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SUMMARY

In September 1994, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the management at the Group Health Associates (GHA) Kenwood facility in Cincinnati, Ohio. The request concerned the potential relationship between previous water damage to the building and reports of respiratory illness among employees. During site visits performed in October, November, and December 1994, NIOSH investigators performed a walk-through of the site; took representative bulk samples from the offices, ceiling space, and the building's air handling units (AHUs); reviewed medical records; and distributed a questionnaire.

Although there was evidence of past water incursion in certain parts of the southwest (SW) corner of the building, there was no visual evidence of unusual microbiological contamination in or above any of the office spaces evaluated. Inspection of the AHUs revealed visible microbial contamination downstream of the coils, both on the sound liner and in the condensate pans.

Medical record review revealed that from April through October 1994 five employees had pneumonia (in general characterized by fever, cough, and infiltrate on chest x-ray). Four of these persons worked in close proximity to each other on the pediatrics unit on the second floor of the SW corner of the building. The etiologies of these illnesses were not determined, and all five recovered completely from their illnesses. None of the employees reported any symptoms of cough, shortness of breath, fever, chills, myalgia or malaise which were temporally related to presence in the building at any time during their illnesses or after recovery. Self-administered questionnaires were completed by 95 (90%) of 106 employees in the Kenwood facility and by 17 (71%) of 24 employees of two other GHA pediatric units at different sites; no employees reported having pneumonia since January 1994 other than these five previously identified.

Analysis of bulk samples collected in and above the office spaces and in the AHUs revealed the growth of various bacteria and fungi. However, no sources of exposure to potentially causative agents were identified which were unique to the second floor pediatrics unit.

Five persons who work at the Group Health Associates Kenwood facility, including four persons from the pediatrics unit located in an area where significant water incursions had occurred previously, were diagnosed with pneumonia between April and October of 1994. Although environmental samples revealed microbiological colonization in the space above the ceiling and in the air handling units, these findings explain neither the type nor the clustering of the illnesses. Recommendations are provided concerning the proper cleaning and maintenance of the ventilation system.

KEYWORDS: SIC 8011 (Offices and Clinics of Doctors of Medicine), Bacteria, Fungi, Hypersensitivity Pneumonitis, Indoor Environmental Quality, Water Damage

INTRODUCTION

In September 1994, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Group Health Associates (GHA) Kenwood facility (8245 building) in Cincinnati, Ohio, concerning the potential relationship between previous water damage to the building and reports of respiratory illness among employees. The HHE request specifically asked NIOSH to evaluate the occurrence of pneumonia among staff who work in the building's southwest (SW) corner, which was the area most affected by the water damage. In response to the HHE request, NIOSH personnel conducted several site visits to the GHA site in October, November, and December 1994.

BACKGROUND

The GHA facility at Kenwood is comprised of the 8245 building and one floor of a neighboring building (8260 building), with a total of approximately 100 employees working at both buildings. The 8245 building is three-story structure, built in 1983, in which several water incursions have occurred since 1986. The most recent occurred in January 1994 when a pipe burst on the third floor, resulting in water damage on all three floors, with the most extensive damage to the floors, walls, and ceilings of the first and second floors in the SW corner of the building. As part of a planned remodeling program, selected areas of carpet, wall material, and ceiling tiles were replaced subsequent to the water damage, with the remainder of the materials being left in place.

In the months following the burst pipe of 1994, the management of GHA was made aware of eight employees who required medical attention for respiratory and sinus infections. Because seven of the ill persons worked in the pediatrics unit, which is located in the SW corner of the second floor, concern was raised over the potential for a building-related contaminant as a cause of the illnesses.

METHODS

On October 18, NIOSH personnel conducted a walk-through evaluation of the portions of the 8245 building affected by past water incursions (the SW corner of the building). During this walk-through, representative bulk samples of office and building materials were obtained for microbiological analysis. On October 25, the NIOSH industrial hygienist, accompanied by the maintenance contractor for the building, inspected and obtained bulk samples from the building's air handling units (AHUs). All samples were submitted to a contract laboratory to be cultured, counted, and identified for fungi, bacteria, and thermoactinomycetes (TA). Selected samples were analyzed for *Legionella* as well. Additional samples were obtained from the AHUs on December 12, 1994. Like the first set of samples, these were analyzed for fungi, bacteria, and TA.

During site visits in October and November, 1994, the NIOSH medical officer reviewed the medical records of eight employees who had notified GHA management of their illnesses. Follow-up telephone interviews were conducted in November with five of the eight employees. In addition, a self-administered symptom questionnaire, including questions concerning illnesses in the past year and various symptoms (chest pain, wheezing, shortness of breath, fever, dry cough, generalized discomfort, upper respiratory symptoms, sinus congestion, and muscle aches), was distributed to all GHA employees in the 8245 and 8260 buildings. This questionnaire was also distributed to GHA employees working in pediatric units at two other GHA facilities (Clifton and Western Hills) at which there had been no known reports of potential building-related illness or symptoms.

EVALUATION CRITERIA

Building Related Illness

Illnesses caused by identifiable agents present in non-industrial indoor environments have been termed building-related illnesses. In general, these illnesses may be grouped into infectious diseases, diseases of hypersensitivity, or symptoms attributable to specific exposures. Examples of building-related illnesses include allergic rhinitis, allergic asthma, hypersensitivity pneumonitis (HP), Legionnaires' disease, Pontiac fever, and carbon monoxide poisoning.[1] Persons with non-infectious building-related illness generally exhibit signs or symptoms of disease in some temporal relationship with exposure to the offending agent. When considering diseases of hypersensitivity, continued exposure to the etiologic agent results in persistent illness.

HP is a pulmonary and systemic illness resulting from an immunologic reaction to a variety of inhaled substances. It is characterized in the acute form by recurrent pneumonias with symptoms of fever, cough, shortness of breath and fatigue occurring six to eight hours after exposure. A large number of microbiologic agents have been implicated in the etiology of HP,[2] including species of the fungus *Penicillium,* which is commonly found in building ventilation systems.[3,4] Although many types of medical tests may be used to aid in the diagnosis of HP, the diagnosis is generally made considering the following factors:[2] (1) history of exposure to a suspected causative agent; (2) consistent clinical history; (3) radiologic evidence of HP (the acute stages may exhibit small, poorly defined or patchy interstitial infiltrates); and 4) immunologic evidence of exposure to the suspected antigen.

RESULTS

Walk-Through - October 18, 1994

There was evidence of past water incursion in the office spaces and the space above the false ceilings on the first and second floors of the SW corner of the 8245 building; this evidence consisted primarily of a small number of water stains on ceiling tiles, furniture, and wall coverings. Some of the areas had been remodeled since the water incursions occurred. In the nurses' station on the second floor, there was a small amount of water dripping from the false ceiling (the source could not be identified). There was no visual evidence of microbiological colonization in or above any of the office spaces evaluated. A brief inspection of the heating, ventilating, and air-conditioning (HVAC) system during the initial walk-through revealed that the outside air and return air dampers were operable, that the filters were in place and fit well, and that both the supply and return fans were operating. All of the AHUs were equipped with pleated filters which the manufacturer stated are rated at 25-30% efficiency. Because microbial colonization was visible at the ends of the pipes carrying condensate from the AHUs on the first and second floor, the NIOSH investigators arranged to inspect the AHUs further with the assistance of the maintenance contractor.

Industrial Hygiene

Inspection of the AHUs on all three floors (which service whole floors and not individual units [such as the pediatric unit]) revealed evidence of microbial colonization downstream of the coils, both on the sound liner and in the condensate pans. There was standing water in all three condensate pans. The

locations of the bulk samples collected on October 18 and 25, 1994, are presented in Table 1 and the results of the analyses in Table 2. These results indicate that microbial colonization, consisting of a variety of organisms, was present in every sample, with the largest number of colony-forming units (CFUs) of *Penicillium* found in the AHUs on the third floor. Neither TA nor *Legionellae* were detected in these samples. The locations and results of the samples collected on December 12, 1994, are presented in Tables 3 and 4, respectively. When these samples were collected the condensate pans were dry, most likely because the
air-conditioning season was over. These samples confirm the continued presence of microorganisms in the AHUs on all three floors, with the largest concentration *Penicillium* again found in the third floor AHU. In addition, TA were found in a few of the samples collected on the December sampling date.

Medical Record Review and Interviews

Eight employees were identified by GHA as having reported illness. Review of their medical records revealed that from April through October 1994, five persons had illnesses characterized by fever, cough, and infiltrate on chest x-ray (CXR). The records indicated that four of the five had infiltrates described as "patchy" or "ill-defined." The same four persons had experienced repeat or prolonged episodes of respiratory symptoms over that time period. Four of the five persons worked in the pediatrics unit on the second floor; the other person worked on the first floor. Although all five were diagnosed with pneumonia by their clinicians, the specific organism(s) responsible for these infections were never identified. One of these five persons had two episodes of pneumonia and was significantly debilitated during the illnesses, although recovery was complete between the illnesses. This person had the most thorough diagnostic evaluation including multiple serologic tests for fungi [*Aspergillus, Histoplasma, Coccidioides*, and *Blastomyces]*, *Legionella*, and *Mycoplasma* and microbiologic studies, all of which were negative. This individual also underwent bronchoscopy (with biopsy and lavage) which was reported as unremarkable. All five of these persons were treated with various antibiotics at some time during their illness. None of the medical records noted any pattern of symptoms, illness, or recovery specifically related to presence in or absence from the 8245 building.

Telephone interviews (November 1994) with the five persons diagnosed with pneumonia revealed that three were currently asymptomatic. One person continued to have intermittent wheezing since the pneumonia, and one reported upper respiratory congestion that was felt to be worse in the 8245 building. None of the employees reported any symptoms of their pneumonia (wheezing, cough, shortness of breath, fever, chills, myalgia or malaise) temporally related to presence in the 8245 building.

Three of the eight employees whose medical records were reviewed were not diagnosed by their clinicians as having pneumonias. These three persons had illnesses diagnosed as sinusitis, bronchitis, and viral infection. Only one of these three had a CXR taken; that CXR was read as normal.

Questionnaire

Self-administered questionnaires were distributed to all employees at the 8245 and 8260 buildings (106 employees); 95 (90%) were completed and returned. In response to a question asking if they had been diagnosed with any illnesses since January 1994, five persons reported a diagnosis of pneumonia. These five were the same persons previously identified (discussed above). In response to questions asking about symptoms experienced since January 1994, the most common symptoms reported were sinus

congestion, upper respiratory symptoms, and cough. Twenty-two (23%) persons reported having none of the nine symptoms included in the questionnaire. Summary results are presented in Table 5.

The results from the Kenwood facility were tabulated in several ways (Table 5) in order to separately evaluate the symptoms and illnesses reported in the whole facility, the second floor (which shares a common HVAC system), and the second floor pediatrics unit (locations A-C, respectively). In addition, the results are also presented for those employees of the pediatrics unit excluding the four employees from that area who had pneumonia (location D). The percentages of employees reporting the various symptoms are similar for locations A, B, and D.

Two other GHA facilities received questionnaires. Six of 12 questionnaires distributed at the Clifton pediatrics unit were completed and returned. Eleven of 12 questionnaires distributed at the Western Hills pediatric unit were completed and returned. There were no reported cases of pneumonia among the pediatrics staff of Clifton or Western Hills. Symptom reporting rates at these sites were similar to those at Kenwood (Table 5).

DISCUSSION

In this investigation we focused our clinical review on the five persons who had pneumonia with abnormal CXRs. Although those five persons had CXR features that could be consistent with HP, the lack of any temporal relationship between their symptoms and potential exposures (exposure to the HVAC system or presence in the building) is not consistent with any building-related illness due to a hypersensitivity or allergic reaction. Pneumonia secondary to *Legionella pneumophila*, an infectious agent which may be the cause of building-related illness, was specifically evaluated and ruled out by the treating physician in the one person who had the most prolonged illness. We found no clinical history or exposure information which would suggest the involvement of other infectious agents which may have been related to the building.

Our evaluation of exposures to potential causative agents focused on the HVAC system and on areas that contained previously water-damaged materials. The results of our sampling illustrate the seasonal differences in the microbial contamination which might occur in a HVAC system. Because this type of sampling detects only viable microbes, non-viable materials, such as fungal spores, antigenic microbial fragments, and endotoxins, would not be detected.

We did not identify a unique source of exposure to a potential causative agent for building-related illness in the office spaces of the second floor pediatrics unit. Bulk samples of water-damaged materials from the space above the second floor ceilings did reveal microbial colonization. The air from the ceiling space travels through the AHU before being returned to the office space. The AHUs on all three floors were heavily colonized with various microorganisms, with the highest number of CFUs of *Penicillium* being found in the first and third floor units, making it unlikely that persons on the second floor had a unique exposure to these organisms.

Although there is no evidence that the contaminated AHUs have caused symptoms or illness among the employees we evaluated, the AHUs should be cleaned to avoid the potential for illness due to exposure to these microorganisms. In addition, water-damaged materials often support microbial growth long after

they appear dry, and spores, antigenic microbial fragments, endotoxins, and irritants can remain in such material for years.[5] Thus, building materials which have been repeatedly water damaged should be considered for removal, especially if they are in the ventilation air stream or otherwise likely to be disturbed.

The occurrence of four cases of pneumonia among the employees of the pediatrics unit (five cases total in the 8245 building) is unusual but does not appear to involve a building-related illness. If further investigation into the etiology of these illnesses were considered, it might begin with an epidemiologic evaluation of clinic and hospital records to determine what respiratory illnesses (among patients) these persons might have been exposed to in their work as health care providers. Further medical evaluation of the illnesses occurring months ago would be difficult to interpret at this point. Medical evaluation of persistent symptoms or recurrent illness among these employees should be dictated by the clinical presentation.

RECOMMENDATIONS

1. To prevent the contamination of indoor air by microbial aerosols, remediation of the heating, ventilating, and air-conditioning (HVAC) system should be performed by qualified individuals.[5]

    a. The fiberglass sound liners downstream of the cooling coils should be discarded and replaced, preferably with a smooth-surfaced insulation to minimize microbial colonization. Prior to the removal of the sound liner, all surfaces (nonporous and porous) should be dried and cleaned with a high-efficiency particulate air (HEPA)-filtered vacuum to remove dirt, debris, and microorganisms. The surface of the insulation should not be damaged by vacuuming.

    b. Once the sound liner has been removed, all components of the AHU, including the following, should be cleaned of debris: outside air (OA) intake, OA dampers, mixing plenum, coils, condensate drain pans, air supply plenum, and the supply air fan. A firm familiar with performing indoor air quality investigations should be consulted to determine if visible contamination is present in the supply air duct work, variable air volume (VAV) boxes, and other components of the HVAC system to determine whether these components should also be cleaned. Components should be cleaned of debris in a manner which avoids creating dust (i.e., HEPA-filtered vacuuming, wet methods).

    c. All remedial activities should be performed when the building is vacant and when the HVAC system is turned off. During remediation the spread of contaminants (e.g., bioaerosols, debris, and fiberglass fibers) via recirculation of air to occupied spaces needs to be controlled. This may be accomplished by: (1) isolating areas being renovated from the rest of the building (including negative pressurization to prevent exfiltration of contaminated air), (2) exhausting air contaminants from the area undergoing renovation directly to the outdoors, and (3) mechanically isolating (i.e., with sheet metal blanks and polyethylene film) ductwork to prevent the redistribution of contaminated air and contamination of ductwork.

    d. After all the debris is removed, the components of the AHUs should be sanitized using a dilute aqueous household bleach (sodium hypochlorite) solution (10%) while the HVAC system is not operating.[6] A water rinse should follow cleaning. Bacterial endospores, produced by

some thermoactinomycetes, may be slightly resistant to disinfectants; therefore, surfaces should be kept moist for a sufficient contact time to allow for disinfection to occur. Hypochlorites have a relatively low order of toxicity and skin irritation potential.

2. If feasible, the low-efficiency filters in the AHUs should be replaced with a filter that is 50 to 70% efficient (according to the ASHRAE dust spot efficiency test) in order to remove a greater proportion of microbial particulates from the airstream.

3. A formal written preventive maintenance schedule for the AHUs should be implemented in consultation with the manufacturers of the equipment. The HVAC cooling coils and condensate drip pans should be kept free of standing water and visible microbial growth. Throughout the year, coils, condensate pans, and drains should be inspected monthly and, if necessary, cleaned.

4. Prompt repair and prevention of water leaks is essential. In the event of a leak or flood, water should be removed quickly (probably within 24 hours) from porous, water-damaged furnishings and construction materials in order to prevent microbial growth.

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Table 1 - Sampling Locations. Group Health Associates, Kenwood, HETA 94-0414
Cincinnati, Ohio, October 18 and 25, 1994

Date	Sample Location	Sample Description	Sample Number
10/18	2nd Floor Mechanical Room	End of condensate line at floor drain	1
10/18	2nd Floor Doctor's Office	Wall covering	2
10/18	2nd Floor Doctor's Office	Fibrous glass insulation above drop ceiling	3
10/18	2nd Floor Doctor's Office	Paper backing of fibrous glass insulation	4
10/18	2nd Floor Doctor's Office	Tape from drywall above drop ceiling	5
10/18	2nd Floor Doctor's Office	Dust from light fixture	6
10/18	2nd Floor Nurses' Station	Damp ceiling tile	7
10/18	1st Floor Mechanical Room	End of condensate line at floor drain	8
10/18	1st Floor X-ray Records	Ceiling tile	9
10/25	1st Floor Mechanical Room	Water from condensate pan of air handler	10
10/25	1st Floor Mechanical Room	Sound liner from fan section of air handler	11
10/25	2nd Floor Mechanical Room	Water and sediment from condensate pan	12
10/25	2nd Floor Mechanical Room	Stirred-up water from condensate pan	13
10/25	2nd Floor Mechanical Room	End of condensate line at floor drain	14
10/25	3rd Floor Mechanical Room	Sound liner of access panel on air handler	15
10/25	3rd Floor Mechanical Room	Sound liner from fan section of air handler	16
10/25	3rd Floor Mechanical Room	Debris from condensate pan	17

Table 2 - Microbiological Analysis of Bulk Samples
HETA 94-0414: October 18 and 25, 1994

#	Total Fungi (CFU/gram)[1]	Identification	Total Bacteria (CFU/gram)	Identification
1	240 60	Penicillium species Penicillium species	160 10	Bacillus species Unidentified Yeast
2	80,000	Penicillium	1,000	Bacillus species
3	617,472 26,800	Penicillium Aspergillus species	5,000	Bacillus species
4	40,000	Penicillium	2,000	Bacillus species
5	30,800 39,200	Penicillium Aspergillus (niger)	3,000	Bacillus species
6	2,000	Penicillium	1,000	Bacillus species
7	1,000	Penicillium	1,000	Bacillus species
8	35,890 1,110	Penicillium Aspergillus species	60,200 60,200 19,600	Bacillus species Unidentified Yeast Pseudomonas species
9	7,040 960	Penicillium Aspergillus (niger)	2,000	Unidentified Yeast
10	98,440 8,560	Penicillium Aspergillus species	252,000 84,000 84,000	Bacillus species Micrococcus species Unidentified Yeast
11	4,980 1,020	Penicillium Aspergillus (niger)	1,980 1,020	Bacillus species Unidentified Yeast
12	2,400	Acremonium	470,000	Unidentified Yeast
13	40	Acremonium	57,000	Unidentified Yeast
14	180,900 54,000 35,100	Acremonium Penicillium Aspergillus species	62,000,000	Unidentified Yeast
15	88,810,000 18,190,000	Penicillium Cladosporium	10,000,000	Bacillus species
16	31,820,000 5,180,000	Penicillium Cladosporium	500,000	Bacillus species
17	21,000 4,000	Penicillium Aspergillus species	19,950,000 1,050,000	Unidentified Yeast Bacillus species

1 CFU - colony forming unit (limit of sensitivity is 1CFU).

Table 3 - Sampling Locations. Group Health Associates, Kenwood, HETA 94-0414
Cincinnati, Ohio, December 12, 1994

Date	Sample Location	Sample Description	Sample Number
12/12	3rd Floor Mechanical Room	Sound liner from fan section of air handler	1
12/12	3rd Floor Mechanical Room	Solids from condensate pan	2
12/12	3rd Floor Mechanical Room	Sound liner from fan section of air handler	3
12/12	3rd Floor Mechanical Room	Slime from floor drain	4
12/12	2nd Floor Mechanical Room	Solids from condensate pan	5
12/12	2nd Floor Mechanical Room	Sound liner from fan section of air handler	6
12/12	2nd Floor Mechanical Room	Sound liner from fan section of air handler	7
12/12	2nd Floor Mechanical Room	Slime from floor drain	8
12/12	1st Floor Mechanical Room	Solids from condensate pan	9
12/12	1st Floor Mechanical Room	Sound liner from fan section of air handler	10
12/12	1st Floor Mechanical Room	Sound liner from fan section of air handler	11
12/12	1st Floor Mechanical Room	Slime from floor drain	12

Table 4 - Microbiological Analysis of Bulk Samples,
HETA 94-0414: December 12, 1994

#	Total Fungi (CFU/gram)[1]	Identification	Total Bacteria (CFU/gram)	Identification	TA[2] (CFU/gram)
1	6,400,000	Penicillium	ND[3]	NA[4]	ND
2	12,500	Penicillium	125,000	Flavimonas-like species	ND
3	45,000,000 24,000 300 300	Penicillium Alternaria Aspergillus Cladosporium	ND	NA	1,500
4	1,300 100	Penicillium[5] Aspergillus (Niger)	3,500	Bacillus species	100
5	750	Penicillium	7,500 1,500	Flavimonas-like species Bacillus species	375
6	ND	NA	ND	NA	ND
7	5,300 750 500	Cladosporium Penicillium Alternaria	500 500	Bacillus species Bacillus species	ND
8	ND	NA	5,750,000	Pseudomonas-like Group 2	ND
9	9,100 200 700	Cladosporium Penicillium Yeast	150,000	Flavimonas-like species	ND
10	2,000 200	Penicillium Cladosporium	225 225	Bacillus species Bacillus species	ND
11	132,000 26,000 650	Cladosporium Penicillium Aspergillus	9,900 6,600 3,300 3,300	Bacillus species Bacillus species Bacillus species Bacillus species	1,650
12	6,550,000	Paecilomyces	6,550,000	Pseudomonas solanacearum	ND

1 CFU - colony forming unit (limit of sensitivity ranged from 60 to 350 CFU/gram);
2 TA - *Thermoactinomycetes* (all were of the genus *Thermoactinomycetes)*;
3 ND - not detected; 4 NA - not applicable; 5 - 50% reverse nonpigmented, 50% orange.

Table 5
Summary of Questionnaire Data
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Symptom/ Condition Reported	# (%) of Persons at Each Location* with Positive Responses					
	Location A	Location B	Location C	Location D	Location E	Location F
Chest Pain	19(20)	7(22)	6(60)	2(33)	3(27)	1(17)
Wheezing	13(14)	6(19)	2(20)	1(17)	2(18)	1(17)
Shortness of Breath	19(20)	9(28)	5(50)	1(17)	2(18)	1(17)
Fever	29(31)	11(34)	6(60)	2(33)	3(27)	3(50)
Cough	43(45)	17(53)	6(60)	2(33)	6(55)	2(33)
General Discomfort	27(28)	11(34)	6(60)	2(33)	2(18)	0(0)
Upper Respiratory Symptoms	54(57)	19(60)	6(60)	3(50)	8(73)	3(50)
Sinus Congestion	68(72)	25(78)	8(80)	5(83)	9(82)	4(67)
Muscle Aches	33(35)	18(56)	5(50)	1(17)	4(36)	3(50)
Diagnosis of Pneumonia	5(5)	4(13)	4(40)	0(0)	0(0)	0(0)
Total # Persons Responding to Questionnaire	95	32	10	6	11	6

* Location A: Whole Kenwood Facility (Response rate=95/106 [90%])
Location B: Kenwood Facility, 2nd Floor of 8245 Building
Location C: Kenwood Facility, Pediatrics Wing, 2nd Floor of 8245 Building
Location D: Kenwood Facility, Pediatrics Wing, 2nd Floor of 8245 Building excluding four persons with chest X-ray documented pneumonia
Location E: Western Hills Facility, Pediatrics Section (Response rate=11/12 [92%])
Location F: Clifton Facility, Pediatrics Section (Response rate = 6/12 [50%])