NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2005-0112-2980
Taft Elementary School
Santa Ana, California

September 2005

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by David Vinson, Eric Esswein, and Elena Page of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Joseph Fernback and Eileen Birch. Desktop publishing was performed by Elaine Moore. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at Taft Elementary School, the Santa Ana Unified School District, and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Respiratory, Allergic, and Neuropsychological Complaints from Possible Mold Exposure

NIOSH received a confidential employee request for a health hazard evaluation at Taft Elementary School in Santa Ana, California, on February 1, 2005. The requesters were concerned about exposure to "toxic mold" in the school, with reports that teachers had been diagnosed with toxic encephalopathy (brain damage); other complaints included migraine headaches, sinusitis, asthma and other health conditions.

What NIOSH Did

- We took indoor environmental quality measurements, including temperature, humidity, and carbon dioxide, as well as moisture meter readings of walls and ceilings.
- We inspected the ventilation systems.
- We took samples of air filters and analyzed them.
- We reviewed medical records and interviewed employees about work-related exposures and symptoms.

What NIOSH Found

- We did not identify any health hazard.
- There was no evidence of significant mold contamination or of toxic encephalopathy.
- We could not conclusively link any reported symptoms directly to the school.
- We found no moisture in the walls, ceiling tiles, or wood framing.
- Minor deficiencies were identified in the ventilation systems.
- Air filters contained mineral fragments, skin cells, pollen, mold spores, and rubber dust and diesel particulates from air pollution.

What Santa Ana Elementary School Managers Can Do

- Address the minor ventilation deficiencies.
- Implement an IEQ Management Plan for the Santa Ana Unified School District.
- Ensure that classrooms are cleaned and dusted at regular intervals.

What the Santa Ana Elementary School Employees Can Do

- Communicate your concerns to the correct school district officials.
- Do not divert air flow at supply or exhaust vents.
- Seek medical care from a residency trained, board-certified occupational medicine physician for work-related symptoms.

CDC Workplace Safety and Health

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2005-0112-2980

NIOSH

Health Hazard Evaluation Report 2005-0112-2980
Taft Elementary School
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David Vinson, Jr., MD
Eric Esswein, MSPH, CIH, CIAQP
Elena Page, MD, MPH

SUMMARY

On February 1, 2005, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at the Taft Elementary School in the Santa Ana Unified School District (SAUSD) in Santa Ana, California. The requesters were concerned about exposure to "toxic mold" in the school. There were reports that teachers had been diagnosed with toxic encephalopathy (brain damage) while other complaints included migraine headaches, sinusitis, asthma and other health conditions related to toxic mold exposure in the school. A site visit was made on April 5–6, 2005, which included an opening conference, an inspection of the school, and confidential employee interviews. A closing conference was held in which preliminary findings and recommendations were presented.

Measurements of indoor environmental quality were made including temperature, relative humidity, and carbon dioxide; and a moisture meter was used to detect moisture in walls and ceilings or wherever evidence of water staining was visible in the buildings. Visual inspections were made on each of the five 30-ton multizone heating, ventilation, and air conditioning (HVAC) units and on 6 of the 12 Trane® (3-ton) air handling units (AHUs). To investigate the nature of fine black particulates on filters installed downstream of the central AHUs, samples of air filters were collected and evaluated using scanning electron microscopy.

Indoor temperature, relative humidity (RH), and carbon dioxide (CO_2) in buildings A and B ranged from 70°–77°, 25%–38% and 569–1060 ppm, respectively. Indoor temperature, RH and CO_2 in bungalows B-3, B-4, and B-9 ranged from 72°–79°, 41%–58% and 1374–1477 ppm, respectively. Outside measurements were 76°–77°, 23% and 443–450 ppm. The presence of moisture was not detected on or in walls, ceiling tiles or wood framing members where evidence of previous water staining was visible. Microscopy results from air filters revealed various mineral fragments, skin cells, pollen and mold spores, and diesel particulates. Other reported particulates appeared physically similar to rubber dust. Minor deficiencies were found in several AHUs.

Fifteen of the 37 (41%) staff members interviewed reported no symptoms related to work. The most common work-related symptoms were nasal symptoms such as runny or stuffy nose (8/37 or 22%). Work-related eye irritation was reported by four persons (11%). Headache, throat irritation, and cough were each reported by three (8%). Two persons described sinus pressure that got better when away from work. Nobody reported shortness of breath, chest tightness, or wheezing. Eight of 37 (22%) reported constant sinus problems or recurrent sinusitis. Three persons reported memory problems and being

diagnosed by the same physician with toxic encephalopathy from mold exposure in the school. Medical records were also reviewed for seven persons. One person had evidence of sinusitis and rhinitis and one had rhinitis. None had evidence of toxic encephalopathy.

NIOSH investigators did not identify an occupational health hazard at the Taft Elementary School. Inspection of the HVAC system revealed minor problems such as evidence of dust intrusion, and presence of standing water and biofilm in some of the condensate drain pans. All water leaks had been repaired, and there was no evidence of mold or fungal growth. Taft employees had rates of work-related nasal problems similar to those reported in studies of buildings with indoor environmental quality complaints; however, we were unable to directly relate any symptom to the work environment. No exposure was identified in the school that would cause toxic encephalopathy, and there was sufficient evidence to conclude that none of the Taft Elementary School employees interviewed had toxic encephalopathy. Recommendations are included in this report to address HVAC deficiencies in all units that were inspected.

Keywords: School, mold, biofilm, allergy, rhinitis, toxic encephalopathy, memory, indoor environmental quality

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Table of Contents

INTRODUCTION

On February 1, 2005, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at the Taft Elementary School in the Santa Ana Unified School District (SAUSD) in Santa Ana, California. The request stated that teachers, custodians, aides, secretaries, students, and administrative staff had concerns about exposure to "toxic mold" in the school. Requesters reported that teachers had officially been diagnosed with toxic encephalopathy (brain damage), migraine headaches, sinusitis, asthma, and other health conditions related to toxic mold exposure in the school. It was reported that the commercially available microbiological settling plates placed in several locations in the school by teachers had demonstrated fungal growth.

After review of the HHE request and telephone consultations with the requesters and risk management officials for the school district, a site visit was made on April 5–6, 2005. An opening conference was held with the school district risk manager, three representatives of the Santa Ana Educators Association (one each for the elementary school, intermediate school, and deaf and hard of hearing school), a representative of the California State Employees Association (which represents the non-teaching staff), and the principal. Following the opening conference, a walk-through survey of the facilities and confidential employee interviews were conducted. At the end of the visit, a closing conference was held in the school; teachers and staff were invited to this meeting, along with those from the opening conference.

BACKGROUND

Facility Description

The Taft elementary school consists of two main buildings (designated as A and B) that are rectangular in shape. The main building (building A) was constructed in 1971 and building B was added a year later. Building A houses kindergarten through grade 5, and building B houses the deaf and hard of hearing school. The school also includes 20 pre-fabricated modular buildings (referred to as bungalows) that are used as classrooms and are designated B1-B20. Some of these bungalows house the intermediate school (grades 6-8), and others house elementary students. A modular restroom building is also on the school grounds adjacent to B-9. Taft Elementary School is situated near several major highways and the Orange County Airport. Also, it is located approximately 2 miles from an agricultural field.

Buildings A and B are single story, slab-on-grade structures with poured concrete walls and a flat roof finished with rolled asphalt roofing material. The two buildings are connected only by roofing that extends over an atrium or courtyard area. Teaching areas in buildings A and B are configured in the open classroom concept with partitions in some locations and bookcases and other storage systems forming walls as needed or desired. The pre-fabricated bungalows appear to be of standard stud wall construction finished on the outside with painted wood siding and a gutterless, pitched metal roof. The school serves 1,310 students and has a teaching and administrative staff of approximately 125 with an average-years-teaching of 12. The average class size for grades K–3 is 19, for grades 4–6 is 32, and for the core subjects the average class size is 30.

Ventilation Description

Heating, ventilation, and air conditioning (HVAC) is supplied to buildings A and B with two different sizes and brands of air handling units (AHUs). Three custom manufactured, 30-ton capacity, constant air volume (CAV), multi-zone systems serve the east and west (interior and perimeter) and the south perimeter (library and computer lab) sections of Building A. These systems were made for SAUSD by Seasons Four (Atlanta, GA). Central classroom areas of the building (as well as a section of the perimeter on the south side) of building A are supplied by twelve 3-ton capacity rooftop package units

manufactured by Trane®. The HVAC systems for Building B include two 30-ton rooftop package units, also manufactured specifically for SAUSD by Seasons Four.

The 30-ton capacity multi-zone units are reportedly configured in a dual-duct design that can supply natural gas heating or refrigerant cooling to the ventilation zone. The AHUs are equipped with an economizer mode that allows the outside air dampers to open fully, allowing 100% outside air to be supplied to the building for use in what is called "free cooling" (when outside air temperature is cooler than building return air). When the units are not operating in economizer mode, the outdoor air dampers are set at 25% of the maximum outside air supply volumes. Filtration of outside and return air consists of four stainless steel filter racks each capable of holding a contiguous section of five two-ply polyester panel filters. Filters were reported to have a minimum efficiency reporting value (MERV) of 6–7, roughly equivalent to a 25%–30% dust spot rating. Electronic direct digital controls are used in these systems. Much of the inside of the units are constructed of stainless steel, making for ease of cleaning when required. Maintenance doors have substantial seals and double locking handles. Condensate drain pans are single sloped, stainless steel and are plumbed to outlet drains and p-traps connected to rooftop drains.

The 3-ton units that serve the central portion of Building A are standard Trane® packaged units controlled by thermostats located in classrooms that can operate in one of the following four modes: heat, cool, auto, and continuous fan. The rooftop units were configured with outdoor air dampers that can be fixed at one of four positions including a minimum setting that appeared to be 25% of maximum. Outside and return air filtration consists of a single two-ply polyester panel filter of MERV 6–7 rating (a single panel of the same media is installed in the 30-ton units). Condensate drain pans are single sloped plastic, designed with an indented area at the drain pan outlet to prevent standing water. The drains are plumbed to a p-trap that was connected to the rooftop drains.

The HVAC systems for the bungalows consists of through-the-wall, terminal fan coil units installed several feet off the ground on the exterior walls. The units that were inspected are configured with a two-ply polyester panel filter (MERV 6–7) with a small condensate pan directly below the coil that drains to the ground with a drain tube extension. These units ventilate directly through the wall into the classroom; there is no supply or return duct work. The units operate on a manually adjusted timer that teachers can reset as often as necessary or when ventilation, heating, and cooling are desired.

A variety of HVAC work was done at the school by Penn Air, a local HVAC contactor and supplier of air filtration products and duct cleaning services. According to a Penn Air representative, the 3-ton units were reconditioned and ventilation duct work was cleaned as part of a reconditioning program at the school several years ago. As part of this work, a test and balance was performed on the five 30-ton multizone AHUs. As part of the AHU reconditioning, fiberglass insulation on the supply side interiors of the Trane® rooftop units was removed and replaced with Astro-Foil®, a reflective, insulating material consisting of two layers of aluminum foil laminated to two layers of polyethylene air-bubble cushioning. The contractor reported that Astro-Foil was used to "entomb" any residual fiberglass that may have remained inside the cabinets after cleaning and reconditioning. Visual inspection of the units suggested that in addition to cleaning and relining, fan housings had also been repainted. Duct cleaning reportedly was done for all metal ductwork in the ventilation systems for buildings A and B. The contractor stated that ductwork was cleaned using "air knife" technology that involves insertion of a high pressure air whip into ducting while the ducts are under negative pressure. Debris dislodged by the flailing action of the high pressure air whip and nozzle assembly is suctioned through the ducts to a filtered collection system.

According to a document sent to NIOSH describing the history of indoor environmental quality (IEQ) problems at Taft Elementary,

some time between 2000 and 2002 (after duct cleaning was completed), unknown black debris or "soot-like substance" was noted accumulating on desks and other interior surfaces. A rumor subsequently circulated that black mold was present in the ductwork and that ductwork in the school would need to be replaced. Because the source of the particulates was unknown, the contractor advised the school district to install point-of-use filtration (3M Filtrete™ rated at MERV 14) to prevent debris from being emitted from ventilation supply grilles in the classrooms. Risk management officials from SAUSD apparently were alerted to the misinformation relayed to the teachers and advised the teachers that mold was not growing in the ducts and the information given to them was inaccurate. After the point-of-use filters had been installed in the classrooms for some time, the filter media began to load and became black. The exact composition of, or the reservoir of, the black colored particulate (presumed to exist) within the HVAC system was never determined according to the ventilation contractor or school officials.

METHODS

Industrial Hygiene Evaluation

Taft Elementary staff identified building A as the main area of concern in their HHE request; however because teachers working in building B also mentioned IEQ concerns in the opening conference, this building as well as several of the bungalows were included in the investigation. A walk-through inspection of buildings A and B was conducted. Measurements of IEQ were made during the walk-through inspection including temperature, relative humidity, and carbon dioxide (CO_2) in mid-afternoon when the school was fully occupied. A Tramex™ non-penetrating moisture meter was used to detect the presence of moisture in walls and ceilings or wherever water stains were visible. Moisture measurements were also made in walls at various locations in buildings A and B where there was no obvious water staining.

Visual inspections were made on each 30-ton multizone AHU and on 6 of the12 Trane® (3-ton) AHUs. After five of the Trane 3-ton units were inspected, it was apparent there were few differences in the mechanical condition, operating status, filtration, or overall cleanliness for the units, so inspection of half of the twelve units was judged to be generally representative of all these AHUs.

The evaluation of the HVAC systems was an overall assessment, with emphasis on the presence of water intrusion, evidence of microbiolgical contamination, potential organic amplifiers for microbiological growth, and potential for dissemination of fungi/molds. We also considered overall cleanliness and operating condition and inspected the outdoor air intakes, dampers, filter racks and condition of filters, heating and cooling coils, condensate pans and drains, belts, fans, and supply and return ducting, terminal diffusers, and filters. For viewing of limited access areas, or for inspecting lengths of duct run and the internal areas of HVAC components, a lighted, flexible fiber optic borescope was used. The rooftop area around the AHU was inspected for evidence of pooling water, adequate rooftop drainage and the presence of appropriate plumbing (i.e., water filled p-traps) and the presence of rooftop stacks or exhausts located in proximity to outside air intakes. From the rooftop, adjacent areas around the school were noted including the presence of two freeways, an airport, the condition of the school grounds, and local flora.

To investigate the composition and possible reasons for the black discoloration of the point of use filters, bulk samples were cut from two filters that had been previously installed in classrooms in buildings A and B. Square sections of filter media (approximately 100 cubic centimeters or 4" x 4") with differing degrees of discoloration were removed. After sample collection, sections of filter media were placed in clean cellulose envelopes and delivered to a NIOSH physical scientist for physical inspection and analysis using scanning electron microscopy. Following microscopy,

samples were provided to a NIOSH analytical chemist for analysis by NIOSH Manual of Analytical Methods (NMAM) Method 5040 (Diesel Particulate Matter as Elemental Carbon). NIOSH Method 5040 is a thermal-optical analysis technique for carbon. The total carbon in a sample is quantified as organic and elemental carbon (OC and EC), but EC is a more specific marker of diesel particulate matter.

The school was occupied at the time of the investigation so traditional IEQ measurements of occupant comfort normally measured in NIOSH investigations were made using a TSI VelociCalc and Q Trak indoor air monitors. CO_2, temperature, and relative humidity were assessed on the first day the survey. Additionally, chemical smoke tubes were used to visually evaluate ventilation airflow patterns and to confirm pressurization of buildings A and B as well as negative pressurization of restrooms in the buildings.

We also reviewed results from the commercial settling plates placed in the school by employees. Additionally we reviewed reports and files from a recent California Occupational Safety and Health Administration inspection and spoke with an industrial hygienist on the phone.

Medical Evaluation

Confidential interviews were conducted either in person or by telephone. The interviews focused on job history, overall health, respiratory and allergic history, and any symptoms perceived to be building related. Each person was asked to compare symptoms at school and away from school. The three requesters were interviewed, as well as individuals who were identified by the requesters as having work-related health problems. In addition, we selected a representative sample of teachers and ancillary staff to interview from a map of the school buildings that depicted the location of each teacher's classroom and all office staff and supportive personnel. We included individuals from the two main buildings and from the portable buildings, ensuring that interviewed employees were located throughout the facilities, in order to capture areas that may have been differentially affected by IEQ problems. We also interviewed people who came to us and asked to be interviewed.

In addition, we reviewed available medical records. Authorization for release of information forms were signed and faxed to physician offices. In addition to obtaining medical records from physicians' offices, some individuals provided us with copies of their records.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[1] (2) the American Conference of

Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[2] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[3] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91-596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Indoor Environmental Quality

Over 70 million American workers spend their workday in indoor environments, and a number of published studies have reported symptoms among occupants of office buildings, schools, healthcare facilities, and other indoor work locales.[4, 5, 6, 7, 8, 9, 10] Since 1972, NIOSH has received approximately 3700 requests for assistance related to indoor environmental quality (IEQ), has conducted over 1250 Health Hazard Evaluations (HHEs) and sent over 1850 informative letters; far more than half (over 2800) of the requests were received since 1990. In 1993, following a primetime news broadcast about IEQ that posted the NIOSH phone number, a record 814 IEQ-related requests were received. Over 160 of these requests were randomly selected for HHE site visit investigations. We have found that significant IEQ improvements can be achieved by following standard recommendations related to the following four areas:

1. Operation and maintenance of ventilation system and other building components
2. Remediation of moisture, mold, and odor problems
3. Addressing employee issues through administrative controls
4. Expanding opportunities for workers to participate in decision making

Symptoms/Illnesses

The symptoms reported by building occupants have been diverse and usually are not suggestive of any particular medical diagnosis nor readily associated with a causative agent. Reports demonstrate closer associations of symptom occurrence with occupant perceptions of the indoor environment rather than with any measurement of indoor contaminants or conditions.[11, 12] A typical spectrum of reported symptoms includes headaches, fatigue, itching or burning eyes, irritation of the skin, nasal congestion, dry or irritated throats, and other respiratory symptoms. These symptoms are also often experienced by people outside of the workplace and could be related to a number of different causes, such as respiratory infections, allergies, discomfort due to temperature and humidity, and stress. Some studies have shown that psychological, social, and organizational factors may modify individuals' and organizations' responses to concerns in the office environment.[5, 13, 14, 15] Typically, workers suspect a workplace cause because their symptoms appear to be worse while at work and better when away from work.

Less often, illnesses and reactions may be found to be related to specific exposures in certain building environments. Hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, and carbon monoxide poisoning are all caused by specific agent(s) which have been found in some building environments. The first

three of these conditions can be caused by microorganisms.

Environmental Evaluations

Although NIOSH investigators have often found multiple environmental deficiencies in buildings with IEQ complaints, the relationship of these environmental deficiencies and symptoms reported by building occupants is often unclear. Environmental deficiencies observed in the indoor environment have been associated with inadequate ventilation systems, overcrowding, microbiological contamination, outside air pollutants, odors, dust or particulate exposures, or low level chemical exposures from office furnishings, office machines, tobacco smoke, cleaning products, personal hygiene products, and structural components of the building and its contents. Problems related to comfort issues, reduced job satisfaction, and stress are commonly present where IEQ complaints are raised. Comfort problems may be due to improper temperature and relative humidity conditions, poor lighting, unacceptable noise levels, unfamiliar odors, or adverse ergonomic conditions. Reduced job satisfaction and stress occurring among workers in buildings with IEQ concerns may be related to personnel organizational factors, conflict among personnel, or lack of job security. Poor communication between employees and supervisors is a particularly common finding in workplaces NIOSH has evaluated for IEQ concerns. [9, 10, 16, 17, 18]

A NIOSH study of 104 buildings where IEQ problems were reported found one or more deficiencies in the operation, design, or maintenance of HVAC systems in 93 of the buildings.[19] The same study found symptoms associated with one or more HVAC deficiencies, as well as with poor housekeeping, job conflict, being female, and being over 40 years of age.[20] A literature review in the early 1990s found consistent associations between symptoms and air-conditioning, carpets, crowding, use of video display terminals, introduction of outside air at rates below 10 liters per second per person (ls-1/person), job stress/dissatisfaction, being female, and having allergies or asthma.[5]

Standards specific to the non-industrial indoor environment do not exist. Measurement of indoor environmental contaminants has seldom proved helpful in determining the cause of symptoms except where there are unusual sources, or a proven relationship between specific exposures and disease. With few exceptions, concentrations of frequently measured chemical substances in the indoor work environment fall well below the published occupational standards or recommended exposure limits set by NIOSH, OSHA, and ACGIH.[1, 2, 21] The American National Standards Institute (ANSI)/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation and thermal comfort guidelines.[22, 23] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related symptoms that might be caused by airborne living organisms or their effluents.[24] Other resources that provide guidance for establishing acceptable IEQ are available through the Environmental Protection Agency (EPA) at (www.epa.gov/iaq,) especially the joint EPA/NIOSH document, Building Air Quality, A Guide for Building Owners and Facility Managers (www.epa.gov/iaq/largebldgs/baqtoc.html) and the EPA Indoor Air Quality Building Education and Assessment Model (I-BEAM) software available for downloading (www.epa.gov/iaq/largebldgs/ibeam page.htm).

Heating, Ventilating, and Air-Conditioning

One of the most common deficiencies in the indoor environment is the improper operation and maintenance of ventilation systems and other building components.[4] NIOSH investigators have found correcting HVAC problems often reduces reported symptoms. The majority of studies of ventilation rates and building occupant symptoms have shown that rates below 10 ls-1/person (which equates to 20 cubic feet per minute per person [cfm/person]), are associated with one or more health

symptoms.[25] Moreover, higher ventilation rates, from 10 ls-1/person up to 20 ls-1/person, have been associated with further significant decreases in the prevalence of symptoms.[25] Thus, improved HVAC operation and maintenance, higher ventilation rates, and comfortable temperature and RH can all potentially serve to improve symptoms without ever identifying any specific cause-effect relationships. When conducting an IEQ survey, NIOSH investigators often measure ventilation and comfort indicators, such as carbon dioxide (CO_2), temperature, and RH to provide information relative to the functioning and control of HVAC systems.

Carbon Dioxide

CO_2 is a normal constituent of exhaled breath and is not considered a building air pollutant. It is an indicator of whether sufficient quantities of outdoor air are being introduced into an occupied space. However, CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level at the time the CO_2 is measured. ASHRAE recommends that the indoor CO_2 concentration be no greater than 700 ppm above the outdoor concentration for comfort (odor) reasons.[23] Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. If CO_2 concentrations are elevated, the amount of outdoor air introduced into the ventilated space needs to be increased. ASHRAE's most recently published ventilation standard, ANSI/ASHRAE 62.1-2004: Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 17 cfm/person for office spaces and libraries, 13 to 15 cfm/person for classrooms (depending on the students' age), 7 cfm/person for reception areas, and 5 cfm/person for auditoriums.[23]

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an IEQ investigation because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature.[26] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The ANSI/ASHRAE Standard 55-2004: 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.[22] Assuming slow air movement and 50% RH, the operative temperatures recommended by 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 also recommends that RH be maintained at or below 65%.[23] Excessive humidity can promote the excessive growth of microorganisms and dust mites.

Microbial Contamination

Concern about IEQ problems related to microbial contamination, especially molds, in the workplace has been increasing with heightened public awareness, primarily through the popular media. However, exposure to microbes in the indoor environment is not a new exposure problem, and exposure to microbes is not unique to the indoor environment. It is important to understand that no environment, indoors or out, is completely free from microbes, not even a surgical operating room. Nevertheless, numerous public media reports and several scientific studies have suggested an association between building occupant symptoms and indoor fungi (mold), bacteria, or endotoxin concentrations, although most of these have recently focused on mold exposure. Similar to improving HVAC operation and maintenance, remediation of microbial contamination may improve IEQ conditions even though a specific cause-effect relationship is not determined. NIOSH investigators routinely recommend the remediation of observed microbial contamination and the correction of situations that are favorable for microbial growth and bioaerosol dissemination.

Mold

The types and severity of symptoms related to exposure to mold in the indoor environment depend in part on the extent of the mold present, the extent of the individual's exposure, and the susceptibility of the individual (for example, whether they have pre-existing allergies or asthma). In general, excessive exposure to fungi may produce health problems by several primary mechanisms, including: (1) allergy or hypersensitivity, (2) infection, and (3) toxic effects. Additionally, molds produce a variety of volatile organic compounds, the most common of which is ethanol, that have been postulated to cause upper airway irritation.[27] However, the potential irritant effects of VOCs from exposure to mold in the indoor environment are not well understood.

Allergic responses are the most common type of health problem associated with exposure to molds. These health problems may include sneezing; itching of the nose, eyes, mouth, or throat; nasal stuffiness and runny nose; and red, itchy eyes. Repeated or single exposure to mold or mold spores may cause previously non-sensitized individuals to become sensitized. Molds can trigger asthma symptoms (shortness of breath, wheezing, cough) in persons who are allergic to mold. A recent review of the scientific literature concluded that exposure to molds in the indoor environment may make pre-existing asthma worse, but also concluded that there was not enough evidence to determine whether exposure to mold in the indoor environment could cause asthma.[28] Hypersensitivity pneumonitis (HP) is another allergic response that has developed in people following extensive short-term (acute) or long-term (chronic) exposure to molds. It is a very rare illness, which may resemble bacterial pneumonia, and typically involves respiratory symptoms (such as cough, wheezing, or shortness of breath) as well as other symptoms (such as extreme fatigue and low-grade fever).

People with weakened immune systems (immune-compromised or immune suppressed individuals) may be more vulnerable to infections by molds. For example, Aspergillus fumigatus, a mold that has been found almost everywhere on every conceivable type of substrate, has been known to infect the lungs of immune-compromised individuals after inhalation of the airborne spores.[29] Healthy individuals are usually not vulnerable to infections from airborne mold exposure.

Recently, there has been increased concern related to exposure to specific molds which produce toxic substances called mycotoxins. Illness associated with exposures (from inhalation and/or skin contact) to mycotoxins in agricultural or industrial environments has been reported. However, there is currently no conclusive evidence of a link between mycotoxin exposure in the indoor environment and human illness.[30, 31, 32] It is important to note that many molds can potentially produce toxins given the right conditions.

No exposure guidelines for mold in air exist, so it is not possible to distinguish between "safe" and "unsafe" levels of exposure. 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. NIOSH concurs with the EPA's recommendations to remedy mold contamination in indoor environments (www.epa.gov/iaq/molds/mold_remediation.html).[33, 34]

RESULTS

Industrial Hygiene Evaluation

Observations and Findings From HVAC System Inspections

An inspection of AHU MZ-4 revealed four rows of two-ply Tri-Dim panel filters (Tri-Dek model, rated to MERV 6) securely in place with a light accumulation of grey dust on the upstream face of the filters. Filter bypass was not evident; the

coils were clean on both the upstream and downstream sides. The interior of the AHU was very clean. The outdoor air intake was unobstructed and was not located near obvious air pollutant sources, standing water, or rooftop stacks. The condensate drain pan was dry and clean, and slope was confirmed with the use of a hand held level. A p-trap was installed and functional. The fan blades on the blower were free of dirt or other accumulated material. Other components such as belts, dampers, seals on access doors, and the exterior of the unit, controls, etc. appeared to be in good operational condition.

On AHU MZ-5, the outdoor air intake was unobstructed and functional. Four rows of MERV 6 Tri-Dim filter panels were in place and filter bypass was not evident, however, some dust was visible on the upstream side of the evaporator coil, suggesting that some filter bypass had occurred. Light grey dust was visible across most of the upstream side of the filter faces. Outside air and return air damper linkages were intact and operational. There was water and a slight build-up of biofilm in the last 7/8 section of the condensate drain pan, indicating that the pan was not draining completely. Other components such as belts, dampers, seals on access doors, the exterior of the unit, controls, etc. appeared to be in good operational condition.

On AHU MZ-1, four rows of MERV 6 Tri Dim filter panels were in place and filter bypass was not visually evident. Filters had a thin layer of grey dust on the upstream side, the coil was clean, the outdoor air intake was unobstructed, and all dampers appeared to be functional. Clear standing water to the depth of an inch or more was present in the lower section of the condensate drain pan. There was a notable accumulation of green vegetative matter near the drain outlet. A thin biofilm was present in the bottom of the pan. The condensate drain was blocked. A thin curled strip of what appeared to be metal shavings (likely from installation of the unit) and a blob of cured sheet metal sealant was removed from the drain inlet. When the plug was removed, the standing water drained freely from the pan. Other components such as belts, dampers, seals on access doors, the exterior of the unit, controls, etc. appeared to be in good operational condition.

On AHU MZ-2, four rows of Tri-Dim MERV 6 filter panels were in place and filter bypass was not visually evident. Filters had a notable accumulation of tan-colored dust visible on the upstream side. The coil was clean, the outdoor air intake was unobstructed, and all dampers appeared to be functional. The bottom of the condensate drain pan was covered with a thin tan and green biofilm, and a small amount of standing water was present in the lower section of the drain pan. The reason for the standing water was undetermined. The insulating sound baffle on the building return air side had notable accumulations of tan dust that appeared to be the same color as the soil from the playground. Other components such as belts, dampers, seals on access doors, the exterior of the unit, controls, etc. appeared to be in good operational condition.

On AHU MZ-3, four rows of Tri-Dim MERV 6 filter panels were in place and filter bypass was not visually evident. Filters had light accumulations of grey dust on the upstream side. The coil was clean, the outdoor air intake was unobstructed, and all dampers appeared to be functional. The bottom of the condensate drain pan was dry but some debris was present. Other components such as belts, dampers, seals on access doors, the exterior of the unit, controls, etc. appeared to be in good operational condition. The maintenance access door to the coil section could not be opened completely because a horizontal section of the natural gas line for the unit was installed incorrectly.

Six of the Trane® 3-ton AHUs were inspected. These units were not numbered on the exterior of the cabinets and were identified by serial numbers listed on the manufacturer's label.

On Unit 325101504L, a single panel filter was in place and had a thin layer of grey dust on the upstream side, the coil was clean, and the drain pan was dry but a thin layer of tan dust/soil was

present in the bottom. No rust was evident inside the unit, and the Astro-Foil lining was intact and well sealed at the back and along the edges. Dust intrusion into the unit was evident due to lack of an adequate flat rubber seal along the edge of the maintenance access panel. The unit was missing a plastic plug designed to fill a half round conduit void built into the sheet metal frame that separates the filter side of the unit from the coil side. The absence of this plug allows some degree of filter bypass.

On Unit N1728S331H, a single MERV 6 filter was in place and had a moderate amount of grey dust on the upstream side; the coil was clean. The drain pan was slightly damp and contained a thin layer of dust or soil. No rust was evident inside the unit. The Astro-Foil lining was intact and sealed at the back and along the edges. Dust intrusion into the unit was evident on the fan blades. This was apparently due to lack of an adequate rubber seal along the edge of the maintenance access panel as well as possible filter bypass, again because the unit was missing the plastic plug to fill the conduit void in the sheet metal frame.

On unit R0334F81H, a single MERV 6 filter was in place and had a moderate amount of grey dust on the upstream side; the coil was clean. The drain pan was slightly damp and contained a thin layer of dust or soil. No rust was evident inside the unit, and the Astro-Foil lining was intact and sealed at the back and along the edges. Dust intrusion was evident by a build up on the fan blades. This was apparently due to lack of an adequate rubber seal along the edge of the maintenance access panel as well as possible filter bypass because the unit was missing a plastic plug to fill a round conduit void in the sheet metal frame separating the filter side from the coil side.

On Unit P244TRO1H, a single MERV 6 filter was in place and had a moderate amount of grey dust on the upstream side; the coil was clean. The drain pan was dry but contained a thin layer of dust and dirt. Rust was not evident inside the unit. The Astro-Foil lining was intact and sealed at the back and along the edges. Dust intrusion was evident by dust streaking along the edges of the maintenance access panel. Some degree of filter bypass was possible because the unit was missing a plastic plug to fill a round conduit void in the sheet metal frame separating the filter side from the coil side of the unit.

On Unit N19275C1H, a single MERV 6 filter was in place and had a moderate amount of grey dust on the upstream side; the coil was clean. The drain pan was dry and contained a very thin layer of tan colored dust and dirt. Rust was not evident inside the unit. The Astro-Foil lining was intact and sealed at the back and along the edges. Dust intrusion was evident by dust streaking along the edges of the maintenance access panel. Some of the maintenance panel screws were missing. Filter bypass was possible because the unit was missing a plastic plug to fill a round conduit void in the sheet metal frame separating the filter side from the coil side.

On Unit R043XCN1H, a single MERV 6 filter was in place and had a moderate amount of grey dust on the upstream side; the coil was clean. The drain pan was dry and contained a thin coating of dust. Rust was not evident inside the unit. The Astro-Foil lining was intact and sealed at the back and along the edges. Dust intrusion was apparent by the presence of dust streaks along the edges of the maintenance access panel where a flat rubber gasket was missing. The plastic plug was installed in the conduit cut out of the sheet metal frame that separates the filter side from the coil side of the unit.

Ceiling plenums (the areas above the suspended ceiling tiles) were inspected in areas with water stained ceiling tiles in buildings A and B. Generally, an inspection revealed that a pipe elbow for a roof drain was located above the water stained area. Apparently there had been roof leaks around the drains, and the presence of the black mastic roofing cement around the perimeter of pipe/roof seal suggested that the area had been repaired. Ducting was also inspected at this time, and it was noted that return air for building A used a ceiling plenum return. In building B, return air was not via the ceiling plenum; rather, round ductwork had been

installed. Water staining was evident in some area of the ceiling plenum but it did not appear to be recent. Mold or fungi, or the presence of water damage from chronic water intrusion was not seen in any location. While fine grey dust was present in some sections of flex ducting leading to point of use filters, mold or fungal growth was not observed in any of the ductwork that was inspected, nor was the characteristic smell of mold detected by the investigators. In one location (classroom 23 of building A) a section of batt insulation had come loose. The area was localized and was not determined to be an issue from an IEQ perspective.

Temperature, RH, and CO_2 measured in building A ranged from 71°–77°, 25%–35% and 569–1060 ppm, respectively. Outside measurements at 2:22 pm were 77°, 23%, and 443 ppm. It was noted that several outside doors were open in building A when these measurements were taken.

Temperature, RH, and CO_2 measured in building B ranged from 70°–77°, 30%–38% and 615–685 ppm, respectively. Outside measurements at 1:30 pm were 76°, 23%, and 450 ppm. Several doors were open in building B when these measurements were collected.

In Bungalow B-3, interior water staining was evident on a section of the north classroom wall where the ceiling and wall adjoin. The most likely reason for the water intrusion was the presence of a wall penetration for electrical conduit containing phone and fire alarm systems. No moisture was detected on the wall, the ceiling, or the wood above the ceiling tiles where water staining was visible. Temperature was 72°, RH was 45% and CO_2 was 1477 ppm. The classroom was fully occupied by students and the teacher. In Bungalows B-4 and B-9, localized water stains were evident in some areas and were investigated using a moisture meter. Measurements did not indicate the presence of moisture behind walls, in wallboard, or ceiling tiles or in wood framing or header components. Temperature, RH, and CO_2 was measured at 79°, 41%, and 1374 ppm in B-4 and 74°, 58%, and 1445 ppm in B-9.

Bulk Sample Results

Results of scanning electron microscopy of the two samples of point of use filters revealed the physical composition was similar for both samples. The filter from building A was more heavily loaded than the filter from building B, and this was consistent with visual observations when the samples when collected. The following materials and substances were reported by the NIOSH analyst: various mineral fragments, skin cells, pollen, and mold spores. Numerous small particles that could not be readily identified were also reported. The analyst commented that the materials seen under scanning electron microscopy were similar to other air samples of air filters that he had analyzed. The presence of "spongy appearing particles" was reported with the comment that they appeared physically similar to reference photographs of rubber dust. Numerous round particles were seen that were reported to be diesel particulates.

Based on this initial analysis, the filters were analyzed by NIOSH Manual of Analytical Methods (NMAM) Method 5040 for the presence of diesel particulate matter. Thermal optical analysis was conducted with a flame ionization detector and confirmatory results indicated the presence of total carbon, which is indicative of diesel exhaust particulates. The presence of diesel exhaust particulate was reported on both filter samples.

Settling Plate Results Review

Microbiological results for the environmental settling plates reported minor amounts of fungal growth, from one to ten colonies of common environmental fungi, including *Cladosporium*, *Ulocladium*, and *Penicillium*.

Medical Evaluation

Thirty-seven employees were interviewed, three by telephone and the rest in person. Of the 37, there were nineteen teachers, three custodians, eight teacher's aides, four administrators, and one school nurse. The rest were other

professional staff, such as audiologists. Thirteen of the 37 (35%) were those reported to have symptoms that they related to being in the school building, two presented themselves for interview, and the rest were selected from the map as described previously. The average age was 42 (range: 23–66), and the average length of employment was 12 years (range: 2–36). Five employees were men, and one employee reported being a current smoker.

Employees were asked about any medical problems or symptoms they had, and whether or not they thought the symptoms were work related. They were also questioned specifically about the relationship of any symptoms to the workplace. Symptoms that were reported to be better when off work are listed below as work-related. Prevalence rates of overall symptoms are listed in Table 1, and are compared to rates in a survey of the general population.

Fifteen of the 37 (40.5%) staff members reported no symptoms related to work. The most common work-related symptoms were nasal symptoms such as runny or stuffy nose (8/37 or 21.6%). Work-related eye irritation was reported by four persons (10.8%). Work-related headache, throat irritation, and cough were each reported by three (8.1%). Two persons described sinus pressure. Sneezing was reported by one person. One person reported having mold spores on a nasal swab. One person reported being diagnosed with asthma since having worked at the building, however, this had been a clinical diagnosis with no objective testing such as peak flows or spirometry. Two persons had preexisting asthma that they reported was not worse when in the school. Nobody reported shortness of breath, chest tightness, or wheezing. Atopy is the genetic predisposition to develop the classical allergic diseases, which are allergic rhinitis, asthma, and atopic dermatitis or eczema. Forty-three percent (16/37) of interviewed employees reported a history of allergic rhinitis, eczema, and/or asthma, and thus would be considered atopic. Atopic employees were 2.4 times more likely than nonatopic employees to report work-related respiratory symptoms. Prevalence rates of work-related sysmptoms are listed in Table 2, and are compared to rates found in a study of buildings where no complaints had been made and to rates in a study of buildings where IEQ concerns were reported.

Eight of 37 (22%) reported constant sinus problems or recurrent sinusitis. One person reported absence of menses for several years, but had not had a gynecologic evaluation of this problem. One person reported a miscarriage that she attributed to workplace exposure. One person reported no current symptoms, but described an incident 3 years prior where there was a significant output of an unknown noxious substance from the ventilation system. This individual was seen by a university occupational medicine clinic and diagnosed with irritant bronchitis after an extensive and appropriate work-up. This individual's condition has since resolved. The school nurse reported that although no formal health surveillance system was in place, she did not observe any changes in student health complaints in the past several years.

Three persons reported memory problems. These were described as forgetting thoughts while in conversation, walking into a room and forgetting why they intended to go there, forgetting phone numbers, and other similar things. These individuals reported being diagnosed with toxic encephalopathy due to mold exposure in the school. They had all been diagnosed by the same physician, and several other employees had also seen this physician. It was reported by the employees that this diagnosis was based upon: 1) brain single-photon emission computed tomography (SPECT) and/or positron emission tomography (PET); 2) settling plates that they had placed in the school; and 3) blood tests for mold exposure. One person reported having a test of variables of attention (TOVA) performed, but no other neuropsychological testing. One of these individuals has depression, diagnosed at about the time the memory symptoms were reported to begin.

Medical records were reviewed for seven persons. Records were reviewed from primary

care physicians for two persons, and neither documented any work-related complaints. Records were reviewed from an ear, nose, and throat specialist who had evaluated two persons. Both individuals had nasal mucosal inflammation on physical exam. Both had CT scans of the paranasal sinuses; one was normal and the other had evidence of sinusitis. One reported a long history of allergies to "everything." The other had allergy testing done and was only strongly positive for dust mites. There was no reaction to mold. Both were diagnosed with chronic rhinitis and mold exposure by the ENT physician.

The brain SPECT results provided for one individual demonstrated hypoperfusion of the frontal and temporal lobes bilaterally. Results of serum tests for this individual were also provided, and other employees reported having the same tests ordered. Extensive panels of immunoassays for fungi were reviewed. Serum immunoglobulin G (IgG), immunoglobulin M (IgM), immunoglobulin E (IgE), and saliva immunoglobulin A (IgA) to a variety of fungi were listed, including *Stachybotrys chartarum*, *Geotrichium candidum*, *Phoma herbarium*, *Cladosporium herbarum*, and *Epicoccum nigrum*, among many others. Similar tests were done for mycotoxins, including satratoxin and aflatoxin. Of note, the reference range for all results was listed as 0–1600, the units as enzyme-linked immunosorbent assay (ELISA), and 100% of these tests were positive. Autoimmune panels were also reviewed, and included anti-centromere, anti-microsomal, anti-myocardial, anti-parietal cell, anti-smooth muscle, anti-thyroglobulin, and C-3 and C-4 complement, among many others. Finally, chemical antibody panels were reviewed, and included IgG, IgM, and IgE to formaldehyde, isocyanate, trimellitic anhydride, phthalic anhydride, and benzene. These two panels were negative.

One physician had done the primary evaluations of several of the teachers as noted above, and coordinated referrals to other physicians. Six teachers provided us with consent to have this physician release their records to us for review prior to our site visit, but then all teachers withdrew their consent after the site visit.

DISCUSSION

Baseline Levels of Symptom Reporting

Taft employees had rates of work-related nasal problems similar to those reported in a study of buildings where IEQ issues had been reported. They also reported high background rates of underlying allergy which could explain the higher reported rates of work-related nasal problems. In addition, chronic daily exposure to air pollution in the area is probably a contributing factor. Analysis of the point of use filters demonstrated that pollutants such as rubber dust and diesel exhaust (as well as other unknown particles) are being captured by the ventilation filtration system. Finally, rates reported in this sample of employees may be higher than they would be if all employees had been interviewed because our entire sample was not randomly selected. While we attempted to select employees who were representative of different job series and locations on the campus, 40% of the employees were interviewed because they had complaints, and these complaints were primarily nasal and sinus problems. Finally, there was heightened awareness of the suspected problem in the buildings; co-workers were urged to get tested for mold exposure by some of those with symptoms, as well as from lawyers who urged employees to join a lawsuit. Other symptoms, such as headache and cough, were present at or below rates that would be expected in the general population and in buildings where no IEQ issues had been reported.

To determine if there is an excess of symptoms in a particular setting, such as Taft Elementary School, we looked at how common these symptoms are in the general population. Non-specific symptoms, such as headache, eye irritation, fatigue, backache, and nausea are common. Of the general population, 86%– 95% has 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 to 6

days.[35] These symptoms are rarely caused by serious illness. The average adult has two to three upper respiratory infections per year, while children have between six and eight.[36] Symptoms have been demonstrated to be more common when pollution or health threats are perceived,[37, 38] and can be affected by fears, emotional triggers, and litigation.[39]

Lipscomb reported 1-year symptom prevalence rates from three populations in California.[40] The top four health complaints in these populations were stuffy nose or congestion, irritated eyes, allergies or asthma, and headaches. Sinusitis is the most frequently reported chronic disease in the United States, topping arthritis, allergies, and hypertension.[41] Fourteen percent of U.S. adults reported physician diagnosed sinusitis in 2003, according to the National Health Interview Survey.[42]

Memory Problems

The rate of memory problems among Taft employees was well below the rates in the general population, and the examples of problems cited by Taft employees did not appear to be out of the ordinary. At least one of the persons diagnosed with toxic encephalopathy had depression, which could account for the symptoms reported. TOVA was the only neuropsychological test done, and is typically used for diagnosis of attention deficit disorder, as it tests attention and not memory per se.

Memory problems are commonly encountered in clinical practice and in the general population. In a study of adults in the Netherlands, 38.8% overall reported memory problems.[43] Another study of community- dwelling adults from Baltimore found that 22% reported memory problems.[44] Bolla examined 199 healthy men and women between the ages of 39 and 89.[45] Sixty-nine percent reported having to keep an appointment book, 83% required a grocery list, 59% used reminder notes and made lists of things to do, and 20% reported they had others remind them to do things so they would not forget. The majority of studies find that self-reported memory problems are not related to actual performance, but are attributable mainly to depression and mood.[44, 46, 47, 48, 49, 50, 51]

Toxic Encephalopathy

Chronic toxic encephalopathy (CTE) represents persistent injury to the brain as a result of cumulative or multiple repeated exposures to certain neurotoxins, over a period of years. Rarely, it can result from a single massive exposure that results in a severe acute toxic encephalopathy, such as severe carbon monoxide poisoning. Clinical manifestations usually involve varying degrees of cognitive impairment. The earliest signs are often subtle, and include changes in behavior, mood, or even emotions. Symptoms are persistent, vague, mild and nonspecific, many of which are seen with other psychological illness like the dementias and depression.[52]

The routine diagnostic procedures for solvent-induced CTE performed in different countries was assessed by surveying international experts about the methods used to diagnose patients with CTE.[53] There was broad agreement that a routine diagnostic procedure for solvent-induced CTE should include an interview and neurological, physical, and neuropsychological examinations. Only one center always used single-photon emission computed tomography (SPECT), and one center used SPECT and/or positron emission tomography (PET) only when indicated. This suggests that these tests are not considered a standard part of a workup for CTE.

Recently, a small number of published reports implicated molds and mycotoxins in indoor environments as a cause of CTE. However, these studies have been reviewed by the Institute of Medicine, which concluded that there is insufficient evidence that the presence of mold or other agents in damp, indoor environments causes neuropsychiatric disease.[28] We also reviewed this literature and concluded there is insufficient evidence that mold, mycotoxins, or damp environments cause neuropsychiatric disease. We found no documentation by the single physician involved in the diagnosis of CTE among Taft employees of exposure to any

agent with sufficient evidence of causing CTE. Moreover, neuropsychiatric testing was not performed to confirm actual performance deficiencies, and there was no mention of alternate explanations for employee symptoms, including the possibility that the symptoms were similar to those found in the general population. These types of documentation are necessary to clearly assess possible CTE. Diagnoses of work-related CTE should be made by a physician who is residency trained and board certified in occupational and environmental medicine or toxicology, in consultation with a residency trained and board certified neurologist and/or psychiatrist.

Functional Neuroradiologic Imaging

The brain SPECT we reviewed was performed in a patient who was taking antidepressant medication, and the report specifically stated that clinical correlation with use of that medication was needed.

Detection of abnormalities on brain scans requires knowledge of normal variations that may be seen on these scans.[54] Both PET and SPECT are highly variable, even in normal subjects.[55, 56] Age, gender, handedness, environment and alertness at the time of the study, glucose levels, and even mood can influence results.[56, 57] The patient's thoughts and experiences at the time of the scan can profoundly affect brain function. Even opening or closing the eyes produces dramatic changes.[54]

A 1996 paper of the Society of Nuclear Medicine Brain Imaging Council (SNMBIC) entitled "Ethical clinical practice of functional brain imaging"[58] states that while SPECT and PET are useful in the management of patients with stroke, epilepsy, brain tumors, and dementia, they have limitations. They note that sensitivity and specificity are unknown and group patterns can be too subtle to detect in individuals. This is especially true in the case of toxic exposures, chronic fatigue syndrome, and other illnesses like autoimmune disorders, where patterns are variable. The SNMBIC clearly state that the utility of brain PET and SPECT in the management of individual patients is far from clear. In addition, they state that the use of functional neuroimaging in forensic situations such as worker's compensation and toxic torts is inappropriate, and are typically rejected by courts. In the years since that publication, only a handful of studies looking at functional neuroimaging in toxic exposures have been published. All suffer from serious methodologic problems that preclude concluding that these tests are diagnostic in cases of purported toxic exposures.[59, 60]

Laboratory Testing of Employees

As noted in the results section, it appears that immunoassays to fungi and laboratory results of sampling using settling plates were accepted by the physicians as documentation of exposure to fungi. Misuse and misinterpretation of this type of testing prompted NIOSH researchers to publish a paper specifically addressing this issue just last year.[61] We concluded that there is not sufficient scientific evidence to support the use of immunoassays as biomarkers of exposure to fungi for a variety of reasons, including the ubiquitous nature of fungi, the lack of specificity of fungal antigens, lack of standardized procedures and reference reagents, and difficulties in interpretation.[61] Tests performed by the particular laboratory used by the treating physician are even more problematic. The reports include unrealistic reference ranges. It is not possible that the reference range would be identical in every antibody test, whether it is IgG, IgA, or IgM, or serum and saliva, and for each type of fungus and mycotoxins. Furthermore, ELISA stands for enzyme linked immunosorbent assay, and is not a unit of measure.

The use of chemical antibody tests in this group of employees was not appropriate. For example, formaldehyde is a fairly ubiquitous chemical and is known to be present in homes as well as schools or offices, as it is a component of particleboard, plywood, countertops, paneling, glues, fabric coatings, insulation, and disinfectants, to name a few. Trimellitic anhydride and phthalic anhydride are both used

in the production of plasticizers for various resins and in dye manufacturing, among other things, and would not be expected to be found in a school. Benzene is a solvent that is present in gasoline and automobile emissions, and thus is a ubiquitous exposure. Biological monitoring for benzene is commonly done by measuring urinary phenol, or benzene in blood or urine.[62]

Extensive serum rheumatologic tests were also performed in some of these employees. Studies have demonstrated that overuse of these tests can lead to unnecessary referrals and further lab work. Careless, uneducated use of these tests leads to diagnostic confusion and increased costs.[63] Ordering rheumatologic panels is poor practice because they often contain tests not relative to the patient.[63] Selected rheumatologic tests are best used in confirming a diagnosis that is made clinically (i.e., the patient has signs and symptoms consistent with a particular diagnosis). This is true of other medical tests as well. Ordering of laboratory and other types of tests should be done in a judicious and focused manner, complementing the history and physical examination, and not in a "shotgun" approach. The more tests ordered the higher the likelihood of a false positive result or a test that is positive, but not clinically significant.

The ethics and procedures at the laboratory that performed all this testing has been called into question. Scientists at this laboratory published a study of salivary secretory IgA in 2003.[64] The authors also submitted a patent application utilizing the same study, but there were several discrepancies between the paper and the patent application, leading the editors of the journal to express their concern.[65] The discrepancies systematically magnified the difference between cases and controls in this publication, making it look like their tests performed better than they really did. The Centers for Medicare and Medicaid Services (CMS) regulates all laboratory testing (except research) performed on humans in the U.S. through the Clinical Laboratory Improvement Amendments (CLIA). In total CLIA covers approximately 175,000 laboratory entities. The objective of the CLIA program is to ensure quality laboratory testing [http://www.cms.hhs.gov/clia/]. In May 2005, the California Department of Health and Human Services, CMS, issued a report on the Immunosciences Lab, Inc. finding that the laboratory was found to be in non-compliance with all of the required conditions in the CLIA program.[66] The 112-page report specified a number of deficiencies pertaining specifically to the immunoassays performed on the employees from Taft, including failure to make available pertinent reference intervals; failure to establish written policies for patient preparation, collection, storage, preservation, transportation, and processing of specimens; failure to determine calibration procedures; and failure to establish the statistical parameters of control materials. The report states that there were no guidelines indicating the limits of acceptability for accuracy, precision, analytical sensitivity or specificity to include interfering substances and reference ranges for mold and mycotoxins test performed.

Finally, one person reported that fungal spores were found in her nose by nasal swab. This is to be expected because, as previously explained, fungi are ubiquitous. A Mayo Clinic study compared patients with chronic rhinosinusitis to healthy controls, and found that 100% of controls and 96% of cases had positive fungal cultures from their noses.[67]

Use of Settling Plates to Document Fungal Exposure

Commercially purchased settling plates were used by employees to test the school for fungal contamination. They demonstrated minor amounts of growth of common environmental fungi. As noted above and in the evaluation criteria, microorganisms, including fungi, are ubiquitous, that is, they are present in all indoor environments with the possible exceptions of specially filtered "clean rooms" in health care and industry. The use of environmental settling plates for collection and enumeration of indoor concentrations of fungi (or bacteria) is not an accepted method of sample collection to make risk-based characterizations of indoor environments. Exposing agar-containing (fungal

growth media) settling plates will always result in the presence of certain organisms if the plates are incubated appropriately. However, using settling plates is a naïve and not a particularly discriminating tool for characterizing building environments for the presence of fungal contamination for numerous reasons. Settling plates are a passive rather than active method. Active sampling methods are preferred and incorporate calibrated sampling pumps and engineered sample collection devices to draw in known quantities of air through specifically sized openings that allow for specific volumes of air to be sampled and specific fungal particle sizes to be collected. Settling plates can be easily cross-contaminated during handling and are non-discriminative in relation to specific particle sizes, relying simply on settling velocity of particles to land on the growth media. Interpretation of results is limited to whatever organisms happen to thrive best under the conditions when the plates were exposed, and subsequently handled and incubated. In other words, the results are vague and unrepresentative at best, especially considering the limited numbers of samples that were collected. When industrial hygiene sampling for fungal agents is needed (not commonly the case if a careful building investigation has been conducted), an experienced certified industrial hygienist should develop a hypothesis and an appropriate sampling strategy to test the hypothesis, plan and execute appropriate sampling (if even necessary), and interpret results considering all sampling conditions.

CONCLUSIONS

No occupational health hazard was found at the Taft Elementary School. We found no exposure in the school that would cause toxic encephalopathy, and there was sufficient evidence to conclude that none of the Taft Elementary School employees interviewed has toxic encephalopathy. In addition, we are unable to directly relate any symptom to the work environment, although many of the common, non-specific symptoms reported, such as sinus problems and headaches, are common in offices and schools. A chronic air pollution problem in the school area likely contributes to the reported upper respiratory and eye symptoms.

There is evidence that isolated and episodic water intrusion/filtration has occurred in a few very localized areas of the school. There is no evidence that water intrusion is or has been a chronic problem or that fungal (mold) contamination is a health hazard to staff and teachers. Moisture was not detected in walls and ceilings. The presence of standing water, a biofilm, and biomass were found in several of the stainless steel condensate pans for several of the 30 AHUs. The reason for the standing water was clearly identified in one case (a plugged drain). No evidence of downstream contamination with mold or fungi in AHU components or ductwork was seen.

Results from this investigation suggest a need for drain pan cleaning on some of the Seasons Four 30-ton air handlers and preventive maintenance on the Trane 3-ton units. The problems that were noted are not uncommon findings based on NIOSH IEQ investigations in commercial and school building AHUs. It is anticipated that because the problems were determined to be cleanliness and maintenance issues, they can be easily addressed.

We consider indoor dustiness, an issue that was reported by some teachers to be a health concern, to be a consequence of classroom clutter, the widespread use of paper products (books, classroom papers, etc.), as well as foot traffic transport of dust and "dirt" from the outdoor playground. The fact that the entire school is carpeted may contribute to dustiness depending on rigorousness of housekeeping. The types of vacuum cleaners used by the cleaning staff were judged to be adequate based on the types of filtration used in these units.

Ventilation distribution in the school can be improved through a complete test and balance of all the AHUs in building A and B. NIOSH investigators do not believe that the point of use 3M filters that have been installed in the school are appropriate for numerous reasons including increased duct static pressure and air balancing

problems that could be created by installation of filtration on the ends of ductwork. Enhancing air filtration in the AHUs is believed to be a better and more cost effective solution.

The elevated CO_2 levels measured in the bungalows on the day of the survey were likely a result of insufficient amounts of outside air (dilution ventilation) due to insufficient use of the through-the-wall, terminal fan coil units by teachers in those bungalows. These units are on timers that the teachers themselves control, so feeling of stuffiness, odors, or perceptions of "lack of air" can be remedied by more frequent cycling of the units.

RECOMMENDATIONS

The following recommendations are based on observations made during the course of the HHE. While we are unable to directly relate any symptom to the work environment, many of the common, non-specific symptoms reported, such as sinus problems and headaches, are common in offices and schools, and may be improved by the recommendations below. Recommendations to address the minor HVAC problems are included.

1. Thoroughly clean all HVAC condensate pans that were identified to have biofilm, standing water, or debris using a standard detergent solution in concentrations consistent with product use directions. Cleaning should be done when the HVAC system(s) are not operating. After cleaning, drain pans can be sanitized using sodium hypochlorite (common bleach) in concentrations of 1%–3% aqueous solution (note standard household bleach is 5.25% in strength, so dilution is required). A clear water rinse should follow any cleaning. The angle of tilt on the condensate pans should be checked with the use of a hand level. If sufficient tilt (to allow drainage when 1 liter of clear water [less for the 3-ton units] is poured in the pan) is not confirmed, the slope of the pans should be modified to allow adequate condensate drainage if possible.

2. Install enhanced filtration (in a range of MERV 10–12) in the 30-ton units and to the degree possible in the 3-ton units. The exact MERV rating will depend on maximum static pressure limits per AHU manufacturer's specifications. The choice of enhanced filtration in the AHU should be balanced between better efficiency of the filter as well as the fit of the filter within the existing filter racks. Filters should be sized so that each filter fits snugly into the filter racks; there should be no gaps where the filters meet with the filter access panel doors.

3. Remove the 3M point of use filters, and have a qualified ventilation engineer perform a complete test and balance of the AHUs in buildings A and B. Ensure teachers and other staff do not obstruct supply or return vents with papers, cardboard, etc. Deliberate obstruction of supply ductwork is usually a sign that occupants feel uncomfortable from drafts or strong flows from the ventilation system. This can be due to several things including the placement of the diffusers too close to a workstation or an imbalanced system, which only becomes more imbalanced as more diffusers are deliberately obstructed.

4. Seal the half round conduit voids in the sheet metal frames of the 3-ton units using appropriately sized strips of foil tape. Alternatively, strips of sheet metal and duct mastic can be used. If this technique is used, this repair should be done using low volatile organic compounds emitting materials or done during the summer when school is not in session. Do not use standard "duct tape" (any fabric-based tape with rubber adhesive) as the adhesive backing on this type of tape eventually oxidizes and hardens and the tape loses its ability to adhere to surfaces as intended. Additionally, this type of tape, despite its name, is not intended for use on ductwork.

5. Relocate the natural gas line serving AHU MZ 3 so that the maintenance access door can be opened all the way.

6. Install flat rubber gasketing material on the maintenance access panels for the 3-ton units to prevent unfiltered dust intrusion.

7. Increase the frequency of operation of the through-the-wall, terminal fan coil units in the bungalows to increase dilution ventilation (add more outside air) to address problems with stuffiness, odors, etc.

8. Implement an IEQ Management Plan for the Santa Ana Unified School District. An IEQ manager or administrator with clearly defined responsibilities, authority, and resources should be selected. This individual should have a good understanding of the buildings' structure and function, and should be able to effectively communicate with occupants. This is a proactive approach that can help prevent IEQ problems from occurring. Although comprehensive regulatory standards specific to IEQ have not been established, guidelines have been developed by organizations such as the ASHRAE, NIOSH, and the EPA. The EPA has several publications on IEQ, including the *IAQ Tools for Schools Action Kit* which is available at *http://www.epa.gov/iaq/schools/toolkit.html*. The *Tools for Schools* document discusses IEQ in some detail, and includes information on common problems, investigative techniques, and solutions to specific problems. The basic elements of a good IEQ plan include:

   ▪Proper operation and maintenance of HVAC equipment, including the need to accommodate occupants who work during hours when the HVAC system is routinely cycled off to ensure that adequate ventilation is provided.

   ▪Overseeing the activities of occupants and contractors that affect IEQ (e.g., housekeeping, pest control, maintenance, food preparation).

   ▪Maintaining and ensuring effective and timely communication with occupants regarding IEQ.

   ▪Educating building occupants and contractors about their responsibilities in relation to IEQ.

   ▪Identifying and managing projects that may affect IEQ (e.g., redecoration, renovation, relocation of personnel,) proactively.

   ▪Designating a school employee representative who can speak for the teachers and other employees, and assist with communication.

   The NIOSH/EPA Document, Building Air Quality: *A Guide for Building Owners and Facility Managers* may be helpful for developing and implementing the IEQ management plan. A companion NIOSH/EPA guide: *Building Air Quality Action Plan* can serve as a checklist for developing and assessing an effective IEQ management program. These are available at http://www.cdc.gov/niosh/98-123a.html and http://www.cdc.gov/niosh/baqtoc.html, respectively. The EPA has also established an IEQ information clearinghouse that can provide information on a number of IEQ-related topics and has a website specifically for IEQ issues (http://www.epa.gov/iaq/index.html). Information on selecting IEQ consultants, if needed, is available from the American Industrial Hygiene Association's (AIHA) *Guidelines for Selecting an Indoor Air Quality Consultant*.

9. Encourage employees with health concerns to seek evaluation and care from a physician who is residency trained and board certified in occupational medicine, and is familiar with the types of exposures employees may have had and their health effects. You can locate these occupational medicine physicians through a variety of sources, including the Association of Occupational

and Environmental Clinics at www.aoec.org, and the American College of Occupational and Environmental Medicine (ACOEM) at www.acoem.org. The University of California at Irvine has a large occupational and environmental medicine clinic that could serve all your needs. It may be useful to provide the physician with a copy of this report.

REFERENCES

1. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

2. ACGIH [2005]. 2005 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. CFR [2003]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

4. Rosenstock L [1996]. NIOSH Testimony to the U.S. Department of Labor on indoor air quality. Appl Occup Environ Hyg 11(12):1365-1370.

5. Mendell MJ [1993]. Non-specific symptoms in office workers: a review and summary of the epidemiologic literature. Indoor Air 3:227-236.

6. Malkin R, Wicox T, Sieber WK [1996]. The National Institute for Occupational Safety and Health indoor environmental evaluation experience. Part two: symptom prevalence. Appl Occup Environ Hyg 11(6):540-545.

7. Gammage RR, Kaye SV, eds [1985]. Indoor air and human health: Proceedings of the Seventh Life Sciences Symposium. Chelsea, MI: Lewis Publishers, Inc.

8. Burge S, Hedge A, Wilson S, Bass JH, Robertson A [1987]. Sick building syndrome: a study of 4373 office workers. Ann Occup Hyg 31:493-504.

9. Kreiss K [1989]. The epidemiology of building-related complaints and illness. Occupational Medicine: State of the Art Reviews 4(4):575-592.

10. Norbäck D, Michel I, Widstrom J [1990]. Indoor air quality and personal factors related to the sick building syndrome. Scan J Work Environ Health 16:121-128.

11. NIOSH [1991]. Hazard evaluation and technical assistance report: Library of Congress, Washington. D.C. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88-364-2104.

12. Berglund L, Cain WS [1989]. Perceived air quality and the thermal environment. In: *Proceedings of IAQ '89: The Human Equation: Health and Comfort*. Atlanta, GA: American Society of Heating, Ventilating, and Air-Conditioning Engineers, pp. 93-99.

13. Boxer PA [1990]. Indoor air quality: a psychosocial perspective. J Occup Med 32(5):425-428.

14. Baker DB [1989]. Social and organizational factors in office building-associated illness. Occup Med: State of the Art Reviews 4(4):607-624.

15. Ooi PL, Goh KT [1997]. Sick building syndrome: an emerging stress-related disorder? Int J Epidemiol 26(6):1243-1249.

16. Morey PR, Shattuck DE [1989]. Role of ventilation in the causation of building-associated illnesses. Occup Med: State of the Art Reviews 4(4):625-642.

17. Molhave L, Bach B, Pedersen OF [1986]. Human reactions to low concentrations of volatile organic compounds. Environ Int 12:167-176.

18. Burge HA [1989]. Indoor air and infectious disease. Occup Med: State of the Art Reviews 4(4):713-722.

19. Crandall MS, Sieber WK [1996]. The National Institute for Occupational Safety and Health indoor environmental evaluation experience. Part one: building environmental evaluations. Applied Appl Occup Environ Hyg 11(6):533-539.

20. Sieber WK, Stayner LT, Malkin R, Petersen MR, Mendell MJ, Wallingford KM, Crandall MS, Wilcox TG, Reed L [1996]. The National Institute for Occupational Safety and Health indoor environmental evaluation experience. Part three: associations between environmental factors and self-reported health conditions. Appl Occup Environ Hyg 11(12):1387-1392.

21. OSHA, Code of Federal Regulations [1997]. OSHA Table Z-1. The Occupational Safety and Health Administration's General Industry Standards, 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

22. ANSI/ASHRAE [2004]. Thermal environmental conditions for human occupancy. American National Standards Institute/ASHRAE standard 55-2004. Atlanta, GA: American Society for Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

23. ANSI/ASHRAE [2004]. Ventilation for acceptable indoor air quality. American National Standards Institute/ASHRAE standard 62.1-2004. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

24. ACGIH [1999]. Bioaerosols: assessment and control. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

25. Seppanen OA, Fisk WJ, Mendell MJ [1999]. Association of ventilation rates and CO2 concentrations with health and other responses in commercial and institutional buildings. Indoor Air 9:226-252.

26. NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, revised criteria. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-13.

27. Miller J [1992]. Fungi as contaminants in indoor air. Atmosphere and Environment 26(A):2163-2172.

28. IOM [2004]. Human health effects associated with damp indoor environments. In: *Damp Indoor Spaces and Health*. National Academy Press, Washington, DC 183-269.

29. Wald P, Stave G [1994]. Fungi (chapter 24). In: *Physical and Biological Hazards of the Workplace*. New York, NY: Van Nostrand Reinhold, pp. 394.

30. Page E, Trout D [2001]. Role of Stachybotrys mycotoxins in building-related illness. AIHA J 62:644-648.

31. Robbins C, Swenson L, Neally M, Gots R, and Kelman B [2000]. Health effects of mycotoxins in indoor air: a critical review. Appl Occup Environ Hyg 15(10):773-784.

32. Terr AI [2001]. Stachybotrys: relevance to human disease. Ann Allergy Asthma Immunol 87:57-63.

33. Redd SC [2002]. State of the science on molds and human health. Statement for the Record Before the Subcommittee on Oversight and Investigations and Housing and Community Opportunity, Committee on Financial Services, United States House of Representatives. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.

34. EPA [2001]. Mold remediation in schools and commercial buildings. Washington, DC: United States Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division. EPA Publication No. 402-K-01-001.

35. Barsky AJ, Borus JF [1995]. Somatization and medicalization in the era of managed care. JAMA 274:1931-1934.

36. Benninger MS, Ferguson BJ, Hadley JA, Hamilos DL, Jacobs M, Kennedy DW, Lanza DC, Marple BF, Osguthorpe JD, Stankiewicz JA, Anon J, Denneny J, Emanuel I, Levine H [2003]. Adult chronic rhinosinusitis: definitions, diagnosis, epidemiology, and pathophysiology. Otolayngol Head Neck Surg. 129(3 Suppl):S1-S32.

37. Williams CW, Lees-Haley PR [1993]. Perceived toxic exposure: A review of four cognitive influences on perception of illness. J Soc Behav Pers. 8(3):489-506

38. Watson D, Pennebaker JW [1989]. Health complaints, stress, and distress: Exploring the central role of negative affectivity. Psychol Rev. 96(2):234-254.

39. Lees-Haley PR, Brown RS [1992]. Bias in perception and reporting following a perceived toxic exposure. Percept Mot Skills. 75(2):531-544.

40. Lipscomb JA, Satin KP, Neutra RR [1992]. Reported symptom prevalence rates from comparison populations in community-based environmental studies. Arch Environ Health 47(4)263-269.

41. Benson V, Marano MA [1993]. Current estimates from the National Health Interview Survey, 1993, National Center for Health Statistics. Vital Health Stat 10(182).

42. CDC [2005]. Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2003. available at www.cdc.gov/nchs/data/series/sr_10/sr10_225.pdf

43. Ponds RWHM, Mommissaris KJAM, Jolles J [1997]. Prevalence and covariates of subjective forgetfulness in a normal population in the Netherlands. Int J Aging and Hum Dev 45:207-221.

44. Bassett SS, Folstein MF [1993]. Memory complaint, memory performance, and psychiatric diagnosis: A community study. J Geriatr Psychiatry Neurol 6:105-111.

45. Bolla KI, Lindgren KN, Bonaccorsy C, Bleecker ML [1991]. Memory Complaints in Older Adults: Fact or Fiction? Archives of Neurology 48:61-64.

46. Grut M, Jorm AF, Fratiglioni L, Forsell Y, Viitanen M, Winblad B [1993]. Memory complaints of elderly people in a population survey: variation according to dementia stage and depression. J Amer Geriatr Soc 41:1295-1300.

47. O'Connor DW, Pollitt PA, Roth M, Brook PB, Reiss BB [1990]. Memory complaints and impairment in normal, depressed, and demented elderly persons identified in a community survey. Arch Gen Psychiatry 47:224-227.

48. Hanninen T, Reinikainen KJ, Helkala EL, Koivisto K, Mykannen L, Laakso M, Pyorala K, Riekkinen PJ [1994]. Subjective memory complaints and personality traits in normal elderly subjects. J Amer Geriatr 42:1-4.

49. Jorm AF, Christensen H, Korten AE, Jacomb PA, Henderson AS [2001]. Memory complaints as a precursor of memory impairment in older people: A longitudinal analysis over 7-8 Years. Psychol Med 31:441-449.

50. Comijs HC, Deeg DJH, Dik MG, Twisk JWR, Jonker C [2002]. Memory complaints; The association with psycho-affective and health problems and the role of personality characteristics. A 6-year follow-up study. J Affec Disord 72:157-165.

51. Derouesne C, Lacomblez L, Thibault S, LePoncin M [1999]. Memory complaints in young and elderly subjects. Int J Geriatr Psychiatry 14:291-301.

52. Firestone JA, Longstreth WT [2005]. Classification of diseases of the central nervous system related to neurotoxins. In: *Textbook of Clinical Occupational and Environmental Medicine.* 2nd edition. Rosenstock L, Cullen MR, Brodkin CA, Redlich CA eds. Elsevier Saunders, Philadelphia 653-670.

53. Hoek JAF van der, Berberk MM, Laan G van der, Hageman G [2001]. Routine diagnositc procedures for chronic encephalopathy induced by solvents: Survey of experts. Occup Environ Med 58:382-385.

54. Newberg AB, Alavi A [2003]. Normal patterns and variants in single-photon emission computed tomography and positron emission tomography brain imaging. Sem Nucl Med. 33: 42-55.

55. Tanaka F, Vines D, Tsuchida T, Freedman M, Ichise M [2000]. Normal patterns on 99mTc-ECD brain SPECT scans in adults. J Nucl Med 41(9)1456-1464.

56. Silverman DHS, Alavi A [2005]. PET imaging in the assessment of normal and impaired cognitive function. Radiol Clin N Am. 43:67-77.

57. Loessner A, Alavi A, Lewandrowski KU, et al [1995]. Regional cerebral function determined by FDG-PET in health volunteers: Normal patterns and changes with age. J Nucl Med 36:1141-1149.

58. Mayberg HS, Alavi A, Bonte FJ, Borys N, Budinger T, et al [1996]. Ethical clinical practice of functional brain imaging. J Nuclear Med 37(7):1256-1259.

59. Heuser G, Mena I [1998]. Neurospect in neurotoxic chemical exposure: demonstration of long-term functional abnormalities. Toxicol Ind Health 14(6):813-827.

60. Fincher C, Te-Sheng C, Harrell E, Kettelhut M, Rea W, Johnson A, Hickey D, Simon T [1997]. Comparison of single photon emission computed tomography in cases of healthy adults and solvent-exposed adults. Am J Ind Med 31:4-14.

61. Trout DB, Seltzer JM, Page EH**,** Biagini RE, Schmechel D, Lewis DM, Boudreau AY [2004]. Use of immunoassays in assessing exposure to fungi and potential health effects related to fungal exposure. Ann Allergy Asthma Immunol 92:483-492.

62. Irons RD [2001]. Benzene and other hematotoxins. In: Sullivan J, Krieger G, eds. *Hazardous Materials Toxicology, Clinical Principles of Environmental Health*. 2nd rev.ed. Baltimore, MD:Williams and Wilkins Publishing, pp 750-762.

63. Lane SK, Gravel JW [2002]. Clinical utility of common serum rheumatologic tests. Am Fam Physician 65:1073-80.

64. Vojdani A, Kashanian A, Vojdani E, Campbell AW [2003]. Salivary secretory IgA antibodies against molds and mycotoxins in patients exposed to toxigenic fungi. Immunopharmacology and Immunotoxicology 25:595-614.

65. Chirigos MA, Jirillo E [2005]. Editorial commentary. Immuno-pharmacology and Immuno-toxicology 27:185.

66. (CDHHS) California Department of Health and Human Services, (CMS) Centers for Medicare and Medicaid Services, Report No. 05D0642471, [2005].

67. Ponikau JU, Sherris DA, Kern EB, et al [1999]. The diagnosis and incidence of allergic fungal sinusitis. Mayo Clin Proc. 74:877-884.

Table 1 Comparison of Overall Symptom Prevalence Between Taft Elementary Employees and the General Population		
	General Population[a,b]	**Taft**
Dry, itchy, or irritated eyes	23.2-24.7	16.2
Runny or Stuffy Nose	28.1-46.2	32.4
Headache	18.4-33	27.0
Dry or Sore throat	11-22.4	8.1
Cough	25.9	8.1
Allergies or asthma	***18.6***	***43.2***
Fatigue	13.9-29.8	5.4
Dizziness	11	2.7
Skin rash, dry skin	12	10.8
Nausea	5-9	0
Muscle aches or pain	11.9	10.8

Table 2 Comparison of Work-related Symptom Prevalence Between Taft Elementary Employees And Workers in Buildings With and Without IEQ Complaints				
	56 Noncomplaint Buildings[a]		**80 Complaint Buildings[b]**	**Taft**
	Female	Male		
Dry, itchy, or irritated eyes	22	14	30.0	10.8
Runny or Stuffy Nose or Sinus Congestion	***15***	***8***	***21.0***	***21.6***
Headache	20	8	25	8.1
Dry or Sore throat	7	4	16.0	8.1
Cough	6	3	9	
Sneezing	14	6	18.0	2.7
Fatigue	18	9	25	0
Dizziness	4	1		0
Skin rash, dry skin	6	2	9	0

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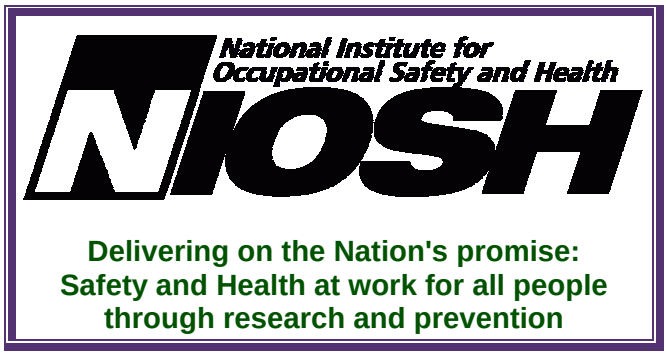

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