Stretching the Boundaries of Healthcare Ceilings

The Potential of Stretched Fabric Ceilings in the Healthcare Environment

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Executive Summary

Through ethnographic research, ceiling systems in the healthcare setting have been identified as an opportunity to affect positive change in the hospital environment. Beyond advancements in lighting technology and ceiling-based distribution systems, little has changed in the function and aesthetics of hospital ceiling systems in the last several decades. Our findings suggest the potential for vastly different approaches to ceiling design that are capable of redefining the patient experience, improving patient comfort and satisfaction levels, as well as enabling flexibility and functionality when compared to conventional ceiling systems.

Our recommendations include: 1) Installation of stretched-fabric ceilings backlit with LED technology, 2) Enhancement of user control in patient rooms, 3) Implementation of positive distraction techniques and improvements in wayfinding through various additions to the stretched-fabric system including projection, and contoured surfaces.

These recommendations address harsh and inappropriate downlighting, poor acoustics, lack of positive distractions, lack of user control, and confusing wayfinding. In addressing these patient considerations, other stakeholders stand to benefit from enhanced wayfinding for all users, more easily accessible ceiling-based systems, and more sanitary building spaces. Also, significant cost savings are possible with the longer product life spans and lower energy consumption associated with stretched-fabric ceilings and LED lighting technology.

Introduction

While the importance of quantitative data in evidence-based design should not be understated, the lack of available data can often be a limiting factor in ceiling design. Thus this study focuses primarily on ethnographic data in a search for the most valuable and useful information.

Working in conjunction with George Simons, Jr., a private consultant hired by the Kaiser Permanente health system to rebrand and redesign their interior spaces, this report represents the further exploration of novel and innovative solutions to environmental issues identified during the ethnographic research conducted by Simons over a period of 10 months spanning from September 2007 to June 2008. This work has been conducted independently of Simons research by two Cornell University undergraduate students in Prof. Frank Becker's Design and Environmental Analysis 4530 - Facilities Planning and Management in the Workplace.

Understanding that a positive patient experience is the cornerstone of most successful healthcare organizations, the sequence of events during a hospital stay was analyzed. Our findings suggest that patients spend a significant portion of their time oriented with their head toward the ceiling surface. After a three-week review of potential alternatives, this report seeks to critique the current lack of thoughtful design in healthcare ceiling structures and to provide novel alternatives which stand to benefit all end users of the space, inclusive of the patient.

Narrative

In order to more effectively explore and understand the patient experience in a conventional hospital setting, a hypothetical scenario was developed in which a patient, Tony Perkiss, navigates several stages of an emergency visit to the hospital. Comfort and quality issues experienced during Tony's visit are identified in the margin.

Tony Perkiss is a rambunctious seventeen-year old and captain of his high school varsity badminton team. During a heated semi-final match, Tony quickly changes direction in order to return a spiked shuttlecock. As he turns, a loud "*SNAP*" accompanies an acute pain in his right knee. Tony falls to the ground and the school trainer comes to his aid, immediately calling an ambulance. Tony is carried off the court screaming in agony and is forced to wait, sitting upright, until the ambulance arrives. When the ambulance arrives Tony is placed on a stretcher and quickly transported to the hospital.

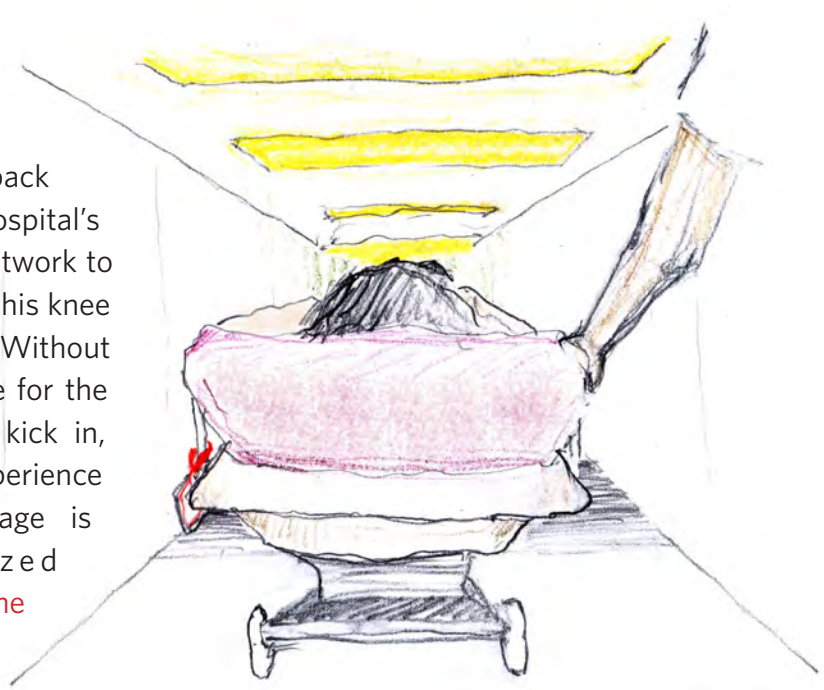
ISSUE 1
Acoustical Comfort

ISSUE 2
Lighting

ISSUE 3
Lack of Positive Distractions

Thirty minutes later Tony is brought through the emergency room entrance and immediately confronted by bright white lights and the sterile hospital environment he knows all too well. He is wheeled through a series of passages into to the receiving area. This area is characterized by excessive noise and human traffic. Tony feels disoriented by the many people rushing by and the harsh acoustics of the space. Here, the EMS hands his care over to a nurse, assuring him that he will be taken care of shortly, and he is wheeled through several more hallways toward an examination room. To cope with the pain Tony tries to close his eyes, but as he moves down the hallway the throbbing pain in his leg starts to sync up with the rhythm created by each successive overhead light, and the pain becomes almost unbearable. Unable to stay quiet, Tony groans and grimaces, eliciting looks from others he passes in the hallway.

Once in the exam room Tony's comfort does not improve. The room is sterile, devoid of distractions, and slightly too cold for comfort. Without anything to take his mind off the pain, it continues to mount, and Tony develops heightened sensitivities for temperature, light, and noise. After what seems like the longest twenty minutes of his life, a welcome tap on the door is followed by Dr. Ficksenstein's entrance into the room. The doctor is brief and conducts a short examination of Tony. He offers him painkillers



to reduce the excruciating pain and sends him back out into the hospital's circulation network to get an MRI of his knee in Imaging. Without sufficient time for the painkillers to kick in, Tony's experience of this passage is characterized by the same discomforts in previous journeys through the hospital hallways, although now while he has somewhat adjusted to the pain in his leg, a headache sets in and his heightened sensitivities couple with the headache to put him in a barely conscious state. His discomfort and delirium increase as he loses any sense of location and direction through the visually undifferentiated and labyrinthine hallways.

ISSUE 3
Lack of Positive Distractions

ISSUE 3
Poor Wayfinding

Upon arrival at the Imaging lab, Tony discovers he is fourth in line for the machine. No longer requiring assistance moving through the halls, Tony's patient transporter situates him out of the way of traffic and responds to another patient call. He has left Tony almost directly underneath an overhead downlight, and with no control over the position of his stretcher, he has no choice but to look into the light when lying down. While he waits, he hears doctors and nurses discussing other patients' situations from down the hall and thinks he might have heard his own name. Once his name is finally called, a nurse assists in wheeling him into the MRI room.

ISSUE 3
Limited User Control

ISSUE 3
Acoustical Privacy

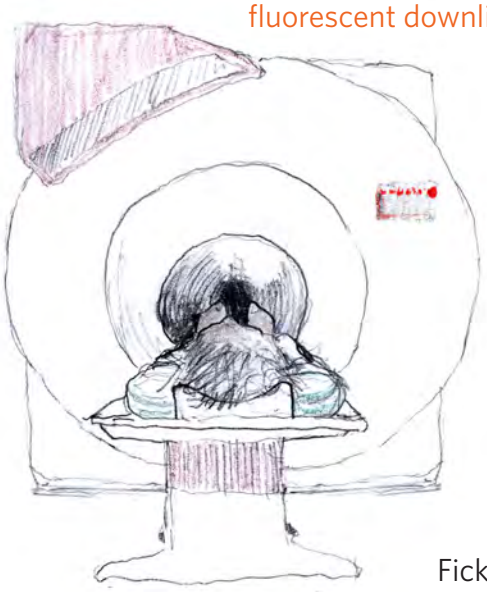
The room has no windows and is painted entirely white. The nurse instructs him to lie still while he is drawn into the MRI machine, but Tony finds this extremely difficult because the headrest is uncomfortably stiff and there is nothing to focus on above him on the bare ceiling tiles and interspersed light boxes. He tries to keep his eyes focused on the joint between two of the ceiling tiles, yet even at an obscured angle, the bright

ISSUE 3
Lack of Positive Distractions

ISSUE 2
Lighting

ISSUE 3
Poor Wayfinding

fluorescent downlighting still hurts his eyes.



After 15 minutes of buzzing, painful stillness, and awkward repositioning, Tony is redirected back into the hospitals circuitous hallways and wheeled into another examination room. His mother is waiting for him in this final exam room. She rushed to the hospital from work, but got caught in traffic and was unable to accompany Tony through his stay at the hospital. Shortly thereafter Dr. Ficksenstein the MRI shows Tony has a torn ACL that will require surgery. A nurse then arrives and tells him he can go home and should be back in the next few days after the swelling has subsided for arthroscopic surgery to fix his torn ACL. She gives him a brace and set of crutches, puts him in a wheelchair and sends him and Mrs. Perkiss to Appointments to set a time for Tony's surgery.

ISSUE 3
Poor Wayfinding

As Tony and his mom attempt to make their way to Appointments, without the aid of a patient transporter, they get lost in the complex hospital network turning down hallway after hallway, each looking identical to one another. After what would turn out to be a 15 minute detour, Tony's mom gets fed up and asks for directions. She is directed back to a central corridor and finally they are able to find the Appointments desk. From here, they book an appointment and are able to finally make their way out of the hospital. By this time, it is dark outside, and Tony and his mother exit through the nearby entrance door to head home after what turned out to be one of Tony Perkiss's longest days of the season.

Identified Issues

Through the analysis of a user's healthcare visit, and the needs of various healthcare environment stakeholders, a number of key issues were identified with the potential for improvement through innovations in ceiling construction. The issues have been broken down into six primary categories: 1) Lighting 2) Acoustical Privacy & Comfort 3) Maintenance & Access 4) Lack of Positive Distraction and Entertainment 4) Poor Wayfinding 6) Limited User Control

LIGHTING

While most hospitals are well lit in terms of luminance, lighting is often accomplished through the most cost-effective solutions. As such, use of fluorescent tube downlighting boxes is ubiquitous in healthcare spaces (*see above narrative illustrations & Fig. 1a, b*). These light boxes are highly efficient and provide bright light, however they offer inconsistent lighting levels, provide harsh and non-adjustable lighting levels and cannot accommodate situational requirements such as colored light. Placement of light boxes is often directly in line of sight for seated or lying patients moving through the hospital in wheelchairs or stretchers, and aesthetically, fluorescent tube lighting leaves significant room for improvement. For Tony, downlighting worsened his headaches, created unnecessary stress during his waits, and made numerous situations where his head was pointed upward practically intolerable.

FIGURE 1A, B Images showing traditional fluorescent light boxes. *(Source: Simons 2009)*

ACOUSTICAL COMFORT

In healthcare settings, the need for sterility and durability has resulted in the use of hard surfaces on most walls and floors. While acoustical ceiling tiles are often installed, they do not often provide enough dampening the spaces with hard floors and walls. This, in turn, has led to poor acoustical dampening in hospitals with surfaces that readily reflect sound, resulting in noisy environments. Noise can lead to increased stress levels and anxiety in patients (Joseph 2008). In Tony's experience, sound reflectivity also resulted in a HIPAA violation when he overheard doctors and nurses discussing the health of other patients. All of this served to exacerbate his pain due to his heightened sensitivity to sound. An improved acoustic experience is desirable for patients with heightened sound sensitivity and stress levels, family members in waiting rooms, and allied health professionals discussing confidential patient information.

MAINTENANCE & ACCESS

As technology rapidly advances, the need to upgrade information and electrical infrastructure becomes increasingly pressing. Advancements continue to occur in shorter and shorter product cycles, and thus more frequent renovations and alterations to existing buildings are required to keep healthcare on the cutting edge. Easily removable and accessible systems are needed to keep construction and renovation costs low and the ease of upgrading high.

LACK OF POSITIVE DISTRACTION AND ENTERTAINMENT

One of the largest problems with conventional hospital settings is the lack of distractions available for those suffering from pain, boredom or stress. Sterility is often accompanied with blank monochromatic walls, ceilings and floors. This is especially true with ceiling structures that provide nothing for patients in wheelchairs and stretchers to look at as they pass through the various spaces in a hospital. Tony, despite desiring some sort of distraction from his pain, found none on the ceiling surfaces that ultimately exacerbated his discomfort with overly bright lighting. The addition of some form of visual stimulus into the ceiling plane stands to greatly improve the patient experience.

POOR WAYFINDING

As a generally overlooked aspect of design, ceiling surfaces often receive a single treatment throughout an entire facility. This results in numerous spaces with similar appearances and no differentiating qualities. Without differentiation, users quickly become disoriented and have difficulty with wayfinding. In Tony's experience, him and his mother were unable to tell the difference between various labyrinthine hallways and ended up lost in the hospital after a long and stressful day.

LIMITED USER CONTROL

The ability of a user to have control over their environmental conditions is essential for providing the highest level of patient satisfaction. With current fluorescent tube lighting solutions, quality and amount of light are uncontrollable for users offering only two options: on and off. Additionally, lighting is unable to dynamically respond to occupant needs and conditions, and results in creating discomfort for patients who require reduced or elevated lighting levels.

Recommendations

The current state of standard hospital ceilings demonstrate design neglect. Many opportunities for improvement exist, and are addressed in the prescriptive recommendations that follow. These recommendations address each of the issues outlined previously (see Issues, *page 8). Our primary recommendation is to use of stretched-fabric ceilings. Use of stretched-fabric opens creates further possibilities to improve the healthcare environment due to the flexibility and versatility associated with this construction technique.*

STRETCHED-FABRIC CEILINGS

Stretched-fabric ceilings should be used to create visually attractive, seamless overhead surfaces. Stretch ceiling systems are easy to install even without a trained professional. The system is simple: its consists of fiberglass fabric, a tensioning track, and a thin layer of acoustical padding if necessary. Stretch-ceilings outlive conventional products by several product life spans, saving a significant amount of money over several years.

Lighting

To respond to the need for better lighting solutions that can be viewed directly without discomfort, light should be projected through the ceiling to provide diffuse and consistent light levels (Jones 1998). It is also important for the lighting to respond to different needs for different spaces. Projection through stretched-fabric offers a flexible solution to these different needs, such as brighter and white or off-white light in circulation spaces compared to the need for less intense, warmer light in patient rooms (Malenbaum 2008).

Innovations:
-Dimmable LED's
-Energy Efficient
-Easier to fit between stretch fabric and acoustical backing

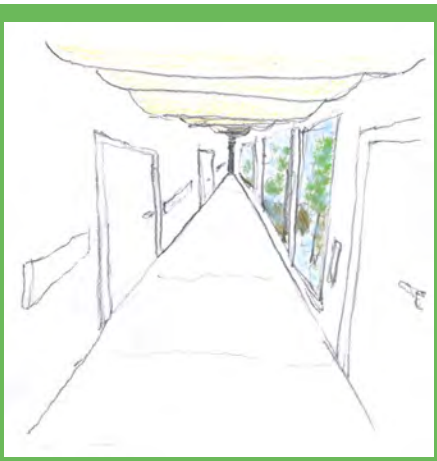


FIGURE 2 Illustration indicating potential for LED backlighting behind stretched-fabric ceiling.

Acoustical Comfort

Stretched-fabric ceilings can also help to address issues of poor acoustics in interior spaces. Utilization of soft surfaced ceiling coverings dampens sound reflectance and reduces noise levels. This reduction in noise can lead to lower stress levels in patients, improved confidentiality and compliance with HIPAA regulations, and fosters an improved patient experience.

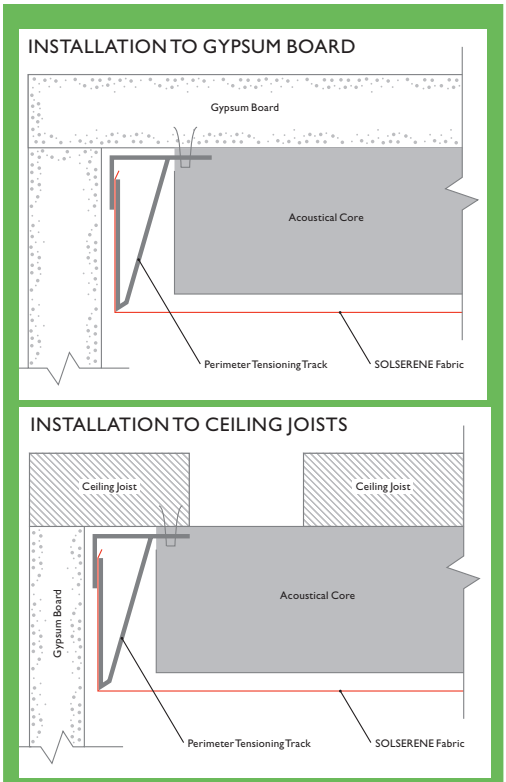


FIGURE 3A, B Sections indicating ease of installation in existing and new construction. *(Source: Quietzone 2004)*

Maintenance & Access

Stretch-fabric ceilings have the potential to both enhance the sanitary conditions of hospital spaces and enable easier and more complete access to ceiling spaces and equipment. Fiberglass cloth is a good option for stretch-ceilings because it is durable, easy to remove and clean, and has antimicrobial and anti fungal properties (Glass 2009). With a ceiling surface that can be completely removed, maintenance and cleaning crews will be allowed far greater access to the ceiling space than with the traditional ceiling tile arrangement.

ADDITIONS TO THE STRETCH-FABRIC SYSTEM

Positive Distraction:

Several different design strategies can be used to help reduce stress levels and provide distraction from pain or discomfort. First, the quality of light projected through the ceiling in all spaces should respond to patients' needs for a fully restorative environment - the quality of light and colors used should reduce our anxiety and ultimately help in reducing length of stay (Malenbaum 2008). Positive distractions can also be much more engaging than simple applications of color and light: projected light can also take on the form of visual displays, with both educational and informative properties. To achieve a significant reduction in patient stress, ceiling surfaces should present educational diagrams, dynamic displays, or information about the current patient's case (Aronsky 2008). Tensile ceilings have the potential to be applied in a virtually infinite variety of forms. By adjusting where each piece is attached and supported, it is possible to affect almost any surface form to create different textures. This attribute can be used to create attractive and inexpensive art in lobby and waiting spaces that can be updated frequently.

FIGURE 4 Illustration of potential projections to provide positive distraction for patients receiving MRIs

Recommendations

Wayfinding:

As previously mentioned, tensile ceilings can be stretched into an unlimited number of forms by adjusting where each piece is attached and where tension is applied. Poor wayfinding is a common source of wasted time and delays in hospitals. More can be done to eliminate this problem and help staff and patients alike to quickly differentiate between spaces more effectively. Applying different ceiling textures to different pathways and spaces consistently throughout the hospital can result in significant reductions in wayfinding issues. Patients, family, and staff will be able to follow a clear path to their respective destinations, and will always be aware of their location within the hospital. Of course, this can be further enhanced by the similar differentiation of lighting intensities and colors across different spaces.

FIGURE 5 Illustration indicating potential for differentiated spaces with unique ceiling patterns.

User Control Over the Environment

With the implementation of backlit stretched-fabric ceilings the potential to give patients much greater control over their immediate environment exists. Dimmable LED lighting or projectors situated behind the stretched fabric can allow for user-controllable lighting levels, visual displays and colored lighting. With increased opportunities for patients to choose aspects of the visual quality of their personal environment, greater patient satisfaction can be achieved.

FIGURE 5 Illustration indicating variable colored displays behind stretched fabric ceiling art in a lobby..

Stakeholders

A functional healthcare environment relies on the cooperation of a number of different stakeholders, each with different requirements, needs and opinions. For innovation to positively affect the healthcare environment, the impact of changes on each group of stakeholders must be considered. A summary of the implications changes to the hospital ceiling structure may have on each respective group has been compiled below. Items in green represent pros and items in red represent cons.

Patients

- Reductions in perceived pain & elapsed time, environmental stress and potentially length of stay from positive distraction
- Increases in the restorative qualities of hospital spaces
- Increased comfort & occupant control
- Disorientation & confusion

Caregivers & Family Members

- Acoustical privacy improvements from sound dampening materials
- Reductions in elapsed time perception and stress associated with waiting from positive distraction
- Improved waiting experience
- Improved wayfinding
- Improved aesthetics of hospital spaces

Doctors & Allied Care Professionals

- Reduction in glare and shadows from inconsistent lighting
- Less difficulties associated with pain and stress in patients due to positive distraction in ceilings
- Improved wayfinding and space differentiation

Administration

- Potential reduction in spread of disease from greater use of antimicrobial surfaces
- Improved public perception of facility from innovation in patient experience
- Reduction in renovations & maintenance costs due to more readily accessible systems, longer product life-span
- Improved customer experience resulting in higher customer satisfaction
- Increased up front costs compared to conventional ceiling tiles

Disease Control Officers

- Improved disease management with anti-microbial fabric ceiling structures
- Ability to more readily wash and cleanse ceiling surfaces

Facilities & Construction Workers

- Improved access to ceiling based delivery systems, wires and ducts
- Reduction in complexities associated with renovations
- Installation involves retrofitting entire ceiling structures that are currently functioning properly (i.e. added workload)

Conclusion

With positive patient experience at the core of a successful healthcare facility, it is crucial for hospitals to continue to innovate in the design of the built environment with which patients interact directly. Ceilings, a surface which patients are often forced to look at in exam chairs, stretchers, wheelchairs and procedure tables, stand to significantly benefit from innovative approaches to their design.

The proposed ceiling system composed of antimicrobial stretched fabric membranes backlit by dimmable LEDs or projectors have the potential to improve the experience of all of the various stakeholders that utilize healthcare facilities. Practical advancements in ease of maintenance and access to ceiling based systems, sanitation, positive distraction for users, and consistency of lighting are augmented by aesthetic enhancements that may better differentiate various spaces throughout the hospital creating a more legible network of spaces that improves wayfinding. Through longer product life spans and greater flexibility for future renovations, these systems also provide more cost effective solutions than the status quo.

This study reveals the vast potential of these ceiling systems and provides insight into specific materials and design strategies that can be used to further innovate the system. As we continue to see improvements to the patient experience in hospitals, the need to address ceilings will become more readily apparent, and hopefully, the opportunities for positive change presented by stretched-fabric ceiling systems will be fully realized.

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