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Aspergillus fumigatus and Other Thermotolerant Fungi Generated by Hospital Building Demolition

A. J. STREIFEL,[1]* J. L. LAUER,[1] D. VESLEY,[1] B. JUNI,[2] AND F. S. RHAME[3]

Department of Environmental Health and Safety,[1] Laboratory Medicine and Pathology,[2] and Infection Control,[3] University Hospitals, University of Minnesota, Minneapolis, Minnesota 55455

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On 13 September 1981, a 51-year-old seven-story building within our hospital complex was demolished by explosives. The concern that this event might release large numbers of thermotolerant fungi (TF), potentially hazardous to immunosuppressed patients, led us to seal hospital windows and doors. The air-handling systems were also manipulated. Concentrations of airborne TF, especially *Aspergillus fumigatus*, were determined before and after demolition, using Andersen and Cassella air samplers with inhibitory mold agar plates. Two outdoor and two hospital ward locations were sampled. The plates were incubated at 37°C; the CFU per cubic meter were counted at 72 h. The outdoor concentration of TF increased at one site by an average of 1.8 $\log_{10}$ (10^2 to 10^5) over the predemolition level. *A. fumigatus* increased 3.3 $\log_{10}$ (10^0 to 10^4) at the other outdoor site. The indoor TF concentrations increased about 1 $\log_{10}$ (10^1 to 10^2) after demolition. Counts on the hospital wards were not remarkable when compared with previous surveillance air sampling. Protective measures apparently minimized the infiltration of TF during explosive demolition.

The success of numerous fungal species is partially due to unique mechanisms of spore dispersal. The primary source of *Aspergillus fumigatus* is decaying organic material (9). *Aspergillus* spores are passively liberated and transported great distances as airborne particles by normal atmospheric conditions (e.g., convection currents and wind). The diameter of *A. fumigatus* spores, 2 to 3 μm, facilitates airborne dispersal and is a major factor in their ability to penetrate deep lung tissue (7). *A. fumigatus* is one of the few fungi that is capable of producing pulmonary infections in humans.

Human exposure to *A. fumigatus* spores is undoubtedly a common occurrence (4). However, exposure does not usually result in an infection unless the individual is immunologically debilitated. In hospitals, immunosuppressed patients, such as organ transplant and cancer patients, are at high risk to nosocomial aspergillosis (4, 6, 8, 15). The most commonly reported mode of transmission is inhalation of hospital air contaminated with *Aspergillus* spores (10, 13). The source of these spores may be external or internal to patient care areas. For instance, Aisner et al. (1) indicated that cellulose-base fire proofing was the source of aspergillosis in their hospital. Arnow et al. (3) described the dissemination of spores to patients during hospital renovation.

The University of Minnesota Hospitals has scheduled replacement construction for a portion of its existing buildings. The construction schedule required explosive demolition of a seven-story building adjacent to the existing hospitals. This study was initiated to evaluate the infiltration of spores into protected patient areas from the large cloud generated by this demolition process.

MATERIALS AND METHODS

Climatic conditions. In Minneapolis, Minnesota on 13 September 1981 at 1 p.m., the wind speed was 10 to 15 miles (ca. 16 to 24 km) per h from the south southwest (200°) under sunny skies, with a temperature of approximately 27°C.

Protective measures. Before demolition, the windows adjacent to the demolition site and those in critical patient care areas (cancer and transplant areas) were sealed with duct tape to prevent the infiltration of air. Air systems for the hospitals were manipulated by either shutting them off before blast time or allowing for 100% recirculation (no outside air). All of the outside air intakes to these systems were sealed with duct tape and plastic sheets. All hospital doors adjacent to the demolition site were closed, and pedestrian traffic was restricted.

Air sampling. Andersen six-stage air samplers were utilized at two outside locations. Sample site A was approximately 50 ft (ca. 15.2 m) north northeast from the demolition site. Site B was about 200 ft (ca. 61 m) east of the building. Site A used a six-stage Andersen sampler with plates in each stage. Site B used a six-stage Andersen sampler with three plates (stages 1, 3,

6). Andersen air samplers were calibrated with standard wet-test apparatus, and air flow rates ranged from 0.95 to 1.1 ft^3 (ca. 27 to 31 liters) per min (2).

Low- (1.06 ft^3 [ca. 30 liters] per min) and high- (5.8 ft^3 [ca. 164 liters] per min) volume Cassella samplers were similarly calibrated and used for internal air sampling. One of the inside hospital sites was located in the corridor of the bone marrow transplant (BMT) ward. The BMT ward is located on the fourth floor of the main hospital, approximately 40 ft (ca. 12.2 m) north northwest of the demolition site. The BMT ward air is supplied through a roll-mat air filter (approximately 60% efficient) to the station corridor. Air from patient rooms is exhausted via the patient bathroom exhaust system. This BMT ward air system was turned off, and the air intake was sealed approximately 1 h before the demolition time.

A ward on the third floor of the Cancer Hospital served as the other inside air-sampling site. This ward was approximately 100 ft (ca. 30.5 m) northeast from the demolition site. The air system for this ward was set for 100% recirculation, and the external air intakes were covered. The air is introduced through roll-mat filters before and beyond an electrostatic precipitator. Each patient room in the cancer ward has its own air supply diffuser and exhaust duct. The sample site was an unoccupied patient room.

Control samples from all locations were taken just before the blast. Sampling commenced within 2 min after the blast. Outside site sample times were selected based on data obtained during a previous building demolition. The sampling time for the inside location was 5 min and continued for 75 min after the blast.

The medium used for this evaluation was inhibitory mold agar (BBL Microbiology Systems, Cockeysville, Md.). Agar (27 ml) was dispensed into sterile glass Andersen plates. Casella plates (100 by 15 mm; Falcon Plastics, Oxnard, Calif.) and the Andersen plates were poured in a high-efficiency particulate arrestance filtered clean bench. After being sampled, the plates were incubated at 37°C. The plates were counted at 24, 48, and 72 h. The colonies were identified by University Hospital Diagnostic Microbiology Laboratories according to standard keys developed by Raper and Fennell (11). Total thermotolerant fungi (TF), *A. fumigatus*, *A. niger*, and *A. flavus* were reported. All sample volumes were corrected to CFU/cubic meter.

RESULTS

Figure 1 shows that at site A the explosive demolition increased the average airborne concentrations of TF, *A. fumigatus*, and *A. niger* by 1.8, 3.3, and 1.5 $\log_{10}$, respectively. The TF, *A. fumigatus*, and *A. niger* airborne concentrations persisted above the outside air surveillance and predemolition control concentrations for the duration of the sampling time. The maximum concentrations of TF, *A. fumigatus*, and *A. niger* during this sampling at site A were 1.6×10^5, 8.4×10^2, and 1.4×10^4 CFU/m^3, respectively. *A. flavus* was only isolated 32 min into the sampling; the concentration recorded was 8.4×10^1 CFU/m^3.

Figure 2 shows that at site B a 3-log increase

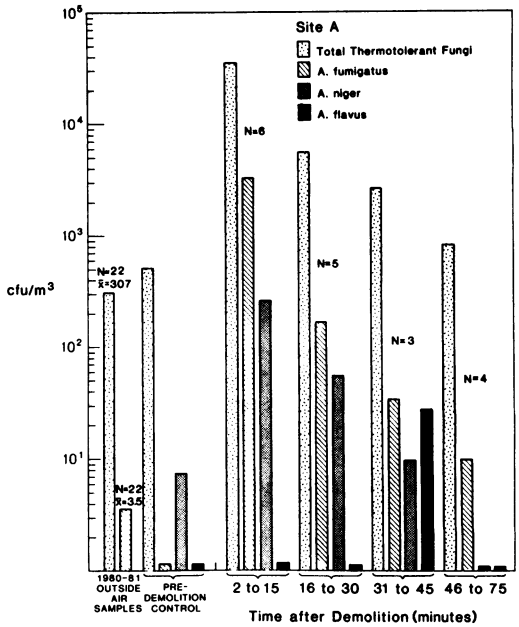

FIG. 1. Outside concentrations of airborne TF at site A were determined before the demolition. Airborne concentrations after demolition were determined by averaging samples taken during the indicated time intervals. Andersen air samplers with six plates containing inhibitory mold agar were used.

was observed for TF. No *A. niger*, *A. flavus*, or *A. fumigatus* was observed in the predemolition control sample, whereas 5.0×10^2, 1.0×10^3, and 5.0×10^3 CFU, respectively, of these fungi per m^3 were observed 2 min after demolition. High concentrations of TF, *A. fumigatus*, and *A. flavus* persisted for about 45 min at that location.

Figure 3A shows that the indoor TF concentration in the BMT ward increased 1 log above the predemolition control level. This level persisted for the remainder of the sampling time and was within the range of previous surveillance sampling data (1980 to 1981). Both *A. fumigatus* and *A. niger* concentrations increased less than 1 log from predemolition control concentrations. *A. niger* air concentrations remained slightly greater than those of *A. fumigatus* until the air system was turned on at 45 min. Apparently, turning on the air circulation system accelerated the decrease of airborne fungi.

The cancer ward was in the direct path of the demolition dust cloud. Figure 3B shows that TF and *A. fumigatus* increased less than 1 log from predemolition control concentrations. *A. niger* increased from <1 to 7.0×10^1 CFU/m^3 and then slowly decreased with time. TF persisted slightly above the 1980 to 1981 cancer ward surveillance sampling data. The air system for

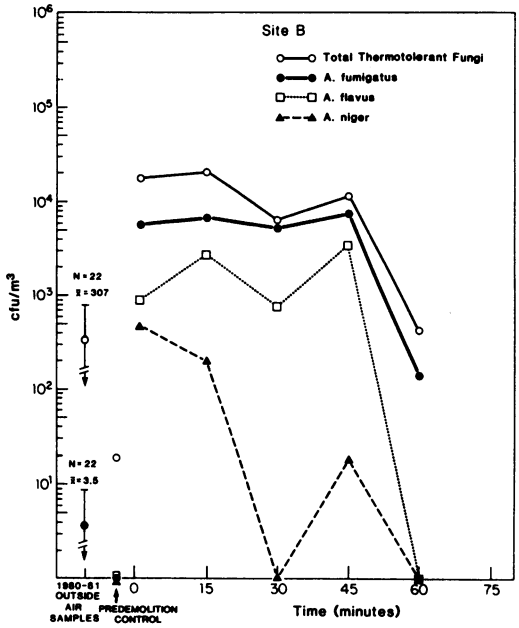

FIG. 2. Outside concentrations of airborne TF at site B were determined before and after demolition. Andersen air samplers using three stages (1, 3, 6) containing inhibitory mold agar were used for these determinations.

the cancer ward was allowed to operate at 100% recirculation during the demolition.

DISCUSSION

Aspergillosis and other systemic mycoses have caused an increasing morbidity among immunologically compromised hospital patients (6). Inhalation is most often the means of entry of these systemic fungal diseases. Nosocomial aspergillosis can be associated with external sources of mold found in the patient environment. Protective measures, such as more efficient filtration of outside air, has decreased the incidence of aspergillosis (12). Spendglove (14) noted that the penetration of potentially hazardous microbes into buildings is dependent upon the structure, ventilation, time of cloud passage, total dosage, season, and wind speed.

With a building demolition scheduled at the University of Minnesota directly adjacent to the Mayo Hospital and Masonic Cancer Hospital, concern for the spread of opportunistic fungi to compromised patients prompted us to consider protective measures. Sealing the hospital building openings and manipulating the air-handling systems was feasible.

A dramatic increase in TF spores was noted in all outdoor locations after explosive demolition. Persistently high levels of *A. fumigatus* and *A. flavus* at site B were remarkable. In outdoor

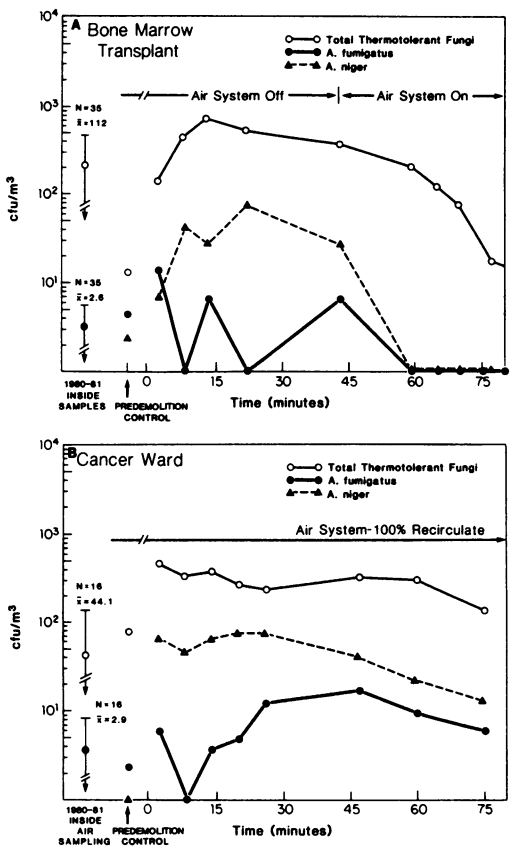

FIG. 3. Concentrations of airborne TF were determined before and after demolition in the corridor of the BMT ward (A) and in a patient room on the cancer ward (B). Cassella air samplers with inhibitory mold agar were used for these determinations.

sampling by other investigators (13), *A. fumigatus* levels greater than 100 CFU/m^3 were rarely found. After the blast, soil and debris from the demolished building were sampled and found to contain generally less than 10^2 CFU/g.

The precautions that were initiated to limit infiltration seemed to be effective in preventing fungal spores from entering patient care areas. Postdemolition fungal levels in immune-compromised patient wards generally increased less than 1 log and returned to ambient levels within 75 min. Weatherproofing, standard in buildings in northern climates, may have assisted in preventing infiltration (14). The presence of high concentrations of potentially opportunistic TF demonstrated by this demolition should encourage individuals involved in the planning of explosive demolition near medical facilities to exercise fundamental precautions to limit microbial exposure of immune-compromised hosts. Procedures such as taping windows, shut-

ting down air-handling systems, and limiting traffic apparently are effective in minimizing unwanted infiltration of dust and various fungal spores into buildings adjacent to explosive demolition. Precautions are also recommended when conventional demolition methods are used since smaller but more frequent dust clouds will occur over an extended time period.

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