HETA 97–0010–2730
Governor Juan F. Luis Hospital and Medical Center
Christiansted, St. Croix
United States Virgin Islands

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PREFACE

The Hazard Evaluations and Technical Assistance Branch 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 Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, 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 the NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Eric J. Esswein and Melody M. Kawamoto of the National Institute for Occupational Safety and Health (NIOSH), Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies, Cincinnati, Ohio and Denver, Colorado. Desktop publishing by Ellen Blythe and Joyce Woody. Review and preparation for printing by Penny Arthur.

Copies of this report have been sent to management and employee representatives at the Juan F. Luis Hospital and Medical Center and to the regional office of the Occupational Safety and Health Administration (OSHA). 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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SUMMARY

In October 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Chief Executive Officer at the Juan F. Luis Hospital and Medical Center for a Health Hazard Evaluation (HHE). The request asked for NIOSH assistance in investigating reasons for mold contamination in the hospital and evaluating employee concerns about adverse health effects possibly related to the presence of mold within the building. Health concerns which were reported included eye irritation, itchy skin, nausea, and respiratory problems.

During November 20–22, 1996, a NIOSH industrial hygienist and a medical officer conducted a walk–through inspection of the hospital and interviewed staff and management to better understand health symptoms, the possible relationships between symptoms and building occupancy, and any related events that might affect building air quality. A walk–through inspection of the building was conducted and the hospital's air conditioning, ventilating, and chiller systems were inspected. An interim report sent to the hospital in January 1997, presented results and observations of the walk–through survey, results of analyses of some, but not all bulk microbiological samples, and a list of explanations for moisture intrusion into the building, based upon results of the investigation. Detailed recommendations for safe clean–up of existing mold contamination were also included. *Aspergillus* was a dominant genera of mold identified from samples of moldy building materials and dusts collected from filters in the building exhaust air plenum. Another fungi, *Stachybotrys chartarum* was also found on many surfaces in the hospital, but was not detected on samples from building exhaust air filters. Fungal growth in the hospital was determined to caused by uncontrolled moisture within the building envelope. Moisture was determined to originate from four specific sources:

1) intrusion of rainwater into the hospital due to roof leaks;
2) uncontrolled flow of moist air into the building (moisture vapor infiltration) through doors and windows;
3) insufficient and ineffective removal of moisture (latent heat) from building supply air, and;
4) sources inside the building (i.e., interior flooding from overflowing roof and floor drains, and moisture generation from laundry and kitchen operations).

Moisture vapor from sources # 2 and 3 were determined to be responsible for the condensation accumulations within ceiling plenums. Condensation was the primary reason for cellulose–containing ceiling tiles and fibrous glass duct insulation to become wet. Left uncontrolled, mold and moisture can cause significant

damage to building structures. Depending on the types of molds present, and the degree of exposures to building occupants, allergy and other health effects can result.

NIOSH identified environmental conditions at this hospital which could contribute to employee exposures to mold. Significant growth of mold (hereafter also referred to as fungi or fungal) was found on building materials and ventilation system components in the hospital. Employee symptoms were consistent with known effects of fungal exposure, particularly allergic symptoms. The pattern of employee symptoms by location suggests a relationship with the presence of fungi and fungal exposures. This final report describes the investigation, provides all sampling results, and contains recommendations to address the problem of controlling moisture in the hospital, preventing moisture infiltration into the building, addressing poor temperature control, and safely cleaning–up existing contamination.

Keywords: Standard Industry Code (SIC) 8062 (General Medical and Surgical Hospitals), hospitals, molds, fungi, *Aspergillus*, *Stachybotrys*, indoor environmental quality, indoor air quality, mycotoxins.

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INTRODUCTION

In October 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Chief Executive Officer at the Juan F. Luis Hospital and Medical Center for a health hazard evaluation (HHE). The request asked for NIOSH's assistance in investigating employee concerns about adverse health effects possibly related to mold exposures at the hospital. The health concerns included eye irritation, itchy skin, nausea, and respiratory problems.

During November 20–22, 1996, a NIOSH industrial hygienist and medical officer visited the facility and performed a walk–through inspection of the hospital. The hospital's air conditioning and ventilating systems and the hospital's chiller systems were also inspected. Hospital staff and management were interviewed to better understand employee health symptoms and any relationships with locations in the hospital where symptoms were reported.

A preliminary report sent to the hospital in January 1997, contained analytical results of microbiologically contaminated building materials and dusts collected from ventilation systems. The report also contained detailed recommendations for clean–up of existing contamination. In May 1997, NIOSH industrial hygienists assisted the United States Virgin Islands Occupational Safety and Health Administration (OSHA) office (Christiansted, St. Croix) by teaching an indoor environmental quality investigation techniques course for regional OSHA staff. The CEO of the hospital, knowing that NIOSH staff were on the island, requested they return to the hospital to evaluate temperature complaints in the hospital operating rooms (ORs). While at the hospital, NIOSH noted that compared to the November 1996 visit, extensive mold clean–up had occurred at the hospital. While visible mold contamination was no longer evident in many areas found to be contaminated during the initial investigation, not all indoor environmental problems appeared to be resolved. Employees working in the ORs reported discomfort related to temperature fluctuation in the ORs. Temperature measurements confirmed inadequate temperature control in the ORs. NIOSH evaluated the areas and provided recommendations to correct temperature control problems.

BACKGROUND

The Governor Juan L. Fransisco Hospital and Medical Center is a rebuilt and renovated building which was first occupied in 1994. Approximately 700 staff are employed at the hospital. The facility has five ORs and provides full–service health care to island residents and visitors. The former hospital, which stood at the same location, was destroyed after it sustained severe structural damage during a hurricane which caused significant property damage across the island. The building is constructed of brick, has three floors with approximately 210,000 ft^2 of indoor floor space. Windows in the hospital can be opened. The hospital is cooled and ventilated using five SEMCO™ air handling units (AHUs) all of which are located in a mechanical room above the ground floor of the hospital. The AHU systems are configured as a single pass, blow–through design (i.e., the supply fan is located upstream of the cooling coils) with pre–filters located upstream and final filters located downstream of the cooling coils. Pre–filters consist of 2" approximately 20–30% efficiency extended surface pleated type filters. Final filters consist of 12"x24"x12" rigid cell, box filters of 90–95% efficiency.

Employees at the hospital have reported "asthma–like" symptoms, bronchitis, eye and skin irritations, and temperature complaints. At the time of the NIOSH investigation approximately 40 people reportedly experienced symptoms and it was reported to NIOSH that more people experienced symptoms everyday. Roof leaks, plumbing leaks, and moisture intrusion of humid outside air had been reported at various times.

Problems with the hospital's chillers such as an inability to maintain sufficiently low chiller temperature (42°F [Fahrenheit] supply water temperature is recommended by the manufacturer) were also reported.

METHODS

The NIOSH investigation began immediately following the opening conference with an inspection of the hospital's five AHUs. The NIOSH medical officer interviewed personnel in charge of each wing of the hospital to inquire about water damage and health symptoms reported among employees in these areas. The employee health nurse was interviewed and employee incident reports were reviewed. A walk–through inspection of all three floors of the hospital was conducted to inspect and log areas of fungal contamination, identify any roof leaks or sources and pathways for moisture vapor intrusion into the building.

Small pieces (bulk samples) of mold contaminated ceiling tile were collected to identify and characterize the genus and species of the fungi visibly colonizing damp and discolored building materials. Clear adhesive tape was also used to collect microbiological growths from hard surfaces by lightly pressing strips of tape against areas of mold growth then removing the tape for optical analyses. The tape contains a portion of the fungal sample intact on the adhesive surface. All samples were placed in clean polyethylene bags, refrigerated, and sent to an environmental microbiological laboratory to determine fungal species and evaluate the presence of fungal spores/hyphae.

The hospital's AHUs were configured with filters in the exhaust air plenums of every AHU. This allowed a unique opportunity to collect samples of the dust cake from the exhaust air filters. The filters protect a rotating energy recovery wheel from becoming soiled with dusts and suspended particles in building exhaust air. Since the ventilation system is a one pass design, building exhaust air has been circulated through the building interior spaces, therefore samples of the exhaust air filter dust cake can be representative of airborne particles circulated through the building. If the fungi collected from filter dusts consistently appear as the same as the fungi on environmental surfaces inside the building, this can suggest the presence of fungal reservoirs in the building (or perhaps the AHU). Dust samples were collected by gently scraping the dust cake on the filter to remove several grams of material or by using an air sampling pump connected to a filter cassette to vacuum a sufficient amount of material from the filter onto the open face of a 37 millimeter filter cassette. Filter cassettes and air sampling pumps were also used to collect three air samples in ORs #1 and #3 to evaluate for the presence of airborne fungal spores or hyphae in the ORs.

Real–time temperature and relative humidity (RH) measurements were collected in various locations throughout the hospital to evaluate occupant comfort parameters. A TSI VelociCalc® Model 8360 hand–held, battery–operated monitor was used to measure dry–bulb temperature, RH, and dew point temperature. Carbon dioxide (CO_2), which has been used as a surrogate for the amount of outside air being delivered to the building was measured using a Gastech Model RI–411A, portable CO_2 indicator. This portable, battery–operated instrument uses a non–dispersive infrared absorption detector to measure CO_2 in the range of 0–4975 parts per million (ppm), with a sensitivity of ±25 ppm. Instrument zeroing and calibration were performed prior to use with zero air and a known concentration of CO_2 span gas (800 ppm).

EVALUATION CRITERIA

General

A number of published studies have reported high prevalence of symptoms among occupants of office buildings.[1,2,3,4,5] NIOSH investigators have completed over 1100 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

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

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building–related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of heating, ventilating, and air–conditioning (HVAC) systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8,9,10,11,12,13] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person [cfm/person]) are beneficial.[14,15] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[16,17] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[18]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[19,20,21] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[22,23,24]

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

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

Standards specifically for the non–industrial indoor environment do not exist. NIOSH, OSHA, and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[25,26,27] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air–Conditioning Engineers

(ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[28,29] The ACGIH has also developed a manual of guidelines for approaching investigations of building–related complaints that might be caused by airborne living organisms or their effluents.[30] One private company has developed a video training program specifically for facility maintenance departments relating to improving indoor environmental quality by educating HVAC technicians and maintenance personnel on this subject.[31]

Measurement of indoor environmental contaminants has rarely proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building–related illness. However, measuring ventilation and comfort indicators such as CO_2, temperature, and RH, is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for the measurements made in this investigation are presented below.

NIOSH and the Environmental Protection Agency (EPA) jointly published a manual on building air quality, written to help prevent environmental problems in buildings and solve problems when they occur.[32] This manual suggests that indoor environmental quality (IEQ) is a constantly changing interaction of a complex set of factors. Four of the most important elements involved in the development of IEQ problems are: (1) a source of odors or contaminants; (2) a problem with the design or operation of the HVAC system; (3) a pathway between the contaminant source and the location of the complaint; and (4) the building occupants. A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems. The basis for measurements made during this evaluation are listed below.

Carbon Dioxide (CO_2)

CO_2 is a normal constituent of exhaled breath and, if monitored at equilibrium concentrations in a building , may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. The American National Standards Institute (ANSI)/ASHRAE Standard 62–1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cfm/person for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 cfm/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[33]

CO_2 is not considered a building air pollutant, but CO_2 measurements can be used as a measure of odorous pollutants which may cause annoyance for building occupants. Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300–350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased.

Temperature and RH

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55–1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[34]

Microbiological Contaminants

Few places on earth are completely free of fungi, primarily because spores are disseminated through the air and travel long distances. Environmental factors that influence fungal survival and growth include humidity (of primary importance), concentrations of nutrients, temperature, and light. Human exposure to fungi occurs continuously by inhalation and ingestion with no apparent ill effects. However, some fungi are important agents of human disease. Many people suffer superficial fungal infections of the skin, nails, hair, and mucous membranes (e.g., ringworm, athlete's foot). These are caused by dermatophytic fungi. Several fungi that may be common in outdoor reservoirs in temperate climates can cause infection in all exposed people. These include *Histoplasma capsulatum, Blastomyces dermatitidis,* and *Coccidioides immitis.* These usually cause a transient flu–like illness that, in certain circumstances, can become serious. The majority of fungi encountered in the environment are innocuous unless the exposed person is severely immunodeficient.[35]

Most fungi produce highly antigenic proteins which can cause allergies or asthma in susceptible persons when exposure conditions are appropriate. Somewhere between 10 and 60% of genetically susceptible (atopic) people have developed allergies to fungi as demonstrated by skin tests. Exposure to some fungi is clearly associated with symptoms of hay fever and asthma. The most widely abundant and well recognized of these include *Cladosporium, Alternaria, Epiccoccum, and Curvularia.*[36] A more severe illness, known as hypersensitivity pneumonitis, may result from exposure to fungal antigens. In this case, it appears that a high level of exposure is essential for the disease to develop.

Some fungi produce mycotoxins, which are non–volatile (not readily vaporized) compounds. These chemicals produce toxic effects in nearly all people. However, the severity of symptoms depends on the level of exposure to the mycotoxin. There are few, if any, convincingly documented cases of the direct effect of mycotoxins on the health of occupants of fungal–contaminated buildings. Two fungi, *Stachybotrys chartarum* and *Aspergillus versicolor*, have been implicated as possible sources of mycotoxin exposure in water–damaged buildings.[37]

Biology and Ecology of Stachybotrys

Fungi of the genus *Stachybotrys* are found worldwide. *Stachybotrys* is a saprophyte (grows on dead or decomposing matter) known to destroy cellulose. It is usually described as dark brown/black or sooty in appearance.[38] It has been isolated from soil and a wide variety of substances rich in cellulose, such as hay, wood pulp, cotton, grains, various dead plant components, paper, and glue in book bindings.[39]

Stachybotrys species tend to be uncommon in ordinary work or home environments. Several studies of viable mold spore counts using various sampling techniques in homes in southern California revealed a frequency of isolation of *Stachybotrys* ranging from 2.9% to 7.1%. This may vary, however, depending on the local mold flora, weather, and outdoor activity present (e.g., mowing the lawn, landscaping, etc.).[40]

The frequency with which *Stachybotrys* is found in buildings with mold problems varies among different studies. This may be due partly to different sampling techniques. Since *Stachybotrys* spores don't aerosolize well, because they prefer a wet niche, air sampling may underestimate the presence of the fungus. And since this fungus competes poorly on typical agar media, it may not be detected unless cellulose–based agar or moist filter paper is used for sampling. Studies using Anderson sampling, Rotorods, and moist filter paper have identified *Stachybotrys* in up to 19% of the buildings sampled; the higher yields were in buildings with known problems with mold contamination.[41]

Various strains of *Stachybotrys* have somewhat different growth requirements; the temperature range for optimal growth is 72 to 82°F, and the minimum humidity required for spore germination is 96.3% to 98.5%. Buildings where *Stachybotrys* growth problems have been reported typically experienced chronic water damage (e.g., due to leaking roofs or plumbing, floods, air conditioner condensation, etc.) and were kept at a temperature conducive to their growth. Examples of building materials which have been found to be growth substrates for *Stachybotrys* include: water–contaminated jute carpet backing, cold air return ducts containing moisture, lint and carpet fibers, wood fiber ceiling board, and moist urea formaldehyde foam insulation in contact with the paper covering on gypsum board.[42,43] Other potential sources for fungal growth, all of which maintain a consistent source of moisture, include humidifiers (vaporizers, water spray conditioners), evaporative coolers, self–defrosting refrigerators, air conditioners, and HVAC systems.[44]

Stachybotrys is one of many fungi that can produce chemical metabolites called trichothecene mycotoxins. Studies of *Stachybotrys* species have revealed that approximately two–thirds of isolates were found to produce these toxins.[45,46,47,48] Sorenson and associates demonstrated that these mycotoxins could be found in the aerosolized spores of this fungus, indicating the potential for inhalation exposure to these compounds.[49]

Human Disease due to Stachybotrys

Possible symptoms or human disease caused by *Stachybotrys* can include respiratory irritation (from inhalation exposure to spores and mycelial parts), allergy, mycosis (infection by the organism) and toxicity or mycotoxicosis (poisoning) from exposure to its metabolic products. Data on the allergic and toxic forms of the disease are limited, but several studies and case reports suggest *Stachybotrys* and its mycotoxins as causes of certain human illnesses. Not all strains of *Stachybotrys* can produce mycotoxins.

Stachybotryotoxicosis

The toxic manifestations of *Stachybotrys* are caused by the absorption of the toxins produced by the fungus. There are several potential routes of exposure to the tricothecene toxins produced by this fungus, including absorption from skin contact, inhalation, or ingestion. There are reports of local skin irritation due to handling of material contaminated by this fungus, but whether or not systemic effects occur due to skin absorption is unknown.[12] Inhalation is the most likely entryway of the spores into the body in occupational exposures. Work sites that provide a *potential* risk for this disease include farms, cottonseed oil plants, grain elevators and facilities used for reprocessing moldy grain, malt grain processors, textile mills using plant fibers, and bindertwine factories. Because occupations at these sites involve close contact with mold–contaminated materials, the affected employees probably received greater exposure to mold spores than would be expected in most non–industrial environments (e.g., homes, offices, schools).

Stachybotryotoxicosis in man is generally uncommon and usually not fatal. The severity of disease is dose–dependent, and symptoms usually resolve with removal from exposure. Initially, patients may experience severe mucous membrane irritation, headaches, dizziness, weakness, vomiting, diarrhea, abdominal pain, fever, sweating, tachycardia (increased heart rate), cyanosis (blue skin coloration due to decreased oxygen in the blood), dry cough, shortness of breath, and chest pain. Late manifestations include suppression of the hematologic (blood) and immune systems leading to petechiae (red spots on the skin), skin necrosis, hemorrhage (bleeding) of the mucous membranes or gastrointestinal tract, and sepsis.

Only one published investigation has described an outbreak of supposed stachybotryotoxicosis secondary to mold contamination in a home. A family of five experienced cold and flu symptoms, sore throats, diarrhea, headaches, dermatitis (skin inflammation), patches of hair loss, and a general ill feeling. Medical investigations of their conditions reportedly did not reveal any identifiable causes. In their home, a cold air return duct and an area of wood fiber board were contaminated with *Stachybotrys*. When the mold was cleaned up, the family members' symptoms resolved. The authors inferred that mycotoxins from the mold were responsible for the symptoms, although the report does not describe any biological testing for mycotoxins in the people affected and provides no information from the records of their medical evaluations.[42]

In November 1994, a cluster of eight cases of acute pulmonary hemorrhage/hemosiderosis was reported among infants in one area of Cleveland, Ohio.[50] Two additional cases were identified in December 1994. In a follow–up investigation, an association between acute pulmonary hemorrhage/hemosiderosis in this cluster of cases and water damage and mold/fungal growth, including *Stachybotrys*, in their water–damaged homes was reported. The conclusions of the investigation are controversial. The investigators used no specific techniques or criteria to either measure or define water damage (such as using a moisture meter to evaluate building materials or an activity of water coefficient to describe wetness in building materials). Additionally, air sampling may not have occurred under representative conditions of occupancy.

Johanning et al. recently reported findings from a study of workers exposed to *Stachybotrys* in a water–damaged office environment. In this study, air samples were positive for *Stachybotrys, Penicillium, Cladosporium, and Aspergillus.* They concluded that prolonged and intense exposure to toxigenic. *Stachybotrys chartarum* and other atypical fungi was associated with disorders of the respiratory and central nervous systems, disorders of mucous membranes, and a few parameters pertaining to the cellular and humoral immune system, suggesting possible immune competency dysfunction.[51]

Aspergillus

Aspergillus is a mold that is common throughout the world. There are over 600 species in the genus *Aspergillus*. Most *Aspergillus* species are found in soil, although many species can be found on a wide variety of substrates including forage and food products, cotton, and other organic debris. *Aspergillus fumigatus*, the most common species, accounts for most disease attributable to Aspergillus, both allergic and infectious. Groups at risk of exposure to this fungus include farmers; bird hobbyists; workers in sawmills, greenhouses, cane mills or breweries; and people who work around mushrooms, tobacco or grain.[52,53,54,55,56,57] Workers who are exposed to dusts from compost piles, decomposing haystacks, or moldy grains may develop hypersensitivity responses.[58]

Aspergillus versicolor has the potential to produce sterigmatocystin, a mycotoxin closely related in structure and biological activity to another class of *Aspergillus* mycotoxins known as aflatoxins.[59] Aflatoxins are potent liver carcinogens and represent a risk to those exposed to high concentrations.[41] There are no data associating cases of liver cancer with exposures to *Aspergillus* in the indoor environment, but this area may be inadequately researched.

Exposure to *Aspergillus* species may cause a variety of health problems. These include asthma, hypersensitivity pneumonitis, allergic bronchopulmonary aspergillosis, allergic sinusitis, and infection. The clinical manifestations of *Aspergillus*–related asthma are no different from other forms of asthma. The symptoms are cough, wheezing, chest tightness, and dyspnea. Obstructive changes on pulmonary function testing are present during acute attacks.

Hypersensitivity pneumonitis can occur in individuals with repeated exposure to organic dusts containing *Aspergillus* species. Acute symptoms may occur 6–12 hours after exposure. Symptoms include muscle aches, weight loss, fatigue, chest tightness, cough, and shortness of breath on exertion. Acute episodes are self–limiting, but upon repeated exposure, the condition can become chronic.

Allergic bronchopulmonary aspergillosis (ABPA) is an inflammatory disease caused by an immunologic response to *Aspergillus fumigatus* and other *Aspergillus* species growing in the bronchi of patients with asthma.[60] Allergic fungal sinusitis (AFS) due to *Aspergillus* species typically occurs in allergic immunocompetent patients. Most patients have asthma, and 85% have nasal polyps. Invasive aspergillosis is a very serious infectious disease that typically occurs in immuno–compromised patients, most notably those with leukemia or lymphoma.

Penicillium

The blue–green molds of *Penicillium* are common contaminants of indoor environments. Exposure to *Penicillium* can occur as a result of contaminated humidifier water and moldy HVAC systems. Inhalation of airborne spores is the major route of exposure. These molds are common contaminants of agricultural commodities and some of the mycotoxins produced by these species are also produced by fungi common in house dust.[61] *Penicillium* infections of clinical importance are very rare, although this mold has been associated with asthma and hypersensitivity pneumonitis. Presently, *Penicillium* mycotoxins are not considered as a serious health threat in water–damaged buildings.

RESULTS

In various locations throughout the hospital black mold was evident on suspended ceiling tiles and, in some locations, on wallboard. In many locations, ceiling tiles were missing because they had been removed due to previous water damage. In a corridor leading to a hospital loading dock, a mushroom was observed growing out of the exterior fiberglass insulation on a supply duct. Fungi growing in duct insulation is uncommon because duct insulation is supposed to be dry. Significant moisture had accumulated in the fiberglass to support the growth of the mushroom. Where visible fungal growth was present on interior building surfaces, it was most often dark black and it was often visible near the metal horizontal gridwork which supported the 2' x 2' suspended ceiling tiles. When the moldy or discolored ceiling tiles were removed and the insulation on supply ducting above the tiles was inspected, the fiberglass insulation was quite often damp and in some cases, saturated with condensation. Some of the offices had a distinctly moldy smell. Other areas of the building having water damage or significant moldy areas included radiology, the birthing suite, social services, finance and medical records, the ORs, the intensive care units, and other areas. The findings are summarized in Table 1, which lists floors of the hospital AHUs, fire escape zones, specific areas in the hospital, environmental findings, and reported health complaints.

Employee health symptoms were most common when mold was present in the area where occupants worked. According to building occupants in various areas of the building, upper respiratory symptoms resolved when repairs, remediation, and mold clean–up were made. In areas with recurring leaks or condensation problems, symptoms among employees were recurrent or continued unresolved. Some of the symptoms (e.g., upper respiratory congestion, bronchitis, and asthma) were consistent with allergic reactions to mold. However, other symptoms, such as burning sensations of the nose and mouth, were also reported. Such symptoms have been reported with exposure to the metabolic products of molds.[62] Air sampling to evaluate for the presence of molds, spores, hyphae, or the metabolic products of molds was not performed. Uncontrolled moisture in the building and the degree of mold contamination was sufficient evidence for NIOSH to identify a general risk for mold exposure. Exposures might be validated by the fact that in some parts of the hospital, everyone, including individuals without mold allergies, were reportedly affected by burning sensations of the nose and mouth. Symptoms of severe itching and redness (erythema) of the skin were found to be confined to areas of the building where ceiling tiles had collapsed, were removed or missing (materials management), or where airborne dust was reported to come from the ceiling or vents (business and finance offices). Some evidence of water damage to the spray–on fibrous fire proofing (falling away from the steel structure) in ceiling plenums was noted in these and other areas where ceiling tiles were missing or, as in the case of materials management, where they were never installed.

The Infection Control Nurse and the Employee Health Nurse reported a few cases of what was described as latex allergy among emergency room and ORs employees. The symptoms were limited to the skin and were reported to resolve with the use of non–powdered, non–latex gloves. No employees were known to have latex asthma. Employees with latex allergy were not particularly affected by the symptoms precipitating this investigation. In addition, many employees with no known latex allergy were reported as having health complaints. The Infection Control Nurse reported no problems of nosocomial infections among immunocompromised patients. Several charge nurses reported that some patients with mold allergies reported upper respiratory congestion while in the hospital.

Occupants on the first floor in social services and radiology reported smelling intermittent "gas–like" odors believed to emanate from floor drains. The odor of rotten eggs was described in social services. This odor is consistent with hydrogen sulfide or sewer gas. Several staff members who reported smelling the odor in the past gave descriptions of when and where the odor was noticed.

Inspection of the five AHUs showed that all the fans were operating and the outdoor air intakes were unobstructed. Pooled water was found on the flat roof directly outside the building makeup air intakes. Pooled water on a flat roof points to inadequate roof drainage. The pre–filters and the final filters in all the AHUs were correctly installed and were intact. The energy recovery wheel was clean and was operational. The condensate drain pans in the AHUs were confirmed to drain. However, as a consequence of the drain tubes installed into the sides (rather than the bottom) of the condensate pans at the floor level, each pan had approximately one quarter inch of standing water present in the drain pan. Red–colored debris was found at the base of several AHU coils. The reddish material was slimy suggesting the presence of a biofilm (microbiological growth). The red material looked like soil, perhaps entrained into the AHU in building make–up air. In a telephone conversation with an engineer employed by the manufacturer of the AHUs, the engineer recalled that excavation and construction activities occurred near the hospital when he was on–site. Shortly after the AHU systems were installed, an accumulation of a reddish material was noticed on the coils. The material looked to be fine red soil which may have ben blown from the construction site and entered the make up air intakes.

The entire bank of 12" x 24" x 12" 95% efficient final filters (Rigipleat™ models, manufactured by Precision Air) in every AHU was saturated (to the touch) with moisture. This problem can result in diminished filter efficiency, and if left unchecked, fungal colonization of the filter media can result in dissemination of fungi throughout the hospital. Mold (determined to be *Penicillium*) had visibly colonized some of these filters. Most commonly the mold was seen on the beverage board filter support material on the upstream side of the filters, but it could also be seen in some cases on the downstream side of filters. Moisture on the filters was determined to be caused by moisture carryover from the cooling coils. Wetness of the final filters was reported to be common for several years. Moisture carryover is related to the engineering design of the AHUs and the consistency of saturation of the filters illustrates an overall deficiency in system engineering design. Air filters in any AHU should always be kept dry to insure maximum filter performance and to discourage the growth of microbiological organisms. For proper performance, air filters in the AHUs should always be dry.

The indoor climate in the hospital was characterized by making a variety of measurements which are listed in Table 2. RH measured on three floors of the hospital on November 22, 1996, between 1:30 and 3:30 p.m. ranged from 64% to 72%. Mean RH in the hospital was 69%. The mean RH in the hospital on floors 1, 2, and 3 was 70%, 68%, and 68%, respectively. Overall mean temperature in the hospital was 73°F. Mean temperatures on floors 1–3 were 74°F, 73°F, and 72°F, respectively. During the period that the indoor measurements were made, the average outside air temperature was measured at 83°F (in the sun) and 79°F (in the shade). Outdoor RH was measured at 75% and 77%.

CO_2 in the hospital ranged from 400 ppm to 500 ppm. The average of CO_2 measurements made on floors 1– 3 were 475 ppm, 450 ppm, and 450 ppm, respectively. CO_2 measured in outdoor air on two occasions was 375 and 425 ppm. The CO_2 measurements made indoors demonstrates that adequate amounts of outside air are being supplied to the hospital (open windows and doors contributed to some of this). One thousand ppm of CO_2 is suggested as an upper limit when the CO_2 measurements are made at equilibrium with occupant densities of seven occupants per thousand square feet.[63]

Results of laboratory culture and analysis for environmental microorganisms from bulk material samples and one filter dust sample are listed in Table 3. The first eight samples listed in Table 3 are dust collected from building exhaust air filters in AHUs 1 – 5. Samples SCX B–6 and SCX B–7 were bulk samples of small pieces of ceiling tile with visible mold growth. The samples were collected near rooms 2230 and 3082. SCX OR1 was a sample of dust that had accumulated on a coarse filter installed in a small cooling fan on the anesthetic gas delivery machine in OR #1. The last two samples in the table were small pieces of the cardboard frames removed from the 95% efficient final filters in the AHUs. In six of the eight (75%) of the dust cake samples from building exhaust air filters *Aspergillus* species were found to be the dominant genera of fungi. Four of the six samples indicate *Aspergillus versicolor* as the dominant fungal species. *Aspergillus versicolor* was also found on the bulk samples of mold–stained ceiling tiles (e.g., samples SCX B–6 and SCX B–7).

Results of environmental surface samples using clear adhesive tape are listed in Table 4. These results support the presence of indoor reservoirs of *Cladosporium*, *Aspergillus*, *Acremonium*, *Stachybotrys*, and *Scolecabasidium* on fungally contaminated surfaces throughout in the hospital (primarily wallboard and ceiling tiles).

DISCUSSION

The types of health effects identified in this investigation are consistent with known health effects, particularly mold allergy. Although the pattern of symptoms by location in the hospital suggests a relationship with the presence of mold and mold exposures, our evaluation did not specifically link health effects to exposure by means such as personal breathing zone air sampling. However, environmental sampling results show that *Aspergillus* and *Stachybotrys* were both found on many indoor substrates throughout the hospital. This suggests an indoor fungal reservoir existed. Significant quantities of *Aspergilli* were cultured from building exhaust air filter dust, this suggests *Aspergillus* dissemination, and possible exposures to building occupants.

The AHUs are all single pass systems, that is, ventilation supply air is not recirculated within the building. The AHUs exhaust virtually all supply ventilation (bathroom, kitchen and lab exhaust excluded) across the exhaust air filters, across the heat exchanger, and out of the building. *Stachybotrys* was found on many surfaces in the hospital, but was not found on the dust cake samples taken from the air filters. One explanation for this is that *Stachybotrys* is a wet niche organism which inhabits wet, cellulose–containing environments. *Stachybotrys* produces slimy spores or conidia that do not easily become airborne when they are wet.

Reports of skin irritation and itching could be related to the irritant effects of skin exposures to fibrous fireproofing material. The release of fireproofing material into the work environment may be caused or aggravated by water leaks. The relatively large fiber size of the fireproofing causes this material to settle out of the air quickly, resulting primarily in skin, rather than respiratory symptoms.

This investigation identified both uncontrolled intrusion of moisture into the building [rainwater, plumbing leaks, and moisture entering the building in the form of latent heat (warm, humid air)] and moisture supplied into the building due to improper design and configuration of the HVAC systems (moisture carryover from the coils). Moisture intrusion and humid ventilation supply air are both reasons for condensation forming on building materials. The damp building materials provide substrates on which the fungi can grow which enables microbiological amplification in the hospital. By measuring dewpoint, condensation was confirmed to be the reason for the water droplet formation on cold metal surfaces. In the business office, the layout of the supply ventilation ducting in the ceiling plenum directly corresponded to areas of visible water damage, staining, and the presence of visible mold on the ceiling tiles below the ductwork. Moisture was visually confirmed to be accumulating on the ductwork, and ductwork insulation, condensing, and then dripping onto the backside surfaces of the ceiling tiles. The moisture problem appears to be multifactorial. Intrusion of warm moist air from the outside, into the cool interior of the building is one problem. Excessive face velocity of supply air across the cooling coils resulting in moisture carryover and saturation of the final filters is another problem. This situation results in saturated air leaving the coils and traveling only a short distance before contacting the AHU final filters still having a high moisture content. It appears that there are problems controlling the water temperature leaving the chiller. Specifically, temperatures being too high (>42°F) or fluctuating to too greatly. In constant air volume systems, such as the system installed in the hospital, a lack of humidistats throughout the hospital can result in uncontrolled relative humidity in the building. Building thermostats are intended to track interior temperature without respect to humidity. In humid climates, humidistats are often necessary to control moisture fluctuation in interior spaces. Humidity is often a more important measure to control for occupant comfort and is a critical element to prevent conditions which favor microbiological growth (i.e., building RH greater than 60– 65%).

NIOSH concludes the rotten egg odor on the first floor in social services and radiology is sewer gas originating from dry plumbing traps. In some locations where the odor was reported, the sinks and showers had not been used for some time. Keeping plumbing traps moist (occasionally running the water) should help to prevent this problem.

The importance of vigilant efforts to insure that removal of microbial contaminated building materials and renovation activities do not result in further contamination of the hospital cannot be overstated. Any construction or renovation work must be planned and executed to assure containment of mold–contaminated material. The involvement of professional contractors experienced in remediation of moldy buildings should be given strong consideration.

The presence of the *Aspergillus* species on moldy building materials indicates a risk for nosocomial (hospital acquired) infections to patients. To prevent nosocomial infections it is imperative that deconstruction and renovation be conducted carefully to prevent release of fungal spores in the building. The presence of Aspergilli in the hospital environment is the most important extrinsic risk factor for opportunistic invasive *Aspergillus* sp. infections.[64] Environmental disturbances caused by construction/renovation activities in and around hospitals can markedly increase airborne *Aspergillus* sp. spores and have been associated with Aspergillosis. Guidelines have been developed for remediation of toxigenic fungi in indoor environments,[65] although they have not been endorsed by NIOSH or CDC.

RECOMMENDATIONS

Visible or suspected microbiological contamination requires remediation efforts which include removal of the water damaged and contaminated materials and/or vacuum clean–up using a high efficiency particulate air (HEPA) filter. Cleaning should be done using a suitable detergent/surfactant ***and*** disinfection with an appropriate and effective chemical agent (e.g., 5–10% chlorine bleach in water solution) is recommended. Because remediation involves deconstruction work, remediation can result in the disruption of microbiological reservoirs.

1. Containment should be used to minimize spreading fungal spores/hyphae which might be contained in construction dusts. The use of negative pressure containment, bagging of mold–contaminated tiles and wallboard before removal, and vigilant housekeeping to clean and control dusts generated during construction/renovation is imperative. Final vacuuming with a HEPA filter vacuum cleaner is recommended to collect fine dusts in the demolition/deconstruction areas. Minimization of airborne Aspergillus spores should be accomplished by using local or central HEPA filter units in high–risk patient care areas.

2. Increased medical surveillance for nosocomial pulmonary Aspergillus infections should be provided for immune compromised, or other patients at high risk for nosocomial infections during and after periods of deconstruction of mold–contaminated materials and during and renovation activities.

3. When removing mold–stained ceiling tiles, the tiles should be carefully removed from the ceiling grids and individually bagged inside polyethylene or sturdy plastic to contain any release of mold spores when the materials are removed from the building. Applying thin sheets of clear plastic with an adhesive backing to mold contaminated sections of wallboard or ceiling tiles can help to contain spores on the side of the wall board that the adhesive plastic is attached. Workers should wear polyethylene or vinyl gloves to prevent skin contact.

4. For situations involving removal of sections of wallboard or any large renovation activity, contaminated wallboard sections should be covered with plastic sheeting or adhesive plastic before removal. Negative pressurization of the remediation area, relative to the adjacent occupied area, is recommended. This can be accomplished using full containment techniques similar to those used during asbestos removal. A HEPA filtered or negative air machine, with the exhaust discharging to the outdoors should be used to maintain negative pressurization of the containment at a minimum of 0.05 centimeters or 0.02 inches water gauge. Isolation of the area to be remediated can be accomplished by blocking pathways, such as walkways, air supply diffussers, and plenum vents, with two layers of polyethylene sheeting. Wet wiping using available hospital floor or surface cleaning solutions (surfactants and disinfectants) and as in Recommendation #1, HEPA vacuuming should be used as a final measure to collect and remove any surface dust or fine dusts generated during and after renovation activities.

A recent case study of a large scale remediation of a building contaminated with Aspergillus versicolor emphasized that removal of fine particulate material is a necessary step in removing fungal dust reservoirs from the building.[66] This study concluded that in buildings with extensive mold contamination, remediation required not only the careful removal of all visibly contaminated materials but also concluded that several surface cleanings were required to completely remove settled or fine dusts from interior building surfaces.

5. Workers performing major renovation activities should have adequate skin protection in the form of disposable coveralls (such as Tyvek® or another brand) and protective gloves. When significant renovation activities are scheduled, respiratory protection in the form of a full–face air purifying respirator equipped with a HEPA cartridge should be used by workers. Physicians or occupational health nurses providing occupational medicine services to individuals involved in renovation work will need to advise employees concerning the health risks of exposure associated with cleanup work. Employees with asthma or allergies who wish to perform renovation work should discuss the risks of possible exposure during clean–up activities and the use of personal protective equipment (e.g., the use of respirators) with occupational health service providers on an individual case–by–case basis, depending on the nature of their medical condition. Heavy work in hot weather while wearing personal protective equipment can increase the risk of heat stress. Workers should be made aware of heat stress hazards and how to recognize these hazards. Work–rest schedules may need to be modified depending on work and temperature conditions.

6. A competent engineering firm specializing in design, construction, or remediation of buildings located in hot and humid climates should be retained to perform an engineering evaluation of the hospital's air handling system to determine whether the present system has the design capacity for sufficient removal of moisture (latent heat load) from building make–up air.

7. Intrusion of moisture vapor from the outside must be prevented because condensation will form when warm, unconditioned air contacts the cooler interior surfaces. Unconditioned outside air is entering the building through open doors (including the main sliding door to the hospital), loading docks, the ambulance entrance, and any other penetrations in the building envelope. This appears to be a significant factor contributing to the moisture problem in the hospital. In several locations, hallway doors leading to the outdoors were propped open. In two locations, automatic door closers were broken or had been disconnected. Doors which lead to the ambulance entrance were reported remaining open for extended periods of time. Because the front entrance to the hospital is a sliding door and not a revolving–style door, significant intrusion of moist air is occurring from the constant passage of patients, staff, and visitors through this door. When doors or windows are left open, unconditioned air infiltrates the building adding to the latent heat load. Because of the problems with open doors and windows it is unlikely the building can maintain a slight overall positive pressurization, a crucial element to prevent intrusion of unconditioned air into cool interior space. Staff should be informed not to open doors or windows for ventilation because this allows for uncontrolled and unplanned ventilation (and humidity) into the building. The hospital should consider installing a turn style type door at the main entrance to eliminate unconditioned and unfiltered air from entering the building though this route.

8. Roof repairs were underway during the NIOSH investigation. All roof leaks and roof drainage be identified and repaired as quickly as possible.

9. NIOSH could not access the filters in the ORs. The presence or absence of HEPA filter units in the terminal diffussers in the ORs should be confirmed. If HEPA filters have not been installed,

retrofitting the system for installation of HEPA filtration is recommended as a control measure to insure adequately filtered air in this area.

10. To limit the intrusion of unconditioned moisture–laden outdoor air, pressurization of the building should be evaluated to assure that the building is maintained under a slightly positive pressure with respect to the outside environment. Specific pressurization into ORs and patient isolation rooms should be examined following modifications or repairs to the AHUs. Chemical smoke tubes area useful tool for this evaluation. Operating and labor and delivery rooms should be positively pressurized with respect to adjoining hallways. Patient isolation rooms should be negatively pressurized. Rooms using chemicals such as the darkroom and janitor's closet should also be negatively pressurized, as should the pathology laboratory, sterilizer rooms, and closets used for storage of soiled linen.

11. The infection control nurse or occupational health nurse should consider maintaining a log of employee visits and symptoms which are believed to be related to the indoor environment, and specifically to fungal exposures. If it is determined that employees report symptoms and have effects related to mold allergy the AHUs and the area(s) involved should be investigated for microbial contamination. Affected employees should seek medical examination and treatment for health complaints.

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Table 1
Environmental Findings and Health Symptoms
HETA 97–0010
Juan Francisco Luis Hospital, St. Croix, USVI
November 20 – 22, 1996

AHU	Fire Zone	Area	Environment	Health Outcome *(Source)*
		First Floor		
1	1–A	Material Management	ceiling tiles missing	redness, itching ***(IR)***
1	1–B	Radiology	ceiling water damage (wet) moisture in cabinets water rising from drains floor water damage mold	itching rashes, sneezing, cough reported during time when ceiling tiles had been removed ***(C,IR)***
1	1–B	Corridor near exit 25	mushroom on duct insulation	
1	1–B	Dialysis	ceiling water damage	sinus problems, allergies ***(C)***
1	1–C	Social Services	ceiling water damage gas with smell of rotten eggs from bathroom history of office flooding (related to flood in business office)	burning sensation of nose and throat ***(C, IR)***
4	1–C	EKG	ceiling water damage	burning eyes, sore throat ***(C, IR)***
4	1–C	Emergency		tearing of eyes and upper respiratory congestion on entering building (2 with hx of allergies, 1 without) ***(C)***
4	1–C	Business Office	condensation on ducts history of collapse of ceiling tiles and flooding	severe itching related to collapse of ceiling tiles, all working near area of collapse and some visitors to business office affected ***(C, IR)***
4	1–C	Finance	ceiling water damage and mold history of dust from air supply vents	itching skin, watery eyes ***(C)***
4	1–C	Medical Records	ceiling water damage history of dust from air supply vents	sore throat, watery eyes, perception of having to clear throat a lot ***(C)***
4	1–C	Medicare	ceiling water damage moldy odor	frequent cold symptoms ***(C)***
4	1–D	Lobby	moldy odor	

Table 1 *(Continued)*

AHU	Fire Zone	Area	Environment	Health Outcome *(Source)*
Second Floor				
2	2–AB	ICU	ceiling water damage	
2	2–AB	Anesthesia	ceiling water damage	
2	2–AB	Operating Rooms	condensation around ceiling light fixtures history of documented mold growth in ceiling history of wide temperature fluctuations	bronchitis, asthma itching throat, chest pain, chest tightness ***(C)*** burning sensation of eyes, nose, lips itching eyes, sore throat chest pain, chest tightness, shortness of breath ***(IR)***
2	2–AB	OR Instrument Room	ceiling water damage report of moldy odor	headache, nausea, vomiting itching throat burning sensation of nose and lips ***(C)***
2	2–AB	Delivery Rooms	ceiling water damage moldy odor in C–section room history of dust falling from vents history of wide temperature fluctuations history of condensation around ceiling light fixtures	symptoms of allergy
2	2–AB	Labor Rooms	ceiling water damage condensation	symptoms of allergy
2	2–AB	L+D Waiting Room	ceiling water damage moldy odor	
2	2–AB	Nursery	ceiling water damage moldy odor	sinus problems ***(C)***
5	2–C	Post–partum	ceiling water damage moldy odor in some rooms	itching skin, itching eyes sinus problems, congestion, loss of voice chest tightness ***(C)***

Table 1 *(Continued)*

AHU	Fire Zone	Area	Environment	Health Outcome *(Source)*
5	2–C	Follow–up Clinics	evidence of condensation on vent fixtures, ceiling water damage, some mold growth	sinus problems, burning sensation of nose, watery eyes—worse when chiller down ***(C)*** dizziness, blurred vision, watery, burning sensation of eyes and nostrils ***(IR)***
5	2–D	Extended Care Unit	ceiling water damage	upper respiratory stuffiness, itching, swelling, sneezing ***(C)***
5	2–D	Surgical Ward	evidence of condensation on vent fixtures	
		Third Floor		
3	3–AB	Administration	flooding from roof in offices near Stair 6	
3	3–AB	Administration	moldy odor in one office	symptoms in office occupant ***(A)***
3	3–AB	Administration	moldy odor in conference room	
3	3–AB	Classroom	ceiling water damage, moldy odor	sore throat, cough ***(IR)***
5	3–AB	Psychiatry	ceiling water damage related to roof leaks, visible mold growth	everyone has problems but no one has reported to Employee Health ***(C)***
5	3–C	Medical I	*(no leaks)*	*(no symptoms reported)* ***(C)***
5	3–C	Medical II	ceiling water damage	
5	3–C	Corridor between Medical 2 and elevator	ceiling water damage moldy odor in corner storage room	
5	3–D	MIS	report of moldy odor	symptoms in affected area ***(A)***
5	3–D	Pediatrics	history of a few leaks and moldy odor no problem since repaired	symptoms related to mold no problems since repaired ***(A)***

Table 1 *(Continued)*

AHU	Fire Zone	Area	Environment	Health Outcome *(Source)*
		General		
		Housekeepers		itchiness, runny nose, swelling under eyes ***(C)***

Health Outcome Sources
A = Administration representative
C = Person in charge of wing
IR = Incident Report

Table 2
Temperature, Relative Humidity, and Carbon Dioxide Measurements
HETA 97–0010
Juan R. Luis Hospital, St. Croix, USVI
November 20 – 24, 1996

Location	Temp. (F)	RH (%)	CO_2	Observations
First Floor				
Emergency Room (ER)	78	69	475	
Business Office	74	68	475	obvious moldy smell
Medical Records	72	70	450	no air flow from supply diffussers
Finance	72	72	425	
Radiology	73	68	575	
Histopathology	73	68	525	
Central Stores	76	72	375	door to loading dock open
Second Floor				
Intensive Care Unit	74	69	475	
Labor & Delivery	72	68	425	condensation on ceiling diffusser/moldy walls
Post Partum	72	68	425	
Surgical II	73	68	450	
Pediatrics	74	67	475	
Third Floor				
Medical I	72	69	475	
Medical II	72	68	500	
Office 3072, Employee Health Services	70	68	425	
Office 3053, Infection Control	71	69	400	
Personnel	73	68	450	
Administration	74	64	425	
Operating Rooms (8:20 - 9:30 am)				
			Dewpoint (F)	
OR #1 (+ pressurization)	63	69	53	condensation on ceiling diffusser
OR #2 (+ pressurization)	71	64	55	reported too warm in afternoon
OR #3 (= pressurization)	66	66	54	reported too warm in afternoon
OR #4 (- pressurization)	66	69	55	only one ceiling exhaust
Cysto (+ pressurization)	68	66	55	
Averages (all ORs and cystocopy)	**67**	**67**	**54**	
Averages				

Location	Temp. (F)	RH (%)	CO_2	Observations
First Floor	74	70	471	
Second Floor	73	68	450	
Third Floor	72	68	446	
All Floors	**73**	**68**	**457**	
Outdoor Temperatures and RH				
Outdoors outside ER (sun)	83	77	375	
Outdoors outside third floor (shade)	79	75	425	

Table 3
Microbiological Bulk Sample Culture Results
HETA 97–0010
Juan F. Luis Hospital, St. Croix, USVI
November 20 – 22, 1996

Sample Location Material	Fungi CFU/Gm.	Identification	Limit of Sensitivity
AHU #1	2,500	Penicilium	50 CFU/Gm
dust on exhaust air filter	150	Tricoderma	
AHU #2	10,000	Aspergillus versicolor	50
dust on exhaust air filter	10,000	Penicillium	
	1,000	Aspergillus niger	
	500	Aspergillus flavus	
AHU #2	100,000	Aspergillus versicolor	1250
dust on exhaust air filter	12,500	Aspergillus niger	
	12,500	Cladosporium	
	12,500	Penicillium	
		Aspergillus flavus	
AHU #3	181,800	Aspergillus versicolor	50
dust on exhaust air filter	27,270	Yeasts	
	18,180	Chaetomium	
	18,180	Penicillum	
	909	Aspergillus flavus	
	909	Aspergillus niger	
AHU #3	50	Aspergillus flavus	50
dust on exhaust air filter	50	Aspergillus niger	
	50	Aspergillus versicolor	
	50	Penicillum	
AHU #4	1,500	Aspergillus flavus	50
dust on exhaust air filter	1,000	Penicillum	
	500	Aspergillus versicolor	
	500	Aspergillus niger	
AHU #5	20,000	Aspergillus versicolor	50
dust on exhaust air filter	500	Cladisporium	
	500	Penicillum	
	500	Unidentified white sterile hyphae	

Table 3 *(Continued)*

Sample Location Material	Fungi CFU/Gm.	Identification	Limit of Sensitivity
AHU #5 white granular debris downstream of final filter in AHU supply plenum	276	Penicillum	92
SCX B–6 1" x 1" piece of ceiling tile, visible black mold growth present on tile	$4.0x10^6$ $4.0x10^6$ $2.7x10^6$ $1.0x10^6$ 136,000	Cladisporium cream, yeast–like mold Penicillum Aspergillus versicolor Aspergillus flavus	136
SCX B–7 1" x 1" piece of ceiling tile from room 3082	$1.0x10^6$ 651,000 217,000 86,800	Aspergillus versicolor Cladisporium Acremonium Aspergillis flavus	217
SCX OR 1 Dust removed from filter anesthetic gas delivery machine in OR1	1,000 500 250 50 50	Penicillium Aspergillis versicolor Cladisporium Aspergillis flavus Geotrichum	50
AHU #5 fiberboard from filter frame, final filters	$1.0x10^7$	Penicillium	212
SCX B–4 fiberboard from filter frames in AHU #2	$1.0x10^6$	Penicillium	136

CFU/Gm. = colony forming units per gram of material

Table 4
HETA 97–0010
Microbiological Surface Sampling
Juan F. Luis Hospital, St. Croix, USVI
November 20 – 22, 1996

Sample ID #*	Location	Microbiological Material Identified on Adhesive Tape Samples
SCH – B1 sample note – almost invisible light tan coloration on tape strip	ceiling between rooms 3081–3082	Spores, hyphae and conidiophores (spore bearing structures) of Cladosporium and Aspergillus (possibly Aspergillus versicolor)
SCH – B2 sample note – light black coloration on tape strip	ceiling tile above and in front of room 3082	Spores, hyphae and conidiophores (spore bearing structures) of Stachybotrys chartarum, Aspergillus and unidentified fungi.
SCH – B3 sample note – light tan–grey coloration on tape strip	ceiling tile, wall board between rooms 3081–3082	Spores, hyphae and conidiophores (spore bearing structures) of Aspergillus (possibly A. versicolor), Cladosporium, and Acremonium.
SCH – B5 sample note – very dark black discoloration on tape strip	Room 3009 wallboard below sink	Pure growth of Stachybotrys chartarum, dust mites and mite droppings
SCH – B7 sample note– dark black discoloration	Room 3082 (Medical 2) wallboard in storage room	Pure growth of Stachybotrys chartarum, dust mites and mite droppings, insects
SCH – B8 sample note– clear, no visible discoloration	Light diffusser, business office	A few Stachybotrys–like spores (<10 spores)
SCH – B12 sample note – dark black, opaque	Room 2064 wallboard in birthing room	Heavy growth of Stachybotrys chartarum, Acremonium, Scolecabasidium.
SCH – B13 sample note – dark black, opaque	ceiling tiles in hallway outside surgical suites	Heavy growth of Stachybotrys chartarum, Acremonium, Scolecabasidium. Many pollen particles
AHU 1 sample note – light green– grey colored fine material	filter dust collected from air handling unit 1 exhaust air filters	Dusty, few Aspergillus and Penicillium–like spores; spores, hyphae and conidiophores of Acremonium seen

* clear adhesive tape used to collect sample of visibly colonized surfaces or building materials

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html

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