Evaluation of Indoor Environmental Quality Concerns in an Elementary School

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received an employee request from an elementary school. Employees were concerned about a perceived high incidence of cancers and other medical conditions and a possible association with the school's indoor environmental quality.

What We Did

- We looked for moisture, water damage, and mold.
- We measured carbon dioxide, temperature, and relative humidity and looked at the ventilation systems in the building.
- We interviewed 89 employees. We asked about their work, medical history, and work-related health concerns.
- We participated in a town hall-style meeting at the school at the end of our visit. We presented our initial findings and answered questions.

What We Found

- We found no widespread areas of current water leaks or wet materials in the building.
- All of the classroom unit ventilators appeared in good condition. We saw no microbial contamination in the units we checked.
- Carbon dioxide levels were high in some classrooms. This means that the ventilation did not provide enough outdoor air throughout the work day.
- Temperatures in the classrooms and offices were within the recommended thermal comfort guidelines, and relative humidity levels were below 65%, and generally between 35% and 50%.
- We saw scented air fresheners in use in a few interior locations, broken or disconnected exterior roof drains, and debris in an exterior dry well.
- Of the 89 employees interviewed, 22 reported symptoms that included headache and upper respiratory symptoms. These nonspecific symptoms are commonly reported in the general population and can occur in buildings with poor ventilation.

We evaluated indoor environmental quality in an elementary school building. We saw no widespread mold or water damage. Carbon dioxide levels were high in some classrooms, meaning that the ventilation did not provide enough outdoor air throughout the school day. Some symptoms reported by employees have been associated with inadequate ventilation; these types of symptoms are also common in the general population. Cancer and other medical conditions reported by some employees are not related to exposures in the school. We recommended a comprehensive ventilation assessment.

What the Employer Can Do

- Hire a licensed professional mechanical engineer to assess the ventilation systems.
- Repair broken or disconnected roof drains, clean debris from the dry well, and discourage the use of air fresheners, scented candles, or potpourri.
- Encourage employees to report symptoms that they are concerned about to their healthcare providers.

What Employees Can Do

- See an occupational medicine physician about health problems that you are concerned may be related to work.
- Tell building managers when the ventilation system is not working properly.
- Recognize that some symptoms may not have a medical diagnosis.
- Learn about things you can do to reduce your risk of cancers.

Abbreviations

ANSI/ASHRAE	American National Standards Institute/ASHRAE
CO_2	Carbon dioxide
HEPA	High efficiency particulate air
IEQ	Indoor environmental quality
NIOSH	National Institute for Occupational Safety and Health
ppm	Parts per million
RH	Relative humidity

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Introduction

The Health Hazard Evaluation Program received a request from three employees at an elementary school. The employees perceived an excess of cancer, Parkinson disease, upper respiratory disorders, and allergies among school employees since the 1980s. Twelve female employees reportedly had been diagnosed with breast cancer during this time frame. The requestors were concerned about an association of these diagnoses with the indoor environmental quality (IEQ) in the building.

In December 2016, we spoke by telephone with the requestors about their health concerns. We were able to determine that no excess of or unusual distribution of cancer existed among employees. We also were able to determine that no potential exposures in the school would cause the reported cancers.

During a January 2017 site visit, we met with the school principal, other school managers, the teachers' union representatives, and building maintenance personnel to discuss the request. We also conducted an environmental and health assessment. At the end of that visit, we met with about 40 school employees to present our findings and answer questions. Additionally, we sent letters summarizing our preliminary recommendations to employer and employee representatives in February 2017.

The school operated in a predominantly single-story masonry building, which was finished around 1955. Fifty elementary school employees, including faculty and staff, 30 district administrators; and 9 other district employees worked there at the time of our evaluation; 400 students attended the school.

Methods

Our objectives for this evaluation were to:

1. Identify if the building had a mold or other IEQ problem
2. Determine to what extent employees were reporting work-related health effects

Prior Indoor Environmental Quality Consultant Reports

We reviewed two IEQ-related consultant reports for work done in 2015 and 2016.

Building Walk-through Survey

We toured the entire building, including classrooms, multipurpose areas, library (referred to as the IMC), art room, gymnasium, and administrative offices for the school and the school district administration, which is also housed in the building. We also examined areas in the school not readily accessible to teachers and students, such as a basement storage area, the roof, and storage areas used by the school district staff.

We visually assessed the school for potential mold contamination. We also used the following instruments to check for the presence of hidden moisture or water damage:

- A FLIR TG165 imaging infrared thermometer. We used this direct-reading device to identify potential moist or water-damaged areas in surfaces such as walls, floors, and ceilings. It uses infrared thermal imaging technology to react to temperature differences to identify dry and wet materials, even materials that are not readily visible, such as behind drywall or above a suspended ceiling.
- A TRAMEX Moisture Encounter Plus nondestructive moisture meter. This hand-held direct-reading device can measure the interior wall moisture levels. We used the moisture meter to confirm if suspected moist areas identified by the infrared thermometer were actually moist.

We measured carbon dioxide (CO_2), temperature, and relative humidity (RH) in classrooms and multipurpose areas over 2 school days with calibrated TSI Q-Trak™ Indoor Air Quality monitors. We selected classrooms on the basis of their location and type of ventilation (either unit ventilator or forced-air). We compared indoor and outdoor CO_2 concentrations to determine if indoor occupied spaces were adequately ventilated [ANSI/ASHRAE 2013]. Carbon dioxide is a normal constituent of exhaled breath and can be used as an indicator of whether enough outdoor air is being introduced into an occupied space to maintain body odors to an acceptable level. Indoor CO_2 concentrations no greater than 700 parts per million (ppm) above outdoor CO_2 concentrations will satisfy a substantial majority (about 80%) of visitors [ANSI/ASHRAE 2016].

We measured temperature and RH because these characteristics can affect how employees perceive their indoor environment. We compared the temperature and RH levels to American National Standards Institute/ASHRAE (ANSI/ASHRAE) thermal comfort guidelines [ANSI/ASHRAE 2013]. The ANSI/ASHRAE Standard 55-2013, Thermal Environmental Conditions for Human Occupancy, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable [ANSI/ASHRAE 2013]. Several factors affect thermal comfort including air movement, operative temperature, relative humidity, clothing levels, and an individual's work activities. A thermal comfort tool developed by the Center for the Built Environment allows comparison to the ANSI/ASHRAE criteria and is available at http://comfort.cbe.berkeley.edu/. The ASHRAE (ANSI/ASHRAE) thermal comfort guidelines recommend RH be maintained below 65%, and the U.S. Environmental Protection Agency recommends that RH be maintained below 60% (ideally 30%–50%) to prevent mold growth. Very low RH levels may contribute to dry and irritated mucous membranes of the eyes and airways [Wolkoff and Kjaergaard 2007].

We visually inspected the exterior and interior of two randomly selected unit ventilators. We checked if these unit ventilators were operational, the type and condition of the air filters, whether the outdoor air damper was in the opened or closed position, and if furniture or school supplies interfered with the flow of room air through the ventilator. We also randomly checked one rooftop air handler.

Employee Interviews and Medical Record Review

We interviewed all available employees in the building about perceived work-related medical conditions or symptoms. We took a medical history to identify unrecognized occupational illness. Medical records were requested if an employee reported symptoms or an illness we thought might be related to work in the school. We did not request medical records for health problems we determined were not related to the school, such as cancers.

Results

Prior Indoor Environmental Quality Consultant Reports

Initial and follow-up evaluations were performed by a consultant hired by the school district. Summary results are provided in Table 1. The consultant followed typical investigative techniques and used appropriate monitoring equipment.

Table 1. Recent IEQ assessments of the school

Report date	Summary
10/30/15	Initial evaluation conducted on October 14, 2015, in response to an apparent increase in work-related health concerns by school staff. Monitoring was performed for volatile organic compounds, temperature, RH, and CO_2. All volatile organic compound levels were far below applicable occupational exposure limits, and only heptane was measured in the ppm range. Temperatures and RH were within ANSI/ASHRAE comfort guidelines, but CO_2 concentrations up to 3,300 ppm were measured in some classrooms, indicating that insufficient outdoor air was being provided by the classroom ventilation systems during peak occupancy.
3/25/16	Follow-up evaluations conducted on January 15, 2016, and March 17, 2016, focused on temperature, RH, and CO_2. On both days the temperature and RH were within ANSI/ASHRAE comfort guidelines. The CO_2 concentrations on January 15, 2016, ranged up to about 3,800 ppm, similar to those measured in October 2015. In response, the school replaced the CO_2 sensors in all of the classroom unit ventilators. CO_2 concentrations on March 17, 2016, after the sensors were replaced, were lower than on January 15, 2016, ranging up to about 1,400 ppm.

Walk-through Survey

We found no areas of active moisture intrusion in any classroom on the basis of our visual assessment and use of an infrared camera and a moisture meter. We did see isolated water-stained ceiling tiles in the auditorium, gym, and classroom 21, but none of these stained surfaces were wet at the time of our visit. We also observed water-staining on the rear wall of the auditorium, behind the curtain. This area was not wet either (Appendix A, Figure A1).

We saw scented air fresheners in use in a few locations. These can be a potential source of irritation, odor, and allergy to some employees (Appendix A, Figure A2). We saw chipped and cracked floor tiles in the lunch room. Considering the age of the building, these tiles could contain asbestos (Appendix A, Figure A3). However, these damaged tiles did not appear friable (easily crumbled), so there is little risk of exposure to asbestos-containing material. We saw rolled faced insulation installed above suspended ceiling tiles in classroom 22. The insulation appeared old and was dusty (Appendix A, Figure A4). Aside from energy conservation, we were uncertain what the purpose of this insulation was because we did not see any rolled faced insulation in the plenum space above another classroom. Finally, we saw dusty ceiling fans in multiple classrooms (Appendix A, Figure A5).

The building's membrane-style flat roof had been replaced within the past 2 years and appeared in excellent condition, with little standing water and no debris that could potentially clog roof drains. While walking around the perimeter of the building, we saw broken and disconnected roof drains along the exterior wall of classrooms 40 to 45 (Appendix A, Figure A6). We also saw leaves and other debris in a shallow storm water well near the exterior wall of classroom 32 (Appendix A, Figure A7). We were informed that the roof drains had been damaged by the local utility company the prior year.

Two of the three vacuums used by the school's custodial staff were not equipped with high-efficiency particulate air (HEPA) filters. The remaining vacuum, a backpack-style unit manufactured by Proteam, could use HEPA filters (according to the manufacturer's website), but a school custodian indicated that this vacuum was seldom used (no reason provided). Products from a list of green certified cleaning products were used throughout the school district. The school had no written program, but we were told the pest management plan included monthly checks of the building and that baits and traps were preferred over pesticide spraying, which was reportedly done only when necessary.

Ventilation

In most classrooms a unit ventilator was located on the exterior wall beneath an operable window, a design not uncommon in older schools. A unit ventilator, also called a fan coil unit, is a simple ventilation system. In this instance hot water from a natural gas-fired boiler or chilled water from a cooling tower was piped to each unit ventilator. A fan inside each unit ventilator circulated classroom room air across the hot or chilled water lines to provide heating or cooling, depending on the season. Each unit ventilator also had an outdoor air intake in the exterior wall that could allow outdoor air to be mixed with recirculated room air. In two classrooms, the unit ventilator was located in the ceiling because of grade and the building's roof line. Each unit ventilator was centrally controlled by the maintenance office. Each unit ventilator had a direct-reading CO_2 sensor (replaced in 2016) installed inside the unit ventilator cabinet that controlled the position of the unit's outdoor air damper (Appendix A, Figure A8). When the CO_2 level in a classroom exceeded 1,000 ppm the outdoor air damper on the unit ventilator would begin to open to provide more dilution air. Sensor data was remotely tracked and recorded by the maintenance staff.

A few interior classrooms, as well as all of the administrative offices, the library, gymnasium, and the auditorium had a forced-air, variable air volume ventilation system, with heating and cooling provided by rooftop package ventilation units. According to the maintenance staff, all of the forced-air and unit ventilators had been replaced in 2010.

The interiors of two unit ventilators and one rooftop ventilation unit that we randomly checked were clean and had no visible evidence of microbial contamination. The air filters in these units were also the correct size, properly installed, and appeared in excellent condition (Appendix A, Figure A9). All of the ventilation systems in the school used medium efficiency reporting value 8 air filters, an air filter type often used in nonindustrial work places such as offices and schools. The air filters in the rooftop air handlers were replaced twice per year, while those in the unit ventilators were replaced three times per year. We saw two unit ventilators that had teaching supplies and furniture partially blocking air intakes and/or air exhausts (Appendix A, Figure A9). We also saw one ceiling-mounted diffuser in the district office that was blocked by what appeared to be a pink blanket (Appendix A, Figure A10).

Carbon Dioxide, Temperature, and Relative Humidity

Table 2 summarizes the CO_2 concentrations and temperature and RH levels we measured in classrooms and other school areas over 2 days. Seven of the eight classrooms with unit ventilators that we tested (rooms 3, 9, 11, 20, 35, 42, and 45) had maximum carbon dioxide concentrations that exceeded the ambient outdoor air concentration (approximately 400 ppm) by at least 700 ppm, and Figure 1 shows the CO_2 concentrations in classroom 35. This suggests that classroom ventilation systems were not always providing sufficient outdoor air to maintain acceptable ventilation throughout the school day [ANSI/ASHRAE 2016]. In comparison, only two of the six classrooms or offices with forced-air ventilation that we tested had CO_2 concentrations above recommended levels (Table 2 and Figure 2). This topic is discussed more in the following section.

On the days of our evaluation, the average lower RH was 40% and average upper RH was 49% in the classrooms and offices that we evaluated. Using these RH averages, and assuming an operative temperature range of 68°F to 78°F (Table 2), a metabolic rate for the occupants of 1.2 (equivalent to standing, relaxed), and occupants wearing typical winter clothing, the classrooms and offices were within the recommended thermal comfort guidelines [ANSI/ASHRAE 2013]. On both days of our evaluation, the RH levels were below 65% [ANSI/ASHRAE 2013], and on January 18, were within 30%–50% as recommended by the U.S. Environmental Protection Agency [EPA 2012].

Table 2. Carbon dioxide, temperature, and relative humidity measurements in the building

Location*	Room ventilation type	Carbon dioxide (ppm)	Temperature (°F)	Relative humidity (%)
January 17, 2017				
Arts studio	Forced air	60–180	68–74	53–67
Curriculum office	Forced air	290†–500	65–75	42–53
Room 5	Unit ventilator	540–900	70–74	44–51
Room 9	Unit ventilator	780–2,200‡	66–74	47–51
Room 35	Unit ventilator	900–3,200‡	68–74	42–52
Room 42	Unit ventilator	820–1,800‡	68–74	42–51
Room 45	Unit ventilator	850–2,220‡	70–78	37–53
January 18, 2017				
Counselor office	Forced air	640–1300	68–72	34–48
Curriculum coaches	Forced air	370†–540	70–72	40–44
Room 3	Unit ventilator	550–1,600‡	68–74	35–45
Room 11	Unit ventilator	960–2,400‡	62–73	34–46
Room 20	Unit ventilator	1,200–2,500‡	69–72	40–48
Room 41	Forced air	660–990	71–73	31–36
Room 38	Forced air	550–1,100	70–73	33–36
Outdoor		430	63	63

*The sampling period was 8:00 a.m. to 4:00 p.m. each day.

†Although calibrated prior to use, this CO_2 monitor appeared to measure unusually low levels, thus CO_2 levels may be underestimated.

‡Maximum carbon dioxide concentrations exceeded ambient outdoor air concentrations by at least 700 ppm.

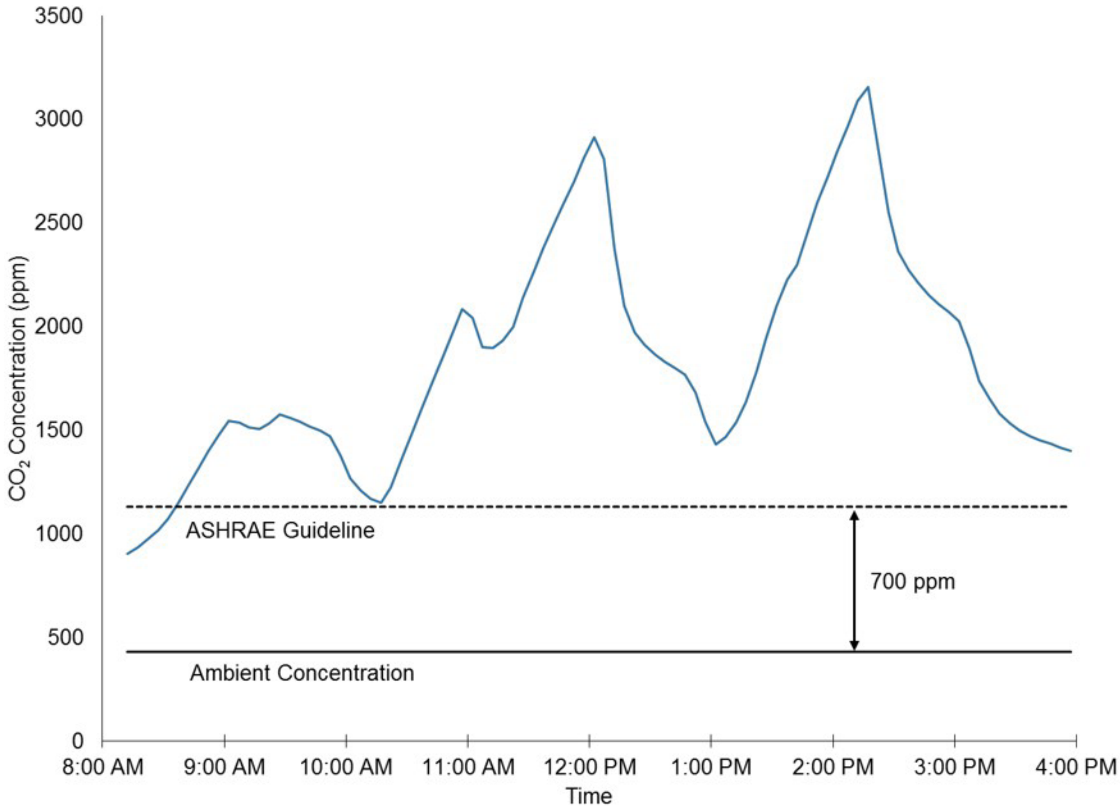

Figure 1. Range of CO_2 concentrations in classroom 35 on January 17, 2017.

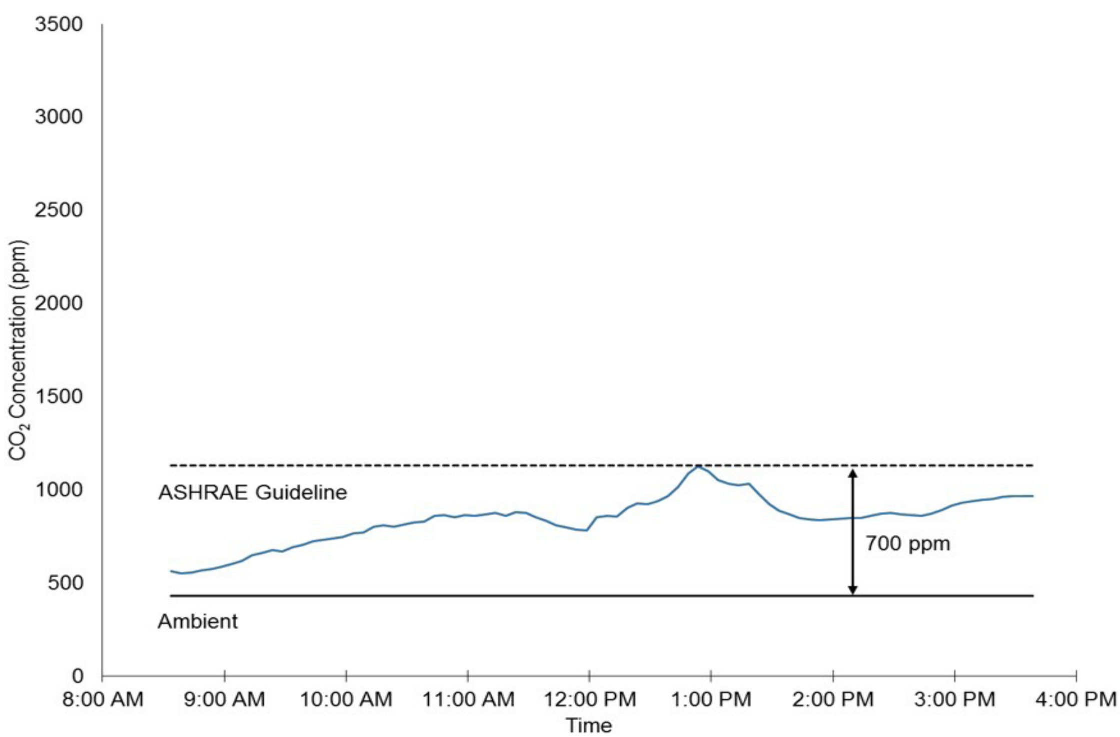

Figure 2. Range of CO_2 concentrations in classroom 38 on January 18, 2017.

Employee Interviews and Medical Record Review

We interviewed all 89 employees present at the school during our visit, including teachers, district administrators, custodial, maintenance, office, supervisory, and cafeteria staff. Of these, 70 (79.5%) were female. The length of employment ranged from less than 1 year to 26 years with a median of 7 years. Seven employees had worked less than 1 year.

Of the 89 interviewed employees, 67 reported no symptoms that they related to work, while 22 employees did report symptoms or medical conditions that they felt were or might be related to work. The most common reported symptoms thought to be related to the building were sinus problems (n = 6), headache (n = 3), nose irritation (n = 3), and throat irritation (n = 3). Symptoms or conditions reported by fewer than five people included frequent upper respiratory infections, worsening of allergies, cough, sneezing, nausea, post-nasal drip, and fatigue.

Fifteen employees reported ever being diagnosed with asthma. Ten of these employees were diagnosed with asthma prior to working at the school. Of those 10, nine reported that their asthma symptoms were the same on days at work as days off work. One was not sure if the asthma symptoms were the same on days at work and days off work. Five employees reported being diagnosed with asthma after beginning work at the school. Two of these five reported that their asthma symptoms were the same on days at work as on days off work, one was unsure, and one reported that symptoms were a little worse on days at work. One of these five employees reported that overall, their asthma had worsened since beginning work at the school. Medical records were requested for one employee who reported seeing a physician for asthma that she thought might be worsened by conditions in the school. We found that the records did not support a relationship between this employee's work and asthma.

Four employees reported having miscarriages, two had Parkinson disease, one had Alzheimer disease, and one had a history of pancreatitis. Additionally, 12 employees had been diagnosed with breast cancer, five with skin cancer, two with ovarian cancer, and one with uterine cancer over the last 2 decades.

Discussion

One of the most common deficiencies we have found over many years of health hazard evaluations in nonindustrial indoor environments like this school is the improper operation and maintenance of ventilation systems, resulting in inadequate ventilation rates. 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]. Employees reported all of these symptoms in our interviews, although the percentage of employees reporting such symptoms was low. Studies in schools and office buildings have found decreased illness absence with increased ventilation rates [Mendell et al. 2013; Milton et al. 2000; Shendell et al. 2004]. Thus, improving heating, ventilation, and air-conditioning 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 the ventilation rates are improved at this school.

The unit ventilators in the school were centrally controlled, and each had a direct-reading CO_2 sensor that opened the unit's outdoor air damper with increasing CO_2 concentrations (Appendix A, Figure A8). These unit ventilator design elements can help maintain temperature and RH within recommended comfort guidelines and ensure that sufficient outdoor air is introduced into the occupied spaces. Therefore, we were surprised to find CO_2 concentrations greater than 1,000 ppm above outdoor levels in all but one of the classrooms with a unit ventilator that we monitored.

We discussed our findings with the maintenance staff and compared our CO_2 measurements with those obtained from a unit ventilator's direct-reading sensor. We selected classroom 35 because this room had among the highest CO_2 concentrations that we measured (up to about 3,300 ppm). The trends in our CO_2 measurements throughout the school day were similar to those downloaded from the unit ventilator sensor. However, the maintenance staff discovered that the computer ventilation controls had been overwritten to prevent the CO_2 sensors from fully opening the outdoor air dampers in the unit ventilators. This reprogramming had been done the prior week in response to a period of unusually cold weather to avoid freezing the water pipes in the unit ventilator and damaging the system. Temporarily restricting how much an outdoor air intake may open during weather extremes is not uncommon. In this instance, the maintenance staff had forgotten to remove the programming change, and the unit ventilator control system did not alert the user that the outdoor air damper restriction was still in place.

We saw damaged exterior roof drains with ponding water near the school's foundation, and a shallow storm water well with debris. Because these were also near outdoor air intakes for classrooms (Appendix A, Figures A6 and A7), the standing water and organic matter could be potential sources of microbial contamination and odors that could affect the IEQ of the school. At least two of the three vacuums used by the custodial staff were not equipped with HEPA filters. Using vacuums with properly installed HEPA filters will reduce the chance that captured particles could be resuspended back into the room. We saw loose pieces of fiberglass apparently from old roll-faced fiberglass insulation installed in the plenum above classroom 22 (Appendix A, Figure A4). Any maintenance activities performed in this plenum space could potentially disturb the fiberglass insulation, thus releasing dust and fiberglass into the classroom below. Roll-faced fiberglass insulation was not present in the plenum in another classroom.

The employees' reported headache, sinus problems, worsening of allergies, eye irritation, frequent upper respiratory infections, fatigue, throat irritation, and cough. These are common symptoms that we have frequently found in people working in buildings with poor ventilation. They can also be found frequently in the general population and can have non-occupational causes. Of the general population, 86%–95% have one or more common 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]. Table 3 lists the general population prevalences of many of the symptoms reported by employees in this school. In addition, the average adult has two to three upper respiratory infections per year [Benninger et al. 2003]. According to the National Health Interview Survey, 12% of U.S. adults reported physician-diagnosed sinusitis in 2012, and women were more likely to be diagnosed with sinusitis (15% compared to 9% in men) [Centers for Disease Control and Prevention 2014].

Table 3. General population prevalence of symptoms similar to those reported by employees

	Clustered random sample of households in Australia	General medical practices in the United Kingdom	Representative sample of general population of New Zealand
Participants	n = 3,016*	n = 2,474†	n = 1,000‡
Time frame	14 days	14 days	7 days
Number of symptoms asked about	12	25	46
Percent reporting at least one symptom	80	> 75	89
Number of symptoms reported, mean (range)	Not reported	3.6 (0–22)	5 (0–36)
Symptoms similar to those reported in this building (%)	Stuffy nose (46) Headache (33) Unusually tired (30) Cough (26) Dry, itchy, or irritated eyes (25) Dry or sore throat (22) Skin rash (12)	Tired/run down (41) Headache (39) Sore throat (19) Cough (18)	Fatigue (36) Headache (35) Congested or runny nose (34) Cough (28)

*Reference: Heyworth and McCaul 2001

†Reference: McAteer et al. 2011

‡Reference: Petrie et al. 2014

The U.S. Environmental Protection Agency conducted a systematic survey of 100 randomly selected office buildings without known IEQ complaints in the United States to develop baseline data about U.S. office buildings [Brightman et al. 2008]. The National Institute for Occupational Safety and Health (NIOSH) conducted a similar study of 80 buildings with IEQ complaints [Malkin et al. 1996]. Occupants in both studies reported work-related symptoms. The rank order of symptoms was the same, but rates were significantly higher in the buildings with IEQ complaints. The most common work-related symptoms reported in both studies were dry, itching, or irritated eyes; unusual tiredness or fatigue; headache; tension or irritability; pain in back, neck, and shoulders; stuffy or runny nose, or sinus congestion; sneezing; sore or dry throat; and difficulty remembering things or concentrating. Of the employees in the randomly selected buildings, 45% reported at least one work-related symptom [Brightman et al. 2008; Malkin et al. 1996]. These common symptoms in the general population and in buildings are also among the most common symptoms reported by employees in this school.

Exposures that could be related to new-onset or worsening asthma include fragrances, dust mites, dander from rodents, and excrement of rodents and other pests such as cockroaches. Some allergens can be carried in on employees and visitors. The most common of these are cat and dog allergens, which can be an unrecognized source of allergic upper and lower respiratory and skin symptoms.

Several employees reported having medical conditions that we determined were unrelated to the school's conditions or exposures in the school based upon current scientific knowledge. These included cancer, Parkinson disease, Alzheimer disease, pancreatitis, and miscarriages. The number and types of medical conditions are not unusual, and general IEQ problems are not known to be linked to the types of medical conditions reported. Appendix B provides a more detailed discussion of cancer and how we determine if cancer is related to a common exposure.

Conclusions

We saw no evidence of a current mold problem in the school, and the ventilation systems and roof were well maintained and in good condition. However, most of the classrooms with unit ventilators that we monitored had inadequate ventilation during at least part of the school day. Inadequate ventilation means that insufficient outdoor air was being brought into the classroom. This situation occurred after the computer ventilation controls were changed in response to unusually cold weather prior to this evaluation, but were not reset. Many of the symptoms employees reported, such as sinus problems, eye and throat irritation, and headaches, have been associated with dampness or inadequate ventilation but are also common in the general population. We found no evidence that other reported health problems were related to the school.

Recommendations

On the basis of our findings, we recommend the actions listed below to create a more healthful workplace. We recommend the school use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Our recommendations are based on the hierarchy of controls approach. This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Hire a licensed professional mechanical engineer to do a comprehensive assessment of the school's ventilation systems. This assessment should include checking the calibration and operation of the CO_2 sensors controlling the outdoor air intakes of classroom unit ventilators. The mechanical engineer should have experience in the design of heating, ventilating, and air-conditioning systems for buildings that include multi-use 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.
2. Remove the rolled faced insulation in the plenum space above classrooms because it could contribute to dustiness in the classroom. The insulation should be removed when

the classroom is not in use. Employees removing the insulation should minimize direct skin contact with the potentially irritating insulation material by wearing gloves and long-sleeve shirts. After removal clean the surfaces in the classroom with a HEPA-filtered vacuum to remove any residual insulation that may have fallen.

3. Repair the cut roof drains to ensure that water does not accumulate around the foundation of the school or near outdoor air intakes. Keep storm water wells clean of debris.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Stop any additional environmental sampling for chemical and biological agents to identify a cause for nonspecific symptoms among employees.
2. Establish a fragrance-free workplace policy. Ensure that it addresses perfumes and other scented personal care products, air fresheners, and potpourri.
3. Use vacuums equipped with HEPA filters when cleaning the school.
4. Clean the ceiling fans regularly.
5. Move objects so that they do not block airflow around unit ventilators or supply air ducts.
6. Minimize the use of carpet and upholstered furniture. Porous materials are more difficult to clean than smooth, nonporous surfaces and can harbor microbes and dust mites.
7. Ask employees to report signs of moisture intrusion to the maintenance staff. Establish a system for responding to requests and notifying the requestor what is being done and when the work is complete.
8. Encourage employees with health concerns to seek evaluation and care from their regular healthcare provider. It may be useful to provide the physician with a copy of this report. If an employee is determined to have an illness related to an occupational exposure, the healthcare provider and the appropriate management personnel should work to eliminate that exposure and assess the need for environmental evaluation. If symptoms persist despite best efforts to address the workplace exposures, an occupational medicine physician may need to recommend work accommodations for the employee. Occupational medicine physicians can be found through a variety of sources, including the Association of Occupational and Environmental Clinics, at http://www.aoec.org/, and the American College of Occupational and Environmental Medicine, at http://www.acoem.org/. Additionally, in such circumstances, evaluation of other employees who may also be potentially affected may be appropriate.

Appendix A: Figures

Figure A1. Old water stains on auditorium wall. Photo by NIOSH.

Figure A2. Electrically-heated scented candle warmer in classroom. Photo by NIOSH.

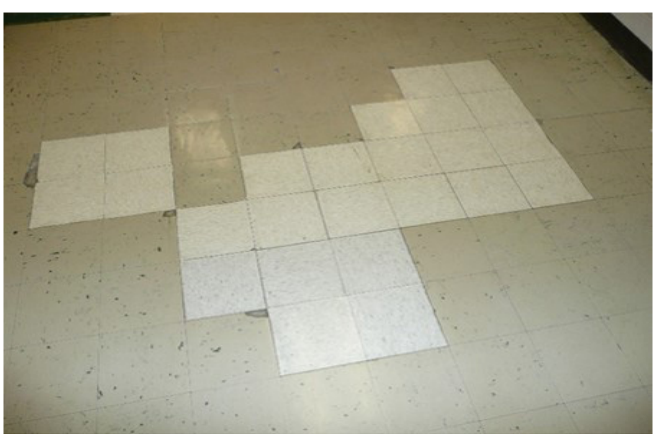

Figure A3. Chipped and cracked 9 inch by 9 inch floor tiles in school lunchroom. Photo by NIOSH.

Figure A4. Dusty roll-faced insulation in plenum above classroom. Photo by NIOSH.

Figure A5. Dusty ceiling fan blades in classroom. Photo by NIOSH.

Figure A6. Broken and disconnected exterior roof drain outside classroom. Photo by NIOSH.

Figure A7. Debris in shallow dry well near outdoor air intake for classroom. Photo by NIOSH.

Figure A8. Interior of a typical classroom unit ventilator. Photo by NIOSH.

Figure A9. Storage cabinet (on floor) and teaching supplies (on top) blocking air intakes on a classroom unit ventilator. Photo by NIOSH.

Figure A10. A blocked ceiling mounted diffuser in an office. Photo by NIOSH.

Appendix B: Cancer and Cancer Clusters

Cancer is a group of different diseases that share the same feature of uncontrolled growth and spread of abnormal cells. Each different type of cancer may have its own set of causes. Cancer is common in the United States. In the United States, one in two men and one in three women will develop cancer over the course of their lifetimes [American Cancer Society 2016a]. This does not include basal or squamous cell skin cancers, which are very common (more than 3 million diagnosed annually), or any in-situ carcinomas other than bladder. If these were included, rates would be even higher. One of every four deaths in the United States is from cancer [American Cancer Society 2016a]. Among adults, cancer occurs more frequently with increasing age. Cancer cases may appear to occur with alarming frequency even when the number of cases is not more than would be expected in the general population because cancer is common, the population is aging, and more people are surviving cancer. This perception is especially common among a small group of people who have something in common with the cases, such as working in the same building as in this school.

Many factors play a role in the development of cancer. The importance of these factors varies for different types of cancer. Most cancers are caused by a combination of several factors. Some of the factors include (1) personal characteristics such as age, sex, and race; (2) family history of cancer; (3) diet; (4) personal habits such as cigarette smoking and alcohol consumption; (5) the presence of certain medical conditions; (6) exposure to cancer-causing agents in the environment; and (7) exposure to cancer-causing agents in the workplace. In many cases, these factors may act together or in sequence to cause cancer. Although some causes of various types of cancer are known, we do not know everything about the causes of cancer. One important point to note is that the absence of a risk factor does not mean there is no risk for developing cancer. For example, employees often say to us that they got breast cancer despite having no family history of breast cancer, so it must be due to their work. In fact, while having a first-degree relative with breast cancer increases one's risk of developing breast cancer, most people who get breast cancer do not have a family history of it.

The American Cancer Society estimates that about 171,000 cancer deaths in 2015 were caused by tobacco use alone [American Cancer Society 2016a]. This is one third of all cancer deaths. It is well known that tobacco use increases the risk of cancer of the lung, mouth, nasal cavities, larynx, pharynx, esophagus, stomach, colorectum, liver, pancreas, kidney, bladder, uterine cervix, and ovary (mucinous), and myeloid leukemia [American Cancer Society 2016a]. There is limited evidence that tobacco smoking causes female breast cancer.

Another one quarter to one third of cancer deaths are due to poor nutrition, physical inactivity, overweight, and obesity [American Cancer Society 2016a]. Being overweight or obese is clearly associated with increased risk for developing cancer of the breast (in postmenopausal women), colon and rectum, endometrium, kidney, pancreas, and adenocarcinoma of the esophagus. Obesity increases the risk of gallbladder cancer and possibly cancers of the liver, cervix, and ovary; multiple myeloma; non-Hodgkin lymphoma; and aggressive forms of prostate cancer [American Cancer Society 2016a].

Alcohol consumption is another modifiable personal risk factor that increases risk of cancer, in addition to the almost two thirds of cancer due to smoking, poor nutrition, physical inactivity, overweight, and obesity. Alcohol causes cancers of the mouth, pharynx, larynx, esophagus, liver, colorectum, and breast [American Cancer Society 2016a]. Even a few drinks weekly increase the risk of breast cancer.

Breast Cancer

Breast cancer is the most common cancer in women in the United States. Approximately 250,000 cases of invasive breast cancer will be diagnosed in women in the United States in 2016, not including 61,000 cases of carcinoma in situ [American Cancer Society 2016b]. One in eight women in the United States will develop breast cancer in her lifetime [American Cancer Society 2016b]. Well-established breast cancer risk factors include family history of breast cancer, biopsy-confirmed atypical hyperplasia, early menarche (first menstrual period), late menopause, not having children or having the first child after age 30, overweight or obesity (especially after menopause), never breastfeeding a child, low physical activity levels, and higher levels of education and socioeconomic status [American Cancer Society 2016b; Weiderpass et al. 2011].

The International Agency for Research on Cancer has classified alcoholic beverages of all types, in utero exposure to diethylstilbestrol, estrogen-progesterone oral contraceptives and hormone replacement therapy, and exposure to x-rays and gamma rays (types of ionizing radiation) as "carcinogenic to humans" with regard to breast cancer [International Agency for Research on Cancer 2017]. The risk from ionizing radiation is highest if exposure occurs during childhood and is negligible if exposure occurs after age 40 [Ronckers 2004]. The International Agency for Research on Cancer classifies digoxin, estrogen hormone replacement therapy, ethylene oxide, polychlorinated biphenyls, smoking, and shift work as "probably carcinogenic to humans [International Agency for Research on Cancer 2017]."

While scientific studies have found an association between certain substances or occupations and breast cancer, the results are conflicting or unconfirmed. Some studies have found increased risk of breast cancer among nurses, librarians, laboratory technicians, telephone operators, glass manufacturing workers, textile workers, meat wrappers and cutters, printers, security personnel, scientific researchers, and hairdressers/cosmetologists, among others [Coogan et al. 1996; Gardner et al. 2002; Labrèche et al. 2010; Morton 1995; Peplonska et al. 1998, 2010; Shaham et al. 2006; Teitelbaum et al. 2003; Zheng et al. 2002].

Several studies have found teachers and other professional and managerial employees to have an increased risk for developing breast cancer [Bernstein et al. 2002; King et al. 1994; MacArthur et al. 2007; Pollán and Gustavsson 1999; Rubin et al. 1993; Snedeker 2006], but others have not [Calle et al. 1998; Coogan et al. 1996; Petralia et al. 1998]. No causative workplace exposures have been identified for these occupations, and it is postulated that the possible increase in risk is a result of nonoccupational risk factors such as parity (number of times a woman has given birth), maternal age at first birth, contraceptive use, diet, and physical activity [MacArthur et al. 2007; Snedeker 2006; Threlfall et al. 1985]. Women with higher educational status are also more likely to have mammograms, thus increasing detection of breast cancer. Several studies have found that about one quarter to one third of invasive breast cancers detected by mammograms were overdiagnosed, i.e., would not have progressed or caused harm [Jørgensen and Gøtzsche 2009; Miller et al. 2014; Zahl et al. 2008].

Cancer Clusters

Cancers often appear to occur in clusters, which scientists define as a greater than expected number of cancer cases that occurs within a group of people in a geographic area over a defined period of time [Centers for Disease Control and Prevention 2012]. A cluster also occurs when the cancers are found among employees of a different age group or sex than is usual. A statistically significant excess of cancer cases may have a common cause but can occur without a clear cause and can occur by chance [Aldrich and Sinks 2002; Thun and Sinks 2004]. In many workplaces the number of cases is small. This makes detecting whether the cases have a common cause difficult, especially when no apparent cancer-causing exposures are present. It is common for the borders of the "cluster" to be drawn around where the cases of cancer are located, instead of defining the population and geographic area first. This often leads to "clusters" that are not real. This is referred to as the "Texas sharpshooter effect" because the Texas sharpshooter shoots at the barn and then draws his bull's eye around the bullet hole.

When cancer in a workplace is described, learning whether the type of cancer is a primary cancer or a metastasis (spread of the primary cancer into other organs) is important. Only primary cancers are used to investigate a cancer cluster. To assess whether the cancers among employees could be related to occupational exposures, we consider the number of cancer cases, the types of cancer, the likelihood of exposures to potential cancer-causing agents, and the timing of the diagnosis of cancer in relation to the exposure. These issues are discussed below in a series of questions that relate to this request.

Do employees at this school have more cancer than those who do not work at this school?

No. Because cancer is a common disease, it may be found among people at any workplace. When several cases of cancer occur in a workplace, they may be part of a true cluster when the number is greater than we expect compared to other groups of people similar in age, sex, and race. Disease or tumor rates, however, are highly variable in small populations and rarely match the overall rate for a larger area, such as the state. Therefore, for any given time period, some populations have rates above the overall rate, and others have rates below the overall rate. Even when a higher rate occurs, it may be consistent with the expected random variability. In addition, calculations like this make many assumptions that may not be appropriate for every workplace. Comparing rates without adjusting for age, sex, or other population characteristics assumes that such characteristics are the same in the workplace as in the larger population, which may not be true. However, general information on cancer rates is useful for providing perspective on the cancers in your population. The occurrence of 20 cases of cancer among employees at this school over more than 30 years is not excessive. It is likely that many more current and former employees have been diagnosed with cancer than those who were reported to us, but the numbers and types of the reported cancers do not suggest a need for further case finding. As employees age, more cases of cancer (of many types) will appear.

Do employees in this school have an unusual distribution of types of cancer?

No. Cancer clusters thought to be related to a workplace exposure usually consist of the same types of cancer. When several cases of the same type of cancer occur and that type is not common in the general population, it is more likely that an occupational exposure is involved. When the cluster consists of multiple types of cancer, without one type predominating, then an occupational cause of the cluster is less likely. The 10 most common cancers in women are (in order): breast; lung and bronchus; colon and rectum; uterine corpus; thyroid; non-Hodgkin lymphoma; melanoma of the skin; kidney and renal pelvis; pancreas; and ovary. The 10 most common cancers in men are (in order): prostate; lung and bronchus; colon and rectum; urinary bladder; melanoma of the skin; kidney and renal pelvis; non-Hodgkin lymphoma; oral cavity and pharynx; leukemia; and pancreas. Several female employees in this school, where 66% of employees are female, have been diagnosed with breast cancer, the most common cancer among women in the United States. Three other of the most common types of cancer were also diagnosed among employees.

Is exposure to a specific chemical or physical agent known or suspected of causing cancer or other health effects occurring at this school?

No. The relationship between some agents and certain cancers has been well established. For other agents and cancers, there is a suspicion of a link, but the evidence is not definitive. When a known or suspected cancer-causing agent is present and the types of cancer occurring have been linked with these exposures in other settings, we are more likely to make the connection between cancer and a workplace exposure.

Office buildings rarely have hazardous exposures relevant to cancer. Asbestos can be a concern in older buildings, but it is known to cause lung cancer and mesothelioma, neither of which were reported among employees. Suspected asbestos-containing floor tiles were present in this school, but because the tiles were not friable (easily crumbled), asbestos would not be released into the air and create a hazard for employees. Radon can be of concern in basement or lower floors of some buildings, but radon causes lung cancer, not other types of cancer. Radon monitoring is performed in the school building every 2 years, and levels have been acceptable.

Has enough time passed since exposure began?

Latency is the time between first exposure to a cancer-causing agent and clinical recognition of the disease. Latency periods vary by cancer type but usually are a minimum of 10–12 years [Rugo 2004].

This question is not relevant when considering the reported cancers at this school because there is not an excess of cancer among employees, the distribution of cancers is not unusual, and no exposures were associated with the cancers diagnosed.

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