



FURNITURE DESIGN FEATURES AND HEALTHCARE OUTCOMES

By

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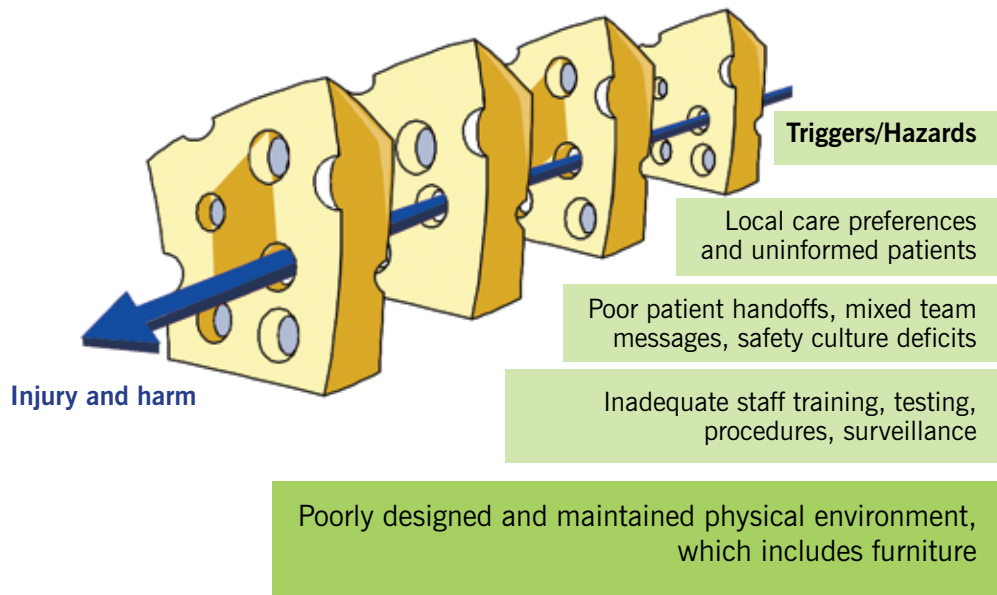
Quality care delivery continues to challenge healthcare leaders. The Society of Actuaries (2010) commissioned a medical claims-based study revealing that 1.5 million avoidable medical errors added \$19.5 billion to the healthcare bill nationwide. In spite of intense efforts to improve patient safety and care outcomes since the Institute of Medicine published its report on medical errors over a decade ago (IOM, 1999), many chronic problems remain stubbornly unsolved, such as the failure to reduce postoperative bloodstream and urinary tract infections (AHRQ, 2010). Landrigan and colleagues (2010) found 25.1 harms per 100 admissions at 10 North Carolina hospitals over six years, 63 percent of which were thought to be preventable. The Department of Health and Human Services' Inspector General found that 13.5 percent of hospitalized Medicare patients experienced adverse events, and another 13.5 percent experienced temporary harm, 44 percent of which were thought by physician reviewers to be preventable (Levinson, 2010). These results continue to occur despite a vast array of patient safety improvement interventions during the past decade (Watcher, 2010).

One of the many reasons for the slow progress in performance improvement may reflect the lack of complete scrutiny and consequent understanding of all the variables and their interrelatedness that shape the complex systems of healthcare delivery. James Reason (2000) hypothesized that healthcare accidents and errors occur as a result of organizational vulnerabilities. A combination of active failures (unsafe acts by those providing care) and latent conditions (termed, resident pathogens) or contributing dormant system conditions (such as chronic understaffing, inexperience, physical environment, and inadequate equipment and furniture), when combined under the right circumstances, can enable a hazard to slip through an organization's flawed defenses. Such active failures and conditions result in patient injury and harm, as shown in Figure 1, an adaptation of Reason's (2000) Swiss cheese model of system accidents.

Complete understanding of these system vulnerabilities requires human factors engineering—an approach that examines human capabilities and limitations with regard to products, processes, systems, and work environments—to maximize safety, reliable performance, and effectiveness and to reduce operational errors, operator stress, fa-

tigue, and training and product liability (Henricksen, et al, 2009; Center for Systems Reliability, 2010). High-risk industries like aviation have long understood the role that the physical environment plays in supporting preferred human responses.

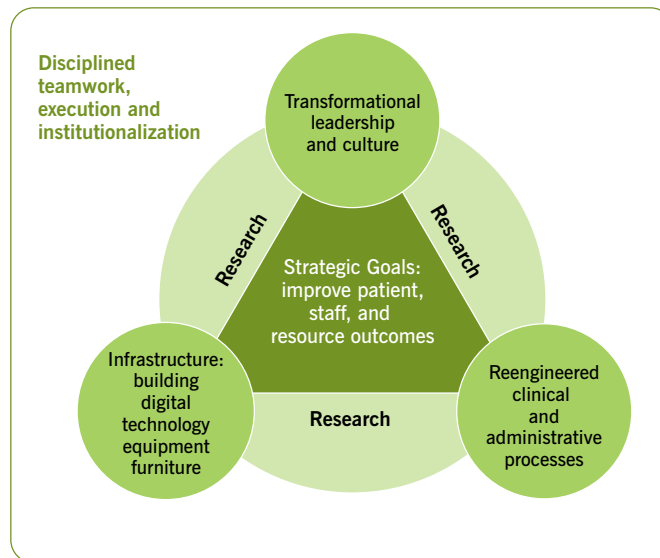
FIGURE 1
Organizational
Vulnerabilities
and Poor Outcomes



In the past quarter century, the healthcare industry has begun to embrace a growing body of work that examined the relationship between the physical environment, human responses, and consequent healthcare outcomes. Evidence-based design (EBD)—or the process of basing decisions about the built environment on credible research to achieve the best possible outcomes (Goetz, et al, 2010)—is being used by a growing field of healthcare architects, practitioners, researchers, and administrators to better understand the impacts of the healthcare environment on healthcare outcomes, including patient safety outcomes (Malone, 2010). Maximizing infrastructure investments like the building, technology, equipment, and furniture to achieve strategic outcomes requires an internal synergy of effort between leaders who can transform organizational culture and a staff that can reengineer clinical and administrative processes, as depicted in Figure 2.

Using a multidisciplinary team to execute and institutionalize the work, all of which is based on evidence-based research, pre and post occupancy measures are used to track desired outcomes, the results of which ultimately further EBD science. Additional information about the Evidence-Based Design Model can be found in The Center for Health Design’s Evidence-Based Design Study Guide 1, page 76 (Goetz, et al, 2010) at http://edac.healthdesign.org/EDAC_StudyGuide1.pdf

FIGURE 2
Evidence-Based
Design Model



Modified from the Evidence-based Design Model in Malone, E., Mann-Dooks, J. R., & Strauss, J. (2007). *Evidence-based design: Application in the MHS (Military Health System)*. Falls Church, VA: Noblis, p.12.

Objects, such as furniture, also require careful EBD research to fully understand the role those objects play in realizing desired patient and staff outcomes. Furniture will be bought and replaced multiple times during the 30-year-plus-lifetime of most healthcare facilities. A typical new 200,000 square foot, 120-bed inpatient hospital may have over 1,600 individual pieces of furniture. Healthcare administrators often consider furniture a sunk cost, similar to walls, lighting, and heat; a facility must have furniture in order to serve patients, families, and the healthcare team. The high-risk healthcare industry demands much from these common objects, ranging from embodying an organization's brand, providing patient comfort and support during stressful times, enabling staff to work efficiently and safely as a team, and perhaps most importantly, not contributing to patient and staff and organizational harm.

Facility managers, designers, and others charged with the responsibility of recommending furniture purchase options for c-suite approval face a dizzying assortment of choices, complicating the furniture evaluation and selection process. First-time costs frequently dictate furniture selection that overlooks facility life cycle costs and organizational performance improvement goals. The purpose of this paper is to describe the creation of an Evidence-Based Design Furniture Checklist, based on current EBD research findings and industry standards. Healthcare leaders can use the list to make informed furniture investment decisions to improve healthcare outcomes

across the furniture life cycle. We conclude the paper with recommendations for future EBD furniture research, government and industry standards development, and further checklist development.

Developing an Evidence-Based Design Furniture Checklist

Recent attention to furniture's impact on sustainability goals, coupled with the healthcare industry's focus on patient safety, has opened the door to a broader consideration about the role furniture might play to improve patient, staff, and resource outcomes. As a component of a comprehensive plan to improve targeted healthcare outcomes, the Evidence Based Design Furniture Checklist was created as a tool to facilitate the best healthcare furniture purchases across the facility life cycle. Furniture in this context includes the more common objects, such as chairs, sofas, tables, systems, and built-in furniture; it does not include the patient bed (which has become more equipment-like) or carts that support medical procedures.

The checklist was developed using EBD research results, industry standards, and Facility Guideline Institute requirements and recommendations. Although initially developed for use by healthcare leaders, administrators, and facility managers, the checklist may also provide a communication tool to stimulate discussion among design team members and manufacturers, as they strive to provide clients with furniture that enables healthcare quality and safety outcomes and provides a good investment. The checklist can be used during any phase of the furniture life cycle from strategic planning and programming, through design, and during operations over the average 30-year life span for all types of healthcare facilities, such as when:

- Evaluating manufacturer product brochures and websites
- Meeting with manufacturers and furniture dealers to evaluate their furniture
- Examining existing facility furniture for life expectancy
- Working with healthcare facility infection control and safety committees
- Working with interior designers to evaluate proposed furniture features, room layout and product specification
- Conducting a return-on-investment analysis

- Developing contract specifications for furniture rental or purchase
- Completing a post-occupancy evaluation

The one-page checklist is divided into eight sections, each associated with a common EBD goal, and 35 variables for which research evidence or an industry standard was found that linked a furniture feature to a healthcare outcome. It was developed using many of the ‘good checklist list attributes’ (described by Gawande, 2009), such as a sans serif font, and the checklist purpose and use instructions placed on the reverse side. A findings scale is provided so that the user can indicate the presence or absence of a furniture feature, if more information is needed about the item, or if the feature does not apply to a particular furniture type. The research supporting each variable is cited and can be found in the checklist appendix.

The checklist was initially developed to support a presentation to marketing leaders at a major healthcare furniture manufacturing company (Malone, 2010). The topic of the presentation was current healthcare leaders’ challenges and the role furniture might play with regard to healthcare outcomes. The goals and variables were created based on the presenter’s EBD knowledge and a cursory review of the literature to identify possible furniture feature and healthcare outcome intersections. After a comprehensive review of the literature, the checklist was created and subsequently reviewed for clarity, practicality and usefulness by a convenience sample of 22 multidisciplinary experts (listed in the acknowledgement section) As a result, the checklist was distilled from 10 to 8 EBD goals and from 47 to 36 key variables for which research results or The Facility Guidelines Institute (FGI, 2010) requirements or recommendations existed. User feedback was provided by an interior design team who used the checklist to evaluate furniture feature options and create furniture specifications for several major hospital replacement projects. A final draft version of the checklist was shared with approximately 300 Healthcare Design ’10 conference participants, who attended a presentation about the development and use of the checklist. Attendees were asked to use the checklist in the conference exhibit hall to evaluate a furniture item and provide feedback about the checklist with regard to its practicality, usability, and clarity. Comments and recommendations were considered in the creation of the final EBD checklist (see Figure 3).

FIGURE 3
Evidence-Based Design
Checklist (See Appendix
for Instructions and
references)

Findings Scale:
Present (+), Absent (-),
More Information Needed (?),
Not Applicable (N/A)

Findings	EBD Goals and Furniture Features
	1. Reduce surface contamination linked to healthcare associated infections^{1 2}
	a) Surfaces are easily cleaned, with no surface joints or seams. ^{3 4 5}
	b) Materials for upholstery are impervious (nonporous). ^{6 7 8}
	c) Surfaces are nonporous and smooth. ⁹
	2. Reduce patient falls and associated injuries¹⁰
	a) Chair seat height is adjustable. ^{11 12 13 14 15}
	b) Chair has armrests. ¹⁶
	c) Space beneath the chair supports foot position changes. ¹⁷
	d) Chair seat posterior tilt angle and seat back recline facilitate patient egress. ¹⁸
	e) Chairs are sturdy, stable, and cannot be easily tipped over. ^{19 20 21}
	f) Rolling furniture includes locking rollers or casters. ²²
	g) Chairs have no sharp or hard edges that can injure patients who fall or trip.
	3. Decrease medication errors²³
	a) Lighting fixtures should provide 90-150 foot candle illumination and an adjustable 50-watt high intensity task lamp for furniture with built-in lighting that is used in a medication safety zone. ^{24 25}
	b) Furniture is configurable to create a sense of privacy to minimize visual distractions and interruptions from sound and noise during medication transcription, preparation, dispensing, and administration activities. ^{26 27}
	4. Improve communication and social support for patients and family members²⁸
	a) Furniture can be configured into small flexible groupings that are easily adjusted to accommodate varying numbers of individuals in a variety of healthcare settings. ^{29 30 31}
	b) Wide-size and age variations are supported. ³²
	c) Acoustic and visual patient privacy are supported. ^{33 34 35 36 37 38}
	5. Decrease patient, family member, and staff stress and fatigue³⁸
	a) Materials suggest a link to nature. ^{39 40 41 42 43}
	b) Appearance is attractive and non-institutional. ^{44 45 46 47}
	c) Furniture is tested for safe and comfortable use by all, including morbidly-obese individuals. ^{48 49 50}
	6. Improve staff effectiveness, efficiency, and communication
	a) Furniture is easily adjustable to individual worker's ergonomic needs. ⁵¹
	b) Design enables care coordination and information sharing. ^{52 53}
	c) Materials are sound absorbing. ^{54 54 56 57 58 59}
	7. Improve environmental safety
	a) Materials do not contain volatile organic compounds (VOC), such as formaldehyde and benzene. ^{60 61 62}
	8. Represent the best investment
	a) Reflect and reinforce the organizational mission, strategic goals, and brand.
	b) Integrate new with existing furniture and objects for facility renovation projects.
	c) Pieces can be flexibly reconfigured and moved to support changing and emerging missions.
	d) Provide casters or glides to reduce floor damage.
	e) Check that there are no protuberances that may damage walls; check chair rail heights.
	f) Manufacturer provides results of safety and durability testing.
	g) Manufacturer describes the specific evidence that has been used to design the product.
	h) Manufacturer includes a warranty appropriate to use, such as furniture used all day, every day.
	i) Replacement parts are available.
	j) Repairs can be done in the healthcare facility.
	k) Manufacturer or local dealer can assist with furniture repair and refurbishing.
	l) Environmental services (housekeeping) staff can easily maintain furniture.
	m) A Group Purchasing Organization (GPO) can be used when purchasing furniture.

Source: Malone, E. B. &
Dellinger, B. A. (2011).
*Furniture design features
and healthcare outcomes.*
Concord, CA: The Center for
Health Design

Furniture Design Features and EBD Research and Standards

The first three EBD goals on the checklist focus on key patient safety concerns that result in significant patient morbidity, mortality, and healthcare costs, providing an important opportunity for healthcare furniture manufacturers. The next three EBD goals focus on the more traditional use of furniture to improve psycho-social and work associated outcomes. Environmental safety is described in the seventh EBD goal. The eighth goal suggests practical considerations for making the best furniture investment. In the following section, each EBD goal is stated with its checklist variables followed by a review of the supporting literature and standards.

EBD Goal 1: Reduce surface contamination linked to healthcare associated infections

- Surfaces are easily cleaned, with no surface joints or seams.
- Materials for upholstery are impervious (nonporous).
- Surfaces are nonporous and smooth.

Healthcare Associated Infection Facts

- Healthcare associated infections (HAIs) are infections that patients acquire during the course of receiving treatment for other conditions within a healthcare setting (CDC, 2010).
- One out of every 20 hospitalized patients will contract an HAI (CDC, 2010).
- In 2002, approximately 1.7 million HAI incidents and 99,000 associated deaths occurred in American hospitals (Klevens, et al, 2007).
- Direct hospital costs for HAIs are estimated to be between \$35.7 billion to \$45 billion annually (Scott, 2009).
- A recent study examined 600,000 cases and found 2.3 million hospitalization days—accounting for \$8.1 billion in hospital costs and 48,000 preventable deaths—could be attributed to HAI sepsis and pneumonia alone (Erber, et al, 2010).
- The Center for Disease Control director has identified the elimination of preventable healthcare infections as one of six ‘winnable battles’ priorities to improve the health of Americans (CDC, 2010).
- The American Recovery and Reinvestment Act of 2009, Public Law 111-5 authorized \$59 million to support states in the prevention and reduction of HAIs (CDC, 2010).

Reducing surface contamination linked to healthcare associated infections (HAIs) is an important EBD goal for which furniture design, cleaning, and maintenance plays a key role. (CDC, HICPAC, 2003; Bartley, Olmsted, Haas, 2010). Most HAIs are transmitted through contact with pathogens transferred from reservoirs on hand-touch sites found on high-risk objects close to the patient (Carling, Parry, Von Beheren, 2008; Weber, et al, 2010). High-risk objects include furniture closest to the patient, such as inpatient room chairs, over-bed tray tables, and bedside tables, as well as medical equipment features like the bed and its rails. Many pathogens cause HAIs—a growing number becoming antibiotic resistant, the most common of which can survive for months on inanimate surfaces (Kramer, Schwebke, Kampf, 2006), as summarized in Table 1.

Table 1 Sample of Common Hospital Pathogens' Survivability on Dry Inanimate Surfaces	
PATHOGEN	DURATION OF PERSISTENCE RANGE
Bacteria	3 days – 5 months
- Acinetobacter spp.	
- Enterococcus spp., including vancomycin-resistant enterococci (VRE)	5 days – 4 months
- <i>Escherichia coli</i> (E. coli)	1.5 hours – 16 months
- Klebsiella spp.	2 hours - >30 months
- <i>Pseudomonas aeruginosa</i>	6 hours – 16 months
- <i>Serratia marcescens</i>	3 days – 2 months
- <i>Staphylococcus aureus</i> , including methicillin-resistant staphylococcus aureus (MRSA)	7 days – 7 months
- <i>Streptococcus pyogenes</i>	3 days – 6.5 months
- <i>Clostridium difficile</i> (C.diff) – spore forms	5 months
Mycobacteria	1 day - 4 months
- <i>Mycobacterium tuberculosis</i>	

Table information adapted from, Kramer, A., Schwebke, I. & Kampf, G. (2006). How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infectious Diseases*, 6, 131-133. See the article for survivability information about additional pathogens.

Prioritized cleaning of high-risk objects provides one important tool to control HAIs, but it requires more awareness, staff training, and consistent execution (Dancer, 2009). Many institutions have adopted the use of invisible fluorescent markers as a component of an enhanced monitoring program to quantitatively assess cleaning and disinfecting practices on high-touch surfaces in hospital rooms (Carling, et al, 2006). Comprehensive, enhanced monitoring programs that include the use of objective monitoring tools in a blame-free culture committed to process improvement have been shown to improve disinfection cleaning by more than 100 percent, on average (Carling, Bartley, 2010).

Hospital furniture that is difficult to clean is not a new problem. Stretton (1915) complained that, “On examining some specimens of hospital furniture it will be seen that the manufacturers have left angles and depressions which act as receptacles for dirt and germs. It is difficult and in some instances impossible to clean them.” The porous nature of some furniture materials and surfaces and consequent ability to be successfully disinfected represents another key challenge in reducing pathogen reservoirs. Lankford and colleagues (2006) assessed four common hospital furniture materials and manufacturer-recommended surface-cleaning disinfectants and methods. They then contaminated each surface with Vancomycin-resistant enterococci (VRE) and *Pseudomonas aeruginosa* (PSAE) demonstrating confluent organism growth (heavy contamination such that the organism mass merges into one growth) at 5 minutes.

Without any surface cleaning, growth was then measured again at 24 hours, 72 hours and 7 days and then again after manufacturer-recommended disinfectants and methods were used. The results are summarized in Table 2. Not only does each material require a different disinfectant and cleaning method, but the recommended methods did not uniformly eliminate all growth. Noskin and colleagues (2000) found that fabric seat cushions served as a VRE reservoir and recommend that “easily cleanable, non-porous material is the preferred upholstery in hospitals.” Weber and his team (2010) examined three emerging HAI pathogens frequently associated with healthcare worker and hospital room contamination—norovirus, *Clostridium difficile* (*c. diff*), and *Acinetobacter* species finding that all three pathogens survive for prolonged periods of time.

A number of cases had demonstrated that the rate of patient-to-patient transmission is directly proportional to the amount of environmental contamination. Available information about furniture manufacturer testing results specific to organism growth pre and post cleaning is complicated by two facts: there is no government or industry standard as to which organisms must be tested; and manufacturers must pay to test each individual product for each organism they select. This surprising reality means that furniture manufacturers are not required to test for the most problematic antibiotic-resistant bacteria, such as Methicillin-resistant *Staphylococcus aureus* (MRSA), VRE, or additional organisms associated with HAIs, such as *C. diff*.

Table 2 Furniture Material as Pathogen Media, Recommended Disinfectants, Cleaning Methods and Results

Material (Source for sample used.)	Pathogen growth without cleaning at 24 hours	Manufacturer recommended disinfectant	Manufacturer recommended cleaning method	Results after cleaning
Fabric upholstery (Designtex, Los Angeles, CA)	Non-confluent growth for VRE and PSAE	Ethylene glycol monobutyl ether ammonium hydroxide morpholine isobutene, anionic surfactant (Woolite Upholstery Cleaner)	Mild detergent shampoo, hot water extraction; material was not saturated	No growth for either VRE or PSAE
Polyester and acrylic blend upholstery (Interspec, Allenwood, NJ)	Non-confluent growth for VRE No growth for PSAE	Water-based proprietary pre-treatment cleaner (Crypton Upholstery Cleaner Pre-Treatment), sodium carbonate linear alkyl benzene sulfonate (Tide)	Pre treatment followed by 1:1 mixture of powdered enzyme detergent and water, liberally rinsed	Non-confluent growth for VRE and PSAE
100 percent polyester upholstery (Omnova Solutions, In, Fairlawn, OH)	Non-confluent growth for VRE and PSAE	Alcohol, ethanol 70 percent by volume (Valu Merchandisers)	5 minutes of hot water extraction; cleaning repeated in 24 hours	Non-confluent growth for VRE No growth for PSAE
Vinyl upholstery (Fantagraph, Standard Textile, Cincinnati, OH)	Non-confluent growth for VRE and PSAE	Sodium carbonate, linear alkyl benzene sulfonate (Tide)	Energetic washing, mild soap	No growth for either VRE or PSAE

VRE: Vancomycin-resistant enterococci; PSAE: *Pseudomonas aeruginosa*

Confluent growth: heavy contamination such that organism growth merges into one mass

Non-confluent growth: less contamination such that organisms form individual colonies

No growth: no organism contamination

Table information adapted from, Lankford, M. G., Collins, S., Youngberg, L., Rooney, D. M., Warren, J. R. & Noskin, G. A. (2006). Assessment of materials commonly utilized in healthcare: Implications for bacterial survival and transmission. *American Journal of Infection Control* 34(5), 260.

Each piece of furniture comes with manufacturer recommended cleaning methods, using disinfectants recommended by the Environmental Protection Agency (EPA). Because furniture is often made of multiple materials, a variety of material-specific cleaning methods and solutions complicates the cleaning process, which can cause inconsistent results (Lankford, et al, 2006) and lengthen the time needed to clean a room, affecting room turnover time. Both of these issues increase costs for healthcare institutions. The housekeeping staff can easily be confused by the vast array of furniture fabrics and materials and consequent cleaning method requirements. Also, there is no standard industry cleaning

code to simplify cleaning instructions for environmental services personnel. Some manufacturers provide a cleaning code for each type of fabric (such as D for Dry clean or W for “clean with only a water-based shampoo or foam upholstery cleaner”); others have their own proprietary EPA-approved disinfecting products, which claim to actually kill the “super bugs” such as MRSA, c. diff, and VRE, when used on their fabrics. Clearly cleaning methodology simplification and standardization is needed so that healthcare leaders and their teams can practically evaluate cleaning requirements and estimate the impact on furniture maintenance and healthcare facility operations.

Further complicating the picture are manufacturer assertions that impregnating materials with antimicrobials helps to reduce the bio-load on furniture surfaces and therefore prevents HAIs (Bartley, Olmsted, Haas, 2010). However, inadequate efficacy evidence exists to recommend antimicrobial-treated fabrics and surfaces. The 2010 FGI requirements specify that “Furniture shall be upholstered with impervious materials according to the functional program and an Infection Control Risk Assessment” (p.63) and a recommendation (p.18) that furniture surface characteristics include the following:

- Easy to maintain, repair, and clean
- Does not support microbial growth
- Nonporous and smooth
- Seamless

More cleaning research, including simplification and standardization as well as an enhanced monitoring program is needed to improve effective cleaning practices. In the meantime, healthcare leaders and designers who specify furniture materials must ask manufacturers for the details of their testing with regard to organism growth and recommended cleaning methodology in order to inform clients about the limitations of desired furniture materials. FGI requires (p. 96) that the frequently touched surfaces and furnishings “in the patient’s environment of care shall be planned and designed to facilitate cleaning and disinfection. Cabinetry, casework and countertops shall have flush surfaces that are smooth, nonporous, cleanable, wipeable, and durable and that do not scratch easily.”

EBD Goal 2: Reduce patient falls and associated injuries

- Chair seat height is adjustable.
- Chair has armrests.
- Space beneath the chair supports foot position changes.
- Chair seat posterior tilt angle and seat back recline facilitate patient egress.
- Chairs are sturdy, stable, and cannot be easily tipped over.
- Rolling furniture includes locking rollers or casters.
- Chairs have no sharp or hard edges that can injure patients who fall or trip.

Patient Falls Facts

- Patient falls and their associated injuries represent the number-one reported hospital adverse incident, accounting for 6.4 percent of reported sentinel events, defined as unexpected occurrences that result in death or physical or psychological injury (The Joint Commission, 2005; 2009).
- Studies examined by Hitcho and colleagues (2004) found that inpatient fall rates ranged from 2.7 to 7 falls per 1,000 patient days, with approximately 30 percent resulting in injury.
- Significant healthcare costs associated with falls were estimated to be \$20.2 billion in 1994 and projected to be \$32.4 billion by 2020 (Chang, et al, 2004).
- Patient falls and injuries are now directly tied to hospital reimbursement. As of October 1, 2008, CMS no longer pays hospitals at a higher rate for the increased cost of care consequent to the patient harm associated with a fall that occurred during hospitalization (Centers for Medicare & Medicaid, Services, 2008).
- Estimated average 2009 DRG (Diagnosis-Related Group) payments associated with injuries sustained by a patient falling from bed were \$24,962 per patient (Hart, Chen, Rashidee, Kumar 2009).

Falls are devastating to patients and their families alike. Although falls and consequent injuries are thought to be entirely preventable, many factors predispose patients to these events. The Joint Commission (2005) has broadly categorized these factors into two main groups: intrinsic factors that pertain to an individual's age, illnesses, strength, and medications; and extrinsic factors that are external to the patient. Tzeng (2008) identified five extrinsic categories based on The Joint Commission's root cause analysis of fatal flaws:

- Inadequate staff communication and incomplete orientation and training
- Incomplete patient assessments and reassessments
- Incomplete care planning and unavailable or delayed care provision
- Inadequate organizational culture of safety
- Environmental issues

Hendrich (2006) reports that approximately 10 to 15 percent of falls are caused by extrinsic factors, which include furniture found in the patient environment. Cummings and colleagues (1995) found in white women that an inability to rise from a chair increased the risk for a hip fracture consequent to a fall. Slow-timed chair stands—getting up and sitting down in a chair three times in a row—were one of four independent predisposing factors associated with patient falls, incontinence, and functional dependence (Tinetti, et al, 1995). Janssen and colleagues (2002) conducted a comprehensive review of 160 studies, finding 39 studies that used an experimental design addressing the effects of determinants on the sit-to-stand movement. Chair seat height, use of armrests, and foot position were found to have a major influence on the ability to successfully complete a sit-to-stand movement.

Seat height plays an important role in successful chair egress without compensatory movement for young and highly functional subjects (Mazza, 2004; Schenkman, 1996). Weiner and colleagues (1993) reported that as chair height increased from 17 to 22 inches, successful chair rise doubled and nursing home and community subjects reported less difficulty. Functionally impaired elderly patients required 97 percent of their available strength when successfully rising from the lowest chair height (Hughes, et al, 1996). Alexander and colleagues (1996) found that increased seat compressibility and associated seat height adjustment interfered with chair egress, but cautioned that seating comfort must be balanced with egress ease. Furniture designers, manufacturers, and clinicians have created a number of different adaptive seating systems that mechanically adjust seat height to facilitate chair rising (Galumbeck, et al, 2004; Edlich, et al, 2003). However, there is no published research about the efficacy of such devices and their association with a reduction of patient falls and associated injuries.

Armrest use provides an important assistive device in the chair-rise process by reducing knee movements by about 50 percent without influencing joint range of motion (Arborelius, 1992). Armrest height relative to an individual's height and arm length was found by Wheeler and colleagues (1985) to also impact chair-rise movement. Chairs designed to support the repositioning of the feet to a more posterior position, shortened sit-to-stand movement time by lowering peak movements at the knee and hip (Shepherd, 1996). In addition, seat posterior tilt angle and seat back recline angle were found to interfere with chair egress in older adults (Alexander, et al, 1996).

No research examines the interrelatedness of chair seat height, use of armrests, and foot position on chair egress and patient falls. However, researchers with furniture manufacturer Herman Miller (2009) interviewed over 200 caregivers in 15 hospitals and healthcare systems and 70 healthcare designers to determine what worked best in patient seating to avoid patient and staff injury. Their recommended design features include Janssen's findings of armrests, foot space under the chair, and seat height, as well as additional features, such as armrests that pivot out of the way to aid in patient transfer and care and armrest length and angle, all of which deserve further study and analysis for efficacy.

FGI (2010, p.369) recommends that furniture in adult day health care facilities should be sturdy and stable to safely support patient transfer and weight-bearing requirements, one of many variables noted in the Department of Veterans Affairs National Center for Patient Safety Toolkit (2004). In addition to providing age-appropriate furniture (Sigrest, 2003), creating a safe environment for children requires particular attention, as furniture tip-over accidents—particularly desks, cabinets, bookshelves, and televisions—have become an important and growing cause of injury to children (Gottesman, et al, 2009). Obviously, furniture must, at a minimum, be free of sharp or hard edges that could injure patients who do trip or fall.

Federally collected national-level data about healthcare facility patient fall rates and associated factors is lacking. Although each healthcare facility is responsible for assessing a patient's fall risk and developing an individualized fall prevention plan, there is no standardized reporting method to gather information about the many variables associated with each fall occurrence. Instead, most facilities develop their own patient fall data collection method within the context of the hospital's performance improvement program. However, the National Quality Forum's (NQF) Serious Reportable Events (2008) has brought increased scrutiny of patient falls. Those events—called Never Events—that should never occur, include patient death or serious disability associated with a fall while being cared for in a healthcare facility. The Centers for Medicare & Medicaid Services (CMS) partnered with the NQF to reduce or eliminate the Never Events by linking payments to performance in the Hospital-Acquired Conditions initiative. As of October 1, 2008, CMS no longer pays hospitals at a higher rate for the increased cost of care consequent to an injury associated with a fall—linking falls to reimbursement. Perhaps the CDC's National Health Safety Network could be expanded to include voluntary reporting about the

circumstances and variables surrounding patient falls, including furniture-specific information. In addition, CMS could establish clear instructions for how their Quality Improvement Organization programs record both the intrinsic and extrinsic variables associated with Medicare-beneficiary falls, such as the furniture features just described (US GAO, 2010).

EBD Goal 3: Decrease medication errors

- Lighting fixtures should provide 90-150 foot candle illumination and an adjustable 50-watt high intensity task lamp for furniture with built-in lighting that is used in a medication safety zone.
- Furniture is configurable to create a sense of privacy to minimize visual distractions and interruptions from sound and noise during medication transcription, preparation, dispensing, and administration activities.

Facts about Medication Errors

- Medication errors represent the most common medical error, causing more than 7,000 annual deaths, found in a review of death certificates between 1983 and 1993 (IOM, 1999).
- Inpatient pediatric populations are especially vulnerable, with one study finding a 5.7 percent medication error rate (Kaushal, et al, 2001).
- Flynn and colleagues (2002) examined 50 pharmacies located in 6 cities across the United States concluding that a pharmacy filling 250 prescriptions a day had an error rate of 4 errors per day—6.5 percent of which were clinically important.
- Researchers found that 429 community pharmacists believed that design significantly contributed to dispensing errors, errors in communication, and efficiency problems (Szeinback, et al, 2007).

Medication therapy represents the central pillar of treatment interventions – from outpatient medication prescriptions to complex inpatient medication regimens. Burt (2002) found that a comparison of National Ambulatory Medical Care Survey data between 1985 and 1999 revealed an increase from 109 to 146 prescriptions per 100 outpatient visits, with the rate of multiple prescriptions rising more than 29 percent. Inpatient medication therapies are the most common therapeutic intervention for patients requiring hospital admission. Safe medication delivery depends on many variables, some of which are found in the environment. In a review of 60 papers on the incidence, type, and cause of errors when dispensing medications in hospital and community pharmacies in the United States, the United Kingdom, Australia, Spain, and Brazil, researchers found that inadequate illumination, interruptions, and distractions increase the occurrence of errors in dispensing medications (James, et al, 2009).

A chapter was added to The United States Pharmacopeia–National Formulary (USP–NF, 2010), which describes the physical environments that promote safe medication practices. The United States Pharmacopeial Convention is a non-governmental official public standards-setting authority for prescription and other health-care products manufactured or sold in the United States. As defined by the USP-NP (2010, p. 4), a medication safety zone is “a critical area where medications are prescribed, orders are entered into a computer or translated onto paper documents and where medications are prepared, dispensed and administered.” All medication safety zones include furniture, whether the location is an outpatient office or exam room, a pharmacy work center, inpatient medication rooms, staff work areas, or the patient’s room itself. Although furniture represents just one environmental variable, it is worth examining furniture from the perspective of the USP’s four environmental factors associated with medication errors: illumination, interruptions and distractions, sound and noise, and work space design and organization (USP-NF, 2010), summarized in Table 3.

Table 3 Medication Safety Zone and Furniture Design Features	
PHYSICAL ENVIRONMENTAL VARIABLES	MEDICATION SAFETY ZONE FURNITURE DESIGN FEATURES
Illumination	<p>Light fixtures found in systems and built in furniture:</p> <ul style="list-style-type: none"> • Provide illumination levels of 1000 lux (100 fc) for computer order entry, handwritten order processing, medication preparation (nursing station), and medication administration work (patient room, cart surface); and 1000-1500 lux (100-150 lux) in sterile compounding and preparation areas. • Provide illumination levels of 900 -1500 lux (90-150 fc) in medication filling and checking areas, patient counseling locations, and prescription filling areas. • Include task lighting with adjustable 50-watt high intensity lamps where critical visual tasks are performed (no shadows on the work surface). • Eliminate glare on the computer monitor. • Use fluorescent cool white deluxe lamps or compact fluorescent lamps to improve medication color discernment.
Interruptions and distractions	Furniture design and layout should minimize visual distraction and interruption.
Sound and noise	Furniture should be constructed of sound-absorbing materials, as appropriate.
Work space design and organization	Furniture (chairs, stools, counters, foot rests, shelving) should be adjustable to accommodate workers of varying sizes.

Table information adapted from The United States Pharmacopeia–National Formulary (USP–NF) (2010). Chapter 1066, Physical environments that promote safe medication use. Revision Bulletin, October 1, 2010, 1-6. Retrieved Jan. 9, 2011 from <http://www.usp.org/pdf/EN/USPNF/gc1066PhysicalEnvironments.pdf>

Illumination. Lighting is frequently available as a component of work station systems and built-in furniture. Buchanan and colleagues (1991) demonstrated that working surfaces lit at 1,460 lux compared with those lit at 1,100 lux and 450 lux were associated with significantly fewer errors, both for content and labeling. Grasha (2002) found that pharmacists detected 38 percent more errors when they used task lights to increase illumination. In addition, visual fatigue that occurred toward the end of a shift was mitigated through the use of high-intensity task lights, resulting in 10.7 percent fewer product verification errors. Brightly lit work surfaces where high-risk medical tasks are performed are especially important for an aging health-care workforce, whose visual acuity diminishes over time. Appropriate illumination can be critical, as many medication packages contain small print (USP-NF, 2010). Even though the addition of barcode technology has reduced medication errors by 41 percent (Poon, et al, 2010), the final safety check will always be performed by the person administering the medication, frequently the nurse. The Government Accounting Office (2001) has estimated that by 2010, 40 percent of all registered nurses will be over 50 years old. More research is needed to specifically examine the interrelatedness of age and visual acuity of those preparing, dispensing, and administering medications, lighting, and medication errors rates. (Ulrich, 2010). In addition, current Illumination Engineering Society Standards for hospitals and health care facilities are less specific and stringent for lighting level and color rendering in medication safety zone areas than those standards recommended in the USP-NF (2010). The USP-NP standards are based on research demonstrating the relationship between lighting and medication errors both for lighting level and color rendering properties.

Interruptions and Distractions. Furniture used in medication safety zones should be designed to facilitate privacy and minimize distractions, both of which have been associated with higher prescription-dispensing error rates. Westbrook and colleagues (2010) found that each interruption of nurses who were preparing and administering medications on inpatient units in two teaching hospitals was associated with a 12.1 percent increase in procedural failures and a 12.7 percent increase in clinical errors. In the ambulatory care setting, Flynn and colleagues (1999) discovered a 6.65 percent error rate for sets of prescriptions with one interruption and a 6.55 percent error rate when there was more than one interruption, most of which involved incorrectly-entered label information. Work station furniture in particular can include design features with the potential to minimize visual distractions and consequent interruptions.

Sound and Noise. Healthcare environments are notoriously noisy—frequently exceeding the World Health Organization’s (Berglund, et al, 1999) recommended a 35 dB maximum background sound level in a patient room—having detrimental impacts on patient and staff health (Ulrich, et al, 2004; Joseph, Ulrich, 2006; Morrison, et al, 2003; Topf and Dillon, 1988). Although many non-healthcare studies document the negative relationship between noise and worker performance (Ulrich, et al, 2008; USP-NF, 2010), few studies have examined the specific relationship between noise—or unpredictable sounds—and medication errors. For those studies that do exist, results sometimes conflict, such as the study by Flynn (1999), which demonstrated that unpredictable but controlled sounds and noise improved the accuracy of prescription filling. However, one hospital examined the relationship between medication errors and several environmental features designed to decrease noise and provide a standardized work environment. That study found a 30 percent reduction in errors on the two new inpatient units (The Center for Health Design, 2010). USP-NF (2010) recommends the sound levels in the medication safety zone be set at conversation level or 50 dB.

The General Services Administration (2008) requires that federally funded projects that include open-setting-systems furniture with acoustical panels have a minimum noise reduction coefficient of 0.65. Furniture design and sound absorbing materials can positively contribute to both auditory and visual privacy, mitigating unintended interruptions and distractions.

Work Space Design and Organization. Work environments should be designed with adjustable features that can accommodate a variety of worker sizes. Medication safety zones represent a high-risk environment that requires individual tailoring to help ensure the best performance, much like car drivers adjusting the seat and mirrors before engaging in a different high-risk activity—driving. Environmental features requiring size adjustments or accommodations include counter height, height of supply storage shelves, location and lighting of drawers, as well as seating and foot rests to minimize staff fatigue and improve safety (USP-NF, 2008). Design features that provide shelving to accommodate space between pharmacy items (Flynn, 2003) and minimize work surface clutter (USP-NF, 2010) may also help to reduce errors. However, much more research is needed about work space design features and its impact on human factors associated with medication errors.

The Institute for Safe Medication Practices provides a voluntary and confidential national Medical Errors Reporting Program. Source-protected reports are forwarded to the Food and Drug Administration, medication manufacturers, and others about labeling, packaging, and nomenclature issues, whose design might be fostering errors. Presently, no environmental variables are listed in their current reporting format.

EBD Goal 4: Improve communication and social support for patients and family members

- Furniture can be configured into small flexible groupings that are easily adjusted to accommodate a varying numbers of individuals in a variety of healthcare settings.
- Wide-size and age variations are supported.
- Acoustic and visual patient privacy are supported.

Patient and family centered care represents an important consumer-driven transition in healthcare delivery practice that advocates for moving the control and power out of the hands of those providing care into the hands of patients and their family members (Berwick, 2009). Two hundred health care executives at a 2007 Nurse Work Environment Innovation Summit, funded by the Robert Wood Johnson Foundation recommended, “Hospital and technology design should be organized around patients needs – helping patients and their families feel engaged in the care-giving process rather than removed from it – and be tailored to address unique factors and diverse populations. (Cole, 2010)” The Institute for Patient and Family-Centered Care (2010) describes four key care concepts, all of which depend on good social support and communication: respect and dignity, information sharing, participation and collaboration.

A great amount of research exists about the positive impact of family and social support on patient physiological and psychological healthcare outcomes and patient satisfaction. Ulrich and colleagues (2008) summarizes the research in a comprehensive review of this literature. Several studies demonstrated that the design of the physical environment impacts social interactions, which underpin social support phenomena. Holahan (1972) found that side-by-side seating configurations along room walls inhibited social interaction between hospitalized male psychiatric patients, while those seated at small tables demonstrated more personal interaction. When space is con-

strained, seats are often placed in a linear ‘airport-like’ fashion rather than preferred small group configurations. Geriatric patients with senile dementia consumed more food and were more communicative when meals were served at small tables with moveable chairs rather than at large dining tables (Melin, Gotestam, 1981).

Social and family support has been significantly improved for inpatients in recent years with the move toward providing single inpatient rooms that include more space for furniture to accommodate significant others. Van de Glind and colleagues (2007) reviewed 25 empirical studies finding that single patient rooms had a moderate effect on patient satisfaction with privacy and dignity, care and the quality of sleep. In a pilot study of medical-surgical units in four northwest hospitals, Chaudhury and colleagues (2006) found that nurses favored single over double occupancy rooms to interact with or accommodate family members. However, some evidence is conflicting with regard to the use of single patient rooms for specific patient populations. Rowlands and Noble (2008) found that in their interviews of 12 inpatients with advanced cancer, the majority of patients preferred multi-bed rooms when they were well enough to interact and private rooms when they were very ill or dying.

FGI (2010, p. 91) recommends that for those institutions providing a patient and family-centered care room, the single patient room include additional clear floor area (30 square feet per family member) and comfortable furniture to create a homelike atmosphere for family members (one or two) without blocking access of staff members to patients. No research was found that addressed furniture type or layout to best enhance patient social support or communication with family and caregivers for patients who receive care in a single patient room.

Encouraging social support is also recommended for the exam and procedure rooms in the ambulatory care setting, where many inpatient services have migrated. The California Healthcare Foundation and The Center for Health Design summarized the research and best-practice case studies of California Safety Netsafety net clinics (Joseph, Keller, Gulwadi, 2009). The research revealed that design elements that positively impacted patient experiences included ample space (implying furniture) for family members in the exam and procedure areas and using furnishings in exam rooms to lower the power differential between provider and patient.

The intersection of provider work environment and patient support in ambulatory care consultation rooms has been recently studied by Steelcase's Nurture team and the Mayo Clinic (Almquist, et al, 2009). Researchers created an experimental consultation room with a semicircular table at which both the provider and patient sat with equal access to the computer screen. Post visit surveys from patients seen in the experimental room versus patients seen in a traditional consultation room indicated that experimental room patients reported a statistically significant greater ability to look at the screen any time clinicians allowed them to review medical record and other shared information on the computer screen. These promising, first-of-a-kind results imply enhanced information sharing facilitated by furniture design and placement. Future studies might examine the impact of such computer screen access, facilitated by furniture design and placement on patient outcomes.

Facilitating good communication between patients and individuals in their social network represents one important aspect of social support. Privacy for confidential discussions has improved significantly because of the growing number of single inpatient rooms, and not just between patients and their loved-ones, but also between patients and providers. However, speech privacy breaches are common in a variety of screening, triage, and waiting room areas, where modular furniture is often used in more open and curtained spaces (Karro, et al, 2005; Olsen, et al, 2008; Olsen, Sabin, 2003; Mlinek, Pierce, 1997). Barlas and colleagues (2001) found that emergency department patients assigned to curtained multi-bed spaces versus rooms with solid walls reported less visual and auditory privacy and consequently 5 percent of the patients withheld portions of their medical history or refused components of their physical examination. Upholstered furniture constructed of high-performance sound-absorbing materials, like the acoustical panels used in modular furniture, may provide an additional auditory privacy solution worth exploring along with high-performance sound-absorbing ceiling tiles and flooring when care is provided in a more open environment.

EBD Goal 5: Decrease patient, family member, and staff stress and fatigue

- Materials suggest a link to nature.
- Appearance is attractive and non-institutional.
- Furniture is tested for safe and comfortable use by all, including morbidly obese individuals.

Many healthcare institutions are exhausting environments where the most personal and complex services are rendered. Visits are often stressful because of frightening and painful procedures—often performed by a staff that speaks a foreign language—and sometimes requires life-and-death decisions, all of which stresses patients, loved-ones, and staff alike. Care is frequently provided in daunting buildings with Byzantine-like windowless corridors filled with unfamiliar scents, sounds, and signs, complicating wayfinding. Such environmental challenges are in addition to the inherent stress and fatigue associated with many healthcare experiences today. Thankfully, a great deal of work has been done over the past 30 years, which began when the Planetree organization helped to focus the entire healthcare industry on the creation of innovative environments to facilitate healing, health, and well-being.

Design features that include or evoke nature have been used with great success to decrease patient stress. It has been hypothesized that humans have a genetic propensity to respond positively to nature, a phenomena called biophilia (Ulrich, 2008). Many studies demonstrate nature's positive impacts on patient outcomes when patients have views of nature, as summarized by Ulrich and colleagues in 2008. Park and Mattson (2009) demonstrated that patients recovering from a hemorrhoidectomy procedure and who had live plants in their room experienced lower blood pressure readings and lower ratings of pain, anxiety, and fatigue. Dijkstra and colleagues (2008) suggested that the perceived attractiveness of a room with plants was responsible for its stress-reducing properties.

Simulated nature views, whether through technology or art, help patients also. Even when nature itself cannot be viewed, studies have shown that viewing images of nature can decrease physiologic and behavioral stress responses such as pain and fatigue. In a study with chemotherapy patients, Oyama and colleagues (2000) demonstrated that cancer patients who used a bedside wellness system that provided a virtual walk in a forest had significantly less fatigue and emesis 3-5 days after a chemotherapy session. Patients undergoing flexible bronchoscopy procedures who could look at a ceiling-mounted nature scene and listen to nature sounds experienced less pain than patients who had no such experience (Diette, et al, 2003). Dental patients demonstrated fewer psychological and physiological markers of stress when a large nature mural was present in the waiting room, compared to the days when the wall was blank. (Heerwagen, 1990). Patients of all ages prefer art work that represents nature (Nanda, et al, 2007).

However, no research specifically links nature-inspired furniture fabric and its potential impact on patient stress and rest.

Healing gardens have been used effectively during the past decade to reduce patient, family members, and staff stress (Marcus, 2010; Ulrich, et al, 2008). Rodiek and Lee (2010) studied design features that encouraged outdoor use for 1,560 long-term care residents and staff from 68 randomly selected assisted living facilities in three diverse climate regions and found that a choice of comfortable sitting areas significantly contributed to residents spending more time outdoors. However, the type of furniture found in the healing gardens was not discussed. Marcus (2010) recommends that materials used in garden furniture not retain heat or cold, with wood and hard plastic being preferable. More research is needed to identify the best outdoor furniture materials and design necessary to elicit the best patient and staff responses.

Well-appointed patient rooms and spacious waiting rooms with comfortable furniture positively contribute to patient and family member satisfaction, decreased patient anxiety, and improved patient-provider communication (Leather, et al, 2003; Rice, et al, 2008). Becker and Douglass' 2008 study examined the relationship between the attractiveness of a clinic's physical environment and patient perception of quality, service and waiting time, finding positive correlations for each variable. They suggest greater attention be paid to patient comfort in the outpatient examination room, because, according to their study, patients spent almost one-third of their time waiting there. Some healthcare services, such as behavioral health, where comfort and safety is central to quality care (Matambanadzo, 2008), require longer periods of sitting than others.

The chair remains the piece of furniture most used to relieve patient, family member, and staff fatigue; it represents the most common healthcare furniture purchase, accounting for more than half of all furniture items. Comfort, safety, good ergonomic design, and other previously described characteristics are obviously important but can be challenging to meet when the needs of a wide-range of individuals must be considered. Add to this complexity the fact that 34 percent of American adults over the age of 20 are obese, with another 34 percent found to be overweight (CDC, 2008).

Bariatric furniture options have increased in recent years and should be included in the planning and programming of waiting rooms as well as with any furniture purchase for other locations, commensurate with population requirements. FGI

recommendations (2010, p.31) includes bariatric-specific design considerations in an appendix, recommending that waiting rooms include “appropriately sized elements with capacity adequate for the obese patient, interspersed with more traditional furnishings to avoid confining bariatric patients to specific areas of the waiting environment.” As accompanying family members are also often overweight or obese, consideration for their seating needs must also be taken into account.

Most waiting areas should include some bariatric seating, with the general rule of thumb being one bariatric seat for every 10 seats—a formula clearly at odds with the reality that two-thirds of the adult population is either obese or overweight (CDC, 2008). Designers typically use 16 square feet to plan for standard chairs compared with 30 square feet as an estimate for bariatric chairs or loveseats, a significant difference that impacts room circulation and design options. Sometimes loveseats can be used to support varied population groupings, such as a parent with a child or as a single bariatric seat. It is more challenging to include bariatric chairs in the small flexible groupings previously described that facilitate social support and communication. Space programming standards to accommodate the needs of a growing bariatric population require research and refinement to ensure that the appropriate space is planned for and budgeted.

Of concern is how to indicate that the furniture is built for bariatric patients, to alleviate the discomfort of obese patients worrying about fitting in a chair, or having a chair break under them. Different design approaches range from matching bariatric chairs to standard-size seating—so that obese patients do not feel like they are being singled out—to distinguishing bariatric furniture using different but complimentary colors and fabric. No research could be found that examined the response of bariatric patients to various design approaches and their consequent sense of comfort and safety using bariatric furniture.

The Business and Institutional Manufacturer’s Association together with the American National Standards Institute produce voluntary standards to guide furniture manufacturing. However, they have not yet developed nomenclature or standards for describing and testing bariatric or oversized furniture leaving each manufacturer to develop its own standard for a variety of higher weight-rated items. Typically, furniture manufacturers note that their bariatric chairs will hold between 300 to 400 lbs. FGI (2010, p.129) provides a new emergency department treatment room requirement for bariatric patients, including a requirement that “all furniture shall be floor-mounted and/or designed to accommodate 1,000 pounds.”

While bariatric seats can look like a large chair or a small loveseat, they are typically 30 inches wide or more and are made with steel supports for added strength and stability. Franklin Furniture Institute researchers at Mississippi State University's (MSU) Forest and Wildlife Research Center (Martin, et al, 2008) have developed a prototype furniture frame that simulates human sitting. Because the frame provides the chief source of strength, they are gathering live data on seating loads and measuring the impact on the frame. Arm strength represents another important consideration, as chair arms must be strong enough for the vertical and horizontal pressures associated with their crutch-like use. MSU is conducting chair loading tests using a prototype chair model with a seat height of 19 inches, seat width of 31 inches, a seat depth of 10.5 inches, an arm height of 25.5 inches. Results are expected in early 2011 (Martin, 2010).

Because there is no industry standard for bariatric healthcare furniture safety testing, purchasers must ask key questions and request documentation about the construction and testing of each product considered. Hubbard (2007) recommends asking about the following items:

- Frame composition. Steel frames of 16 gauge or lower and 1.25 inches or more with box welds at the joints are sturdier than wood frames.
- Cushion composition. Cushions with extra thick, high density, 100 percent urethane foam ensure that the individual's full weight does not rest on the chair cushion foundation.
- Chair cushion foundation. The chair cushion foundation should be at least 0.75 inches of engineered wood.
- Hardware composition. Screws, nuts, and bolts must be of sufficient grade and length to sustain heavy use.
- Furniture testing methods. Read the testing methods documentation and look for:
 - The maximum static load that a chair withstood during testing. Static load tests measure the amount of weight applied for a specific period of time, for example applying 400 pounds over 10 minutes.
 - The use of cyclic tests. Cyclic testing means repeated testing, for example applying a 400 pound weight for 10 minutes, 12 within four hours.

Staff fatigue, stress, and injury represent additional important issues to consider, as they can contribute to slower reaction time, reduced vigilance, deficits in information processing, and short-term memory impairment (TJC, 2008). The Joint Commission requires health care organizations to identify the conditions and practices that contribute to worker fatigue, implement processes to detect fatigue, and take action to mitigate risks to patient safety. Since much of worker fatigue is associated with inadequate sleep, the Veterans Administration in Palo Alto, California instituted a voluntary Strategic Nap Program for medical-surgical intensive care and intermediate care staff, including an education program, guidelines, and the creation of a napping room that included a residential bed. Preliminary results are positive, with participating staff reporting program effectiveness of 4.6 out of 5.0, such that the VA is now rolling out the program to more Palo Alto departments as well as across the VA system (AHRQ, 2010).

No published research could be found that addressed specific furniture used by staff as a means to effectively reduce fatigue. Howard (2008), the VA napping program creator, submitted a proposal to the American Institute of Architects' Health Revisions Guideline Committee to include strategic rest areas in the 2010 edition of the Guidelines for the Construction of Hospitals and Healthcare Facilities. However, current FGI (2010) requirements for staff lounges do not address furniture to facilitate staff rest, including naps; nor is the topic listed as an area targeted for study by the HGRC Research and Development Committee to support 2014 FGI guideline development. Much more research is needed to further understand the impact of furniture design as a tool to help mitigate staff fatigue.

Taking care of patients is physically difficult, especially when obesity has become a significant problem in America. Nurses are particularly vulnerable, given the amount of time they spend moving and repositioning patients during the course of care delivery, accounting for over 10 percent of all back injuries nation-wide (Fragala, Bailey, 2003), one-third of which are associated with patient handling (ANA, 2009). According to the Bureau of Labor Statistics (2007), nursing aides, orderlies, and attendants have the highest incidence rate of musculoskeletal disorders requiring days away from work, with registered nurses ranking fifth. It is estimated that more than 52 percent of the nursing workforce suffers from chronic back pain—a condition cited by 12 percent of nurses as a reason for leaving the profession (ANA, 2009). Many of the patient chair design characteristics to reduce patient injuries and falls

described previously may also help reduce the number of staff injuries that occur when assisting patients who are moving from the bed to the chair and back. Again this is an area that deserves more study.

A great deal of research about office furniture , ergonomics, and worker injuries was conducted over the past several decades, resulting in specific Occupational Safety & Health Administration furniture recommendations, perhaps the most important of which is that furniture be adjusted and tailored to the needs of each worker (OSHA, 2010). Additional recommendations for specific furniture feature include the following:

Chairs

- Backrests that conform to the natural curve of the worker and provide adequate lumbar support
- Comfortable seats that allow workers’ feet to rest flat on the floor or footrest
- Soft armrests that allow relaxed shoulders and elbows to remain close to the body
- A five-leg base with casters that allows easy movement along the floor

Desks

- Desk surfaces that allow computer monitors to be placed 20 inches away from and directly in front of the worker
- Designs that accommodate a variety of postures
- Ample space under the desk for leg clearance and non-awkward positions, but free of CPUs and other equipment

In addition to musculoskeletal disorders (MSD) associated with patient handling, nurses are also at risk for developing cumulative trauma disorders associated with computer use. The American Nurses Association (2010) reported to the Senate Committee on Health, Education, Labor & Pensions Subcommittee on Employment and Workplace Safety that “Healthcare workers are over represented for upper extremity MSD among worker’s compensation claims. Injured nurses contribute to about one-fourth of all claims and one-third of total compensation costs.” While there are many definitions of ergonomics, The National Council on Nursing

Research noted that the “application of patient care ergonomics to the patient-nurse-machine interaction” is a priority for nursing informatics research because nurses perform so many different tasks (Nielsen, Trinkoff, 2003). Tasks that may cause recurrent and persistent long-term pain and that involve many body parts include repetitive tasks and awkward postures associated with bedside charting, reaching for patient information, bending over patients, and sitting for long periods of time at the computer while entering patient information. McHugh, Schaller (1997) estimated that nurses worked 1.6 to 4.8 hours per shift at standing workstations. Clearly nurse work station design should be a high priority for research.

EBD Goal 6: Improve staff effectiveness, efficiency, and communication

- Furniture is easily adjustable to individual worker’s ergonomic needs.
- Design enables care coordination and information sharing.
- Materials are sound absorbing.

Staff represents the most precious resource for any healthcare organization, with fierce competition and investment dedicated to attracting and retaining the very best. The demand for a quality workforce is expected to continue to grow in future years as demographics shift and baby-boomers require more care. Fundamental changes in care delivery processes that more actively engage patients and their family members, coupled with a historically high level of healthcare facility construction (FMI, 2010), provide ample opportunity to improve the healthcare work environment and examine the role that furniture plays. Rapid changes in technology, particularly information technology, new care delivery processes, and shifting patient caregiver demographics, profoundly impact staff and healthcare work environment design features.

In each instance, furniture is needed to support patient care delivery performed by staff, provide staff respite, and support staff engaged in completing administrative tasks. Delivering quality patient care represents one of the most complex and challenging work experiences—one that depends on formal and information communication and collaboration across a multidisciplinary team. Becker (2007) proposed five factors to increase informal interactions and learning, all of which impact furniture requirements:

- Eco-diversity: more varied work settings inside and outside the “office”
- Spatial transparency: more opportunities for employees to observe the behavior of each other and the work they are doing
- Neutral zones: more deliberate planning, design, and use of spaces not owned by any particular discipline or unit
- Human scale: smaller-scale work areas on each floor and less separation of related functional areas
- Functional inconvenience: designing space to increase the opportunity for chance encounters.

In three pilot studies at the Cornell International Workplace Studies Program, researchers explored how the design of the physical inpatient unit environment impacted communication and interaction patterns between healthcare personnel, finding that seating orientation was one of many common themes found to influence communication and interaction patterns (Becker, 2010). The Joint Commission Center for Transforming Healthcare (2010) recently examined miscommunication between caregivers during patient hand-offs or transfers—estimated to account for 80 percent of serious medical errors—in 10 leading US hospitals, finding that handoffs were defective 37 percent of the time, with staff identifying an additional 21 percent of the handoffs as poor quality. More research is needed to understand the role that furniture might play, especially in those locations where handoffs frequently occur as a micro-design feature shaping preferred communication and collaboration. Research should include the patient room, team work rooms, and hubs—pivotal areas to the emerging Medical Home concept in primary care delivery—as well as inpatient unit nurses’ stations.

Recent design trends include the use of decentralized nurses’ stations, and using distributed supplies, to mitigate the amount of time nurses spend walking. One study of a 233-bed teaching nursing home (Burgio, 1990) estimated that nurses spent 28.9 percent of their time walking. Hendrich and colleagues (2008) found that the largest proportion (38.6 percent) of nurses’ time at medical-surgical units of 36 hospitals was spent at the central nursing station compared with less than one-third of their time in the patient room. These results were validated by Zborowsky, et al (2010) in their exploratory design study, conducted in two hospitals, that examined the ef-

fects on nurses' functional use of space in work environments with centralized versus decentralized nursing stations. The study results found that time spent at centralized nursing stations on the telephone, computer and performing other administrative tasks was significantly higher. Having decentralized nursing stations just outside each patient's acuity-adaptable room increased the nurses' time with patients and reduced the distance they had to travel when responding to patient's needs. Less travel time was associated with fewer patient falls (Hendrich, et al, 2004). Gurascio-Howard and Malloch (2007) found that patients thought nurses responded in a timelier manner from decentralized nursing stations. However, the nurses described fewer opportunities for informal mentoring, networking, and cooperating with other nurses.

In an ethnographic research project conducted by Steelcase's Nurture team, interactions at nurses' stations were studied to understand how care-givers work and patients receive care. They developed design principles that reflect the environmental features outlined in Becker's (2007) previously described factors: different types of spaces for interactive team work, visual connections to facilitate information seeking and interaction, flexible work spaces, small unit size to foster interaction, and neutral spaces that minimize professional and status hierarchies.

Five key design principles were identified to accommodate three activity zones (curb-side, step-in, and immersive space) to guide nurses' station design:

- Allow for control and flexibility
- Understand work processes
- Reduce cognitive load
- Maximize spatial relationships
- Support the social ecology (Bromberg, 2006)

Furniture designed using these principles supports multi-user work surfaces at three different heights, accommodating both sitting and standing staff (Eagle, 2008). However, in spite of careful product development research, no peer-reviewed published findings could be found that validate furniture design feature impact on staff and patient outcomes.

Noise reduction represents one environmental variable that furniture manufacturers have attempted to mitigate within the design, as described previously. Staff often reports noise as a distraction and stressor (Ulrich, et al, 2008; Joseph, 2007) and it has recently been found to be associated with increased risk of cardiovascular disease (Gan, et al, 2010). Studies suggest that a relationship between noise-induced stress and staff burnout among nurses (Morison, et al, 2003; Toft, Dillion, 1988), is linked to nurse dissatisfaction and intent to leave or even change their profession (Poncet, et. al., 2007 and Aiken, et. al., 2002). The Cost-effective Open-Plan Environments comprehensive research project by the National Research Council of Canada, Newsham (2003) found that job satisfaction was linked to privacy and acoustics. In addition to high-performance sound-absorbing acoustical ceiling tiles, sound-absorbing materials have been incorporated into panels in systems furniture to reduce noise. For federally funded projects, where systems furniture is used in open areas of a facility, acoustical panels must have a minimum noise reduction coefficient (NRC) of 0.65 (General Services Administration, 2008). The panels should ideally be higher than the head of the seated occupant, while balancing the need for privacy, daylight, and air circulation.

The Army Corps of Engineers Construction Engineering Laboratory (Schomer, et al, 1988) created a test house to examine mitigating strategies to minimize building vibration and rattle inside structures inhabited in areas of blast noise. When the test house contained furniture with items such as a small sofa, stuffed chair, table, cabinet, lamps, and drapes, they found that at frequencies above 200 Hz sound absorption by the furniture was sufficient to reduce the sound level in the room by 2 to 3 dB. At frequencies below 200 Hz, the furniture contributed negligible sound absorption. Exploring the use of sound-absorbing materials in upholstered furniture to absorb noise as an additional noise reduction strategy may be worth further inquiry.

EBD Goal 7: Improve environmental safety

- Materials do not contain volatile organic compounds (VOC), such as formaldehyde and benzene.

The US Green Building Council's (USGBC) internationally recognized program LEED – Leadership in Energy and Environmental Design—provides third-party verification that a building or community was designed and built using a variety of strategies to improve building performance measures, including indoor air quality.

The LEED program has transformed the design, construction, and facility maintenance industries. Since 1998, through the LEED Green Building Certification System, almost 20,000 projects have been registered and 2,476 projects certified, with many more projects anticipated given expected healthcare sector growth (USGBC, 2009). The Green Guide for Health Care (GGHC) (2007) provides a tool-kit to enhance environmental principles and practices across a healthcare facility's life cycle.

Material and resource credits are awarded based on furniture requirements regarding the level of toxic emissions produced by the product after installation. Avoiding furniture that emits Volatile Organic Compounds (VOCs), including formaldehyde and benzene (GGHC, 2007; FGI, 2010) and Persistent Bioaccumulative Toxic chemicals (PBTs), can positively contribute to indoor air quality (GGHC, 2007).

USGBC and GGHC have collaborated to create the LEED 2009 for Healthcare Rating System, which is expected to be available for project certification in the spring of 2011 and will use a point scale with weighted credits similar to the LEED Design and Construction certification system. The intent of the LEED 2009 for Healthcare Rating System's Materials and Resources credit for furniture and medical furnishings is to "enhance the environmental and human health performance attributes associated with freestanding furniture and medical furnishings products." (U.S. Green Building Council, 2011, p. 61.) One of the credit requirements is that all furniture components contain less than 100 parts per million of at least four of five chemical groups:

- Urea formaldehyde
- Heavy metals including mercury, cadmium, lead, antimony
- Hexavalent chromium in plated finishes
- Stain and non-stick treatments derived from Perfluorinated Compounds (PFCs), including Perfluorooctanic Acid (PFOA)
- Added antimicrobial treatments (U.S. Green Building Council, 2011, p. 61.)

The new LEED credit requirements will be considered as potential additional checklist variables when the checklist is next updated.

EBD Goal 8: Represent the best investment

- Reflect and reinforce the organizational mission, strategic goals, and brand.
- Integrate new with existing furniture and objects for facility renovation projects.
- Pieces can be flexibly reconfigured and moved to support changing and emerging missions.
- Provide casters or glides to reduce floor damage.
- Check that there are no hard protuberances that may damage walls; check chair rail heights.
- Manufacturer provides results of safety and durability testing.
- Manufacturer describes the specific evidence that has been used to design the product.
- Manufacturer includes a warranty appropriate to use, such as furniture used all day, every day.
- Replacement parts are available.
- Repairs can be done in the healthcare facility.
- Manufacturer or local dealer can assist with furniture repair and refurbishing.
- Environmental services (housekeeping) staff can easily maintain furniture.
- A Group Purchasing Organization (GPO) can be used when purchasing furniture.

Like all major purchases, healthcare leaders must ensure that furniture acquisition is based on best-investment practices for their institution. Although no published evidence-based design, return-on-investment (ROI) analysis associated with furniture purchases could be found, certain considerations are important for every major investment whether it is medical equipment, information technology, or furniture. An important first step is to consider how the new furniture will fit with the overall aesthetic—one that reflects organizational mission, strategic goals and brand, and existing objects. Engaging facility management and environment-of-care experts in the purchasing process is essential to ensure that potential furniture is evaluated for easy maintenance and its potential environmental harm. Furniture with hard protuberances may damage walls; a lack of casters or gliders could tear softer flooring materials more frequently used now to mitigate patient falls and staff fatigue. Furniture salesmen should have ready access to product safety and durability testing results, such as the research used to design the product, organism growth testing—in-

cluding cleaning solution and methods requirements—weight-load tolerance testing, and sustainability features, as well as any published research involving the product.

Because healthcare missions evolve rapidly to accommodate shifts in patient demand and changing technology, furniture choices should be evaluated for their flexibility to be reconfigured and moved. Herman Miller (2009) and Steelcase’s Nurture (Orsborn, 2008) suggest furniture standardization as a means to balance the “surety of change,” in order to facilitate the following:

- Rapid response to changing missions, including emergency preparedness and response situations
- Improved cost efficiencies—limited inventory; fewer purchasing processes
- More efficient materials management—fewer products to adjust, clean, and maintain, such as:
 - Sizes that mix and match and are easily moveable, providing reconfiguration flexibility
 - Standard rather than custom finishes
 - A palette of fabrics, choosing the most limited finishes first
- Upholstery cleaning requirements can be accomplished by the environmental services team
- Consistent facility-wide aesthetic that reflects the organization’s brand

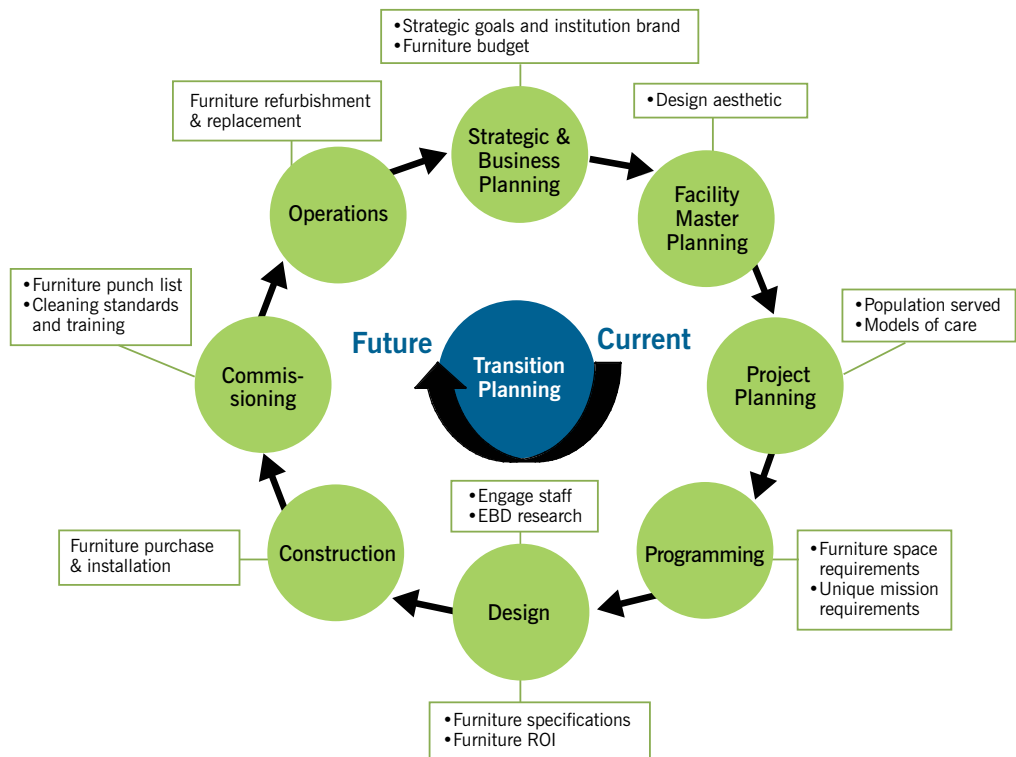
On-going manufacturer or local dealer support represents another important consideration to maximize furniture dollars. Ensuring that the furniture comes with a warranty specific to use length and conditions is important, as some furniture, such as in an emergency department waiting room, is used all day, every day. The availability of replacement components for heavily used furniture parts could mean potential additional life cycle cost savings. Ascertaining whether the manufacturer or local dealers can repair and refurbish damaged furniture—ideally within the healthcare facility—can reduce costs by reducing turn-around time and eliminating expenditures associated with full-replacement costs. Eagle (2010) recommends drafting a request-for-proposal to provide detailed information about the organization and information about the topics just described, as well as delivery options, staff training, pricing quotes, and payment terms. The responses would facilitate a side-by-side comparison of the proposals.

The US laboratory and hospital (excluding dental) institutional furniture manufacturing industry represents big-business, with a total product shipping value of \$4.2 billion in 2002, as reported by the US Department of Commerce, Census Bureau, Economics and Statistics Administration (2004). Key to selecting the best manufacturer is identifying healthcare furniture manufacturers who have been recognized for their expertise, have a broad range of products to support the full healthcare continuum, are financially strong, can support the furniture’s life cycle requirements, and who remain committed to conducting and publishing the research about how furniture can contribute positively to healthcare outcomes and maximize furniture investments.

Using the EBD Furniture Checklist across the Furniture Life Cycle

Furniture evaluation and selection occurs in a repetitive fashion over the life of a facility. In Figure 4, The Facility Life Cycle Management and Performance model (Malone, Mann-Dooks & Strauss, 2007) with its well-known life-cycle phases was modified to create a Furniture Life Cycle Model that includes corresponding furniture considerations. Furniture related activities for each phase are described in this section along with suggested checklist use opportunities.

FIGURE 4
Furniture Life Cycle Model



Strategic, Business, Facility Master and Project Planning The eight broad goals found on the EBD Furniture Checklist provide an important research-and-standards-based framework to use when considering how to realize the organizational strategic goals. During strategic and business planning phases, organizational and sustainability goals and desired outcomes are identified and used to shape project decision-making. Although specific furniture choices per se are not usually dealt with during this phase, project principles, goals, and the budget issues will impact furniture selection, as furniture aesthetics are expected to reflect the overarching strategic vision, mission, and goals or brand, and not exceed budget allowances. Furniture typically accounts for roughly 2 to 4 percent of the capital budget for new facilities and renovation projects; most administrators consider furniture a sunk cost, typically depreciating systems furniture over a 7-year period and other furniture over 25 years.

Furniture warranties have become another common investment variable, with some hospitals now requesting a minimum 10-year warranty that typically covers the furniture workmanship and structure. Designers find that some—but not all—furniture manufacturers can repair and refurbish furniture, but that it is also not uncommon for facility managers to discard broken furniture rather than pursue warranty guarantees. Rarely is furniture thought of as a performance improvement tool for which a return-on-investment analysis is conducted. *Facility master planning* integrates new projects into an institution's facility portfolio, ensuring that aesthetics are linked to support strategic goals. Furniture represents one of the most ubiquitous objects found in any healthcare care organization, significantly contributing to first impressions (Orsborn, 2008). *Project planning* provides a detailed description of the population to be served and the models of care to be used, both of which profoundly impact furniture requirements. Visioning sessions are frequently used to translate strategic and operational goals into an image or brand that reflects the institution's aesthetic.

Programming, Design, Construction and Commissioning. These phases represent the portion of the life cycle when thousands of furniture options and decisions occur, resulting in the specification of furniture requirements, selection, purchase, and placement. Well conceived projects engage interior designers during programming activities so that adequate space is planned to accommodate furniture requirements. Unfortunately, furniture is not always fully considered during *programming*, frequently resulting in a search for furniture that can be retrofit into a room or space with fixed boundaries. Such an oversight can often result in negative and long-lasting impacts

on patient care delivery and family support functions. If small groupings of chairs are desired in a large waiting room to allow for privacy and flexibility, additional space will be needed beyond the norm of 16 square feet per person and even more space if the population served requires more bariatric furnishings. If a sleep sofa that opens is needed in the patient room, additional space is required. Most of the furniture-related decisions—a component of the interior design package—occur in the *design phase*. Historically, design aesthetics, function, and cost drive the most important decisions. Evidence-based design considerations, especially those related to sustainability concerns are now more routinely considered as a component of interior design specifications. The EBD Furniture Checklist can be used to guide the product inquiry and evaluation, facilitate discussion about desired features, and provide a baseline for comparing products. During the *construction* phase, interior designers generally finish furniture specifications and coded plans, which are then put out to bid either by the facility manager or the designer. They then work with the selected manufacturing companies to ensure that furniture specifications are met, including those specified through use of the EBD Furniture Checklist. Frequently, to support the myriad administrative activities that begin at the end of the construction phase, some of the furniture is needed long before the facility opens for patient care. Patient furniture is often installed just before opening. The EBD Furniture Checklist can be used along with the punch list during the *commissioning* phase to identify and replace any damaged furniture. Housekeeping and environment of care teams receive training about the manufacturer-recommended furniture cleaning and maintenance practices.

Transition Planning. This phase includes all of the necessary activities to move an organization from its present state, across all of the project phases, to occupancy and the future state. It begins the moment a decision has been made to pursue a facility project of any size or scope. Included in transition planning activities are the pre-occupancy measurements of baseline outcome variables that the furniture would be expected to impact. The checklist can provide a framework for pre and post occupancy evaluation, as well as a staff educational tool that helps staff to understand the research that underpins furniture features and healthcare outcomes.

Operations. The operations phase remains the longest of any facility's life cycle phases, requiring countless furniture decisions and investments over a 30-year plus timeframe to accommodate wear and tear, mission changes, and facility renovations. Frequently, the initial furniture specifications for a new facility become the stan-

dards for all replacement items over the life of the building. Interiors are regularly refreshed, necessitating additional furniture purchases in keeping with the new image. Oftentimes these renovations occur in a piece-meal fashion requiring careful furniture selection to create a sympathetic bridge between old and new spaces. In busy, high-volume public spaces, furniture may need to be replaced or refurbished as frequently as every three to five years.

Many furniture options and ultimate selections are recommended by facility managers and often approved by c-suite leaders who face an endless range of choices and who often lack a framework for considering these investments relative to the overarching healthcare outcome goals for the organization, including patient safety goals, which may provide important decision discriminators. The EBD Furniture Checklist provides a tool that can be used to facilitate furniture evaluation and investment decisions across each life cycle phase, especially important during new facility projects and major renovations. Practical considerations for checklist use during each Furniture Life Cycle Phase are summarized in the article, *Using an Evidence-based Design Furniture Checklist* (Malone, Dellinger, 2011, in Press).

Checklist users are urged to share their experiences and recommendations with the Director of Research for The Center for Health Design at ajoseph@healthdesign.org. The feedback will be used along with new research findings to refine the checklist and keep it current. Additional checklist development may include the creation of checklists specific to furniture types and for specific practice environments, such as cancer care. Furniture manufacturers will soon find the line blurring between healthcare institutional care furniture requirements and furniture needed at a patient's home, where many strategic healthcare leaders imagine much care will migrate because of new technologies, demographic shifts, patient preferences, and healthcare trends (Landers, 2010). A version of this checklist could be developed in tandem with such organizations such as Consumers Report to guide a broader lay population when purchasing or renting home furniture.

Research Recommendations

Furniture used in a healthcare setting must achieve a different and higher standard from furniture used in the hospitality industry. Hospitals are not hotels. As discussed in this article, patients are vulnerable and at high risk for many of the patient safety issues plaguing healthcare today. Just as with all objects and individuals involved in the complex choreography that healthcare delivery depends on, research reveals that furniture can play a role in eliminating patient harm and improving the healthcare experience for patients, their families, and caregivers. However, much more human factors engineering research is needed to better understand the precise role furniture plays in organizational vulnerabilities and healthcare outcomes. In addition, an analysis about the quality of the existing furniture research would strengthen the EBD science. Specific research recommendations are made throughout this article (see Table 4). A number of additional research recommendations were provided by the multidisciplinary subject matter experts (as noted by name) who reviewed an earlier checklist version.

Table 4 Recommended Research Topics

EBD GOAL	RECOMMENDED RESEARCH TOPICS
General EBD furniture research	<ul style="list-style-type: none"> • Human factors evaluation of furniture and its impact on care providers, patients, and their families • Home furniture and its ability to support safe quality-care delivery outside of healthcare institutions
Reduce surface contamination linked to healthcare-associated infections	<ul style="list-style-type: none"> • Furniture surface durability associated with the use of CDC Environmental Infection Control Guidelines for Healthcare Facilities cleaning and disinfectant methods and materials (Bartley, 2010) • Furniture surface organism growth and patient HAI rates after cleaning and disinfecting furniture made of the following materials (Leib, 2010): <ul style="list-style-type: none"> ◦ Monofilament or coated mesh material ◦ Self-skimming foam ◦ Micro-porous membrane upholstery like Gore ◦ Washable slip covers ◦ Material that allows furniture to be cleaned using cart-washing technology ◦ The impact of a Federally-sponsored collaborative partnership to strategically map product, process, and technology innovations needed to minimize furniture surface contamination and facilitate effective cleaning.
Reduce patient falls and associated injuries	<ul style="list-style-type: none"> • Association between furniture features and patient falls and associated injuries • Impact of adaptive seating designs on patient fall and injury rates • Impact of chair seat height, use of arm rests, and foot position on chair egress and falls • Impact of pivoting arm rests on patient falls and injuries • Impact of arm rest length and angle on patient falls and injuries

Table 4 Recommended Research Topics (Continued)

EBD GOAL	RECOMMENDED RESEARCH TOPICS
Decrease medication errors	<ul style="list-style-type: none"> • Relationship between work surface height adjustment and medication errors (McDermott, 2010) • Relationship between work surface space design and medication errors (Bromberg, 2010) • Relationship between illumination, print size, and medication errors in a variety of medication safety zone environments (Ulrich, 2010) • Relationship between illumination and medication errors among workers of varying ages (Ulrich, 2010) • Relationship between unpredictable noise and medication errors • Use of sound-absorbing materials in upholstered furniture and its impact on sound decibel levels in patient care areas
Improve communication and social support for patients and family members	<ul style="list-style-type: none"> • Impact of inpatient room furniture configuration on patient and family communication patterns (Leib, 2010) • Use of sound-absorbing materials in upholstered furniture and its impact on noise and consequent patient privacy and communication concerns
Decrease patient, family member and staff stress, fatigue and safety	<ul style="list-style-type: none"> • Impact of inpatient room configuration on patient, family member, and staff stress • Therapeutic impact of furniture upholstered with nature-themed fabrics on patient, family member, and staff stress • Impact of furniture that promotes short-period relaxation on staff stress and fatigue levels (Leib, 2010) • Impact of heated chair seat cushions on patient stress (Delmetri, 2010) • Correlation of outdoor furniture materials and patient preferences • Impact of various furniture options in staff rest areas (nap rooms, break rooms) on staff fatigue and stress • Relationship between patient chair design and staff injuries • Means to indicate bariatric-developed furniture
Improve staff effectiveness, efficiency and communication	<ul style="list-style-type: none"> • The role of furniture configuration on staff effectiveness, efficiency, and communication • How decentralized and centralized nurses station furniture impact patient handoffs • Relationship between medical home furniture design and effective and efficient caregiver team communication
Improve environmental safety	<ul style="list-style-type: none"> • Impact of antimicrobial treatments on environmental and human health.
Represent the best investment	<ul style="list-style-type: none"> • Create a valid and reliable furniture EBD return-on-investment model to evaluate costs and return over the furniture life cycle?

Our first and strongest recommendation is that furniture manufacturers routinely share their furniture research and development work in peer-reviewed journals. Given manufacturer proprietary and competitive edge concerns, industry mechanisms must be established to facilitate this outcome and allow manufacturers to remain successful. We strongly recommend that all future research be conducted using a multi-disciplinary approach to include manufacturers, clinicians, designers, facility managers, patient safety experts, human factors engineers, and industry standards-making institutions to ensure that each stakeholders' unique perspective is considered.

The British provide an interesting multi-disciplinary model of collaborative innovation for consideration. In 2008, The British Department of Health and the National Health Service Supply Purchasing and Supply Agency commissioned the British Design Council as a part of its HCAI Technology Innovation Programme to speed the development and adoption of new and novel technologies to combat HAIs (British Department of Health, 2010). The Design Council partnered with the British Design Business Association, who sponsored a design competition to find new designs for five complex healthcare design challenges—one of which was included the patient chair and bedside cabinet found in the bedside environment. The goal was to design a complete bedside system that is easy to clean and maintain, cost effective, and sustainable.

The resulting patient chair is made of a molded plastic shell that minimizes joints on a stainless steel frame with an adjustable gas lift. Interchangeable foam-filled waterproof cushions with removable fabric cases—changed with the bed linen—are held in place by magnets, facilitating individual patient comfort. Cushions can be individually replaced if damaged; plastic arm rests can be removed for complete cleaning (Design Bugs Out, 2010; Pro Nurse Design Bugs Out, 2010). Furniture prototypes are being used and tested at eight National Health Service Trust healthcare facilities, with results expected in 2011.

This collaborative, multi-disciplinary approach provides an exciting and replicable method for harnessing evidence-based technology and creative solutions vetted with front-line staff to quickly prototype, test, and produce furniture that may help to reduce surface contamination, which causes most HAIs. With the establishment of the Center for Medicare and Medicaid Innovation in 2010, perhaps the time has arrived to create a federally sponsored collaborative partnership to strategically map product, process, and technology innovations needed to minimize furniture surface contamination and facilitate effective cleaning and foster other furniture research and development activities.

Furniture Standards Development Recommendations

The research findings described in this paper suggest many opportunities to broaden and improve government and industry standards, particularly those that deal with patient safety issues. Government and industry standards are non-specific about which organisms must be tested by furniture manufacturers, in spite of the growing number of antibiotic resistant organisms and consequent difficulty in treating subsequent HAIs. Much confusion exists about

manufacturer assertions that materials impregnated with antimicrobials—those substances that will inhibit organism growth—will reduce surface bio-load contamination and thus help to prevent HAIs. As there is no government requirement or voluntary industry standard that specifies the organisms that must be tested on furniture, some manufacturers have begun to assert antimicrobial-properties for their furniture when only one organism has been tested. FGI (2010) found insufficient evidence to recommend antimicrobial treated fabrics and surfaces in the latest version of their guidelines (Bartley, Olmsted, Haas, 2010). Also of concern is the use of proprietary chemicals by manufacturers and their impact on human health and the environment. Table 5 summarizes other industry standard development recommendations made throughout the paper.

Table 5 Recommended Furniture Standards Development

EBD GOAL	RECOMMENDATION(S) FOR STANDARDS DEVELOPMENT
Reduce surface contamination linked to healthcare-associated infections	<ul style="list-style-type: none"> • Use a standard industry approach for testing specified HAI-associated organisms on furniture surfaces after recommended cleaning and disinfection, as a component of published product development and research. • Develop a lexicon to describe and simplify required cleaning and disinfection processes. • Use an anti-microbial definition that includes chemical property characteristics using standard testing methods.
Reduce patient falls and associated injuries	<ul style="list-style-type: none"> • Explore the expansion of the CDC's National Health Safety Network to include voluntary reporting mechanisms about the circumstances surrounding patient falls. • Expand CMS's instructions to Quality Improvement Organizations to include information about furniture variables associated with patient falls and injuries.
Decrease medication errors	<ul style="list-style-type: none"> • Reevaluate the Illuminating Engineering Society of North America reference "Lighting for Hospitals and Healthcare Facilities" in view of the 2010 United States Pharmacopeial Convention recommended lighting recommendations for medication safety zone illumination. • Expand the Institute for Safe Medication Practices' medical Errors Reporting Program to include environmental feature variables, including furniture features.
Improve communication and social support for patients and family members	<ul style="list-style-type: none"> • Reevaluate recommended programmed space to support inpatient room family zones as well as family support in ambulatory care examination and treatment locations.
Decrease patient, family member, and staff stress and fatigue	<ul style="list-style-type: none"> • Develop bariatric furniture standards for construction and testing. • Reevaluate recommended programmed seating space for handicapped and bariatric furniture.
Improve staff effectiveness, efficiency, and communication	<ul style="list-style-type: none"> • Consider the impact on staff effectiveness, efficiency, and communication of various staff furniture design configurations, including decentralized nurses stations and centralized team work rooms. • Consider the impact on staff outcomes of furniture that accommodates wireless technology use.

Conclusion

Healthcare facilities provide the physical structure that shapes care delivery and the experience of patients, their families, and the staff who care for them, ultimately impacting healthcare outcomes and cost. With healthcare expenditures now representing 17.6 percent of the GDP (Martin, et al, 2011), attention must be focused on all of the many variables that contribute to healthcare costs, directly and indirectly. Porter (2010) describes healthcare value as the health outcomes achieved per dollar spent; he includes structure as one of the factors that can influence or enable processes that result in improved outcomes.

In this article, we have focused on furniture as one of the many structural elements that research has revealed can play an important, but often unconsidered role, in quality care outcomes. Existing research findings have been translated into a practical checklist tool to facilitate furniture decision-making activities across the furniture life cycle to maximize investments. Through its development and use, we have learned that the checklist also provides designers with a helpful evaluation and communication tool when developing furniture solutions for their clients. We have identified many research opportunities for interdisciplinary teams to expand the science and help us better understand the role furniture plays in affecting outcomes, as well as recommending specific examination of government and industry standards to enhance patient safety and improve the healthcare experience. As a result of this work, we have come to appreciate that furniture represents far more than just something to sit on, an overhead expense, or sunk cost, but rather an important piece of the quality healthcare puzzle.



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APPENDIX

FIGURE 3
Evidence-Based
Design Checklist

Findings Scale:
Present (+), Absent (-),
More Information Needed (?),
Not Applicable (N/A)

Findings	EBD Goals and Furniture Features
	1. Reduce surface contamination linked to healthcare associated infections^{1 2}
	a) Surfaces are easily cleaned, with no surface joints or seams. ^{3 4 5}
	b) Materials for upholstery are impervious (nonporous). ^{6 7 8}
	c) Surfaces are nonporous and smooth. ⁹
	2. Reduce patient falls and associated injuries¹⁰
	a) Chair seat height is adjustable. ^{11 12 13 14 15}
	b) Chair has armrests. ¹⁶
	c) Space beneath the chair supports foot position changes. ¹⁷
	d) Chair seat posterior tilt angle and seat back recline facilitate patient egress. ¹⁸
	e) Chairs are sturdy, stable, and cannot be easily tipped over. ^{19 20 21}
	f) Rolling furniture includes locking rollers or casters. ²²
	g) Chairs have no sharp or hard edges that can injure patients who fall or trip.
	3. Decrease medication errors²³
	a) Lighting fixtures should provide 90-150 foot candle illumination and an adjustable 50-watt high intensity task lamp for furniture with built-in lighting that is used in a medication safety zone. ^{24 25}
	b) Furniture is configurable to create a sense of privacy to minimize visual distractions and interruptions from sound and noise during medication transcription, preparation, dispensing, and administration activities. ^{26 27}
	4. Improve communication and social support for patients and family members²⁸
	a) Furniture can be configured into small flexible groupings that are easily adjusted to accommodate varying numbers of individuals in a variety of healthcare settings. ^{29 30 31}
	b) Wide-size and age variations are supported. ³²
	c) Acoustic and visual patient privacy are supported. ^{33 34 35 36 37 38}
	5. Decrease patient, family member, and staff stress and fatigue³⁸
	a) Materials suggest a link to nature. ^{39 40 41 42 43}
	b) Appearance is attractive and non-institutional. ^{44 45 46 47}
	c) Furniture is tested for safe and comfortable use by all, including morbidly-obese individuals. ^{48 49 50}
	6. Improve staff effectiveness, efficiency, and communication
	a) Furniture is easily adjustable to individual worker's ergonomic needs. ⁵¹
	b) Design enables care coordination and information sharing. ^{52 53}
	c) Materials are sound absorbing. ^{54 54 56 57 58 59}
	7. Improve environmental safety
	a) Materials do not contain volatile organic compounds (VOC), such as formaldehyde and benzene. ^{60 61 62}
	8. Represent the best investment
	a) Reflect and reinforce the organizational mission, strategic goals, and brand.
	b) Integrate new with existing furniture and objects for facility renovation projects.
	c) Pieces can be flexibly reconfigured and moved to support changing and emerging missions.
	d) Provide casters or glides to reduce floor damage.
	e) Check that there are no protuberances that may damage walls; check chair rail heights.
	f) Manufacturer provides results of safety and durability testing.
	g) Manufacturer describes the specific evidence that has been used to design the product.
	h) Manufacturer includes a warranty appropriate to use, such as furniture used all day, every day.
	i) Replacement parts are available.
	j) Repairs can be done in the healthcare facility.
	k) Manufacturer or local dealer can assist with furniture repair and refurbishing.
	l) Environmental services (housekeeping) staff can easily maintain furniture.
	m) A Group Purchasing Organization (GPO) can be used when purchasing furniture.

Source: Malone, E. B. &
Dellinger, B. A. (2011).
*Furniture design features
and healthcare outcomes.*
Concord, CA: The Center for
Health Design

FIGURE 3
(continued)
Evidence-Based
Design Checklist
Instructions

Product: _____ Manufacturer _____

Cost: _____ Date _____

Notes:

The purpose of the **Evidence-Based Design (EBD) Furniture Checklist** is to help improve targeted healthcare outcomes by providing healthcare leaders and designers with an evidence-based tool that assists them in making the best furniture investments. Furniture generally includes chairs, sofas, tables, systems and built-in furniture and does not include the patient bed or carts that support medical procedures. The checklist is divided into eight sections that correspond to common EBD goals for which furniture has been shown to play a role. Each section includes recommended furniture features based on cited research and standards, which are in the References Appendix.

EBD Furniture Checklist Instructions and Summary Information about Variables

Information about furniture features can be gleaned from numerous sources: manufacturer product brochures, websites and catalogs; furniture manufacturer and dealer representatives; and furniture trade publications. Use the checklist to guide inquiry and product evaluation, facilitate team and client communication about desired furniture features, to compare furniture options, and evaluate existing furniture.

A scale is provided to indicate whether the degree to which the furniture being reviewed has the recommended features:

(+) Present – The furniture has the feature

(-) Absent – The furniture feature is absent

(?) More information needed – Cannot determine if the feature is present. Need more information from the manufacturer.

(N/A) Not applicable – Some features will only apply to certain types of furniture.

Additional information about each checklist variable:

1a - Joints and seams complicate effective cleaning, creating organism reservoirs that can further the spread of contact transmitted healthcare associated infections. A space between the chair back and seat can facilitate cleaning.

1b - Contaminated body fluids soak into porous upholstered furniture complicating effective cleaning

1c - Nonporous, smooth solid surfaces such as laminate or poly resin products facilitate effective cleaning.

Note: Hard metal surfaces like copper and surface antimicrobial treatment claims presently lack sufficient evidence for efficacy.

2a/b/c/d – Chair seat heights sized to individual needs, armrests, and space beneath a chair to support posterior foot placement facilitate safer sit-to-stand movements.

2e - Increased chair posterior seat tilt and increased chair back recline interferes with egress, especially in older adults.

2f - Tipped-over-furniture-caused injuries for children are increasing

2g - Locking rollers and casters prevent unwanted furniture movement

2h - Sharp furniture edges, such as wooden chair arms with corners, can injure vulnerable patients who bump into them

3a – For systems and built-in furniture used in an area where medications are prescribed, medication orders are entered into a computer, or onto paper documents, and where medications are prepared and administered that includes lighting, brighter illumination results in fewer visual medication errors

3b - Distractions and interruptions are associated with more medication errors

4a - Smaller, more intimate furniture groupings foster communication

4b/c - Systems furniture should include acoustical panels with a minimum noise reduction coefficient of 0.65

5a - Humans have a genetic propensity to positively respond to nature

5b - Perception of quality, service, and waiting time are linked to physical environment attractiveness. Non-institutional appearing environments are associated with less patient stress

5c – Sixty-eight percent of Americans are either overweight or obese and require furniture safely designed for their comfort

6a - OSHA recommends furniture that can be tailored to worker ergonomic requirements

6b - Quality healthcare delivery depends on informal interactions by the healthcare team, facilitated by furniture design

6c - Noise distracts and stresses staff, resulting in more time needed to complete procedures and in staff burn-out

7a - Furniture made with VOCs is a source of indoor air pollution

8a - Furniture provides important visual cues about the healthcare organization

8b – Furniture color, material, and style contribute to an image

8c - Emergency preparedness and response situations require furniture that can be easily moved and reconfigured

8d – Some soft flooring products used to reduce noise, fatigue and injury are more vulnerable to furniture-caused damage

8e - Hard furniture protuberances can damage walls

8f - Manufacturer-conducted furniture testing for safety and durability is required; ask for the results

8g - Manufacturers engage in significant product design and research; ask for the results

8h - Some furniture is used 24 hours a day, every day

8i - The availability of replacement furniture parts, especially for those components exposed to more wear and tear can prolong the life of the object

8j - Furniture that can be repaired in the healthcare facility will be potentially out of use for a shorter period of time

8k - Manufacturer or dealer-supported furniture repair and refurbishing will prolong the life of the object

8l - The environmental services team must be able to easily clean, disinfect, and maintain the furniture; involve them!

8m - Group purchasing organizations are used to lower costs



CHECKLIST REFERENCES

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