the menstrual cycle or sex hormone production in women include cancer treatment drugs, heavy metals, ionizing radiation (including x-rays), nitrous oxide, some pesticides, carbon disulfide, and polychlorinated biphenyls (PCBs).

More information about infertility can be found at:
https://www.cdc.gov/reproductivehealth/womensrh/index.htm and
https://www.cdc.gov/niosh/topics/repro/default.html.

Miscarriage

Pregnancy loss is the unexpected loss of a fetus before the 20th week of pregnancy [NIH 2017]. Pregnancy loss is sometimes called miscarriage, early pregnancy loss, mid-trimester pregnancy loss, fetal demise, or spontaneous abortion. Stillbirth is used to describe the loss of a fetus after 20 weeks of gestation.

Pregnancy loss is common; studies have documented that between 10% and 28% of recognized pregnancies end in pregnancy loss [NIH 2017; Rossen 2018]. This may be an underestimate because pregnancy loss can occur before a woman's pregnancy is confirmed by a health care provider or pregnancy test, or even before a woman knows she is pregnant.

It is difficult to identify the causes of pregnancy loss (miscarriage) because it can occur before confirmation of a pregnancy. A majority of pregnancy loss happens when genetic abnormalities are present in the embryo [Krieg 2016]. Known risk factors for pregnancy loss include older maternal age, hormonal imbalances, uterine abnormalities, and immunological interactions. Lifestyle factors such as tobacco and alcohol use are also thought to contribute to miscarriage.

Studies have examined the association between occupational or environmental exposures and pregnancy loss [Krieg 2016; Patelarou and Kelly 2014; Silbergeld and Patrick 2005]. Specific occupational exposures that may be associated with reproductive outcomes such as miscarriage include anesthetic gases, antineoplastic (chemotherapy) drugs, antiviral drugs, sterilizing agents (disinfectants), and ionizing radiation [Lawson 2012].

Exposure to some chemicals (for example, endocrine-disrupting chemicals) or heavy metals either in the environment or while at work is associated with miscarriage [Hertz-Picciotto 2000; Krieg 2016]. Examples of such chemicals include pesticides (e.g., DDT), bisphenol-A (BPA), PCBs, phthalates and their metabolites, and lead. A person may be exposed to these chemicals through the environment and consumer products, or through their work.

Some evidence suggests that exposure to air pollution may be associated with an increased risk of miscarriage; however, this relationship and the specific components of air pollution that may affect a pregnancy remains unclear [Silbergeld and Patrick 2005]. In addition, a recent review of published studies found that more research is needed to fully understand whether indoor exposures are associated with an increased risk of reproductive outcomes including miscarriage [Patelarou and Kelly 2014].

More information about miscarriage and pregnancy loss can be found at:
https://www.nichd.nih.gov/health/topics/pregnancyloss/conditioninfo.

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