Hospital Epidemiological Surveillance During a Major Construction Project

Sherry Sexton

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HOSPITAL EPIDEMIOLOGICAL SURVEILLANCE DURING A MAJOR CONSTRUCTION PROJECT

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Date 4/26/05

Date

Date 5/4/05

Date

Date 5/4/05
Abstract

The purposes of this study were a) to determine if organism migration occurred from a construction area into other areas of the hospital—especially adjacent operating suites, b) to monitor and evaluate the incidence of construction-related surgical site infections, and c) to monitor the incidence of employee illnesses that could be construction-related. This was also the opportunity to evaluate the effectiveness of infection control and prevention employee or patient infections related to construction. The framework for this study was Florence Nightingale’s Environmental Adaptation theory which focused on the environment and changes which could affect patient outcomes. The results of the study indicated that environmental factors during a construction project could in fact be controlled to limit construction-related surgical site infection or respiratory illness in employees.

A Thesis Presented for the
Master of Science in Nursing Degree
Southern Adventist University
Collegedale, Tennessee

Sherry Sexton
April 2005
Abstract

The purposes of this study were: a) to determine if organism migration occurred from a construction area into other areas of the hospital—especially adjacent operating suites, b) to monitor and evaluate the incidence of construction-related surgical site infections, and c) to monitor the incidence of employee illnesses that could be construction-related. This was a descriptive correlational study and provided epidemiological data to evaluate the effectiveness of infection control measures in preventing employee or patient infections related to construction. The framework for this study was Florence Nightingale’s Environmental Adaptation theory which focused on the environment and changes which could affect patient outcomes. The results of the study indicated that environmental factors during a construction project could in fact be controlled to limit construction-related surgical site infection or respiratory illness in employees.
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My journey to an advanced degree has been a long and arduous one. A journey often frustrating, sometimes painful, and frequently leading to tears. Many have helped on this journey. God truly shined his light on the path when I most needed it.

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And finally, a very, very special thank you to my mother. You unselfishly gave of yourself time and time again to make this journey fruitful. Without you this could never have happened. It is to you that this is dedicated.
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The Association of Professionals in Infection Control (APIC) Handbook of Infection Control (Jennings & Manian, 1999) defines a healthcare-acquired infection as “a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s) not present or incubating at the time of admission to the healthcare facility” (p. 372). In simplified language, healthcare-acquired infections are infections that occur as a result of exposure to microbial organisms while in the hospital. Preventing healthcare-acquired infections from occurring is a priority for healthcare facilities.

Construction and renovation within facilities increases the risk of exposure to harmful organisms for patients, staff, and community visitors (Carter & Barr, 1997). Preventing that exposure is an essential part of a health care facility's safety program. The infection control practitioner of a hospital is responsible for overseeing and maintaining a healthy environment free from the potential for healthcare-acquired infection. Guidelines, policies, and procedures are designed to create a safe environment that safeguards the health of staff, patients, and visitors. While it is unrealistic to expect that healthcare-acquired infections can be completely prevented, the goal is to minimize occurrences of those infections whenever possible. One method of prevention involves strict monitoring and surveillance of construction and remodeling.
CHAPTER 1

INTRODUCTION

Background and Significance to Nursing

Infections are treated in healthcare facilities every day. Patients are admitted for the diagnosis and treatment of those infections with the expectation of improved health. The Association of Professionals in Infection Control (APIC) Handbook of Infection Control (Jennings & Manian, 1999) defines a healthcare acquired infection as "a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s) not present or incubating at the time of admission to the healthcare facility" (p. 272). In simplified language, healthcare acquired infections are infections that occur as a result of exposure to microbial organisms while in the hospital. Preventing healthcare acquired infections from occurring is a priority for healthcare facilities.

Construction and renovation within facilities increases the risk of exposure to harmful organisms for patients, staff, and community visitors (Carter & Barr, 1997). Preventing that exposure and possible infection is paramount in a healthcare facility's safety program. The infection control practitioner of a hospital is responsible for overseeing and maintaining a healthy environment free from the potential for healthcare acquired infection. Guidelines, policies, and procedures are designed to create a safe environment that safeguards the health of staff, patients, and visitors. While it is unrealistic to expect that healthcare acquired infections can be completely prevented, the goal is to minimize occurrences of those infections whenever possible. One method of prevention involves strict monitoring and surveillance of construction and remodeling...
activities to identify potential problems related to microbial exposure and to correct or prevent those problems.

Statement of Problem

During construction and renovation, demolition of current structures or excavation for new areas can mobilize microbial organisms long dormant. Organisms lodged within wall and ceiling areas, under flooring, and in cracks, crevices, and moldings, may attach to dust particles and those particles may be transported throughout the facility. In addition, organisms (especially *Aspergillus* and *Penicillium* species) may be transported into facilities with dust, debri, and soil when construction supplies are moved in and out of the building (Pyrek, 2003). Fungal spores are buoyant and may also become airborne during construction and can stay airborne for extended periods of time (Streifel & Hendrickson, 2002). Construction precautions designed to limit migration of organisms can minimize exposure to staff, patients, and visitors. Precautions include barriers erected to enclose construction areas and isolate them from other areas of the facility and mechanical air handlers to clean the air. In addition to cleaning the air, the air handler (better known as an air “scrubber” because of triple filtration to clean air), also generates a negative pressure air environment, to prevent germ laden dust particles from moving out of the construction area.

When the construction is adjacent to surgical areas, the risk of healthcare acquired infection may be increased (Carter & Barr, 1997). If organisms migrate via dust over, through, or around erected barriers, they can be deposited in body cavities during surgical procedures. In a Massachusetts out-of-court settlement in 1999 (Massachusetts Lawyers Weekly, 1999), a $717,000 out-of-court settlement for a 55 year old patient who had a
herniated disc repair surgery at a Massachusetts hospital was recorded. During the spinal procedure, *Aspergillus* contaminated the surgical site, leading to a disc space infection. The patient had two additional surgeries, and nine hospitalizations resulting in 115 hospital days. The patient filed claims against the hospital medical staff, including the infection control committee and the hospital infection control practitioner. In addition, claims were brought against the general contractor and an environmental testing company.

The risk of infection is inherently greater during a construction phase within a hospital. The primary problem is determining whether there are organisms present, whether there is organism migration, and whether that migration is into adjacent operating suites or out into the hospital commons. Post-operative patients developing infections must be monitored and evaluated to determine if there is any correlation between the surgical procedure and organism migration into the operating room during construction. In addition, employees must be monitored to identify potential trends in illness that can be related back to the construction phase and dust or organism migration.

**Statement of Purpose**

While there is limited research on construction issues and surgical patients, there is much information available related to exposure of immunocompromised patients to microbial organisms made airborne during construction. The purposes of this study are a) to determine if organism migration does occur from construction into other areas of the hospital—especially the adjacent operating suites b) to monitor and evaluate the incidence of construction-related surgical site infections, and c) to monitor the incidence of employee illnesses that may be construction-related.
Hypotheses

Hypothesis 1

Microbial growth in the construction areas will be increased beyond that measured prior to initiation of construction activities.

Hypothesis 2

Increased microbial growth will be limited to the construction area and will not occur in the surgical areas or other areas of the hospital.

Hypothesis 3

Employee illness trending will not reflect an increase in respiratory tract infection that can be related back to construction activities.

Hypothesis 4

Surgical site infection rates during construction will not reflect an increase over rates noted prior to construction.

Framework

Florence Nightingale, long called the founder of modern nursing practice, was a strong advocate for environmental cleanliness. In Notes on Nursing: What It Is and What It Is Not, (Nightingale, 1859), Florence Nightingale discussed the air patients breathe. She stated...

The very first canon of nursing, the first and the last thing upon which a nurse’s attention must be fixed, the first essential to a patient, without which all the rest you can do for him is as nothing, with which I had almost said you may leave all the rest alone, is this: TO KEEP THE AIR HE BREATHES AS PURE AS THE EXTERNAL AIR, WITHOUT
CHILLING HIM. Yet what is so little attended to? Even when it is thought of at all, the most extraordinary misconceptions reign about it. Even in admitting air into the patient’s room, few people ever think, where that air comes from. It may come from a corridor into which other wards are ventilated, from a hall, always unaired, always full of the fumes of gas, dinner, of various kinds of mustiness; from an underground kitchen, sink, washhouse, water-closet, or even, as I myself have had sorrowful experience, from open sewers loaded with filth: and with this the patient’s room or ward is aired, as it is called --- poisoned, it should rather be said.” (p. 12).

Nightingale’s Environmental Adaptation theory focused on the environment and addressed environmental changes that could be made by the nurse. Major concepts of her theory revolved around her belief that the nurse was in charge of the environment and that the nurse should control the environment in an effort to protect the patient from psychological and physical harm (Tomey & Alligood, 1998). Within her theory, Nightingale included five essential components she deemed necessary for environmental health. These included cleanliness, light, pure air, efficient drainage, and pure water. Her concepts, established over 150 years ago, are still valid today. Providing a clean environment, free from the dust debris of construction gives patients the “pure air” advocated by Nightingale. According to Tomey and Alligood (1998), “Nightingale envisioned health as being maintained through the prevention of disease via environmental control.”
Conceptual and Operational Definitions

**Variable – Microbial Growth**

*Conceptual Definition.* “Increase in the number of cells, due to cell division”, (Black, 2001, p. G18).

*Operational Definition.* Presence of growth, indicated as either “yes” or “no”, by direct observation of incubated Petri dishes exposed to the environment for a predetermined period of time.

**Variable – Construction Area**

*Conceptual Definition.* “Continual health care facility upgrade through renovation and new construction involving existing facilities” (Guidelines for Design and Construction of Hospital and Health Care Facilities, 2001, p. 15).

*Operational Definition.* Area of the hospital undergoing construction or renovation activities including demolition, reconstruction, and re-finishing of existing structures and creation, and completion of new structures.

**Variable – Surgical Site Infection Rate**

*Conceptual Definition.* Number of surgical site infections in a specified time divided by total number of surgical cases during the same specified period of time. (Arias, 2000, p. 169).

*Operational Definition.* Number of surgical site infections in a specified time period divided by the total number of surgical cases during the same specified period of time.
Variable – Surgical Area


*Operational Definition.* Department of the hospital containing operating suites, recovery rooms, pre-operative holding areas, and central sterilization areas.

Variable – Employee Illness

*Operational Definition.* Illness of an employee reported by the employee or supervisor.

Variable – Respiratory Tract Infection

*Conceptual Definition.* “Any infectious disease of the upper or lower respiratory tract. Upper respiratory tract infections include the common cold, laryngitis, pharyngitis, rhinitis, sinusitis, and tonsillitis. Lower respiratory infections include bronchitis, bronchiolitis, pneumonia, and tracheitis.” (Mosby’s Medical, Nursing, & Allied Health Dictionary, 1999, p. 1357).

*Operational Definition.* Illness affecting the respiratory system and having symptoms such as cough, sore throat, congestion, mucous production, fever, foul smelling sputum.

Significance and Implications of Study

Florence Nightingale’s advocacy for hygienic surroundings and pure air are directly applicable in this study. Her argument for clean air as being essential to a patient (Nightingale, 1859) clearly indicates the importance of maintaining an environment free from contaminants and harmful organisms. Construction invariably aerosolizes many contaminants such as paint powder, sheetrock or drywall dust, welding dust, etc., along
with microorganisms, that can be detrimental to patients when inhaled or when the contaminants re-settle. Results of this study will allow the healthcare facility to further develop construction-related policies and procedures directed toward safeguarding the health of its patients and staff. Knowledge and experience gained dealing with issues related to this construction project can provide insight for other facilities anticipating or undergoing construction or renovation. Corrective action taken during this construction project can become preventative action for future projects. Construction crews, initially unfamiliar with the rigors of maintaining a safe hospital environment while completing a construction project on schedule will now have new knowledge that will allow them to better respond to needs within healthcare facilities.

Summary

Construction anywhere is a dirty and dusty endeavor. However, construction projects within healthcare facilities raise a number of concerns related to infection risks. Patients come to hospitals for treatment of infections; they do not expect to acquire new infections while in the facility. The potential for healthcare acquired infections increases during construction due to the disturbance and circulation of once-dormant organisms. The nursing profession’s infection control champion, Florence Nightingale, advocated a clean environment to decrease the risks of illness. Barriers, surveillance, and quick corrective action for identified problems all play an integral part in reducing staff and patient exposure to organisms released during construction. All aspects of infection control practices are utilized to prevent healthcare acquired infections at all times and particularly during construction or renovation.
CHAPTER 2

REVIEW OF LITERATURE

Purpose of Review

The purpose of the literature review was to examine the literature regarding hospital construction as related to microbial migration. When developing a study designed to monitor microbial migration, construction-related surgical site infections, and construction-related employee illness trends, a vast amount of literature based on current standards and Nightingale’s theory should guide the study.

Several studies involving immunocompromised or neutropenic patients have been conducted in relationship to construction contaminant migration. However, there are limited studies related to hospital employee illness trending and microbial migration during construction. While improvement in health status of hospitalized patients is important, little consideration has been given to monitoring employee health.

Delimitations of Literature Review

Many literary works were reviewed to expand the knowledge base prior to execution of the proposed study. Articles relating to infection control and construction issues, microbial migration, and applicable theory were evaluated for content and application. Most articles dealt specifically with Aspergillus species as the problematic construction-related microorganism. Texts and instructional manuals were reviewed for procedural applications and infection control guidance. Architectural guidelines and federal regulatory guidelines were also reviewed for useful data. Law journals provided insight into case law and associated malpractice or injury court cases involving
construction-related hospital infections. Literature reviewed spanned from 1992 to the present.

Keywords, Databases, and Resources

Key words used in literature searches included construction, infection control, hospitals, *Aspergillus*, aspergillosis, healthcare acquired infections, policies, guidelines, regulations, and employee health. The World Wide Web, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Pub Med were used for electronic data searches. Federal web sites accessed included The Centers for Disease Control and Prevention (CDC), The Joint Commission on Accreditation of Hospital Organizations (JCAHO), National Institutes for Health (NIH), The Occupational Safety and Health Administration (OSHA), and The Healthcare Infection Control Practices Advisory Committee (HICPAC). Local resources included the Baroness Erlanger Medical Center Library, the Southern Adventist University McKee Library, Community Hospital Systems, and a personal literature collection of infection control texts and journals.

Description of Literature

Construction and renovation represent progress. To hospitals, progress can mean increased resources for patient care. While the end result of construction is positive, many negative things can happen during construction and renovation projects. Although healthcare acquired infections are generally thought of as occurring via patient-to-patient transmission, they can be precipitated by construction projects (Pyrek, 2003). The literature review evaluated construction and infection control-related issues including microbial migration from construction areas into clean areas, post-operative healthcare acquired infections related to construction, and employee illness monitoring for trends
related to construction activities. Each issue is addressed separately in the literature review.

Regulatory Information

Many local, state, and federal agencies regulate day-to-day hospital operations. In addition to those regulations and/or guidelines, there are additional standards and guidelines that apply specifically to construction within hospital walls. JCAHO specifically addresses infection control issues within hospitals. The guidelines are neither prescriptive nor restrictive, meaning each facility must read and interpret the standards as it relates to that facility’s practice. Guidelines deal with specific types of healthcare acquired infections (device-related infections, surgical site infections, tuberculosis, etc.) and provide guidance to format hospital policy (Hansen, 2002).

To encourage a multidisciplinary approach to infection control and facility management, in January 2002, the JCAHO added infection control requirements to their Environment of Care (EC) chapter, which in the past has been the domain of the facilities engineer or maintenance director. The revised Environment of Care Standards reflect increased vigilance during construction projects. Effective January 1, 2002, the revised standard states that when designing the environment of care (building, grounds, facility, etc.), facilities should utilize current design criteria that is accepted and referenced by the healthcare community at large (Hansen, 2002). According to Hansen, the standard indicates that healthcare organizations should conduct a proactive risk assessment using risk criteria to identify hazards that could potentially compromise patient care in occupied areas of the organization’s buildings when planning demolition, construction or renovation work. The scope and nature of the activities should determine the extent of
risk assessment required. In addition, the risk criteria should address the impact
demolition, renovation, or new construction activities have on air quality requirements,
infection control, utility requirements, noise, vibration, and emergency procedures. As
required, the organization selects and implements proper controls to reduce risk and
minimize the impact of these activities. Hansen also indicates that the JCAHO
encourages the use of the American Institute of Architects Guidelines for Design and
Construction of Hospitals and Healthcare Facilities (2001 edition) in conjunction with
applicable federal and state rules and regulations. To meet the intent of this newly
restructured JCAHO chapter, infection control practitioners and facility engineers will
have to work closely together.

An intent statement under the newly revised EC.3.2.1 requires facilities to
“consult the American Institute of Architects (AIA) Guidelines for Design and
Construction of Hospitals and Health Care Facilities when undertaking any project
involving demolition, renovation, or new construction” (Hansen, 2002, p. 44). It requires
the facility’s infection control practitioner to complete a pre-construction risk assessment
or Infection Control Risk Assessment or ICRA. Hansen (2002), further states that the
program is designed to “decrease the number of and reduce the potential for hospital-
acquired illness, and maintain appropriate pressure relationships, air exchange rates, and
filtration efficiencies for ventilation systems that serve areas specially designed to control
airborne contaminants (such as biological agents, gases, fumes, and dust)” (p. 44).

Maintaining a debris-free construction zone and using antimicrobial misting can
help reduce microorganism migration. Specific infection control procedures provide
guidance for construction crews to help reduce exposure to dust that may carry microbial organisms.

The 2001 edition of the American Institute of Architects *Guidelines for Design and Construction of Hospital and Healthcare Facilities* provides architectural guidance for design and construction for facilities. The AIA guidelines provide technical guidance for designing each area of a facility and for incorporating requirements such as infection control needs, fire safety requirements, etc. In discussing the ICRA, the AIA guidelines identify key elements such as:

- The impact of disrupting essential services to patients and employees
- Patient placement or relocation
- Placement of effective barriers to protect susceptible patients from airborne contaminants such as *Aspergillus* species
- Air handling and ventilation needs in surgical services, airborne infection isolation, protective environment rooms, laboratories, local exhaust systems for hazardous agents, and other special areas
- Determination of additional numbers of airborne infection isolation or protective environment room requirements, and,
- Consideration of the domestic water system to limit *Legionella* species and waterborne opportunistic pathogens

(AIA Guidelines, 2001, p. 15).

The CDC has recently completed a draft review of their new *Guidelines for Environmental Infection Control in Healthcare Facilities* which places greater emphasis
on construction, renovation, and repair projects. The guidelines will provide new information on construction-related contamination issues.

**Summary**

Regulatory guidelines affect many aspects of hospitals, including construction and renovation. Regulatory guidelines from the CDC, JCAHO, AIA, and others provide the guidance necessary to safely implement construction or remodeling projects within the confines of the hospital. Issues related to harmful organism migration, employee illness related to construction, and post-operative construction-related infections are all addressed in varying degrees by agencies with jurisdictional, licensing, or accrediting responsibilities. If these issues are not appropriately addressed, difficulties may arise related to funding or licensure.

Construction-Associated Healthcare Acquired Aspergillosis and Microbial Migration

A quantitative research study has been completed linking hospital construction and renovation to Aspergillosis in immunocompromised patients. In this study, Anderson, et. al., (1996), associated building hygiene with an outbreak of Aspergillosis in pediatric patients who were immunocompromised. Their study results revealed that vacuum cleaners, when not thoroughly cleaned on a frequent basis, can pick up and harbor *Aspergillus* spores which migrated from construction areas. While other areas of the pediatric unit did not have significant levels of *Aspergillus* (recorded as colony forming units or CFUs), the cultures from vacuum cleaner exhaust were significantly increased (p<0.002). The Mann Whitney U test was use to evaluate significance of environmental data collected when appropriate. Study limitations included an inability to
sample aerosols consistently and rapidly, and the potential for reaction by staff to an identified or suspected problem making exact replication impossible.

In a related study by Cornet, et al., (1999), quantitative research was conducted to determine the efficacy of high efficiency particulate air (HEPA) filtration and laminar airflow in preventing *Aspergillus* contamination during hospital renovation. In this study, a hematological department adjacent to a hospital renovation project collected 1047 air samples and 1178 surface samples in the 3 units to determine whether *Aspergillus* spore contamination from construction was present. Epi Info (version 6.04, CDC, Atlanta, GA) was used to perform statistical analysis. Chi-square and Fisher's Exact tests were used to evaluate data, and means were compared with Student's t or Kruskal-Wallis tests. Results of the study indicated that samples positive for *Aspergillus* in Unit A (with HEPA filtration) were similar in frequency to the unprotected (no HEPA filtration) Unit B (47.5% and 51.5% respectively; p = 0.7). However, the results were significantly lower (p<10^-7) during periods without renovation. For HEPA protected and non-protected units, the mean levels of *Aspergillus* spore concentrations were comparable (24.7 countable colony forming units and 41.8 countable colony forming units respectively; p=0.3). Colony counts were expressed as colony-forming units (CFU/m3). The HEPA-protected unit (A) had a significantly lower mean level of *Aspergillus* spore concentration during the period without construction than did the non-protected unit B, (4 colony forming units versus 21.3 colony forming units; p = 0.01). Unit C, located far from the renovation site, had similar *Aspergillus* contamination rates during and out of construction (42.9% and 38.1% respectively; p = 0.5). P values of 0.05 or greater were not considered significant. Study results showed a tremendous increase in environmental
contamination with *Aspergillus* in units A and B which are adjacent to the construction site, yet the amount of contamination remained stable in the distant unit (C); which serves to confirm the strong association between environmental *Aspergillus* contamination and construction.

Iwen, Davis, Reed, Winfield, and Hinrichs (1994) used the gravity air settle plate (GASP) method to correlate increased *Aspergillus* levels to hospital construction. The study involved a protective environment unit adjacent to a hospital construction staging area. Settle plates were used to measure *Aspergillus* colony forming units (CFUs) per hour per plate in the special care unit. Before construction was initiated, the colony forming unit count in patient rooms adjacent to the construction site was 0.14 CFU/hr/p and increased to 0.40 CFU/hr/p ($p = 0.02$) after construction began. In corridors adjacent to the construction site, counts rose from 0.43 CFU/hr/p prior to construction, to 2.44 CFU/hr/p ($p = 0.002$) after construction began. However, the level was reduced to 0.80 CFU/hr/p ($p = 0.02$) after infection control measures were introduced. Researchers concluded that although the GASP method of environmental sampling was an effective tool for evaluating mold presence, it was not sensitive enough when dealing with immunocompromised patients. This finding was based on two patients identified as developing invasive Aspergillosis even though the settle plates did not indicate *Aspergillus* growth.

In a study conducted at Cedar-Sinai Medical Center (Pegues, Daar, & Murthy, 2001), researchers identified 72 cases of Invasive Pulmonary Aspergillosis (IPA) from a retrospective study of 505 solid organ transplant (SOT) patients with respiratory culture(s) positive for *Aspergillus* species. Most of these patients were categorized as
being “colonized” with *Aspergillus* because they lacked a histopathology report that was consistent with Invasive Pulmonary Aspergillosis, or they did not have a discharge diagnosis of IPA. Of the 505 patient charts evaluated, ninety three patients met criteria by having a histopathology report deemed consistent with IPA (n=59), or they had diagnosis at discharge of Aspergillosis (n=34). Out of these, 72 patients were classified as definitive (n=59) or probable (n=13), and another 32 were considered colonized. During the study period (January 1, 1990 to December 1998), the rate of IPA decrease from 2.45 per 100 solid organ transplants (SOTs) to 0.52 (trended chi-square, 5.44; p<0.05). During this time period, the hospital-wide IPA rate was constant at 0.03 based on 1,000 patient days. The decrease in the solid organ transplant rate was attributed to carpet removal in the patient rooms, and remarkably, was not adversely affected by an earthquake in January, 1994 which measured 6.7 on the Richter scale and was responsible for major damage to patient-care and research buildings.

A related quantitative study by Raad, et al., (2002), evaluated the practice of masking neutropenic patients during transport out of their protective environment rooms (positive pressure rooms) and correlated that with a reduction in construction-related healthcare acquired Aspergillosis. In this study, surveillance was performed utilizing medical records to identify positive *Aspergillus* cultures. Whether a patient was considered to have an infection or colonization was determined by reviewing microbiology reports, medical charts, and radiologic reports. Air samples were collected from the old facility (both protected and unprotected environment rooms), outside, and in the new facility once it was in use. The Fisher Exact test and chi-square test were used to evaluate categoric variables. The study was designed to evaluate the use of high
efficiency particulate air (HEPA) masks by patients with hematologic malignancy and/or having undergone bone marrow transplant. During the construction period (September 1993 to August 1999), these patients were required to wear HEPA masks anytime they were out of their protective environment rooms.

The construction project was divided into 2 phases: phase A, (September 1993 to August 1996), marked the preliminary construction period, and phase B (September 1996 to August 1999), involved full construction activities. Higher Aspergillus levels in outdoor air samples (as compared to indoor air samples) were identified in both phases. Although rates for community-acquired Invasive Pulmonary Aspergillosis (IPA) in patients with hematologic malignancy were found to be increased from 0.43 per 1,000 patients during phase A, to a phase B rate of 0.78 per 1,000 patients (p=0.002), there was a significant decrease in healthcare acquired IPA infections identified during this same time period. Patients with leukemia had a similar trend (p=0.002). The healthcare acquired IPA infection rate dropped from a construction phase A rate of 0.73 per 1,000 patient days (for patients with hematologic malignancies), to a phase B rate of 0.24 per 1,000 patient days (p=0.001) with the use of HEPA mask precautions. Leukemia patients and bone marrow transplant patients had significant decreases in healthcare acquired IPA infection rates (p<0.001 and p=0.02, respectively). Based on the significant decrease in healthcare acquired IPA infections identified in this study, researchers made the recommendation that high-risk patients with hematologic malignancy or bone marrow transplant should wear HEPA masks when being transported outside their protective-environment rooms for treatment of diagnostic tests.
In a study by Patterson, Zidouh, Miniter, Andriole, and Patterson (1997), researchers concluded that certain patient populations without hematologic malignancy should be considered at-risk for healthcare acquired IPA. Other patients considered at risk were immunocompromised patients, solid organ transplant patients, trauma patients, patients with solid tumors, and bone marrow transplant patients. The quantitative study evaluated active case surveillance methodology and antigen detection of Invasive Aspergillosis. A convenience sample of 153 patients with Aspergillosis antigen testing and culture was used. The sample came from an 850-bed tertiary-care medical teaching facility. Whole or full-house surveillance for positive microbiology reports of Aspergillus was utilized to identify patients. Positive cultures were identified by reviewing all culture reports generated by the microbiology department. Established surveillance definitions were used to categorize cases. Healthcare acquired cases were defined as “an infection occurring during hospitalization that was present or incubating, or a case occurring within 2 weeks of discharge” (p. 105). Community-acquired cases were defined as “clinical evidence of infection present on admission, or appearing within the first seek of admission, or more than 2 weeks after discharge” (p. 105). Probable cases were defined as “patients with clinical evidence of Aspergillosis plus a positive Aspergillus culture, but without histopathologic evidence” (p. 105). Possible cases were defined as “a patient with clinical evidence of Aspergillosis, with negative cultures for Aspergillosis and other pathogens” (p. 105). Those patients not meeting any of these criteria were defined as “not a case” (p. 105).

Of the 26 patients who had positive Aspergillus cultures, 14 patients were diagnosed with Invasive Aspergillosis and 12 patients with positive culture reports had no
clinical evidence of disease. Of the 26 patients identified, 17 were classified as community-acquired Aspergillosis, and 7 were found to be healthcare acquired in nature. Definitively, there were three proven cases, 11 probable cases, and 10 possible cases of Aspergillosis. Antibody assays for Aspergillosis were positive in 1 possible case, 1 proven case, 4 probable cases, and also positive for 15 non-cases. Results of this study indicated that use of serology antigen testing in addition to surveillance criteria allowed for a greater level of sensitivity for identifying and treating patients with Aspergillosis who may have a wide variety of disease processes not limited to hematologic malignancies.

As seen in this literature review, patients with hematology disorders are at great risk for Aspergillosis when construction is active. Loo, et al., (1996), carried out research involving an antiquated hematology unit, nearby construction, and an increased level of healthcare acquired Aspergillosis. The basis for this study was founded on the premise that older, antiquated facilities may not be environmentally sound and may inadvertently place patients at higher risk for contracting healthcare acquired Aspergillosis during hospitalization. This study, a combined retrospective and prospective quantitative one, evaluated air and surface samples after an outbreak of Aspergillosis was identified. Evaluation was to determine if the outbreak could be related to the age of the facility and/or an adjacent construction project. The study encompassed 69 months, from January 1988 to September 1993. Prior to the study, sporadic cases of Aspergillosis had been identified. However, the rate of Aspergillosis during active construction was 3.1 times higher than the pre-construction period (CI-95, 1.1 to 8.9). Following identification of an outbreak, infection control measures were implemented, and the rate of Aspergillosis
declined to one third the rate prior to infection control interventions (CI-95, 0.10 to 0.83).

Air and surface sampling during the outbreak period resulted in mean concentration levels of *Aspergillus* species of 6.77 colony forming units (CFU)/m3. Infection control measures implemented included use of portable HEPA filter units, and other environmental measures. Four months following infection control interventions, air and surface samples did not yield any *Aspergillus* colonies.

Another quantitative study involving bone marrow transplant patients was conducted by Lai, (2001). In this study, Lai failed to substantially link construction activities to an increase in cases on Invasive Aspergillosis. The air sampling to identify the presence of *Aspergillus* did not begin until a cluster of patients with Invasive Aspergillosis was identified. Once the cluster was identified, the bone marrow transplant unit was closed for thorough cleaning. Air samples were taken prior to cleaning and again after cleaning of patient rooms. According to study tables, not all rooms had air samples taken. The study reports a six month pre-construction rate of 0.8 cases per month (five cases during the six month period) in wards adjacent to construction. During construction, eleven cases were identified in the same wards, resulting in a rate of 2.3 cases per month. In the bone marrow transplant unit, one case of Aspergillosis was identified in the 6 month pre-construction period, yielding a rate of 0.2 cases per month. Two cases were identified in the bone marrow transplant unit during construction, resulting in a rate of 0.5 cases per month-still lower than the facility rate. Following construction, both the bone marrow transplant unit and the adjacent wards returned to their pre-construction rate of 0.2 and 0.8 cases per month, respectively.
Flynn, et al., (1993), described a prospective quantitative study conducted in an eight bed intensive care unit at St. Jude Children’s Research Hospital in Memphis, Tennessee. During this study, renovation was ongoing in the two floors just below the unit (4th and 5th floors). The study was initiated after four patients in the unit were found to have respiratory cultures positive for *Aspergillus terreus*. An evaluation of environmental fungal cultures during the investigation found significantly higher *Aspergillus* levels (p=0.04 using the Kruskal-Willis test) and fungi levels than were reported previous to the outbreak. No other hospital area being monitored reported a similar increase. Although higher levels of *Aspergillus* were identified by culture, *Aspergillus terreus* could not be isolated from the environment. The researchers suggested that the outbreak should be considered construction-related, although no concrete evidence supported contamination of the unit with *Aspergillus* from the construction area.

Bryce, et al., (1996), conducted a slightly different quantitative study that looked at direct wound inoculation by *Aspergillus* spores. The study was conducted at Vancouver Hospital, a 900-bed adult, tertiary-care facility with surgical, medical, and burn intensive care units located in different hospital areas and with their own unit-dedicated staff. The study originated after the infection control department was notified of three cases of Cutaneous Aspergillosis occurring in a three-week period. Retrospective chart reviews and environmental surveillance was conducted to determine the origination of the contamination. Blood agar settle plates were placed at patient bedsides and swab cultures of ventilation shafts, air vents, mechanical ventilator circuitry, counter tops, monitor surfaces, and cleaning solutions were completed. All cultures were
negative for *Aspergillus* except for settle plates in affected patients' rooms. All other ICU patient wound and sputum cultures were also negative, but swab cultures taken from the ICU supply rooms were positive for *Aspergillus*. Following an intensive review, and further culturing, it was determined that initial contamination occurred in the central supply department that was undergoing major renovation while remaining in operation. Cultures from open and closed boxes of supplies (dressing trays, IV bags, bandages, gauze, tape, bins, wooden pallets, etc.) produced heavy growth of *Aspergillus* species.

Upon this discovery, appropriate construction barrier techniques to limit construction exposure were initiated. The supply and inventory department were closed, and all areas were thoroughly cleaned. All opened packages of dressings, bandages, tapes, etc. were discarded and an urgent message was sent to all departments instructing them also to clean their supply areas and discard open supplies. Weekly patient and environmental cultures were obtained for six weeks following decontamination measures. All subsequent cultures were negative. Although no statistical evidence is offered by these researchers, identification of source contaminant and correction of the problem indicates a thorough understanding of the implications and potential for an epidemic had the outbreak not been appropriately evaluated (Bryce, et. al., 1996).

**Surgical Site Infections Linked to Construction**

Construction-related *Aspergillus* was found to be associated with increased cases of Ocular Aspergillosis in a qualitative case study analysis by Tabbara and Jabarti (1998). Five patients with *Aspergillus Endophthalmitis* were identified during a three week period which coincided with hospital construction. The five cases were evaluated for *Aspergillus Endophthalmitis* following cataract surgery at a hospital facility where
construction was ongoing adjacent to the surgical department. Environmental studies from hospital records indicated that *Aspergillus fumigatus* was isolated from the patients' ward. While no statistical data were provided, the article asserted that the researchers felt they had made a correlation between cataract surgeries in a surgical department adjacent to an active construction site based on the fact that infection developed in the patients within 4 to 15 days following the surgery. Cultures of aqueous or vitreous humor did grow *Aspergillus fumigatus*. No colony counts were provided.

**Employee Illness**

Preventing construction-related healthcare acquired infections in patients is an accepted standard in healthcare. However, preventing those same infections from occurring in employees and healthcare workers does not seem to be as clear. Hansen, (2002), presented employee illness in an easier to understand analysis when describing the financial cost to a facility. “These human assets are the most valuable and expensive assets of any hospital. Studies have shown that, in terms of cost/square foot, the human asset is around 10 times the building operating cost, and nearly 100 times the energy cost... ...In other words, it would take a 50% reduction in energy consumption in order to equal a 5% gain in personal productivity” (p. 160). During the current nursing shortage, any reduction in productivity adversely affects the hospital.

Hansen reported a trend in workers' compensation claims for 1980 through 1994 for lung and respiratory cases. In 1980, lung and respiratory-related cases were around 1000, but had increased to more than 6000 by 1994, a six-fold increase. Other data reported by Hansen detail the average cost of a workers' compensation claim (without consideration of ancillary costs, such as cost to the facility in terms of healthcare worker
productivity). The average cost of a workers’ compensation claim for medical treatment - $21,000, human resource costs - $2,100, and workers’ compensation insurance increases $4,750, with a total claim national median average of $27,850. Additional costs include expenditures to recruit new physicians when unhappy physicians vacate an office suite due to hospital-related illness claims. If staff and physicians leave a facility due to illness issues, recruitment strategies, vacant offices, lost revenue from referred ancillary services, and incentive packages to entice new tenants may skyrocket. Additional expense may occur when litigation related to unresolved workers’ compensation issues becomes fodder for the courts. Hansen’s (2002) text deals with issues related to resolving workers’ compensation dilemmas when they involve facility environmental issues.

Summary

In all studies reviewed, prophylactic anti-fungals were only utilized in the Lai (2001) study. During or following all reviewed studies, infection control measures were either implemented or recommended to limit patient exposure to *Aspergillus* spores and other harmful organisms. Some infection control measures affected only construction, such as barrier wall construction (Cornet, et al., 1999, Raad, et al., 2002). Other measures affect areas adjacent to the construction zone such as removal of carpet which may hold organisms (Pegue, Daar, & Murthy, 2001), sealing of windows (Tabbara & Jabarti, 1998, Loo, et al., 1996), increased staff awareness (Flynn, et al., 1993), and stringent cleaning procedures (Tabbara & Jabarti, 1998, Loo, et al., 1996). Many of the studies also advocated a process for environmental cultures and increased microbial surveillance during construction projects (Tabbara & Jabarti, 1998). Cornet, et al., (1999), and Iwen, Davis, Reed, Winfield, and Hinrichs, (1994), recommended development of an industry-
wide standardized protocol for aerobiological surveillance to prevent or limit healthcare acquired infections related to construction. Anderson, et al., (1996), also recommended the development of a checklist comparable to the pre-flight checklists utilized by pilots to ensure all aspects of construction as it relates to infection control are addressed.

The research related to Aspergillosis and construction primarily addresses units or areas housing patients with hematological malignancies and bone marrow transplant patients. While some literature is available that addresses Ocular Aspergillosis, and Cutaneous Aspergillosis, no literature has been identified which addresses the overall health and well-being of patients in hospital facilities undergoing renovation or new construction. Many patients who come into hospitals may be immunocompromised, and may not be bone marrow transplant patients and may not have hematological malignancies. While Patterson, Zidouh, Miniter, Andriole, & Patterson, (1997) addressed other patients who may be at higher risk for infection by *Aspergillus* during construction, no other literature on that subject was identified. This indicates a need for further study.

Various methods of environmental surveillance were identified including the gravity air settle plate (GASP) method to determine the presence of *Aspergillus* spores. Other methods of surveillance included retrospective and prospective chart and microbiology report review. Although the literature did not specifically address migration of microbial organisms out of the construction area and into patient areas, it can be accepted that this migration does occur as evidenced by study data indicating the presence of organisms in patient areas and patient infection with construction-related organisms. While much data is available, much more needs to be done in the arena of infection control.
CHAPTER 3

METHODS AND PROCEDURES

Description of Research Design

The study was a descriptive correlational study exploring relationships among construction, microorganisms, and employee and patient illness. By systematically and scientifically conducting a study to determine if relationships do exist, better guidelines for managing construction projects can be developed, and current guidelines can be revised if necessary. Design strengths include consideration of multiple aspects of hospital construction and renovation (i.e., patient, staff, and microorganism issues). In addition, results of this study will provide needed guidance for future projects and will validate current infection control practices designed to prevent or minimize construction-related infections. No significant weaknesses to this research design were identified.

Population and Sample

As this was a three-pronged study, there were multiple elements involved. For the purposes of this study, the accessible population consisted of all patients of the facility, and facility employees during the construction period dating July 3, 2002 through April 30, 2003 (approximately 10 months in duration). Inclusion criteria for patients included individuals who had surgical procedures performed in the surgical department during the period July 3, 2002 through April 30, 2003, irregardless of whether they were in-patient or out-patient. Inclusion criteria for facility employees included employees who actually worked in the main building during the construction period July 3, 2002 through April 30, 2003. No prerequisites such as reading or writing were required of
employees or patients as this portion of the study was retrospective in nature and did not require active participation in the study.

Data for the study were obtained by completing a chart review of medical and employment records. Utilization of an existing employee illness reporting system eliminated the need to develop a method of tracking illnesses in employees, and allowed for an easy comparison of pre-construction and “during construction” employee illness. Similarly, utilization of existing methods of surgical site infection tracking/reporting and data collection enabled comparison of “pre-construction” surgical site infection rates with “during construction” rates.

Setting

The setting used was a small community hospital undergoing extensive remodeling and expansion of an existing surgical area. During remodeling and construction, surgical procedures continued—no delays in surgical procedures occurred as a result of the project. Since this was a small facility, the number of surgical cases occurring, and the amount of surveillance for related surgical site infections was easily manageable. The facility performs an average of 400 surgical procedures monthly. Similarly, the small size of the facility dictated a proportionately small number of employees. Therefore, surveillance and tracking of employee illnesses was easily accomplished.

Ethical Considerations

Verbal permission was obtained from the Facility CEO and pertinent committees (privacy, environment of care, infection control, utilization review, and performance improvement). Data were stored in a locked file cabinet during the research project.
Once the research and analysis was completed and verified, all raw data were returned to the facility for their disposal. Confidentiality was maintained throughout the study, by limiting review of data to thesis committee members.

Due to the nature of the study, and the fact that routine scheduled procedures were taking place, all necessary precautions were taken. Infection control barriers were utilized including solid wall barriers (1/4 to ½ inch drywall), heavy plastic sheeting barriers (40 mil) and commercial grade sticky step-off pads. Other infection control interventions included a large industrial quality portable HEPA filtered air scrubber (Force Air model 2000 EC) with the capacity to generate a large negative pressure zone. These interventions were employed to prevent movement of any microbial organisms (actively or passively) out of the construction area. All APIC and CDC construction-related infection control guidelines and AIA construction requirements were utilized in an effort to protect patients, family members, and staff from exposure to organisms.

Section II of the CDC Guidelines for Environmental Infection Control in Health-Care Facilities, (pages 10-13) outlined specific protective measures to be taken. EC 3.2.1 of the JCAHO standards manual was utilized for further infection control precautionary measures such as walking inspections, daily construction meetings with contractors, etc.

Data were collected using medical record numbers or partial employee social security numbers as an identifier to protect the identity of patients and staff. Collected data were stored in a locked file cabinet and secured via password on a computer data base. At no time were patients, staff, or visitors subjected to any extraordinary procedures or techniques. All activities related to construction, surgery, and general hospital procedures continued without alteration in respect to, or because of this study. No one
was knowingly subjected to hazardous or potentially hazardous situations as a result of the ongoing construction.

Review Process

Form A was submitted to the institutional review board at Southern Adventist University and was approved (see Appendix A). It was determined that only Form A need be completed because there was no manipulation of human subjects, and no exposure to hazardous situations. In addition, subjects were not expected to experience any psychological discomfort or invasion of privacy as a result of this study. Hospital approval for the study was also obtained. The letter of approval from the facility is on file with the researcher for institutional privacy.

Data Collection Related to Microorganisms

The presence or absence of microorganisms was determined based on the gravity air settle plate (GASP) method familiar to standard infection control environmental sampling practice. The process involved identifying a total of 12 plate locations within the construction area and the facility in general. A 13th site was designated as the control plate site. This control plate was placed at an designated point outdoors and away from construction activities and ventilation intake or output points. Although the appearance and design of the construction area changed over the ten-month project, overlay maps of the construction zone were used to ensure plates were placed in the same location (+/- 2 feet) for each collection period (see Appendix B). In addition, to ensure that all plates were exposed for the same period of time, plates were distributed in the same sequence each and every time, beginning with the control plate. Plates were exposed for a 2-hour period, and then were collected in the same sequence as they were distributed. This
procedure ensured that all plates were exposed for the same period of time. Each plate was marked on the base with the location, date, time placed, and time collected, and were numbered sequentially in the order of distribution. See Appendix D for photographs of plates collected from the construction area on July 22, 2002 during heavy demolition.

Plates were taken directly from the facility’s laboratory media refrigerator (temperature range 34° F – 39° F) and were then distributed. When plates were collected, they were placed in the facility’s Labline Instrument Model 417 Imperial II CO2 incubator for incubation and monitoring of growth. A temperature range of 34° F – 36°F was maintained. Auto injection of CO2 was confirmed. Three and one fourth inch culture media plates containing Trypticase Soy Agar with 5% sheep’s blood from Becton Dickson were used. Evaluation of settle plates was done on day three and seven, and again on day 10 if needed, to confirm growth. Plates having an overgrowth of organisms were re-plated and incubated a second time. The process of microbial growth evaluation was re-plated specimens similar to the first evaluation (i.e., day three, seven, and 10 if necessary). Evaluation was completed by a micro/bacteriology technician with laboratory certification in microbiology. The microbiology technician conducting specimen evaluation has an American Society of Clinical Pathologists (ASCP) certification. A sample microbiology specimen report may be found in Appendix E. Following the initial read of plates, any fungal organisms identified were sent to a commercial lab for confirmatory evaluation.

To ensure safety of patients and staff, the lab microbiology technician was instructed to report any organism growth verified on plates located in the surgical suites, sterile corridor, or central sterile area immediately to the infection control practitioner for
appropriate intervention. All culture results, whether positive or negative, were reported to appropriate facility safety committees and administrative representatives. If interventional activities were required, these were also reported to committee. Following evaluation of the plates, they were discarded in appropriate containers for hazardous biologicals incineration.

Construction workers were educated at the beginning of the project regarding handling or tampering with plates. The importance of uncontaminated specimens was explained to all workers and the project manager. All construction workers were also educated regarding types or organisms that might be aerosolized and the importance of wearing appropriate protection (N95, particulate respirator) to protect themselves from exposure to harmful organisms.

Employee Illness Report Data

Employee illness data were collected from facility employee illness records. Facility Infection Control policy requires that all departments report employee illnesses on a monthly basis. The report used indicates type of illness, any diagnostic tests completed, and duration of illness, in addition to the employee’s identifier. Data were gathered for all respiratory-related employee illness for the period July 2001 through April, 2002 (baseline) and July 2002 through April 2003 (construction phase).

Comparison of the baseline data with the construction data was used to identify illnesses that could potentially be attributed to construction. Any illnesses identified as “attributable to construction” were to be reported through safety committees and to appropriate administrative representatives.
Patient Surgical Site Infection Data

Surgical site infections were monitored as part of the surveillance for this study. Data related to surgical site infections were collected by the infection control practitioner and then analyzed to determine whether the infection was healthcare acquired or community acquired. The Center for Disease Control and Epidemiology (CDC) Guidelines for surgical site infection classification (see Appendix C) were used by the Infection Control Practitioner to differentiate healthcare acquired from community-acquired infections. Data from the pre-construction period (July 2001 through April 2002) were used as a baseline; while data and statistics for the construction period dated July 2002 through April 2003 were used for comparison to determine if any surgical site infections could be attributed to construction activities. All surgical site infection statistics were reported to safety and quality assurance/performance improvement committees, in addition to being reported to appropriate administrative staff.

Data Analysis

Data analysis for employee illness and surgical site infections was based on increases in incidence and relativity data. Data were analyzed for the relationship to the study hypotheses and clinical significance. Any significant findings negative or positive were reported to appropriate facility committees and administrative staff. The General Contractor for the project was also apprised of any information pertinent to construction (i.e., need to enhance/change infection control interventions, changes in surveillance schedules, etc.).
CHAPTER 4

RESULTS OF RESEARCH

Once research and data collection and review were completed, statistical analysis was undertaken to evaluate the significance of the study findings. Data for each of the hypotheses were carefully reviewed. This chapter presents these findings.

Purpose

The purpose of the data analysis and review was to better understand the possible movement or growth of microorganisms during construction and renovation projects. By evaluating settle plate results, employee illness statistics, and surgical site infection rates, decisions could be made regarding the need to enhance or continue current infection control activities during future construction projects.

Sample Demographics

The type of study and the type of data collected did not require collection of demographic data. The facility where data were collected is located in the southeastern part of the United States. It serves a multi-ethnic population that is primarily white Caucasian, with widely variant socioeconomic status. All age groups are represented in the patient population. Employees are adults of varying ages.

Performance and Reliability of Instruments

The instruments used in the study were simple and well proven as reliable indicators. Due to the simplicity of the collection procedure, sampling could be performed in occupied areas. Iwen, et. al. (1994) used the GASP method for sample collection to allow collection in patient-occupied areas. Other, more technical methods of sampling could have been used to obtain data regarding specific colony counts, but at a
much greater expense. The intent of this study was simply to identify the presence or absence of harmful microorganisms. The criteria for determining surgical site infection was taken directly from the CDC’s “Guidelines for Surgical Site Infection Classification” and reflects the same criteria also used by the NNIS (National Healthcare acquired Infection Surveillance organization) to identify surgical site or surgical site infections. This tool has been used for many years and adequately reflects standard criteria for determination of infection.

The data collection tool for employee illness, while utilized by this facility for five years, does allow for subjective inference by the employee or supervisor when completing the form. The form (See Appendix C) requires indication of what type illness the employee is experiencing. In addition, duration of illness, and whether medical treatment was obtained is also requested on the form. No data regarding reliability and validity of their tool are available.

Description of Findings

Hypothesis 1 stated that microbial growth in the construction area would be increased above that measured prior to initiation of construction activities. This hypothesis was tested using settle plate environmental testing. Week one of data collection was prior to construction. Weeks two to 41 were during construction; and week 42 was following construction and terminal cleaning. Data showed no growth on construction or sterile environment plates on week one or 42, except on the control plate. Growth was present on most construction plates during the construction time period, weeks two to 41. The settle plate sampling, did in fact verify the presence of microbes in
the environment that were noticeably absent in the pre-construction testing period, supporting hypothesis 1 (See Appendix C).

Hypothesis 2 states that increased microbial growth will be limited to the construction area, and will not occur in the surgical areas or other areas of the hospital. In figure 1, settle plates from OR 1, OR 2, OR 3, the sterile corridor, central sterile, the recovery room, and the plate placed far distant on south wing were all without evidence of growth. Plates from construction locations A, B, C, D, and E, all exhibited various percentages of microbial growth. The plates with growth can better be

Figure 1. Percent of plates from all areas, both construction and non-construction that showed no growth
visualized in Figure 2. The control plate which was placed outside demonstrated constant growth which was expected due to exposure to multiple organisms in the environment.

![Graph showing percent of plates that showed growth](image)

**Figure 2. Percent of plates that showed growth**

In Figure 2 it becomes apparent that the settle plates in the construction areas and the control area had high percentages of microbial growth, indicating a causal relationship between construction and increased microbial growth in the construction area. Stated differently, prior to construction, no microbial growth was noted in the construction areas; however, once construction began, the majority of settle plates utilized in the construction areas had positive microbial growth. Hypothesis 2 was supported.
As a point of interest, the microbial organisms most frequently identified on the settle plates were either bacteria or fungus. Of the fungi, *Aspergillus flavus, Aspergillus fumigatus,* and *Aspergillus niger* from the *Aspergillus* species were positively identified. In addition *Penicillium* was also identified. Both gram negative and gram positive bacteria were identified during settle plate evaluation. Gram positive bacteria included *Streptococcus pyogenes, Streptococcus agalactiae, Staphylococcus aureus,* and *Staphylococcus epidermidis.* In addition, several species of *Bacillus* (not anthracis) and *Clostridium* were also identified. *Corynebacteria* and *Actinomycetes* were also identified. Of the gram-negative bacteria, the following were identified: *Klebsiella pneumoniae, Serratia marcescens, Escherichia coli,* and *Pseudomonas aeruginosa.*

Hypothesis 3 states that employee illness trending would not reflect an increase in respiratory tract infections that could be related back to construction activities. After gathering the data and performing a *t*-Test for related samples, it was found that there was no significant difference in employee illness rates during pre-construction and construction time periods (*p* = .85). These findings support hypothesis 3.

**Table 1**

**Employee illness rate comparison**

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</tbody>
</table>
Rates during construction would not reflect an increase over rates noted prior to construction. These rates were compared using a paired sample t-Test (p=.77).

Differences in surgical case numbers were calculated into the data. In Table 2 it can be seen that there was no significant difference in the surgical site infection rate during the construction period and the identical period one year prior to construction. Hypothesis 4 was supported.

**Table 2**

*Postoperative infection rate comparison*

<table>
<thead>
<tr>
<th>Paired Samples Test</th>
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<tr>
<td><strong>Paired Differences</strong></td>
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<tr>
<td>Mean</td>
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<tr>
<td>Paired 1</td>
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</table>

Summary

This chapter presented the statistical data analysis for each hypothesis of the study. Demographics of samples were addressed. Charts and figures provide enhanced visualization of the data analysis.
CHAPTER 5
DISCUSSION AND CONCLUSIONS

The results of the research undertaken during the surgical area renovation and expansion were ideal. Each hypothesis was supported, indicating that the infection control procedures used during construction were effective.

The high rate of positive results reflecting microbial growth on the construction area plates once construction started is supportive of Hypothesis 1. Conversely, the marked absence of microbial growth in the surgical areas and at the outlier south wing site, provided overwhelming support for Hypothesis 2. Given the findings, it can be confidently stated that the plates provide strong evidence against any form of microbial migration or transfer from the construction area.

Statistical analysis of the employee illness data for Hypothesis 3 showed no significant difference in pre-construction and construction rates of employee illness. When looking at specific monthly numbers some variation is seen, this can easily be accounted for by factoring in the time frame of the data collection. Data collection occurred from July 2001 through April 2002 for pre-construction data, and July 2002 through April 2003 for data collected during construction. In evaluating these time frames, minimal, non-significant increases can easily be accounted for by summer pollen season and fall flu season in each time period, pre-construction and construction. Surgical infection rates also did not reflect significant differences in rates pre-construction and construction. Unlike employee illness, when any subtle differences can be explained by environmental allergens and flu season, there is no variable to explain a
difference in surgical rates. However, the differences were so insignificant as to require no further explanation.

Significance of Findings

The significance of this study lies in the support for each of the four study hypotheses. There was no significant difference in pre-construction surgical site infection rates and pre-construction employee illnesses when compared to construction time frame surgical site infections rates and employee illnesses. The fact that such an expansive construction project with major demolition and reconstruction could be undertaken while surgeries continued on the other side of the wall without increases in surgical infection rates or employee illnesses is the most significant point to be made.

The significant absence of growth noted on the surgical plates in comparison to the construction plates which were grossly positive for growth is representative of the very effective infection control measures utilized for the construction project. While this study did not focus on specific infection control interventions and precautions, the fact that infection control practices in place prevented transfer of microbial organisms out of the construction area, and consequently played a significant role in the prevention of construction related surgical site infections and employee infections is central to primary infection control practice. The AIA Guidelines for Design and Construction of Hospital and Healthcare Facilities (2001) were followed during this construction project. This research supports that these guidelines are effective.

Implications for Health Care

Patient safety is at the forefront of any health care discussion. Providing a safe environment for all patients of a health care facility is paramount. In an era when patients
can “go online” and evaluate facility performance, simply providing the minimum in patient care and safety is not enough.

By evaluating infection control practices during a major construction and renovation project, it was hoped that information could be gleaned which would allow evaluation of current infection control and patient safety practice, while identifying any unmet needs. In today’s world, when microbial organisms can be used as weapons, not only is it important to prevent or control infectious illness, it also becomes necessary to identify potential risks inherent in health care facilities. When walls and ceilings are opened, long dormant organisms are exposed to the environment, and consequently to the staff and patients. By implementing safe and effective infection control practices, communities can rest comfortably knowing that even though the world may not be a safe place, their local health care facility is.

Recommendations for Future Research

Currently, the Association for Professionals in Infection Control (APIC) does not have recommendations for routine environmental cultures during construction. Enhanced targeted patient surveillance for respiratory illnesses associated with construction is recommended. Even without current recommendation, more studies need to be completed to determine if environmental culturing is beneficial. Should a culture identify organism presence in a surgical suite, that might be the sentinel parakeet to instigate an investigation into the cause. This in turn could identify a significant problem with could be corrected before many patients and staff are exposed.

When conducting environmental sampling, sample plates are a simple and inexpensive method of identifying whether organisms are present. While this type of
sampling provides valuable information, if a facility can afford technologically advanced equipment, then qualitative sampling can be done, and more emphasis can be placed on types of organisms and colony counts.

Summary

Infection control practitioners are presented with many challenges today. The advent of patient safety goals with increasing emphasis on preventing or minimizing health care acquired infections places pressure on facilities to ensure the safety of patients and staff. The research study conducted indicates how readily information can be obtained to assist in desirable outcomes. While this study did identify microbial growth in the construction area, it also verified that the organisms were contained within the construction area. Comparison of employee illness rates pre-construction and during construction and similar comparison of surgical site infections pre-construction and during construction provide evidential proof that infection control measures are effective in preventing construction-related illness. Pre-construction rates and construction rates were not significantly different, and so require no action beyond continued diligence in monitoring of patient and employee data. This study does stress the importance of vigilance in all aspects of infection control and the necessity of implementing environmental safety strategies to prevent potential infections.


Cheng, S. M., & Straif, A. J. (2001). Infection control considerations during...
References


Joint Commission on Accreditation of Healthcare Organizations. (2002). Designing the


APPENDIX A: Approval Communication

1. Approval from Facility to Conduct Research
   - The researcher has on file the health care facility and the facility CEO's response letter granting permission for the research. The letters are secured to prevent unauthorized access of the facility.

2. IRB Form

3. IRB Approval Letter
Approval From Facility to Conduct Research

The researcher has on file the letter requesting permission to do research at the health care facility and the facility CEO’s response letter granting permission for the research. The letters are secured to protect the privacy of the facility.

Directions: Please complete this form and submit with the following documents if used: (1) Informed Consent Form, (2) Data Collection Instrument (e.g., questionnaire) or Protocol.

Level I review: Obtain approval and signature from the course professor/student club or association sponsor. Submit Form A with signature to course professor and keep copy for self.

Level II review: Obtain approval and signature(s) from Chair/Dean. Submit copies of Form A with signatures to course professor, Chair/Deans(s), and self.

I. Identification of Project

Principal Investigator: Sherry L. Sexton
Address: PO Box 763, Hixson, TN 37343
Tel & E-mail: (423) 338-4243, sherry.sexton@jax.net
Co-Investigator(s): None
Address: NA
Tel & E-mail: NA

Title of Project: Nursing
Department: Nursing
Faculty Supervisor (for student investigator): Helen Quid
Starting Date: July 1, 2002
Estimated Completion Date: March, 2005
External Funding Agency and Identification Number: NA, no funding required
Grant Submission Deadline: NA

II. Purpose of Study

The purpose of this study is to evaluate the effectiveness of current infection control processes utilized during construction projects to protect employees and surgical patients from exposure to potentially harmful microorganisms that could become airborne during construction activities. Specifically, this study will look at employee illness rates and surgical post-operative infection rates during a construction project and will also seek to identify presence of microorganisms migration outside of the construction barriers.
SOUTHERN ADVENTIST UNIVERSITY

Research Approval Form

Form A

Directions: Please complete this form and submit with the following documents if used: (1) Informed Consent Form, (2) Data Collection Instrument (e.g., questionnaire) or Protocol.

Level I review: Obtain approval and signature from the course professor/student club or association sponsor. Submit Form A with signature to course professor and keep copy for self.

Level II review: Obtain approval and signature(s) from Chair/Dean. Submit copies of Form A with signatures to course professor, Chair/Dean(s), and self.

I. Identification of Project

Principal Investigator: Sherry L. Sexton
Address: PO Box 763, Hixson, TN 37343
Tel. & E-mail: (423) 339-4243 sherry_sexton@chs.net
Co-Investigator(s): None
Address NA
Tel. & E-mail NA

Title of Project: Nursing
Faculty Supervisor (for student investigator): Holly Gadd
Starting Date: July 1, 2002 Estimated Completion Date: March, 2005
External Funding Agency and Identification Number: No funding required
Grant Submission Deadline: NA

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III. Description and Source of Research Subjects (e.g., humans, animals, plants, documents)

Air settle plates will be used to collect airborne microorganism samples within and outside of the construction areas.

No human subjects will be used. All data related to patients or employees will be gathered retrospectively from reports generated by the Employee Health / Infection Control Department of the facility.

If human subjects are involved, please check any of the following that apply:

- _NA_ Minors
- _NA_ Prison inmates
- _NA_ Mentally impaired
- _NA_ Physically disabled
- _NA_ Institutionalized residents
- _NA_ Vulnerable or at-risk groups, e.g., minority, poverty, pregnant women (or fetal tissue), substance abuse populations
- _NA_ Anyone unable to make informed decisions about participation

If any of the above is checked, proposal requires Level III review. **Form B must be completed in addition to Form A.**

IV. Materials, Equipment, or Instruments

For air settle plate evaluation, the following materials will be used: PSA II Blood Agar petri plates, CO2 incubator, lab equipment/instruments

For data collection related to employee illness and surgical post-operative infections, the following materials will be used: Employee Health monthly employee illness reports and Infection Control Surgical Site Infection (SSI) monthly reports.

Statistical analysis will be completed using SPSS.
V.  Methods and Procedure

VI. Sensitivity: *Psychological discomfort or harm experienced by human participants because of topic under investigation, data collection, or data dissemination.*

On a scale of 0 (not sensitive) to 5 (extremely sensitive), rate the degree of sensitivity of the behavior being observed or information sought:

_1_ Sensitivity of behavior to be observed or information sought.

If greater than “1” proposal requires Level III review. Form B must be completed in addition to Form A.

VII. Invasiveness: *Extent to which data collected is in public domain or intrusive of privacy of human participants within context of the study and the culture.*

On a scale of 0 (not sensitive) to 5 (extremely sensitive), rate the degree of invasiveness of the behavior being observed or information sought:

_1_ Sensitivity of behavior to be observed or information sought.

If greater than “1” proposal requires Level III review. Form B must be completed in addition to Form A.

VIII. Risk: *Any potential damage or adverse consequences to researcher, participants, or environment. Includes physical, psychological, mental, social, or spiritual. May be part of protocol or may be a remote possibility.*

*On scale of 0 (no risk) to 5 (extreme risk), rate the following by filling each blank.*

<table>
<thead>
<tr>
<th>Extent of Risk</th>
<th>To Self</th>
<th>To Subjects</th>
<th>To Environment</th>
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<tbody>
<tr>
<td>Physical harm</td>
<td>0</td>
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<td>Psychological harm</td>
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<tr>
<td>Spiritual harm</td>
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If any blank is greater than “1,” proposal requires Level III review. Form B must be completed in addition to Form A.
IX. Benefit-Risk Ratio (Benefits vs. Risks of this Study)

The benefits of this study include a review of infection control management activities of a construction site within an existing hospital facility in which construction/remodeling will progress concurrent with day-to-day hospital activities. Information obtained from this study can be used to maintain or improve current construction management procedures. The risks of this study to researcher and subjects is minimal to nonexistent and therefore does not require extraordinary action to be taken to ensure the safety and well-being of subjects or researcher.

X. Confidentiality/Security Measures

Collection:
Collection of settle plate samples does not require confidential measures beyond those normally taken using current hospital confidentiality procedures. Specimens are secured using current lab procedures to protect lab specimens and lab technicians from contamination during processing.

Collection of data related to employee illness rates and types of illness, and surgical patient post-operative infection rates does not require confidential measures beyond those utilized by the facility to maintain confidentiality and security of data.

Coding:
Air settle plate specimens are coded/identified according to location of collection, date, and time, and do not require security and confidentiality measures beyond those currently used at the facility.

Employee illness records are recorded as numerical values by department and are thus protected from accidental breach of confidentiality.

Surgical patient post-operative data is coded utilizing medical record numbers to eliminate unnecessary or accidental breach of security and confidentiality.

Storage:
Settle plate specimens will be stored in the facility laboratory using NACL approved procedures. Once plates have matured and have been read by the microbiology technician, the plates will be destroyed, again using a NACL approved disposal procedure.

Data related to employee illnesses and surgical patient post-operative infections is maintained in a locked file cabinet maintained by the researcher. The original data is maintained in the facility’s Employee Health and Infection Control Office in secured files.

Analyzing:
All data will be analyzed and interpreted for completeness by the researcher prior to statistical analysis. Statistical analysis will be performed in the Learning Lab of Southern Adventist University Nursing Department. All appropriate measures will be taken to
ensure confidentiality, and no data will be stored on the campus computer; but will instead be down-loaded to a disk and stored securely by the researcher.

Disposing:
All facility-related documentation utilized during this research study will be returned to the facility for their determination of proper disposal or use.

Reporting
Any findings related to employee or patient safety issues will immediately be reported to the facility for their immediate action. The facility requests a final report on the findings of the study and this will be provided to the facility in the form of an oral report and copy of the completed research.

XI. Informed Consent Process

None Potential for coercion, which is considered any pressure placed upon another to comply with demand, especially when the individual is in a superior position. Pressure may take the form of either positive or negative sanctions as perceived by the participants within the context and culture of the study.

None Coercion or Deception involved. If so, explain.
If either checked, proposal requires Level IV Full Review.

XII. Debriefing Process

As this research study only monitors current practice methodology for infection control during construction by evaluating organism migration out of construction areas, construction-related post-operative infections, and construction-related employee illness, no debriefing is required as there are no “subjects” to debrief. The facility will be debriefed as described earlier.

XIII. Dissemination of Findings

As the results of this study may provide opportunity for the facility to improve or expand upon current infection control processes during construction, finding results will be provided to the facility. The findings may also provide guidance for current infection control practices in the area of construction management, so may be presented for publication to infection control-related journals.

Yes Potential for presentation or publication outside of University.
If so, proposal requires Level II Review.

XIV. Compensation to Participants

No compensation will be provided to the facility’s employees or to the surgical patients whose charts will be reviewed for post-operative infections.
By compliance with the policies established by the Institutional Review Board of Southern Adventist University, the principal investigator(s) subscribe to the principles and standards of professional ethics in all research and related activities. The principal investigator(s) agree to the following provisions:

- Prior to instituting any changes in this research project, a written description of the changes will be submitted to the appropriate Level of Review for approval.
- Development of any unexpected risks will be immediately reported to the Institutional Review Board.
- Copies of approval for off-campus sites of data collection will be obtained from the site and submitted in triplicate to the appropriate Level of Review prior to data collection.
- Close collaboration with and supervision by faculty will be maintained by SAU student investigator.

Principal Investigator Signature ___________________ Date __

Co-Principal Investigator(s) Signature ________________ Date ___

As the supervising faculty, I have personally discussed the proposed study with the investigator(s), and I approve the study and will provide close supervision of the project.

Supervising Faculty/Sponsor Signature ___________________ Date ___

(Required by all SAU student investigators)

As Dean/Chair, I have read the proposed study and hereby give my approval.

Chair(s)/Dean(s) Signature ____________________ Date ___

(If Level II approval required)
January 31, 2005

Ms. Sherry Sexton
P. O. Box 763
Hixson, TN 37343

Dear Ms. Sexton:

The Human Participants in Research Subcommittee has approved your research application to study the effectiveness of current infection control processes used during hospital and clinical construction projects. We understand that you will be investigating the occurrence of employee illness and post-operative surgical infections during construction projects, and that this study will conclude April, 2005.

It is our understanding that your dissertation research is being conducted through the School of Nursing, and that you will be collecting airborne microorganisms samples on exposed microbiological media. Data collected from the Employee Health/Infection Control Department will be correlated with those data from your airborne sampling. All information regarding employee and patient data will be kept confidential.

Sincerely yours,

Linda Ann Foster, Ph.D., Chair, Human Participants in Research Subcommittee
Professor, Biology Department
Southern Adventist University
APPENDIX B: Construction Maps
APPENDIX C: Miscellaneous Data and Forms

1. CDC Surgical Site Infection Criteria

3. Plate Data: Presence or Absence of Microbial Growth
   pre-construction, construction, and post-construction

---

Deep Incisional SSI

Infection occurs within 30 days after the operation if an implant is left in place or within 90 days if implant is in place and the infection occurs to be related to the operation.

Infection involves deep soft tissues (e.g., fascial and muscular layers) of the incision, and at least one of the following:

- Purulent drainage from the deep incision but not from the organ/space component of the surgical site
- A deep incision postoperative abscess or incision/space opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (≥100°F), localized pain, or tenderness, induration, or culture-negative
- An abscess or other indication of infection involving the deep incision
- Infection within direct contact, during reoperation, or by histopathologic or microbiologic examination

Diagnosis of a deep incisional SSI by a surgeon or including physician.

Notes:
1. Report infection rates based on intent-to-treat and deep incisional rates or deep incisional SSI
2. Report an organ/space SSI that drains through the incision or a deep incisional SSI
Surgical Site Infection Criteria

Superficial Incisional SSI

Infection occurs within 30 days after the operation and at least one of the following:
- Purulent drainage, with or without laboratory confirmation, from the superficial incision
- Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision
- At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat and superficial incision is deliberately opened by surgeon, unless incision is culture-negative.
- Diagnosis of superficial incisional SSI by the surgeon or attending physician

DO NOT report the following conditions as SSI:
1. Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration)
2. Infection of an episiotomy or newborn circumcision site
3. Infected burn wound
4. Incisional SSI that extends into the fascial and muscle layers (see deep incisional SSI)

Note: Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.

Deep Incisional SSI

Infection occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation AND Infection involves deep soft tissues (e.g., fascial and muscle layers) of the incision and at least one of the following:
- Purulent drainage from the deep incision but not from the organ/space component of the surgical site
- A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38 C), localized pain, or tenderness, unless site is culture-negative.
- An abscess or other indication of infection involving the deep incision is found on direct examination, during re-operation, or by histopathologic or radiologic examination
- Diagnosis of a deep incisional SSI by a surgeon or attending physician

Notes:
1. Report infection that involves both superficial and deep incisional sites as deep incisional SSI
2. Report an organ/space SSI that drains through the incision as a deep incisional SSI

Guideline for Prevention of Surgical Site Infection: 1999 Centers for Disease Control and Epidemiology
**Organ / Space SSI**

Infection occurs within 30 days after the operation if no implant is left in place, or within 1 year if implant is in place, and the infection appears to be related to the operation and

Infection involves any part of the anatomy (e.g., organs, spaces) other than the incision, which was opened or manipulated during an operation and at least one of the following:

- Purulent drainage from a drain that is placed through a stab wound into the organ/space.
- Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space.
- An abscess or other evidence of infection involving the organ/space that is found on direct examination, during re-operation, or by histopathologic or radiologic examination.
- Diagnosis of an organ/space SSI by a surgeon or attending physician.

### Site specific Classification of Organ / Space SSI

- Arterial or venous infection
- Breast abscess or mastitis
- Disc space
- Ear, mastoid
- Endocarditis
- Endometritis
- Eye, other than conjunctivitis
- Gastrointestinal tract
- Intra-abdominal, not specified elsewhere
- Intracranial, brain abscess or dura
- Joint or bursa
- Mediastinitis
- Meningitis or ventriculitis
- Myocarditis or pericarditis
- Oral cavity (mouth, tongue, or gums)
- Osteomyelitis
- Other infections of the lower respiratory tract (e.g., abscess or empyema)
- Other male or female reproductive tract
- Sinusitis
- Spinal abscess without meningitis
- Upper respiratory tract
- Vaginal cuff

1 Guideline for Prevention of Surgical Site Infection, 1999, Center for Disease Control and Epidemiology
## Employee Infection Tracking Log

<table>
<thead>
<tr>
<th>Date Of Onset</th>
<th>Employee ID</th>
<th>Urinary Tract</th>
<th>Resp Tract</th>
<th>Wound Site</th>
<th>Skin Lesions</th>
<th>GI</th>
<th>Oral</th>
<th>Blood</th>
<th>Other</th>
<th>Cult</th>
<th>X-rays</th>
<th>Meds</th>
<th>Resolved</th>
<th>Hospitalized</th>
<th>Work Hours Lost</th>
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APPENDIX D: Photographs of Gravity Settle Plates

Gravity Settle Plates from the Construction Area During Heavy Demolition.

July 22, 20XX.
Picture 1.

Gravity Settle Plates from the Construction Area During Heavy Demolition.

July 22, 2002.
Picture 2.

Gravity Settle Plates from the Construction Area During Heavy Demolition.

July 22, 2002.
Picture 3.
Gravity Settle Plates from the Construction Area During Heavy Demolition.
July 22, 2002.