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Health Hazard Evaluation Report

HETA 88-001-1995
BROWARD COUNTY LIBRARY
FT. LAUDERDALE, FLORIDA

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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

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I. SUMMARY

In October, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request from the county Director of Libraries for technical assistance at the Broward County Library, Fort Lauderdale, Florida. The request concerned an evaluation of eye and upper respiratory tract irritation and allergies among library employees, and to determine whether the building indoor air quality was contributing to these complaints. An initial site visit was conducted on December 14-16, 1987, and an environmental and medical survey was conducted on February 3-5, 1988.

The library building is an eight-story structure built in 1983. Since the building was constructed, problems were reported with the heating, ventilation, and air conditioning (HVAC) system. Many areas throughout the building had recurring water leaks due to rain water collecting on the patio areas. Soon after the building was occupied, employees complained of eye and upper airway irritation, difficulty in breathing, and headaches. Some workers' symptoms were severe enough for them to require sick leave.

Air samples for viable aerosols (yeasts, molds, thermophilic and mesophilic actinomycetes) were collected throughout the building, outdoors, in a building adjacent to the library, and in a branch library in accordance with a comparison sampling strategy. Very low counts of mold were found on all of the samples. Yeasts were isolated from two samples collected on terraces outside the library. No thermophilic or mesophilic actinomycetes were found on any of the samples. The microbial air sample results did not indicate any specific sources of contamination, amplification of microorganisms in or from the air handling systems, or from the areas where water leaks were evident at the time of the NIOSH evaluation. Formaldehyde air sampling results ranged from trace levels [less than 0.01 parts per million (ppm)] to 0.07 ppm.

Measurements of temperature, relative humidity, and carbon dioxide (CO₂) were obtained to assess the indoor air quality of the building. Temperature and relative humidity in the building ranged from 67 to 75°F, and 60 to 73%, respectively. The high end of these parameters exceeds the acceptable comfort range guidelines recommended by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). The indoor CO₂ measurements ranged from 400 to 900 ppm, as compared to 300 to 400 ppm outside the building. CO₂ levels in some areas of the library were approaching the point which may indicate that inadequate quantities of fresh air were being distributed to an occupied space (1000 ppm, or 2 to 3 times the outdoor level).

From the medical questionnaire, the most commonly reported symptom (by 100 employees) was sneezing (14% on the day of the survey and an additional 43% on other days), with 58% reporting that they had a work-related sneeze. Eye irritation and cough were the next most common symptoms, with 97 (56%) and 93 (54%) employees, respectively, reporting these symptoms. Post-nasal drip and nasal irritation were reported by 75 (43%) and 76 (44%) of the employees, respectively. Thirty-nine (22%) of employees reported symptoms of chest tightness and shortness of breath. The least commonly reported symptom was wheezing, with 20 workers (12%) reporting work-related wheezing.

There was no difference in the proportion of employees reporting having had work-related symptoms when categorized by areas within the library with different mold counts. If the environmental sampling the day of the survey accurately reflected the relative exposure to molds for employees working in the library, it would appear that the employees' symptoms were not the result of exposure to molds released through the ventilation system. On the other hand, working with historical documents does appear to be related with the health complaints of the workers in this library.

On the basis of the data obtained in this investigation, the reported health complaints could not be definitely associated with exposure to mold, other microorganisms, nor formaldehyde. Problems with the building's ventilation system were identified, which may have contributed to the complaints of stale air and discomfort. Recommendations are offered in Section IX which are aimed at improving the air quality of the library building.

Keywords: SIC 8231 (Libraries and Information Centers), indoor air quality, mold, microorganisms, viable aerosol sampling, library, historical documents, formaldehyde.

II. INTRODUCTION

In October, 1987, NIOSH received a request from the Director of Libraries, Broward County, Fort Lauderdale, Florida for technical assistance in the evaluation of the indoor air quality of the Main Library Building.

This request was prompted by employees' and management's concern about eye and upper respiratory tract irritation and allergies among library employees. Air monitoring for formaldehyde, microbiological aerosols, and carbon dioxide levels, plus temperature, and relative humidity measurements were conducted by NIOSH to evaluate the overall indoor air quality of the building. Evaluation of the medical complaints was assessed by private interview, chest examination, and self-administered questionnaire.

Preliminary environmental monitoring results and recommendations to improve the air quality of the building were submitted by letter reports dated January 26 and October 4, 1988.

III. BACKGROUND

The Broward County Library, Fort Lauderdale, Florida is an eight-story library building. Approximately 300 county employees work in this building in various functions for the Division of Libraries. The building was first occupied in November 1983 and opened to the public in April 1984. Soon after the building was occupied, employees began complaining of eye and upper airway irritation, difficulty in breathing, and headache. Their symptoms appeared to be temporally related with work. Some workers' symptoms were severe enough for them to require sick leave.

The fifth floor of the building houses government documents. This floor was the initial area where numerous complaints of allergy-like symptoms, respiratory tract irritation, and eye infections occurred. Some of the historical documents (books of patent records), which had been previously stored in moist conditions and were placed on this floor, were reported to have had visible mold growth on the document covers. It was believed by the library employees that these may have been the source of mold in the library.

Ever since the building was constructed, problems were reported with the heating, ventilation, and air conditioning (HVAC) system. Also, many floors have had recurring water leaks due to rain water collecting on the patios. As a result of the high humidity, normal to the Fort Lauderdale area, and the above problems with the building, it was felt by the employees that the growth of various molds and fungi could occur inside the building.

IV. METHODS AND MATERIALS

Based on the information collected during the initial site visit, the following environmental and medical methods were chosen to evaluate the air quality of the building and characterize the extent and degree of medical complaints and problems. These methods were believed to provide the most insight into the indoor air quality problems reported by the library employees.

A. Environmental

1. Viable Aerosols

The purpose of the air monitoring for microorganisms (viable aerosol sampling) was to collect, identify, and quantitate yeasts, molds, thermophilic and mesophilic actinomycetes. Viable aerosol samples were collected using Ace #7540 All Glass Impingers, drawing air into 5 milliliters (ml) of modified Amie's transport medium plus 0.1% Tween 60, 0.1% agar, and 20 ml of sterile distilled water. An average air sampling rate of 6.1 liters per minute (L/m) for 60 minutes was maintained for an approximate air sample volume of 366 L; or 0.366 cubic meters per 25 ml sample. Serial dilutions were made from the samples, and 0.5 ml of each dilution were inoculated to 100 mm plates of malt extract agar for yeasts and mold, and to trypticase soy agar for the actinomycetes. The plates were incubated at 20-21°C for yeasts, molds, and mesophilic actinomycetes, and at 55°C for thermophilic actinomycetes. The incubation and final counts were concluded at fifteen days for all organisms. Counts were made and reported as colony forming units per cubic meter of air (CFUs/m³).

Sampling locations for viable aerosols were selected under a comparison sampling strategy. The premise of such a sampling strategy employs comparing results from the complaint areas with results from non-complaint areas, and outdoors. In accordance with this strategy, samples were collected in two locations on each floor of the library, on the outdoor terrace area of each floor, in a building adjacent to the library, and in a branch library building across town. The individual floor samples provided a means of determining variations between areas on the same floor (attributable to contamination and/or distribution within a ventilation system area) and variations between floors. The outdoor samples provided a reference point for the determination of whether or not certain microorganisms were being amplified in the indoor environment. The samples from the adjacent building were used as comparison of

ventilation systems and a determination of inter-building variation for a specific geographic location. Samples collected in the branch library provided a reference point of comparison for similar work activity within two separate buildings.

2. Formaldehyde

Formaldehyde samples were collected using calibrated battery-operated sampling pumps, at a flow rate of 1.0 L/m, through midget impingers containing 20 ml of 1% sodium bisulfite solution. Sampled air volumes ranged from approximately 90 - 180 liters. Sample analysis was conducted by visible absorption spectrophotometry according to NIOSH Method 3500.¹ The analytical limit of detection (LOD) for this method was 0.3 micrograms (ug) per sample, and the limit of quantitation (LOQ) was 0.9 ug/sample [0.01 ppm (parts of formaldehyde per million parts of air) for a 90 liter sample]. Values between the LOD and LOQ are considered to be trace concentrations and are only semi-quantitative. This means that formaldehyde at a concentration between the LOD and LOQ can not be reliably quantitated.

3. Ventilation

The heating, ventilation, and air conditioning (HVAC) system was physically examined to determine the mode of operation and overall condition. Measurements of temperature, relative humidity, and carbon dioxide (CO₂) were obtained in the occupied spaces to assess the operational ability of the HVAC system to adequately condition (heat and cool) the air, provide enough fresh air, and distribute the air throughout the building. To evaluate the thermal comfort, the temperature and relative humidity data were collected using a battery operated psychrometer at three or more locations on each floor twice daily. CO₂ measurements were obtained in three or more locations on each floor twice daily using a portable CO₂ analyzer.

B. Medical

On December 15 and 16, 1987, 31 current and 1 former employees of the library were interviewed. These employees were identified from a list of workers responding to a memorandum circulated by library management throughout the library. Workers were asked a brief medical and occupational history (with respect to their current jobs). A physician examined the chests of individuals who complained of cough, wheezing, or shortness of breath.

On February 3 and 4, 1988, a self-administered questionnaire was given to every employee in the Broward County Library Building, employees in another building across the street, and employees located at a branch library located a few miles away. The employees of the latter two buildings were surveyed as referent groups for comparison of symptoms prevalences. The questionnaire was designed to obtain information on work history, medical history, and demographics. The questionnaire included a floor plan and each worker was asked to mark where they spent most of their workday.

Medical complaints at the library and the referent buildings were assessed in the following manner. Eight symptoms (sneeze, eye irritation, runny nose, cough or throat irritation, chest tightness, breathing difficulty, and wheeze), possibly related to mold exposure were analyzed from the questionnaire. Each employee was asked if he/she suffered from these symptoms on the day the questionnaire was administered and, if not, whether they had these symptoms on other work days. The employees were also asked for their opinion as to whether-or-not these symptoms were work related. Only symptoms reported to have been work-related were included in the analysis. A new variable (symptom count) was created by summing the number of symptoms experienced by an individual. Thus the value for symptom count ranged from 0 to 8. The symptom count was analysed in two ways: the symptom count for the day of the study and the symptom count on other workdays. Symptom count was divided into three categories: employees with no symptoms, employees reporting 1-3 symptoms, and employees reporting 4-8 symptoms. The association between mold exposure obtained from the environmental sampling and symptom count was then examined.

Using the environmental results to estimate exposure to viable molds three categories of mold exposure were identified. These levels were designated as levels '0' (lowest exposure), '1' (middle exposure), and '2' (highest exposure). The association between symptom count and mold exposure was then examined.

The association between symptom count and an employee's age, sex, smoking status, work with historic documents, length of employment at the library, and history of prior allergies was also examined.

V. EVALUATION CRITERIA

Since 1971, NIOSH health hazard investigators have responded to more than 530 complaints of indoor air quality problems in a wide variety of office settings. The majority of these investigations have been conducted since 1979, paralleling the "energy efficiency" concerns of building operators and architects.

While the majority (80%) of indoor air investigations have been conducted in government and private-sector office buildings, we also have evaluated problems in schools, colleges, and health care facilities.

Commonly, the symptoms and health complaints reported by building occupants have been diverse and not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, varying degrees of itching or burning eyes, irritations of the skin (including rashes), sinus problems, dry and irritated throats, and other respiratory problems. The workplace environment has been typically indicated because workers' symptoms normally disappear when they are away from the office. At times, these symptoms have been severe enough to result in missed work or reassignment.

Although some of these episodes were multifactorial, the investigations we have conducted can be classified by primary type of problem found: inadequate ventilation (53%); contamination from inside the building (15%); contamination from outside the building (10%); microbiological contamination (5%); contamination from the building fabric (4%); and unknown (13%).²

A. Microbial Aerosols

Neither NIOSH nor OSHA has developed recommendations or standards for airborne microbial contamination. NIOSH investigators have in the past, through work addressing airborne microbial contamination in office buildings, suggested that a level of viable microorganisms in excess of about 1000 CFU/m³ of air indicates that the indoor environment may be in need of further investigation and possible improvement.³ It should be noted that this level does not discriminate between the different classes of microorganisms (i.e., bacteria, fungi, actinomycetes), nor does it represent a fine line between safe and hazardous air concentrations. Essentially this level represents a guideline which indicates the need for further evaluation. This particular guideline had limited applicability in this particular evaluation because of the nature of the complaints/symptoms.

Even though microbiological contamination is not a common cause of indoor air problems, it can result in a potentially severe health condition known as hypersensitivity pneumonitis. This respiratory problem can be caused by bacteria, fungi, protozoa, or microbial products that may originate from contaminated ventilation system components. A similar condition known as humidifier fever is also

the result of microbiological contamination of ventilation systems. In the NIOSH investigations, microbiological contamination has commonly resulted from water damage to carpets or furnishings, or standing water in ventilation system components.

The American Conference of Governmental Industrial Hygienists (ACGIH), Committee on Bioaerosols, has developed guidelines for the assessment and sampling of saprophytic bioaerosols in the indoor environment.⁴ These guidelines indicate that straightforward remedial action can resolve most problems where visible microbial contamination is evident. Because most microbial contamination problems in office environments have been associated with moisture incursion problems in heating ventilation and air conditioning (HVAC) systems, remedial actions have focused on elimination or control of these problems.

In cases where air sampling for microorganisms is warranted (i.e., to identify the source of airborne microorganisms or the etiological agent causing the health complaints) the ACGIH guidelines call for a sampling strategy based upon comparison of complaint to non-complaint and outdoor air environments. ACGIH proposes that: "in most situations, less than 50 CFU (of saprophytic organisms) will not constitute a contamination problem." The presence of any one fungal specie in levels exceeding 500 CFU/m³ can implicate a building related source. For fungal spores, indoor levels should be less than one-third of the outdoor levels. High levels (> 500 CFU/m³) of bacteria (bacillus spp., staphylococcus spp., or streptococcus spp.) may indicate poor ventilation, overcrowding, or a contamination source. The presence of thermophilic actinomycetes at levels exceeding 500 CFU/m³ has been associated with hypersensitivity lung illness. To determine whether or not one or more microbial species are in abundance due to amplification which may result in indoor air problems, the individual species of microorganisms should be rank ordered by sample.⁴

B. Formaldehyde

Formaldehyde and other aldehydes may be released from foam plastics, carbonless paper, particle board, plywood, and textile products. Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat and nose, headaches, nausea, nasal congestion, skin rashes, and infrequently asthma. It is difficult to ascribe specific health effects to specific concentrations of formaldehyde to which people are exposed, because people vary in their subjective responses and complaints. Irritation symptoms may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and greater.

In 1976 NIOSH developed a recommended exposure limit (REL) of 1.0 ppm to prevent the irritant effects of exposure to this compound.⁵ This recommendation predated animal carcinogenicity data implicating formaldehyde as an animal carcinogen and potential occupational carcinogen. Formaldehyde has also produced positive results in mutagenicity testing, supporting the classification of this compound as a potential occupational carcinogen. NIOSH currently considers formaldehyde a potential occupational carcinogen and recommends that formaldehyde exposures be maintained at the lowest feasible level.⁶

On December 4, 1987, OSHA promulgated a new health standard for formaldehyde, which became effective on February 2, 1988.⁷ In this revised standard, OSHA considers formaldehyde a human carcinogen. The OSHA permissible exposure limit (PEL) was reduced by two thirds, from 3 ppm to 1 ppm, as an 8-hour time-weighted average (TWA), with an action level of 0.5 ppm. Exposures up to 2.0 ppm would be permitted for 15-minute periods, as long as the daily exposure does not exceed 1.0 ppm.

The American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV) for formaldehyde is 1.0 ppm, as an 8-hour TWA, and has proposed a ceiling limit of 0.3 ppm due to the irritant properties of formaldehyde. ACGIH also classifies formaldehyde as a suspected human carcinogen, necessitating that exposures be kept to a minimum.⁸

The American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has recommended, based on personnel comfort, that exposure to formaldehyde be limited to 0.1 ppm.⁹ This guideline has also been adopted by the National Aeronautics and Space Administration (NASA), and the federal governments of Canada, West Germany, and the United Kingdom. An indoor air formaldehyde concentration of less than 0.05 ppm is of limited or no concern according to the World Health Organization (WHO).¹⁰

C. Ventilation and Indoor Air Quality

The primary sources of air contamination criteria generally consulted for indoor air quality evaluations include: (1) NIOSH Criteria Documents and recommendations for occupational exposures, (2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), (3) the U.S. Department of Labor (OSHA) federal occupational health standards, and (4) the indoor air quality standards developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The first three sources provide environmental limits based on

air concentrations of substances to which workers may be occupationally exposed in the workplace environment for 8 to 10 hours a day, 40 hours per week for a working lifetime without adverse health effects. The ASHRAE standards are general air quality standards for indoor environments, and are applicable for the general population exposed for up to a 24-hour day of continuous exposure without known toxic effects.

Indoor air should not contain concentrations of contaminants known to impair health or cause discomfort to a substantial majority of the occupants. Ambient air quality standards/guidelines available from federal, state, or local authorities should be consulted. If the air is thought to contain any other contaminants, reference should be made to OSHA, ACGIH, and NIOSH recommendations.

Neither NIOSH nor OSHA has developed ventilation criteria for general offices. Criteria often used by design engineers are the guidelines published by ASHRAE.

Until recently, the ASHRAE Ventilation Standard 62-73 (1973) was utilized, but recommendations were based on studies performed before the more modern, air-tight office buildings became common. These older buildings permitted more air infiltration through leaks in cracks and interstices, around windows and doors, and through floors and walls. Modern office buildings are usually much more airtight and permit less air infiltration. Due to the reduced infiltration, ASHRAE questioned whether the 1973 minimum ventilation values assure adequate outdoor air supply in modern, air-tight buildings.

Subsequently, ASHRAE has revised its standard and has published the new standard, ASHRAE 62-1989, "Ventilation for Acceptable Indoor Air Quality."⁹ The new standard is based on an occupant density of 7 persons per 1000 ft² of floor area, and recommends higher ventilation rates for areas where smoking is permitted. The new ASHRAE standard states that indoor air quality for "General Offices" shall be considered acceptable if the supply of outdoor air is sufficient to reduce carbon dioxide to less than 2500 ppm and to control contaminants, such as various gases, vapors, microorganisms, smoke, and other particulate matter, so that concentrations known to impair health or cause discomfort to occupants are not exceeded. However, the threshold levels for health effects from these exposures are poorly documented. For "General Offices" where smoking is not permitted, the rate recommended under the new standard is 20 cfm of outdoor air per

person. Higher ventilation rates are recommended for spaces where smoking is permitted because, according to ASHRAE, tobacco smoke is one of the most difficult contaminants to control. When smoking is allowed, the amount of outdoor air provided should be 60 cfm per person. Nonsmoking areas may be supplied at the lower rate (20 cfm/person), provided that the air is not recirculated from, or enters from, the smoking areas.⁹

The ASHRAE Standard 62-1989 also provides ventilation requirement guidelines for a wide variety of commercial, institutional, residential, and industrial facilities and should be consulted for application to the specific situation under evaluation.

VI. RESULTS

A. Environmental

Microbial air sampling was conducted to identify sources and species of microorganisms in the library and in the referent buildings. There were no thermophilic or mesophilic actinomycetes isolated from these samples. Yeasts were isolated in only two samples; samples collected on terraces which were being re-landscaped yielded 750,000 CFU/m³ of an unidentified yeast (taxonomic data was not available at the laboratory) and 15,000,000 CFU/m³ of Cryptococcus albidus. The results of the microbial air sampling for fungi are presented in Table I. Very low counts were noted for molds. Penicillium was the predominant fungal species found on the 4th, 5th, 6th, 7th, and 8th floors. Concentrations of penicillium found in these areas ranged from 100 to 820 CFU/m³. Penicillium was found on the 5th floor in at least one of two sampling locations each day for the three days of sampling. One sample was collected during the unpacking and handling of old patent books to determine if these books may have been associated with the reported health problems. This sample contained 135 CFU/m³ of Penicillium species, a concentration no different from other samples collected in this area. For comparison, Penicillium was found on the 4th floor terrace, but not in other samples collected outside on the other library terraces, in the building across the street, in the branch library, or in a hotel room. The hotel room was the only sample from which Aspergillus species was isolated. Penicillium species of mold are ubiquitous and collection of this species at these concentrations in Florida is not surprising. The microbial sample results did not indicate any specific sources of contamination, amplification of microorganisms in or from the air handling systems, or from the areas where water leaks were evident.

The air sampling results for formaldehyde are presented in Table II. These results indicate formaldehyde levels inside the library building were extremely low and essentially similar to formaldehyde concentrations outdoors and in the branch library. Comparison of these results with the ASHRAE, WHO, and ACGIH criteria (based on irritant properties) indicates that the irritation complaints from library staff were probably not due to formaldehyde exposure.

The results of the other indoor air quality measurements for temperature, relative humidity, and CO₂ are presented in Table III. The temperature and relative humidity in the building ranged from 67 to 76 degrees F, and 60 to 73%, respectively. The high end of these parameters exceeds the acceptable comfort range guidelines recommended by ASHRAE (ANSI/ASHRAE Standard 55-1981). The indoor CO₂ measurements ranged from 400 to 900 ppm, as compared to 300 to 400 ppm CO₂ outside the building. CO₂ as a normal constituent of exhaled breath is used as a screening technique to evaluate whether adequate quantities of fresh outdoor air is introduced into the working space of the building. If the CO₂ concentrations are three to four times the outside level, there is probably a problem of inadequate ventilation. Based on the CO₂ measurements collected during this survey, there did not appear to be a problem with adequate ventilation of the library.

The HVAC systems were examined on each floor. A design problem was identified on each air handling unit; the units were not equipped with access panels for cleaning condensate pans or performing visual inspection of this part of these units. At our request, a hole was cut into the side of the air handling units to facilitate examination of the units' interior. There was slime and mold growth in the condensate pans, which was expected since the units could not have been properly cleaned during the four years of use. It was not possible to determine if this problem caused or contributed to the reported health problems. The inability to clean the units and the condition of the units' interior provided a point source for growth, amplification, and distribution of microorganisms. At the time of the survey, environmental sampling did not indicate air contamination with microorganisms. Even though the numbers of colony forming units were relatively low, the number of CFU did vary from floor to floor. The number of CFU by floor was used to categorize exposure to molds into three areas. The following categories were developed: "0" represented floors 1 and 2 where the CFUs were zero; "1" represented a CFU exposure ranging from 135-275 CFU/m³ (floors 6 and 8); and, "2" represented an exposure ranging from 354-465 CFU/m³ (floors 4, 5 and 7).

Several water leaks were noticed on floors 2 through 7. The existence of these leaks had been documented since the building was first occupied and may have contributed to mold contamination in the building. The four year existence of these leaks has led to conditions conducive to mold growth in the carpet and the occupied space of the building. Even so, at the time of the survey there was no indication of significant air contamination by molds.

B. Medical

At the Broward County Library, 174 of 185 employees from eight floors participated in the medical study. The remaining 11 employees either refused to participate, or were not present on the day of the survey. The employees age, gender, and race distribution appear in Table IV. Information on length of employment with Broward County and at the Broward County Library are given in Table V.

As shown in Table VI, the most commonly reported symptom (by 100 employees) was sneezing (14% on the day of the survey and 43% on other days), with 58% reporting that they had a work-related sneeze. Eye irritation and cough were the next most common symptoms, with 97 (56%) and 93 (54%) employees, respectively, reporting these symptoms. Post-nasal drip and nasal irritation was reported by 75 (43%) and 76 (44%) of the employees, respectively. Thirty-nine (22%) of the employees reported symptoms of chest tightness and shortness of breath. The least commonly reported symptom was wheezing, with 20 workers (11.6%) reporting work-related wheezing.

A total of 159 employees completed the questionnaire (Table VII) on floors 1, 2, 5, 6, 7, and 8 (no environmental samples were collected on the ninth floor). The workers were stratified into the three exposure categories (based on CFU mold counts) and a comparison was made of these strata by symptom count. (Table VII) There was no association between mold category and symptom count ($X^2=1.60$, 4 df, p greater than 0.05)

The associations between symptom count and age, gender, cigarette smoking, working with historical documents, length of employment at the library and previous allergy were examined and are reported in Table VIII. There was no association between symptom count and employee's age. Female employees reported a higher symptom count than male employees, with 30% of the male employees reporting no symptoms compared to only 14% of the female employees. More than

50% of the workforce smoked cigarettes. However, smoking was not related to the number of symptoms reported by the workers. All employees who had ever worked with historic documents reported symptoms: 38% reported 1-3, and 62% reported 4-8 symptoms. The relative rate for working with historic documents was 1.37 (95% CI 1.18-1.61). Length of employment at the library was not related to workers' symptoms. Ninety-two percent of the workers with a history of allergy reported symptoms compared to 72% of the workers with no history of allergy.

The prevalence of symptoms described by employees as work-related in the office building across the street from Broward County Library was lower than at the Broward County Library. A total of 57 employees completed the questionnaire. (The investigator did not enumerate the number of nonrespondents.) The relative rates of sneezing (RR=1.27, 95% CI 0.93-1.73), nasal drip (RR=2.05, 95% CI 1.20-3.48), chest tightness (RR=4.15, 95% CI 1.33-12.93), shortness of breath (RR=1.68, 95% CI 0.86-3.27), and wheezing (RR=6.59, 95% CI 0.90,48.0) were all elevated when comparing the prevalence of symptoms at the Broward County Library with the office building.

The symptom prevalence among the branch library employees was more comparable to that seen at the Broward County Library, however only 19 employees completed the questionnaire (the number of employees available to complete the questionnaire is not known). Sneezing was reported by 53%, eye irritation by 48%, chest tightness and wheezing by 10%, and shortness of breath by 16% of the employees.

VII. DISCUSSION

The complaints of eye irritation, conjunctivitis, and allergic response to molds (specifically aspergillus sp.) originated on the 4th and 5th floors of the library. The receipt, unpacking, sorting, and storage on the 5th floor of old patent books that had visible water damage and mold (in some instances) were suspected by the employees as the possible source of the microbial problem. As well, during the initial survey in December, 1987, a problem with the inability to clean condensate pans in the air handlers of the ventilation system was noted. Although the extent of microbial growth (slime) in these pans appeared to be minimal at the time of this investigation, this element of the air handling systems could have been the source and/or amplification point for microbial contamination. Several water leaks also were noticed on floors 2 through 7 which may have contributed to mold contamination in the building. The four year existence of these leaks had led to conditions conducive to mold growth in the carpet and occupied space of the building. Any one, or a combination, of these factors could have resulted in conditions which may have caused or contributed to the reported health problems.

The microbial air sampling and formaldehyde sampling results represent conditions at one point in time and may not truly reflect conditions which existed when the health complaints originated. At the time of sample collection, visibly contaminated books were not being handled, the condensate pans of the air handling systems on each floor had been cleaned, and the weather conditions were such that no substantial moisture was entering the building through the leaks.

VIII. CONCLUSIONS

In summary, there was no difference in the proportion of employees with work-related symptoms when categorized by areas with different mold counts. Workers at the Broward County Library did have a higher prevalence of symptoms they associated with work than workers at an office building located across the street. If the environmental sampling accurately reflects the relative exposure to molds for employees working on these floors, it would appear that their symptoms were not the result of exposure to mold. On the other hand, the results from a questionnaire survey indicated that working with historical documents was related to the health complaints of the workers in this library.

The environmental sampling results did not indicate any current airborne microbial or formaldehyde contamination which could be associated with the reported health effects. Response and adherence to the following recommendations should minimize the potential for future indoor air quality problems and associated health complaints.

IX. RECOMMENDATIONS

The following recommendations are aimed at improving the indoor air quality of the library. These recommendations were provided in letter reports previously submitted to the library.

1. Access panels should be installed on the air handling units as soon as possible to facilitate cleaning of the condensate pans and filters. This will also enable the maintenance staff to add biocide tablets to the condensate pans and prevent the growth of microorganisms.
2. The temperature control of the ventilation system should be evaluated and adjusted to provide thermal conditions acceptable to a majority of the building occupants. Measurements of temperature and relative humidity from various areas throughout the building indicated that conditions are not maintained within the comfort range recommended by ASHRAE.

3. Tobacco smoke is a major contributor to indoor air quality problems. Tobacco smoke contains several hundred toxic substances which can irritate the respiratory system and, in allergic or sensitive individuals, result in eye and nasal irritation, coughing, headache, and sinus problems. Eliminating or reducing the contamination of indoor air from cigarette smoke can be effectively accomplished by restricting smoking to designated areas. A minimum of 20 cubic feet per minute of fresh air per occupant should be provided to designated smoking areas (ASHRAE 62-1981, Table 3, Section 3.1).⁹ Air should be exhausted from these areas directly to the outside. As a minimum, the state of Florida Indoor Air Quality Requirements should be adhered to in this building.
4. The water leaks throughout the building should be repaired as soon as possible to eliminate conditions suitable for mold growth. These leaks pose not only an inconvenience to the employees and patrons of the library, but they may also be a safety hazard, a psychological detriment for affected employees, and an aesthetic detraction to otherwise beautiful architecture.
5. A high efficiency particulate air (HEPA) filtered vacuum cleaner should be used to clean the dust and debris from books and historical documents. This vacuum cleaner also could be used to clean the ventilation duct diffusers. Using a brush or non-HEPA filtered vacuum cleaner for these tasks may distribute mold spores, dust, and dust mites throughout the library. Books or documents with visible mold growth should not be handled nor cleaned in the library. Such documents should be decontaminated using appropriate biosafety procedures. The Florida State Archives in Tallahassee has an ethylene oxide fumigation chamber which is suitable for this purpose.

X. REFERENCES

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XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Broward County Library
2. NIOSH, Atlanta Region
3. OSHA, Region IV

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.

TABLE I
 CONCENTRATIONS OF AIRBORNE FUNGI
 BROWARD COUNTY LIBRARY
 FORT LAUDERDALE, FLORIDA
 HETA 88-001

FEBRUARY 3-5, 1988

Date	Location	Sample Time	Sample Volume Liters	Fungi (CFU/m ³)	
				Total	By Species
2/3/88	5th Floor, Westside	0953-1108	465	0	
	5th Floor, Eastside	0955-1104	428	100	Pensp. (100)
	5th Floor, Outside on Terrace	0958-1106	429	25,000	NDF (25,000)
	4th Floor, Westside	1138-1242	397	0	
	4th Floor, Eastside	1140-1239	366	0	
	4th Floor, Outside on Terrace	1142-1240	365	0	
	6th Floor, Westside	1310-1410	372	0	
	6th Floor, Eastside	1312-1413	379	135	Pensp. (135)
	7th Floor, Eastside	1320-1417	354	820	Pensp. (820)
	7th Floor, Westside	1420-1522	384	275	Pensp. (275)
	8th Floor, Eastside	1431-1538	415	0	
	8th Floor, Westside	1435-1539	397	275	Pensp. (275)
	2nd Floor, Westside	1528-1632	397	0	
	2nd Floor, Eastside	1545-1648	390	0	
	1st Floor, Northside	1545-1655	434	0	
	2/4/88	5th Floor, Outside Terrace	0819-0931	446	0
5th Floor, Westside		0819-0932	458	135	Pensp. (135)
5th Floor, Information Desk		0819-0935	476	410	Pensp. (410)
5th Floor, Information Desk		1535-1642	415	0	
5th Floor, Old Patent Books*		1537-1641	390	135	Pensp. (135)
5th Floor, Outside on Terrace		1540-1642	384	0	
Govt. Center, Tax Assessor's Office (West)		1049-1155	409	0	
Govt. Center, Tax Assessor's Office (East)		1052-1157	403	0	
Govt. Center, Tax Assessor's Office (Center)		1055-1158	384	0	
Branch Library, Staff Area		1401-1502	378	0	
Branch Library, Inform. Desk		1403-1505	384	0	
Branch Library, Mezz. Level		1409-1504	403	135	Alt. (135)
Hotel Room		1718-1815	353	135	Alt. (135)

(Continued)

TABLE I (continued)

Date	Location	Sample Time	Sample Volume Liters	Fungi (CFU/m ³)	
				Total	By Species
2/5/88	5th Floor, Near Boxed Patent Books	0814-0912	360	0	
	5th Floor, Near Box Patent Books	0814-0913	378	135	Pensp. (135)
	5th Floor, Information Desk	0817-0913	348	135	Pensp. (135)
	4th Floor, Outside on Terrace	0915-1014	366	1635	Cladp. (1500) Pensp. (135)
	4th Floor, Eastside	0917-1014	353	0	
	4th Floor, Westside	0915-1014	366	680	Pensp. (680)

* - Collected during unpacking and handling of old patent books.

Abbreviations:

CFU/m³ = Colony-forming units per cubic meter of air
 NDF = Nonsporulating dermatiaceous fungi
 Pensp. = Penicillium sp.
 Alt. = Alternaria sp.
 Asp. = Aspergillus fumigatus
 Cladp. = Cladosporium sp.

TABLE II

AIR SAMPLING RESULTS: FORMALDEHYDE
BROWARD COUNTY LIBRARY
FORT LAUDERDALE, FLORIDA
HETA 88-001

FEBRUARY 3-4, 1988

Area	Sample Time	Sample Volume Liters	Formaldehyde Concentrations (ppm)
4th Floor, Westside	1138-1525	227	0.01
4th Floor, Outside on Patio	1141-1527	224	(0.01)*
6th Floor, Westside	1312-1647	215	0.07
7th Floor, Eastside	1320-1659	219	0.01
5th Floor, Southside	0820-1258	278	0.01
5th Floor, at Information Desk	0819-1250	279	0.01
Branch Library, at Information Desk	1359-1507	68	(0.01)

*Values in parentheses are between the Analytical Limit of Detection (LOD, 0.3 ug/sample) and the Limit of Quantitation (LOQ, 0.9 ug/sample).

TABLE III
 INDOOR AIR QUALITY MEASUREMENTS
 BROWARD COUNTY LIBRARY
 FORT LAUDERDALE, FLORIDA

HETA 88-001

December 15, 1987 and February 3-4, 1988

Location	December 1987			February 1988		
	°F	RH%	CO ₂ (ppm)*	°F	RH%	CO ₂ (ppm)
Outdoors, AM	76	73	300-400	74	73	350
PM	75	78	300	76	68	400
2nd Floor, East, AM	75	66		74	66	550
East, PM				73	66	700
West, AM	75	66		75	69	600
West, PM				74	69	800
3rd Floor, East, AM	74	65	600	74	69	500
East, PM				74	68	700
West, AM	75	66	600	73	70	500
West, PM				74	69	700
4th Floor, East, AM	74	66		72	68	500
East, PM	75	66		74	67	700
West, AM	74	61	600	73	68	550
West, PM	73	64		74	65	800
Center, AM				73	68	500
Center, PM				74	65	700
5th Floor, East, AM	71	68	600	72	70	500
East, PM	72	68	700	74	68	700
West, AM				74	68	500
West, PM				74	66	700-800
Center, AM	72	68	600	74	68	500
Center, PM	73	69	600	73	65	700-800
6th Floor, East, AM	71	68	600	71	71	500
East, PM	73	68	700	74	68	600
West, AM				74	70	400
West, PM				69	66	600
Center, AM				75	66	500

(Continued)

TABLE III (continued)

Location	December 1987			February 1988		
	°F	RH%	CO ₂ (ppm)*	°F	RH%	CO ₂ (ppm)
7th Floor, East, AM	72	73	600	75	68	500
East, PM				75	68	500
West, AM	72	73	400	74	66	500
West, PM				74	66	600
8th Floor, East, AM	67	62	600	72	69	450
East, PM	69	63	700	73	65	600
West, AM	73	57		73	66	500
West, PM				74	60	600
Center, AM	74	61	900	74	65	600
Center, PM	75	62	900	75	64	900

*Temperature was measured in degrees Fahrenheit, RH% indicates the percent of relative humidity, and CO₂ represents parts per million (ppm) of carbon dioxide. As carbon dioxide levels approach or exceed 1000 ppm, or 3 to 4 times the outside level, there is an indication that inadequate amounts of fresh air are being introduced to the space.

TABLE IV

DEMOGRAPHIC INFORMATION PERTAINING TO EMPLOYEES AT
BROWARD COUNTY LIBRARYBROWARD COUNTY LIBRARY
FORT LAUDERDALE, FLORIDA

HETA 88-001

<u>Age</u>		
Age (years)	Frequency	Percent
22-34	48	28%
35-45	60	35%
46-78	58	33%
total	166*	95%
mean = 43 years (standard deviation = 12 yrs)		
*8 employees did not give their age		

<u>Sex</u>		
Sex	Frequency	Percent
male	34	20%
female	140	80%
total	174	100%

<u>Race</u>		
Race	Frequency	Percent
White	137	79%
Black	28	16%
Hispanic	4	2%
American Indian	1	1%
Asian	1	1%
total	171*	98%

*3 employees did not give information about race.

TABLE V

DURATION OF EMPLOYMENT WITH BROWARD COUNTY
AND THE BROWARD COUNTY LIBRARY

BROWARD COUNTY LIBRARY
FORT LAUDERDALE, FLORIDA

HETA 88-001

Duration of Employment with Broward County		
Years	Frequency	Percent
0-4	81	47%
5-9	49	28%
10-14	35	20%
15-19	8	5%
20-24	0	
25-29	1	1%
Total	174	100%

Mean = 6.8 years (standard deviation = 4.6 years)

Length of Employment at Broward County Library		
Years	Frequency	Percent
0-1	34	20%
2-3	72	41%
4-5	63	36%
Total	169*	97%

Mean = 3.2 years (standard deviation = 1.3 years)

* 5 employees did not give information on their duration of employment at the Broward County Library

TABLE VI

FREQUENCY OF SYMPTOMS REPORTED AS WORK-RELATED
WHILE EMPLOYED AT THE BROWARD COUNTY LIBRARY

BROWARD COUNTY LIBRARY
FORT LAUDERDALE, FLORIDA

HETA 88-001

Work-Related Symptoms	Presence Today*		Presence on Other Days Only		Never	
	No.	%	No.	%	No.	%
Sneeze	25	14	75	43	73	42
Nasal Drip	33	19	42	24	99	57
Eye Irritation	35	20	62	36	76	44
Nasal Irritation	16	9	60	35	96	56
Cough	33	19	60	35	80	46
Tight Chest	9	5	29	17	136	78
Shortness of breath	8	5	31	18	134	78
Wheeze	3	2	17	10	153	88

* The day of the investigation.

TABLE VII

DISTRIBUTION OF SYMPTOMS ON ANY DAY BY MOLD COUNT

BROWARD COUNTY LIBRARY
FORT LAUDERDALE, FLORIDA

HETA 88-001

*Mold Category	Symptom Count (N and %)			Total
	0	1-3	4-8	
0	5 (28%)	10 (56%)	3 (17%)	18
1	15 (29%)	24 (46%)	13 (25%)	52
2	22 (26%)	40 (48%)	21 (25%)	83
TOTAL	42 (27%)	74 (48%)	38 (25%)	154

*0= floors 1 and 2 where no colony forming units of molds or fungi were detected.

1= floors 6 and 8 where 135 to 275 CFU/M³ were detected.

2= floors 4, 5, and 7 where 354 CFU/M³ and higher.

TABLE VIII

DISTRIBUTION OF OTHER VARIABLES BY SYMPTOMS LEVEL

BROWARD COUNTY LIBRARY
FORT LAUDERDALE, FLORIDA

HETA 88-001

	0	Symptom Level		total
		1-3	4-8	
AGE				
22-34	6	20	22	48
35-45	9	26	26	61
46-78	12	24	22	58
Column Total	27	70	70	167
SEX				
Male	10	11	13	34
Female	19	62	59	140
SMOKING HISTORY				
Smokers	17	32	40	89
Nonsmoker	12	40	32	84
HISTORICAL BOOKS				
Not Exposed	29	64	56	149
Exposed	0	8	13	21
LENGTH OF EMPLOYMENT				
Up to 3.5 years	13	31	34	78
Over 3.5 years	15	40	36	91
ALLERGY				
Yes	8	38	52	98
No	21	35	20	76