

Detecting potential pathogens on hospital surfaces:

An assessment of carpet tile flooring in the hospital patient environment

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Do modular flooring seams maintain integrity against moisture and microbial contamination?

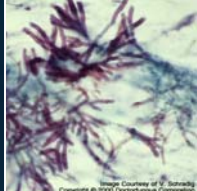


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Aspergillus

- Healthcare facilities “electing to use carpeting for high-activity patient care areas may choose carpet tiles in areas at high risk for spills.”
- “In the event of contamination with blood or other organic substances, carpet tiles can be removed, discarded, and replaced.”

The Center for Disease Control and Prevention (Sehulster et al., 2003)



<http://www.interfacefloor.com/Default.aspx?Section=2&Sub=5>



CARPET TILE BACKING SUBFLOOR


Thermal Comfort Standards

- Ambient Temperature** for occupied spaces is 68°F - 75°F w/ acceptable RH of 65% or less
- Allowable range of **Floor Temperature** is 66.2°F - 84.2°F
- Relative Humidity** – no established lower limits for thermal comfort in healthcare facilities
 - Limits on the acceptability of very low humidity environments
 - Dry skin
 - Irritation of mucus membranes
 - Dryness of the eyes
 - Static electricity generation


(ASHRAE, 2004)

Product (independent variable)

- Square modular tiles with a non-permeable backing consisting of:
 - thermoplastic vinyl composite material
 - reinforced with fiberglass
 - treated with
 - soil and stain protection
 - proprietary antimicrobial treatment, and
 - had a post-industrial recycled content of 39%



- Primary modular tile
 - Tufted textured loop nylon type 6, 6
 - 71% solution-dyed and 20% yarn-dyed
 - 23 oz/yd² tufted yarn weight
 - 7886 pile density
- Secondary (border) modular tile
 - 100% solution dyed tufted tip-sheared nylon type 6, 6
 - 24 oz/yd² tufted yarn weight
 - 6545 pile density



Site Environmental Conditions Data Collection

- Ambient air temperature
- Relative humidity
- Surface temperatures
 - Flooring
 - Subfloor
- Reference for moisture content (Scale 0-100)
 - Carpet tile flooring
 - Subfloor

Sample Site




- A Midwest community hospital
- Medical patient unit corridor
- 5-month period
- Randomized samples
- Collected every 4 weeks from January 2006 through May 2006
- Corridor floor cleaned using hot water extraction method 48 hours prior to the final sample collection period

Sample Collection – Mold and Moisture

- Tape lift method (Khan & Wilson, 2003)
- Three samples from each of the 6 modular flooring sample sites for both participating laboratories
 - Surface
 - Profile
 - Backing
- Control locations including
 - Nursing station sheet vinyl
 - Modular flooring tiles in front of the elevator
 - Existing non-tile carpet on similar unit

Data Analysis

- Double Blind Study
- Non-cultured analysis to screen for active fungi colonization within the setting
- Lactophenol Cotton Blue Stain
- Sample area scanned using standard light microscopy
 - 100X for suspect structures
 - 400X for fungi identification based on morphology




Aspergillus Fumigatus



Environmental Context

- 74 °F mean ambient air temperature
- 26% mean relative humidity
- 73 °F mean floor finish material surface temperature
- 73 °F mean surface temperature of the sub-floor



Ambient air temperature and relative humidity **did not** contribute to an environment conducive to the growth of fungi and other biological contaminants

- Floor finish material consistently had a lower (drier) reference number for **moisture level** than the sub-floor
 - 13.0 mean floor finish material moisture level
 - 20.0 sub-floor reference
 - Between visits 4 and 5 when the floor was cleaned with hot water extraction, there was *no change* in the moisture at the subfloor




Modular Flooring

- Showed no elevated numbers of spore contaminants or fungal colonization in comparison to the non-tiled carpet and resilient flooring control samples
- Performed comparably to the control flooring materials
- No fungal colonization was observed in the modular flooring tile samples or the controls

New Road

Mold and Moisture

- Hospital's operating environment
 - Ideal for **patient safety** in terms of microbial contamination
 - Not ideal for **biological studies**
- Modular flooring seam integrity intact – no moisture penetration
- Microbial contaminants did not travel from the surface to back of carpet tile



Bacteria ... and the Patient Environment

Hospital Acquired Infections

- 120+ studies linking hospital environment to infection (Ulrich & Zimring, 2004)
 - studies focused on sources of airborne infections
 - Natural and forced ventilation
 - Use of HEPA filters
 - Vehicles of transmission
 - Strategies surrounding hand washing policies and practices

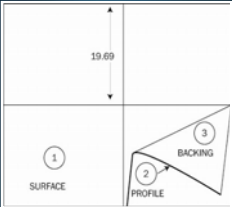
- Nosocomial infections
 - Up to 2 million U.S. hospital patients infected during hospital stays every year
 - Contributed to more than 98,000 documented deaths in 2002 (Klevens, Edwards, Richards, Horan, Gaines, Pollock & Cardo, 2007)
- Pathogens linked to contaminated surfaces in hospital environments
 - *Clostridium difficile* (*C. difficile*)
 - Methicillin-resistant *Staphylococcus aureus* (MRSA)
 - Vancomycin-resistant Enterococci (VRE)
 - *Aspergillus fumigatus*

- *C. difficile*
 - Organisms survive up to 5 months on hospital floors
 - Correlation between environmental contamination and healthcare worker hand contamination
 - One of the most prevalent clostridial infections in hospitals
- MRSA
 - Ability to survive on environmental surfaces for up to 9 weeks after drying
 - Found on carpet, plastic laminate and other common materials typical in hospital environments
 - Transferred from the environment to healthcare workers
- VRE
 - Epidemiological link between patient acquisition of VRE and environmental contamination of their immediate surroundings
- *Aspergillus fumigatus*
 - the most threatening aerial *fungus* pathogen, especially in those patients undergoing immunosuppressive therapies.

Sample Collection & Analysis - Bacterial

- Surface swab samples (Khan & Wilson, 2003)
 - collected every 4 weeks from January 2006 through May 2006
- Maintenance for cleaning as scheduled
- Hot water extraction cleaning 48 hours prior to the final sample collection

- 270 samples collected
 - Surface
 - Profile
 - Backing
- DNA Analysis
 - Identification of pathogens at the genus and species level




Findings

- Within a single visit revealed high variability among tiles even in adjacent locations
- Impact of time on community composition showed dramatic differences
- Surface and profile samples exhibited an increase in the number of major components with time
- Samples removed from the backing of the carpet showed less bacterial diversity and a reduction in DNA recovery over time

- Each modular flooring location dominated by different bacterial genera
- Crossover at the Profile
 - Profile - 19 identified genera
 - Surface - 13 identified genera
 - Backing - 8 identified genera

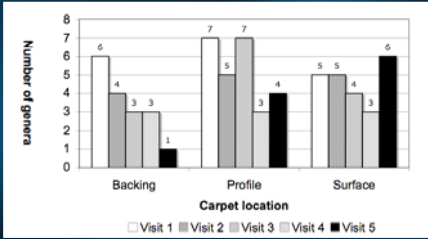
- Control surfaces did **NOT** show any trend in bacterial genera diversity over time
 - Non-tiled carpet exhibited 12 genera
 - Resilient floor surface exhibited 7 genera
 - Elevator vestibule modular flooring tile exhibited 10 genera
 - Surface of the modular flooring tile exhibited 13 genera



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Bacteria Identification

- Modular flooring **surface** showed the same number or fewer identified genera as the profile
- Carpet backing exhibited less diversity with each visit




Carpet location	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Backing	6	4	3	3	1
Profile	7	5	7	3	4
Surface	5	5	4	3	5


Findings: other hospital surfaces

- Aims
 - To assess sources of pathogens
 - To determine the potential for mobile sources to spread bacterial contaminants

- Other surfaces swabbed during Visit 3 (March) and visit 4 (April)
 - Nurse's shoe sole
 - Elevator floor
 - Wheels of a patient bed
 - Medical monitor
 - Laundry cart



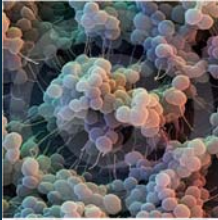
- **Control flooring (resilient)** exhibited a greater potential for harboring pathogens than the modular flooring tile
- Surfaces with highest number of components
 - Elevator floor
 - Wheel of the medical monitor



- Dominance of only 1 organism on other mobile surfaces
 - Sole of nurse's shoe
 - *Pseudomonas syringae*, a plant pathogen
 - Patient bed wheel
 - Two species of *Stenotrophomonas*, plant pathogen
 - Laundry cart wheel
 - *Psychrobacter* - gram negative aerobic bacterial associated with meat, fish and poultry


Clinical Relevance

- Bacteria found on the modular flooring were not closely related to known bacterial pathogens
- Resilient Floor Control observed strains
 - *Bacillus subtilis*
 - *Acinetobacter*
 - *Rhodococcus*
 - *Streptomyces*




So what?

- Hospital surfaces may act as **vectors** of disease
 - the presence of unique species on:
 - nurse's shoe sole
 - elevator floor
 - wheels of a patient bed
 - medical monitor
 - a laundry cart
- Routine, in-hospital cleaning of **shoes and medical equipment** may reduce the spread of potential pathogens to other hospital surfaces
- High abundance of saprolithic bacteria in the modular flooring may suggest the:
 - presence of a high content of organic material
 - need for further cleaning



- Preventive cleaning may reduce nosocomial infection rates
 - **Spot cleaning** - considerably reduced the number of organisms present in the carpet
 - After four weeks, the bacterial community increased greatly
 - Rapid re-contamination may occur in this very heavily traveled carpet corridor (Mitchell, 2006)
- More rigorous **cleaning practices** may be required in different seasons of the year



Comparing diversity and composition of different flooring types revealed:

- Non-tiled carpet was not significantly different from the modular flooring
- Vinyl flooring showed the lowest diversity but showed the greatest potential for harboring known pathogens

Future Studies

Recommendation for further studies:

- Assess external sources of variation, such as the effect of cleaning practices
- Primary sources and vectors of pathogenic bacteria
- Any study of the sources and sinks of bacteria should include mobile components of a hospital setting - staff, carts, and equipment
- Additional study should include a rigorous statistical sampling and analysis to reduce modular flooring variability

QUESTIONS?

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