The Impact of Healthcare Environmental Design on Patient Falls

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Abstract

Falls in healthcare settings are a frequent occurrence, costing approximately $3.6 billion annually and having significant negative outcomes for fallers. The physical environment is an often-overlooked factor that can serve either to increase risk or mitigate risk. A literature review was conducted to explore environmental correlates of falls in healthcare settings. Information was categorized according to four environmental factors that emerged as common across healthcare populations and settings: (a) spatial organization, (b) interior characteristics, (c) sensory attributes, and (d) use of environment. While the quality of some of the information is well-grounded, much of it requires interpolation or further study because specific characteristics of the physical environment are either poorly articulated or missing altogether.

Acknowledgements

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Introduction

The phenomenon of falls is a growing concern in various community, workplace, and healthcare settings. When falls occur, three important interrelated aspects demand attention: the health and physical condition of the faller, a risk of fall recurrence, and the immediate and long-term costs associated with a fall. Fall incidents are precipitated by personal (e.g., physiological) and environmental (e.g., type and condition of floor) factors. Interventions aimed at fall reduction vary in their emphasis; some identify and monitor individual conditions of the person experiencing the fall, others seek to alter specific environmental circumstances surrounding the fall incident.

The majority of research focuses on community-based falls and addresses factors influencing the safe, independent mobility of people (particularly older adults at risk of recurrent falls) within their homes and surroundings. There have also been some efforts at studying fall-prevention measures to maintain worker safety (OSHA, 2007) and create awareness of fall risk factors. For example, O'Dell (1998) discusses fall-related workplace concerns among employees who spend long hours on their feet. However, regardless of the location of a fall, many fall-related incidents result in at least a visit to a healthcare setting, and often a more extended stay. Given that a previous fall is the number one risk factor for a future fall, healthcare settings must attend to a complex interaction of intrinsic and extrinsic factors that collectively contribute to fall risk and falls among their patients.

Falls occur in various types of healthcare settings—surgical units, perioperative units, labor/delivery/recovery/postpartum units, rehabilitation units, nursing homes, assisted living centers, etc. Although older adults are more prone to fall risk than younger people (Brandis, 1999), falling and fall-related injuries are pervasive phenomena among those younger than 65 as well (Rollins, 2004) and present expensive post-fall healthcare and litigation costs. While some research has examined fall risk factors related to cohorts of individuals with similar conditions, such as lower-limb amputees (Gooday & Hunter, 2002), people in palliative care (Goodridge & Marr, 2002), cancer patients (Holley, 2002), people with dementia (Van Doorn,et al. 2003), and visitors (Sicher, 1995), much of the focus in the literature is on intrinsic factors only. However, the pervasiveness of falls in healthcare settings suggests a need to take a broader perspective. Recognizing that widening the perspective will better define the role of environmental factors in fall detection and prevention, this report explores environmental correlates of falls in healthcare settings.

The Scope of the Problem

In 2005, there were 1.8 million fall-related nonfatal injuries (e.g., fractures, traumas) that were severe enough to seek medical attention; while in 2003, there were 13,820 fall-related fatalities among people 65 years and older (National Center for Injury Prevention and Control, 2006). Approximately 10% (or 180,000) of these fall-related injuries occurred in healthcare institutions (ECRI, 2006). The Minimum Data Set (MDS) active resident information report indicates that state rates of nursing home residents falling during a six-month period vary from 16.9% to 35% (CMS, 2005), which translates to roughly 593,700 falls. However, there is other evidence that the MDS underreports falls (Hill-Westmoreland & Gruber-Baldini, 2005).

Risks of recurrent falls and injuries from falls present both direct insurance costs and legal/liability costs and consequences (National Center for Injury Prevention and Control, 2006; Zinn, 2003). The average healthcare cost for a fall injury (without factoring in physician services) was close to $20,000 (Rizzo et al., 1998) and continues to rise. The direct costs for fall-related injuries in the United States for people 65 and older are projected to reach $43.8 billion by the year 2020 (Englander, Hodson, & Terragrossa, 1996), of which at least $3.6 billion would be associated with falls occurring within a healthcare setting. Thus, there are significant financial reasons why attending to risk factors for falls and injuries from falls is an urgent task at the core of many research efforts.

Challenges in Conducting Falls Research

Underreporting and inconsistencies in reporting are complicated by multiple definitions of falls both in literature (Zecevic, Salmoni, Speechley, & Vandervoort, 2006) and in hospital and nursing home incident reports. Further, falls are typically unanticipated events, and, thus, are seldom directly observed. As such, most falls are retrospectively recorded in incident reports. This retrospective process has led to the documentation of person-related factors such as physiological or psychological condition and medication, but often insufficient documentation of environmental conditions surrounding the fall. Additional challenges are presented when falls occur outside the purview of a documentation system such as an incident report, e.g., when hospital visitors fall. These types of incidents are likely to be severely underreported in terms of both frequency of occurrence and description of factors that led to the incident. Beyond these challenges, the majority of falls researchers do not conceptualize or include environmental factors as discrete variables in their research, making it virtually impossible to determine the relative role of the built environment on fall and fall risk.

Exploring Fall Risk Factors

Fall risk is clearly a multimodal function. If a person is weak, he or she may fall while trying to get up from bed, even if there is a bedrail. A loose rug or deep threshold at a doorway may cause a fully healthy and ambulatory individual to trip and fall. Most often, it is a combination of factors that leads to a fall. In developing a framework from which to examine fall risk, it is useful to refer back to Lawton and Nahemow's competence press model (1973). Adapting a model originally developed by Lewin (1951), they suggested that events are the result of individual, environmental, and interactive factors, represented by the equation $B = f(P, E, (PxE))$.

In this model, B (behavior, or in the case of this paper, falls or fall risk) is the interface between P, the person (intrinsic factors); E, environment (extrinsic factors); and PxE, or the unique interaction between the person and the environment (for instance, how a person performs an activity or views the environment). Thus, to impact B (falls), the most efficacious strategy would be to impact all the elements on the other side of the equation: P, E, and PxE. The charge of this project, however, was to focus specifically on the E factor—particularly the design of the built environment of healthcare settings. By focusing on a detailed, comprehensive, and evidence-based analysis of just E, future projects will be better able to incorporate intrinsic (P) and interactional (PxE) factors to explore both fall risk and intervention strategies.

Environmental factors ranging from lighting levels to type of flooring are significant fall risk factors and can be relatively easily manipulated to create fall-prevention and injury-reduction design interventions. However, the first step in developing environmental design interventions is to find evidence-based environmental correlates of falls. This paper presents the findings from a review of 171 fall-related articles, specifically focusing on environmental factors that were empirically studied, mentioned, or recommended in each article. To further discern the validity and clarity of the environment-related information from each article, a four-tier rating system (described in the next section) was used to provide an easy method for readers to ascertain the level of confidence they should place in the information.

Finding Environmental Correlates of Falls: The Search Strategy

The project's main goal was to examine and report empirical evidence that links environmental features with outcomes related to falls in healthcare settings, including acute care, assisted living, and nursing home. The gold standard from which evidence-based medicine and practice guidelines are drawn relates to (a) the validity of the information and (b) the clarity of the intervention (de Vet, Touler, & Bouter, 2003). Thus, the literature review focused particularly (but not exclusively) on peer-reviewed empirical evidence that is specifically related to the physical environment. Database searches were conducted on Medline, Ageline, CHID/ADEAR, and National Library of Medicine. Initial search parameters included the following terms: falls, injury, healthcare, nursing home, assisted living, flooring, and glare. The most productive search strategy was reviewing the references of previously acquired articles to identify new references.

Articles were included if they met the following criteria:

- Peer-reviewed (for the initial search—some non-peer-reviewed articles were subsequently included)
- Published in English
- Published in 1980 and after
- Theoretical and/or empirical
- Addressed healthcare settings (includes long-term care and acute-care settings)
- Included a conceptualization of the physical environment even if a specific environment or environmental features were not the research focus

Some articles were clearly less relevant than others, having very little information about the physical environment. However, they were included if they presented information on factors that were closely related to the environment or had direct implications for the environment. Some articles pertaining to falls among community-dwelling residents were included if they presented relevant instructive information regarding the environment. The articles covered topics on reducing risk of falling, preventing falls, detecting falls, and reducing the risk of injury from falls. While interventions were directed at the intrinsic/individual factors, environmental factors, and interactional or performance of activity factors (Whitney, 1999), included in this report are recommendations that are specifically relevant to the design and use of the physical environment.

Organization of the Information

In developing a framework within which to organize the literature, there were many ways the information could be organized. As mentioned in the Introduction, falls have been identified in multiple healthcare-related populations and settings. Also, falls occur at a differential rate for different groups of individuals. For instance, there is clear evidence that older individuals fall more often than their younger counterparts. Brandis (1999) retrospectively studied 207 falls in an inpatient unit and found that people over the age of 80 accounted for 40% of the falls, and 77% of the falls occurred in people aged 60 and older.

Thus, this report could have been organized by age of cohort groups. Yet none of the references identified in this literature review suggested differential physical environmental interventions based on age. Alternatively, while various populations have been studied (e.g., cancer victims, lower-limb amputees), those articles generally did not present information that could be related to the built environment.

Finally, the information could have been organized by setting: acute care, rehabilitation, long-term care, psychiatric. Each of these, and other healthcare settings, have been the subject of falls studies. But again, there was no clear differential set of physical environmental recommendations by setting. Therefore, the decision was made to categorize the information according to four environmental factors that emerged as common across healthcare populations and settings: (a) spatial organization, (b) interior characteristics, (c) sensory characteristics, and (d) use of the environment.

Rating the Quality of Information

As each article was reviewed and annotated, environmental factors were classified as *risk factors* (whose absence is critical to fall prevention) or *supportive factors* (whose presence is critical to fall prevention). While a few of the environmental factors were specifically and empirically studied, most were a part of a broader array of intrinsic and interactional factors mentioned in staff training modules or acknowledged as influencing the prevention of falls. Thus, in most cases, it is difficult or impossible to evaluate the specific differential impact of the environmental factors on outcomes. To address this limitation and make the literature analysis useful, each element was assigned a *confidence rating* based on the quality of the evidence.

Rating 1: Refers to information that can be considered empirically derived, specifically related to the physical environment as a single intervention, and essentially without contradictory evidence.

Rating 2: Refers to information that is empirically based but for which there is either contradictory information or the intervention was multimodal and included either personal or behavioral components as well (making it difficult or impossible to separate the effect of the physical environmental variable).

Rating 3: Refers to information that is not empirically derived, but reflects the opinion of more than one expert.

Rating 4: Refers to information that is not empirically derived, but is extant in the literature and has some support from either one expert or several care providers.

A summary of the results of the literature review is organized in Table 1 according to this three-tiered organizing system (categories, risk/supportive factor, confidence rating).

Environmental Factors

The following section discusses the environmental factors found in the literature review under the four categories—spatial organization, interior characteristics, sensory characteristics of the environment, and use of the environment. It is important to note that the primary focus of this literature review was to identify features in the physical or built environment that were either risk factors or supportive factors. However, the last category, *use of the environment*, addresses items or artifacts (e.g., wheelchairs, personal furnishings, etc.) that interface with the designed environment to contribute to human experience.

Spatial Organization

Factors pertaining to the spatial organization of rooms and spaces within the healthcare setting mentioned in the literature include the layout of the unit (e.g., proximity of nurses' station to high fall-risk rooms) and layout of the patient room, particularly bathroom and bedroom design. These factors impact staff-patient visibility and patient-destination visibility as it relates to fall prevention. There were no articles that specifically studied the impact of individual spatial characteristics of the environment on falls or fall risk (i.e., no articles rated a rating of 1). There were, however, several articles that included spatial characteristics as part of multimodal interventions.

Layout of the unit

At the scale of unit design, one factor that was mentioned was designing the unit so that bedrooms were easily visible from the nursing station (Hitcho et al., 2004). In most cases, the intervention was defined in terms of locating residents with high fall risk close to the nursing station to maximize visibility (which is addressed further in the Use of the Environment section). However, descriptions of three facilities were found that specifically mentioned design or spatial layouts designed to maximize visibility between staff and residents in their bedrooms. Each of these projects is part of the Pebble Project, sponsored by the Center for Health Design. Pebble Project partners seek to increase evidence-based knowledge on quality of care and financial outcomes of intentionally designed healthcare settings.

Of the three projects in which design efforts to mitigate falls are specifically mentioned, only two had apparently been evaluated. No original research reports were located, only a reference to the results in other publications/websites (Livingston, 2004; Center for Health Design, 2007). In all three projects, patients' visual access to functional spaces (e.g., bathroom) within the unit and visual exposure of the patient to nursing staff were given primary consideration in the design of the patient room and the unit. At Methodist Hospital/Clarian Health Partners in Indianapolis, IN, a decentralized design layout, which increased opportunities for patient observation, contributed to a 75% reduction in falls over a five-year period (though other factors may have had an impact on the outcomes).

Angled doorways and room layouts that provided patients with better sightlines were associated with a 6% reduction in falls at the Barbara Ann Karmanos Cancer Institute in Detroit, MI, (Livingston, 2004). A number of innovative design features to reduce fall/fall risk were implemented at St. Joseph's Community Hospital in West Bend, WI. Of particular relevance here, the units were designed such that every bedroom has a charting alcove with a window into the room to increase staff visibility to the patient (see Image 1) (Livingston, 2004; Center for Health Design, 2007).

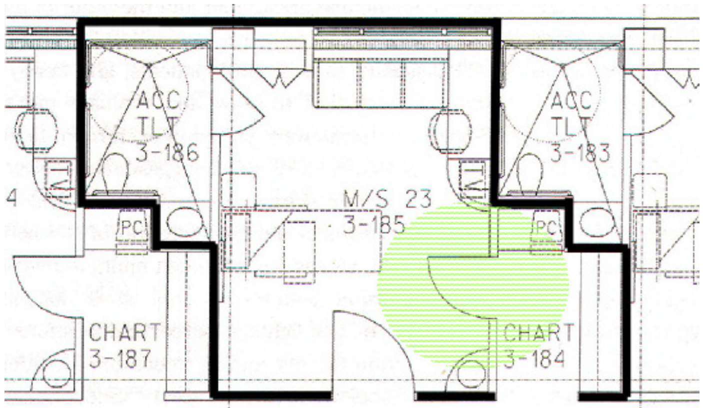

Image 1: Patient room with adjacent staff charting room with window into bedroom to facilitate observation at St. Joseph's Community Hospital (from Reiling et al. 2004).

The three projects described above are atypical in their active consideration of falls risk during the design phase and their subsequent evaluation. More often, environmental correlates of fall risk are considered as part of a host of other factors within an existing building design.

Layout of the patient room—Bathroom and bedroom design

In one study, poor ward and bathroom design were targeted as risk factors during staff feedback after a retrospective audit of 270 inpatient falls in an acute-care hospital in Australia (Brandis, 1999). This feedback and results of the audit were used to identify high-risk patient groups, high-risk activities, and relevant environmental features and to implement a collaborative fall-prevention approach by occupational therapy and nursing staff. After finding that 24% of the falls occurred in bathrooms, a detailed environmental audit was conducted in bathroom areas at the hospital. Particular design shortcomings identified in the audit were inappropriate door openings (specific feature not defined); slippery floors; poor design or placement of bedrails, handrails, and accessories; and incorrect toilet and furniture heights.

The inappropriateness of door openings affects the layout and spatial organization that are being discussed here—the other factors will be revisited later in this paper under other environmental categories. The reference indicated that minor modifications were made as part of the multimodal fall-prevention approach although, unfortunately, specific details were not provided (e.g., there is no information about whether door openings were widened as part of the project). A second audit two years later found a 17.3% overall reduction in the number of fallers and a 23.2% reduction in reported fall-related injuries, though it is not clear how much of this decrease was due to environmental interventions and how much was due to staff management or other interventions.

Clear visual access is not the only supportive feature in a room layout; clear physical access, e.g., a clear pathway to the bathroom from the bed, is a supportive factor (Lieberman, 2004; Josephson, Fabacher, & Rubenstein, 1991, cited in Dickinson, et al. 2004; Reiling et al., 2004). Since the bathroom itself is the location of many falls, proximity and access to the bathroom is an important consideration. Urge incontinence has been linked to an increased risk of falling (Brown et al. 2000) in a study of community-dwelling women—weekly or more frequent urge incontinence increased the risk of falls by 26% and the risk of fractures by 34%. They concluded that rushing to the bathroom to avoid urge-incontinent episodes was associated with an increased risk of falling.

Hitcho et al. (2004) found that 50% of the falls reported in a 1,300-bed hospital over 13 weeks were elimination-related, that is, when ambulating to or from a bathroom or bedside commode, reaching for toilet tissue, etc. Although the fallers included people of all ages, those 65 or older were more likely to have an elimination-related fall than those younger than 65. In St. Joseph's Community Hospital, West Bend, bathrooms are placed close to the head of the bed to enable easy access and a continuous handrail within standardized patient rooms (Reiling et al., 2004). Effects of the new design on patient falls are currently being evaluated at this facility (see Image 1).

For a variety of reasons, some facilities, such as St. Joseph's Hospital, West Bend, are moving toward designing same-handed rooms. Essentially, this means every bedroom in the hospital is designed identically. This not only allows a staff person entering the room to know exactly where equipment or supplies are stored, it minimizes the need to relocate patients from one wing or unit to another. This may be important, because, as Creditor (1993) writes, unfamiliarity with the environment leads to incontinence, often within a day of hospitalization. This can be exacerbated if a patient is transferred multiple times within a facility based on acuity and caregiving needs and if the room layout differs from unit to unit.

Single-patient same-handed rooms incorporating acuity-adaptable headwalls were designed in a cardiac critical-care unit in Methodist Hospital/Clarian Health Partners Hospital (Hendrich, Fay, & Sorrells, 2004). When baseline data were compared with data three years after the move, the need to transfer patients within the unit was minimized by 90%, and the falls index dropped from around 4 falls/1,000 patient days to 2 falls/1,000 patient days, a significant decrease. However, the results should be viewed with caution, as many other factors were different between the old hospital and the new one, so the design of the bedroom might only be one of many factors that impacted this decrease in falls.

Interior Characteristics

As mentioned above, there are significant challenges in trying to isolate factors pertaining to spatial layout as individual variables related to falls. First, most often, all rooms are designed with a similar layout to minimize construction costs, so there are seldom good naturally occurring experimental settings. Second, overall unit or room layout is difficult and costly to modify, thus making changes at this level for research purposes is seldom practical. Finally, when changes of this scale are made, there are typically many other changes that are made simultaneously (staffing model, new equipment, etc.), which also makes teasing out the differential impact of spatial layout difficult. However, interior features of the environment, such as the type of flooring, furniture, and presence of assistive features (e.g., handrails) are more easily modified and studied. Literature related to these types of factors is described below.

Flooring

Characteristics of flooring material may impact fall risk; references in the literature pertain to the type of floor material (resilient vs. soft), the amount of contrast in the pattern, transitions with other floor materials, and the coefficient of friction of the floor surface as considerations in fall prevention. Most studies in this category have been conducted with older adults living in the community; there are no studies specifically examining the effects of flooring on risk of falls in healthcare facilities, although flooring is mentioned as a risk factor in some multimodal interventions.

Floor material

Dickinson, Shroyer, and Elias (2002) studied the effect of commercial-grade carpet on postural sway and balance strategy among 45 healthy older adults who had not fallen more than twice in the six months preceding the study. Each participant was exposed to various sensory limitations on carpeted and noncarpeted conditions on a balance machine while postural sway and balance measurements were taken. The authors note that, in previous studies, postural sway has been found to increase on compliant or softer flooring surfaces such as carpeting, and increases in postural sway have been correlated with falling. The balance machine had a computerized forceplate and visual surround of a mountain scene, both of which moved during four simulated test conditions. The researchers found that the commercial-grade, low-pile, tightly woven carpet did not negatively impact static balance. Although researchers did not include frequent fallers in this study or check a more dynamic measure that could be directly relevant to mobility and falls (i.e., walking on the different surfaces), this study's findings suggest carpeting, in and of itself, may not be a fall risk factor.

Floor pattern

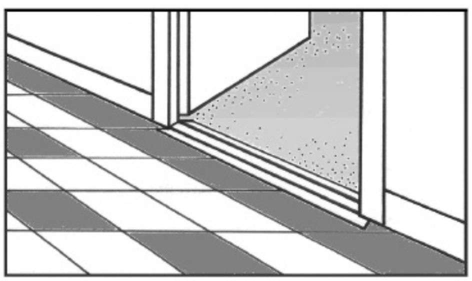

Image 2: Example of a bad transition: High threshold and high color contrast in the floor which can be perceived as level changes.

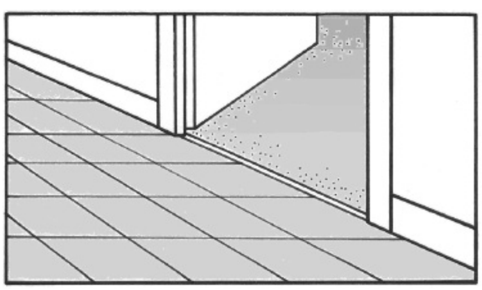

Image 3: Example of a good transition: level and low contrast change at the threshold.

Perritt, McCune, and McCune (2005) studied carpeting with different piles (depth) and patterns with a sample of 107 older adults with dementia who either participated in adult day health programs or lived in a shared residential facility. Carpeting with high contrasting patterns was associated ($p < .0001$) with more incidents (stumbles, reaching for handrail, veering, purposeful stepping, pausing, stopping) than carpeting with low color contrast. Participants wore a safety belt to eliminate falls for safety reasons. While not conducted specifically within a healthcare setting, the results are clearly applicable, particularly to nursing homes and assisted living facilities where 50% or more of the residents may have dementia and efforts to create a more homelike environment often include the use of carpeting.

Floor transitions

Describing a multimodal intervention for preventing falls in nursing homes, Theodos (2003) reports that transitions in flooring—for example, from carpeting to hard flooring surfaces (see Images 2 and 3)—could also be a risk factor, though he does not cite specific studies to support this claim. Hazards such as contact between rubber tips of canes or crutches and different types of flooring have also been pointed out (Burnside, 1981).

Coefficient of friction

The coefficient of friction of the floor surface is a potential risk factor—common sense indicates that slippery floors may lead to more falls than floors with a higher coefficient of friction (Healthcare Hazard Management Monitor, 2003). But friction is the surface resistance related to *two* surfaces—so it is the interaction between the two materials (the flooring and what is on the foot) that is the important issue. Tencer et al. (2004) monitored falls among 1,371 adults 65 years and older for a two-year period. They selected 327 fallers and 327 matched controls to determine fall risk factors. In particular, they studied the shoe/surface interface properties, particularly focusing on the dynamic coefficient of friction (a measure of the degree of friction between the shoe/foot and the floor material) and found that there was no statistically significant relationship between the coefficient of friction and fall risk. This suggests that the type of flooring is not a factor in fall risk.

Other floor properties

Image 4: Light from windows and ceiling light fixtures on a highly reflective floor can cause glare. (St. John's on the Lake, Milwaukee, Wisconsin).

Image 5: A hallway with no glare. (St. John's on the Lake, Milwaukee, Wisconsin. Aldrian Guszkowski, Architect).

The floor finish—polished or high-gloss surface—is often considered a risk factor because of how it could be perceived. For example, a high-gloss surface could contribute to glare conditions, whereas a carpeted floor might reduce or minimize glare (see Images 4 and 5). However, these factors are yet to be studied empirically in healthcare environments.

Floor mats that are placed strategically to absorb spills are also often considered to be a potential fall hazard. Floor properties are not only fall risk factors, but influence risk of injury from falls. Carpeted floors are associated with fewer fall injuries than vinyl floors (Healey, 1994, cited in Lord, Sherrington, & Menz, 2001). More research is needed to distinguish fall correlates of different flooring surfaces. The properties (e.g., how absorbent or how slippery when wet) and condition of the floor are also considered risk factors (Tideiksaar, 1989; Tideiksaar, 1998; Van Doorn et al., 2003).

Furniture

Location and placement

The presence and location of furniture are associated with a risk of falling. It is considered important (though there is no empirical evidence to support this) to appropriately locate furniture in each space so as to prevent it from becoming an obstacle and to enable clear circulation paths within the patient room (see Image 6) (Newton, 2003).

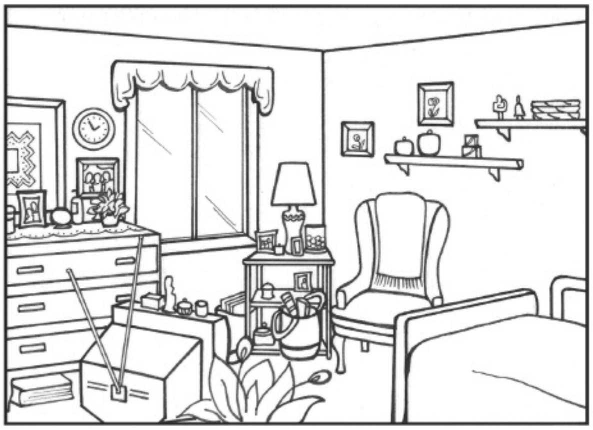

Image 6: Lack of a clear path through the room to the bathroom may lead to increased number of falls

Furniture heights

Similarly, the depths, heights, and sizes of furniture in the patient room may impact their supportiveness in independent use, transfer, and daily activities (Tideiksaar, 1998; Shroyer, Elias, Hutton, & Curry, 1997, cf. Dickinson, Shroyer, Elias, Curry, & Cook, 2004). Becker et al. (2003) included modification of chair and bed height among other environmental modifications, in a prospective, cluster-randomized, controlled 12-month trial in six nursing homes in Germany, three nursing homes randomized to interventions, and the other three to the control group. Participating facilities in the intervention group could select any combination of the intervention options: modification of nursing care, environmental adaptations advice (which included height of chairs and beds), exercise, and/or use of hip protectors.

Overall results indicated statistically significant density rates of falls between control and intervention groups. A great difference was observed for frequent fallers—13% experienced falls in the intervention group versus 24.4% in the control group. The overall density rate of falls in the intervention group decreased from 1,406 falls per 1,000 resident years (RY) in the first quarter to 1,022 falls per 1,000 RY in the last quarter. The control group demonstrated an increase instead. However, because of the multimodal interventions and the self-selection process, both adherence to suggested environmental modifications and differential impact of environmental modifications could not be tracked.

Furniture design

Furniture characteristics and placement also influence episodes of incontinence, which was noted previously as a risk factor for falls. As stated earlier, rushing to the bathroom to avoid urge-incontinent episodes has been associated with an increased risk of falling. A part of this behavior is often the need to get up from a chair or the bed to reach the bathroom in time. Therefore, the design (height, size, supportive features) of the furniture in the room can play a role in assisting or hindering this endeavor.

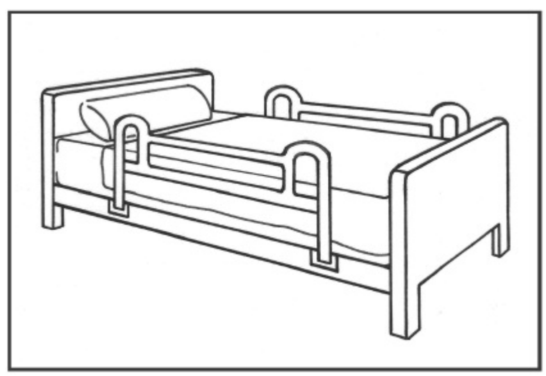

Image 7: Bedrails can be both a supportive factor providing a source of balance when an individual gets up from the bed, or a hazard, when the open rail system creates opportunities for getting caught, which can lead to injury and strangulation.

For example, Creditor (1993) writes that intimidatingly high beds and bedrails (see Image 7) influence incontinence. Functional incontinence is also thought to be influenced by environmental factors such as low chairs that are difficult to get out of, poor lighting, and physical restraints (Klusch, 2003). This phenomenon has two implications mentioned repeatedly by experts with respect to interior characteristics: the presence of a proximal, clutter-

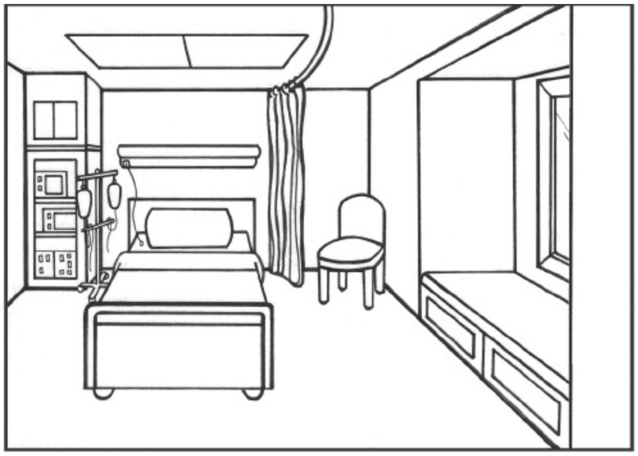

Image 8: Chairs without arms and a low window seat with no means of support while standing—both may increase the risk of falls, though there is little empirical evidence to support this.

free path to the bathroom and properties of the furniture from which a patient needs to rise to reach the bathroom. Unfortunately, specific recommendations for the latter are absent in the research literature.

In developing a predictive fall-risk points system, Hendrich, Bender, and Nyhuis (2003) used the Get up and Go Test in a case/control study on fallers and nonfallers in a 750-bed acute-care facility. Focusing on the one test item that proved statistically significant—rising from a chair—they found that a patient who needed to push up with his or her arms, legs, or walking aid to rise from a chair was 2.16 times more likely to fall than a patient who could rise in a single movement. A patient who could not rise at all was more than 10 times more likely to fall than the unimpaired patient. While at first glance this finding might seem to refer solely to an intrinsic risk factor, chair design can also play a significant role in enabling patients with impaired abilities. Features such as the presence or absence of chair arms, how far the arms extend toward the front of the chair, the seat height, seat depth, slope of the seat, etc., can have a significant impact on ability to rise from the chair easily (see Image 8).

Unfortunately, neither characteristics of the chairs used in the research nor recommendations for appropriate sizes are described in this research. This lack of attention to environmental variables, which are often easily manipulated, is relatively common. For instance, in a study of 927 residents aged 72 years and older, Tinetti, Inouye, Gill, and Doucette (1995) associated slow-timed chair stands (due to lower-extremity impairment) with incontinence and falls. The researchers identified four independent intrinsic predisposing factors for the outcomes of incontinence, falling, and functional dependence including slow-timed chair stands (lower-extremity impairment), decreased arm strength (upper-extremity impairment), decreased vision and hearing (sensory impairment), and either a high anxiety or depression score (affective impairment). There was a significant increase in each of incontinence, falling, and functional dependence as the number of these predisposing factors increased. But once again, no effort is directed at identifying characteristics of chairs that make it easier or more difficult to stand. More research is needed on the relationship between these intrinsic factors and the characteristics of furniture, which may serve to mitigate functional limitations.

Other furniture properties

Unlocked bed wheels and unstable furniture (e.g., medical equipment and IV poles, overbed tables that move when grasped for support) have also been identified as risk factors in the literature (Quang Vu, Weintraub, & Rubenstein, 2004; Theodos, 2003; Morse, et al. 1987). Tideiksaar (1989) also mentions factors such as sagging mattress edges (which increase the possibility of fall when transferring) and shelf layouts in closets (having to reach high or bend low to retrieve objects from high or low shelves) as risk factors. Braun and Capezuti (2004) suggest that low beds that can be elevated electronically for transfer and activities of daily living may mitigate fall risk. None of these factors have been examined empirically.

Assistive environmental features for ambulation

Image 9: Grab bars located at the back and side of the toilet are most useful for individuals who use a side-slide method to transfer.

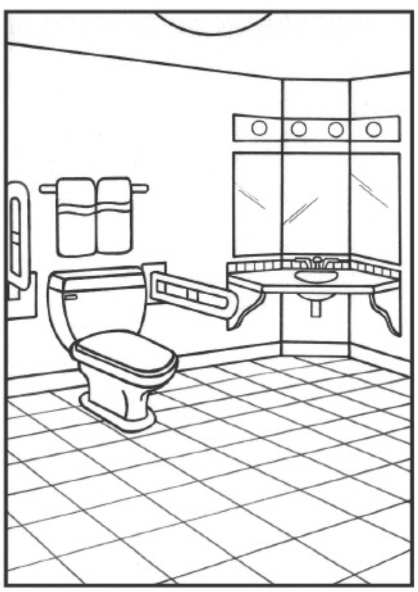

Image #10: The fold-down grab-bars on each side of the toilet may be more supportive for individuals who are capable of weight-bearing, especially for older adults who often experience hemiplegia, or weakness on one side.

Fixed assistive features in the patient environment such as adequate and appropriately secured handrails and guardrails in the bathrooms, corridors, and pathways are considered supportive factors for fall prevention. A lack of handrails and guardrails in the home environment has been associated with risk factors for falls (Marshall et al., 2005). Lord et al. (2001) include handrails in their list of environmental interventions for fall prevention.

While there is a significant amount of research on grab bars in bathrooms (Sanford 2001; Sanford, Echt, & Malassigné, 1999 (see Images 9 and 10), no research was found that specifically linked the presence, absence, or location of handrails in healthcare settings to fall rates.

Sensory Characteristics of the Environment

Many people in healthcare settings experience changes to or deficits in their sensory systems—either as a reaction to medications and/or treatment or because of age-related declines in sensory systems—that can impact fall risk. The sensory characteristics of the environment can serve to mitigate the impact of these risk factors. Sensory factors that relate the visual and acoustic environments are discussed below.

Visual environment

Aspects of the visual environment discussed in this category include lighting levels, presence of night lights or call lights, surface contrast, and visual interventions in the patient environment.

Lighting levels

Lighting is a significant part of the patient's experience in the space. Poor lighting has been associated with incontinence (Klusch, 2003) and affects patients' attempts to navigate successfully in their spaces, especially at night. Poor lighting is a key risk factor for falls mentioned by Quang Vu et al. (2004); Rogers, Rogers, Takeshima, and Islam (2004); and Tideiksaar (1989). Creditor (1993) refers to subdued lighting as a risk fac-

Image 11: Uneven spacing of the light fixtures on the walls creates repeated dark shadows along the corridor. (Evergreen Retirement Community, Oshkosh, WI).

Image 12: Metal guttering was used to create an inexpensive cove detail, allowing continuous fluorescent lighting down the length of the corridor, resulting in even lighting throughout. (Evergreen Retirement Community, Oshkosh, WI).

tor for recently hospitalized elderly, causing delirium among those who may have left their eyeglasses behind at home, for example. It is not simply the amount of light that is important, but it's evenness (see Images 11 and 12).

Dickinson et al. (2004) suggest adequacy of lighting as a topic for future research, in part because adequacy of lighting is a subjective judgment and may not correspond with actual required lighting levels. Bakker, Iofel and Lachs (2003) measured light levels in the apartments of 40 homebound older adults in New York City and compared them with industry-standard minimum light levels. Although most participants had light levels inadequate by IESNA [Illuminating Engineering Society of North America] standards, they rated their lighting as adequate.

Meyer et al. (1994) measured light levels in respiratory and medical intensive care units (ICUs) in a hospital setting and looked in particular for peak light levels that could disrupt sleep patterns. Disrupted nighttime sleep has been associated with daytime sleepiness and linked as a potential risk factor for falls among community-dwelling older adults (Brassington, King, & Bliwise, 2000). However, Meyer et al. (1994) found that peak light levels in the ICUs were dependent on window orientation and shading and coincided with daytime-nighttime rhythms, thereby not influencing sleep disruption in the hospital.

Many falls are experienced when light levels are much lower than daylighting levels—at night. Nocturnal falls have been associated with the use of antidepressants (Ray, Thapa, & Gideon, 2000), and short-acting drugs have been associated specifically with an increased rate of nighttime falls while longer-acting drugs increased fall risks in general. Given the high frequency of use of these drugs in long-term care settings, Wood (2004) refers to the importance of staff anticipating resident needs such as the need to go to the bathroom in the middle of the night. Orienting patients to their new surroundings upon hospitalization may enable more successful nighttime navigation (Theodos, 2003).

Presence of night lights or call lights

However, staff and medical interventions are ineffective without environmental features such as night lights within the spaces or visible call lights so that the patient may request assistance. In documenting the success of a fall-prevention program within an acute-care setting in Arizona, McCarter-Bayer, Bayer, and Hall (2005) mention two relevant factors—the position of the call light with respect to the location of the fall and whether it was found on at the time of the fall. These two

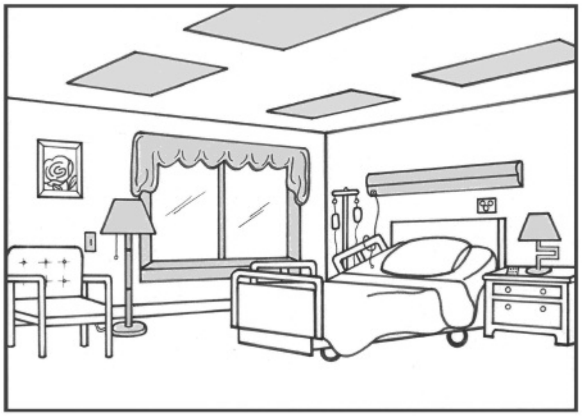

Image 13: Room with multiple lighting options

factors were among other environmental factors documented in their Quality Improvement Data Collection Tool for Falls. They describe general success in reducing falls using the multimodal intervention, but do not specifically relate some of the documented environmental factors to fall reduction.

Surface contrast

Contrast between surfaces for visual acuity is another factor that influences a risk for falls (Harwood, 2001). There is much evidence to indicate that dementia is associated with a deficit in contrast-sensitivity function (Gilmore, 1996; Gilmore, Neargarder, & Morrison, 2005). Ivers, Mitchell, and Attebo (1998) found independent relationships between poor vision and reduced contrast sensitivity and recurrent falls. Appropriate lighting may serve to reduce functional deficits associated with poor vision (see Image 13), and increasing the appropriate use of contrasts (such as between floor and wall surfaces or between the toilet and the surrounding floor and wall area) are possible but as yet untested environmental interventions to reduce falls.

Image 14: Example of a fall-risk identification sign in a nursing home.

Visual cues

While the lighting levels and contrast in surfaces are needed for orientation and navigation by patients in their rooms, other visual interventions have been introduced, mainly to assist staff and caregivers in identifying those patients at risk for falls. These visual cues primarily include instructional posters and bed signs.

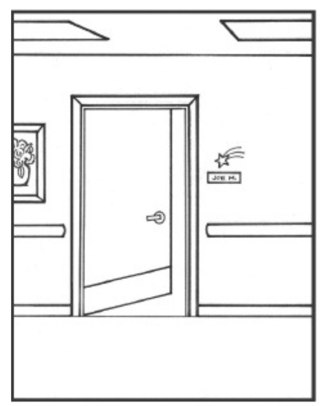

Image 15: Another example of a falling star used to identify a high falls-risk patient

Brandis (1999) documents a flagging system used in an acute-care hospital that included a green bed sign at the head of the bed, green armbands on the patient, and posters displayed in wards. McCarter-Bayer et al. (2005) describe a yellow hallway door sign outside patients' rooms, a yellow memory trigger sign for patients, a yellow reminder/education sign for staff and visitors, and yellow armbands for patients. Mills, Neily, Luan, Stalhandske, and Weeks (2005) included door signs (see Images 14 and 15), wristbands, and falling stars as cues, while Alcee, Mather, and Jefferson (2000) report the use of bright orange armbands for patients at risk for falls. Poe, Cvach, Gartrell, Radzik, and Joy (2005) describe color-coded interventions for different levels of fall risks in a hospital—low (no color used,) medium (yellow), and high (red). The interventions in the physical environment—yellow or red cards placed outside patient rooms and yellow or red stickers placed on medical records—were less obtrusive than some of the others. Because of different methodologies in different studies, it is not possible to determine the relative efficacy of these different strategies.

Auditory environment

Sound levels and sound peaks

While the visual environment is the most obviously experienced, auditory cues and their perception, particularly by the older patient or resident, play a significant role in maintaining balance amidst age-related decline in other senses during an environmental experience (Newton, 2003). Meyer et al. (1994) studied the sound levels in a medical ICU, a multiple-bed respiratory care unit (RCU) room, a single-bed RCU room, and a private room. Peak daytime and nighttime sound levels were significantly higher than values recommended by the Environmental Protection Agency as acceptable for a hospital environment. The number of sound peaks (sudden bursts of sounds) greater than 80 decibels (with potential for sleep arousal) was high in the ICU and RCU areas.

For good sleep, the World Health Organization (WHO) guidelines recommend that the sound level of continuous background noise should not exceed 30 decibels, and individual noise events exceeding 45 decibels should be avoided. Based on current studies (mostly conducted with young adults) WHO concludes that relationships between noise exposure and sleep disturbance are established only for immediate effects, and not yet clearly established for next-day or long term effects.

While a certain amount of decibel levels is preferred by the aging ear, sound peaks such as those caused by chair and bed alarms alter the environmental experience and could be considered fall risk factors. Shumway-Cook and Woollacott (2000) found that, among older adults, attentional demands for postural control and balance increase as sensory information decreases. Postural sway is affected by reduced or inaccurate sensory information, especially when multitasking and particularly among older adults with balance impairments who were recent fallers.

Further, nighttime noise peaks that disrupt sleep patterns may lead to increased drowsiness the next day, which could increase fall risk. However, no research specifically explored the impact of various noise factors on fall rates.

Use of the Environment

Image 16: Locating high fall-risk patients in bedrooms closest to the nursing stations.

The environment is experienced in a dynamic interactive process by individuals. Thus, it is important to consider factors related to how the environment is used by patients and staff.

Assigning or re-assigning patient rooms for fallers

One of the more commonly cited recommendations found in the literature was to locate high-risk patients in visual proximity to staff. In a study conducted at the Johns Hopkins Hospital in Baltimore, MD, Poe et al. (2005) created an evidence-based, institution-specific fall-risk stratification tool for use by staff in three units. Based on this assessment, staff members were presented with fall-prevention protocol using three categories—low, medium, and high risk.

Each category required multimodal interventions, including a flagging system (identifying people at high risk of falls) and basic environmental safety interventions. In the high fall-risk category, one of the interventions suggested is moving the patient to the room with best visual access to the nursing station to enable more careful monitoring by staff (see Image 16).

The main goal of the study was to test the ease of use and acceptance of the fall-prevention protocol by staff, and, therefore, they did not specifically look at numbers of falls before and after the intervention. However, on one unit, where 17 patients were assessed and nine were considered to be high fall risk, one of the interventions included bed placement (location of the individual near the nurses' station); there were zero patient falls during the testing phase.

Similarly, designating a special room for high-risk fallers was implemented in a study of fallers in various units in a 1,300-bed hospital (Hitcho et al., 2004). Six percent of the population studied (patients involved in 200 consecutive fall events) were assigned to special rooms that were either equipped with video surveillance cameras or were close enough to the nursing station to support easy surveillance. Unfortunately, the prevalence of falls was not large enough to determine the effect size of decreased occurrence of falls.

Mills et al. (2005) conducted a root cause analysis and studied subsequent fall-reduction action plans implemented by 100 Department of Veteran Affairs (VA) acute- and long-term care facilities. They reviewed 745 actions/interventions in various stages of implementation that together resulted in reducing falls in 34.4% of the facilities and reducing major injuries due to falls in 38.9% of the facilities. Most facilities implemented multiple interventions, so it is not possible to determine the impact of specific environmental interventions. However, 6% of the interventions related to deploying assistive devices (walkers and canes), 4% included signage to identify high fall-risk patients, and 3% implemented other environmental interventions such as designating a room for high-risk patients (room located close to the nursing station).

Neily, Howard, Quigley, and Mills (2005) reviewed interventions implemented at VA acute- and long-term care facilities that helped in reducing the aggregate major injury rate by 62%. Environmental interventions at acute-care facilities included creating a falls-safe room and designating a high fall-risk room near the nurses' station in a psychiatric unit so that nurses could hear alarms better (no further information is provided regarding what specific features were a part of the falls-safe room or the types of alarms referred to, e.g., positional monitors, bed or chair alarms). In the long-term care facilities, interventions included requesting laptops for nurses so that documentation could occur closer to patients, where bed alarms could be heard more quickly (Neily et al., 2005).

Finally, Mosley, Galindo-Ciocon, Peak, and West (1998) also found that confused patients and patients identified at risk for falls were placed near the nurses' station where they could be closely monitored. No outcome data was provided on reduced incidence of falls. Thus, locating patients or residents close to staff (or moving staff activities closer to the patients/residents) appears to be a fairly widely implemented strategy, despite the lack of much empirical evidence that it is effective. It is worth noting, however, that most near falls, in which a fall might be averted by this increased staff visibility/presence, are generally not recorded.

Type of footwear

Exploring other use factors, Koepsell et al. (2004) found that, regardless of the flooring material, persons who were shoeless had a higher risk of a fall—8 to 11 times higher than those who were wearing athletic shoes (which have high floor-contact area). Taken with the Tencer et al. (2004) study, evidence suggests that the type of flooring material does not matter to fall risk, but that wearing shoes with flat soles is a supportive factor.

Clutter in the patient room

As mentioned previously, clutter is frequently mentioned as a fall risk in the literature on falls in the community/at home, though no research was found that explored this topic in healthcare settings, even though many nursing home rooms are very cluttered (Josephson et al., 1991; Tideiksaar, 1998).

Transfer

Two articles specifically explored transfer-related falls. Sadigh, Reimers, Andersson, and Laflamme (2004, studying 469 facilities in Sweden, found that a majority of falls occurred in bedrooms and were often related to transferring from a wheelchair. However, no specific features of wheelchair design were identified or specifically explored. Fox and Vanderford (2000, studying falls in a variety of settings, suggest that having different sizes of wheelchairs (for youth and adults), particularly in areas such as radiology that are likely to service both groups, would serve to minimize falls when transferring from a wheelchair.

Wet floors

Hitcho et al. (2004) and Rubenstein, Jospehson, and Osterweil (1996, cited in Lord et al., 2001), in exploring falls related to incontinence, both note that, in addition to the previously mentioned factors (e.g., ability to rise from chair or bed), an additional risk factor is present when an episode of incontinence happens and the floor becomes wet. The ability of staff to quickly clean up and dry a wet floor may impact the ongoing fall risk of patients (as well as staff and visitors).

Use of throw rugs

While most literature on community-dwelling older residents mentions the presence of throw rugs as a risk factor (Northridge, Nevitt, Kelsey, & Link, 1995, cited in Dickinson et al., 2004) evidence has linked throw rugs with a *decreased* risk for falling among community-dwelling older adults either because they were extra careful around them or used them to hide electrical cords or other hazards (Sattin, Rodriguez, DeVito, & Wingo, 1998). More research is needed to explore this difference and its applicability to healthcare environments such as dementia-care units in which residents are permitted to bring in their furnishings.

Conclusion and Directions for Future Research

The first step in implementing fall detection and targeted fall- and injury-prevention measures among patients occurs when staff is able to identify those patients at risk for falls. While a well-designed fall risk assessment tool is an asset, the process of recording and documenting fall risk factors and later monitoring the use of fall-prevention measures can be influenced by spatial characteristics on the medical unit.

At such a juncture, clustering the patients according to need, placing frequent fallers in patient rooms that are close together, for example, might enable a better fit between staffing needs and patient needs, especially because risk-management procedures typically include frequent monitoring of patients. New design features such as decentralized nurses' stations, better visual access, and same-handed and acuity-adaptable rooms highlight design improvements that could assist both staff and residents in fall-prevention measures. In addition, the systematic examination of fall-related patterns, such as a higher number of fall incidents when getting out of bed at night to go to the bathroom, can point to targeted environmental interventions (e.g., better night lights and more accessible call bells) (Donoghue, Graham, Gibbs, & Mitten-Lewis, 2003).

Mostly existing as expert design recommendations, interior environment factors such as flooring and furniture continue to appear in fall-prevention material disseminated to providers without much solid evidence of their efficacy. More research is needed on lighting and sound levels and their effect on sleep disruption patterns and next-day functioning of cognitively intact and cognitively impaired persons in healthcare environments. Multiple factors might interact with environmental factors to contribute to higher nocturnal fall rates—staffing ratios, incontinence, disrupted sleep, subdued lighting, etc. More research is needed to offer a nuanced approach to these factors.

Much progress has occurred in flagging systems on the unit, some are less obtrusive than others. While some flagging systems such as the green posters and bed signs serve caregiver needs, others are meant to be cues for the patient (for example, a poster reminding him or her to call for assistance if needed). The level of obtrusiveness, its coexistence with other necessary cues in the environment meant for patients, and its effect on psychosocial factors among residents/patients and their caregivers remains to be investigated.

The influence of individual- versus shared-room occupancies on fall risk factors has not been studied. Private rooms have been implicated both as a supportive factor, because families are more likely to spend more time visiting in a private room and, therefore, are available to provide assistance, and as a risk factor because there is no roommate to remind an at-risk individual to call for assistance (Chaudhury, Mahmood, & Valente, 2005; Tutuarima, van der Meulen, de Haan, van Straten, & Limburg, 1997).

Because most of the research is multimodal in nature, it is difficult to know the exact contribution environmental factors play in reducing falls and injury from falls. Further, environmental factors are broadly and loosely defined in research literature. For example, in one study researchers included time and activity in their conceptualization of the environment (Donoghue et al., 2003). This makes it difficult for both designers and caregivers to create healthcare settings that minimize fall risk. Rein Tidieiksaar, PhD, in an interview for this project, identified a need for a resource that specifically links disease condition and functional impairment with design interventions that would minimize fall risk and to consider whether they should be differentially applied in different settings.

On the one hand, there is simply not enough empirical information in the literature to be able to complete this task within the scope of this project. Structuring this type of information, using the empirical information from this report supplemented by expert knowledge where there is insufficient empirical evidence, as a searchable database would be an excellent next step that would benefit the healthcare industry. On the other hand, there is much work to be done in terms of fall research—this report offers an organizing framework within which to situate future empirical efforts.

Appendix: Environmental Corrleates of Falls

Table 1: Spatial Organization			
Environmental Factor	**Citation**	**Risk Factor or Supportive Factor***	**Rating**
Location of patient room with respect to nursing station	Rubenstein, Josephson, & Robbins (1994) cited in Van Doorn et al. (2003)	Move fallers with dementia closer to nurses' station to increase observation—supportive factor	2
	Poe, Cvach, Gartrell, Radzik, & Joy (2005)	Visual access from nurses' station to patient room—supportive factor	2
	Hendrich, Fay, & Sorrels (2004)	Decentralized nurses' station—supportive factor	2
Bathroom and ward design	Brandis (1999)	Poorly designed bathrooms—risk factor	2
Location of patient bed and chairs with respect to door of bathroom	Reiling (2004)	Location of bathroom at headwall of bed—supportive factor	3
	Livingston (2004)	Angled doorways for better visibility—supportive factor	4
Bedroom design	Hendrich et al. (2004)	Identical/acuity-adaptable bedroom design throughout facility—supportive factor	2

Table 2: Sensory Attributes of the Environment			
Environmental Factor	**Citation**	**Risk Factor or Supportive Factor***	**Rating**
Floors	Dickinson, Shroyer, & Elias (2002)	Low pile, tightly woven carpet—supportive factor. This study, however, examined static balance and not a dynamic measure, e.g., gait.	1
	Perritt, McCune, & McCune (2005)	Carpet with high contrast pattern—risk factor	1
	Tencer et al (2004)	Type of flooring by coefficient of friction—not a risk factor	1
	Healey (1994)	Vinyl floor—risk factor for injury from falls	2
	Healthcare Hazard Management Monitor (2003)	Low coefficient of friction—risk factor	3
	Tideiksaar (1989) (1998); Van Doorn et al. (2003)	Various characteristics/ properties of flooring—risk factor	4
	Theodos (2003); Burnside (1981)	Change in flooring material—risk factor	4

Table 2 (continued): Sensory Attributes of the Environment

Environmental Factor	Citation	Risk Factor or Supportive Factor*	Rating
Furniture	Tideiksaar (1998); Shroyer, Elias, Hutton, & Curry (1997) cited in Dickinson, Shroyer, Elias, Curry, & Cook (2004); Newton (2003); Becker et al. (2003)	Appropriate sizes and heights of furniture —supportive factor	2
	Capezuti, Maislin, Strumpf, & Evans (2002)	Siderails—risk factor	2
	Tideiksaar (1998)	Unequal heights of chairs and beds—risk factor	3
	Klusch (2003)	Low chair—indirect risk factor because of its link to incontinence	3
	Creditor (1993)	High beds, bedrails—indirect risk factor because of incontinence	3
	Hendrich, Bender, & Nyhuis (2003); Tinetti, Inouye, Gill, & Doucette (1995)	Chair design to support ease in standing—supportive factor	4
Handrails	Quang Vu, Weintraub, & Rubenstein (2004)	Unstable furniture—risk factor	3

Table 3: Sensory Attributes of the Environment

Environmental Factor	Citation	Risk Factor or Supportive Factor*	Rating
Lighting	Meyer et al. (1994)	Light levels impacting sleep—not a risk factor	1
	Ivers, Mitchell, & Attebo (1998)	Poor contrast in surfaces—risk factor	2
	Creditor (1993)	Subdued lighting—risk factor	2
	Klusch (2003); Quang Vu et al. (2003); Rogers, Rogers, Takeshima, & Islam (2004); Tideiksaar (1998)	Decreased light levels—risk factor	4
	Dickenson (2004)	Glare associated with increased light levels—risk factor	4
Visual interventions and their location	Brandis (1999); Alcee, Mather, & Jefferson (2000); Poe et al. (2005); McCarter-Bayer, Bayer, & Hall (2005); Mills, Neily, Luan, Stalhandske, & Weeks (2005)	Color-coded flagging and identification system —supportive factor	1
	Shumway-Cook & Wollacott (2000)	Peak noises at night that potentially disrupt sleep	4
Sounds and sound peaks	Meyer et al. (1994)	Sound levels and peaks—risk factor	1

* Risk factor: Absence is important in fall prevention or in preventing injury from a fall.

* Supportive factor: Presence is important in fall prevention or in preventing injury from a fall.

Rating 1: Refers to information that can be considered empirically derived, specifically related to the physical environment as a single intervention, and essentially without contradictory evidence.

Rating 2: Refers to information that is empirically based but for which there is either contradictory evidence or the intervention was multimodal and included either personal or behavioral components as well.

Rating 3: Refers to information that is not empirically derived, but reflects the opinion of more than one expert.

Rating 4: Refers to information that is not empirically derived, but is extant in the literature and has some support from either one expert or several care providers.

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Environmental Correlates of Falls

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Study funded by a grant from the Coalition of Health Environments Research (CHER) and The Center for Health Design (CHD)

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OUTLINE OF PRESENTATION

Falls – Prevalence and Costs

Theory: Focus on Environmental Factors

Literature Review Process

Rating System

Environmental Factors

THE CENTER FOR HEALTH DESIGN®

FALLING PREVALENCE

Fall-Related Non-Fatal Injuries

- 1.8 Million total fractures, traumas, etc for the year 2005 (National Center for Injury Prevention and Control, 2006)
- 10% of fall-related injuries occurred in health-care institutions (ECRI, 2006)

Fall-Related Fatalities (65 years and older)

- 13,820 fatalities in 2003 (National Center for Injury Prevention and Control, 2006)

THE CENTER FOR HEALTH DESIGN®

FALLING COSTS

Types of Costs

- Direct insurance costs (National Center for Injury Prevention and Control, 2006)
- Legal/liability costs and consequences (Zinn, 2003)
- 10% of fall-related injuries occurred in health-care institutions (ECRI, 2006)

Average and Projected Costs

- Average healthcare cost for a fall injury (without factoring physician services) was close to $20K (Rizzo, et al, 1998)
- Projected costs for fall-related injuries in the US for people 65 and older are $43.8 billion by the year 2020 (Englander, et al, 1996)

ENVIRONMENTAL FACTORS

Falls are often not witness and expected. Environmental factors are not documented.

$$B = f\,(P, E, PxE)$$

Falls → B

Person → P

Environment → E

Interaction → PxE

LITERATURE REVIEW

Search Strategy

- Database searches conducted on Medline, Ageline, CHID/ADEAR and National Library of Medicine.
- Initial search parameters included the following terms. Falls, injury, health care, nursing home, assisted living, flooring, and glare.

Criteria

- Peer-reviewed (some non peer-reviewed articles included)
- Published in English
- Publication date of 1980 and after
- Theoretical and/or empirical
- Health care settings (includes long-term care & acute care)
- Includes a conceptualization of the physical environment even if an actual environment is not the research focus.

ORGANIZING AND RATING INFORMATION

Environmental Factors Categorized

- Spatial organization
- Interior characteristics
- Sensory attributes
- Use of environment

Environmental Factors Classified

- Risk factors (whose absence is critical to fall prevention)
- Supportive factors (whose presence is critical to fall prevention)
- Each element was assigned a ‘confidence rating’ based on the quality of the evidence.

FOUR TIER CONFIDENCE RATING

Rating One

– Empirically derived, specifically related to the physical environment as a single intervention, and essentially without contradictory evidence.

Rating Two

– Empirically based but for which there is either contradictory information, or the intervention was multi-modal and included either personal or behavioral components as well.

Rating Three

– Not empirically derived, but reflects the opinion of more than one expert.

Rating Four

– Not empirically derived, but is extant in the literature and has some support from either one expert or several care providers.

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SPATIAL ORGANIZATION

Supportive Factors (Rating Two)

- Visual access from nurses’ station to patient room (Poe, et al, 2005)
- Located close to the nurse station (Hitcho, et al, 2004)
- Decentralized design for nurse station (Hendrich, Fay & Sorrells, 2004)
- Acuity adaptable rooms (Hendrich, Fay & Sorrells, 2004)

Supportive Factors (Rating Four)

- Angled doorways for better visibility (Livingston, 2004)

Risk Factor (Rating Two)

- Poorly designed bathrooms (Brandis, 1999)

INTERIOR CHARACTERISTICS: FLOORS

Supportive Factors (Rating One)

– Low pile, tightly woven carpet (Dickinson, Shroyer & Elias, 2002)

Risk Factors (Rating One)

– Carpeting with high contrasting patterns

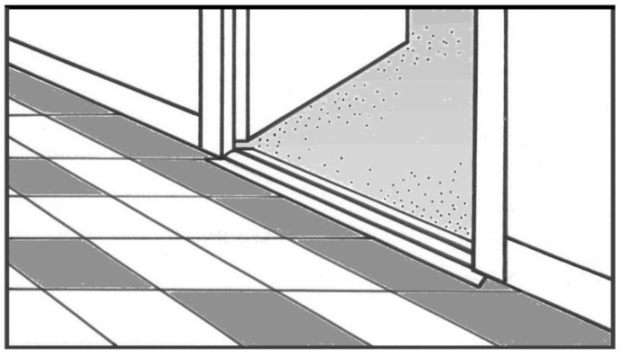
Risk Factors (Rating Three)

– Low coefficient of friction (Healthcare Hazard Management Monitor, 2003)

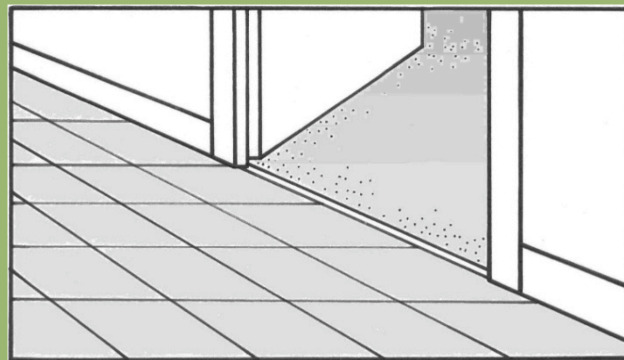
Risk Factors (Rating Four)

– Change in flooring material

INTERIOR CHARACTERISTICS: FLOORS



Example of a bad transition:
High threshold and high color contrast in the floor which can be perceived as level changes.



Example of a good transition:
Level and low contrast change at the threshold.

INTERIOR CHARACTERISTICS: FURNITURE

Appropriate Sizes & Heights of Furniture (Rating Two)

– Supportive Factor (Tideiksaar, 1998; Shroyer, Elias, Hutton & Curry, 1997.)

Unequal Heights of Chairs & Beds (Rating Three)

– Risk Factor (Tideiksaar, 1993)

Unstable Furniture (Rating Three)

– Risk Factor (Quang Vu, Weintraub & Rubenstein, 2004)

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INTERIOR CHARACTERISTICS: FURNITURE

Low Chair (Rating Three)

– Risk Factor (Klusch, 2003)

High Beds, Bedrails (Rating Three)

– Risk Factor (Creditor, 1993)

INTERIOR CHARACTERISTICS: FURNITURE

Lack of a clear path through the room.

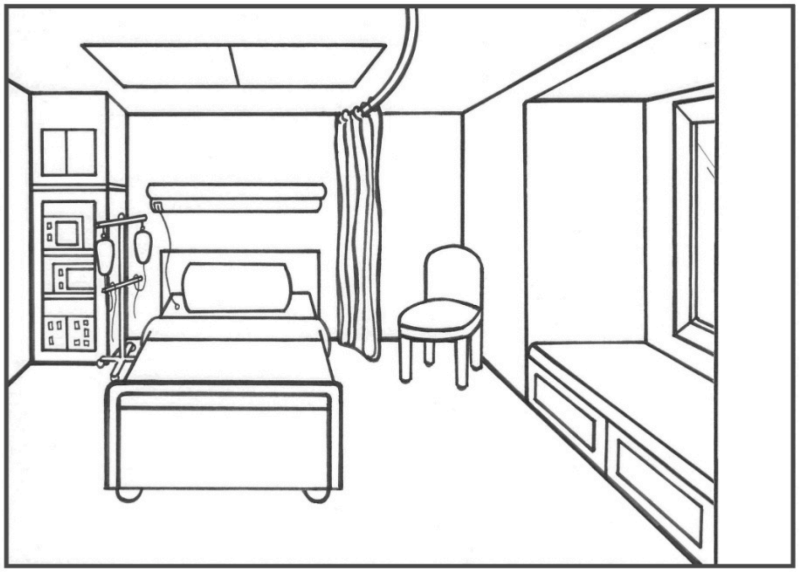
Location of furniture within patient room

Obstacles – Risk factor

(Newton, 2003)

Rating 4

INTERIOR CHARACTERISTICS: FURNITURE



Chairs without arms and a low window seat with no means of support while standing may both increase the risk of falls, though there is little empirical evidence to support this.

Slow timed chair stands
Risk factor
Tinetti, Inouye, Gill, & Doucette (1995)
Rating 4

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INTERIOR CHARACTERISTICS: ASSISTIVE FEATURES FOR AMBULATION

Grab bars located at the back and side of the toilet are most useful for individuals who use a side-slide methods to transfer.

The fold-down grab-bars on each side of the toilet may be more supportive, especially for older adults who often experience hemiplegia or weakness on one side.

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SENSORY ATTRIBUTES

Subdued Lighting (Rating Two)

– Risk Factor (Creditor, 1993)

Poor Visual Contrast (Rating Two)

– Risk Factor (Ivers, Cumming, Mitchell & Attebo, 1998)

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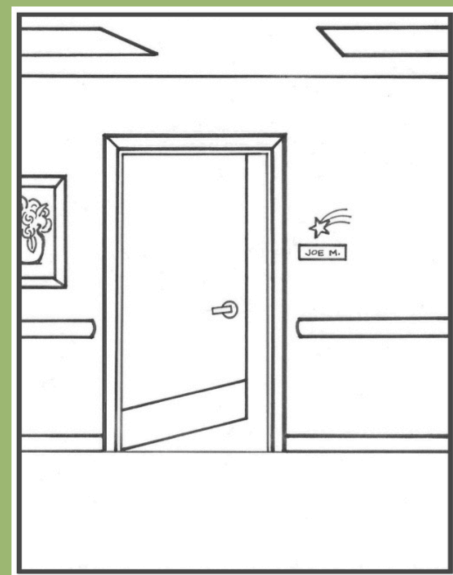
SENSORY ATTRIBUTES

Color coded flagging and Identification system (Rating 2)
Supportive Factor
Brandis (1999), Alcee,Mather & Jefferson (2000),
Poe, Cvach, Gartrell, Radzik, & Joy (2005)
McCarter-Bayer, Bayer, & Hall (2005)



Example #1 of a falling star- used to identify a high falls-risk patient

Example #2 of a fall-risk identification sign in a nursing home.

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USE OF ENVIRONMENT

Specially Designated Room with Video Surveillance(Rating One)

– Supportive Factor (Hitcho, Krauss, Birge, Dunagan, Fischer, Johnson, Nast, Costantinou & Fraser, 2004))

Specially Designated Room for High Risk Fallers(Rating Two)

– SupportiveFactor (Mills, Neily, Luan, Stalhandske & Weeks, 2005)

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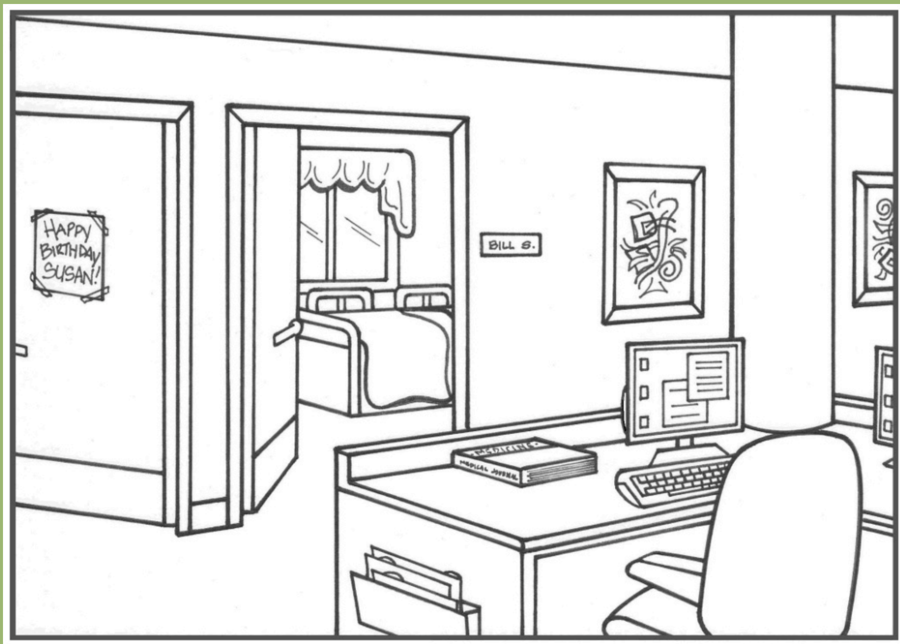
USE OF ENVIRONMENT



Locating high fall-risk patients in bedrooms closest to the nursing stations.

Move fallers with dementia closer to nurse station
Supportive factor
Rubenstein, Josephson, & Robbins (1994)
Rating 4

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SUMMARY AND REFLECTION

Highlighting Improvements that Assist Staff & Residents in Fall Prevention Measures

– New design features such as decentralized nurse stations, better visual access, and acuity adaptable rooms.

Target Environmental Interventions

– In addition to the systematic examination of fall-related patterns, such as the higher number of fall incidents when getting out of bed at night to go to the bathroom, can point to other target interventions such as better night lights, more accessible call bells (Donaghue, Graham, Gibbs, Mitten-Lewis, 2003).

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