

Flooring in Patient Units: Testing Carpet Tile Seam Integrity for the Impediment of Microbial Contamination and Moisture to the Backing and Subfloor

Statement of Purpose

The purpose of this study was to test the viability of carpet tile in an acute healthcare setting by measuring the level of microbial penetration at the seams. The Center for Disease Control and Prevention (Sehulster et al., 2003) states that 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.” Carpet tiles offer a solution to flooring choices in healthcare facilities that may have positive impacts on life cycle costs, maintenance and repair, and indoor environmental quality.

The risk of moisture penetration and microbial contamination to the backside of any flooring finish material and the sub-floor increases the demand for material choices with high performance in the constructed product, including the profile (seam) and the impermeable backing. The assumption is that if carpet tiles do not have heat-welded seams, like rolled carpet, then there is an opportunity for the carpet tile seam to allow moisture and contaminants through to the back of the tile. The hypothesis for this study is that carpet tile seams have the integrity to prevent moisture and contaminants from traveling from the surface of the tile to the back of the tile. The objective of this study is to evaluate the integrity of the carpet tile seam by measuring the levels of selected contaminants of the surface, profile and backing of the carpet tile in a patient unit corridor located in an acute care facility.

Context

Well-being and productivity are affected by the quality of the indoor environment (Samet & Spengler, 2003). The relationship between environment and health is of growing interest by healthcare providers and design professionals. While design professionals endeavor to provide patient care environments that support the psychological, physiological and behavioral connections and their impact on healing and health, there is an increased need to balance the aesthetic and comfort with the identification of environmental elements that compromise healthcare environments (Harris, 2000). Samet & Spengler (2003) make a case for a greater emphasis on prevention in regard to how the indoor environment impacts occupants, suggesting that a holistic approach to design and maintenance of the indoor environment may provide health benefits as opposed to merely sustaining the status of the health of the environment and its occupants.

This study contributes to the knowledge of interior design, specifically within the specialty of healthcare design and the potential impact on users – patients, families, and healthcare staff. Interior designers benefit from this and other related research by using the evidence in making decisions about flooring material specifications in patient environments, generally a topic of interest to practitioners within this specialty design area.

Review of Literature

ASHRAE 55-2004 states that the operative temperature for occupied spaces is 68 °F-75 °F (20-23.9°C) based on the acceptable relative humidity of 65% or less for thermal comfort. There are no established lower humidity limits for thermal comfort, though non-thermal comfort factors, such as dry skin, irritation of mucus membranes, dryness of the eyes, and static electricity generation may place limits on the acceptability of very low humidity environments

(ASRAE, 2004). Thermal comfort relies on the concept of thermal neutrality for the human body. The allowable range of floor temperature is 66.2 °F-84.2 °F (19-29°C), though this is based on floor surface, not material of the floor covering, and based on people wearing lightweight indoor shoes (ASRAE, 2004).

The indoor environment is a host to a wide range of microorganisms, including bacteria, mucobacteria, and molds, as well as endotoxins and mycotoxins produced by existing microorganisms (Kuhn & Ghannoum, 2003). Valid concerns exist regarding human disease and indoor air, mold exposure and mycotoxins, particularly human associations with ergotism (*Claviceps* species), alimentary toxic aleukia (*Fusarium*), and liver disease (*Aspergillus*) (Kuhn & Ghannoum, 2003). Indoor mold and other microbial growth are variable; just because it is discovered in a building does not mean the occupants have been exposed (Chapman, Terr, Jacobs, Charlesworth & Bardana, 2003). Furthermore, hospital patients that are most severely immunocompromised need to be concerned about the potential for opportunistic fungal infection, and the only recommendation is to avoid recognizable fungal reservoirs including, but not limited to, indoor environments where there is uncontrolled mold growth (ACOEM, 2003).

Methodology

The product chosen for this study was tufted textured loop nylon type 6,6 square modular tiles (19.69 in) with a non-permeable backing consisting of thermoplastic vinyl composite material reinforced with fiberglass and treated with a soil and stain protection, a proprietary antimicrobial preservative permanently incorporated into the backing with a post-industrial recycled content of 39%.

Sample collection

The study was conducted in a community hospital in the Midwest on a medical patient unit corridor over a 5-month period. Randomized samples were collected every 4 weeks from January 2006 through May 2006 (See Figure 1). Forty-eight hours prior to the final sample collection period, the corridor floor was cleaned using the hot water extraction method.

The environmental conditions sampled consisted of ambient air temperature and relative humidity, surface temperatures of flooring and subfloor, and a reference for moisture content for flooring and subfloor.

Surface samples were collected using the tape lift method (Khan & Wilson, 2003). Three samples were procured from each of the 6 sample sites (surface, profile and backing) for both participating laboratories. In addition, samples were collected from the control locations including 2 from the nursing station sheet vinyl, 2 from carpet tiles installed in front of the elevator, and 2 samples from existing rolled carpet on a similar patient unit floor.

Data analysis

Descriptive statistics showed the environmental measures for the duration of the study and compared to industry standards for hospital patient environments.

The microscopy analysis of surface samples required a non-cultured analysis to screen for active fungi colonization within the setting. Lactophenol Cotton Blue Stain (Fisher Scientific, Hampton, NH, USA) was used to enhance visual examination of fungal structures and enumeration of spores. Using standard light microscopy, the sample area was scanned at 100X for suspect structures and 400X for fungi identification based on morphology.

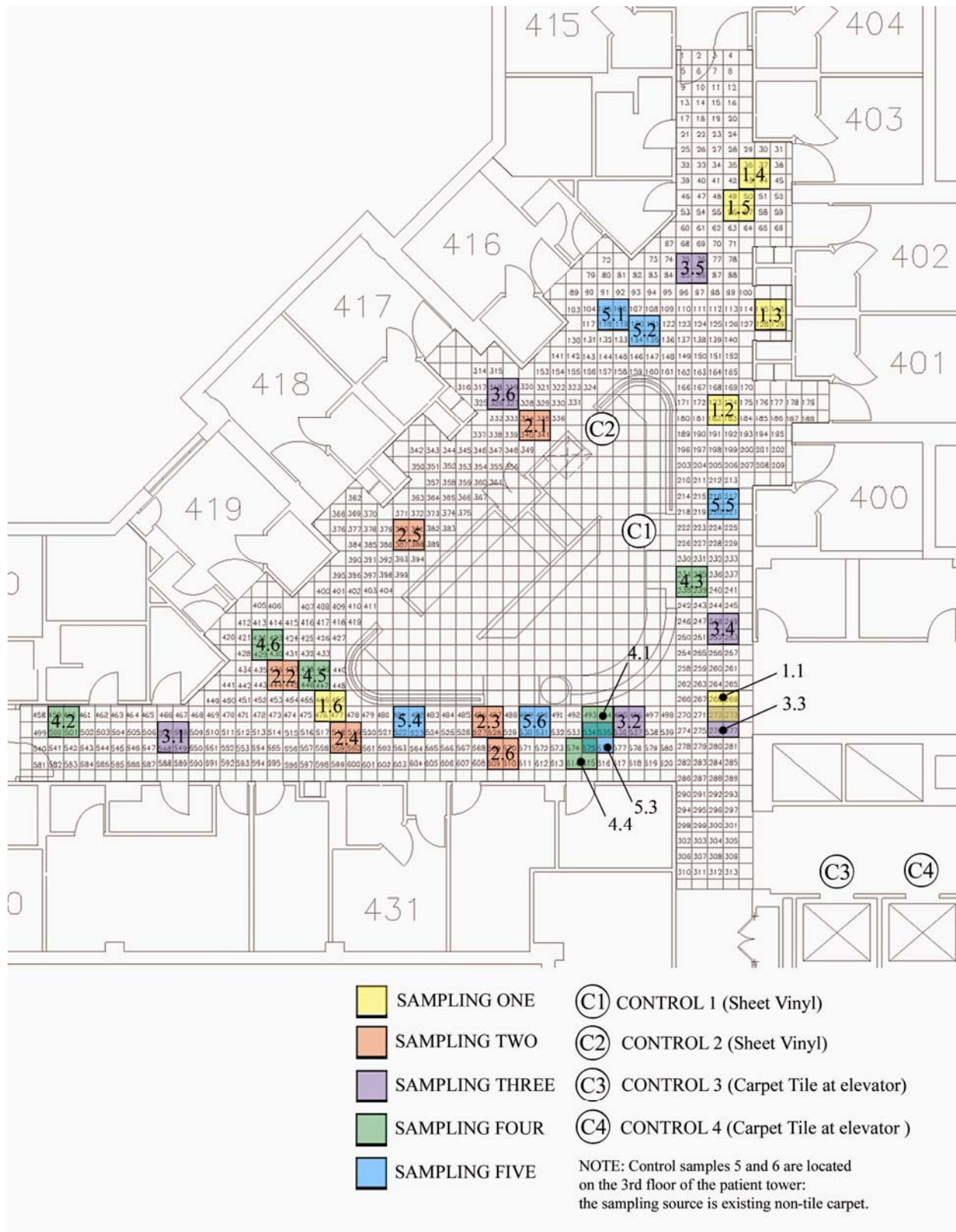


Figure 1. Map of the locations on medical unit floor sampled over the January-May 2006 period.

Results

Environmental Context

The mean ambient air temperature at the sample sites was 73.4 °F; the mean relative humidity was 26.5%; and the mean floor finish material surface temperature was 72.7 °F while the sub-floor had similar results. The mean surface temperature of the sub-floor was 72.7 °F. The floor finish material consistently had a lower (drier) reference number for moisture level than the sub-floor. The mean floor finish material moisture level was 13.1 while the sub-floor reference for moisture level was 19.9. The moisture levels recorded between visits 4 and 5, when a hot water extraction method cleaning was performed 48 hours prior to data collection visit 5, did not show a significant change. Consistency in the moisture levels of the sub-floor suggests that the integrity of the seam prevents moisture from traveling from the surface to the back of the carpet tile.

Microbial Contamination

The difference in spore counts in adjacent locations within a single visit can be assessed by comparing results from samples 1.4 and 1.5, 2.3 and 2.6, 4.1 and 4.4, and 5.1 and 5.2, each pair located in adjacent 4-tile blocks, as shown in Figure 1. In no case do the results show that any one location on the adjacent pairs of 4-tiled sampling regions is more or less populated by spores than the other. Also, no trends in specific genera in a specific location were observed.

A comparison of counts from sampling locations 1.1 and 3.3 and 4.1 and 5.3 may provide an indication of the impacts of time, as these sampling sites overlap (Figure 1). Both laboratories reported an increase in the spore counts in the surface and profile with time. Regardless of the visit number, no major difference in scores between the samples removed from the carpet tile floors and those removed from the controls were observed.

Discussion

The mean ambient air temperature was within the range for thermal comfort based on acceptable relative humidity of 65% or less according to ASHRAE 55-2004. Since there are no established lower relative humidity limits for thermal comfort, the mean of 26.5% RH meets the criteria for thermal comfort as defined by ASHRAE 55-2004. However, low relative humidity levels of less than 30% may impact comfort for the occupant, not in terms of thermal neutrality, but cause dryness of skin, eyes, and nasal passages. The ambient air temperature and relative humidity in this patient unit did not contribute to an environment conducive to the growth of fungi and other biological contaminants.

No colonization of any of the “most relevant” pathogenic fungi was detected, and, even with the genera observed, no considerable vegetative growth was evident. While *Aspergillus/Penicillium*, *Cladosporium*, *Alternaria*, *Stachybotrys*, *Fusarium*, and *Curvularia* species were reported to be present in the selected samples from all visits delivered to laboratory 2, only *Aspergillus/Penicillium*, *Aspergillus*, *Penicillium*, and *Chaetomium* species were reported by laboratory 1 in the visit 1, 3, and 4 samples.

Interestingly, laboratory 2 reported the largest diversity of genera in a single sample in visit 2’s control taken from the resilient flooring location in the nurse’s station (Figure 1, control circle C1). Two unidentified fungi and one readily identified species in the *Fusarium* genus were observed in this control sample. Other single samples in which multiple genera were observed included two other control samples, visit 1’s resilient floor control (with species of *Curvularia* and *Fusarium*) and visit 2’s non-tiled carpet location (with two species of *Cladosporium*).

In comparison to the non-tiled carpet and resilient flooring control samples, the carpet tiles showed no elevated numbers of spore contaminants or fungal colonization and, in this study,

performed comparably to the alternative flooring materials. While no fungal colonization was observed in the carpet tile samples, it was also not observed in the controls.

In summary, the hospital's operating environment was ideal for patient safety but not so for biological studies. The results suggest that the integrity of the carpet seam is intact, preventing moisture from traveling to the back side of the tile and subfloor, and, while not proving the hypothesis, did not conclude that microbial contaminants travel from the surface to back of carpet tile. It is recommended that future studies consider mimicking conditions conducive for fungal colonization in order to better assess carpet tile seam integrity.

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