NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2001-0067-2896
Somerset County Assistance Office
Somerset, Pennsylvania

March 2003

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

PREFACE

The Field Studies Branch of the Division of Respiratory Disease Studies (DRDS/FSB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSH) 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.

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

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Dr. Ju-Hyeong Park, Sandra Goe, Dr. Kyoo T. Choe, Dr. Muge Akpinar-Elci, and Dr. Kay Kreiss of the Field Studies Branch, Division of Respiratory Disease Studies. Field assistance was provided by Michael Berakis, Dr. Khaled El-Sherbini, Dr. Paul Enright, Diana Freeland, Jim Taylor, Kathy Fedan, Raymond Petsko, Dr. Lu Ann Beeckman-Wagner, Thomas Jefferson, Michelle Johnson, Dr. Hector Ortega, Chris Piacitelli, Marty Pflock, Dr. Carol Rao, Randy Boylstein, Kenneth Greene, David Spainhour, Kimberly Jo Stemple, and Liesa Stiller. In addition, the following DRDS/FSB staff assisted in the survey: Amber Harton, Steve Game, Brian Tift, Dee Cress, and Michael Beaty. Dr. Daniel Lewis and Michael Whitmer of the Health Effects Laboratory Division performed the assays for endotoxin. Dr. Lennart Larsson at the University of Lund, Sweden, performed analyses for ergosterol, and Dr. Ginger Chew at Columbia University, NY, assayed (1→3)-β-D-glucan. Dr. Jean Cox-Ganser assisted with questionnaire preparation. Dr. Mark Hoover and Dr. Robert Castellan provided guidance and valuable review. Desktop publishing was performed by Terry Rooney. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Somerset County Assistance Office (SCAO), to the landlord of the inspected SCAO building, and to the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

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Highlights of the NIOSH Health Hazard Evaluation of Somerset County Assistance Office

In November 2000, NIOSH was asked by Somerset County Assistance Office (SCAO) employees to conduct a health hazard evaluation at their rented building at 600 Aberdeen Drive in Somerset, Pennsylvania. Concerns included possible work-related asthma, hypersensitivity pneumonitis, sinus infections, breathing problems, bronchial infections, chronic fatigue, muscle aches, and irritation of the throat, nose and eyes. On December 28, 2001, SCAO relocated their employees to a newly constructed building.

What NIOSH Did

- Conducted questionnaire surveys to assess SCAO employees' respiratory health.
- Examined employees using objective medical tests to assess respiratory health.
- Inspected the heating, ventilating, and air conditioning (HVAC) system.
- Conducted environmental sampling to assess bioaerosol exposure in the building.

What NIOSH Found

- Building-related chest symptoms: wheezing (60% of survey respondents), chest tightness (31%), shortness of breath (24%), and cough for three consecutive months (40%).
- More diversity in fungal flora indoors compared with outdoors, suggesting possible contamination of the building with mold or microbial growth.
- Inappropriate installation and maintenance of the HVAC system, and imbalance of airflow within occupied spaces.
- Higher exposure to indices of mold, ergosterol and glucan, respectively, associated with asthma and cough in SCAO employees.

What Managers Can Do

- SCAO managers should disseminate the findings of this report to inform employees that a respiratory hazard existed in their previous water-damaged building.
- SCAO managers should replace or remediate water-damaged furniture that may have been brought from the evaluated building to current SCAO offices.
- The landlord of the evaluated SCAO building should replace or remediate contaminated or water-damaged areas and remediate and maintain the HVAC system so that future tenants can benefit from the findings of this investigation. Specific recommendations are included in the full interim report.

What Employees Can Do

- Be aware of symptoms suggestive of work-related (better when away from work) lower and upper respiratory problems, asthma and fungal allergies.
- Consult a doctor about persistent work-related symptoms.
- Report water incursion or mold growth to building managers so that remedial action can be taken in a timely manner.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for HETA Report #2001-0067-2896

Health Hazard Evaluation Report HETA #2001-0067-2896
Somerset County Assistance Office
Somerset, Pennsylvania
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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from employees of the Somerset County Assistance Office (SCAO) in November 2000. The request included health complaints (sinus infections, breathing problems, bronchial infections, chronic fatigue, muscle aches, and irritation of throat, nose and eyes) and environmental concerns about water incursion and malfunction of ventilation. At the time of the request, there had been four reported cases of hypersensitivity pneumonitis (HP) and eight reported cases of doctor-diagnosed asthma among a staff of 68 employees.

In response to the request, NIOSH investigators conducted an initial walk-through survey in March 2001. The results of sample analyses and the screening questionnaire from the initial survey suggested possible biological contamination of the building and adverse respiratory effects. A second visit was planned and conducted from July 25 through August 15, 2001, to conduct environmental sampling, a heating, ventilating, and air conditioning (HVAC) inspection, medical testing, and a more extensive questionnaire survey. In December 2001, SCAO relocated their employees to a newly constructed building.

The objectives of the second visit were to assess potential fungal contamination in the building and exposure levels of occupants, to characterize respiratory symptoms among occupants, to objectively test occupants' pulmonary function, and to examine the association of symptoms and medical test results with environmental exposure. For those aims, we conducted an interviewer-administered questionnaire survey, objective medical tests (spirometry and methacholines challenge tests, carbon monoxide diffusion capacity test, and exhaled nitric oxide measurements), and environmental measurements for microbial contaminants (culturable fungi, spore counts, endotoxin, ergosterol, and (1→3)-β-D-glucan), and evaluation of the HVAC system during the survey period.

The participation rate was 93% for the screening questionnaire and 59% for the main questionnaire. There were 62 participants in the screening questionnaire survey and 15% reported asthma, 10% HP, and 36% any chest symptoms (wheeze, chest tightness, or shortness of breath in the past 4 weeks). Work-relatedness was reported by about 61% of the symptomatic people with one or more lower-respiratory symptoms (cough, wheeze, chest tightness, shortness of breath in the past 4 weeks). There were 40 participants in the main questionnaire survey and shortness of breath was reported by 52%, chest tightness by 40%, wheezing by 38%, and coughing for three consecutive months in the past 12 months by 25%. Up to 60% of the symptomatic people with the lower respiratory symptoms reported work-

relatedness. Ninety-two percent of the participants in the main survey reported nasal symptoms and 90% reported sinus symptoms.

In our study, we defined a case of probable work-related HP as a building occupant who reported one or more work-related (getting better away from work) lower respiratory symptoms (cough, wheeze, shortness of breath, and chest tightness) AND one or more systemic symptoms (fever/chills, flu-like/muscle achiness, weight loss of 10 pounds or more). From the questionnaire we identified 11 probable work-related HP cases. Note, however, that only 4 of these 11 symptomatic individuals were diagnosed as having HP by their physicians.

We found two employees with borderline airways obstruction from our objective pulmonary function tests. One participant had mildly elevated exhaled nitric oxide. Three employees had low vital capacity with normal total lung capacity. No participants had test results indicating airways hyperresponsiveness or difficulties in gas transfer in the lungs.

Our environmental investigation showed that the count of total airborne fungal spores (geometric mean=20,654 spores/m^3) was about 60 times higher outdoors than indoors (geometric mean=348 spores/m^3). A total of twenty fungal genera were identified in 180 indoor spore trap samples, and *Cladosporium*, basidiospores, and *Epicoccum* were the most frequently identified fungi indoors and outdoors. The level of total culturable airborne fungi (geometric mean=1,224 colony forming units (CFU)/m^3) was about 10 times higher outdoors than indoors (geometric mean=123 CFU/m^3). A total of 55 species of culturable fungi were identified in indoor air samples, and only 15 species were identified in outdoors samples. Both airborne spore counts and culturable fungi data showed different fungal composition between indoors and outdoors which implies that the SCAO indoor environment is likely to have had indoor sources of fungal contamination. However, we did not observe visible sources of fungal contamination within the occupied spaces at the time of investigation. *Stachybotrys chartarum* was found in 7 chair dust samples, but not in floor and air samples. In air, floor and chair dust samples, a total of 77 fungal species were identified, and air showed the most diverse range of fungal species. Our indoor monitoring data for relative humidity, temperature, carbon dioxide, and particles, along with bioaerosol measures, clearly showed variation of those parameters in association with human activity. Occupants were exposed to more bioaerosol and particles toward the end of the workweek. The levels of indoor carbon dioxide were lower than the recommended level (1,000 ppm, which is 700 ppm plus the outdoor level) from ASHRAE (the American Society of Heating, Refrigerating and Air-Conditioning Engineers)[1]; temperature during the survey period ranged from 70 to 80°F and relative humidity ranged from 43 to 55%, both of which are within the recommended ranges for comfort and minimizing microbial growth (68-77°F and 30-60% relative humidity).

Although our analyses were limited by a possible participation bias and by the small number of subjects participating in the study, we found a significant association of (1→3)-β-D-glucan level as a surrogate for fungal level in chair dust with usual cough using multivariate logistic regression analysis adjusting for age, gender, and atopic status. Airborne ergosterol, a surrogate measure for airborne fungi, was significantly associated with self-reported asthma after adjusting for gender.

In our interim report on the NIOSH investigation of the HVAC system (see Appendix A), we recommended the remediation of roof leaks and problems with the HVAC system. Based on our HVAC evaluation and on the health evaluations described above, we make the following recommendations to SCAO, the previous building managers, and the SCAO employees.

We recommend that the SCAO manager take the following actions:

1. Replace or clean the water-damaged furniture which may have been brought from the evaluated building to current SCAO offices.

We recommend that employees take the following actions:

2. Consult a doctor for persistent or work-related lower respiratory symptoms such as wheeze, chest tightness, shortness of breath and/or cough or a combination of work-related lower respiratory symptoms and systemic symptoms (such as fever/chill, flu-like/muscle achiness, weight loss of 10 pounds or more). Objective medical tests can help your doctor diagnose the respiratory condition and its severity, and may help establish that it is work-related.

We recommend that the manager of the evaluated building take the following actions to protect future tenants:

3. Fix or renovate areas with water incursion (roof, walls, and floor). Especially, repair the damaged roof to prevent condensed water from the air handling units (AHUs) from leaking through the roof.

4. Redirect the drainage from the AHU drain traps directly to the gutter, at least until the damaged roof is completely repaired.

5. Replace any water damaged building materials and water-stained carpet or ceiling tiles.

6. Inspect internal insulation linings of HVAC systems for degradation. Remove all degraded internal linings and install external insulation on the ducts with degraded internal linings that carry supply air from the AHUs. Make sure that occupants are not exposed to fibers while the internal insulation lining is removed or external insulation is applied.

7. Routinely inspect and replace the HVAC filters. Pay special attention to the main filters on AHU #3 and #4, which were inaccessible during the NIOSH inspection because the screws holding the access panels for these filters were rusted in place. Fix them to allow easy access to the filters for routine inspection.

8. Balance the HVAC system to provide appropriate air flow (15 cfm/person recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)) and outside air to all building occupants and minimize re-circulation of unfiltered plenum air introduced into the mixing boxes or the distribution chambers.

9. Confirm that all HVAC system components are functioning as programmed.

10. Inform future tenants of past problems with the building and actions taken to address them.

We recommend that both SCAO and the evaluated building managers take the following actions:

11. Develop and implement a written routine inspection and preventive maintenance plan for their respective buildings to prevent recurring problems in the previous building and the new building.

NIOSH environmental measurement data and analyses documented that the SCAO building is likely to have had indoor sources of microbial growth including fungi. Significant associations were observed between mold exposure in the building and self-reported asthma and cough.

Keywords: SIC 8399 (Indoor air, bioaerosol, mold, fungi, endotoxin, ergosterol, glucan, respiratory symptoms)

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INTRODUCTION

In November 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the safety committee chairperson for the Somerset County Assistance Office (SCAO) at 600 Aberdeen Drive, Somerset, PA. NIOSH had investigated the indoor air quality at the SCAO building in 1990 and found evidence of poor ventilation, but no indication of mold or fungal growth. At the time of the new request, the building had a history of water incursion from leaks in the roof, malfunction of the HVAC system, and contamination with mold and bacteria. There had been four reported cases of hypersensitivity pneumonitis (HP) and eight reported cases of doctor-diagnosed asthma among a staff of 68 employees. There also had been reports of several other health complaints including: sinus infections, breathing problems, bronchial infections, chronic fatigue, muscle aches, and irritation of the throat, nose and eyes.

NIOSH made an initial visit to the facility in March 2001. The purpose of the visit was to do a walk-through investigation of the building, to interview workers, and to administer a short screening questionnaire to better understand the reported respiratory health concerns. During the walk-through survey, we used Air-O-Cell cassettes to collect fungal spores from 4 locations in the indoor occupied space, one outdoor location, and two locations within the ventilation plenum area. Indoor spore counts (173, 160, 106, and 172 spores/m^3: average=153 spores/m^3) were similar to those from outdoors (106 spores/m^3). However, the fungal spore levels in the plenum (1,094 and 956 spores/m^3: average=1,025 spores/m^3) were, on average, 7 times higher than indoor levels, implying that there might be fungal contamination in the plenum or attic. In addition, the screening questionnaire that was administered to all employees identified six reported cases of HP and nine reported cases of doctor-diagnosed asthma. Based on these findings, NIOSH investigators decided to expand the survey with a second site visit for a more in-depth investigation.

The second site visit was conducted from July 25 through August 15, 2001. The aims of the second site visit were as follows:

1) to assess potential fungal contamination in the building and exposure levels of occupants;

2) to characterize respiratory symptoms among occupants;

3) to objectively test occupants' pulmonary function; and

4) to examine associations of symptoms or medical test results with environmental exposure.

To achieve those aims, we conducted the following surveys:

1) administration of a questionnaire to all employees from July 25 through 27, 2001;

2) medical tests offered to each employee from July 30 through August 3, 2001;

3) environmental sampling from July 30 through August 3 and from August 14 through 15, 2001; and

4) inspection of the ventilation system from August 7 through 10, 2001.

An interim report issued in June 2001 provided results of the ventilation system inspections. This final report provides the findings from the other surveys at this facility and serves to close out this health hazard evaluation.

BACKGROUND

The Somerset County Assistance Office (SCAO) building was located in Somerset, Pennsylvania, a rural area of the state about 70 miles southeast of Pittsburgh. SCAO is part of the Pennsylvania Department of Public Welfare and has a total staff of 68 employees who work between 7:00 am to 5:30 pm. SCAO provided assistance to approximately 125 clients per day in the interview area of the building.

The facility was completed and occupied in June 1987. It is a 13,500 square-foot, one-level structure, most of which has an open-area design with 4 to 6 foot partitions used to create individual workstations (cubicles). In addition to open office areas, there are

19 separate rooms including personal offices, staff room, conference room, seminar room, kitchen, and rest rooms. At the time of the NIOSH evaluation in 2001, floors in workstations were mostly carpeted with the exception of the reception area; and many employees used plastic floor mats on the carpet in their cubicles or offices. There were four air-handling units, each serving about a quarter of the building. The building was privately owned and leased to the Pennsylvania Department of Public Welfare.

The first NIOSH involvement with the building was in December 1990 when the director of SCAO asked NIOSH to evaluate potential health and comfort problems of employees. These complaints included skin and eye irritation, afternoon fatigue, lack of fresh air and poor air circulation, temperature extremes, low humidity, and cigarette smoke. NIOSH investigators conducted a general walk-through survey of the building in April 1991. NIOSH concluded that the health and comfort complaints reported were attributable to substandard ventilation and exposure to cigarette smoke.[2] There were no indications of mold growth in the building. NIOSH recommended that the ventilation system be adjusted to allow more fresh air into the building and that smoking be prohibited in all areas of the building. Smoking was subsequently prohibited in all parts of the building; however, there was no clear evidence that the ventilation system was adjusted accordingly.

Since 2000, water damage on the roof, floor, and walls have consistently been an issue of concern for the building occupants. SCAO has contracted environmental consulting companies to investigate the building environment several times and to make recommendations for remediation. In June 2000, Advanced Applied Sciences Incorporated (A2SI) was contracted by the Pennsylvania Department of Public Welfare to conduct an indoor air quality survey of the building. Air, swipe, and vacuum samples were taken for bacteria and fungi. A2SI reported that significant levels and types of bacteria and fungi were found in the carpeting, insulation materials, and the ceiling plenum, including *Aspergillus*, *Penicillium*, *Flavobacterium*, and *Rhodotorula*. A2SI recommended cleaning all carpeted surfaces in the building, fogging the ceiling plenum with Oxine®, repairing the roof, and replacing the insulation in some areas. In August 2000, fogging of the ceiling plenum and carpet cleaning were completed by Novatec, Inc. However, it was not clear that contaminated insulation was removed or replaced.

A post-remediation survey was conducted in September 2000 by A2SI to evaluate the efficacy of the remediation efforts. Although air and swipe sampling showed improved levels of bacteria and fungi, A2SI showed that floor dust had elevated levels of *Bacillus species* and *Flavobacterium species*. In addition, there was one sample with high levels of *Penicillium species*. Based on these findings, A2SI recommended monitoring and fogging of the building to control microbial growth until new carpeting could be installed.

In December 2000, A2SI did a follow-up survey and recommended re-balancing the HVAC system and replacing the carpet and insulation throughout the building. In the short-term, it was recommended that the carpet in the reception area be replaced with vinyl flooring, and that all damaged insulation and vapor barriers be replaced. The carpet in the reception area was replaced with vinyl flooring. A follow-up 2001 letter from A2SI indicated that "vapor barrier is in good condition and had apparently been repaired." An additional report by an independent consultant also recommended a complete air balance of the HVAC system. However, as of March 2001, a complete air balance of the HVAC system had not been done.

After the NIOSH survey described below, the SCAO vacated the building in December 2001 and moved to a newly constructed building nearby. The new building contains all new chairs, office furniture, and cubicles, except for furniture from the switchboard office and supervisors' office, telephones, typewriters, and other office accessories which were brought over from the evaluated SCAO building.

METHODS

Epidemiologic Survey

Questionnaire Survey

On the preliminary visit in March 2001, each employee was given a one-page self-administered questionnaire. The questionnaire inquired about lower and upper respiratory symptoms in the previous four weeks, work-related patterns of symptoms, asthma or hypersensitivity pneumonitis diagnoses, and the date he or she began working at SCAO. After completing the questionnaire, each participating employee returned it to NIOSH in a sealed envelope. Of 68 SCAO employees, 62 (91%) responded to the questionnaire.

The main epidemiologic survey at the SCAO Building was conducted from July 25 through August 15, 2001. It was a cross-sectional study to examine simultaneously participants' exposure and disease status at a certain time point. A cross-sectional study can provide information on possible associations between exposure and disease, but cannot confirm a causal relationship between exposure and disease. The study population of this cross-sectional survey consisted of all 68 full-time employees who were working at the building during the study period, and all employees were offered medical tests and were asked to answer a questionnaire.

After obtaining a signed informed consent, trained NIOSH interviewers administered the questionnaire face-to-face to SCAO employees and immediately recorded all responses in a Microsoft Access® database. Questions inquired about demographics, lower and upper respiratory symptoms in the previous 12 months, work-related patterns of symptoms, asthma, medication usage for breathing problems, work history, and home environment (Appendix B). Employees who were unavailable during the on-site interview were later contacted by telephone for consent and interview. All data entered into the database were validated by the interviewer's double-check of the data. From the questionnaire, probable HP cases were defined as subjects with one or more lower respiratory symptoms AND one or more systemic symptoms AND work-relatedness of the lower respiratory symptoms. To obtain the demographic information for all SCAO occupants, we later requested and received information on gender, race/ethnicity, and age of all employees at SCAO.

Medical Testing

Spirometry and Bronchodilator Response

Spirometry refers to the measurement of the volume and flow rate of exhaled air from individuals who are coached by trained technicians. Spirometry was performed using a dry rolling-seal spirometer (SensorMedics Spirometer, Yorba Linda, CA) interfaced to a computer using standardized techniques[3] to measure forced vital capacity (FVC), the volume of air forcefully exhaled from a maximal inspiration to a complete exhalation, and forced expiratory volume in one second (FEV1), the volume of air exhaled in the first second of the forced expiration. The ratio between the two (FEV1/FVC) was computed. The test results were compared to expected values for a healthy, nonsmoking person of the same age, height, sex and race.[4] Abnormal test results were categorized as having a pattern suggesting obstruction or restriction.[5] A bronchodilator (beta-agonist medication) was administered before a repeat spirometry test for those who did not have clearly normal spirometry.

Methacholine Challenge Test

The methacholine challenge test (MCT) measures the presence and degree of non-specific bronchial hyper-responsiveness (BHR). To detect BHR, MCT was performed using standardized techniques[6] with 5 different doses (0.125, 0.5, 2.0, 8.0, and 32.0 mg/mL) of methacholine (WVU Medical Center Pharmacy, Morgantown, WV). Five breaths of nebulized methacholine were administered for each dose, starting with 0.125 or 2.0 mg/mL depending on the individual's symptoms, and spirometry was measured 30 and 90 seconds after the fifth breath. If the highest FEV1 after any dose was greater than 80% of the highest baseline FEV1, the next higher dose of methacholine was administered. If the highest FEV1 was less than 80% of the highest baseline FEV1 at any dose, 2 puffs of bronchodilator were administered to assess post-bronchodilator FEV1. We reported methacholine dose as PC_{20}, which was defined as the provocative concentration of methacholine that caused a 20% or greater decline in FEV1 from the baseline. BHR was defined by PC_{20} less than 4 mg/mL.

Single-Breath Carbon Monoxide Diffusion Capacity Test

Single-breath carbon monoxide diffusion capacity (DLCO) is a type of pulmonary function test that measures the ability of carbon monoxide (CO) gas to pass across the lung tissue into the bloodstream. Testing was performed using Medgraphics pulmonary testing machine (Medical Graphics Corp., St. Paul, MN). DLCO was determined using standardized techniques.[7] In short, the patient inhaled a test gas through a demand valve from a gas tank which contained 10% helium, 0.3% CO, 21% oxygen, and the balance nitrogen. The test gas was held in the lungs for 10 seconds, and then the subject exhaled quickly. The mechanical and anatomical dead space air was discarded and an alveolar sample was collected in a chamber. The concentrations of helium and CO were then measured from this sample. A maximum of five trials was attempted to obtain at least two DLCO values that were within 5%. The mean value of those two was reported as DLCO. If the DLCO was below the limit of normal,[8] a subject was considered abnormal.

Exhaled Nitric Oxide

Nitric oxide (NO) gas, produced by various cells within the respiratory tract, is detectable in the exhaled air. The level of exhaled nitric oxide (eNO) is generally increased in subjects with airway inflammation such as asthma and rhinitis. NO was measured offline using standardized techniques.[9] Exhaled air collected in balloons (Sievers model 01410, Boulder, CO) was analyzed with a rapid-response chemiluminescence analyzer (Sievers model 280; Boulder, CO) for NO level. To evaluate work-relatedness of eNO level change, we measured eNO after the shift on the last work day of the first week (Thursday or Friday depending on the worker's work schedule), before the shift on the first work day of the second week (Monday or Tuesday), and after the shift on the last day of the second week (Thursday or Friday) during the study period. The average eNO level for each participant was computed by taking average values over three measurements.

Environmental Survey

Long -Term Air Sampling for Endotoxin and Ergosterol

Thirty indoor locations and two outdoor locations were selected for air sampling (Figure 1), and duplicate samples were taken at two of these indoor locations for endotoxin and one of these indoor locations for ergosterol. At each sampling location, long-term air samples for endotoxin and ergosterol were taken using pre-weighed 0.8-micrometer (μm) pore size polyvinyl chloride (PVC) filters (Omega, Chelmford, MA) assembled in 37-millimeter (mm) diameter polytetrafluroethylene (PTFE) open-faced cassettes (Millipore, Bedford, MA) at a flow rate of 5 liters per minute (L/min). Air sampling for endotoxin was performed during work hours (7 am to 5 pm) for 2.5 days (from Monday to Wednesday noon), and then the sampled cassette was replaced with a new one which was sampled for another 2.5 days (from Wednesday noon to Friday 4 pm). Airborne ergosterol was sampled 24 hours per day for 3 days because the limit of detection for sample analysis for ergosterol with gas chromatography-mass spectrometer (GC-MS) was high.

At the end of each sampling period, sample cassettes were stored in a cooler with desiccant bags in the field and during shipping. In the NIOSH weighing room, sampled filters were carefully removed from the cassette and re-weighed (ATI Cahn C-35, Boston, MA). Filters were then sent to the laboratories for sample analysis. Post-weighed filters for endotoxin were sent to the NIOSH laboratory and assayed with the Limulus amoebocyte lysate (LAL) assay using Kinetic-QCL™ kits (BioWhittaker, Walkerville, MD), and results were reported as endotoxin units (EU) per cubic meter (EU/m^3). Air filters for ergosterol were sent to the University of Lund, Lund, Sweden, and assayed with a gas chromatography-mass spectrometry (GC-MS) method, and reported as picogram per cubic meter (pg/m^3).[10] Two blank filters were also submitted for each integrated air sample for endotoxin and ergosterol; they were handled and assayed in the same way as sample filters.

Short-Term Air Sampling for Culturable Fungi and Fungal Spores

Airborne culturable fungi and fungal spores were sampled using single-stage multiple-hole impactors

(SKC, Eighty Four, PA) and Air-O-Cell cassettes (SKC, Eighty Four, PA), respectively, at each sampling location in the morning and afternoon on Monday and Thursday. Culturable fungi were sampled on malt extract agar (MEA) plates at 1 cfm (cubic feet per minute) for 5 minutes, and fungal spores were sampled at 15 Lpm for 5 minutes. Prior to collecting each sample, the impactor was cleaned with isopropyl alcohol. Duplicate samples for culturable fungi and fungal spores were taken from 15 of the 30 sampling sites within the building. Sampled agar plates and Air-O-Cell cassettes were directly sent by overnight delivery from the sampling site to the AIHA (American Industrial Hygiene Association) accredited Environmental Microbiology Laboratory (Daly City, CA) for analysis. Culturable fungi were incubated at room temperature and then fully speciated and reported as colony forming units per cubic meter (CFU/m^3) for each species. Airborne spore samples were counted by light microscopy and reported as number of spores per cubic meter ($number/m^3$) for each identified genera.

Particle Count, CO_2 , Temperature, and Relative Humidity Real-Time Monitoring

Three indoor sampling locations were chosen to monitor the number of suspended particles, carbon dioxide (CO_2), temperature and relative humidity 24 hours per day for 5 days. For comparison, the same parameters were also measured outdoors for about 24 hours on Wednesday and in the ventilation plenum for about 24 hours from Thursday morning to Friday morning. A mini-aerosol spectrometer (Grimm Technologies, model 1.108, Douglasville, GA) with a real-time data logger was used to measure one-minute averages of the number of suspended particles of 15 different aerodynamic size ranges from 0.3 μm to 20 μm. CO_2, temperature, and relative humidity were also monitored using a Q-Trak IAQ monitor (TSI, St. Paul, MN) with a data logger. Measurements were downloaded to a laptop computer to secure the data every day.

Settled Dust Sampling for Culturable Fungi, Endotoxin, Ergosterol, and (1→3)-β--D-glucan

Settled dust on the floor and chairs was separately collected through a crevice tool onto a 142-mm diameter glass fiber filter (Gelman Type A/E, Ann Arbor, MI) which was installed on a filter holder connected to a vacuum cleaner (L'il Hummer™ backpack vacuum, 100 cfm, 1.5 HP). Two square meters of area on the floor, including the whole floor mat and carpeted area at each sampling location, was vacuumed for a total of 5 minutes (1 minute for the floor mat, and 4 minutes for the carpeted floor). Seat, back holder, and arm holders of the main chair for each employee were also vacuumed for 5 minutes with a separate filter. Prior to collecting each sample, the filter holder was cleaned with water and dried with paper towels and a new filter was installed on the holder. All dust samples were stored with desiccant bags in a cooler in the field and during shipping. Dust sample filters were weighed at the NIOSH laboratory using a calibrated Mettler balance (AE240, Highstown, NJ). Collected dust were made into aliquots for various analyses such as culturable fungi, ergosterol, (1→3)-β-D-glucan, and endotoxin. Dust samples for culturable fungi were sent to the Environmental Microbiology Laboratory (Daly City, CA) for analysis. Fungi were cultured on MEA, cellulose agar, and DG18 (Dichloran-18% Glycerol) agar. Culturable fungi were fully speciated for each sample and reported as CFU/g for each species. Dust samples for endotoxin were sent to the NIOSH laboratory and assayed with the LAL assay using kinetic-QCL kits (BioWhittaker, Walkerville, MD), and results were reported as EU per milligram dust (EU/mg). Dust samples for ergosterol were sent to the University of Lund, Lund, Sweden, and assayed with a gas chromatography-mass spectrometry (GC-MS) method, and reported as picograms per milligram dust (pg/mg).[10] (1→3)-β-D-glucan was assayed with enzyme linked immunosorbent assay (ELISA)[11;12] and reported as nanograms per gram of dust (ng/g).

Ventilation System Assessment

The HVAC system in the SCAO building was assessed during the survey period. The details of the HVAC system evaluation have already been separately reported (Appendix A).

Data Analysis

Environmental results were initially assessed by examining the distributions of the raw data. If the data showed a right-skewed distribution, they were transformed by taking logarithms of each measurement to get a normal or approximately normal distribution which may give more efficient estimates. Geometric mean (GM) and geometric

standard deviation (GSD) were computed by exponentiating the mean and standard deviation of the log-transformed data. Two non-detectable spore trap samples were not included in computation of GM and GSD, and data analysis; it was suspected that these two samples were disconnected from the pump during sampling. In the analysis of fungal genera and species for airborne fungal samples, samples with non-detectable genera and species were not included in data analysis because statistical methods for treating missing values for each fungal genera and species have not been established. Adjusted geometric mean and standard deviation were also computed by controlling for some confounding factors in statistical regression models. The generalized linear regression models were used to test for significant differences of means of measurements among two or more groups, and test p-values were reported. For multiple comparisons, we adjusted test statistics using the Tukey-Crammer method.[13]

Environmental monitoring data such as particle counts, temperature, relative humidity, and carbon dioxide were plotted using 60-minute running averages of the one-minute average measurements reported by the Grimm or Q-Trak instruments over the past 60 minutes. This analytical technique gives smoother curves in graphs for those real-time monitoring data.

Questionnaire data were analyzed by examining the proportion of respondents with each symptom and the association of symptoms with environmental exposure. We used logistic regression models to examine the significance of the associations between health outcomes and exposures after controlling for confounding factors and reported odds ratios and 95% confidence intervals (95% CI). Odds is defined as the ratio of the probability of disease to the probability of no disease, and the odds ratio is computed by dividing odds for one group (high exposure group) by the odds for another group (low exposure group or reference group). Due to low participation (N=40) in the main questionnaire survey, we could not control for more than three confounding factors (age, gender, atopy status) in each logistic regression model. Environmental measurements (floor dust and air measurements) representative of each area (Figure 1) were assigned to all individuals working within the area. The environmental measurements were treated as continuous or categorical independent variables for examining associations with respiratory symptoms and reported asthma in the logistic regression models. Exposure measurements were dichotomized using a median value of the measurements to create binary variables.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs), (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®), and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). However, none of these sources provide standards or guidelines for bioaerosol exposure. Detailed discussion on this subject is in Appendix C.

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

RESULTS

Epidemiologic Survey

Demographics of Study Population and Results of the Initial Screening Questionnaire

Based on all 68 employees' demographic information obtained from a personnel representative, the majority of workers at SCAO were female (70.2%) and white (98.5%). The mean age of employees was 47.5 years, ranging from 26 to 78 years with a standard deviation of 9.6 years.

In the screening questionnaire administered in March 2001, 63 employees returned the questionnaire. Among those respondents, one person answered none of the symptom questions, and thus the person was excluded from the computation of symptom prevalence. The screening questionnaire data indicated 15% of responding employees had been diagnosed with asthma (9/61) (Table 1). In addition, 10% (6/62) of participants reported physician-diagnosed hypersensitivity pneumonitis (HP). In the screening questionnaire, nasal symptoms were the most commonly reported complaint among participants (69%), followed by systemic symptoms (flu-like achiness or joint pain, fever, chills, night-sweats, or unusual tiredness or fatigue) (62%). Lower respiratory symptoms were reported less frequently, which included coughing attacks (48%), chest tightness (26%), wheezing (23%), and shortness of breath attacks (20%). And 30% of occupants had both systemic symptoms and one or more work-related lower respiratory symptoms (probable HP). Approximately 63% of participants with one or more symptoms had not experienced any of these symptoms before beginning work at SCAO. Furthermore, 61% of participants considered their symptoms to be better away from work (Table 1).

Results from the Main Study Questionnaire

Participation in the main questionnaire survey in July 2001was considerably lower than in the March 2001 screening questionnaire, with only 59% of all employees participating (40/68). Fifty-eight percent of participants were female and the average age was 46.7 years, ranging from 23 to 63 years (only for respondents who answered the question about age; N=33) (Table 2). Only 3 people (8%) were current smokers and 65% of participants never smoked. On average, participants had been employed with SCAO for 14 years (standard deviation, SD= 8.6).

Among lower respiratory symptoms in the previous 12 months, shortness of breath was reported most frequently (52%) among study participants (Table 3). This was followed by chest tightness (40%), wheezing or whistling in the chest (38%), and usual cough (30%). Coughing for three consecutive months was reported by 25%. Only 20% of the participants reported dry cough without any phlegm. Seventy-eight percent of all respondents reported having at least one or more chest symptoms (defined as wheezing, chest tightness, shortness of breath, or cough) in the past 12 months. Sixty percent of respondents reporting wheeze reported their symptom to be better away from work, as did 24 to 40% of respondents reporting chest tightness, shortness of breath or chronic cough. The minimum chest symptom prevalence (any one of 4 lower respiratory symptoms) which was computed by dividing the number of symptomatic people by the total number of occupants working in the building was 43%.

The proportion of respondents reporting upper respiratory symptoms among study participants was very high, with 92% reporting nasal symptoms (stuffy or blocked nose, itchy nose, runny nose, or episodes of sneezing) and 90% reporting sinus symptoms (sinus headache, facial pain and/or pressure, postnasal drip or drainage in back of the throat, thick mucus from nose) in the previous 12 months (Table 4). The minimum prevalence of upper respiratory symptoms was about 50%. In addition, 85% of participants reported having itching, burning eyes in the last 12 months. Seventy-one percent of symptomatic respondents reported that eye symptoms were better when away from work. However, work-relatedness of nasal (43%) and sinus (39%) symptoms was less frequently reported than that of eye symptoms (71%).

Twelve (30%) of the study participants reported ever having asthma (Table 5). Nine of these reported that asthma had been confirmed by a physician or other health care provider. The mean age at first onset was 37.0 years, with a standard deviation of 14.4 years; only one case among them had asthma before being hired. Only one respondent with asthma had ever been treated for an acute attack of asthma or been

hospitalized for asthma, but half of the asthmatics reported asthma attacks in the past 12 months. Fifty-eight percent of the asthmatics considered their asthma to be better away from work, and no individuals reported asthma symptoms worsening away from work. Our questionnaire survey also identified 11 probable work-related HP cases. Six people reported having been diagnosed with HP by their physicians; however, two of them did not report lower respiratory symptoms associated with their work environment.

Respondents were asked to recall their use of medications for breathing problems in the previous 12 months (Table 6). Thirty-two percent of all participants had either used or been prescribed a beta-agonist inhaler in the past 12 months. Fifteen percent of respondents had reported taking corticosteroid inhalers, and 15% used an oral corticosteroid in the last 12 months. Forty-four percent (4/9) and 33% (3/9) of physician-diagnosed asthma cases reported use of inhaled corticosteroid and oral corticosteroids, respectively. However, 2 of those diagnosed with asthma by a physician and 3 self-reported asthmatics were not taking any medications.

In the main study in July, individuals who reported symptoms in the March questionnaire tended to participate more than those who did not report symptoms in March. Table 7 shows that the prevalence of respiratory symptoms in the screening questionnaire was higher among those who participated in the July 2001 survey than among those who did not participate in the July 2001 survey. Proportions of wheezing, chest tightness, shortness of breath, and coughing in the past four weeks were significantly ($p<0.05$) higher (33%, 39%, 31%, and 63%, respectively) for those who participated in the July 2001 survey than for those who did not (8%, 8%, 4%, and 28%, respectively).

Medical Tests

Of the 68 employees working in the building at the time of the August visit, 32 (47%) participated in the spirometry and MCT tests, 30 (44%) participated in DLCO test, and 36 (53%) participated in one or more eNO measurements.

The median FEV1 was 97.6% of predicted (range: 68.5 - 117.0%). Two employees had low FEV1 on spirometry and no response to bronchodilator; both had normal FEV1/FVC. Three employees had low FVC, but their total lung capacity (alveolar volume from the DLCO test) was normal. One DLCO test could not be interpreted due to poor technique, but all of the other employees had DLCO results which were within normal limits. None of the employees demonstrated bronchial hyperresponsiveness (BHR); in fact, all employees had a PC_{20} >32 mg/mL. One participant had a mildly elevated eNO, but the others were normal (<12 ppb).[14] We did not observe significant changes in eNO levels across the week. The mean and the median of 36 individual average eNO levels were 6.1 and 5.7 ppb (range 3.2 -14.7 ppb), respectively.

Environmental Survey

Total Fungal Spore Count in Air

The morning average fungal spore levels in the building were significantly higher than afternoon levels ($p=0.004$), and the levels of fungal spores on Thursday were also significantly ($p < 0.0001$) higher than those on Monday (Figure 2). Figure 3 shows the total airborne spore levels by indoor locations and outdoor. Of 180 samples taken indoors, 178 showed detectable levels of fungal spores. The fungal spore levels ranged from 53 to 1,427 spores/m^3, and the geometric mean (GM) was 348 spores/m^3 (geometric standard deviation (GSD)=1.87). The outdoor spore levels (8 samples) were about 60 times higher than indoors and ranged from 10,767 to 44,800 spores/m^3; GM was 20,654 spores/m^3 (GSD=1.62). Figure 3 also indicates that some locations (such as "AK", "JJ", and "KK2") showed significantly higher spore levels than others (such as "AF", "E", and "SS"). When the building was divided into four different zones served by four unique air handling units (AHU) (Figure 4), total spore levels in Zones 1 and 2 were significantly higher ($p < 0.03$) than Zone 4. The significant difference between Zones 1 and 4 appeared to be driven by spore levels of *Cladosporium,* and *Epicoccum* (Figure 5). However, the spore level of *Pithomyces* in Zone 3 was highest among the four zones, and multiple comparison with the Tukey-Crammer adjustment showed spore levels of *Pithomyces* in Zone 3 were significantly higher

than those in Zone 4 (p=0.02) and Zone 1 (p=0.04).

A total of 20 fungal genera were identified in spore trap samples taken indoors, and *Paecilomyces*-like fungi (n=2, average spore count (ASC)=747 spores/m^3), *Chaetomium* (n=1, spore count=13 spores/m^3), *Myrothecium* (n=1, spore count=13 spores/m^3), and *Ulocladium* (n=1, spore count=13 spores/m^3) were only found indoors although they were not found frequently (Figure 6). *Cladosporium,* basidiospores, *Epicoccum,* ascospores, and *Bipolaris/Drechslera* group fungi were identified in all outdoor samples. Average percentages of genus-specific spore counts to the total counts for fungal genera found both indoors and outdoors were higher in indoor samples than in outdoor samples except for ascospores (Figure 7).

Airborne Culturable Fungi

The levels of total culturable fungi found in air are shown in Figure 8. The number at each sampling location denotes the level of culturable fungi averaged over 4 samples (or 8 samples if there are duplicates) which were sampled in different days and times (AM/Monday, PM/Monday, AM/Thursday, and PM/Thursday). The indoor levels of total airborne culturable fungi ranged from 42 to 374 CFU/m^3 (GM=123 CFU /m^3, GSD=1.5), while outdoor levels ranged from 466 to 4,007 CFU/m^3 (GM=1,224 CFU/m^3, GSD=2.3). We recovered 55 species of fungi from indoor airborne fungal samples while only 15 species of fungi were recovered from outdoor samples. Forty fungal species were found only indoors (Figure 9). The most frequently found fungus indoors was *Cladosporium herbarum*, followed by *Epicoccum nigrum, Alternaria alternata, Basidiomycetes*, and yeast species. The most frequently found outdoor fungal species were *Cladosporium herbarum*, *Epicoccum nigrum*, *Alternaria alternata, Cladosporium sphaerospermum,* and *Aureobasidium pullulans*. The most abundant fungal species found both indoors and outdoors was *Cladosporium herbarum* (Figure 10). Average percent contribution of *Cladosporium sphaerospermum* to the total was higher than that of *Cladosporium herbarum* outdoors, but not indoors. Twenty *Penicillium* species were recovered from indoor samples; on the other hand, only 4 *Penicillium* species were recovered from outdoor samples. Figures 9 and 10 show that the composition of fungal taxa are different indoors and outdoors.

Within the building, levels and species of culturable fungi differed somewhat by AHU zone (Figure 11). Adjusted multiple comparisons showed that AHU Zone 3 had a significantly (p-values < 0.02) higher average level of total culturable fungi (n=52, GM=141 CFU/m^3, range=77-374 CFU/m^3) than Zone 2 (n=40, GM=115 CFU/m^3, range=42-261 CFU/m^3) and Zone 4 (n=52, GM=109 CFU/m^3, range=49-232 CFU/m^3); however, the differences were small. A similar pattern was shown for *Cladosporium herbarum*, *Penicillium*/*Aspergillus* species, and *Cladosporium sphaerospermum,* although the significance test results were a bit different (Figure 11). The level of all *Penicillium*/*Aspergillus* species in Zone 3 (n=27, GM=17 CFU/m^3, range=7-148 CFU/m^3) was significantly higher (p =0.02) than that in Zone 4 (n=27, GM=10 CFU/m^3, range=7-35 CFU/m^3) (Figures 11 and 12). The average indoor level (n=98, GM=13 CFU/m^3, range=7-148 CFU/m^3) of all *Penicillium*/*Aspergillus* species was marginally (p=0.11) higher than outdoors (n=5, GM=7 CFU/m^3, all samples were 7 CFU/m^3). Average level of *Epicoccum nigrum* was significantly (p-values < 0.02) higher in Zone 1 (number of detectable samples (n)=24, GM=14 CFU/m^3, range=7-56 CFU/m^3) than in Zone 3 (n=24, GM=9 CFU/m^3, range=7-28 CFU/m^3) and in Zone 4 (n=20, GM=7 CFU/m^3, range=7-21 CFU/m^3). However, all those differences were also very small and may have little biological implication. Zone 3 showed the most variety of fungal species (40 species) of all zones (Zone 1: 27 species; Zone 2: 34 species; Zone 4: 30 species), implying that certain species were only found in a certain AHU zone (Figures 13-14).

Airborne total culturable fungi levels were significantly (p < 0.001) higher on Thursday (n=90, GM=136 CFU/m^3, GSD=1.4) than on Monday (n=90, GM=112 CFU/m^3, GSD=1.4); however, the levels did not significantly vary between the morning and afternoon. The levels of culturable *Cladosporium herbarum*, *Epicoccum nigrum,* and *Alternaria alternata* followed the same pattern as the total fungi. However, the levels of all culturable *Penicillium*/*Aspergillus* species were not different by day but were different by time (AM and PM) within

a day; the levels in the afternoon (n=61, GM=15 CFU/m^3, GSD=1.1) were marginally higher (p=0.056) than those in the morning (n=37, GM=11 CFU/m^3, GSD=1.1). On the other hand, the level of culturable yeast *Rhodotorula* species was significantly (p=0.033) higher in the morning (n=38, GM=10 CFU/m^3, GSD=1.1) than afternoon (n=8, GM=7 CFU/m^3, GSD=1.2), but did not change by day. The level of culturable *Aureobasidium pullulans* and *Cladosporium sphaerospermum* did not change by sampling day or time of day.

Culturable Fungi in Settled Floor and Chair Dust Samples

A total of 46 culturable fungal species were identified in chair dust, and 37 species were identified in floor dust. The total culturable fungi in chair dust ranged from 4,400 to 199,800 CFU/g (GM=27,408 CFU/g, GSD=2.5), and in floor dust ranged from 400 to 28,000 CFU/g (GM=15,072 CFU/g, GSD=3.7) (Figure 15). *Cladosporium herbarum* (in more than 85% of samples), *Epicoccum nigrum* (in more than 80% of samples), and *Alternaria alternata* (in more than 70% of samples) were the most frequently found fungal species both in chair and floor dust. *Penicillium*/*Aspergillus* species were found in about 75% of chair samples and about 40% of floor dust samples. The total culturable fungi level was significantly higher in chair dust than floor dust ($p < 0.05$). *Cladosporium herbarum* and *Alternaria alternata* also followed the same pattern as the total culturable fungi level; however, the level of *Epicoccum nigrum* was not different between chair and floor dust. *Stachybotrys chartarum* (*atra*) was identified in 7 of 72 chair dust samples, and the range of this fungus was 400 - 15,000 CFU/g (Table 8 and Figure 16). Tables 8 and 9 show the levels (CFU/g) of selected culturable fungal species by the sampling locations for chair and floor dust samples.

A total of 77 fungal species were identified by culturing samples from air, chair dust and floor dust (Figure 17). Air samples showed the greatest number of fungal species. Twenty-four fungal species were only recovered in air samples, and 7 and 6 species were recovered only in chair and floor dust samples, respectively. The number of species found in both air and chair dust was 30, which is larger than the number of species found in both air and floor dust (22 species). Only 21 fungal species were found in all three types of samples (Figures 17 and 18). In terms of number and composition of species found from three types of samples, fungal flora in air resembles chair dust more than floor dust, since 9 of 16 (56%) fungal species found in chair dust but not in floor dust were also found in air, while 1 of 7 (14%) fungal species found in floor dust but not in chair dust were found in air.

Cladosporium herbarum was the only species found in more than 80% of the total samples (n=180) in air while *Cladosporium herbarum* and *Epicoccum nigrum* were the only individual species found in more than 80% of both chair and floor dust (Figure 18). *Penicillium* spp. were also frequently (more than 50%) found in air and chair dust, but less frequently (about 30%) in floor dust. *Aureobasidium pullulans,* all yeast spp. and *Eurotium amstelodami* were also more frequently found in chair than in floor dust while *Pithomyces chartarum,* and *Trichoderma koningii* were more frequently found in floor than in chair dust (Figure 18).

Endotoxin, Ergosterol, and β-(1,3)-D-Glucan

Airborne endotoxin levels by location are presented in Figure 19. Our two field blank filters were contaminated, and we could not identify the source of contamination. The levels of blank filters were 26.0, and 21.7 endotoxin unit (EU)/filter, which were higher than the median of the levels for air samples collected from Monday to Friday noon (range= 9.5-49.9 EU/filter; median= 16.65 EU/filter). Therefore, our airborne endotoxin measurements may not be representative of the true levels of endotoxin in air. Endotoxin levels in chair and floor dust are presented in Figure 20. Levels of endotoxin in floor dust (collected on carpet and floor mat) ranged from 0.5 to 14.1 EU/mg, and the geometric mean (GM) was 6.28 EU/mg which was significantly ($p < 0.0001$) higher than that in chair dust (range=1.2-9.7 EU/mg; GM=3.69 EU/mg).

On the other hand, the levels of (1→3)-β-D-glucan and ergosterol in chair dust were significantly (p-values < 0.0001) higher than those in floor dust (Figures 21 and 22). The levels of floor dust glucan ranged from 62 to 5,757 microgram (μg)/g dust (GM=1,610 μg/g dust which is equivalent to 1.6 μg/mg dust; GSD=2.3) and the levels of chair dust glucan from 898 to 10,272 μg/g dust (GM=3,466 μg/g dust equivalent to 3.5 μg/mg dust; GSD=1.6). The levels of floor dust ergosterol ranged from 69 to 2,555 pg/mg dust (GM=795 pg/mg dust; GSD=2.0) and the levels of chair dust ergosterol from 401 to 4,278 pg/mg (GM= 1,026 pg/mg dust; GSD=1.5). Airborne ergosterol was also measured and the levels ranged from non-detectable to 14.7 pg/m^3 (GM=2.8 pg/m^3; GSD=2.5); all measurements are shown in Figure 23.

Particles, Temperature, Relative Humidity, and Carbon Dioxide

The lowest particle counts were Monday morning. The number of respirable particles suspended in air started to increase each day immediately after the offices were occupied in the morning, and then continued to rise until around 7:30 to 8:00 pm when almost all employees were out and housekeeping personnel were finishing their cleaning (Figure 24). After that, the level decreased until the time when employees re-occupied the office areas the next morning. This characteristic pattern was shown throughout the work days during the week, and the general levels of particles appeared to gradually increase until late afternoon on Friday. The difference between the Monday morning level and the Friday afternoon level was more than 2 orders of magnitude. The number of respirable particles in the location AE1 (Figure 1) was lower than the other two locations (T-1 and KK-2). The outdoor particle levels were higher than the indoor levels, and the levels in the plenum were within the range of the occupied spaces. The respirable particle levels remained within 10,000 and 100,000 particles/liter for most of the time during the week after Monday afternoon (Figure 24).

The concentration of larger (inhalable) particles show an even more characteristic pattern which followed the level of human activity within the office space (Figure 25). They quickly increased with an increase of human activities and quickly decreased with decrease of human activities. The concentrations of larger, inhalable particles ranged from 10 to 70 particles/liter during the daytime when human activity was highest. During the nights, the concentrations went down to practically "none." The concentrations of larger particles were also lower in the location AE1 than any other locations monitored in the building, and the concentrations outdoors were generally similar to indoors during the daytime, and then suddenly increased to much higher concentrations than indoors. The concentrations in the plenum did not show higher particle counts than occupied spaces.

Temperature inside the building also showed a characteristic pattern according to human activity and operation of the ventilation system (Figure 26). The temperature started to increase with occupancy by the employees in the morning and increased more when the ventilation rate, which was controlled by variable air volume controllers, decreased at the time all occupants left. And the increased ventilation rate before 7:30 in the morning seemed to drop the temperature. Temperature in the building ranged from about 70 to 80°F. The temperatures measured at location AE-1 were lower by 4 -7°F than those in the two other office locations. The temperatures in the plenum were lower than those in locations T1 and KK2 during work hours, but higher than those in location AE1. Relative humidity (RH) varied between about 43 and 55%, and the RH levels in all monitoring locations within the occupied spaces of the building were similar (Figure 27). However, RH in the plenum was generally lower than that in occupied spaces. CO_2 concentration ranged from about 600 to 900 ppm during work hours, with the levels increasing when people started to occupy the space in the morning and decreasing at about 3:30 pm when people started to leave the building (Figure 28). The outdoor levels of CO_2 were lower than 400 ppm, which is the normal level for outdoor environments.

Association of exposure measurements with respiratory symptoms

We examined the associations of upper respiratory symptoms (nasal or sinus symptoms), eye irritation, lower respiratory symptoms (wheeze, shortness of breath, chest tightness, cough, dry cough, and/or breathing problem), reported allergy, reported asthma, and physician-diagnosed asthma and hypersensitivity pneumonitis with environmental

measurements (fungi, ergosterol, spore count, and endotoxin in air; fungi, endotoxin, ergosterol, and glucan in floor dust; and fungi, endotoxin, ergosterol, and glucan in chair dust). From these many analyses, we found a significant association of cough ("yes" to the question "Do you usually have a cough?") with (1→3)-β-D-glucan level in chair dust after controlling for age, gender and atopic status of an individual (Table 10). People with a level higher than the median of glucan in chair dust showed about a 5-fold increased risk (odds) of cough compared with those with levels of the median and lower. After we further controlled for age, the odds ratio still remained significant, but the confidence interval became very large (1.03 - 61.9), which means that the model was not efficient because of the small sample size (N=40).

Airborne ergosterol was significantly associated with self-reported asthma in a model adjusting only for gender. The odds of self-reported asthma were approximately 4-fold in persons with airborne ergosterol in the top half of exposure levels compared to those with lower ergosterol exposures (Table 10).

DISCUSSION

Medical Evaluations

Asthma

The NIOSH epidemiologic investigation found that the prevalence of ever having a physician-diagnosis of asthma was about 15% among occupants working in the Somerset County Assistance Office Building. The Behavioral Risk Factor Surveillance System (BRFSS) found from a national telephone interview survey that the prevalence of asthma estimated by the question of "Has a doctor ever told you that you have asthma?", was 10.5%. For the state of Pennsylvania, the same data source indicated that the prevalence of asthma from the first question was 9.3%.[15] The prevalence of self-reported physician-diagnosed asthma in the SCAO building (15%) is higher than the state (9.3%) and national (10.5%) statistics.

Despite an excess of reported physician-diagnosed asthma among the buildings occupants, we did not find objective evidence of uncontrolled clinical asthma in medical testing of most of those who volunteered for the survey. The volunteer group included most of those who had reported respiratory symptoms four months before medical tests, and a majority of this unrepresentative respondent group reported at least one chest symptom within the 4 months before medical testing. Three quarters of those reporting they had asthma were taking some medication for breathing problems, suggesting they had active disease requiring medication control. Eight of 12 asthmatics were taking corticosteroid medication, which suppresses inflammation and can lead to normalization of both bronchial hyperresponsiveness (reflected in the methacholine challenge test) and exhaled nitric oxide tests. Our inability to confirm uncontrolled asthma suggests that either: 1) most of the asthmatics were being treated adequately or had such mild asthma that clinical asthma tests were insensitive; or 2) those participants reporting asthma, did not have asthma. Other conditions that can lead to asthma-like symptoms include hypersensitivity pneumonitis or irritant cough, both of which can be building-associated.

Hypersensitivity Pneumonitis (HP)

Physicians diagnosing acute HP in very ill patients often find them to have: 1) low lung volumes (restriction) with a low DLCO; 2) chest X-ray infiltrates; 3) exposure to a recognized cause of HP; 4) flu-like symptoms (cough, shortness of breath, chest tightness, fever, chills, malaise, and myalgias) within 4-12 hours after exposure; and 5) antigen-specific IgG "precipitating" antibodies in the blood. However, pulmonary function tests and chest X-rays are not sensitive in acute disease,[16] and DLCO abnormalities occur largely in advanced chronic disease and transient acute disease episodes. Antigen-antibody reaction tests are not specific; the tests are a sign of exposure rather than disease. In building-related HP, the antigen is normally unknown and commercially-available precipitin tests are usually not helpful. Bronchial hyperresponsiveness (twitchy airways denoted by an abnormal methacholine challenge test) is found in about half of patients with clinical HP. In the setting of building-related HP, a small minority of the

symptomatic occupants may have objective abnormalities on usual screening tests, even in the presence of granulomatous change on lung biopsy in many of symptomatic co-workers.[17] Effective medical treatment can also reverse abnormalities in tests.

Our finding of borderline or normal tests in a population with a cluster of physician-diagnosed HP cases suggests that: 1) tested building occupants have not developed chronic severe lung disease; 2) treatment of physician-diagnosed cases may have led to improvements; and/or 3) participants reporting physician diagnoses or symptoms of respiratory and flu-like conditions may not have had HP. We were not able to obtain medical records of building occupants with physician diagnoses of HP to confirm either of these last two possibilities.

Regardless of the explanation of finding only six persons with borderline abnormalities that might reflect HP and asthma, both of these respiratory conditions are commonly found in occupants of buildings with water damage. Building-related asthma and HP can serve as important sentinels that other building occupants may be at risk. The sooner cases of these diseases are recognized, the better the outcome is of individual case patients. With early removal from further exposure to the implicated building environment, building-related asthma may resolve completely. With continued exposure, affected building occupants can develop irreversible chronic asthma that continues after removal from the building. Even after renovation of the conditions leading to water damage, some persons with building-related HP or asthma cannot return to the cleaned environment without having symptoms recur. This is thought to be due to immune system sensitization of HP cases which can lead affected individuals to react to low and even unmeasurable levels of microbial products that are amplified and disseminated in the setting of water-damaged building materials. The relocation of the SCAO staff to another building in December of 2001 has effectively eliminated SCAO employee exposure to the building environment at 600 Aberdeen Drive. However, new potential tenants in the former SCAO building may be subject to the previous risks of respiratory disease found in SCAO employees, if the building has not undergone remediation of conditions leading to water damage and replacement of water-damaged structural materials and contents.

Environmental Measurements

Comparison between Indoor and Outdoor Airborne Fungi

The comparison of fungal levels and of composition of fungal flora found indoors and outdoors is a useful tool for evaluating potential indoor fungal contamination.[18] We observed that the outdoor total fungal spore level and total airborne culturable fungi were much higher than those indoors, which is normal during the summer.[19;20] However, there was evidence that the indoor composition of fungal flora was different from the outdoor composition. Our spore samples showed that although most fungal genera (e.g., *Penicillium*/*Aspergillus*, *Alternaria*, rusts, *Polythrincium*, *Stemphylium* and *Torula*) were found more frequently outdoors than indoors (Figure 6), the average percent contribution of fungal genera to the total (spore count of specific fungi/total spore count) was higher indoors than outdoors (Figure 7).[18] Similarly, the average percent contributions to the total for almost all indoor culturable fungal species were higher than those outdoors (Figure 10). For some common fungal species (*Alternaria alternata*, *Basidiomycetes,* yeast *Rhodotorula* spp.*,* and other yeast spp. (neither *Rhodotorula* spp. or *Sporobolomyces* spp.)) recovered both indoors and outdoors, frequencies (percentage of detectable samples) were higher indoors than outdoors.

If there is no internal building source of fungi, the major source of indoor fungi is the outdoors, and the composition of indoor and outdoor fungal flora should be similar.[21] In a building with fungal contamination, the fungal flora composition would be different from outdoors because internal sources can modify indoor fungal composition.[16] Our spore count and culturable fungi data indicate that the indoor fungal flora in the SCAO building is different from the outdoors. These findings along with our observation of increased spore level in the plenum area and of water incursion through the roof reported in the interim report (Appendix A) imply that there may be internal sources contributing to indoor fungal flora in the SCAO building, resulting in indoor fungal composition different from outdoors.

However, we could not confirm the sources of fungi since none were obvious and we did not take any samples from hidden spaces (wall cavities, attic spaces etc).

All airborne culturable fungal species found outdoors (except for *Talaromyces flavus*) were also found indoors (Figure 10) and forty fungal species were recovered only indoors. However, less diverse fungal species outdoors than indoors may have been influenced by the small number of outdoor samples (n=8 outdoors versus n=180 indoors) and overgrowth of high concentration of *Cladosporium herbarum* which was a predominant outdoor fungal species. If we had collected as many outdoor samples as indoors, we might have found more diverse fungal genera and species, but this was not a practical way of outdoor sampling for our study purposes with limited resources. Possible culture plate overgrowth of this fungal species in the outdoor samples may have obscured the identification of other slower-growing fungal species, which may have reduced the diversity of fungal species found in the outdoor samples.

We observed significant differences of fungal concentration for some fungal genera and species among areas within the building and between indoors and outdoors. However, the levels of indoor fungi in the building were low, and those differences were very small and close to the limit of detection (13 spores/m^3 for airborne fungal spores and 7 CFU/m^3 for airborne culturable fungi). Therefore, the small differences of fungal levels may have little biological implication to human health although the differences were statistically significant.

Space- and Time-Varying Characteristics of Indoor Airborne Fungi

Occupants in the SCAO building seemed to be exposed to different levels of total fungal spores at different times within a workweek (Figure 2). The exposure to fungi in the building increased toward the end of the week (spore levels on Thursday were significantly higher than on Monday). Fungal spores released from sources inside the building or infiltrated from outdoors or re-suspended from secondary sources such as floor or chairs due to human activity may be suspended in air for a long time and accumulate in air over the workweek. This pattern was shown from real-time monitoring data of respirable particles in air (Figure 24). Among the fungal species found in the building, spore sizes for some abundant species such as *Aspergillus niger, A. versicolor, Cladosporium cladosporiodes,* and many *Penicillium* species are smaller than 3 μm in aerodynamic diameter. These small particles take more than 2 hours to settle from a two-meter height to the floor in still air.[22-24] This settling time would be much longer in turbulent air with human activity, vacuuming and cleaning after work, and ventilation. However, the temporal variation of levels of fungal spores within a day appeared to be dependent upon the species of fungi present in the building. Some workers in some areas within the building may have also been exposed to a higher level of some fungi than those in others. In general, air handling unit (AHU) Zones 1 and 3 appeared to have the highest level of fungi, and AHU Zone 4 seemed to have the lowest fungal concentration in air. However, the concentration gradient in the building may not be an important factor for those who are already sensitized to some fungal allergens because sensitized people can be reactive to tiny amounts of allergen.

Distribution of Fungal Taxa among Air, Chair, and Floor Samples

Penicillium spp. (*P. citrinum, P. commune, P. digitatum, and P. minioluteum*) were most frequently found among the 24 airborne-only species, half of which were *Penicillium*. Since *Penicillium* spp. produce small spores (many less than 3 μm aerodynamic diameter), the spores could be suspended in air for relatively longer times than larger spores. Among 21 species common to air, chair dust, and floor dust, the fungi most frequently found were *Cladosporium herbarum, Epicoccum nigrum,* and *Alternaria alternata* (Figure 18) which are all phylloplane fungi (which colonize and are disbursed from plant leaves).[25] Considering that the area surrounding the SCAO building is covered with trees, bushes, grasses, and many other wild plants, those fungi would be expected to be the most frequent and abundant species in both indoor and outdoor environments.

We found *Stachybotrys chartarum* in about 10% of chair dust samples. We also found *Botrytis cinerea* in both air and chair dust. Both fungi are hydrophilic (only grow in very damp conditions). *Stachybotrys chartarum* does not compete well with other fungi (mesophilic or xerophilic fungi) which can grow in less damp conditions than hydrophilic fungi– that is, they grow slowly when they are cultured with other fungi.[26] On the other hand, *Stachybotrys chartarum* will predominantly grow in the condition of high water availability in environmental materials, especially cellulose-containing materials.[27] While *Penicillium* and *Aspergillus* spores are easily released into air, *Stachybotrys chartarum* spores do not easily become airborne because the spores are sticky and wet, causing them to agglomerate to form larger aggregate particles.[28] For those reasons, culture methods do not easily recover *Stachybotrys chartarum* from the air, and the spore trap method is often recommended for demonstration of the presence of this fungus by analytical laboratories.[27] However, we did not find these fungi in air with spore trap sampling. Detailed information about health effects of exposure to *Stachybotrys chartarum* in indoor environments can be found in the report issued by the California Department of Health Services (Appendix D).

Endotoxin and Other Fungal Component Exposure

Blank sample analyses indicated that our airborne endotoxin samples were contaminated during our sampling or shipping or analytical procedures. We could not identify the point of contamination, and thus we could not interpret our airborne endotoxin results. For dust endotoxin levels, we can not easily compare the results from different studies using different endotoxin assay methods due to different sampling media and extraction procedures, and different methods of estimating potency.[29-35] However, the geometric mean levels of endotoxin in chair dust (3.7 EU/mg) and floor dust (6.3 EU/mg) at the SCAO building appeared to be slightly lower than those found in chair (5.6 EU/mg) and floor (7.8 EU/mg) dust that NIOSH collected from a hospital environment with water damage and assayed with the same methods.[36]

Ergosterol and (1→3)-β-D-glucan are surrogate measures for fungal exposure in the environment.[8;37] Since the fungal concentration in air is extremely variable in time and space, it is very hard to accurately classify exposure levels of occupants to airborne fungi with snap-shot (4 to 5 minutes) sampling unless we take many expensive air samples. Ergosterol and (1→3)-β-D-glucan measurements allowed long-term air sampling for exposure assessment to fungi in this epidemiologic study, which may overcome the limitations of traditional snap-shot sampling methods for airborne culturable fungi. However, these many-hour, long-term methods are still under active investigation to evaluate their usefulness and representativeness for fungal exposure assessment. To date, insufficient data exist from other studies to interpret our measurements in terms of health implications.

Association of Respiratory Symptoms with Environmental Measurements

Our epidemiologic questionnaire documented that the majority of symptomatic building occupants in the screening survey in March (Table 1) and 24-60% of participants in the August survey (Table 3) reported work-related exacerbation of their symptoms. Work-related chest symptoms suggest that the SCAO building environment may have adverse health effects on its occupants, although only 17% of participants with any medical test had a borderline abnormality. However, the associations between indices of mold exposure and reported health outcomes support the possibility that mild building-related respiratory disease was present among SCAO occupants at the time of our evaluation. Specifically, we found very large excess risks of asthma and cough in those with higher mold exposure in air and chair dust, respectively, compared to those with lower exposure. These are among the first findings linking mold exposure to respiratory health conditions using innovative measures to characterize environmental mold exposures. Additional studies of this kind at other buildings in the future may provide a way to predict health effects from measured levels of glucan and ergosterol.

We chose (1→3)-β-D-glucan as a surrogate measure for assessing mold exposure since it is a component of mold cell walls. The level of glucan is positively associated with fungal level in dust,[37] and glucan itself induces inflammation in airways.[38] Rylander et al.[39] demonstrated that students at a moldy school building showed significantly increased prevalences of dry cough and cough at night without colds for both atopic (defined as hereditary or familian predisposition to produce IgE antibodies to environmental allergens and develop allergic disease) and non-atopic children. Atopic children in a moldy school building had significantly increased prevalence of cough with phlegm than did students at a control school with no mold problem. And the airborne levels of (1→3)-β-D-glucan were significantly higher in the moldy school than in the control school. In our investigation, we obtained a high odds ratio (greater than 5) for usual cough in relation to (1→3)-β-D-glucan exposure even after controlling for individual atopic status. It seems likely in this cross-sectional study that the association between glucan and cough suggests that glucan or another environmental agent paralleled by glucan measurement has caused disease.

Similarly, our finding of higher ergosterol measurements in the air around occupants reporting asthma is evidence that a building factor has caused the excess asthma among SCAO employees. Ergosterol, like glucan, is a primary cell membrane sterol of mold. These two long-term sampling indices of mold exposure have produced similar associations with respiratory symptoms. We did not find such associations with spore concentrations and culturable fungal samples, which are likely much less representative of exposure because of their short sampling times. Little literature exists evaluating ergosterol as an index of indoor mold exposure. It has been reported that ergosterol level is associated with the number of spores and the surface area of a spore.[40] Saraf *et al.* also showed that ergosterol is a reproducible measure for total fungal biomass in indoor environments.[10] Results of the SCAO health hazard evaluation suggest that these environmental measurements have promise as a way of predicting respiratory health hazards in water-damaged buildings. Our findings of association of cough and asthma with bioaerosol exposure in the office building environment are consistent with and extend the substantial epidemiologic evidence that home dampness and indices of mold exposure from questionnaire and environmental investigation increase the risk of asthma and respiratory symptoms.[41-43] For office building environments, the evidence that moisture incursion can contribute to asthma is less developed, although evidence of increased risk of respiratory disease among occupants of damp buildings has been accumulating.[44-50] However, the association between respiratory health and objective environmental measurements of fungal exposure is not yet consistent. Inconsistent findings in the scientific literature may be due to the lack of objective and sensitive measures for diagnosis of mold-related allergic diseases, as well as the limitations of traditional air sampling methods for culturable fungi. Research on fungal allergens, which provides an objective measure for diagnosing allergic diseases to fungi, has been slow because there are still many problems to be resolved, such as the multiplicity and variability of allergens, extraction of allergens, and variation in allergenic potency of extracts. Nevertheless, many fungal species have been implicated as having allergenic features.

The most commonly recognized fungal allergens are *Alternaria*, *Cladosporium*, *Aspergillus* spp., and *Penicillium* spp., which are commonly found in the indoor environment and were also found in the SCAO building. A 1992 workshop in the Netherlands recommended indicator fungi which may implicate moisture presence or a potential health effect. Those microorganisms are *Trichoderma*, *Exophiala*, *Stachybotrys*, *Phialophora*, *Fusarium*, *Ulocladium*, yeasts (*Rhodotorula* species), *Aspergillus versicolor*, *Eurotium* and *Wallemia* spp., and *Penicillium* species.[21] In the SCAO building, all of those fungal genera, except for *Exophiala* and *Phialophora*, were found in either air, or floor dust, or chair dust samples. Unfortunately, no official standards for fungal exposure level indoors currently exist because a dose-response relationship between fungal exposure and health has not yet been clearly demonstrated.[22] However, the type of fungi in the SCAO building and their indoor/outdoor ratios seem

to substantiate its history of water damage and the plausibility of associated health effects.

Limitations of the Study

In our investigation, we examined participants for asthma and hypersensitivity pneumonitis using objective medical tests, and sampled environmental bioaerosols using objective measures to demonstrate the association of bioaerosol exposure and respiratory diseases. Our study was limited by several factors. First, our epidemiological analyses involved a limited number of participants (N=40) due to the small number of people in the building (N=68) and the low rate of participation. We obtained high participation (93%) in the short (screening) questionnaire survey; however, the participation rate for the main study was only 59%, and participation was even lower for objective medical tests. Our statistical models were inefficient (wide confidence intervals) with this small sample size, which limited our ability to control for potential confounding factors– that is, some strata in the statistical models had too few subjects. Second, participation bias was introduced because those who had reported respiratory symptoms in the screening survey were more likely to participate in the main study than those who had not reported symptoms. We examined the exposure levels for glucan in chair dust in the nonparticipants, and found they were equally distributed between low and high exposure categories. We re-estimated odds ratios using the conservative assumption that all nonparticipants were non-diseased, which reduced the odds ratio for cough only slightly to about 4. This indicates that participation bias was not likely to account for the strong associations found, although we might have slightly overestimated the magnitude of risks. Third, we were unlikely to have obtained representative individual exposure levels for airborne culturable fungi or spores because our area samplings did not directly measure personal exposure and those indoor levels are highly variable, and thus four grab samples per week (two per day on Monday and Thursday) are probably insufficient to accurately assess their exposure. Such exposure misclassification usually makes it difficult to demonstrate statistical associations when they, in fact, exist, as suggested by our longer term sampling of mold components, ergosterol and (1→3)-β-D-glucan.

CONCLUSIONS

Our environmental survey showed that (1) more diverse fungal genera and species were detected indoors than outdoors, and that (2) for some fungi such as *Penicillium* and *Aspergillus* species, *Epicocum*, or *Alternaria,* the average indoor levels were higher than outdoors when expressed as percent of total fungal level. These findings implied that the SCAO building is likely to have been contaminated with mold.

Our epidemiologic investigation showed that the prevalence of work-related respiratory symptoms was high among building occupants, and that higher levels of airborne ergosterol and higher concentrations of (1→3)-β-D-glucan in chair dust were significantly associated with more than 4-fold increased risks of self-reported asthma and self-reported cough. Because ergosterol and (1→3)-β-D-glucan are biological markers of mold, our results suggested that the respiratory symptoms of building occupants were related to mold exposure in the building. Respiratory symptoms appeared to be mild according to the objective medical tests.

RECOMMENDATIONS

Based on our investigation, we recommend the following for the SCAO manager, employees, and the manager of the previous building:

We recommend that the SCAO manager take the following actions:

1. Replace or clean the water-damaged furniture which may have been brought from the evaluated building to current SCAO offices.

We recommend that employees take the following actions:

2. Consult a doctor for persistent or work-related lower respiratory symptoms such as wheeze, chest tightness, shortness of breath and/or cough or a combination of work-

related lower respiratory symptoms and systemic symptoms (such as fever/chill, flu-like/muscle achiness, weight loss of 10 pounds or more). Objective medical tests can help your doctor diagnose the respiratory condition and its severity, and may help establish that it is work-related.

We recommend that the manager of the evaluated building take the following actions to protect future tenants:

3. Fix or renovate areas with water incursion (roof, walls, and floor). Especially, repair the damaged roof to prevent condensed water from the air handling units (AHUs) from leaking through the roof.

4. Redirect the drainage from the AHU drain traps directly to the gutter, at least until the damaged roof is completely repaired.

5. Replace any water damaged building materials and water-stained carpet or ceiling tiles.

6. Inspect internal insulation linings of HVAC systems for degradation. Remove all degraded internal linings and install external insulation on the ducts with degraded internal linings that carry supply air from the AHUs. Make sure that occupants are not exposed to insulation fibers while the internal insulation lining is removed or external insulation is applied.

7. Routinely inspect and replace the HVAC filters. (Pay special attention to the main filters on AHU #3 and #4, which were inaccessible during the NIOSH inspection because the screws holding the access panels for these filters were rusted in place. Fix them to allow easy access to the filters for routine inspection.)

8. Balance the HVAC system to provide appropriate air flow (15 cfm/person recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)) and outside air to all building occupants and minimize re-circulation of unfiltered plenum air introduced into the mixing boxes or the distribution chambers.

9. Confirm that all HVAC system components are functioning as programmed.

10. Inform future tenants of past problems with the building and actions taken to address them.

We recommend that both SCAO and the evaluated building managers take the following actions:

11. Develop and implement a written routine inspection and preventive maintenance plan for their respective buildings to prevent recurring problems in the previous building and the new building.

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Table 1. Reported conditions and symptoms, March 2001 screening questionnaire

Characteristic	Percentage (numbers*)
Physician-diagnosed asthma	15 (9/61)
Physician-diagnosed hypersensitivity pneumonitis	10 (6/62)
In the past four weeks:	
Lower respiratory symptoms	
Coughing attack	48 (29/60)
Chest tightness	26 (16/61)
Wheezing	23 (14/61)
Shortness of breath attack	20 (12/61)
Systemic symptoms†	62 (38/61)
AND one or more lower respiratory symptoms	42 (25/60)
AND one or more lower respiratory symptoms AND work-relatedness of symptoms‡	30 (18/60)
Upper respiratory symptoms	
Nasal symptoms (apart from a cold)	69 (43/62)
For those reporting one or more of the above respiratory and/or systemic symptoms	
Any of the above respiratory or systemic symptoms prior to working for SCAO:	16 (8/49)
Yes	63 (31/49)
No	20 (10/49)
Don't know	
Any change in reported respiratory or systemic symptoms when away from work on weekends or vacations:	
Better	61 (28/46)
Worse	0 (0/46)
Same	28 (13/46)
Don't know	11 (5/46)

* Denominator varies because the number of respondents for the specific questions varied with the question.
† Defined by having any of the following signs or symptoms: flu-like achiness or joint pain, fever, chills, night-sweats, or unusual tiredness or fatigue.
‡ Work-relatedness was defined as "getting better away from work on weekends or vacations."

Table 2. Demographics of participants, July 2001 main questionnaire

Characteristic	Percentage (numbers) or mean ± standard deviation
Gender (Female)	58 (23/40)
Race (White)	98 (39/40)
Age (n = 33 respondents)	46.7 ± 8.4
Years Employed at SCAO	14.0 ± 8.6
Smoking status	
Current smoker	8 (3/40)
Former smoker	28 (11/40)
Never smoker	65 (26/40)

Table 3. Reported lower respiratory symptoms in the past 12 months and work-related patterns, July 2001 main questionnaire

Symptoms	Percentage (numbers*)	Minimum prevalence (number †)
Any chest symptom‡	78 (31/40)	46 (31/68)
Wheezing	38 (15/40)	22 (15/68)
Symptom away from work:		
Same	33 (5/15)	
Better	60 (9/15)	
Worse	7 (1/15)	
Chest tightness	40 (16/40)	24 (16/68)
Symptom away from work:		
Same	69 (11/16)	
Better	31 (5/16)	
Worse	0 (0/16)	
Shortness of breath	52 (21/40)	31 (21/68)
Symptom away from work:		
Same	76 (16/21)	
Better	24 (5/21)	
Worse	0 (0/21)	
Cough (usual)	30 (12/40)	18 (12/68)
Cough for three consecutive months	25(10/40)	15(10/68)
Symptom away from work:		
Same	60 (6/10)	
Better	40 (4/10)	
Worse	0 (0/10)	
Dry cough without phlegm	20 (8/40)	12 (8/68)

* Denominator varies because the number of respondents for the specific questions varied.
† Minimum prevalence was computed by dividing the number of symptomatic people by total number of occupants working in SCAO.
‡ Any chest symptom was defined as any wheezing, chest tightness, shortness of breath, or cough in last 12 months

Table 4. Reported upper respiratory symptoms in the past 12 months and work-related patterns, July 2001 main questionnaire

Symptoms	Percentage (numbers*)	Minimum prevalence (number †)
Nasal symptoms	92 (37/40)	54 (37/68)
Symptom away from work:		
Same	57 (21/37)	
Better	43 (16/37)	
Worse	0 (0/37)	
Sinus symptoms	90 (36/40)	53 (36/68)
Symptom away from work:		
Same	61 (22/36)	
Better	39 (14/36)	
Worse	0 (0/36)	
Itchy, burning eyes	85 (34/40)	50 (34/68)
Symptom away from work:		
Same	29 (10/34)	
Better	71 (24/34)	
Worse	0 (0/34)	

* Denominator varies because the number of respondents for the specific questions varied.
† Minimum prevalence was computed by dividing the number of symptomatic people by total number of occupants working in SCAO.

Table 5. Description of persons reporting asthma and hypersensitivity pneumonitis, July 2001 main questionnaire

Characteristic	Percentage (numbers) or mean ± standard deviation
Asthma	
Reported ever having asthma	30 (12/40)
Physician-diagnosed asthma	22 (9/40)
Age at first onset (n = 12)	37.0 ± 14.4
Treatment of acute asthma attack at ER or MD office	8 (1/12)
Ever hospitalized for asthma	8 (1/12)
Asthma attack in past 12 months	50 (6/12)
Asthma symptoms away from work:	
Same	42 (5/12)
Better	58 (7/12)
Worse	0 (0/12)
Asthma in the year prior to hire	8 (1/12)
Hypersensitivity Pneumonitis (HP)	
Physician-diagnosed HP	15 (6/40)
Probable work-related HP*	28 (11/40)
Physician-diagnosed HP (among those with probable work-related HP)	36 (4/11)
Physician-diagnosed asthma (among those with probable work-related HP)	18 (2/11)

* Probable work-related HP was defined as one or more lower respiratory symptoms (cough, wheeze, shortness of breath, and chest tightness) AND one or more systemic symptoms (fever/chill, flu-like/muscle achiness, weight loss of 10 pounds or more) AND work relatedness of the lower respiratory symptoms (getting better away from work).

Table 6. Medication use for breathing problems in the past 12 months, July 2001 main questionnaire

Characteristic	Percentage (numbers)
Bronchodilator (beta-agonist) inhaler	32 (13/40)
Used on daily basis	39 (5/13)
Over-the-counter medications	5 (2/40)
Corticosteroid medication*	20 (8/40)
Other medications for breathing problems	18 (7/40)
Any medications for breathing problems among 12 self-reported asthmatics	75 (9/12)
Any medications for breathing problems among 9 physician-diagnosed asthmatics	78 (7/9)

* Two of the 8 corticosteroid users used only inhaled corticosteroids, and two used only oral corticosteroids.

Table 7. Symptom prevalences in participants and non-participants in the July 2001 main questionnaire, based on data from the March screening questionnaire

Symptom	Percentage (numbers)	
	Participants	**Non-participants**
Wheezing*	33 (12/36)	8 (2/25)
Chest tightness†	39 (14/36)	8 (2/25)
Shortness of breath*	31 (11/36)	4 (1/25)
Cough†	63 (22/35)	28 (7/25)

* p-value < 0.05, based on chi-square.

† p-value < 0.01, based on chi-square.

Table 8. Levels (CFU/gram dust) of selected fungi cultured from chair dust samples at each sampling location*

Location	Total	*Clado_herba*	*Alter_alter*	*Epico_nigru*	*Penic/Asper*	*Stach_chart*
E	17,500	7,700	.	3,200	1,400	.
F1	103,70	53,800	11,500	19,200	7,700	7,700
F2	0	.	6,700	13,300	.	.
G	86,700	10,000	10,000	15,000	10,000	.
G3	50,000	4,000	12,000	.	.	.
H1	40,000	17,600	.	.	11,800	.
I1	105,80	14,800	1,500	3,000	3,000	.
I2	0	9,500	9,500	19,000	4,800	.
J1	26,400	8,800	800	3,600	1,200	800
L1	57,100	3,800	.	2,900	1,700	.
L2	18,000	3,200	1,100	2,500	700	.
K1	15,200	2,400	2,800	2,000	800	.
K2	11,200	3,200	800	1,200	2,400	.
M1	13,200	1,100	700	400	400	.
M2	10,400	.	.	4,800	1,300	.
N	9,500	.	1,300	.	900	.
P	7,700	18,900	2,900	2,500	1,500	.
Q	4,400	1,500	800	3,800	1,600	.
R	47,200	4,200	8,300	8,300	4,200	.
R3	16,600	.	500	1,600	1,600	.
T1	29,200	20,000	5,000	.	5,000	.
T2	8,400	17,400	.	4,300	.	.
S1	70,000	54,500	13,600	31,800	.	.
S2	43,400	7,400	18,500	7,400	7,400	.
U1	104,40	.	13,000	13,000	8,700	.
U2	0	.	15,400	.	.	.
V1	55,500	20,000	5,000	15,000	.	15,000
V2	43,400	18,800	6,300	.	.	.
X1	88,400	30,000	10,000	10,000	15,000	.
X2	90,000	5,900	11,800	.	5,900	.
W	56,500	19,000	9,500	9,500	.	.
Y	85,000	54,500	9,100	18,200	.	.
Y3	58,900	4,500	13,600	13,600	13,600	.
CC	71,500	.	.	15,400	7,700	.
DD	127,20	3,800	1,300	3,300	.	.
EE	0	11,100	.	27,800	5,600	.
FF	54,300	7,700	.	6,400	500	.
GG	38,400	5,400	2,900	7,100	2,500	400
	13,700					
	66,800					
	16,900					
	19,500					

* The full names (Genus and species names) for the fungal species in this table are in Appendix E.

Table 8 (continued). Levels (CFU/gram dust) of selected fungi cultured from chair dust samples at each sampling location*

Location	Total	*Clado_ herba*	*Alter_ alter*	*Epico_ nigru*	*Penic/ Asper*	*Stach_ chart*
QQ	13,200	3,100	.	400	800	.
SS	25,000	.	4,200	8,300	.	.
JJ	9,100	3,300	.	1,700	800	.
KK1	14,600	3,300	2,100	7,100	1,700	.
KK2	14,200	400	.	.	13,000	.
AS	60,700	8,700	4,300	8,700	.	.
LL	11,600	7,900	.	.	.	.
MM	12,500	800	.	2,100	2,100	.
NN	12,800	3,200	1,400	2,700	500	.
OO	14,000	4,500	.	.	5,000	.
AK	73,700	17,400	13,000	.	8,600	.
AL	16,900	2,100	.	1,400	2,100	.
AM	16,700	7,100	2,500	2,900	1,700	.
AN	76,100	13,900	1,300	4,800	3,000	.
TT	17,200	6,100	700	700	2,800	.
UU	20,100	10,400	2,300	3,100	1,200	.
VV	9,200	800	1,200	3,200	2,400	.
WW	20,600	10,000	.	1,300	2,100	.
AI	44,400	14,800	11,100	.	.	.
XX1	79,200	12,500	12,500	16,700	.	.
XX2	145,400	18,200	.	22,700	.	.
ZZ1	26,100	6,400	900	900	1,400	.
ZZ2	11,200	.	400	1,200	2,800	.
AB1	12,500	3,300	.	1,700	1,700	.
AB2	11,400	3,300	700	1,500	1,800	.
YY	77,700	25,900	.	.	7,400	.
AG	16,200	6,500	1,500	1,200	2,700	.
AH	9,600	3,300	700	3,000	800	400
AC	199,800	33,300	33,300	44,400	.	.
AD	10,100	2,300	1,500	1,200	800	400
AD3	7,800	900	1,800	.	1,400	.
AE1	5,600	.	2,200	1,500	1,100	.
AE2	13,900	3,000	700	2,200	1,500	400
AF	81,700	18,200	4,500	4,500	.	.

* The full names (Genus and species names) for the fungal species in this table are in Appendix E.

Table 9. Levels (CFU/gram dust) of selected fungi cultured from floor dust samples at each sampling location*

Location	Total	*Clado_herba*	*Alter_alter*	*Epico_nigru*	*Penic/Asper*	*Stach_chart*
E	11,100	5,800	.	2,500	.	.
F2	19,500	10,000	.	5,200	400	.
H2	400	.	.	.	.	.
I1†	213,900	3,500	1,300	400	205,200	.
L2	9,500	2,600	1,300	5,200	.	.
K2	16,600	8,100	2,300	2,700	.	.
N	6,500	1,800	.	2,300	.	.
P	5,600	2,000	800	1,200	1,200	.
Q	9,600	4,000	.	4,400	.	.
R	100,100	28,600	14,300	23,800	23,800	.
U2	15,600	8,300	3,500	1,700	.	.
V2	10,800	2,700	1,900	3,800	.	.
Y	11,600	5,800	2,500	2,900	.	.
CC	168,250	48,700	38,700	14,350	60,000	.
EE	18,000	7,500	2,000	4,500	.	.
EE†	2,000	800	400	.	.	.
FF	12,500	3,300	.	4,600	1,700	.
GG	17,900	11,300	800	4,200	800	.
SS	15,900	4,400	1,100	3,000	700	.
JJ	19,200	10,000	2,400	6,000	.	.
KK	5,800	.	.	.	400	.
NN	5,800	.	.	3,600	.	.
AK	20,400	9,600	2,500	2,500	800	.
WW	60,100	20,000	26,700	6,700	.	.
AI	18,700	12,000	1,300	4,000	700	.
XX	72,900	23,100	15,400	3,800	.	.
AB	12,400	3,300	3,300	5,000	.	.
AG	15,100	2,500	1,300	.	1,900	.
AH	6,200	1,700	.	2,200	600	.
AC	60,700	26,100	4,300	.	.	.
AE2†	1,700	600	.	1,100	.	.
AF	14,500	5,500	1,800	4,500	900	.

* The full names (Genus and species names) for the fungal species in this table are in Appendix E.

† Samples were taken from under the floor mat.

Table 10. Adjusted odds ratios of self-reported asthma and cough in relation to environmental measurements*

Outcomes (Number)	Exposure Measurements		Adjusted Factors	Odds Ratio	95% Confidence Interval
	≤50 percentile	>50 percentile			
Self-reported asthma	Airborne ergosterol level				
Yes (12)	4	8	none	4.2	1.002-17.8
No (28)	19	9			
Self-reported asthma	Airborne ergosterol level		gender	4.4†	1.02 - 18.70
Cough‡	Glucan level in chair dust				
Yes (12)	3	9	none	5.1	1.1-23.4
No (27)	17	10			
Cough	Glucan level in chair dust		gender	5.3	1.13 - 24.68
Cough	Glucan level in chair dust		atopy	5.1	1.11 - 23.61
Cough	Glucan level in chair dust		gender & atopy	5.4	1.14 - 25.40
Cough	Glucan level in chair dust		age, gender & atopy	8.0	1.03 - 61.91

* Except for these models, no significant associations of reported respiratory symptoms and environmental measurements were found. The first model for each outcome is an univariate model. And the models in this table could not be controlled further for other potential confounding factors due to small sample size (N=40).

† This model could not be controlled for atopy because the model controlling for atopy was unstable since there was only one subject in the stratum of non-allergic reported asthma.

‡ Cough was defined as "yes" to the question "Do you usually have a cough? (Count a cough with first smoke or on first going out-of-doors, and exclude clearing of throat)." One subject was missing an exposure measurement (N=39).

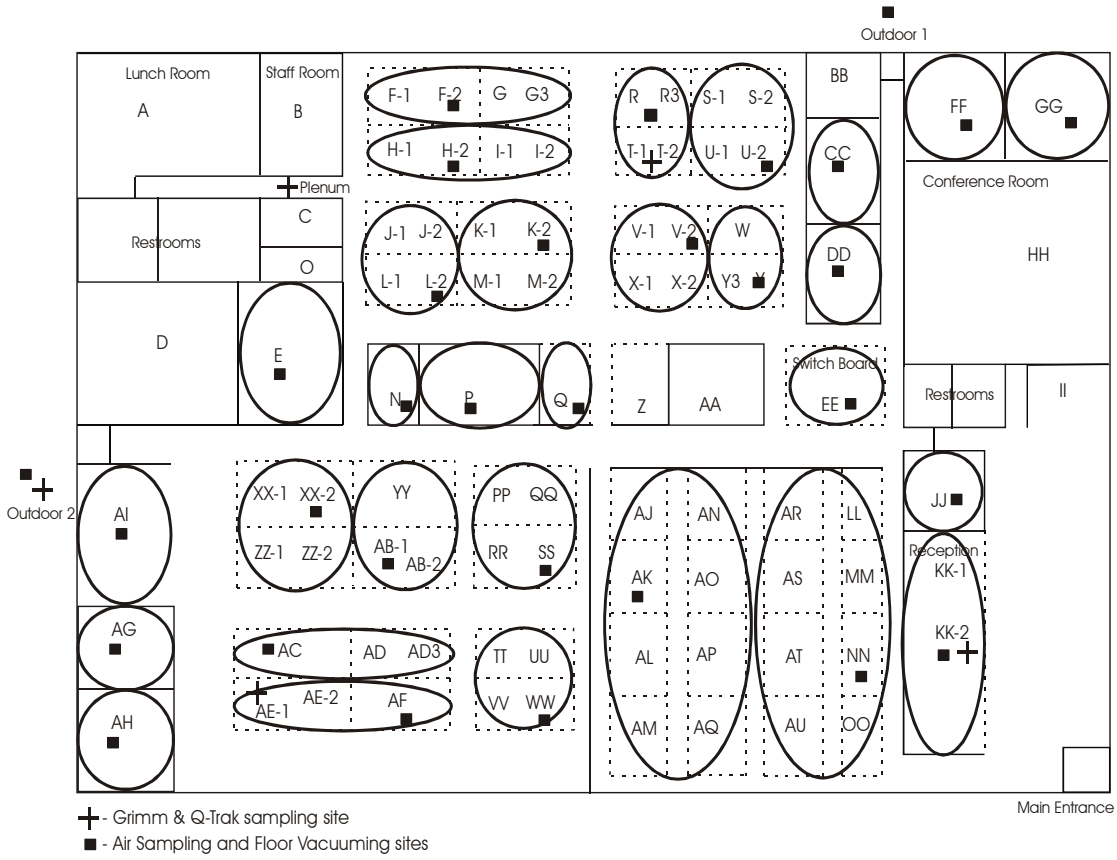


Figure 1. Sampling locations in each sampling zone inside the SCAO building. Squares denote the air and floor dust sampling stations, and crosses denote the locations where particle count, temperature, relative humidity, and carbon dioxide were monitored. Each occupants' main chair was vacuumed for chair dust sampling. Thin solid lines in the layout represent physical walls, dotted lines represent cubicles or partial walls, and letters designate rooms and workstations for the study building. Each circle/ellipse represents a sampling area. For the analyses, all employees within an area were assigned the same exposure level which was measured in the same area.

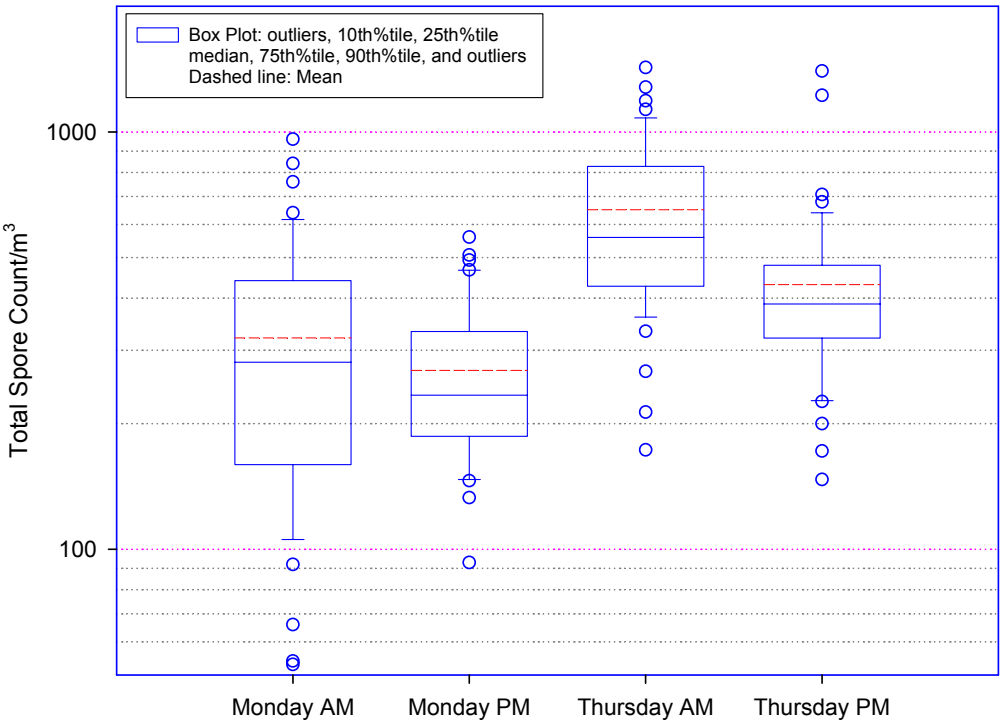


Figure 2. Distribution of total airborne fungal spore levels measured at different times in the building. The dashed lines and the solid lines in the box are mean and median values, respectively, from 30 sampling locations.

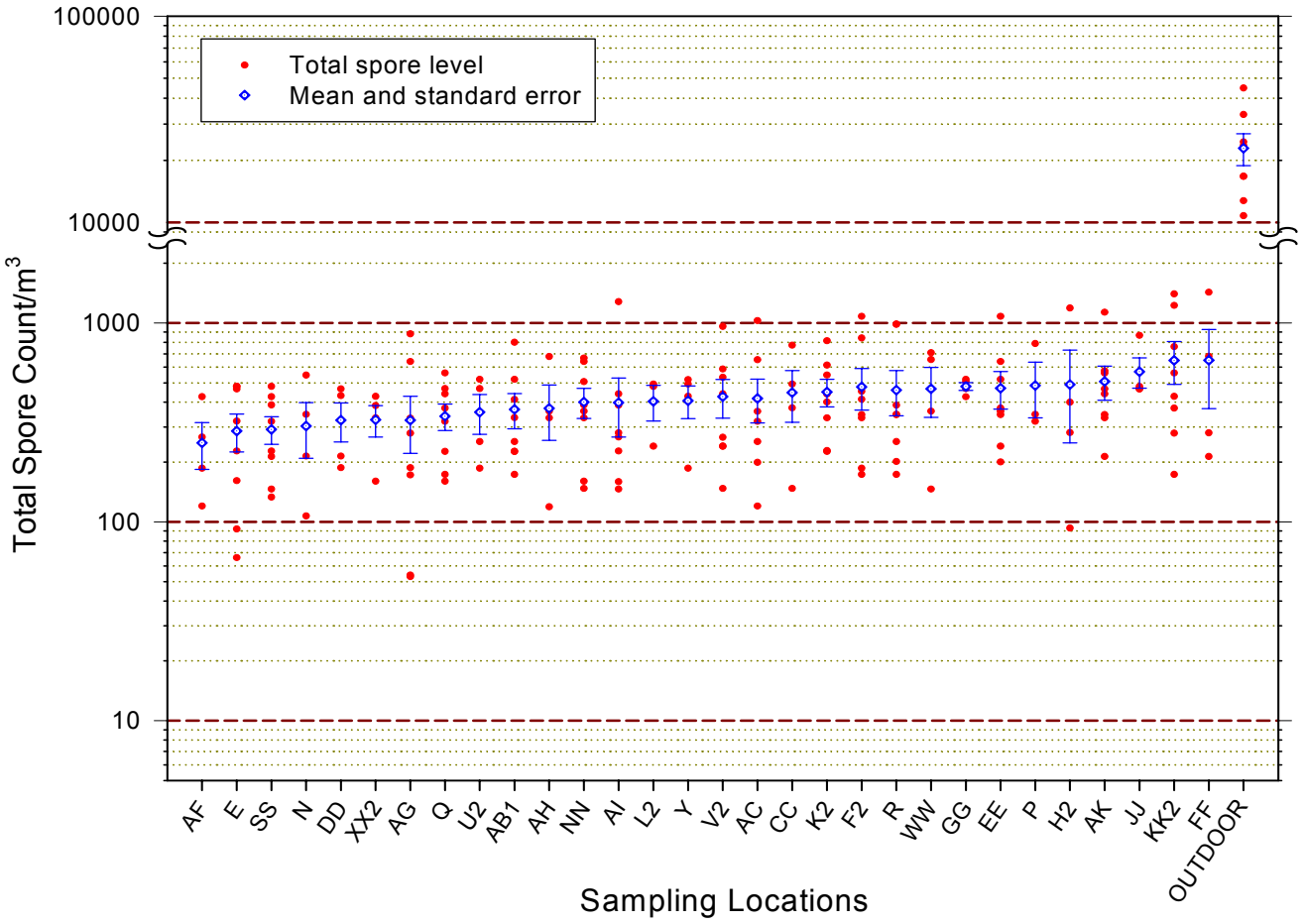


Figure 3. Total airborne fungal spore level at each indoor sampling location and outdoors. Closed dot denotes 4 (Monday AM/PM, Thursday AM/PM) or 8 (if there are duplicates) measurements for every sampling location, open dots show mean value, and bars show standard error at each location.

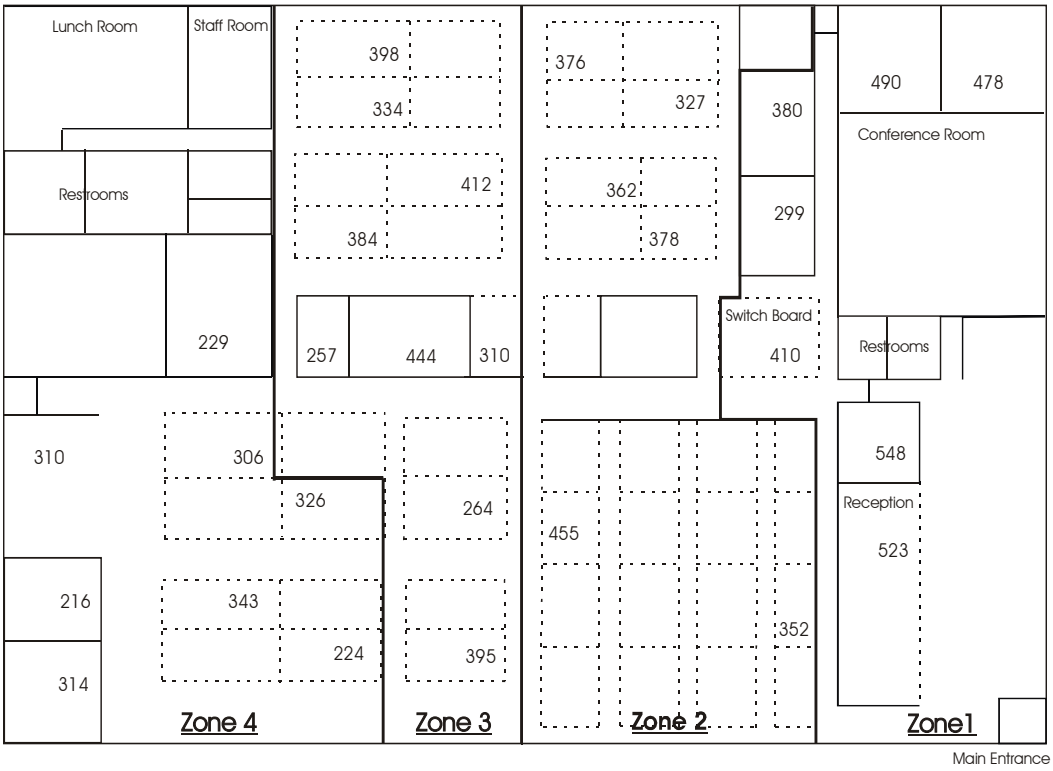


Figure 4. Geometric mean of total airborne fungal spore level (number of spores/m^3) at 30 indoor sampling locations within air handling unit (AHU) zones in the building. Geometric mean outdoor level was 20,654 spores/m^3.

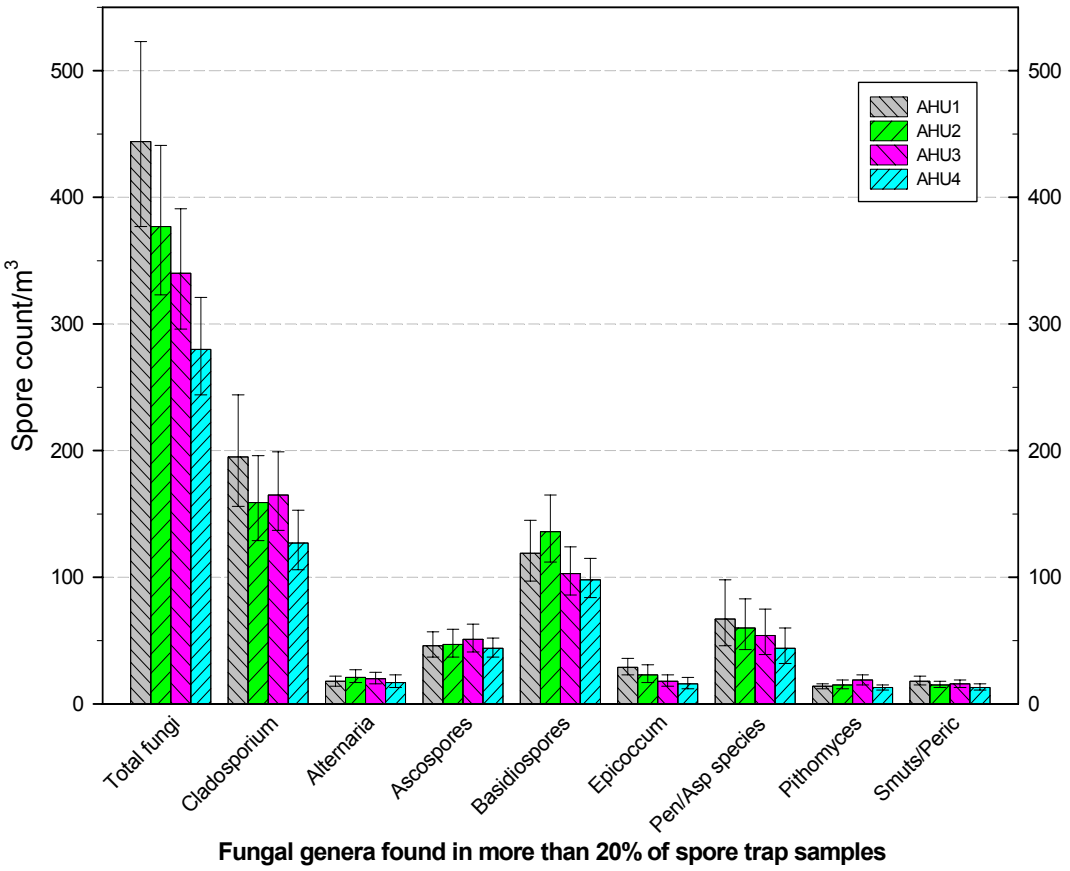


Figure 5. Geometric mean airborne fungal spore levels and 95% confidence limits in different zones served by each of the four air handling units (AHUs).

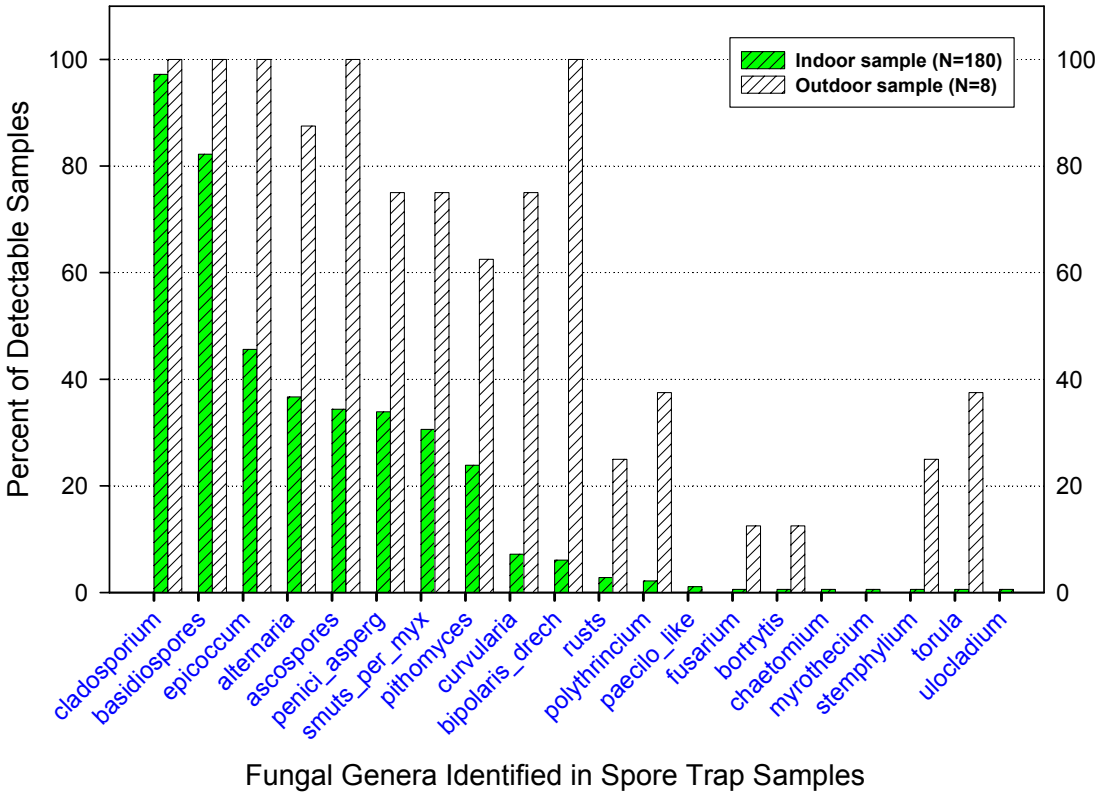


Figure 6. Percent of air samples with detectable fungal spores of each genus, indoors and outdoors. Percent was computed by dividing the number of positive samples for each fungal genus by the total number of samples taken. The full names for the fungal genera are in Appendix E.

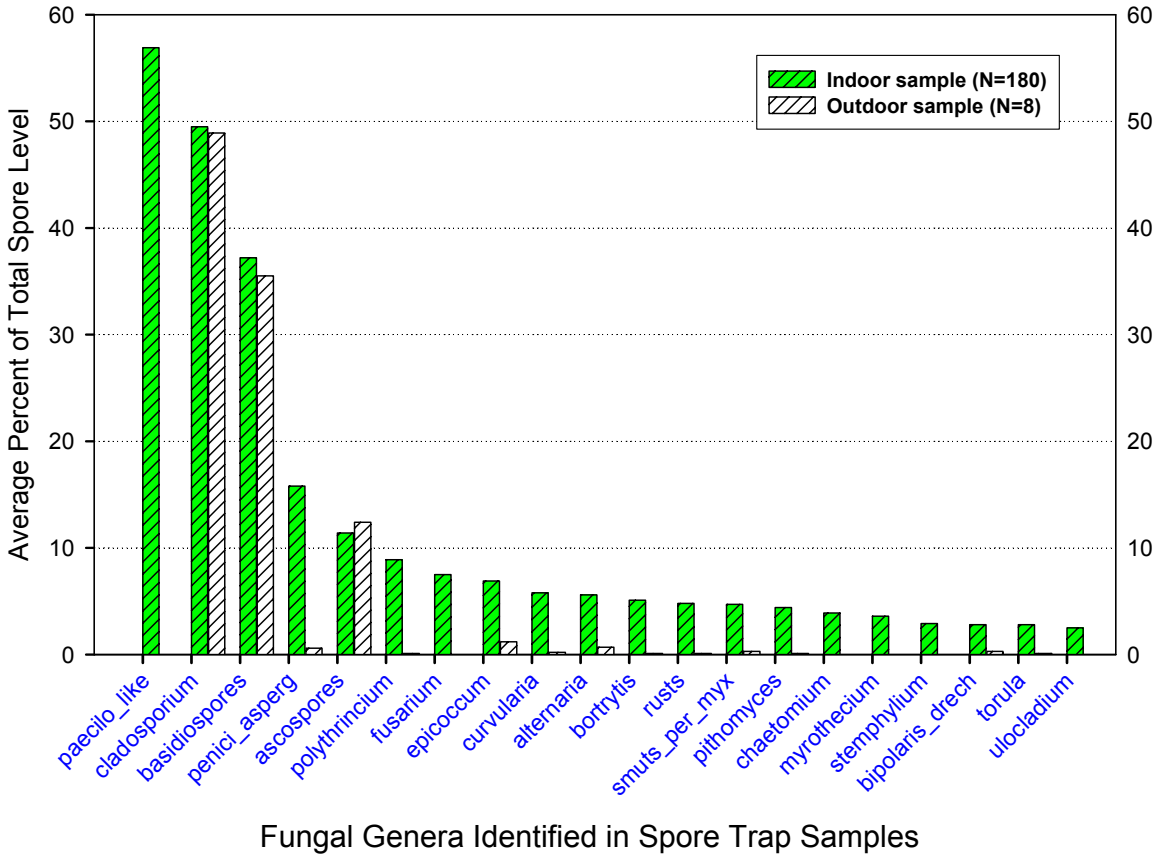


Figure 7. Average percent of spores represented by each fungal genus in indoor and outdoor samples. The percent spore level within a sample was computed by dividing the number of spores for the specified fungal genus by the total number of spores found for the sample. The percent spore levels for each genus was averaged over all samples detected for the genus. The average percent of total spore levels do not add up to 100% because samples had different numbers of genera found. The full names for the fungal genera are in Appendix E.

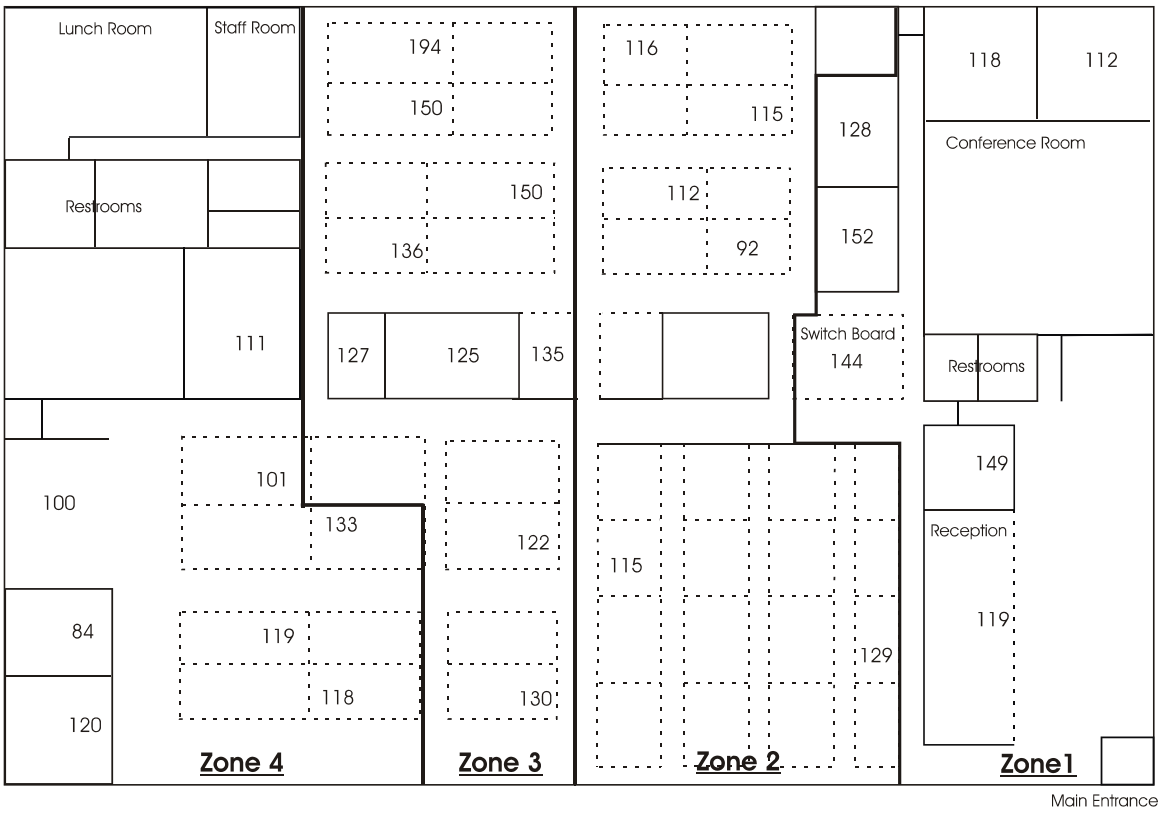


Figure 8. Geometric mean level (CFU/m^3) of total airborne culturable fungi at each indoor sampling location. Geometric mean outdoor level was 1,224 CFU/m^3.

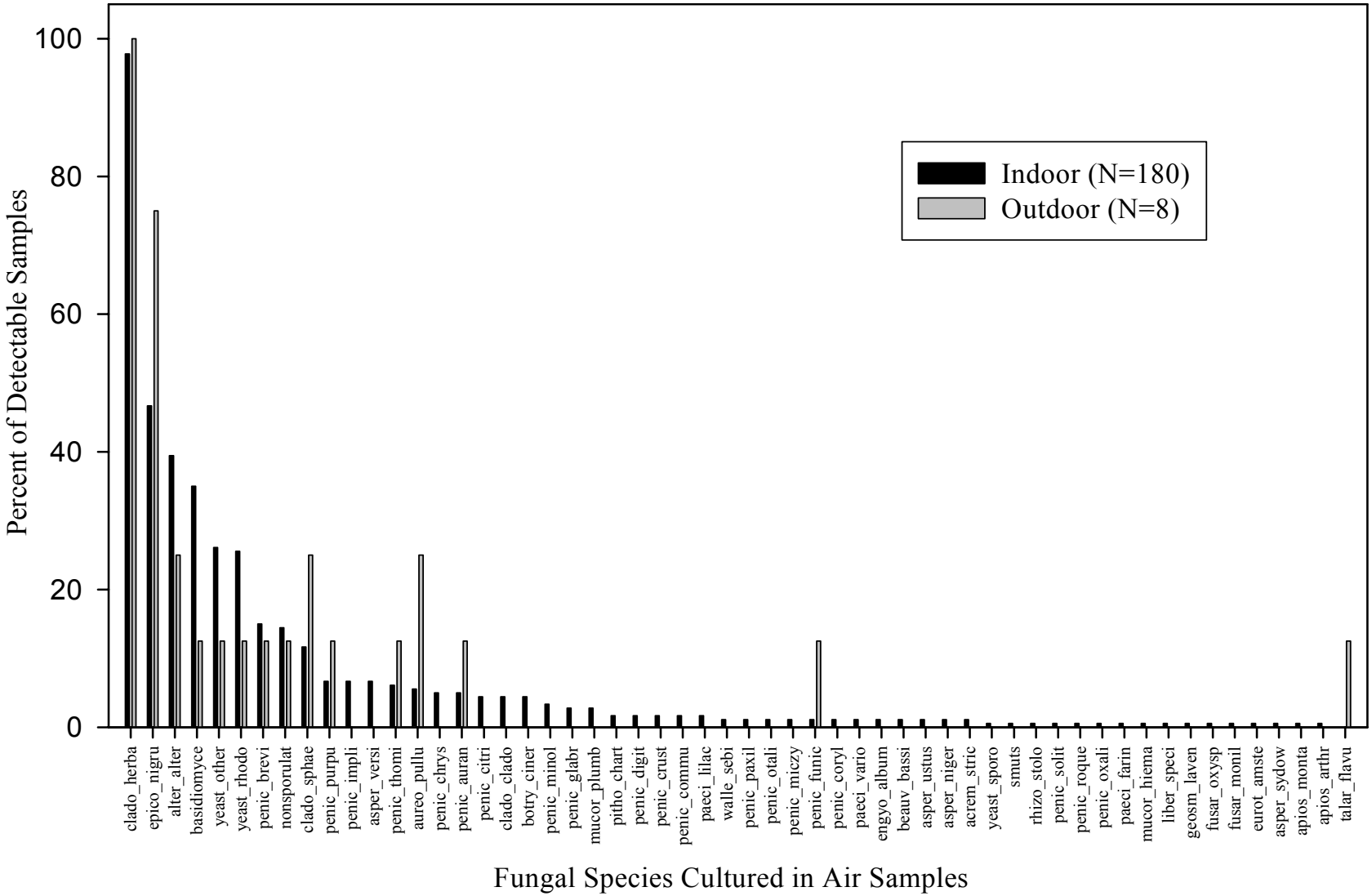


Figure 9. Percent of air samples with specified fungal species cultured, indoors and outdoors. Percent was computed by dividing the number of samples that detected each fungal species by the total number of samples taken. The full names for the fungal species are in Appendix E.

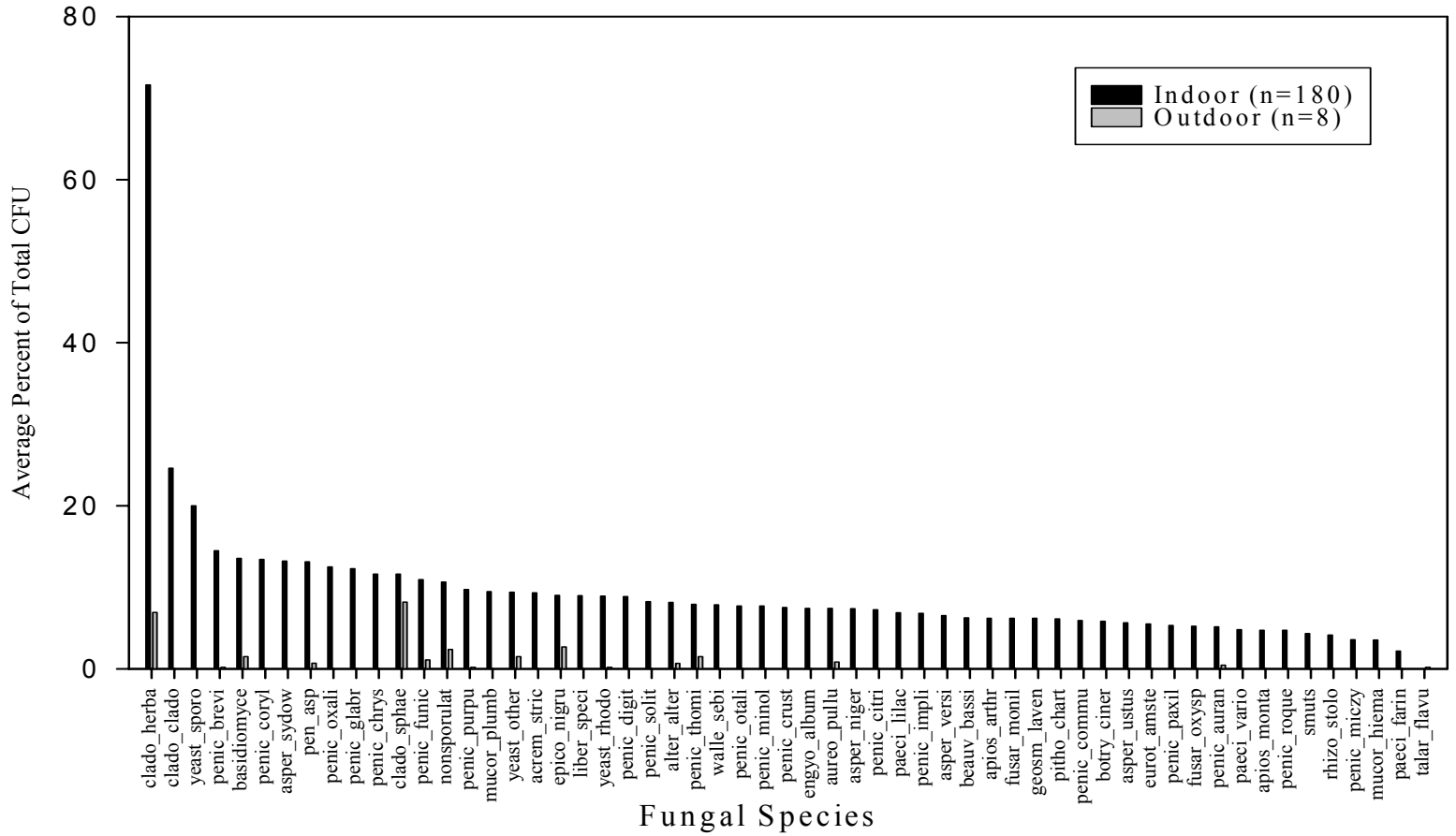


Figure 10. Average percent of total CFUs represented by each fungal species in indoor and outdoor air samples. The percent within each sample was computed by dividing the number of CFUs of the specified fungal species by the total CFU for that sample. The percent CFUs for each species were averaged over all samples that detected that fungal species. The full names for the fungal species are in Appendix E.

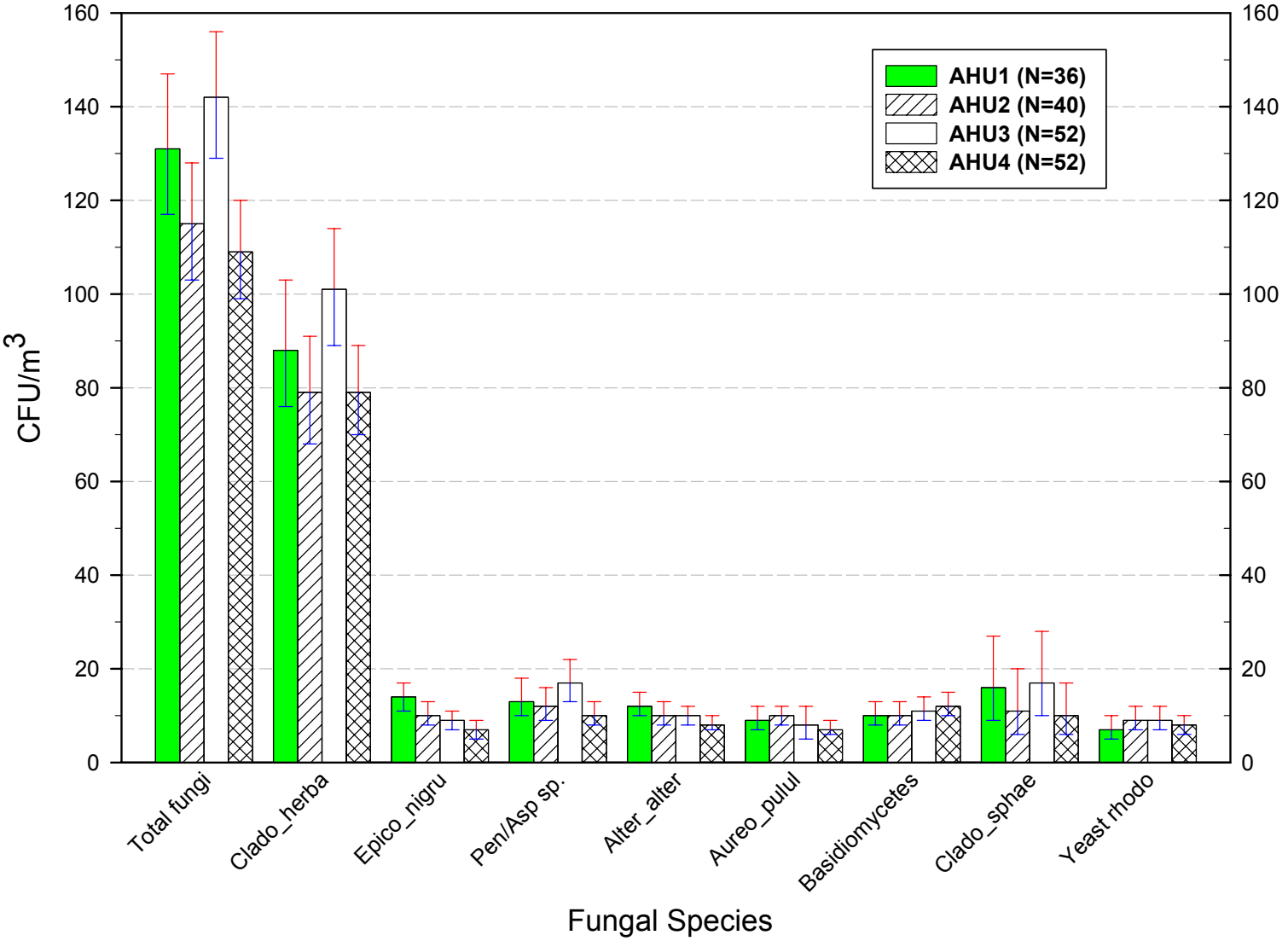


Figure 11. Geometric means (CFU/m^3), adjusted for sampling day and time, and 95% confidence intervals for fungal species identified in more than 20% of indoor air samples, by AHU zone. The full names for the fungal species are in Appendix E.

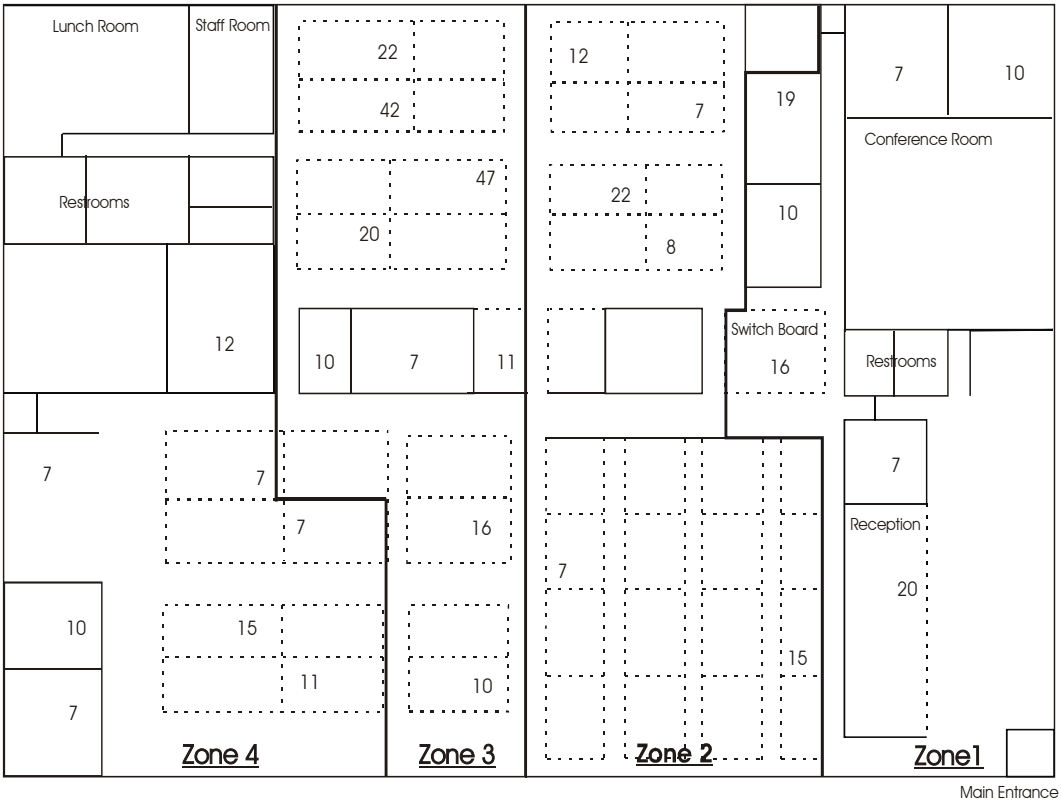


Figure 12. Geometric mean level (CFU/m^3) of airborne *Penicillium/Aspergillus* species in the building by AHU zone. Geometric mean outdoor level was 7 CFU/m^3.

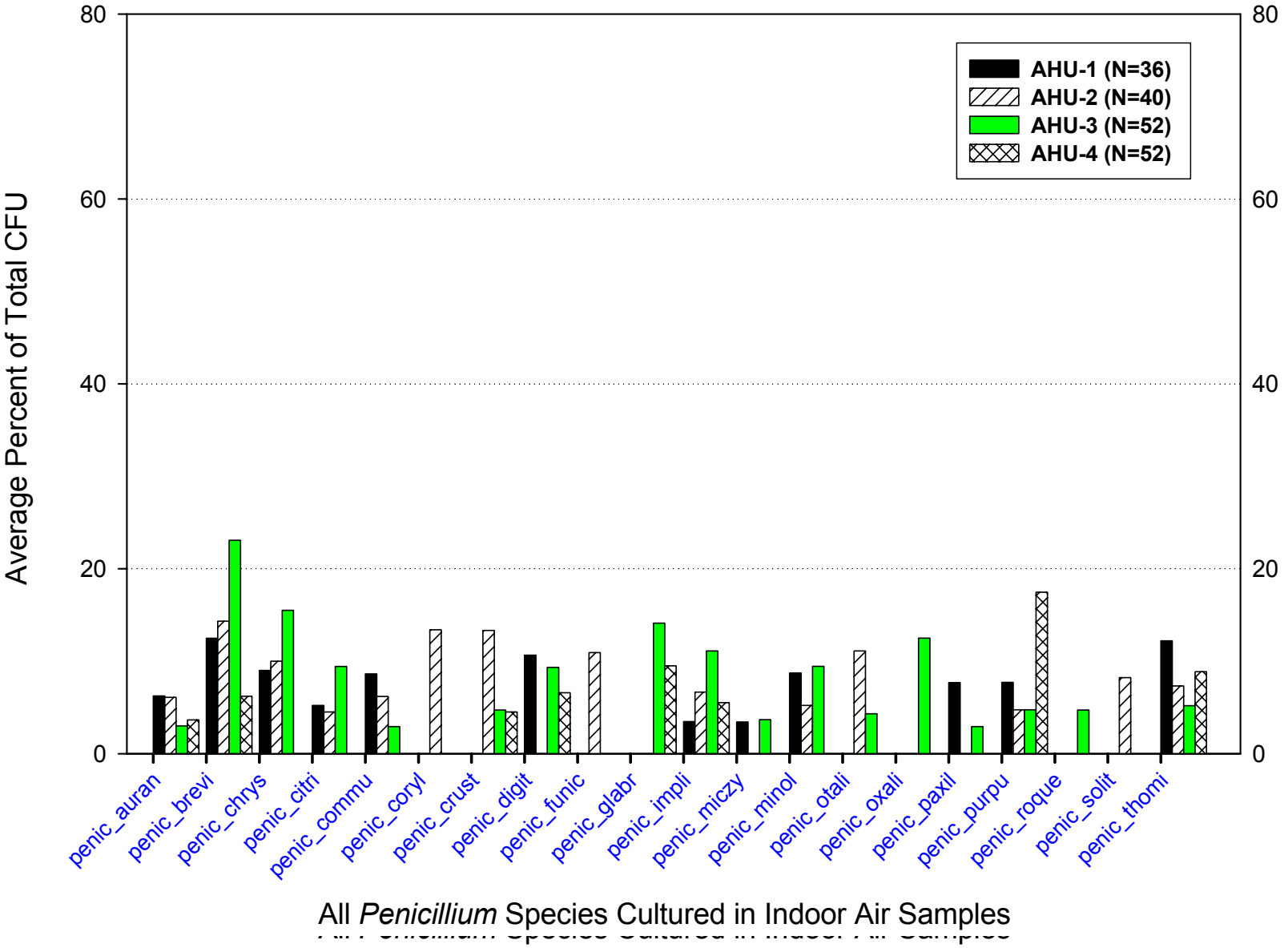


Figure 13. Average percentage of total CFUs represented by each fungal species in indoor air samples by AHU zone. The full names for the fungal species are in Appendix E.

Figure 14. Average percentage of total CFU represented by each *Penicillium* species in indoor air samples by AHU zone. The full names for the fungal species are in Appendix E.

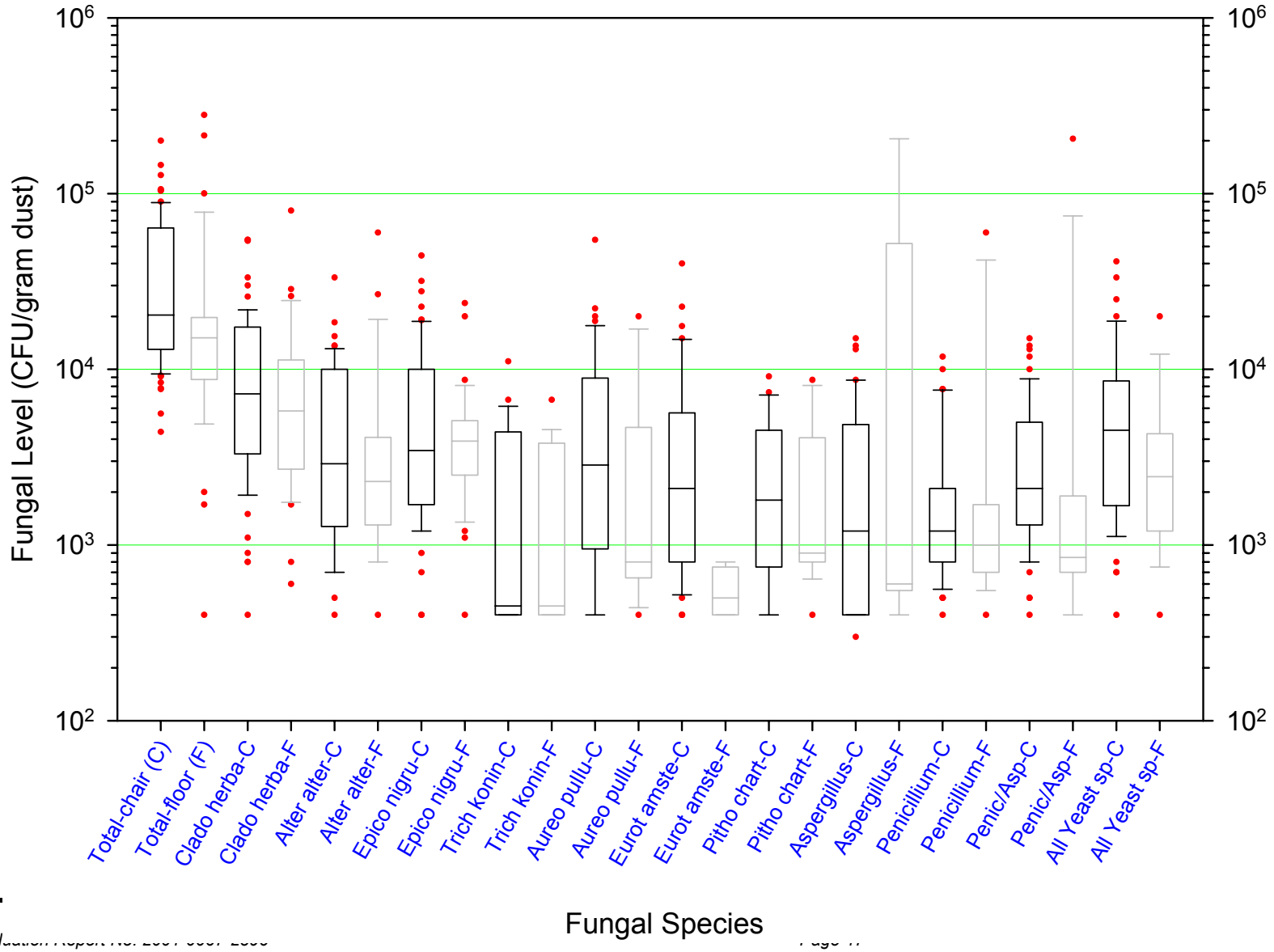
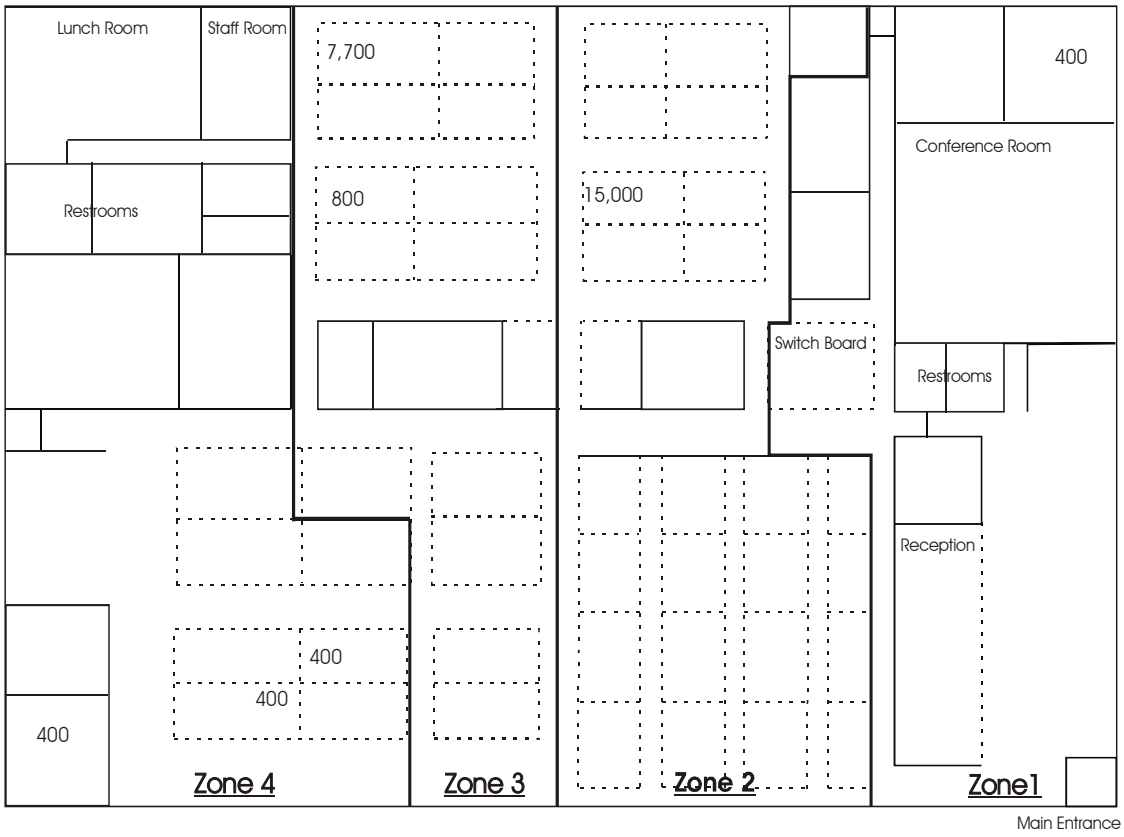


Figure 15. Distribution of fungal species cultured in ore than 20% of chair and floor dust samples in the building. The line within the box denotes the median (50th percentile), the box denotes middle the 50% of the

data, the whiskers denote the middle the 80% of the data, and the dots outside the whiskers are outliers. If there are no dots, it means thre are not enough dta to determine whether outliers exist.



The full names for the fungal species are in Appendix E.

Figure 16. *Stachybotrys chartarum* (CFU/gram dust) cultured in chair dust by location. Only cubicles and offices with positive results for this fungi are presented in the diagram. All locations (cubicles and offices) where chair dust was sampled are shown in Figure 1.

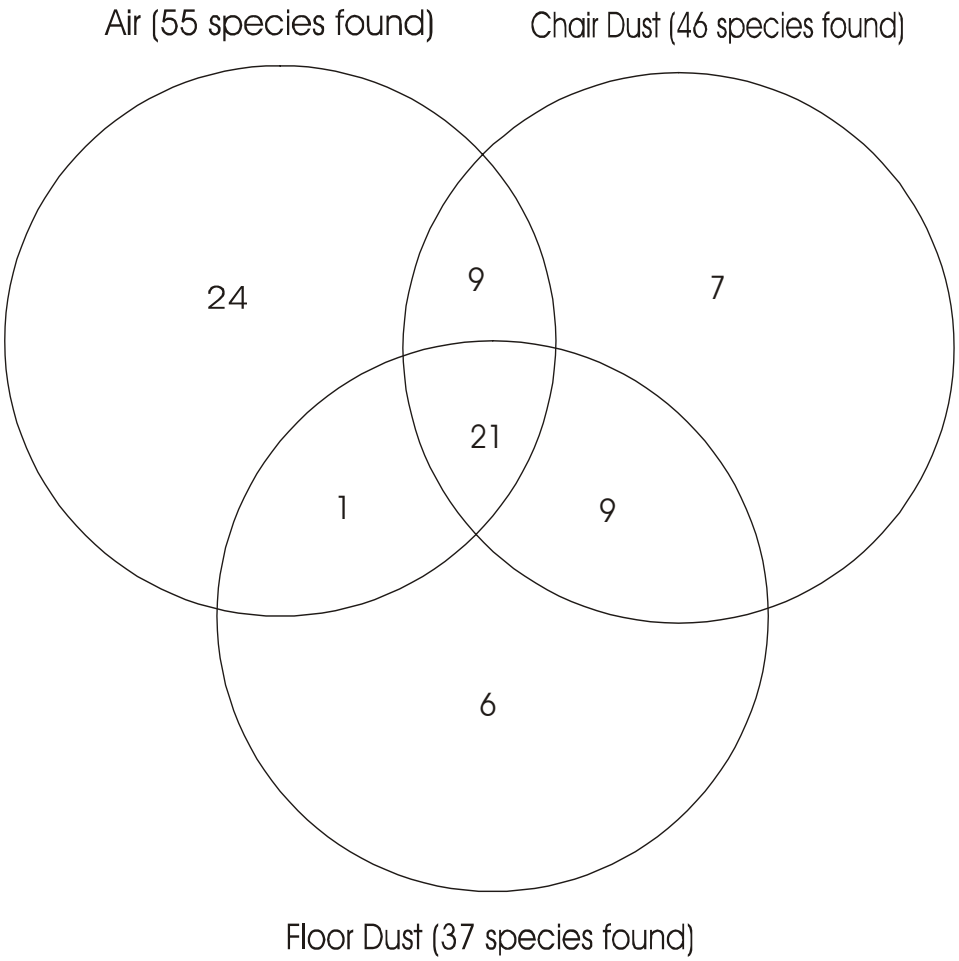


Figure 17. Venn diagram showing the number of fungal species cultured from air, chair dust, and floor dust.

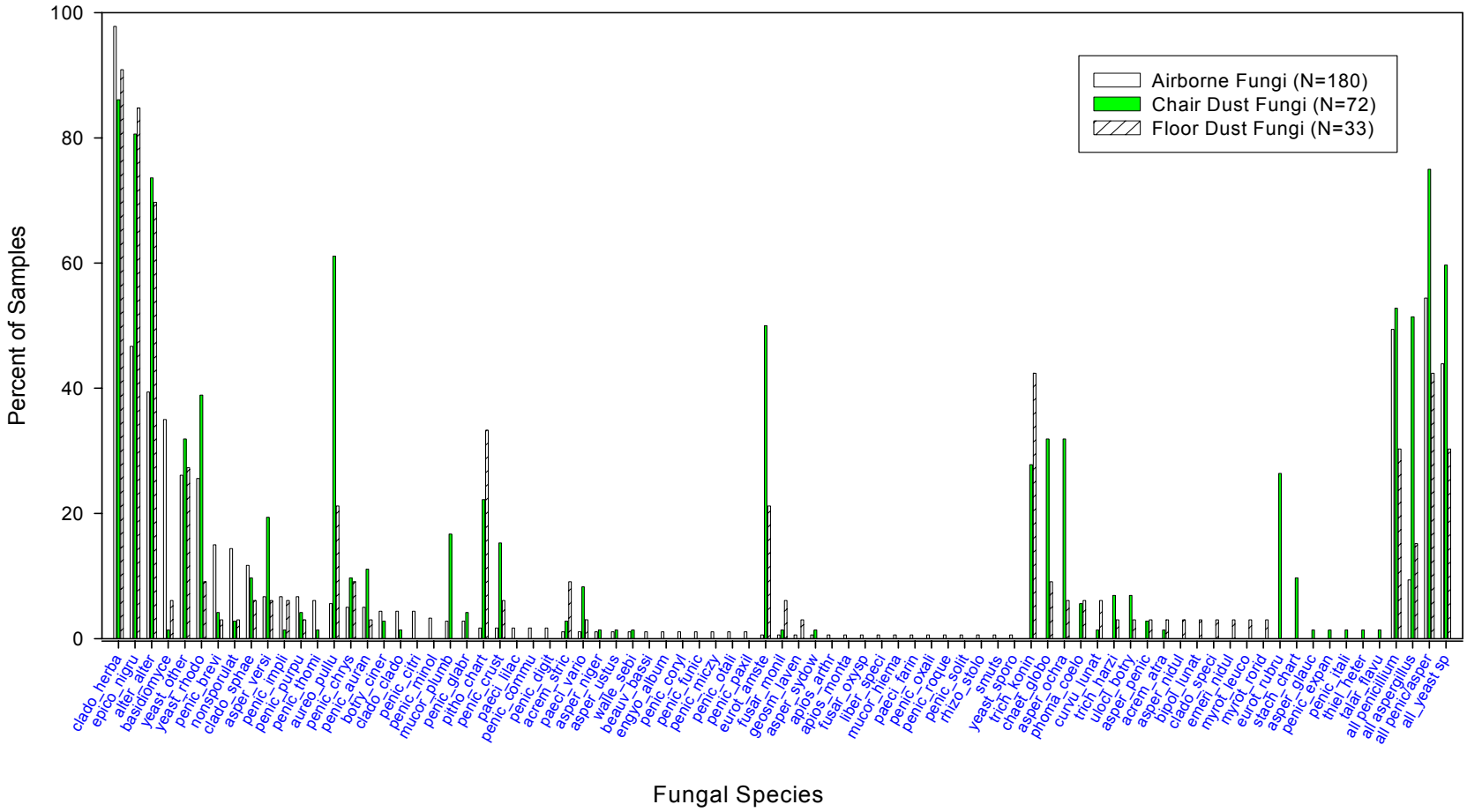


Figure 18. Percent of samples with specified fungal species detected by sample type (air, chair dust, and floor dust). The full names for the fungal species are in Appendix E.

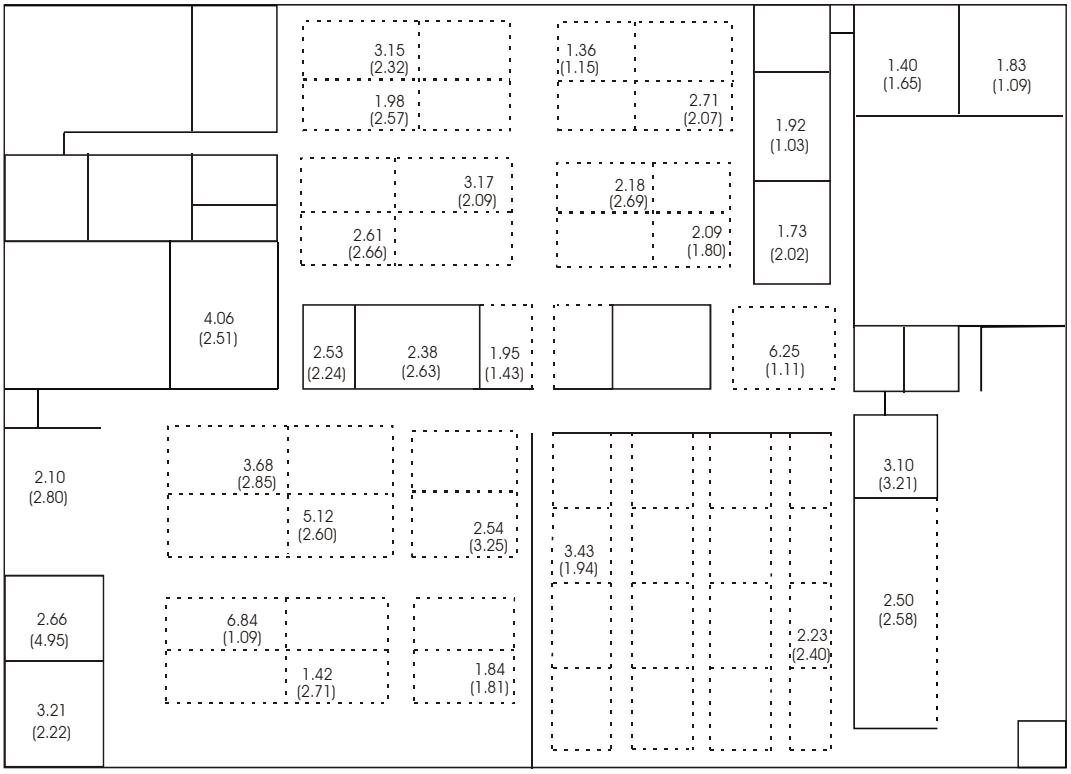


Figure 19. Endotoxin levels (EU/m^3) in air samples collected from Monday 7:00 am to Wednesday noon. Endotoxin levels from Wednesday noon to Friday 4:00pm are in parenthesis. Outdoor samples were collected from two outdoor sampling sites marked on Figure 1. Outdoor average airborne endotoxin level was 1.61 EU/m^3. Note: The levels in this figure may not be representative of true airborne endotoxin levels due to contamination of blank filters.

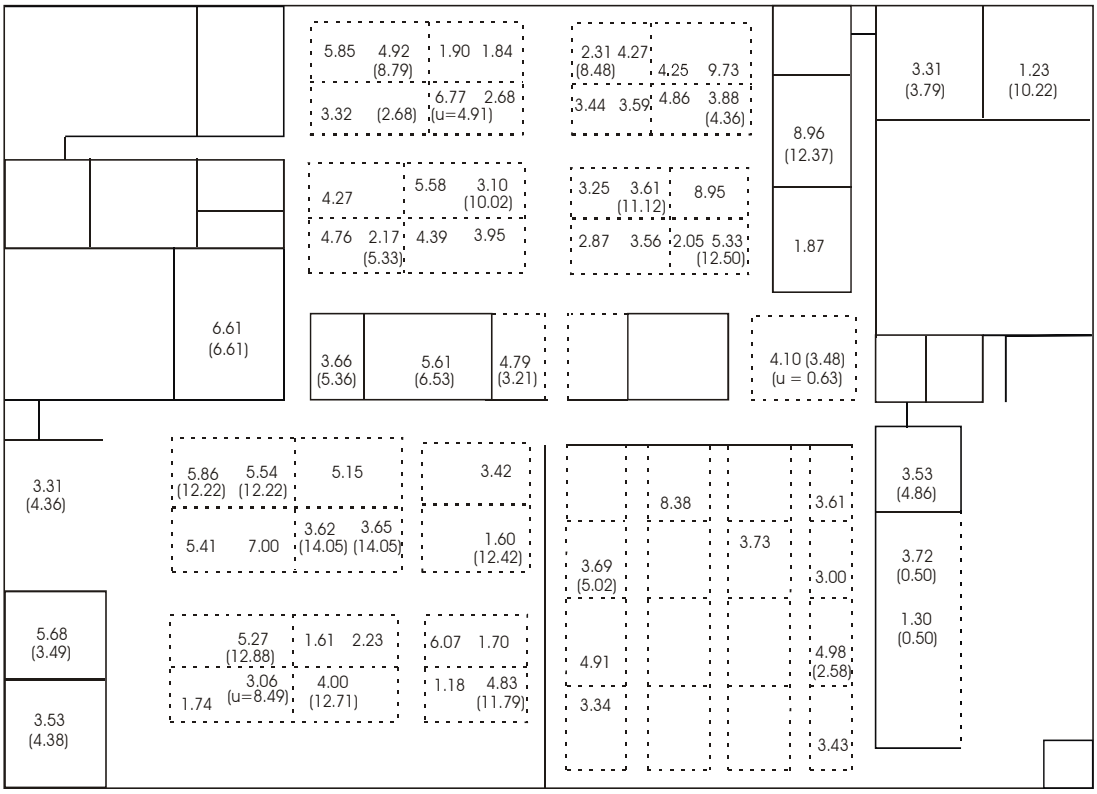


Figure 20. Endotoxin levels (EU/mg dust) in dust collected on chair or floor (carpet and floor mat, and under floor mat). Dust samples were collected by vacuuming after work hours. Floor dust endotoxin levels are in parenthesis and floor dust samples from under floor mats are designated by "u".

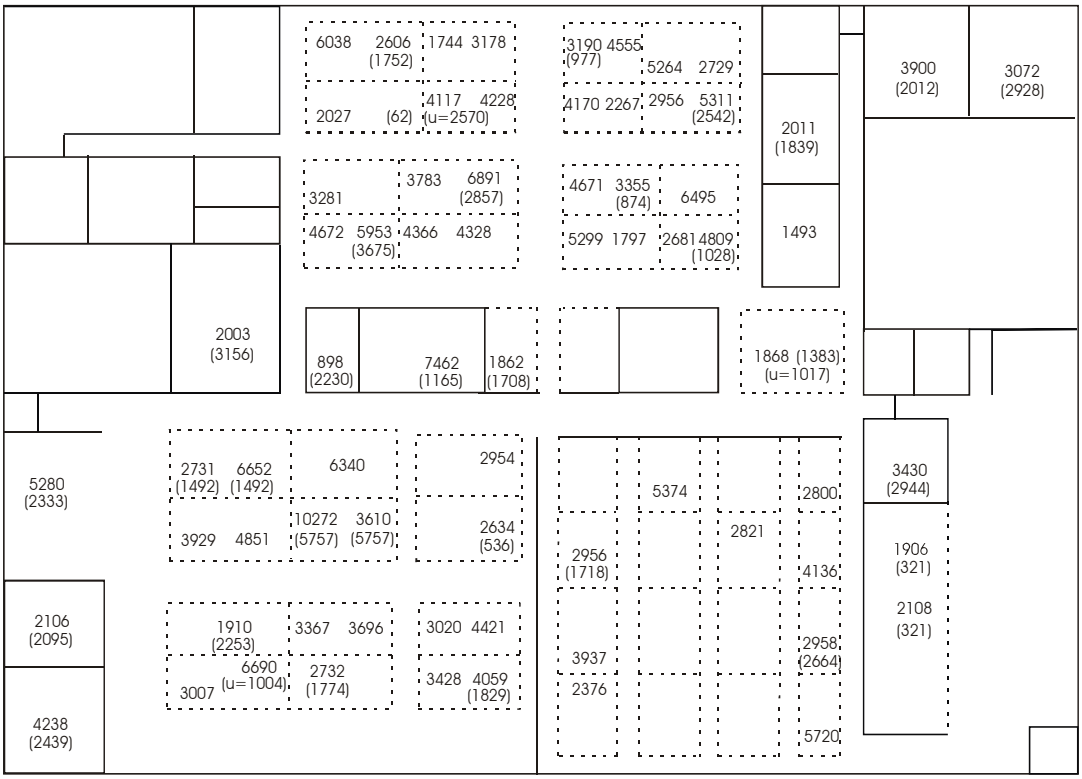


Figure 21. (1→3)-β-D-glucan levels (ng/mg dust) in dust collected on chair or floor (carpet and floor mat, and under floor mat). Dust samples were collected by vacuuming after work hours. Floor dust glucan levels are in parenthesis and floor dust samples from under floor mats are designated by "u".

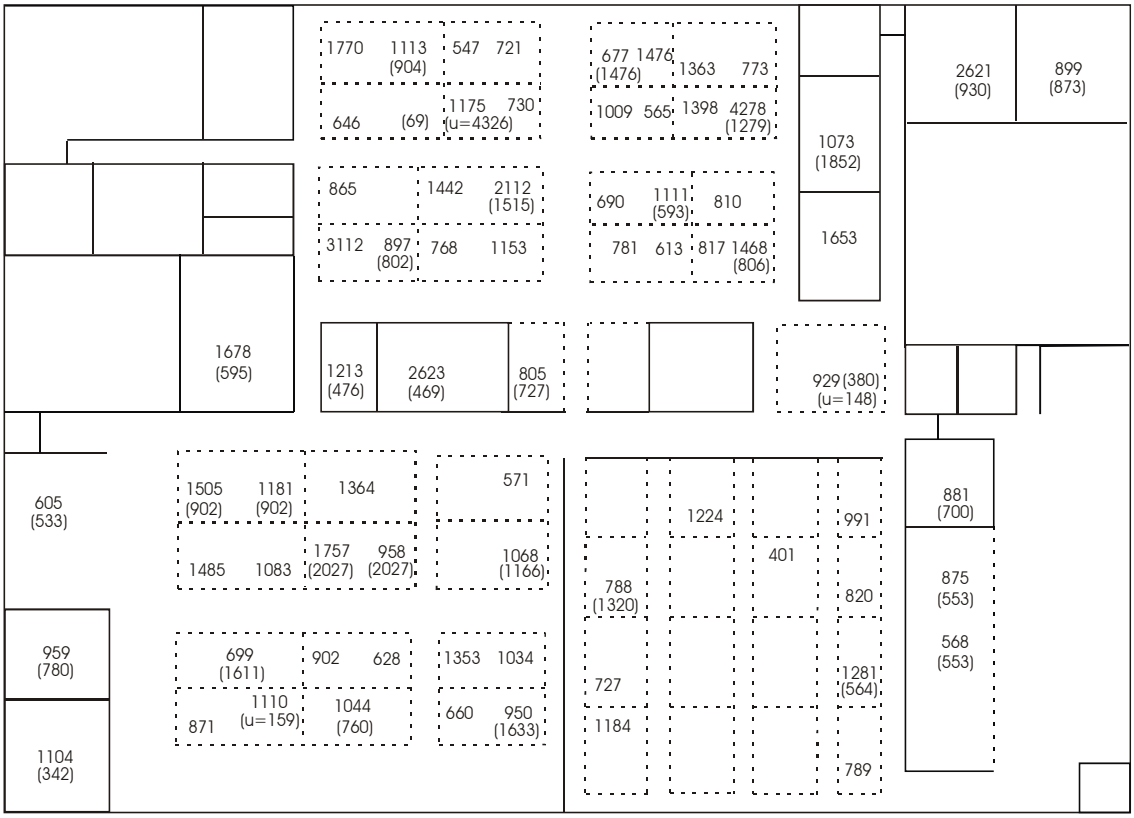


Figure 22. Ergosterol levels (pg/mg dust) in dust collected on chair or floor (carpet and floor mat, and under floor mat). Dust samples were collected by vacuuming after work hours. Floor dust ergosterol levels are in parenthesis and floor dust samples from under floor mats are designated by "u".

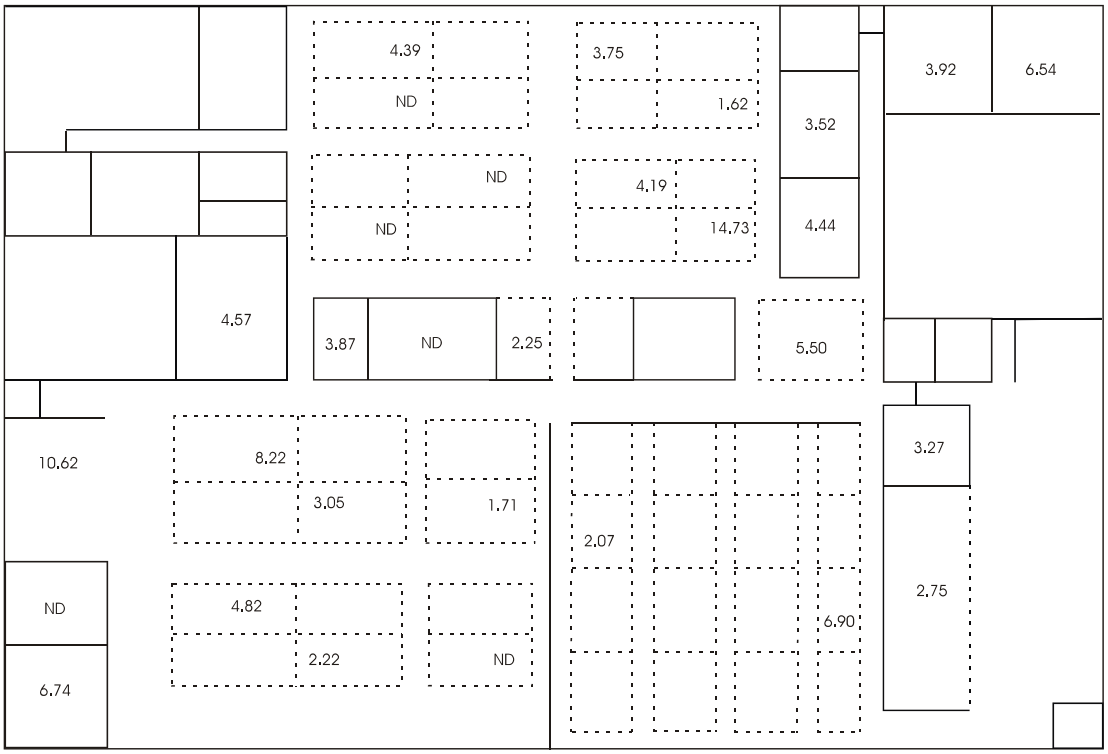


Figure 23. Airborne ergosterol levels (pg/m^3) at 30 sampling locations. Ergosterol was not detected in 6 locations noted as non-detectable (ND). Outdoor average airborne ergosterol level was 119 pg/m^3.

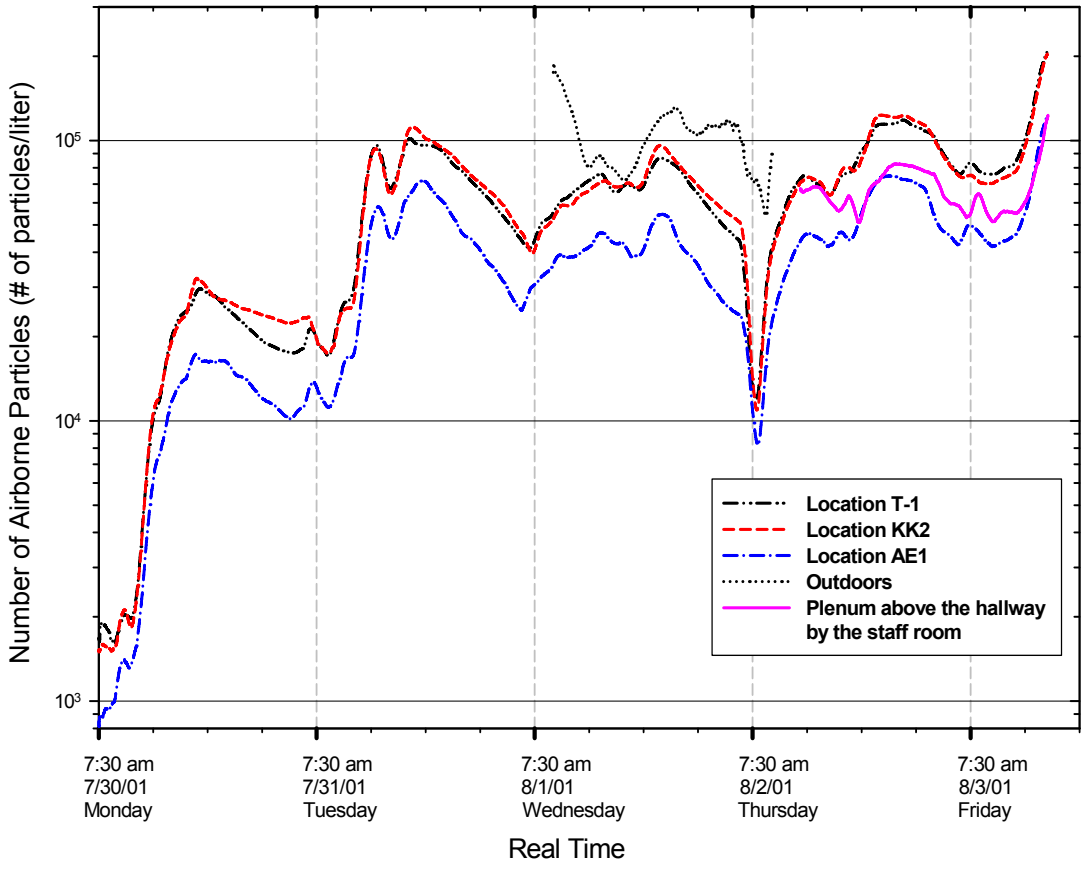


Figure 24. Real-time monitoring of respirable particles (aerodynamic diameter=0.4 to 4 μm) at three locations in the office area, in the plenum, and outside the building. Suspended airborne particles were monitored for about 4.5 days in the office areas, 24 hours outdoors, and about 30 hours in the plenum.

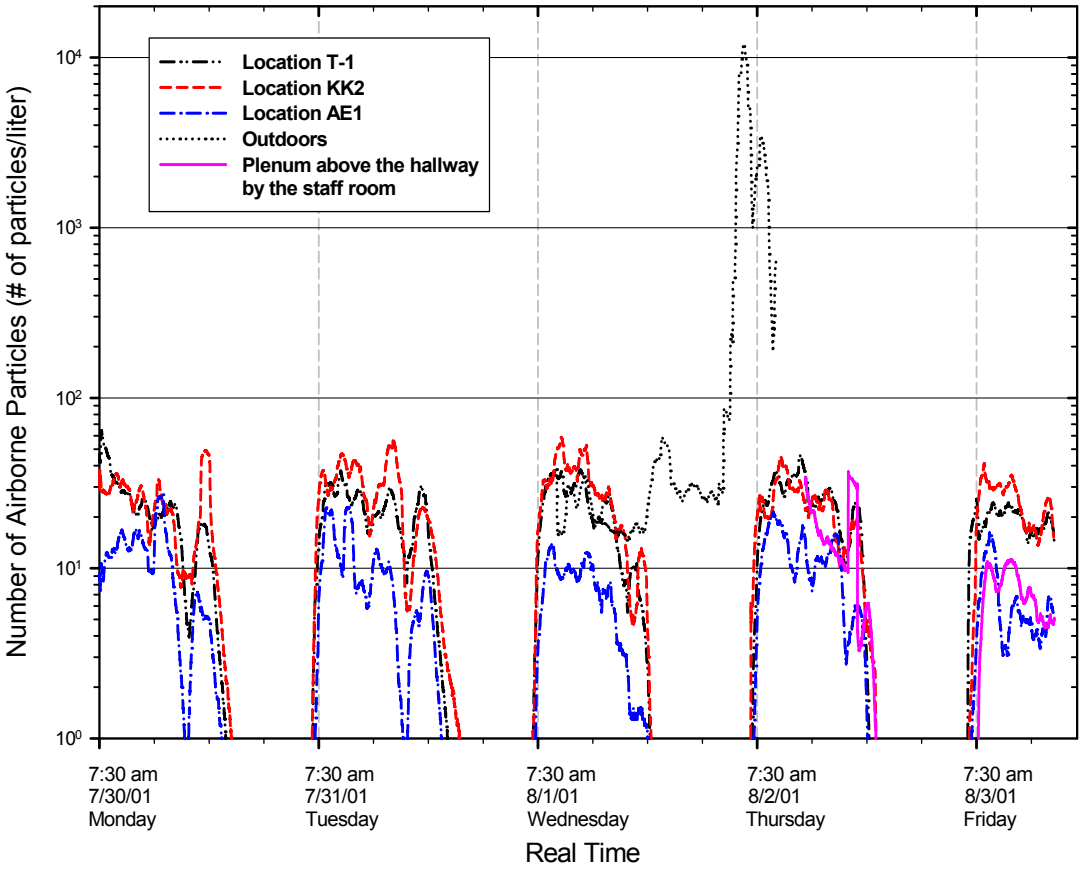


Figure 25. Real-time monitoring of inhalable particles (aerodynamic diameter=4 to 20 μm) at three locations in the office area, in the plenum, and outside the building. Suspended airborne particles were monitored for about 4.5 days in the office areas, 24 hours outdoors, and about 30 hours in the plenum.

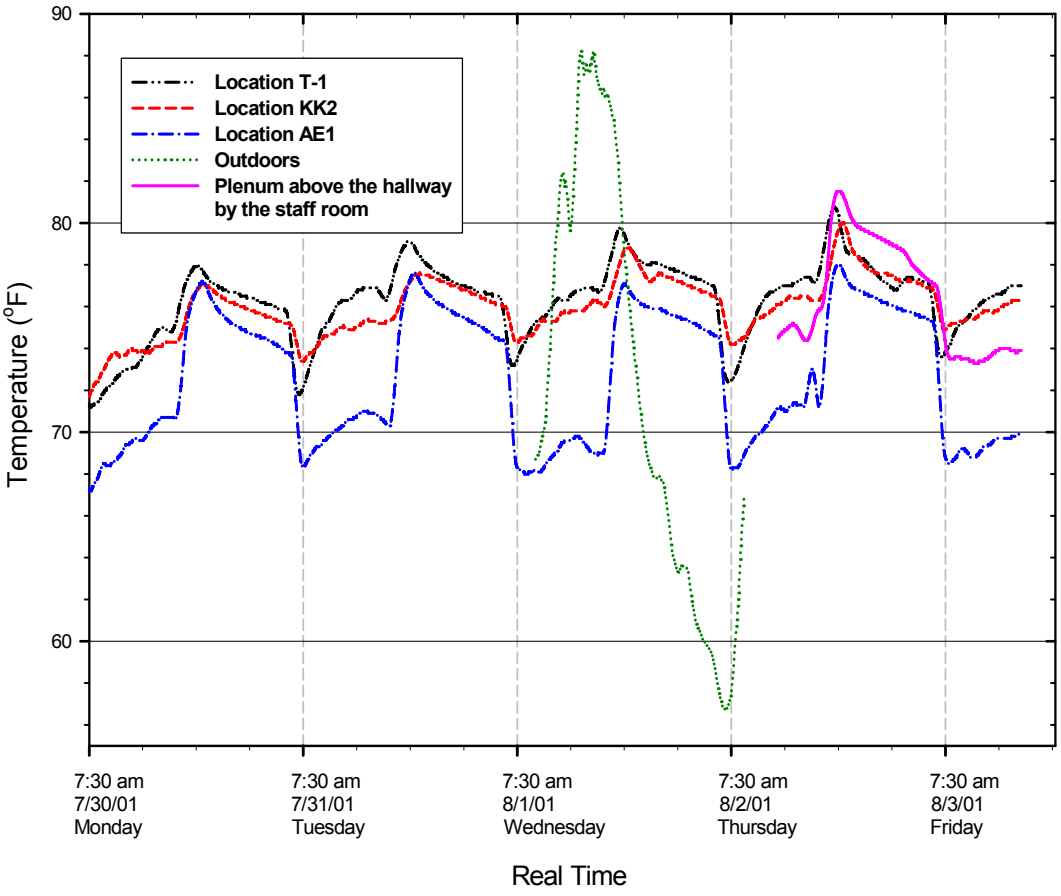


Figure 26. Real-time monitoring of temperature at three locations in the office area, in the plenum, and outside the building. Suspended airborne particles were monitored for about 4.5 days in the office areas, 24 hours outdoors, and about 30 hours in the plenum.

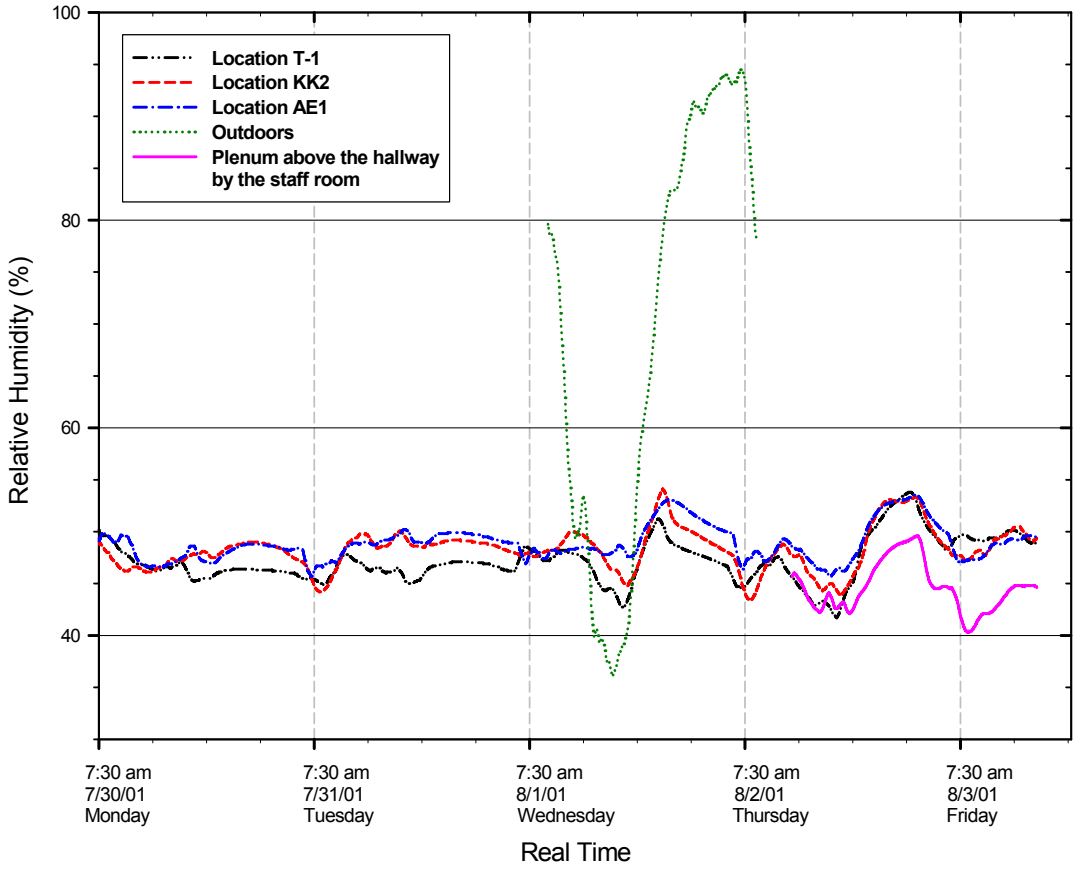


Figure 27. Real-time monitoring of relative humidity at three locations in the office area, in the plenum, and outside the building. Suspended airborne particles were monitored for about 4.5 days in the office areas, 24 hours outdoors, and about 30 hours in the plenum.

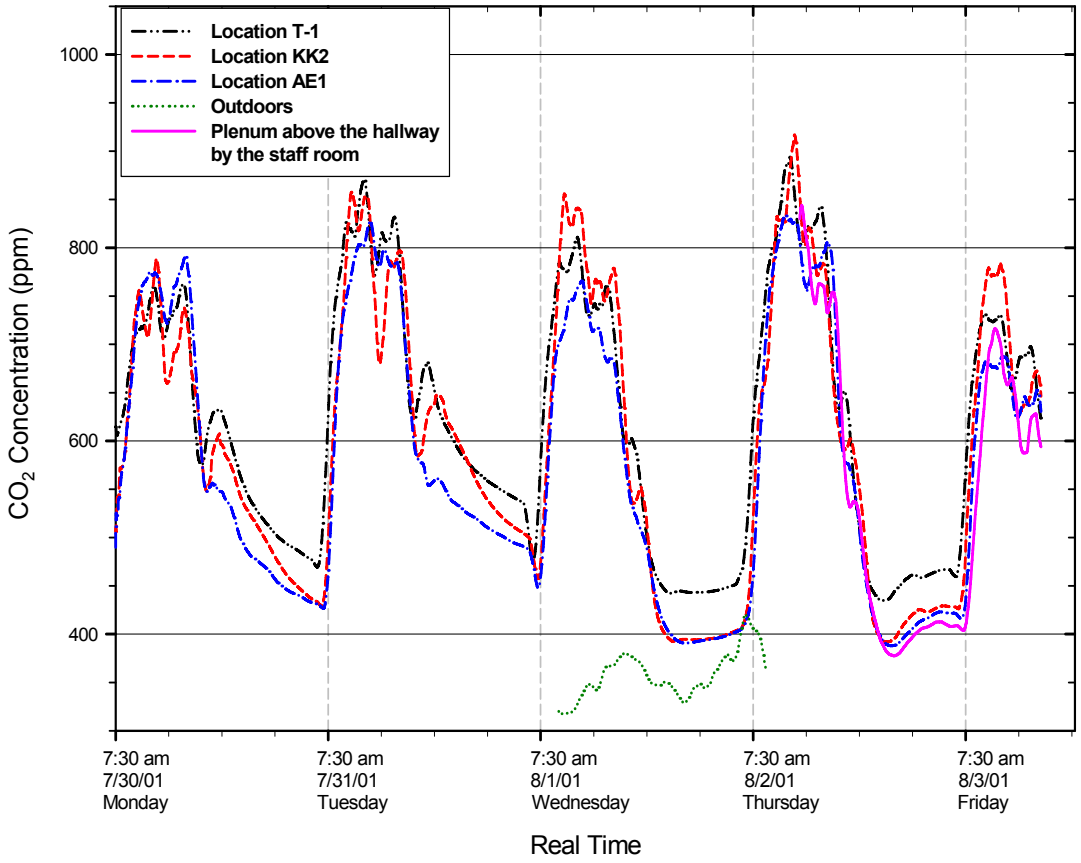


Figure 28. Real-time monitoring of carbon dioxide at three locations in the office area, in the plenum, and outside the building. Suspended airborne particles were monitored for about 4.5 days in the office areas, 24 hours outdoors, and about 30 hours in the plenum.

Appendix A

Interim Report of Evaluation of the HVAC System

Interim report for HETA 2001-0067
June 26, 2002

Mr. Larry Klein, Director
Division of Office Services
Department of Public Welfare
PO Box 2675
Harrisburg, PA 17015

Dear Mr. Klein:

The National Institute for Occupational Safety and Health (NIOSH) received a request from workers at Somerset County Assistance Office (SCAO) on November 13, 2000 for a Health Hazard Evaluation (HHE). At the time of the request their health concerns were asthma, hypersensitivity pneumonitis, chronic fatigue, fibromyalgia, sinus problems, eye infections, and thyroid problems.

Following a series of communications to obtain and exchange additional information, NIOSH conducted walk-through site visit on March 27, 2001. During the walk-through visit, NIOSH investigated the building environment and ventilation system. Based on the walk-through survey, NIOSH staff decided to do an in-depth study on the building environment.

NIOSH conducted an extensive heating, ventilation, and air conditioning (HVAC) inspection of the building on August 8 and 9, 2001 as part of a medical and environmental site visit on July 25 through August 9, 2001. The HVAC inspection included visual inspection of four rooftop-mounted air-handling units, the associated ductwork, the plenum, and measurements of airflows inside the supply and return air ducts and from the diffusers in the occupied spaces of the building. The enclosed interim report describes the results of the HVAC inspection performed during the site visit and recommendations. We hope that the report will be useful in providing an understanding of the conditions that existed in the old building at the time of the inspection. These recommendations may also be helpful to your efforts to ensure a healthful environment of your new building. Please feel free to forward these recommendations to the building owner or current occupants.

Our inspection of the HVAC system identified problems with the general maintenance of the system, introduction of unfiltered plenum return air into the mixing boxes or the distribution chambers, the distribution of supply air in occupied spaces, and the amount of outside air being supplied. Especially, due to uneven distribution of supply air in occupied spaces some people received too much air and some people received too little air within a day, indicating that the air distribution system was not properly balanced.

Our attached interim report confirms the recommendations that we made on August 9, 2001, during the closing meeting of our ventilation inspection visit:

1. Repair and clean the drain traps as needed in all four air handling units (AHUs).

2. Repair the damaged roof to prevent condensed water draining out of the AHUs from leaking through the roof. Redirect the drainage from the AHU drain traps directly to the gutter until the damaged roof is completely repaired.

3. Remove all internal linings and reinstall external insulation linings for the ducts that carry supply air from the AHUs. Make sure that occupants are not exposed to the fibers while the internal insulation lining is removed.

4. Confirm that all flexible air supply ducts are properly attached to the supply-air diffusers.

5. Routinely inspect and replace the HVAC filters. Pay special attention to the main filters on AHU #3 and #4. These filters were inaccessible during the NIOSH inspection because the screws holding the access panels for these filters were rusted in place.

6. Check the HVAC system settings and make sure that the system is appropriately programmed. Pay special attention to the damper settings for supplying enough outdoor air to comply with the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) recommendations.

7. Confirm that all HVAC system components are functioning as programmed.

8. Balance the HVAC system to provide appropriate airflow and outside air to the building occupants.

9. Minimize re-circulation of unfiltered plenum air introduced into the mixing boxes or the distribution chambers.

10. Develop and implement a routine inspection and preventive maintenance plan to prevent recurring problems.

This interim report provides the detailed results of the NIOSH inspection of the HVAC system at the SCAO building. We are in the process of completing a report of the results of medical, epidemiologic, and environmental testing and their inter-relationships. We have been delayed by not receiving measurements of environmental endotoxin from a laboratory. If you have any comments or questions, please contact me at (304) 285-5967.

Sincerely,

Ju-Hyeong Park, MPH, Sc.D.
Project Officer, Industrial Hygienist
Respiratory Disease Hazard Evaluation and
Technical Assistance Program
Field Studies Branch
Division of Respiratory Disease Studies

Enclosures

Cc: Don Miller, Executive Director of SCAO
Larry Stewart, SCAO Safety and Health committee
Marian Fake, IMCW
Barbara Zerfoss, Clerk typist II
Bcc: Requesters

Interim Report

NIOSH EVALUATION OF THE HVAC SYSTEM AT THE SOMERSET COUNTY ASSISTANCE OFFICE BUILDING SOMERSET, PENNSYLVANIA

HETA 2001-0067

June 26, 2002

Khaled Elsherbini, Ph.D.

Ju-Hyeong Park, MPH, Sc.D.

Mark D. Hoover, Ph.D., CHP, CIH

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) inspected and measured airflows in the heating, ventilation, and air conditioning (HVAC) system at the Somerset County Assistance Office (SCAO) building on August 8 and 9, 2001, as a part of response to occupant concerns for indoor air quality.

SCAO is a 13,500 square foot office building, which was built and occupied in June 1987. It had been leased by the state of Pennsylvania and used as a public assistance building since 1987. The SCAO building is located in a suburban area of Somerset (600 Aberdeen Drive) and has brick veneer walls and a slanted asphalt-shingled roof. The Somerset County Assistance Office had 68 employees and received an average of 125 visitors daily at the time of the site visit.

This report describes the design of the HVAC system, summarizes the problems that were found during the investigation, and makes recommendations for remediation of these problems.

OVERVIEW OF THE HVAC SYSTEM

Figure 1 is a schematic diagram of the Somerset County Assistance Office HVAC system. The system includes four air handling units (AHUs) on the roof of the building and a network of duct work, mixing boxes, distribution chambers, variable air volume (VAV) controllers, supply diffusers, and return air grilles. The four AHUs are sequentially numbered AHU #1, the unit serving the reception area and conference room, through #4, the unit that serves the lunchroom and adjacent restrooms. Figure 2 shows the areas served by each of the four units at the time of the inspection.

The HVAC system at this building uses a ceiling plenum (space between the ceiling tiles above the occupied space and attic of the building) for returning air from the occupied space to the AHUs. This plenum also contains all the HVAC system ductwork, as well as electric wires and computer network connections. The plenum is separated from the attic by a vapor barrier (a large sheet of plastic) and insulation. The vapor barrier prevents penetration of water into the building envelope via vapor diffusion, and insulation prevents large temperature differences between attic air and plenum.

The general flow of air supplied by each AHU (Figure 1) is as follows:

- Outside air (OA) enters the AHU through inlet pre-filters.
- The OA mixes with re-circulating air coming from the plenum return air to make supply air (SA). The relative amounts of OA and re-circulating air are regulated by an OA damper and a re-circulating air damper that are synchronized depending on the thermostat settings for the occupied space.
- The supply air (SA) flows through the main filters.
- After the main filters, the supply air passes through cooling coils and is cooled if required.
- The air then passes through a fan, which provides the pressure to operate the system.

- The air passes through heating coils and is heated if required.

- The air is delivered to the mixing box in the plenum, and mixed with some portion of unfiltered return air from the plenum if compensation is needed for enough supply air for occupants. VAV controllers regulate the amount of unfiltered return air. Note that this allows unfiltered air from the plenum to be returned to the occupied space.

- The air from the mixing box is then sent to two distribution chambers. These boxes also introduce non-filtered return air from the plenum to the supply airflow through VAV controllers as needed.

- The supply air travels through flexible ducts from the distribution chambers to the supply air diffusers in the occupied area.

- Finally, air from the occupied space is returned to the plenum through return air (RA) grilles in the ceiling tiles. Some of the RA is recirculated, as noted above, and the remaining RA is exhausted into the outside environment.

HVAC INSPECTION

The investigation of HVAC system included visual inspections of all components of the system.

1. Air Handling Units

The inlet filters, main filters, dampers, fan casing, heating coils, cooling coils, drain pan, drain trap, and the supply air ducts were visually inspected in each of the four rooftop-mounted AHUs.

1) General Observations

The AHUs have drain pans under the cooling coils to collect any water that condenses on the cooling coils. There are drains to allow the condensed water to leave the drain pans. After flowing through a drain trap, the condensed water was observed flowing from the open drain directly onto the roof of the building just under the AHUs. This drainage mode itself is not a problem if the roof is waterproofed and undamaged. However, if the roof is damaged and not properly functioning, the condensed water could cause roof leaks. NIOSH observed that some water-damaged areas of ceiling tile in the building were located in areas where water drains onto the roof. The damaged roof around AHUs should be repaired so that rainwater and condensed water do not leak through the roof.

The main supply air (SA) duct of each of the AHUs in the facility is internally lined. Some areas of the lining were observed to have detached from the duct wall, which could cause dirt to accumulate on the material and insulation fibers to be released into the occupied space. Internal lining of ducts should be carefully used. Materials used as internal insulation exposed to the air in ducts should be durable when rated in accordance with UL 181 or ASTM C1071 erosion tests, and the material should not trap dirt or moisture that could support microbial growth. However, in the building, the internal linings are near moisture producing equipment (cooling coils), and thus the internal fiberglass insulation lining may trap moisture as well as dust. Therefore, external lining would be recommended in this building.

Inspection summaries are presented in Table 1 and specific observations for each of the AHUs are provided in the following sections.

2) AHU #1

The drain trap for AHU #1 was found to be only 2" tall. The height of the drain trap should be 40% more than the fan static pressure to ensure proper drainage. The height of the drain trap should be increased to 2.5" to comply with the recommended pressure difference.

The water from the drain was also found to leak onto the edge of the AHU and flow towards the power supply at which point it would drop onto the roof. This leak needs to be repaired to avoid contact between the water and the power supply.

The lining of the supply air duct was detached from the duct wall over six feet from the duct inlet. The internal lining should be removed and external lining should be reinstalled.

3) AHU #2

The drain trap in this unit was clogged, and no water was flowing out of it, even after shutting down the system. The drain pan was full of water and was overflowing into the fan casing. The drain trap needs to be unclogged, and the drain pan and fan casing need to be dried and cleaned.

The dampers were found to be wide open. This condition was permitting the AHU to supply more than twice the required airflow. This could have been the result of a malfunction in the dampers or an incorrect system setting. The AHU needs to be inspected to identify and correct the root cause of the improper condition.

The inner lining of the supply air duct was also found to be detached from the duct wall. The improperly high air velocity may have contributed to the separation of the lining from all walls of the duct. The lining was also found to be very dirty, and most of the torn parts of the lining appeared to have already flown into the ductwork. Therefore, the internal lining should be completely removed and external lining should be reinstalled.

4) AHU #3

There was a large amount of water in the fan casing of AHU#3. This water was leaking through the fan-casing wall. The leaking area was very close to the power supply. This situation was the same as what was found in the AHU #1. The water in the AHU needs to be drained and dried, and the causes of water buildup need to be identified and repaired.

We could not open the access panel on this unit because the panel retaining screw was rusted. This prevented us from inspecting the main filters in the unit. The poor condition of the panel retaining screw indicates that the filters might not have been changed in some time. The screw needs to be repaired to provide access to the filters, and the filters need to be checked and replaced, if necessary.

One of the four sides of the lining in the supply air duct was detached, as with AHU #1. Remove the internal lining and reinstall external insulation lining for the duct.

5) AHU #4

As with AHU #3, the screw holding the panel that gives access to the filters was rusted and could not be opened. The screw should be fixed and the filters should be inspected and replaced, if necessary. This was the only AHU where the inner lining inside the SA duct was found intact.

2. Plenum

We inspected the plenum by raising the ceiling tiles at numerous locations in the occupied space. The plenum was found to be clean.

3. Mixing Boxes

The mixing boxes were visually inspected, including the condition of the flexible ducts attached to the mixing boxes. Randomly selected flexible ducts were inspected and found to be internally clean.

4. Distribution Chambers and Ducts

The distribution chambers were visually inspected, including the condition of the lining of the ducts and the connections between the flexible ducts and the distribution chambers. The ducts from the distribution chambers were connected to the diffusers by duct-tape, which was found to be loose at some locations, although no leaking of air was found at any of these connections. The loose connections should be repaired to prevent leaks from developing. Some of the flexible ducts from the mixing boxes go through the vapor barrier and the attic to the distribution chamber. The vapor barrier was visually inspected and NIOSH found no areas of water accumulation on the vapor barrier above the plenum during the HVAC inspection period. This does not guarantee that the roof was leak-free at the time of the inspection and may have been simply due to the dry August weather condition at the time of the inspection. NIOSH could visually inspect the connections and the parts of the ducts that were in the plenum, but not the parts that were in the attic. There was no evidence that the sections of the ducts in the attic were disconnected or damaged.

Note, however, that during the walkthrough inspection of the building in March 2001, NIOSH had found several spots with water accumulation on the vapor barrier below the insulation that separates the plenum and the attic. The main spot where water accumulation was found was in the small hall in front of the smoking room. Other spots were in areas where roof leaks had been previously reported. NIOSH found holes in the vapor barrier at these locations. It appeared that holes were made to drain and collect accumulated water. The best method to prevent water accumulation is to keep the roof in good repair. If leaks do occur, and accumulated water needs to be removed, the holes should be immediately sealed and the leak repaired.

AIRFLOW MEASUREMENTS

The investigation of the HVAC system also included airflow measurements.

1. Airflow in the Ductwork

The face velocities of unfiltered, re-circulating air introduced from the plenum through the damper to the mixing boxes were measured in the return air ducts of the mixing boxes with a VelociCalc® hot wire anemometer. The airflows were calculated by multiplying the average face velocities by the area of the ducts. Similarly, the airflows in the supply air ducts from the mixing boxes to the two distribution chambers were determined. One distribution chamber from the mixing box for each AHU is located on the main-entrance side of the building, while the other chamber is located on the hill side of the building that is the side where the conference room and lunch room are located (Figure 2). The face velocities in the outside inlets of AHUs measured with a VelociCalc® hot wire anemometer and the areas of the inlets were used to determine the amount of outside air pulled into the units.

Table 2 shows the flow rates measured in the return air ducts and supply air ducts at the mixing boxes. Airflow measurements at the return air ducts at the mixing boxes indicate the amounts of unfiltered plenum return air added to supply air from the AHUs (filtered outdoor and re-circulating air). The data show that the occupied areas served by AHU #2 and #4 were receiving more than 700 feet^3/minute of unfiltered plenum return air at the mixing boxes at the time of investigation. That comprises more than 20% of supply air. Furthermore, the amount of unfiltered re-circulating air could be underestimated because additional unfiltered plenum air could be introduced into the distribution chambers, which is controlled by another VAV box. From Table 2, we determined the total amount of air being supplied to the area of the building that was served with each unit. This was done by summing air flows that were measured in the two supply air ducts from each mixing box to the two distribution chambers (Figure 2). We also computed the total amount of re-circulating air for each of the AHUs by subtracting the amount of outdoor air from the total amount of supply air.

Table 3 shows the flow rate and the percentage of Supply Air (SA), Outside Air (OA), total Re-circulating Air (RA), and unfiltered re-circulating air for each of the four AHUs. The data indicate that 70% to 91% of the supply air is composed of re-circulating air and that some proportion of the re-circulating air contains unfiltered make-up air from the plenum. The AHUs were in an "energy-saver" mode, which is used in the summer to minimize the amount of outside air that must be cooled to an acceptable indoor-air temperature. Tables 1 and 3 indicate that the amount of OA supplied by AHU #3 and 4 was lower than the ASHRAE (American Society of Heating, Refrigerating, and Air-conditioning Engineers) recommendation of 20 feet^3/minute per person. Therefore, AHU #3 and #4 should be adjusted to provide more OA. The OA ratio was highest for AHU #2, which is likely due to the observation mentioned previously that the outdoor damper was open too much for this AHU. The amount of supplied OA for AHU #1 and #2 is much higher than ASHRAE recommendation. However, if we consider that the building receives an average of 125 visitors daily in the areas served by AHU #1 and 2 (reception and interview area), the amount of OA supplied by these AHUs should be greater than ASHRAE recommendation that would be calculated based on the number of regular employees only.

2. Airflow into the Occupied Space

The flow of air into the occupied space of the building was measured from each supply air diffuser using a TSI® flowhood. We measured this twice on two different days for an understanding of day-to-day variation: on August 8 from noon until 2:30 pm and on August 9 from 1:00 pm until 3:45 pm. Figures 3 and 4 provide the airflow measurements from the supply air diffusers on August 8, 2001 and on August 9, 2001, respectively.

The data in Figures 3 and 4 were used to check the condition of the system balance and the functionality of the VAV boxes and the diffusers. The ratios of the flow rates observed through the diffusers were similar on both August 8 and August 9, even though the absolute airflow on August 9 was two to three times higher than the absolute airflow measured on August 8. This shows that the system was not properly balanced, even though all the VAV boxes seem to be working together. Therefore, the system needs to be balanced and routinely maintained.

CONCLUSIONS AND RECOMMENDATIONS

NIOSH inspection of the Somerset HVAC system identified problems with the general maintenance of the system, the distribution of air in occupied spaces, and the amount of outside air being provided. Our airflow measurements indicated that airflow in occupied spaces is not evenly distributed suggesting an improperly balanced system, and that AHU #3 and #4 do not provide enough outdoor air to the occupants served by each unit.

The recommendations for remediation of the problems are as follows:

- Repair and clean the drain traps as needed in all four AHUs.
- Repair the damaged roof to prevent condensed water drained out of the AHUs from leaking through the roof. Redirect the drainage from the AHU drain traps directly to the gutter until the damaged roof is completely repaired.
- Remove all internal linings and reinstall external insulation linings for the ducts that carry supply air from the AHUs. Make sure that occupants are not exposed to the fibers while the internal insulation lining is removed.
- Confirm that all flexible air supply ducts are properly attached to the supply-air diffusers.
- Routinely inspect and replace the HVAC filters. Pay special attention to the main filters on AHU #3 and #4. These filters were inaccessible during the NIOSH inspection because the screws holding the access panels for these filters were rusted in place.
- Check the HVAC system settings and make sure that the system is appropriately programmed. Pay special attention to the damper settings for supplying enough outdoor air complying with ASHRAE recommendation.
- Confirm that all HVAC system components are functioning as programmed.
- Balance the HVAC system to provide appropriate air flow and outside air to the building occupants.
- Minimize re-circulation of unfiltered plenum air introduced into the mixing boxes or the distribution chambers.
- Develop and implement a routine inspection and preventive maintenance plan to prevent recurring problems.

Table 1. Inspection Results for the Air Handling Units (AHUs)

Inspected Items	Inspection Results			
	AHU #1	**AHU #2**	**AHU #3**	**AHU #4**
Number of people served	8	23	26	14
Outdoor air (OA)				
Duct velocity (feet/minute)	110	400	137	90
Inlet area (inch × inch)	32" x 12"	32" x 12"	32" x 12"	32" x 12"
Flow rate* ($feet^3$/minute)	293	1067	365	240
Requirement† ($feet^3$/ minute)	160	460	520	280
Compliance	Acceptable	Acceptable	Not Acceptable	Not Acceptable
Main Filter				
Condition (visual observation)	Clean and properly-sized	Clean and properly-sized	Inaccessible	Inaccessible
Last filter change	6/7/2001	6/7/2001	Inaccessible	Inaccessible
Coil pan condition (Visual observation)	Rusty, wet, and muddy	Wet and muddy	Very wet	Wet
Fan casing condition	Clean	Clean	Very wet	Wet
Static pressure Across the fan (inch)	1.8"	1.3"	1.1"	0.98"
Drain trap:				
Height (inch)	2"	3.25"	2.25"	1.5"
Compliance of Height ‡	Not adequate	Adequate	Adequate	Adequate
Condition	Clean	Clogged	Clean	Clean
OA duct insulation lining				
Method of lining	Internal	Internal	Internal	Internal
Condition	Detached	Detached	Detached	Intact

*** OA flow rate = (Average face velocity at OA inlet) × (Area of OA inlet).**
† OA requirement is based on an ASHRAE recommendation of 20 $feet^3$/minute per person
‡ Drain trap height is recommended to be 40% more than the fan static pressure.

Table 2. Airflow Measurements in the Return Air Duct at the Mixing Box and in the Supply Air Ducts from Each Mixing Box to the Two Distribution Chambers for All AHUs

AHU #	Measured Duct*	Location†	Air velocity (feet/minute)	Diameter (inch)	Air flow rate ($feet^3$/minute)
1	RAD	At MB	400	16	558
	SAD	Between MB and HDC	1500	12	1178
		Between MB and MDC	1430	16	1996
2	RAD	At MB	540	16	754
	SAD	Between MB and HDC	1765	16	2463
		Between MB and MDC	795	16	1109
3	RAD	At MB	132	16	184
	SAD	Between MB and HDC	1425	16	1989
		Between MB and MDC	545	16	761
4	RAD	At MB	530	16	740
	SAD	Between MB and HDC	565	16	788
		Between MB and MDC	1330	16	1856

*** RAD is return air duct, and SAD is supply air duct.**

† MB is the Mixing box, and HDC is the distribution chamber on the hill side of the building, and MDC is the distribution chamber on the main entrance side of the building.

Table 3. Flow Rate (feet^3/minute) and Percentage of Supply Air (SA), Outside Air (OA), Re-circulating Air (RA), and Unfiltered RA for each of the four Air Handling Units (AHUs)

AHU#	SA (%)	OA (%)*	RA (%)*	Unfiltered RA (%)*
1	3174 (100)	293 (9)	2881 (91)	558 (18)
2	3572 (100)	1067 (30)	2505 (70)	754 (21)
3	2750 (100)	365 (13)	2385 (87)	184 (7)
4	2644 (100)	240 (9)	2404 (91)	740 (28)

*** Percent of OA in SA = (OA/SA) ×100;**
Percent of RA in SA = (RA/SA) ×100;
Percent of Unfiltered RA in SA = (Unfiltered RA/SA) ×100.

Figure 1. Diagram of HVAC system at Somerset County Assistance Office Building

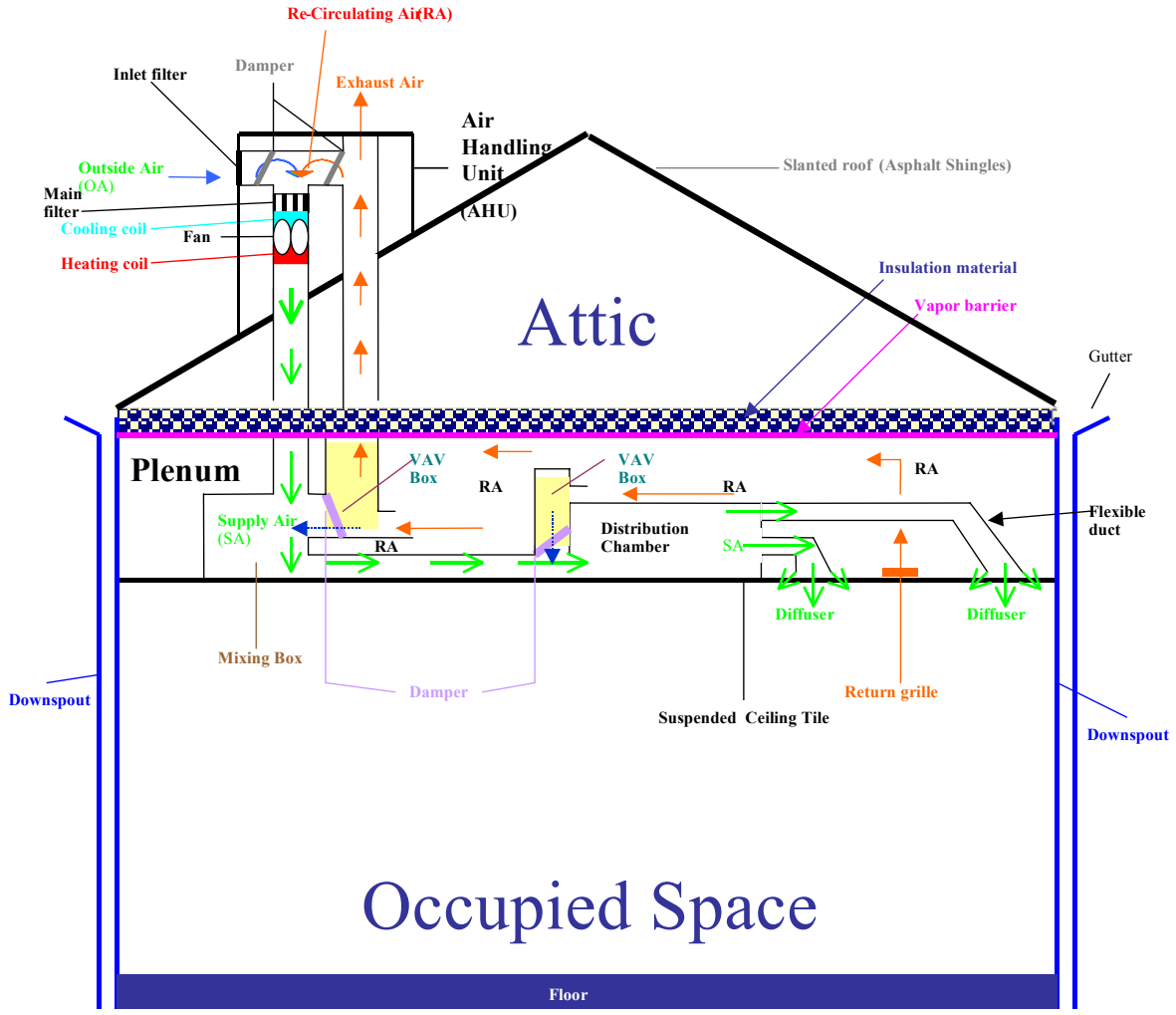
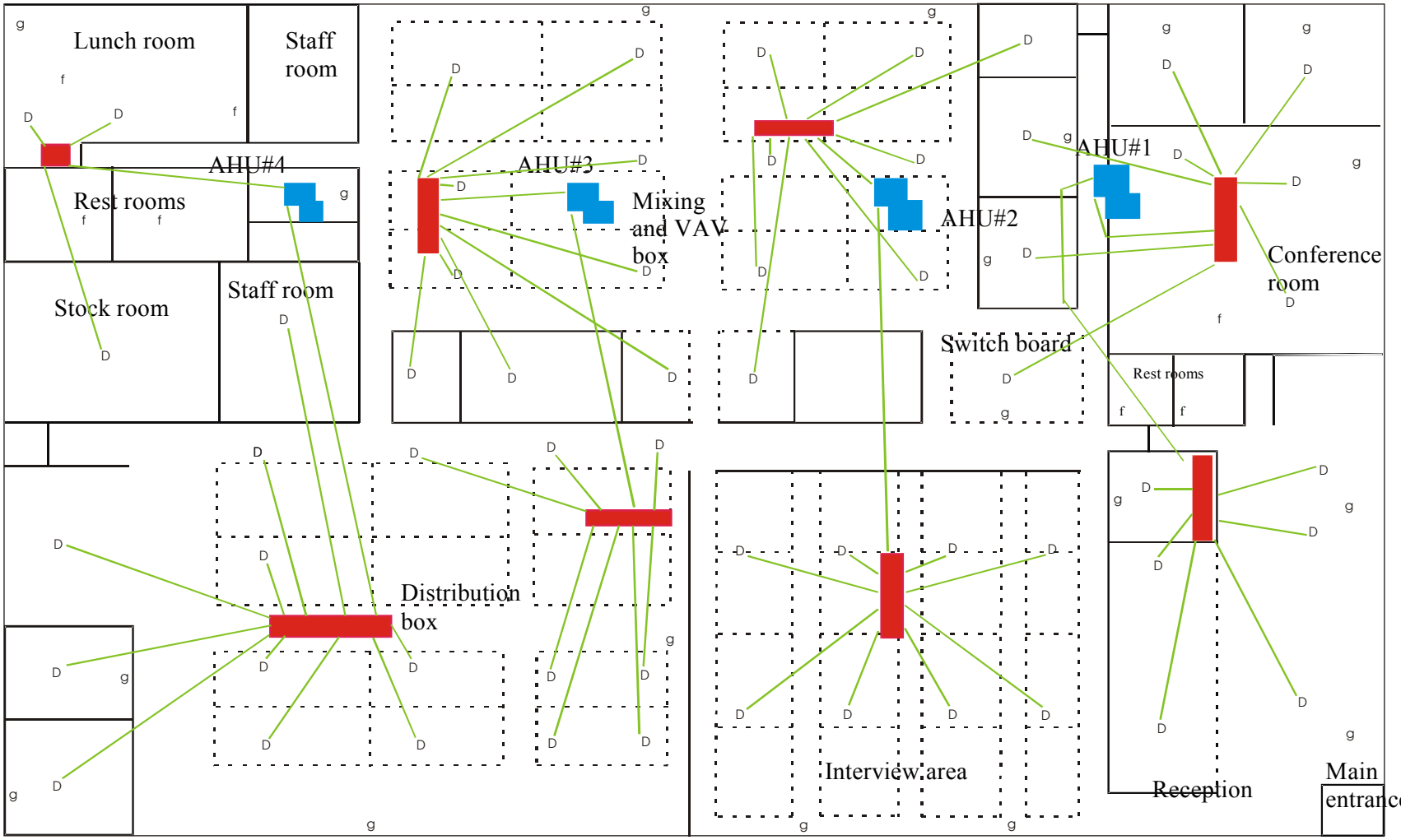
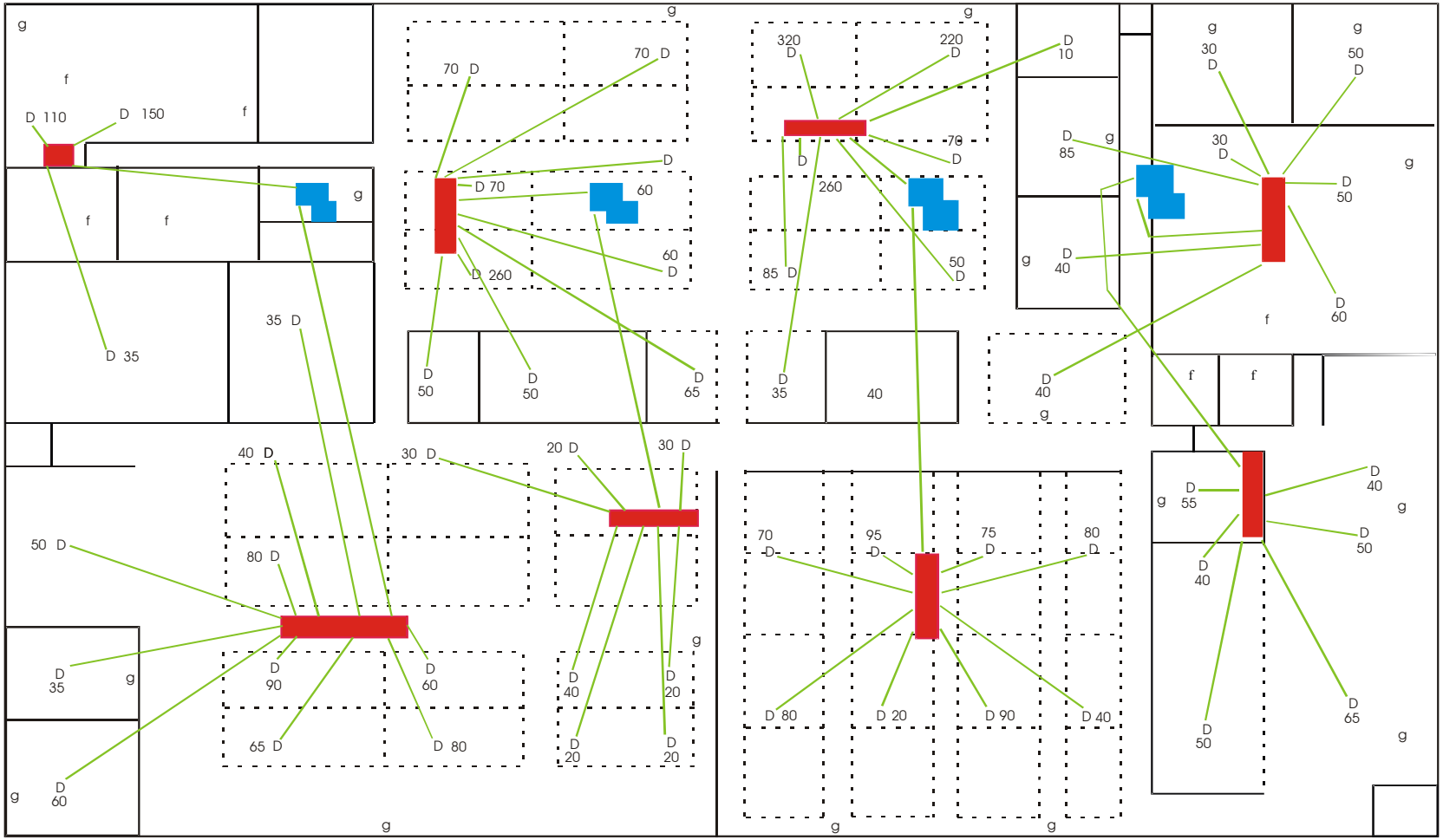


Figure 2. Layout of and Air Distribution Network in the Building



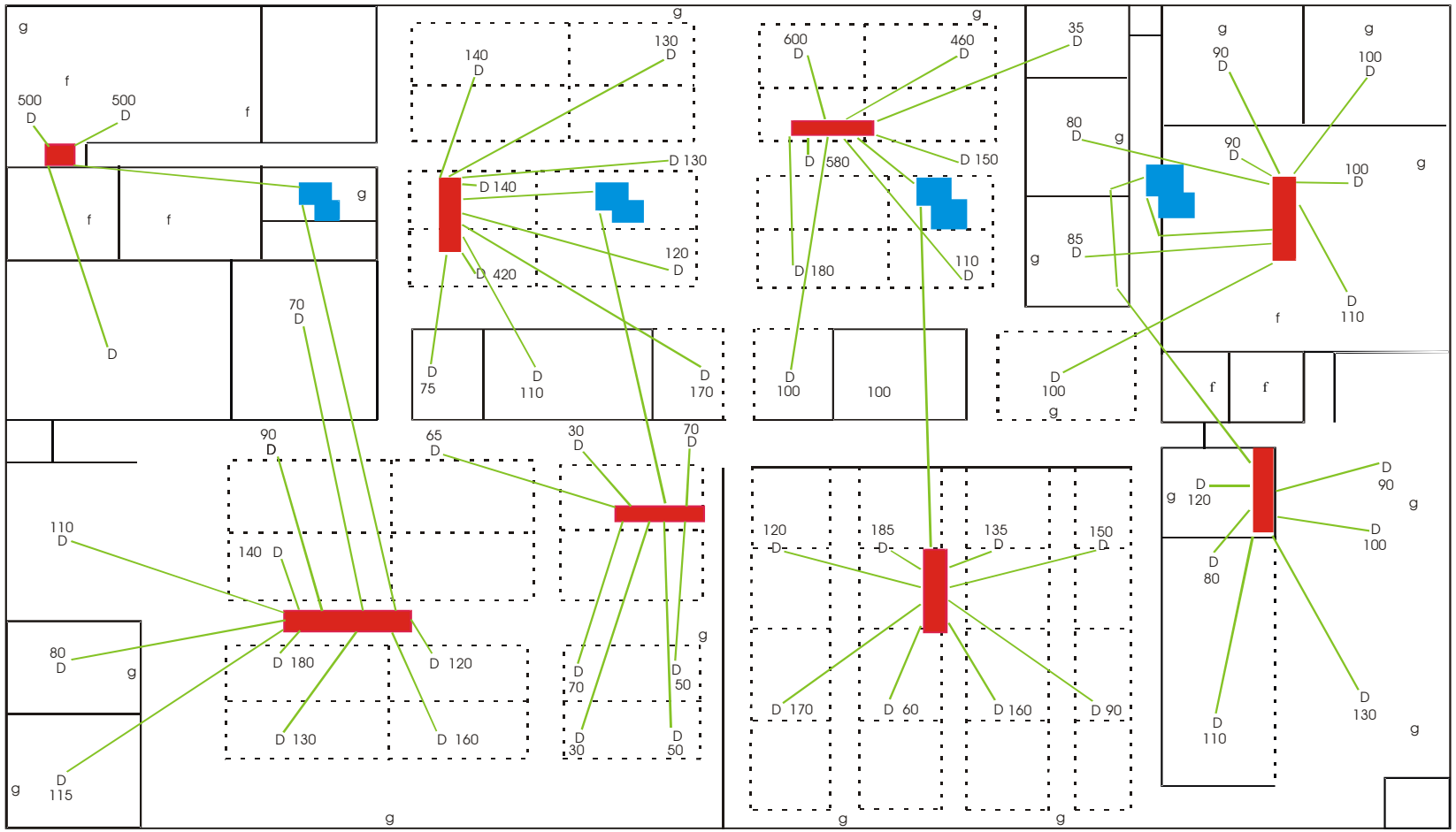
D: Diffuser; g: Return Grille; f: Exhaust fan; AHU: Air Handling Unit; Green lines: Supply air ducts; Black lines: Physical walls; Black broken lines: Cubicles.

Figure 3. Airflow (feet^3/minute) Measurements at Each Diffuser inside the Building on August 8, 2001



D: Diffuser; g: Return grille; f: Exhaust fan; Red boxes: Distribution boxes; Blue boxes: Mixing and VAV boxes; Green lines: Supply air ducts.

Figure 4. Airflow (feet^3/minute) Measurements at Each Diffuser inside the Building on August 9, 2001



D: Diffuser; g: Return grille; f: Exhaust fan; Red boxes: Distribution boxes; Blue boxes: Mixing and VAV boxes; Green lines: Supply air ducts.

Appendix B

The Short Screening Questionnaire for the March Survey and the Long Questionnaire for the July through August Survey

Screening Questionnaire

Somerset County Assistance Office
HETA 2001-0067

*ID*_____

Somerset County Assistance Office Screening Questionnaire

1. *In what year did you begin working at the Somerset County Assistance Office?* *Year_____*

2. *Have you had wheezing in your chest at any time in the **last four weeks?*** *1. Yes_____ 2. No_____*

3. *Have you had tightness in your chest in the **last four weeks?*** *1. Yes_____ 2. No_____*

4. *Have you had an attack of shortness of breath in the **last four weeks?*** *1. Yes_____ 2. No_____*

5. *Have you had an attack of coughing in the **last four weeks**?* *1. Yes_____ 2. No_____*

6. *Apart from a cold, have you had nasal symptoms, such as a stuffed or blocked nose, itchy nose, runny nose or episodes of sneezing at any time in the **last four weeks?*** *1. Yes_____ 2. No_____*

7. *Have you experienced **any** of the following signs or symptoms in the **last four weeks:** flu-like achiness or joint pain, fever, chills, night-sweats, or unusual tiredness or fatigue?* *1. Yes_____ 2. No_____*

8. *If you answered 'Yes' to **any** of the questions in the box above (Questions 2-7) then please answer Questions 8a & 8b. If not, then please skip to Question 9.*

   *8a. Did you have **any** of these symptoms **in the year before** you started working at the Somerset County Assistance Office?*

   1. Yes_____ 2. No_____ 3. Don't Know _____

   8b. When you are away from work on weekends or vacations, do you consider your symptoms to be the

   1. Same_____ 2. Worse_____ 3. Better_____ 4. Don't Know_____

9. *Has a doctor ever diagnosed you with asthma?* *1. Yes_____ 2. No_____*

   9a. If 'Yes', in what year were you diagnosed with asthma? *Year _____*

10. *Has a doctor ever diagnosed you with hypersensitivity pneumonitis?* *1. Yes_____ 2. No_____*

11. *Do you have any additional comments or concerns that have not been addressed in the questions above?*

_____

_____

_____

Thank you!

Long Questionnaire

Somerset County Assistance Office
HETA 2001-0067

ID #__ __ __

SECTION I: IDENTIFICATION AND DEMOGRAPHIC INFORMATION

Please print your answers.

Name: 1._____ 2._____ 3._____
(Last Name) (First Name) (MI)

Home Address: 4._____
(Number, Street, and/or Rural Route)

5._____ 6._____ 7._____
(City) (State) (Zip Code)

Home Telephone Number: 8. (__ __ __) __ __ __ - __ __ __ __

Work Telephone Number: 9. (__ __ __) __ __ __ - __ __ __ __

---

10. Date of Birth: *__ __/__ __/__ __ __ __*
(Month) (Day) (Year)

11. Gender: *1. _____ Male 2. _____ Female*

12. Race:

1. _____ White
2. _____ African-American/Black
3. _____ Asian
4. _____ American Indian or Alaska Native
5. _____ Native Hawaiian or Other Pacific Islander
6. _____ Other (13. Please specify:_____)

14. Are you of Hispanic origin? *1. _____ Yes 2. _____ No*

SECTION II: HEALTH AND WELL-BEING INFORMATION

The following questions concern chest symptoms and breathing problems.

Wheeze

15. Have you had wheezing or whistling in your chest at any time in the ***last 12 months?***

1. _____ Yes 2. _____ No

If 'Yes' to Q.15, please answer Q.16-Q.18. If not, skip to Q.19.

16. In what month and year, during your lifetime, did this wheezing or whistling in your chest first start?

__ __/ __ __ __ __
(Month) (Year)

17. Have you woken up with wheezing in the ***last 12 months?***

1. _____ Yes 2. _____ No

18. When you are away from work on weekends, days off, or vacations, is this wheezing the

1. _____ Same
2. _____ Worse
3. _____ Better

Shortness of Breath

19. Have you experienced any shortness of breath in the ***last 12 months?***

1. _____ Yes 2. _____ No

If 'Yes' to Q.19, please answer Q.20-Q.23. If not, skip to Q.28.

20. In what month and year, during your lifetime, did this shortness of breath first start?

__ __/ __ __ __ __
(Month) (Year)

*21. Have you been woken by an attack of shortness of breath at any time in the **last 12 months?***

1. _____ Yes 2. _____ No

22. When you are away from work on weekends, days off, or vacations, is this shortness of breath the

1. _____ Same

2. _____ Worse

3. _____ Better

23. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?

1. _____ Yes 2. _____ No

If 'Yes' to Q.23, please answer Q.24-Q.27. If not, skip to Q.28.

24. Do you have to walk slower than people of your age on the level because of breathlessness?

1. _____ Yes 2. _____ No

25. Do you ever have to stop for breath when walking at your own pace on the level?

1. _____ Yes 2. _____ No

26. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?

1. _____ Yes 2. _____ No

27. Are you too breathless to leave the house or breathless on dressing or undressing?

1. _____ Yes 2. _____ No

Chest Tightness

*28. Have you experienced any chest tightness in the **last 12 months?***

1. _____ Yes 2. _____ No

If 'Yes' to Q.28, please answer Q.29-Q.31. If not, skip to Q.32.

29. In what month and year, during your lifetime, did this chest tightness first start?

__ __ / __ __ __ __
(Month) (Year)

*30. Have you woken up with a feeling of tightness in your chest at any time in the **last 12 months?***

1. _____ Yes 2. _____ No

31. When you are away from work on weekends, days off, or vacations, is this chest tightness the

1. _____ Same
2. _____ Worse
3. _____ Better

Cough

32. Do you usually have a cough? (Count a cough with first smoke or on first going out-of-doors. Exclude clearing of throat)

1. _____ Yes 2. _____ No

If 'Yes' to Q.32, please answer Q.33. If not, skip to Q.37.

33. Do you usually cough like this on most days–or at night--for as much as three months during the year?

1. _____ Yes 2. _____ No

If 'Yes' to Q.33, please answer Q.34-Q.36. If not, skip to Q.37.

34. In what month and year, during your lifetime, did you first start having this cough?

__ __ / __ __ __ __
(Month) (Year)

*35. Have you been woken by an attack of coughing at any time in the **last 12 months?***

1. _____ Yes 2. _____ No

36. When you are away from work on weekends, days off, or vacations, is this coughing the

1. _____ Same
2. _____ Worse
3. _____ Better

If 'Yes' to Q.17 AND/OR Q.21 AND/OR Q.30 AND/OR Q.35, please answer Q.37. If not, skip to Q.38.

37. In the last 12 months, how often were you awakened from sleep by one or more of these chest symptoms in an average month (wheezing, shortness of breath, chest tightness, and/or cough)?

1. _____ 2 or less/month

2. _____ 3 - 4/month

3. _____ 5 - 6/month

4. _____ 7 or more/month

If 'Yes' to Q.15 AND/OR Q.19 AND/OR Q.28 AND/OR Q.32, please answer Q.38-Q.39. If not, skip to Q.40.

*38. Over the last 12 months, **on average**, how many episodes per week did you experience any chest symptoms (an episode of wheezing, shortness of breath, chest tightness, and/or cough)?*

1. _____ Less than 1/week

2. _____ 1 or more/week but less than 1/day

3. _____ Daily (1/day)

4. _____Continuous (2 or more/day)

39. In the last 12 months, have you experienced any limitation of daily activities, such as dressing or walking on the level, that you feel are due to chest symptoms (wheezing, shortness of breath, chest tightness and/or cough)?

1. _____ Yes 2. _____ No

Phlegm From the Chest

40. Do you usually bring up phlegm from your chest? (Count phlegm with the first smoke or on first going out-of-doors. Exclude phlegm from the nose. Count swallowed phlegm)

1. _____ Yes 2. _____ No

If 'Yes' to Q.40, please answer Q.41. If not, skip to Q.42.

41. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?

1. _____ Yes 2. _____ No

If 'Yes' to Q.41, please answer Q.42. If not, skip to Q.43:

42. In what month and year did you first start having trouble with phlegm?

__ __ / __ __ __ __
(Month) (Year)

Breathing

43. Do you ever have trouble with your breathing?

1. _____ Yes 2. _____ No

If 'Yes' to Q.43, please answer Q.44. If not, skip to Q.45.

44. Do you have this trouble (Choose only one of the following)

1. _____ continuously so that your breathing is never quite right?

2. _____ repeatedly, but it always gets completely better?

3. _____ only rarely?

45. When you are near animals, such as cats, dogs or horses, near feathers, including pillows, quilts, or down or feather comforters, or in a dusty part of your house, do you ever get a feeling of tightness in your chest?

1. _____ Yes 2. _____ No

Asthma

46. Have you ever had asthma?

1. _____ Yes 2. _____ No

If 'Yes' to Q.46, please answer Q.47-Q.54. If not, skip to Q.55.

47. Was this confirmed by a doctor?

1. _____ Yes 2. _____ No

48. When did you have your first attack of asthma?

__ __ / __ __ __ __
(month) (year)

*49. Have you had an attack of asthma in the **last 12 months?***

1. _____ Yes 2. _____No

50. Did you have asthma in the year before you started working here?

1. _____ Yes 2. _____No

If 'Yes' to Q.50, please answer Q.51. If not, skip to Q.52:

51. Overall, since you started working here, has your asthma been the

1. _____ Same

2. _____ Worse

3. _____ Better

52. When you are away from work on weekends, days off, or vacations, are your asthma symptoms the

1. _____ Same

2. _____ Worse

3. _____ Better

*53. In the **last 12 months**, how many times did you get treatment for an acute asthma attack at a doctor's office, urgent care facility, or emergency department (ER)?*

_____ times

54. When was your most recent overnight hospitalization for asthma?

1. _____ I have never been hospitalized overnight for asthma

2. _____ Within the past month

3. _____ More than 1 month but less than 6 months ago

4. _____ 6 months to 1 year ago

5. _____ More than 1 year ago

Medications for Breathing Problems

55. Over the last 12 months, have you taken or been prescribed any inhaled beta-agonists (quick-relief medicine, such as Albuterol or Proventil) for breathing problems?

1. _____ Yes 2. _____ No

If 'Yes' to Q.55, please answer Q.56. If not, skip to Q.57.

56 . In the last 12 months, have you used your beta-agonist inhaler on a daily basis?

1. _____ Yes 2. _____ No

57. Over the last 12 months, have you taken any over-the-counter inhalers or pills (e.g. Primatene) for breathing problems?

1. _____ Yes 2. _____ No

If 'Yes' to Q.55 AND/OR Q.57, please answer Q.58. If not, skip to Q.60.

*58. In the **last 12 months**, did your use of beta-agonist inhalers or over-the-counter medications change on weekends, days off, or vacations?*

1. _____ Yes 2. _____ No

If 'Yes' to Q.58, please answer Q.59 . If not skip to Q.60.

59. Do you use these inhalers or pills more or less on workdays?

1. _____ More on workdays

2. _____ Less on workdays

60. Over the last 12 months, have you taken or been prescribed any inhaled corticosteroids for breathing problems?

1. _____ Yes 2. _____ No

If 'Yes' to Q.60, please answer 61. If not, skip to Q.63.

61. Which inhaled corticosteroid(s) are you currently taking, and how many puffs or inhalations do you use per day? (check all that apply)

Drug	✓	***No. of puffs/inh per day***
Beclovent (beclomethasone) 42 mcg		
Beclovent (beclomethasone) 84 mcg		
Vanceril (beclomethasone) 42 mcg		
Vanceril (beclomethasone) 84 mcg		
Pulmicort (budesonide) 200 mcg		
Dexacort (dexamethasone) 84 mcg		
Aerobid (flunisolide) 250 mcg		
Flovent (fluticasone propionate) 44 mcg		
Flovent (fluticasone propionate) 110 mcg		
Flovent (fluticasone propionate) 220 mcg		
Flovent Rotadisk (fluticasone propionate) 50 mcg		
Flovent Rotadisk (fluticasone propionate) 100 mcg		
Flovent Rotadisk (fluticasone propionate) 250 mcg		
Advair Diskus (fluticasone propionate/salmeterol) 100 mcg		
Advair Diskus (fluticasone propionate/salmeterol) 250 mcg		
Advair Diskus (fluticasone propionate/salmeterol) 500 mcg		
Azmacort (triamcinolone acetonide) 100 mcg		
Other (62. please specify_____)		
None		

63. Over the last 12 months, have you taken or been prescribed any steroid or corticosteroid pills such as Prednisone, Medrol, or Decadron for breathing problems?

1. _____ Yes 2. _____ No

64. In the last 12 months, have you taken or been prescribed any other medications for breathing problems?

1. _____ Yes 2. _____ No

If 'Yes' to Q.64, please answer Q.65. If not, skip to Q.67.

65. What other medications are you currently taking? (check all that apply)

Drug	✓
Serevent (salmeterol)	
Combivent (albuterol/ipatropium)	
Intal (cromolyn sodium)	
Tilade (nedocromil sodium)	
Duraphyl, Slo-bid, Slo-phyllin, Theo-24, Theobid, Theo-dur, Uniphyl (theophylline)	
Choledyl (oxitriphylline)	
Aminodor, Dura-Tabs (aminophylline)	
Singulair (montelukast sodium)	
Accolate (zafirlukast)	
Zyflo (zileuton)	
Other (66. please specify_____)	
None	

<u>Nasal Symptoms</u>

67. Have you had any nasal symptoms, such as a stuffy or blocked nose, itchy nose, runny nose or episodes of sneezing, at any time in the ***last 12 months?***

1. _____ Yes *2. _____ No*

If 'Yes' to Q.67, please answer Q.68. If not, skip to Q.69.

68. When you are away from work on weekends, days off, or vacations, are these nasal symptoms the

1. _____ Same
2. _____ Worse
3. _____ Better

Sinus Symptoms

69. Have you had any sinus symptoms, such as a sinus headache or facial pain and/or pressure, postnasal drip or drainage in the back of your throat, or thick mucus from your nose, at any time in the ***last 12 months?***

1. _____ Yes *2. _____ No*

If 'Yes' to Q.69, please answer Q.70. If not, skip to Question 71.

70. When you are away from work on weekends, days off, or vacations, are these sinus symptoms the

1. _____ Same
2. _____ Worse
3. _____ Better

Eye Symptoms

*71. Have you had itchy, burning eyes at any time in the **last 12 months?***

1. _____ Yes *2. _____ No*

If 'Yes' to Q.71, please answer Q.72. If not, skip to Q.73.

72. When you are away from work on weekends, days off, or vacations are these eye symptoms the

1. _____ Same
2. _____ Worse
3. _____ Better

Allergies

73. Do you have any nasal allergies, hay fever, asthma, or eczema?

1. _____ Yes *2. _____ No*

74. Does any of your blood relatives have nasal allergies, hay fever, asthma, or eczema?

1. _____ Yes *2. _____ No*

General Symptoms and Conditions

*In the **last 12 months**, have you had any of the following signs or symptoms?*

75. Frequent episodes of fever and/or chills?

1. _____ Yes *2. _____ No*

76. Frequent episodes of flu-like achiness or muscle aches?

1. _____ Yes 2. _____ No

77. Unintentional weight loss of 10 pounds or more?

1. _____ Yes 2. _____ No

Hypersensitivity Pneumonitis

78. Has a doctor ever diagnosed you with hypersensitivity pneumonitis?

1. _____ Yes 2. _____ No

If 'Yes' to Q.78, please answer Q.79. If not, skip to Q.80.

79. When were you diagnosed with hypersensitivity pneumonitis?

__ __ / __ __ __ __
(Month) (Year)

SECTION III: SMOKING AND OTHER INFORMATION

80. Have you ever smoked cigarettes? (Answer 'No' if less than 20 packs of cigarettes in a lifetime or less than 1 cigarette a day for 1 year) *1. _____ Yes 2. _____ No*

If 'Yes' to Q.80, please answer Q.81-Q.83. If not, skip to Q.85.

81. How old were you when you first started smoking regularly?

_____ *Years Old*

82. Over the entire time that you have smoked, what is the average number of cigarettes you smoked per day?

_____ *Cigarettes/Day*

83. Do you still smoke cigarettes? 1. _____ Yes 2. _____ No

If 'No' to Q.83, please answer Q.84. If not, skip to Q.85:

84. How long has it been since you have stopped smoking?

_____ *Years* _____ *Months*

*85. In the **last 12 months,** have you noticed any water damage, molds/mildew, or a moldy odor in your home?*

1. _____ *Yes* *2.* _____ *No*

86. Do you currently have any pets that spends time inside your home?

1. _____ *Yes* *2.* _____ *No*

If 'Yes' to Q.86, please answer Q.87. If not, skip to Q.89.

87. What kind of animals (pets) do you have (check all that apply):

A. _____ *Dog*

B. _____ *Cat*

C. _____ *Bird*

D. _____ *Other (88.Please specify_____)*

89. Do you currently live in an apartment or house/duplex?

A. _____ *Apartment*

B. _____ *House/Duplex*

*90. Have you seen any signs of cockroaches in your home, duplex, or apartment in the **last 12 months**?*

1. _____ *Yes* *2.* _____ *No*

91. Which best describes the carpeting in your home?

1. _____ *All carpeted*

2. _____ *Part carpeted*

3. _____ *None*

SECTION IV: WORK HISTORY INFORMATION

92. When did you <u>first</u> begin working at the Somerset County Assistance Office?

__ __/__ __ __ __
(Month) (Year)

*93. How many **hours per day** do you <u>usually</u> work at the Somerset County Assistance Office?*

_____*Hours/Day*

*94. How many **days per week** do you <u>usually</u> work at the Somerset County Assistance Office?*

_____*Days/Week*

*95. I am now going to ask you about the cubicle or office where you spend the **majority of your time**. Please take a moment to look at the map of the building. Each office, room, and cubicle has been given a code. Please think about which office or cubicle you have been assigned to in the last 12 months and give me the code corresponding to that office or cubicle. Please start with where you currently sit.*

DATES		***AREA CODE***
FROM	***TO***	
(Month/Year)	*(Month/Year)*	
__ __/__ __	*CURRENT*	_____
__ __/__ __	__ __/__ __	_____

__ __/__ __ __ __/__ __ _____

__ __/__ __ __ __/__ __ _____

__ __/__ __ __ __/__ __ _____

96. Have you used the interviewing area at all in the last 12 months?

1. _____ Yes 2. _____ No

If 'Yes' to Q.96, please answer Q.97. If not, skip to Q.98.

97. Please look at the map again and show me any section within the interviewing area you have used in the last 12 months (check all that apply)

1. _____ Section 1
2. _____ Section 2
3. _____ Section 3

98. Have you ever changed offices or cubicles due to chest problems?

1. _____ Yes 2. _____ No

If 'Yes' to Q.98, please answer Q.99-Q.101. If not, interview is completed.

99. In what month and year were you relocated (answer for the first relocation due to chest problems)?

__ __/__ __ __ __
(month) (year)

100. Using the map provided, please identify which office or cubicle you were relocated ***from.***

_____ *Code*

101. Using the map provided, please identify which office or cubicle you were relocated ***to.***

_____ *Code*

THANK YOU FOR YOUR PARTICIPATION!

Appendix C

Evaluation Criteria for Microbiologicals

Microorganisms are ubiquitous in the indoor environment. All microorganisms produce antigens–molecules, often proteins or polysaccharides, that stimulate the immune system. A single exposure to an antigen may result in sensitization. If the sensitized person is exposed again to the same antigen, a hypersensitive or allergic response may occur to an antigenic dose that would elicit little or no reaction from nonsensitized persons. Allergic reactions to inhaled antigens may be limited to the upper respiratory tract (e.g., allergic rhinitis), or they may affect the distal airways (e.g., allergic asthma), or the distal portions of the lung (e.g., hypersensitivity pneumonitis).

No standards or guidelines have been set by NIOSH, the Occupational Safety and Health Administration (OSHA), or the American Conference of Governmental Industrial Hygienists (ACGIH) for culturable or countable bioaerosols[1]. The ACGIH policy[2] is that a general Threshold Limit Value (TLV) for culturable or countable bioaerosol is not scientifically supportable because:

1. Culturable microorganisms and countable biological particles do not comprise a single entity.
2. Human responses to bioaerosols range from innocuous effects to serious, even fatal diseases depending on the specific material involved and workers' susceptibility to it.
3. It is not possible to collect and evaluate all bioaerosol components using a single sampling method (different methods of collection and analyses may result in different estimates of concentration).
4. At present, information relating culturable or countable bioaerosol concentrations to health effects is generally insufficient to describe exposure-response relationships.

"Specific TLVs for individual culturable or countable bioaerosols have not been established to prevent hypersensitivity, irritant, or toxic responses. At present, information relating culturable or countable bioaerosol exposure to health effects consists largely of case reports and qualitative exposure assessments." Therefore, results of airborne bacteria and fungi air sampling should not be used for compliance testing. Air sampling for microbials provide a short-term snapshot which may not be representative of the fungal conditions over the whole work day or under different environmental conditions. Because of the limitations in air sampling for fungi and bacteria, air sampling results should not be used to prove a negative case. Microbes in air vary seasonally, diurnally, and with activity level. These data should be used to help characterize the microbial environment rather than to establish safety exposures. In addition, in a research setting, microbial concentrations may be a marker of causal exposures for health effects. The occurrence of work-related health effects or lack thereof is the only way to assess whether an environment is acceptable.

References

1. Rao CY, Burge HA, Chang JCS. Review of quantitative standards and guidelines for fungi in indoor air. Journal of the Air & Waste Management Association 1996; 46 (9): 899-908.
2. ACGIH Bioaerosols Committee. Bioaerosols: Assessment and Control. Cincinnati: ACGIH, 1999

Appendix D

Report Issued by the California Department of Health Services about *Stachybotrys chartarum* a Mold that May Be Found in Water-Damaged Homes

Stachybotrys chartarum

a mold that may be found in water-damaged homes

November 2000

Environmental Health Investigations Branch
California Department of Health Services

Stachybotrys chartarum ecology

Stachybotrys chartarum (SC) is a greenish black mold that grows on material with a high cellulose content, such as fiberboard, the paper covering of gypsum wallboard, wallpaper, dust, and wood when these become chronically water damaged. This mold requires very wet conditions for days or weeks in order to grow. Excessive indoor humidity resulting in water vapor condensation on walls, plumbing leaks, spills from showering or bathing, water leaking through foundations or roofs may lead to growth of many types of mold, including Stachybotrys. No one knows how frequently this mold is found indoors since buildings are not routinely tested for its presence.

Toxin production

Stachybotrys chartarum is one of many molds that are capable of producing one or more mycotoxins (chemicals produced by molds that may be able to cause symptoms or illness in people). It has recently gained notoriety as some strains are capable of producing a very potent toxin. However, finding Stachybotrys within a building does not necessarily mean that occupants have been exposed either to allergens (pieces of the fungus or spores that can cause allergic symptoms in people prone to allergies) or toxins produced by this fungus. Laboratory studies indicate that molds such as Stachybotrys that have the ability to produce toxins do not always do so. Whether a mold produces a toxin while growing in a building may depend on what the mold is growing on, conditions such as temperature, pH, humidity or other unknown factors. When mycotoxins are present, they occur on spores and the small mold fragments that may be released into the air. While Stachybotrys is growing, a wet slime layer covers its spores, preventing them from becoming airborne. However, when the mold dies and dries up, air currents or physical handling can cause spores to become airborne. There are no commercial laboratory tests currently available that can detect mycotoxins in a building where molds are present.

Health Effects

Health problems associated with Stachybotrys chartarum were first noted in Russian and Eastern European farm animals that ate moldy hay in the 1930's and 1940's. Horses eating heavily SC-contaminated fodder experienced immune system suppression, infection and bleeding that was fatal with high doses. The first reported human health effects were seen in agricultural workers who handled the moldy straw or hay. These high level exposures were associated with coughing, runny nose, burning sensations in the mouth or nose, nose bleeds, headache, fatigue and skin irritation (rashes and itching) at the site of moldy hay contact.

Much less is known about health effects of SC when it occurs in indoor environments, such as homes or office buildings, where the most likely route of exposure is inhalation. If large numbers of SC spores are released into the air, some people may develop symptoms such as coughing, wheezing, runny nose, irritated eyes or throat, skin rash,

fatigue or diarrhea. Researchers have theorized that these symptoms may result from toxins produced by SC or exposure to a combination of several molds or bacteria and the chemicals they produce. Most people who experience health effects associated with moldy buildings fully recover following removal and clean-up of the mold contamination.

Much of the concern about toxin-producing indoor molds and especially Stachybotrys followed its identification in the mid-1990s in the homes of a small number of Cleveland infants with an unusual form of lung bleeding. The original investigation, cosponsored by the U.S. Centers for Disease Control and Prevention (CDC) suggested that very wet homes and Stachybotrys growth played a role in these lung hemorrhage cases. However, after reviewing the methods used to conduct the original study, the CDC concluded in May, 2000 that a possible association between the lung bleeding in the Cleveland infants (now called "acute idiopathic pulmonary hemorrhage") and exposure to molds, specifically Stachybotrys chartarum, was not proven. However, both the CDC and other research groups are continuing to examine the role of indoor molds in both child and adult health, particularly for those molds that may produce toxins.

How can I tell if my health problems are caused by Stachybotrys?

It is currently difficult to prove that individual health symptoms are due to SC exposure for several reasons:

1) *When buildings are sampled, usually several other molds or bacteria (some capable of producing chemicals such as endotoxin) are found in addition to SC, and these may also contribute to symptoms;*
2) *These symptoms are very nonspecific and may be related to exposure to other sources (such as dust mites, animal dander, pollen or other allergens) or to infectious agents such as viruses that cause common colds or flu;*
3) *Research has not identified how much Stachybotrys exposure is necessary to produce symptoms;*
4) *There is no test that can determine if a person was exposed to this fungus or its toxins.*

Laboratory Tests for Human Exposure to SC mold or toxins

A few physicians have used a blood antibody test to determine whether their patients have been exposed to the SC mold or its toxins. However, this procedure has not been proven to be valid. In one study of 48 people exposed to SC, only 4 had elevated antibodies. The Stachybotrys antibody test can also be positive when an individual is exposed to other types of mold altogether (i.e., cross-reaction). Therefore this test cannot be used to definitively determine whether someone has been exposed to the Stachybotrys mold or its toxins. In addition, since we do not know how long antibodies remain elevated after SC exposure, it is also possible that a positive test may be evidence of a previous encounter with SC or a cross-reacting mold, not a current one.

Prevention of Mold in Dwellings

As part of routine building maintenance, buildings should be inspected for evidence of water damage and visible mold. Water damage should be corrected early (within 48 hours) and building surfaces or furnishings dried to prevent mold growth. If any type of visible mold growth is found, whether Stachybotrys or any other mold, the water damage leading to it should be corrected and visible mold removed by appropriate methods as described below.

Correction of Visible Mold

Visible mold should be removed by the simplest and easiest method that is proper and safe. Common household molds found around bathtubs or between shower tiles should be removed with a household cleanser. For building components like walls or ceilings showing any type of fungal growth, including Stachybotrys, specific methods for removal are based on the extent of visible contamination and underlying water damage. New York City Department of Health produced a set of voluntary guidelines in April, 2000 that incorporate the best available knowledge on removing mold contaminated building components. Their recommendations are summarized here, but the full text should be consulted before deciding on a remediation strategy. Text is available at the New York City Department of Health website listed at the end of this document.

1) ***Level I :*** *If the area of mold is small and isolated (10 square feet or less) – e.g., ceiling tiles, small areas on walls*

   A) The area can be cleaned by individuals who have received training on proper clean up methods, protection and potential health hazards. These individuals should be free from asthma, allergy and immune disorders. Gloves, eye protection and an N95 disposable respirator (available at neighborhood hardware stores) should be worn.

   B) Contaminated material that cannot be cleaned should be removed and placed in a sealed plastic bag before taking it out of the building. This will prevent contamination of other parts of the building.

   C) The work area and areas used by the remediation workers while exiting the building should be cleaned with a damp cloth or mop. All areas should be left dry and visibly free of mold contamination and debris.

2) ***Level II:*** *mid-sized isolated areas (10-30 square feet) – e.g., a wallboard panel*

   The recommendations are the same as Level I, with the added precaution that

   A) Moldy materials should be covered with plastic sheets and taped before any handling or removal is done. For instance, a moldy panel of gypsum wallboard should have plastic sheeting taped over the affected area on the wall before it is cut to remove the contaminated section. Once cut from the wall, that section should be placed inside another layer of plastic and sealed up with tape before it is carried through the building for disposal.

   B) Following removal of contaminated material, the work area and exit areas should be HEPA vacuumed (a vacuum equipped with a High-Efficiency Particular Air filter) in addition to cleaning with a damp cloth or mop.

3) ***Levels III, IV, V:*** *Large area (more than 30 square feet) – e.g., several wallboard panels or more*

A health and safety professional with experience performing microbial investigations should be consulted prior to any cleaning activities to provide oversight for the project. See the specific recommendations in "Guidelines on Assessment and Remediation of Molds in Indoor Environments", New York City Department of Health, on their website (see Additional Resources). If you do not have access to the Internet you may request a copy through the California Department of Health Services Indoor Air Quality Assistance Line at (510) 540-2476.

Summary

Exposure to high levels of Stachybotrys chartarum and other mold spores may cause health symptoms in some individuals. Therefore, any fungal growth on building materials should be cleaned off or removed as rapidly as possible to maintain a healthy indoor environment. New York City Department of Health guidelines provide detailed information on mold remediation strategies and are available from their website (see Additional Resources).

At present there is no environmental test to determine whether Stachybotrys growth found in buildings is producing toxins. There is also no blood or urine test that can establish if an individual has been exposed to Stachybotrys chartarum spores or its toxins. Anyone with persistent health problems that they believe may be related to indoor molds should consult their physician.

Additional Resources

New York City Department of Health. Guidelines on Assessment and Remediation of Molds in Indoor Environments. Full text document available at http://www.ci.nyc.us/health. For further information about this document contact New York City Department of Health at (212) 788-4290.

U.S. E.P.A. Indoor Air Quality Web Site – Mold Links and General Information Page
http://www.epa.gov/iedweb00/pubs/moldresources.html

U.S. E.P.A. Indoor Air Quality Information Clearinghouse: 1-800-438-4318
For information on many types of indoor air contaminants.

Centers for Disease Control and Prevention. Questions and Answers on Stachybotrys chartarum and other molds http://www.cdc.gov/nceh/asthma/factsheets/molds/default.htm

Centers for Disease Control and Prevention. Update: Pulmonary Hemorrhage/Hemosiderosis Among Infants – Cleveland, OH, 1993-1996. Morbidity and Mortality Weekly Report 49(09):180-4 March 10, 2000. Full text available: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4909a3.htm

Appendix E

Keys for the Short Names of Fungal Genera and Species Used in the Tables and Figures through the Report

Table E1: Key for the fungal genera identified from spore trap samples

Short name	***Full name of genera***
alternar	*Alternaria*
arthrini	*Arthrinium*
ascospor	*Ascospores*
aureobas	*Aureobasidium*
basidios	*Basidiospores*
bipolaris_drech	*Bipolaris and Drechslera*
bortyris	*Botrytis*
chaetomi	*Chaetomium*
cladospo	*Cladosporium*
curvular	*Curvularia*
epicoccu	*Epicoccum*
fusarium	*Fusarium*
myrothec	*Myrothecium*
nigrospo	*Nigrospora*
othercol	*Other colorless*
paecilo_like	*Paecilomyces-like*
penici_asperg or pen/asp	*Penicillium/Aspergillus species*
pithomyc	*Pithomyces*
polytrin	*Polytrincium*
rusts	*Rusts*
scopular	*Scopulariopsis*
smuts_per_myx smuts/peric	*Smuts, Periconia, Myxomycetes*
stachybo	*Stachybotrys chartarum, (atra)*
stemphyl	*Stemphylium*
torula	*Torula*
ulocladi	*Ulocladium*

Table E2: Key for the fungal species cultured from air and dust samples

Short name	***Genera Species Name***
all Penicillium	*all Penicillium species*
all Aspergillus	*all Aspergillus species*
all_yeast sp	*all yeast species*
acrem_stric	*Acremonium strictum*
alter_alter	*Alternaria alternata*
apios_arthr	*Apiospora (Arthrinium) montagnei*
apios_monta	*Apiospora montagnei*
asper_glauc	*Aspergillus glaucus*
asper_nidul	*Aspergillus nidulans*
asper_niger	*Aspergillus niger*
asper_ochra	*Aspergillus ochraceus*
asper_penic	*Aspergillus penicillioides*
asper_sydow	*Aspergillus sydowii*
asper_ustus	*Aspergillus ustus*
asper_versi	*Aspergillus versicolor*
aureo_pullu	*Aureobasidium pullulans*
basidiomyce	*Basidiomycetes*
beauv_bassi	*Beauveria bassiana*
bipol_lunat	*Bipolaris lunata*
botry_ciner	*Botrytis cinerea*
chaet_globo	*Chaetomium globosum*
clado_clado	*Cladosporium cladosprioides*
clado_herba	*Cladosporium herbarum*
clado_speci	*Cladosporium species*
clado_sphae	*Cladosporium sphaerospermum*
Short name	***Genera species name***
curvu_lunat	*Curvularia lunata*
emeri_nidul	*Emericella nidulans*
engyo_album	*Engyodontium album*

epico_nigru	*Epicoccum nigrum*
eurot_amste	*Eurotium (Asp.) amstelodami*
eurot_rubru	*Eurotium rubrum*
fusar_monil	*Fusarium moniliforme*
fusar_oxysp	*Fusarium oxysporum*
geosm_laven	*Geosmithia lavendula*
liber_speci	*Libertella species*
mucor_hiema	*Mucor hiemalis*
mucor_plumb	*Mucor plumbeus*
myrot_leuco	*Myrothecium leucotrichum*
myrot_rorid	*Myrothecium roridum*
nonsporulat	*Non-sporulating fungi*
paeci_farin	*Paecilomyces farinosus*
paeci_lilac	*Paecilomyces lilacinus*
paeci_vario	*Paecilomyces variotii*
penic_auran	*Penicillium aurantiogriseum*
penic_brevi	*Penicillium brevicompactum*
penic_chrys	*Penicillium chrysogenum*
penic_citri	*Penicillium citrinum*
penic_commu	*Penicillium commune*
penic_coryl	*Penicillium corylophilum*
penic_crust	*Penicillium crustosum*
penic_digit	*Penicillium digitatum*
penic_expan	*Penicillium expansum*
Short name	***Genera species name***
penic_funic	*Penicillium funiculosum*
penic_glabr	*Penicillium glabrum*
penic_impli	*Penicillium implicatum*
penic_itali	*Penicillium italicum*
penic_miczy	*Penicillium miczynskii*

penic_minol	*Penicillium minioluteum*
penic_otali	*Penicillium otalicum*
penic_oxali	*Penicillium oxalicum*
penic_paxil	*Penicillium paxilli*
penic_purpu	*Penicillium purpurogenum*
penic_roque	*Penicillium roquefortii*
penic_solit	*Penicillium solitum*
penic_thomi	*Penicillium thomii*
phoma_coelo	*Phoma/coelomycetes*
pitho_chart	*Pithomyces chartarum*
rhizo_stolo	*Rhizopus stolonifer*
smuts	*Smut*
stach_chart	*Stachybotrys chartarum (atra)*
talar_flavu	*Talaromyces flavus*
thiel_heter	*Thielavia heterothallica*
trich_harzi	*Trichoderma harzianum*
trich_konin	*Trichoderma koningii*
ulocl_botry	*Ulocladium botrytis*
walle_sebi	*Wallemia sebi*
yeast_other	*Yeasts, other*
yeast_rhodo	*Yeasts, rhodotorula species*
yeast_sporo	*Yeasts, sporobolomyces species*

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