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Jordan Hospital
Plymouth, Massachusetts

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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 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 employer 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.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by David C. Sylvain, M.S., CIH, and Robert Malkin, Dr. P.H., of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing by Pat Lovell.

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Health Hazard Evaluation Report 95–0362–2587
Jordan Hospital
Plymouth, Massachusetts
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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at Jordan Hospital in Plymouth, Massachusetts, in response to a request from employees in the Bailey Building, who reported experiencing headache, skin rash, breathing difficulty, hypertension, and fatigue. In addition, employees stated that they were concerned about potential exposure to electromagnetic fields produced by a cogeneration facility which is located in the basement of the building.

On February 7 – 8, 1996, a NIOSH industrial hygienist conducted an initial site visit consisting of an opening conference, employee interviews, and a walk–through inspection of all occupied areas and mechanical rooms. Medical and environmental consultants' reports were obtained from the hospital, and were reviewed following this site visit. On March 20 – 22, 1996, a second site visit was conducted, which included a second walk-through inspection, and employee interviews conducted by a NIOSH medical officer.

The most prevalent symptoms reported by the 70 interviewed employees were headache, eye irritation, fatigue, and skin irritation. Employees reported various environmental concerns, in some cases specific to their area of the building, that they felt aggravated their symptoms. These included contact with medical records, handling carbonless copy paper, construction dust and odors, improper room temperature and humidity; and various other odors, such as vehicle exhaust, "chemicals," and perfume.

The Bailey Building was clean, and appeared to be well–maintained. Physical inspection of the building revealed no indication of microbiological growth, or any specific environmental factor or condition responsible for the range of symptoms that continue to be reported in various work areas. Similarly, review of medical and environmental consultants' reports covering the period between April 1994 and January 1996 were not revealing. These reports included the results of environmental monitoring for formaldehyde, total volatile organic compounds, total suspended particulate, glutaraldehyde, carbon monoxide, carbon dioxide, air temperature and relative humidity, allergens, and fibers. However, "nonspecific" factors, such as inadequate isolation of construction projects, and the location of building air intakes below grade near a parking lot, can contribute to IEQ problems.

Consultants' reports, environmental sampling data, and observations made during the HHE did not provide an explanation for the entire range of symptoms reported by employees. No one environmental factor is likely to be the source of all problems reported in the Bailey Building; however, environmental factors were found which may have been related to some symptoms in some people. These included humidification of the building using treated boiler steam, the location of building air intakes, and dust and odors from materials used in construction.

Keywords: SIC 8062 (general medical and surgical hospitals), cyclohexylamine, extremely–low–frequency electromagnetic fields, indoor environmental quality, treated boiler steam.

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INTRODUCTION

On August 18, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from employees at Jordan Hospital in Plymouth, Massachusetts. The request stated that employees in the Bailey Building were experiencing headache, skin rash, breathing difficulty, hypertension, and fatigue. The requestors also expressed concern about exposure to electromagnetic fields produced by a cogeneration facility located in the basement of the building.

On February 7 – 8, 1996, a NIOSH industrial hygienist conducted an initial site visit which included an opening conference, employee interviews, and a walk–through inspection of all occupied areas and mechanical rooms in the Bailey Building. Medical and environmental consultants' reports were obtained from the hospital and reviewed following the site visit. On March 20 – 22, 1996, a second site visit was conducted by the industrial hygienist and a NIOSH epidemiologist. During this visit, a conference was held with representatives from hospital management, support staff, nursing staff, Engineering Department, and the environmental consulting firm retained by Jordan Hospital. A second walk–through evaluation was conducted. The NIOSH epidemiologist conducted a medical evaluation that included employee interviews and discussions with physicians who treated the employees.

BACKGROUND

Jordan Hospital is a 130 bed facility housed in several, interconnected buildings of various ages. The most recent addition to the hospital is the two–level, 60,000 ft^2 Bailey Building. Although the building was largely completed at the time of occupancy in March 1994, various construction projects have been ongoing in and around occupied areas since the time of occupancy. There were approximately 400 employees working in the Bailey building at the time of the NIOSH evaluation.

The lower level of the Bailey Building is occupied by several departments which had been located elsewhere in the hospital complex. The lower level presently houses the Medical Records Department, Quality Assurance, Management Information Systems (MIS), and Patient Accounts. The first floor is occupied by the Emergency Department, Oncology Center, Rehabilitation (speech, occupational, and physical therapy), the cafeteria, and various other work areas.

The heating, ventilating, and air conditioning (HVAC) system is a variable air volume (VAV) system with two air handling units (AHUs) located in a basement mechanical room. The air intakes for the AHUs are located below grade level in a courtyard near a parking lot and the Emergency Department entrance where ambulances drop–off patients. Each AHU is equipped with prefilters and 90% efficient air filters. AHU–2 serves the lower level (basement), and AHU–1 serves the first floor. As of September 1995, AHU–2 has been operated in a constant volume mode. An AHU that serves the East Wing (an older building) also serves a short hallway, and two offices in the Oncology Center. The portion of the Bailey Building that is occupied by the Oncology Center is contiguous with an older area, which is also occupied by the Oncology Center.

The cogeneration (cogen) plant is located in the basement of the Bailey Building, and is powered by two Waukesha natural gas engines. The engines are equipped with catalytic converters for control of nitrogen oxides and carbon monoxide, and are exhausted through welded steel stacks that extend 65 feet above ground level. The stacks pass from the basement in a chase which extends through the first floor area occupied by the Emergency Department. The stacks were rebuilt and insulated following a fire that ignited near the roof, adjacent to the stacks, in October 1995. The cogen plant was out of operation from October 1995, until January 1996.

Each cogen engine powers an electric generator rated at 480 volts, 570 kilowatts, 60 hertz. The engines also produce low pressure steam that is used for heating and humidification. The steam is treated with additives to prevent corrosion in the system. Humidification is provided by injecting steam into supply air downstream of the AHUs.

The cogen room has a dedicated ventilation system that is entirely separate from the systems that serve occupied areas. The intake and exhaust for cogen room ventilation are located below ground level in a concrete well, near a separate well containing the intakes for the AHUs.

In April 1994, the Medical Records Department moved out of the Bailey Building due to symptoms reported by employees. Symptoms included mucosal and upper respiratory irritation, headache, and dizziness. The frequency of reported symptoms decreased when the department was relocated to its previous location in 3–North. In April, Jordan Hospital retained the services of an environmental consulting firm to evaluate the indoor environment. Starting in April 1994, the consulting firm conducted an ongoing evaluation which included air monitoring, evaluation of the heating, ventilating, and air conditioning (HVAC) system; tracer gas studies; assessment of allergens; wipe sampling for fibers; and sampling for surface and airborne latex.

In May 1994, Medical Records returned to the lower level of the Bailey Building. Construction was ongoing at this time, and HEPA vacuuming and wiping of surfaces was instituted to control construction dust. During the spring and early summer of 1994, workers reported rashes and itching. Fiberglass was identified on surfaces, and in skin scrapings. Workers were again removed, and the lower level was cleaned.

The Medical Records Department returned to the Bailey Building later that year, and reports of symptoms seemed to decrease for a while. In August 1994, medical staff in the Emergency Department and Oncology reported upper respiratory and eye irritation. Entries in the Occupational Safety and Health Administration (OSHA) Log of Occupational Injuries and Illnesses (OSHA Form 200) reveal an apparent increase in rashes and eye irritation among Medical Records staff. At the same time, environmental consultation reports indicate that efforts to clean glass fibers from surfaces had reduced levels to those found in other buildings of similar design and use.

In October 1994, a consulting physician reported that some individuals were experiencing "significant symptoms," which consisted of shortness of breath, cough, and possible numbness of the lips. He observed that "a number" of individuals who work in the emergency room were experiencing similar symptoms. Employees continued to report irritative symptoms at varying frequencies throughout 1995.

The environmental consultant made recommendations for correcting various deficiencies, and conducted a comprehensive evaluation of the HVAC system. Although recommendations and remediation were expected to reduce the likelihood of IEQ problems (e.g., capping of drains, latex reduction, modified cleaning procedures) nothing was identified that could account for the varied symptoms that continued to be reported by building occupants. The consultant also provided review and oversight of the environmental aspects of ongoing construction projects. The hospital distributed questionnaires to collect ongoing symptoms information, and evaluated affected employees in its Occupational Health Department. In addition, some employees were seen by private physicians.

METHODS

Environmental Evaluation

During the environmental evaluation, descriptive information was collected for the building, occupied work areas, the HVAC system, and the cogeneration facility. Information was obtained from the Occupational Health Department, engineering staff, interviews with 29 employees, and a comprehensive review of consultants' reports (medical and environmental). Inspections of the entire building, HVAC systems, and cogeneration facility were conducted. The purpose of the environmental evaluation was to determine the condition of the building, and its current indoor environmental status.

Extremely–Low–Frequency Magnetic Fields

Because of the potential for exposure to electromagnetic fields (EMF) at the cogeneration facility, measurements were made of extremely–low–frequency (ELF) EMF (60 Hz); the frequency of the generated current. The evaluation to determine ELF electric and magnetic fields was designed to survey potential worker exposures to these fields during work tasks, although ELF EMF exposure is not known to be related to symptoms associated with the indoor environment. The limited number of measurements were intended to identify areas of high exposure (walk–around mode) where workers might be present during the course of the workday.

Selected magnetic field measurements were made with the EMDEX II exposure monitoring system, developed by Enertech Consultants, under project sponsorship of the Electric Power Research Institute, Incorporated. The EMDEX II is a programmable data–acquisition meter which measures the orthogonal vector components of the magnetic field through its internal sensors. Measurements can be made in the instantaneous read or storage mode. The system was designed to measure, record, and analyze power frequency magnetic fields in units of milliGauss (mG) in the frequency region from 40 to 800 Hz.

Medical

The medical evaluation included interviews with the hospital employee health physician, the occupational medicine physician who was hired by the hospital to review cases, and employees. All employees present at work on the day of the evaluation in the Medical Records, Quality Assurance, and Patient Accounts Departments were released from their job duties and were interviewed. Interviews were usually conducted in groups of five, and employees were given the option of meeting individually with the NIOSH medical investigator if they desired.

Emergency Department (ED) employees who wished to speak with the NIOSH investigator were allowed to leave the worksite one at a time for the interview. A group of five employees from the ED were interviewed during their lunch hour. In addition, the requester furnished a list of individuals from the ED for interview, and every attempt was made to interview these employees. Because of the need to provide on–going care in the ED, it was not possible to interview all ED employees. Only workers from the day or evening shift were evaluated in the ED.

Since the hospital had been evaluated previously by both environmental and medical consultants, NIOSH investigators decided to concentrate the evaluation on employees' symptoms that were present at the time of the evaluation or up to four months before the evaluation. Evaluation of present symptoms is less likely to be subject to memory lapses and recall bias. During the interviews, employees were asked if they have had any symptoms they felt were related to working at the hospital.

EVALUATION CRITERIA

Indoor Environmental Quality

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.[1,2,3] NIOSH investigators have completed over 1200 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

The symptoms reported by building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory irritations. Typically, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building–related occupant complaints.[4,5] Among these factors are imprecisely defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[?,?,?,4] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial.[6] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[7] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor or indoor sources.[8]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[9] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[10,11]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building–related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by Legionella bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel–burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems that NIOSH investigators have found in the non–industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job–related psychosocial stressors. In most cases, however, no cause of the reported health effects could be determined.

Standards specifically for the non–industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[12,13,14] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The ASHRAE has published recommended building ventilation design criteria and thermal comfort guidelines.[15,16] 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.[17]

Measurement of indoor environmental contaminants has rarely proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building–related illness. However, measuring ventilation and comfort indicators such as carbon dioxide (CO_2), temperature, and relative humidity

(RH) is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces, and 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[16] Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 parts per million [ppm]). Carbon dioxide concentration is used as an indicator of the adequacy of outside air supplied to occupied areas. When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. It is important to note that CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level.

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an indoor environmental quality 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.[18] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1992 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable.[15] Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68–74°F in the winter, and from 73–79°F in the summer. The difference between the two ranges is largely due to seasonal clothing selection. ASHRAE also recommends that RH be maintained between 30 and 60% RH.[15] Excessive humidities can support the growth of microorganisms, some of which may be pathogenic or allergenic.

Extremely–Low–Frequency Magnetic Fields

The ACGIH has published TLVs for sub-radio frequency electric and magnetic fields (30 kiloHertz [kHz] and below).[14] The TLV for magnetic fields (B_{TLV}) states that routine "occupational exposures in the extremely–low–frequency (ELF) range from 1 Hz to 300 Hz should not exceed the ceiling value given by the equation:"

B_{TLV} in milliTeslas (mT) = 60/f

where f is the frequency in Hertz."

This means, for example, that at 60 Hz, the magnetic flux density TLV is 1 mT (or 10,000 mG). This TLV has been established to limit the maximum induced current density within the human body to 10 milliamperes per square meter (mA/m^2) as a root–mean–square (rms) value.[19] The majority of biological effects that have been observed occurred where induced current densities exceeded this value.[19]

RESULTS

Environmental

The Bailey Building was clean, and appeared to be well–maintained. No evidence of microbiological growth was observed. Most workstations throughout the lower level were equipped with a computer, and photocopiers and laser printers were located throughout office areas. In the Coding room, there were two computers at each workstation. There are no windows in the lower level.

In the Medical Records Department, records are stored in a condensed filing system consisting of 30 rows of storage shelving located in a large, open room. Each row is approximately 20 feet long, with seven storage shelves. Several small offices are located around the perimeter of the room, and six partitioned workstations are located in the storage room, near the shelves. The Medical Records Department is served by AHU–2, which serves the entire lower level.

The Emergency Department (ED) is located in an open, well–lighted, first–floor area. The nurses' station is centrally located between two patient treatment bays. The ED is served by AHU–1, which serves virtually all of the first floor. On March 20, a portion of the ED was sealed–off with plastic where linoleum was being replaced. A portable ventilation unit was installed in the work area to exhaust dust and odors outside the building. Tile was not being removed at this time; however, grout was being applied to tile near the ambulance entrance which caused ED staff to report an odor of "burning linoleum."

The Oncology Center includes examination rooms, staff offices, medication preparation room, nurses' station, and medical dictation booths. Overall, the Oncology Center was well–lighted; however, lighting in the medical dictation booths did not appear to be adequate. Each booth is approximately three feet wide, and is enclosed by floor–to–ceiling walls on three sides. Lighting is provided by a single fluorescent fixture located beneath a shelf above a desk. Lighting in the booth located behind the nurses' station seemed to be especially dim. In addition, there was no perceptible air flow at the diffuser serving this booth.

Oncology staff reported that the odor of vehicle exhaust occasionally enters their work area. Examination rooms were identified as another source of odors. Examination rooms are served by AHU–2, and are not equipped with dedicated exhaust ventilation.

At the time of the walk–through inspection in March, the temperature in the Coding Room appeared to be higher than other areas in the building. Workers reported that there was very little air movement in the room. Six employees worked in the room, each of whom had two computers and monitors on a desk. According to the building engineer, the ventilation to the room had not been adjusted to accommodate the extra heat from additional electronic equipment.

The HVAC system is controlled by a direct digital control (DDC) system. Computer printouts of AHU operating conditions were obtained for February 7 and March 13. The February 7 printout indicates that AHU-1 was supplying 59% outside air at discharge temperature of 52.6°F, and 81.9% RH; AHU–2 was supplying 49% outside air at 50.9°F, and 55% RH. On March 13, AHU–1 supplied 74% outside air at 57°F, and 82.7% RH; and AHU–2 supplied 39% outside air at 59.4°F, and 54% RH. Return air temperatures and RH for both AHUs on both dates were 70.1 – 70.7°F, and 37.6 – 43% RH. The HVAC system was reported to supply a minimum of 20% outside air. Each AHU is equipped with a manometer to measure pressure–drop across the filter bank. Because inspection of AHU filters would have required the AHUs to be shut–down, the filters were not examined.

The building is humidified by injecting steam from the cogen plant into supply air, downstream of the AHUs. Although the steam is presently treated with various additives to reduce scale and control pH in the system, the use of cyclohexylamine was temporarily discontinued in September 1995. Treated steam is used throughout the hospital for heating, sterilization, food service, and humidification. Engineering staff reported that treated steam (containing an amine anticorrosion additive) has been used since 1988 in operating rooms, ICU, CCU, obstetrics, and transitional care. The manufacturer's material safety data sheets (MSDSs) indicated that, at the time of the evaluation, boiler additives contained sodium polyacrylate copolymer, sodium hydroxide, sulfites, and hydroxyethylidene diphosphonic acid.

Manometers have recently been installed outside the cogen room to ensure that the ventilation system in the room maintains negative pressure with respect to the rest of the building. Prior to installation of the manometers and a fan tracking system, the environmental consultant to the hospital reported that the room could become positively pressurized.

Ventilation from the cogen room (not the cogen engines) is exhausted into a concrete well approximately 20 feet from a separate well containing the intakes for AHUs 1 and 2. The below–grade wells were clean, and are provided with drains which were reported to have traps. There was no evidence of standing water in the wells. Smoke tubes were used to visualize the airflow at the top of the cogen room exhaust well; however, turbulence interfered with visualization. Although a trace of smoke may have been reentrained into the cogen room air intake, the separate ventilation system and negative pressure within the cogen room should prevent any transfer of air from the cogen room to other areas of the building.

On February 7, water was dripping from the ceiling in a corridor near an entrance to the cogen room. Engineering personnel attributed the water to condensation on the outer surface of the intake ductwork that supplied cold, outside air to the cogen room. On March 20, engineering staff reported that modifications had been made to moderate the air temperature in this duct by mixing return air with outside air. No moisture was observed in this area during the March visit.

The air intake for air handler RTU–1 is located on the roof, approximately 9 feet from a soil stack (plumbing vent). RTU–1 is a Trane air conditioning unit with an economizer mode which serves the linear accelerator room in the Oncology Center. It appeared that odors from the soil stack could enter Oncology via the air handler.

Extremely–Low–Frequency Magnetic Fields

The intensity of ELF electromagnetic fields (predominantly power line frequencies) was surveyed using a "walk–around" mode. Field intensity levels in occupied areas of the hospital were usually between 0.3 and 19 mG, with19 mG being measured on the floor near the X–ray rooms in the Emergency Department. A level of approximately 2 mG was measured at the head of employees working on computers in the Medical Records, and Quality Assurance Departments, and the nurses' station in the emergency room. The levels in the middle of the surveyed rooms, which were not associated with any electric equipment, ranged from 0.3–1.6 mG. Higher field strengths were found at the generators (600 mG), generator output wiring (800 mG), and transformers associated with the generators (1200 mG). The generators, output wiring, and transformers are located in the cogeneration room, and are separate from the rest of the hospital. Personnel, other than the plant operator, are not likely to be in the cogen room; and the plant operator is unlikely to be in this area for an extended period. Individual employee exposure to EMF was not evaluated.

Medical

A total of 71 employees were interviewed either during the site visit or by phone from Cincinnati. Employees interviewed included:

17 employees from the ED including 14 of the 19 ED employees who were identified by requestor,

15 of the 17 employees present on the day of the evaluation from Patient Accounts,

20 of the 25 employees present on the day of the evaluation from Medical Records (including transcriptionists),

6 of the 6 employees present on the day of the evaluation from Quality Assurance.

Additional employees included: eight from the cancer center, two from management information services (MIS), one from infection control, and one switchboard operator. One symptomatic individual from another part of the hospital who was not working in the Bailey Building, was also interviewed, but not included in the following analyses.

Forty of the 53 employees who were not selected by the union for interview or did not request an interview reported at least one symptom that they felt was related to working in the building (75%). The most prevalent employee symptoms (for all interviewed employees) included:

Headaches – 41%
Eye irritations – 31%
Fatigue – 28%
Skin irritations or rashes – 27%
Memory loss or concentration problems – 20%
Nose or throat irritations – 19%
Variations in blood pressure (either higher or lower) – 19%
Numbness in the lip – 10%

Other symptoms (and prevalence rates) included chest tightness (10%), nose bleeds (9%), pain or pressure in the head (6%), worsening of pre–existing asthma (6%), and the inability to tolerate exposure to some chemicals (6%).

Workers reported various environmental problems during the interviews. Six workers (9%) reported that it was frequently too damp in the basement, particularly in the morning. They stated that, at times, the basement of the Bailey building was like a "swamp" or a "fishtank" in the morning. Five employees (7%) reported that there were wide temperature differences in the building and that it was too hot in the morning and cold in the afternoon. Employees in the Medical Records Department reported that contact with certain medical records was sufficient to generate symptoms of skin or mucosal irritation. Employees reported that symptoms were exacerbated by ongoing construction in the building.

DISCUSSION

Reports of building–related health complaints have become increasingly common in recent years; unfortunately the causes of these symptoms have not been clearly identified. As discussed in the Evaluation Criteria section of this report, many factors have been suspected (e.g., volatile organic compounds, formaldehyde, microbial proliferation within buildings, inadequate amounts of outside air, etc.). While it has been difficult to identify concentrations of specific contaminants that are associated with the occurrence of symptoms, it is felt by many researchers in the field that the occurrence of symptoms among building occupants can be lessened by providing a properly maintained interior environment. Adequate control of the temperature is a particularly important aspect of employee comfort.

It is not possible to exactly relate symptom prevalences in this building to those found in similar NIOSH studies, in that a standardized questionnaire was not used in this building. Nevertheless, prevalence rates for some symptoms that occurred more than once a week are presented as a rough comparison (see table on the following page). The question asked during the Jordan Hospital interviews was whether the employee had a symptom that he or she felt was related to working in the hospital. As can be seen from this table, prevalence rates for most symptoms were similar for both this study and the larger NIOSH study. Limitations of both this study and the larger NIOSH study were that the questionnaire was only given to employees present at work on the day of the evaluation, that the areas to be evaluated were self–selected by the requestor (the entire building was not evaluated).

Questions concerning blood pressure fluctuation, which were reported among employees in the Bailey building, were not asked in the questionnaire used in other NIOSH studies. The cause of the reported blood pressure fluctuations (which we did not attempt to document), and whether they are related to an exposure in the building, is not known; we identified no plausible environmental causes. The skin rashes and irritations reported when touching certain medical records were not seen by NIOSH investigators. Medical reports and employee interviews, however, indicate that the onset of symptoms is associated with the direct handling of some records for employees in both the Medical Records and Emergency Departments.

NIOSH investigators found that carbonless copy paper (CCP) is used by some staff in the Bailey Building and was also found in stored medical records. The extent to which carbonless copy paper (CCP) is used in the various departments varied; the clerks who registered patients in the emergency room appeared to use CCP frequently. Studies have reported that extensive use of CCP is related to certain health symptoms in the indoor environment, including an elevated prevalence of red or swollen eyelids, red or itching conjunctiva, swollen or red hands as well as upper respiratory symptoms of sneezing, stuffed nose, and coughing.[20] Components of carbonless paper, in particular hexamethylenediisocyanate, and mono isopropyl butylated biphenyl, and PTMSMH (paratoluene sulfonate of Michler's hydrol) have been shown to be antigenic for some people. The skin reaction in a reported case was characterized by intermittent eruption of the face and neck in a clerk in a college registrar's office.[21]

Symptom	Bailey Building 65 interviewed employees	NIOSH study of 80 office buildings 2453 questionnaires*
headache	41%	35%
eye irritation	31%	42%
fatigue	28%	42%
skin irritation	27%	26%
concentration problems	20%	17%
nose or throat irritation	29%	***
stuffed nose, or sinus congestion	***	39%
chest tightness	10%	9%

* symptoms that occurred more than once a week in the last 4 weeks
*** question not asked in a similar manner

Steam humidification is the preferred way to humidify commercial spaces, as this method does not generally create an environment favorable for microbiological growth and amplification (i.e., standing water). In addition, the high temperature of the steam kills nearly all microorganisms that may be present in water used for humidification.[22] While the Bailey Building and other areas of the hospital were humidified using a steam system, the steam was generated using water to which cyclohexylamine had been added to prevent corrosion. Cyclohexylamine was used until September 1995, when its use was temporarily discontinued. According to the manufacturer's MSDSs, steamline treatment chemicals, when present in concentrated form, can elicit a variety of symptoms which include irritation of the eyes, skin, and mucous membranes. Levels of cyclohexylamine present in air are not easily measured; and, in fact, could not be measured by NIOSH investigators since cyclohexylamine was not being used at the time of the evaluation. Based on information on the use of cyclohexylamine in boiler water at Jordan Hospital, it appears likely that only low concentrations of cyclohexylamine had been present in workplace air. Nevertheless, amine boiler additives are potent irritants, and we believe that it is not advisable to add these compounds to steam that is used to humidify a workplace, regardless of whether people are reporting symptoms.

The location of AHU air intakes, below grade near a parking lot and ambulance entrance, is likely to exacerbate IEQ problems by entraining vehicle exhaust and odors into hospital air. Even though drivers are instructed to shut off vehicle engines near the ED entrance, Bailey Building occupants reported that vehicle exhaust occasionally enters the building. Although episodic low–level exposure from entrainment of these contaminants is unlikely to cause acute or chronic health effects, odors can precipitate symptoms in some people in the indoor environment.

Ongoing construction contributes to employee discomfort in many areas of the Bailey Building. Employees in the Emergency and Medical Records Departments attributed some of their symptoms to construction dust and odors. Sources of odors include paint, flooring adhesives, and grout. Dust from drywall construction was reported as a source of discomfort by many building occupants. New construction with drywall has been shown to be associated with increased asthma reporting in a NIOSH study of 80 office buildings.[23]

CONCLUSIONS

Neither the consultants' reports nor our observations provided an environmental explanation for the widespread problems reported in the Bailey Building. No single environmental factor is likely to be the source of all complaints reported in the Bailey Building; however, some environmental factors were found which may have been related to some symptoms in some people. These included humidification of the building using treated boiler steam, the location of building air intakes, and dust and odors from materials used in construction.

RECOMMENDATIONS

1. Develop and implement an IEQ management plan. An IEQ manager or administrator with clearly defined responsibilities, authority, and resources should be selected. This individual should have a good understanding of the building's structure and function, and should be able to effectively communicate with the building occupants. The elements of a good plan include the following:

   a. Proper operation and preventive maintenance of HVAC equipment.

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

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

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

   e. Pro–active identification and management of projects that may affect IEQ (e.g., redecoration, renovation, and relocation of personnel).

The NIOSH/EPA Building Air Quality–A Guide for Building Owners and Facility Managers guidance manual should be consulted for details on developing and implementing IEQ management plans.[24]

2. Employees should by notified of any planned construction activity, and the possible impact of these activities on hospital personnel (e.g., transient odors). Construction contractors should be instructed in methods to reduce the impact on hospital staff, and the importance of implementing these methods effectively. The environmental consultant should continue to oversee environmental aspects of construction in the hospital.

3. Install a direct steam humidification system which uses untreated water. A separate direct steam humidification system would provide needed humidification without the risk of introducing amine additives into the workplace. Use of anticorrosion

additives in the cogeneration system could then be resumed.

4. The hospital should chart the temperature and relative humidity in areas such as Patient Accounts, Medical Records, and the Coding Room. This data should be compared with ASHRAE guidelines, and any needed adjustments or modifications should be made.

5. The hospital should investigate the possibility of modifying the AHU air intakes to minimize the entry of vehicle exhaust. In the interim, vehicles should not be permitted to idle near the air intakes.

6. The soil stack, near rooftop unit RTU–1, should be extended to prevent odors from entering Oncology via the air intake for this unit.

7. A flow hood should be used to determine if ventilation in Oncology Center offices and physicians' dictation booths meets ASHRAE guidelines. Lighting could be improved in the dictation booths, especially in the booth behind the nurses' station.

8. Dedicated exhaust ventilation should be installed in Oncology examination rooms where odors are a problem.

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