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SAINT JOSEPH'S CATHOLIC CHURCH
SAINT LEON, INDIANA

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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at Saint Joseph's Catholic Church in Saint Leon, Indiana, at the request of the Secretary of the church's parish council. The request concerned evaluation of the health risks associated with worker exposures to a large accumulation of bat droppings during renovation activities in the church's 6700 square foot attic.

NIOSH researchers collected twenty samples of bat droppings from the church's attic, one sample of moldy wood from its rafters, and four soil samples around its foundation to be analyzed for the fungus, *Histoplasma capsulatum*. *H. capsulatum* is the etiologic agent of histoplasmosis, the most common pulmonary mycosis of humans and animals. Acute, severe pulmonary histoplasmosis usually occurs in small epidemics involving exposure to an aerosol containing numerous spores resulting from the disturbance of highly infected material. A primary source of *H. capsulatum* is soil, especially in regions of bird or bat habitats. While wind is probably the most important means of disseminating *H. capsulatum*, the fungus can survive and be transmitted from one location to another on the feet of both birds and bats. Unlike birds, bats can become infected with *H. capsulatum* and consequently may excrete the organism in their feces.

The twenty-five samples collected at Saint Joseph's Catholic Church will be analyzed qualitatively by a new method using a polymerase chain reaction (PCR) probe detection system. The time period required to develop such an analytical method was uncertain when this report was written; however, sampling results were not expected for several months. An amended report will be prepared and distributed when results are available.

As explained in this report, it is prudent to assume that the bat droppings in the attic of Saint Joseph's Catholic Church are contaminated with *H. capsulatum* and that disturbing this material represents a potential health hazard. Recommendations were made to reduce exposures to aerosolized dust by spraying the bat droppings with water prior to and during renovation activities. Further, each worker was recommended to wear a NIOSH/MSHA-approved full-facepiece powered air-purifying respirator with high-efficiency filters, disposable protective clothing with a hood, disposable latex gloves under cotton work gloves, and disposable shoe coverings. Because the recommended ensemble of disposable personal protective equipment is more insulating than normal work clothing, precautions should be taken during renovation activities to reduce the risk of heat stress-related illnesses.

Keywords: SIC 8661 (religious organizations), bats, *Histoplasma capsulatum*, histoplasmosis, and respiratory protection.

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at Saint Joseph's Catholic Church in Saint Leon, Indiana, at the request of the secretary of the church's parish council. The request concerned evaluation of the health risks associated with worker exposures to a large accumulation of bat droppings during renovation activities in the church's attic.

The cornerstone of Saint Joseph's was laid in 1859, and the church was dedicated in 1861. In 1993, the parish council initiated a church renovation project which included repairing and reinforcing wooden structural supports in the attic, an area of approximately 6700 square feet. However, soon after the project was begun, workers expressed concern about the large accumulation of guano that had been created over the past several years by a colony of bats that had resided in the attic. NIOSH was contacted for guidance concerning a personal protective equipment recommendation to be followed by the employees of the renovation contractor.

An initial site visit was conducted by two NIOSH researchers on the evening of September 20, 1993. Access to the attic was gained by climbing the ladder in the bell tower. Guano was observed at a depth of 0.5 to 1 inch covering nearly the entire floor of the insulated attic. Deeper deposits of 10 to 15 inches were found under roosting locations that appeared to have been used most frequently. At the entrance to the attic leading from the bell tower, a heavy layer of droppings also covered a small metal roof just above the attic floor that protected the pipe organ located on the floor below. Lights along the peak of the attic were operated continuously and were apparently an effective deterrent, since bats no longer congregated in the church's attic.

On October 28, 1993, the NIOSH researchers returned to Saint Joseph's and collected samples of bat droppings from the church's attic, a sample of moldy wood from its rafters, and soil samples around its foundation to be analyzed for the fungus, *Histoplasma capsulatum*. Soil samples will be analyzed for *H. capsulatum* so that if the soil is contaminated, appropriate precautions can be taken during any future renovation activities involving disturbance of the ground near the building. This report provides recommendations for protecting workers who might be exposed to aerosols of bat dropping dust during renovation activities. Analysis of the samples collected during this study are anticipated to be conducted using a polymerase chain reaction (PCR) probe detection system. However, the time period required to develop this new analytical method was uncertain when this report was written. A description of the analytical method and the sampling results will be provided in an amended HHE Final Report that will be distributed shortly after completion of the sample analyses.

BACKGROUND

Histoplasma capsulatum

Histoplasma capsulatum is a dimorphic fungus (i.e., exhibits growth in two different forms in different environments); it has a mycelial form at lower growth temperatures (optimal 25°C) and a yeast form when incubated at 35°C on enriched media.[1] The mycelial form is found in nature and is frequently designated as saprobic (i.e., derives its nutrition from dead or decaying organic matter), whereas the yeast form occurs in a host's tissue and is the pathogenic form. Hyphae, microaleuriospores (microconidia), and macroaleuriospores (macroconidia) are infectious particles of the mycelial form.[2] *H. capsulatum* infections in humans result predominantly from inhalation of these aerosolized spores. The spores of *H. capsulatum* are of a respirable size, with 70% to 95% reported by one author to have diameters less than 4.8 micrometers.[3]

H. capsulatum is the etiologic agent of histoplasmosis, the most common pulmonary mycosis of humans and animals.[4] Forty million people in the United States are estimated to have been infected by *H. capsulatum*, with approximately 500,000 new infections occurring each year.[4] Asymptomatic or mild infections due to *H. capsulatum* are the rule, whereas the serious chronic or disseminated types are fairly uncommon.[2] The extent of acute pulmonary involvement that a person experiences when infected with *H. capsulatum*, whether it be asymptomatic, mild, moderate, or severe, depends on the inoculum dose and the immunologic status of the host.[2] Acute, severe pulmonary histoplasmosis usually occurs in small epidemics involving exposure to an aerosol containing numerous spores resulting from the disturbance of highly infected material. Symptoms of acute respiratory histoplasmosis, including fever and cough, occur within two weeks of exposure.[5] Approximately 95 per cent of histoplasmosis cases are inapparent, subclinical, or completely benign. These cases are diagnosed only by x-ray findings of residual areas of pulmonary calcification and a positive histoplasmin skin test. Resolution of the benign form confers a certain degree of immunity to reinfection and, in addition, varying grades of hypersensitivity to the antigenic components of the organism. As a consequence, massive reinfection may result in a fatal acute allergic reaction in a person with highly sensitized lungs.[6]

A small percentage of histoplasmosis cases may have a chronic progressive lung disease, a chronic cutaneous or systemic disease, or an acute fulminating, rapidly fatal, systemic infection. The latter form is particularly common in children.[6] In the United States, 1500 to 4000 hospitalizations and 25 to 100 deaths occur annually due to histoplasmosis.[1, 4] These estimates were made before 1980 and do not include the increasing incidence of opportunistic histoplasmosis in patients with acquired immunodeficiency syndrome (AIDS).[1] In addition to AIDS, a rapidly progressive opportunistic infection occurs in some patients with the lymphoma-leukemia-Hodgkin's group of diseases, or those on steroid therapy or other immunosuppressive agents.[6] "*H. capsulatum* is now considered a regularly encountered opportunist in these circumstances and appears to be involved in opportunistic infections more often than the other "true" pathogenic fungi."[6]

For many years, only the severe disseminated form of histoplasmosis was recognized, and the disease was thought to be uniformly fatal. However, in the mid 1940's it was shown that histoplasmin skin reactivity was common in asymptomatic individuals. The skin test antigen, histoplasmin, is a valuable epidemiologic tool.[1] However, a positive histoplasmin test merely indicates that a person has probably lived in an endemic region of the United States at one time, and the test by itself has limited diagnostic value.[1, 6]
In addition, the prevalence of histoplasmin reactivity at any given time underestimates the prevalence of all past and present infections, since the skin test may revert to negative over a period of time with no exposure.[5]

The overall incidence of histoplasmin sensitivity in the United States is about 22%.[5] However, the risk of infection is not uniform, but varies from location to location. The region with the highest level of reactivity is the central United States, along the valleys of the Ohio, Mississippi, Missouri, St. Lawrence, and Rio Grande rivers.[1] In a series of studies conducted in the highly endemic area of Kansas City, it was found that, by age 20, between 80 and 90 per cent of the population had a positive histoplasmin skin test. The same is true in the Cincinnati-southern Ohio and southern Indiana region, southern Illinois, central Missouri, and areas of Kentucky, Arkansas, and Tennessee. The first documented human case of histoplasmosis in the United States was reported in Tennessee in 1932, and epidemiologic surveys have implied that a positive histoplasmin skin test will be found in over 60% of the residents of this state.[7] Focal areas of high endemicity also occur in Michigan, Wisconsin, Minnesota, Georgia, and Louisiana.[6]

The largest outbreak of acute respiratory histoplasmosis occurred in Indianapolis, Indiana, between September 1978 and August 1979.[8-10] Over 100,000 people were estimated to have been infected during the period, and over 300 people were hospitalized. Forty-six patients had progressive disseminated histoplasmosis, and 15 deaths were directly or indirectly related to histoplasmosis.[8] On the basis of epidemiologic data, the site where an abandoned amusement park had been dismantled was suspected as the environmental source of this outbreak. However, *H. capsulatum* was not recovered from any of the soil samples collected there.

While an *H. capsulatum* infection is most often a pulmonary disease, or a systemically disseminated disorder, a multifocal choroiditis (inflammation of the vascular coat of the eye) termed "presumed ocular histoplasmosis" has been described by many investigators.[7] This disease was called ocular histoplasmosis throughout the early 1960's, even though evidence for ocular histoplasmosis was circumstantial since *H. capsulatum* has not been recovered from eye lesions, cultured, and recovered in an animal model.[11] Although structures suggestive of an organism have been found in such lesions, the identity of the fungus has been difficult to demonstrate.[7] A correlation between exposure to *H. capsulatum* and ocular abnormalities has been suggested from the results of epidemiologic studies, but the characteristic multifocal choroiditis has rarely been reported in patients who have the typical forms of this disease.[7] While the results of laboratory tests suggest that presumed ocular histoplasmosis is associated with hypersensitivity to *H. capsulatum*,[12] the incident that converts asymptomatic to symptomatic presumed ocular histoplasmosis remains unknown.[7]

A primary source of *H. capsulatum* is soil, especially in regions of bird or bat habitats. While wind is probably the most important means of disseminating *H. capsulatum*, the fungus can survive and be transmitted from one location to another on the feet of both birds and bats.[6] The organism thrives in humid areas where large numbers of birds have roosted over a period of several years. It is found in association with old or unused chicken houses, and under blackbird/starling roosts. Bird excreta provides nutrients that promote the growth of the organism in the soil, although the requirements for growth are not precisely defined. Caves sheltering bats, and soil at the base of buildings fertilized by droppings from bats inhabiting the buildings, also often provide environmental conditions suitable for the existence and propagation of the fungus.[13] Unlike birds, bats can become infected with *H. capsulatum* and consequently may excrete the organism in their feces.[5] *H. capsulatum* has been isolated from bat guano collected from around the world, and by 1970, twenty-five bat species had been reported to harbor this organism. Isolations of *H. capsulatum* from bats captured in the United States have been extensive.[14]

While accumulations of bat droppings alone have been shown to be contaminated with *H. capsulatum*,[14-22] similar results have been reported far less frequently for samples taken from accumulations of bird droppings.[23] In avian habitats, the organism seems to grow preferentially where the guano is rotting and mixed with soil rather than in nests or fresh deposits.[6] Attempts to

demonstrate the presence of *H. capsulatum* in the organs and excreta of birds have never proven them to be carriers of the organism.[21] It has been suggested that birds do not harbor *H. capsulatum* because the organism does not survive at elevated avian body temperatures of 41 to 42°C.[5] However, the same temperature has been recorded in certain bats (*Molossus major*) for which *H. capsulatum* was demonstrated from cultures of their internal organs.[21]

Exposure to accumulations of bird droppings alone can not be assumed to be risk-free, however, since disturbance of bird habitats are associated with a risk of infection by *Cryptococcus neoformans* and the development of cryptococcosis.[24] *C. neoformans*, an encapsulated yeast, is ubiquitous in the soil and in avian fecal material, such as pigeon droppings, which apparently provide a reservoir of organisms.[25] *C. neoformans* has the ability to use the creatine found in avian feces as a nitrogen source. There, it gains a competitive advantage over other microorganisms and multiplies exceedingly well in bird droppings.[24] *C. neoformans* has also been recovered from bat droppings and associated dusts during studies for which samples were also found to contain *H. capsulatum*.[17, 18, 22] Unlike outbreaks of other mycoses, outbreaks of cryptococcosis traced to environmental sources have not been described, and it is presumed that most people can mount adequate host defenses when exposed to the organism.[26] However, as with histoplasmosis, the prevalence of cryptococcosis is markedly increased among immunocompromised patients.[26] More detailed information on *C. neoformans* and cryptococcosis is available elsewhere.[25-27]

METHODS

NIOSH researchers collected twenty samples of bat droppings from the church's attic, one sample of moldy wood from its rafters, and four soil samples around its foundation to be analyzed for *Histoplasma capsulatum*. Each sample was collected in a sterile, nonpyrogenic plastic 50-cubic centimeter (cc) centrifuge tube. The volume of material collected at each sampling location ranged from 40 to 50 cc (approximately 14 to 17 grams). While collecting samples, each NIOSH investigator wore a NIOSH/Mine Safety and Health Administration (MSHA)-approved full-facepiece powered air-purifying respirator with high efficiency filters, disposable protective clothing with a hood, disposable latex gloves over cotton work gloves, and disposable shoe coverings.

DISCUSSION

Mice are extremely susceptible to infection with *H. capsulatum* spores, and infection of mice inoculated with single spores has been demonstrated experimentally.[28] However, while mouse inoculation is the most reliable method for detecting *H. capsulatum* in environmental samples such as the bat droppings collected during this study, the method has a disadvantage of requiring several weeks before results are available. The method also has the limitation of using only a very small portion of a sample. This limitation might explain why *H. capsulatum* was isolated from a sample collected at the same location from which a negative sample was collected on the previous day. Nevertheless, the laborious and time-consuming procedure required for the isolation of this fungus from its natural sources remains the important factor that restricts more extensive investigation into ecological relationships. The expense, space, and personnel required for large-scale studies are also important limiting factors.[13] Direct isolation of *H. capsulatum* in culture from soil samples has been accomplished,[29] but the sensitivity of the method is inferior to mouse inoculation.[21]

To overcome the disadvantages associated with mouse inoculation, development of a simple and reliable technique is necessary for the detection of *H. capsulatum* in samples collected from its natural environment.[13] Researchers are currently experiencing success identifying pathogenic fungi in clinical samples using polymerase chain reaction (PCR) probe detection systems and chemiluminescent DNA probe assays.[30-33] PCR probe systems have an advantage over DNA probe assays in that identification of pathogenic fungi in samples can be accomplished directly, without the need to wait for the growth of isolates from culture. A PCR probe system would also be capable of analyzing a larger portion of a sample of material at one time than the very small portion used with the mouse inoculation method. More importantly, development of a PCR probe system for the analysis of *H. capsulatum* in environmental samples would reduce the time presently necessary for analysis using mouse inoculation from weeks to only a few days.

Disinfection of soils contaminated with *H. capsulatum* has been tried with various chemicals. Formaldehyde has fungicidal properties, and it has been shown to be the most effective of the chemical agents tried based on the performance of pre- and post-treatment sampling for *H. capsulatum*.[2] A 37% to 40% solution by weight (formalin) stabilized with 10% to 15% methanol has been the basic formulation used. For decontamination procedures outdoors, a 3% formalin solution has been found to be effective.[24, 34, 35] However, exposures to formaldehyde during soil disinfection operations have been reported to cause adverse health effects among applicators. Workers at one site reported burning eyes and mucous membrane irritation,[34] while workers at another site reported nausea with vomiting.[35]

In addition to soil disinfection, formaldehyde has also been reported to be effective for disinfecting *H. capsulatum*-infected accumulations of bat droppings in the attics of buildings, using formalin concentrations of 3%[18] and 4%.[22] Formaldehyde solutions should be used with caution since this chemical may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.[36] Mild to unpleasant eye irritation occurs in acclimated workers at 2 to 10 ppm, and intolerable irritation (tissue damage possible) occurs at levels above 25 ppm.[36] Workers exposed to 0.3 ppm of formaldehyde have reported symptoms of upper respiratory and acute bronchial irritation during a work shift.[37] There have also been reports of primary skin irritation and allergic dermatitis as a result of skin contact with water solutions of formaldehyde. Although a threshold for the development of these skin conditions has not been clearly defined, it is estimated to be a water solution containing less than 5 percent formaldehyde.[38] Based upon the results of laboratory tests which have demonstrated carcinogenic and mutagenic activity of formaldehyde in animals, NIOSH and OSHA recommend that formaldehyde be handled in the workplace as a potential occupational carcinogen.[39, 40] NIOSH recommends that occupational exposures to formaldehyde be controlled to the lowest feasible limit.[39]

CONCLUSIONS AND RECOMMENDATIONS

Because of the large accumulation of bat droppings in the church's attic and because the church is located in an endemic region for *H. capsulatum*, it is prudent to assume that a health risk exists. Therefore, precautions should be taken to protect workers from inhalation exposure to dust disturbed during renovation activities in the church's attic.

Prior to the start of renovation activities, the health risks associated with exposure to *H. capsulatum* should be communicated to each worker who might be exposed to bat droppings during the course of the project. Individuals with compromised cell-mediated immunity are at greater risk of clinical histoplasmosis should infection occur, so such workers should avoid exposure to all materials potentially contaminated with *H. capsulatum*.

To reduce the potential for aerosolization of dust, the bat droppings should be sprayed with water. Because the water will evaporate over the course of the removal operation, additional water will need to be sprayed as needed. The addition of a surfactant (wetting agent), such as a small amount of detergent, to the water may improve the dust suppression ability of the water alone.

Workers should wear personal protective equipment while spraying water on the bat droppings, and while working in the attic. A NIOSH/MSHA-approved full-facepiece powered air-purifying respirator with high efficiency filters, disposable protective clothing with a hood, disposable latex gloves under cotton work gloves, and disposable shoe coverings should provide adequate protection. Respirators should be used in accordance with the regulations of OSHA[41] and the recommendations of NIOSH.[42] The floor at the base of the bell tower should be used by the workers to remove and discard their suits, gloves, and shoe coverings. All discarded items should be collected in heavy-duty trash bags and disposed of at a landfill. Since the recommended ensemble of disposable personal protective equipment is more insulating than normal work clothing, sweat evaporation will be impeded during renovation activities. Therefore, precautions should be taken during these activities to reduce the risk of heat stress-related illnesses. If possible, renovation activities should be scheduled when temperatures in the attic can be expected to be relatively cool.

Health risks are associated with exposures to even low air concentrations of formaldehyde.[38] Therefore, alternative chemicals should be used to disinfect those materials for which removal is impractical, such as a large volume of contaminated soil. Household bleach is one possible alternative since it contains sodium hypochlorite, which has bactericidal and sporicidal properties. Household bleach also has the practical advantages of being readily available and less expensive than most other chemical bactericidal and sporicidal agents. However, a disadvantage of hypochlorites is that their activity is greatly reduced in the presence of organic matter.[43] The effectiveness of bleach solutions or other disinfectants should be documented before their use is recommended for decontaminating environmental materials containing *H. capsulatum*.

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DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report were sent to:

1. Secretary of Parish Council, Saint Joseph's Catholic Church (Saint Leon, Indiana)

2. OSHA Region V (Chicago, Illinois)