


On the Planning and Design of Hospital Circulation Zones: A Review of the Evidence-Based Literature

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Abstract

Objective: This present literature review explores current issues and research inconsistencies regarding the design of hospital circulation zones and the associated health-related outcomes.

Background: Large general hospitals are immense, highly sophisticated institutions. Empirical studies have indicated excessively institutional environments in large medical centers are a cause of negative effects to occupants, including stress, anxiety, wayfinding difficulties and spatial disorientation, lack of cognitional control, and stress associated with inadequate access to nature. The rise of patient-centered and evidence-based movements in healthcare planning and design has resulted in a general rise in the quality of hospital physical environments. However, as a core component of any healthcare delivery system, hospital circulation zones have tended to remain neglected within the comparatively broad palette of research conducted and reported to date. **Method:** A systematic literature review was conducted based upon combinations of key words developed vis-à-vis a literature search in 11 major databases in the realm of the health sciences and the planning and design of built environments for healthcare. **Results:** Eleven peer-reviewed articles were included in the analysis. Six research themes were identified according to associated health-related outcomes, including wayfinding difficulties and spatial disorientation, communication and socialization patterns, measures and control of excessive noise, patient fall incidents, and occupants' stress and satisfaction levels. **Conclusions:** Several knowledge gaps as well as commonalities in the pertinent research literature were identified. Perhaps the overriding finding is that occupants' meaningful exposure to views of nature from within hospital circulation zones can potentially enhance wayfinding and spatial navigation. Future research priorities on this subject are discussed.

Keywords

hospitals, circulation zones, health outcomes, systematic literature review, evidence-based design, patient-centered care

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Hospitals are large, complex institutions that continually evolve (Latimer, Gutknecht, & Hardesty, 2008). In many cases, these care settings are built and expanded in phases across a period of decades in a manner that inadvertently isolates their occupants from experiencing sustained visual-spatial sensory contact with the external world. This condition, in the extreme, is tantamount to occupants' exposure to environmentally induced sensory deprivation, as in exposure to perceptually underwindowed or entirely windowless conditions (Verderber, 1986). In addition, large healthcare institutions are highly compartmentalized entities, with numerous layers of functional requirements governing their planning processes and spatial attributes. This phenomenon has its roots in the Middle Ages, whose large monastic hospital campuses expressed a clear functional separation between sacred and secular structures, with the open chapel-ward possessing a superordinate role apart from all other spatial zones on the campus, circulation or otherwise (Goldin, 1994; Thompson & Goldin, 1975). Various support functions were interconnected via a network of internal and external circulation paths. As these places evolved through the centuries, they were shaped in time by more advanced medical practices as well as by advanced building technologies.

By the 19th century, when germs were revealed as the primary cause of most illness, the contagious patients were isolated from other types of patients, which resulted in an unprecedented wave of spatial compartmentalization in hospitals (Pangrazio, 2013; Verderber, 2010). Certain types of spatial separation/isolation took on extreme high priority, and this was attributable to evolving best safety and treatment practices. Concurrently, this, together with greater emphasis on patients' rights and desires for self-actualization, greater personal control, family inclusiveness, and overall participation in caregiving and healing, has more recently governed the landscape of spatial compartmentalization in hospitals and other types of healthcare facilities, with significant consequences for the planning and design of hospital circulation zones.

Empirical studies have shown that excessively institutional environments of large medical centers have caused various adverse outcomes in their inhabitants, among which hospital wayfinding, usually defined as a spatial-solving process based on cognitive map (Passini & Arthur, 1992), becomes the biggest challenge (Allison, 2007). Other adverse outcomes include heightened stress and anxiety levels, a lack of perceived personal control, lack of accessibility to positive distractions, and, more specifically, inadequate meaningful contact with nature (Ulrich, Zimring, Quan, Joseph, & Choudhary, 2004; Verderber, 2005, 2010, 2015). Circulation zones in healthcare facilities, typically defined as spaces expressly dedicated for the movement of people, equipment, and supplies between myriad internalized departments, are essential components of any care delivery system (Carthey, 2008). Circulation zones belong to hospitals' public spaces, those spaces that the public who use the hospital can reach independently, including such as the area in front of the entrance, the entrance hall, reception areas, corridors, vertical connections, and waiting rooms (Setola & Borgianni, 2016). The planning and design of circulation zones may in fact significantly impact users' perceptions and experiences from the perspective of multiple stakeholders. In fact, these spatial zones contribute greatly to one's first impressions of any care setting, and for this reason alone warrant a thoughtful examination of their broad planning and design potentialities.

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Essential Components of a Healthcare Delivery System

Hospital circulation zones can occupy a significant percentage of a facility's overall physical footprint. According to the Australasian Health Facility Guidelines, healthcare circulation spaces may constitute up to 40% of total functional floor areas in general hospitals (Carthey, 2008). This

estimate is comparable in the United States in similar institutions. For instance, in a typical 32-bed adult inpatient care unit, the departmental grossing factor can reach up to 1.6 in current healthcare programming best practices (Latimer et al., 2008), which signifies that circulation zones may occupy up to around 30% of the department gross area.¹ Such spaces are essential in terms of the services and functions they afford on a 24/7 basis, as they link interdepartmental transportation and communication. Additionally, they serve a medicinal function, because patients with certain levels of ambulation capabilities use corridors and adjacent public spaces for rehabilitation activities. For instance, to facilitate rehabilitation therapies, patients are encouraged to participate in the “walking for wellness” programs (Callen, Mahoney, Grieves, Wells, & Enloe, 2004).² They are usually accompanied by trained escorts and walk throughout hospital corridors several times per day. In addition, hospital circulation zones serve as a “backstage” or “neutral space” for interpersonal communications. These exchanges among medical team members, and others, as well as the various informal learning activities these spaces facilitate, render them essential amenities (Carthey, 2008).

Essential Components of the Total Healthcare Experience

Hospital circulation zones occupy a vital role in the experience of the total environment for all types of users. Bitner (1992) and, more recently, Fottler, Ford, Roberts, Ford, and Spears (2000) concluded that public spaces in healthcare facilities were closely related to patients’ overall satisfaction levels and may also impact their mood and physical behaviors. Pangrazio (2013) also pointed out that healthcare public zones can create a memorable and positive experience by providing orientation, enhancing self-actualization, building self-confidence, and therefore furthering the overall healing process. This especially pertains to hospital staff, specifically, who spend most of their time traveling the corridors providing care and retrieving supplies. A nurse on shift can travel upward of 5 miles during an average

12-hr period, with an assignment of four patients; this traveling distance increases significantly when more patients are assigned (Welton, Decker, Adam, & Zone-Smith, 2006). Nurses and other support personnel also spend a significant amount of time from the nurse station viewing adjacent corridor environs and associated spaces, which is both inevitable and essential. Ample empirical evidence has shown the physical work environment (including circulation zones) can affect one’s overall job performance, job satisfaction, interpersonal communication patterns, employee fatigue, error rates, and physical and psychological stress (Hendrich, Chow, Skierczynski, & Lu, 2008; Pati, Harvey, & Barach, 2008; Stichler, 2009; Ulrich et al., 2004, 2008; Vischer, 2008). Therefore, hospital circulation zones, as part of the major physical work environment for nurses and other caregivers, may significantly impact job performance, satisfaction, and well-being.

Essential Transitional Linkages Connecting Interior Spaces With Nature

Significant empirical evidence indicates views of nature from within a hospital possess therapeutic benefits (Ulrich, 1984; Verderber, 1986). The thoughtful integration of nature into a healthcare physical environment has been demonstrated to reduce people’s stress (Dijkstra, Pieterse, & Pruyn, 2008; Ulrich, 1999), reduce people’s perceived pain (Vincent, 2009), improve one’s mood status (Cooper Marcus, 2007; Jiang, 2015), enhance staff’s alertness, and contribute to a reduction of medical errors (Pati et al., 2008; Buchanan, Barker, Gibson, Jiang, & Pearson, 1991). As for space expressly devoted to nature content, many “healing gardens” in hospitals remain disconnected from their adjoining interiors. Four major barriers to their usage persist in most hospitals have been identified, among which two limitations are (1) inadequate knowledge of the existence of the hospital garden and (2) low visibility and difficulty in physically accessing this space (Whitehouse et al., 2001). Pasha (2013) has observed that therapeutic nature and gardens located directly off highly trafficked zones (e.g., a corridor intersection, lobbies, or

main circulation arteries) are more likely to be discovered and inhabited by users. In a broader sense, having a view to nature from a patient room, waiting area, staff office, and corridor can greatly increase the probability of knowing about the existence of a hospital garden, hence encourage engagement with nature (Cooper Marcus, 2007). Therefore, as a transitional link connected the patient's room to the outdoor environment, hospital circulation zones justify their being examined in order for them to be planned and designed to maximize their nature-transparency quotient. Circulation zones, therefore, warrant them becoming more central in the overall planning and design of healthcare settings, as these spaces can promote positive distractions and cognitive respite from the rigors of one's daily routine and simultaneously serve an essential role as transport of equipment and supplies. Yet, to date, there have not been an adequate number of studies on the design of hospital circulation zones, neither a comprehensive review of the empirical research conducted on this topic. The primary aim of the analysis is therefore to examine the existing literature on the relationship between the planning and design of hospital circulation zones and associated health-related outcomes for human well-being.

Therefore, as a transitional link connected the patient's room to the outdoor environment, hospital circulation zones justify their being examined in order for them to be planned and designed to maximize their nature-transparency quotient.

Method

A systematic literature review on this subject was conducted by means of a three-step procedure. First, a key word search was conducted to identify all relevant studies published in the English language from the year of 2000 to present. The key word combinations included two groups: (1) hospital, healthcare facility, healthcare environment, assisted living facility, care unit, patient ward and (2) corridor, hall/hallway, circulation zone/space, mover space, transfer area. Database used for the

literature search included Academic Search Complete, Avery Index to Architectural Periodicals, Applied Science and Technology Source, ScienceDirect, EBSCOhost Online Research Databases (EBSCO), Medical Literature Analysis and Retrieval System Online (MEDLINE), The Cumulative Index to Nursing and Allied Health Literature Database (CINAHL), Scopus Database, PsycINFO – American Psychological Association Database, SAGE Journals, and Journal Storage Database (JSTOR).

However, relatively few studies were identified that fulfilled the database search criteria. Next, the literature search was extended to reports of research studies on healthcare public spaces/common spaces and the general physical environments of healthcare facilities. After scrutinizing the search results, 11 peer-reviewed publications identified as relevant; these sources were further sorted into two categories according to their level of relevance to the overall research topic: Level 1—primary resources, included five articles pertaining to healthcare circulation zones as the major focus (see Appendix Table A1). Level 2—secondary resources included six articles with general healthcare public spaces as their principal research focus with hospital circulation zones mentioned as a component (see Appendix Table B1). Finally, based on a careful perusal of each source identified, seven research themes were identified based on health-related outcomes discussed in each inclusive article. These associated outcomes included (1) wayfinding difficulties and spatial disorientation, (2) communication and socialization patterns, (3) measures and control of excessive noise, (4) patient fall incidents, (5) occupants' stress level, and (6) occupants' satisfaction level. These results are reported in Figure 1.

Results

Appendix Tables A1 and B1 present the set of publications chosen for inclusion in the literature review, with key background information and findings presented. These consist of a description of the topic and scope of the study, key research theme(s), the type of healthcare facility studied, the research design and sample, key measures of health outcome, the impact of healthcare circulation spaces

Research Theme/ Health Outcome		2-Level-Resources						
		Wayfinding Difficulties	Communication and Socialization Patterns	Measures and Control of Excessive Noise	Patient Fall Incidents	Occupants' Stress Level	Occupants' Satisfaction Level	Other Patient-Centered Care Issues
Level 1 - Primary Resources	Allison, D. (2007)	●						◐
	Carthey, J. (2008)	◐	●					◐
	Edgerton, E., Ritchie, L., & McKechnie, J. (2010)		●			◐		○
	Wang, Z., et al., (2013)			●		●	●	○
	Lau, S. & Roy, K. P. (2014)			●			○	○
Level 2 - Secondary Resources	Foureur, M.J., et al. (2010)					○	○	●
	Topo, P., Kotilainen, H., & Eloniemi-Sulkava, U. (2012)						○	●
	Pangrazio, J. R. (2013)						●	◐
	Wood-Nartker, J., Guerin, D. A., & Beuschel, E., (2014)	○			●			◐
	Andersson, M., Ryd, N., & Malmqvist, I. (2014)		●					◐
	Xie, H. & Deng, Z. (2014)			●				

● Primary investigative focus; ◐ Secondary investigative focus; ○ Indirect investigative focus

Figure 1. Principal themes/health outcomes identified in the literature/precedent analysis. Courtesy of the authors.

on well-being, and design recommendations, if applicable. This analytical framework was adapted from a literature review conducted on evidence-based environment and aging research in Japan (Verderber & Song, 2005). Below, a description of these various research themes is reported.

Wayfinding Difficulties and Spatial Disorientation

Two articles included in the literature analysis addressed hospital corridor design and wayfinding (Allison, 2007; Carthey, 2008). Multiple renovations/expansions of a hospital’s physical envelope often yield labyrinthine-like configurations of internal corridors, which make wayfinding a challenge at the very least, and a source of significant environmental stress, in the extreme. Since a general hospital is in many ways rather analogous to a small city regarding its functional

complexity, Allison (2007) concluded that urban planning and design principles were in fact relevant and applicable to the design of such facilities. Carthey (2008) supported Allison’s findings, concluding that every corridor should “be considered a part of the larger circulatory system of a hospital, in much the same way urban streets are part of a hierarchy of connecting routes within a city” (p. 24).

As a means to improve hospital internal wayfinding behaviors, the findings from Lynch’s (1960) seminal study, *The Image of the City*, provide insight by clearly identifying five physical elements of the physical setting that possess a significant role in helping develop one’s mental map of a place: paths, nodes, landmarks, edges, and districts. “Hospitals, like cities, should have landmarks, public places and green spaces for both therapeutic and navigational purposes” (Allison, 2007, p. 61). Because of this,

circulation zones should be designed in a hierarchical manner like the hierarchy of circulation pathways within a city: boulevards, secondary streets, and service street or back alleys (Allison, 2007). In healthcare settings, “boulevards” or internal “streets” can be planned and designed as central spines, which also connect the constituent parts of larger healthcare complexes. If thoughtfully planned and built, these spaces can simultaneously afford natural daylight, internal and external landmark cues, and provide related spatial orientation amenity. Similarly, secondary arteries or “streets” can function as corridors between hospital diagnostic, treatment, and ambulatory care zones, similar to a series of “storefronts.” Accordingly, so-called service and equipment-only “back alleys” in hospitals can be principally for back-of-house functions yet this is not an excuse to design these zones devoid of meaningful contact with the outside world (Allison, 2007).

Communication and Socialization Patterns

Three published research articles addressed the theme of communication and socialization patterns among the various users. Carthey (2008) stated that hospital corridors often serve as an ancillary setting for clinical care interactions among multidisciplinary care team members. Literature examined by Carthey pointed out the value of “backstage” spaces or “neutral zones,” such as corridors, that foster conversations and cross-disciplinary communication, and which break down traditional hierarchical barriers and specializations that otherwise exist within a medical caregiver team. A significant amount of informal learning can also occur due to the frequency of casual encounters and conversations among scientists, physicians, nurses, administration, internists, and allied professionals-in-training and that these spaces are particularly invaluable in teaching institutions (Carthey, 2008).

The built environment has been shown to be a relevant support modality for patients with dementia and related psychological disorders. Edgerton, Ritchie, and McKechnie (2010) studied the impacts on patients’ behaviors and

users’ perceptions of a redesigned corridor environment in a psychiatric hospital. One primary corridor in this hospital was redesigned by (1) replacing its largely “institutional” physical attributes to bring about a sense of greater connectivity with nature; (2) breaking up the perceptually vast, undifferentiated expanse of the corridor space itself through the introduction of multiple informal seating areas; and (3) blocking unpleasant views to the outdoors while enhancing visual and physical access connectivity to an adjacent courtyard garden (Edgerton, Ritchie, & McKechnie, 2010). Observational studies and a survey of the patients and staff were conducted before and after these design interventions. Results indicated a significant increase in the number of patients conversing with other people in the corridor after the design interventions. Patients, furthermore, were more likely to be accompanied by a staff member or a visitor, and more patient–nurse communications occurred in the redesigned corridor environment.

Andersson, Ryd, and Malmqvist (2014) explored the function and use of common spaces in 14 assisted living facilities dedicated for older residents in Sweden. Common spaces studied in each facility included shared spaces adjacent to the apartments, the dining room, the sitting dayroom, the kitchen, the corridor, adjoining staff spaces, and outdoor balconies and open spaces. They concluded that residents and employees have differing objectives and goals for space use, and this in turn influenced space use. Common spaces were deemed important for social interactions among residents and between the residents and staff. The design recommendations that resulted from this study centered on improvements in lighting conditions in facility corridors (Andersson, Ryd, & Malmqvist, 2014).

Measures and Control of Excessive Noise

Three articles explored noise-related aspects within hospital circulation zones. Xie and Deng (2014) identified characteristics of primary noise sources in hospital corridors, by focusing on a long, undifferentiated corridor within a

cardiology department in a hospital in Mainland China. By using sound level meter monitoring devices, the acoustic levels in the corridor were measured across a 24-hr period. An on-site observational study was conducted simultaneously in the same period. Types of noise sources were identified and ranked according to the occurrence of frequency. The top 10 noise sources included doors closing and squeaking, footsteps, coughing, loud conversations, general movement activities, thumping and banging of carts and the like, housekeeping services, telephone ringing, cabinet doors closing loudly, and equipment cart/trolleys (Xie & Deng, 2014).

Using a somewhat similar research method, Lau and Roy (2014) compared different design materials used in the hospital corridor environment, and their impact on noise control at Palomar Medical Center, in San Diego in the United States. Materials compared in this study included (1) carpeting versus hard flooring/vinyl tile surfaces and (2) standard acoustical ceilings versus high-performance acoustical ceiling systems. The results indicated that corridors with either carpeting or high-performance acoustical ceiling grid systems were associated with lower noise levels as well as a significant decrease in these spaces cited as a source of annoyance and distraction to patients and medical professionals (Lau & Roy, 2014).

Wang et al. (2013) explored the role of a dedicated service corridor adjoining an older Intensive Care Unit (ICU) setting in relation to the incidence of excessive noise levels, staff stress, and a decrease in overall staff satisfaction in an academic medical center located in Central Illinois. A comparative before–after analysis was conducted in an adult cardiac ICU that had recently been relocated from an older, traditional hospital to a new addition with its own dedicated service corridor. A survey regarding pre- and postmove perceptions of environmental comfort, stress levels, and staff satisfaction was conducted with the nursing staff. Acoustical measures of noise sources were also compared. Results indicated the new, dedicated service corridor reduced noise levels and staff stress while improving staff satisfaction levels (Wang et al., 2013).

Patient Fall Incidents

Wood-Nartker, Guerin, and Beuschel (2014) examined the environmental cues and associated impacts on patient falls at 140 assisted living facilities located in the lower peninsula of Michigan in the United States. This study utilized a checklist instrument consisting of 110 environmental sensory cues to classify and document the presence/nonpresence of such cues in the public spaces at each facility. Public spaces studied included 41 types of rooms. Five specific room types were found where patient falls occurred most frequently, including living room/lounges, dining rooms, corridors, public restrooms, and circulation foyers. A correlational analysis between the level of presence of sensory cues and the incidence of patient falls was then examined. Results showed that overall facility size mattered in patient fall occurrence rates. With respect to the circulation zones in medium-large facilities, a converse relationship existed between the number of environmental cues present and the number of patient falls. Design suggestions for the injection of effective fall-reducing environmental cues in these public spaces included (1) incorporating high-contrast conditions between wall and floor surfaces and furnishings; (2) the use of matte finishes; (3) the use of color, artwork, photos, and various memorabilia on wall surfaces to enhance wayfinding; (4) clear, well-placed signage in all circulation spaces; (5) use of visual and auditory alarms; (6) use of graphic images on walls; and (7) the nonuse (removal) of distracting graphic images and colors on floor surfaces (Wood-Nartker, Guerin, & Beuschel, 2014).

Occupants' Stress Levels

Two published investigations examined occupants' stress levels and one study focused on patients' fears and anxiety levels (albeit not as a primary research theme in the case of the latter). As previously mentioned, Edgerton et al. (2010) concluded, in part, that patients felt more relaxed when traversing a corridor environment with natural features such as natural daylight and views to exterior gardens, and particularly when

associated with a noninstitutional interior design palette. Wang et al. (2014) concluded that having a dedicated service corridor in the ICU reduced staff's perceived stress and improved their job satisfaction. Foureur et al. (2010) found that long, windowless, undifferentiated corridors in a birthing/maternity unit setting can be frightening and a cause of anxiety, even contributing to the status of a patient's labor.

Occupants' Satisfaction Levels

Pangrazio (2013) discussed the general public's circulation zones in healthcare settings and the positive impacts on users' perceptions and experiences (Pangrazio, 2013). Five types of public spaces were identified, including collector spaces (i.e., arrival and orientation spaces such as entry lobby and reception zones), introspective spaces (i.e., arrival zones and other spaces perceived as of calming effect such as a chapel and support spaces such as cafes and dining areas), movement spaces (i.e., corridors), and transition zones (i.e., spaces situated between departments and most general public areas such as elevator lobbies). It was concluded this typology of public circulation spaces could impact patients' positive perceptions of the quality of care dispensed and one's overall satisfaction with the healthcare facility. From a cost-to-benefit perspective, a rethinking of healthcare facility planning best practices should more directly address these public space design opportunities (Pangrazio, 2013).

Other Patient-Centered Care Issues

Most investigations to date have examined this subject area from a patient-centered perspective. Among them, two articles developed postoccupancy evaluation tools for healthcare facilities where circulation zones were carefully considered. Topo, Kotilainen, and Eloniemi-Sulkava (2012) developed the "Residential Care Environment Assessment" (RCEA) tool for the assessment of dementia care units. This method was used to examine the impact of the quality of the setting and its affordances relative to patient well-being. Six specific attributes comprised this

assessment tool including (1) building configuration, (2) fixed/attached objects, (3) nonfixed/movable objects, (4) malleable materials, (5) opportunities for socialization and personal privacy, and (6) the auditory/sensory environment (Topo, Kotilainen, & Eloniemi-Sulkava, 2012). Specific physical qualities found to be closely related with hospital circulation zones included (a) hallways, corridors, and vestibules with electronic surveillance devices and abundant lighting and (b) direct physical access to the outdoor environment and exterior gardens. Similarly, postoccupancy evaluations were subsequently carried out in 10 residential dementia care facilities in Finland, using the same RCEA tool. The results, with regard to corridor spaces, indicated that corridors with windows on their end points invited the user to venture, engage, look outside, and rest (when seating was provided). Second, facility conditions featuring abundant natural daylight in circulation spaces supported wayfinding and provided an inviting ambiance. Conversely, facilities characterized by underwindowed or windowless and undifferentiated corridors were found to be less preferred (Topo et al., 2012).

Foureur et al. (2010) developed a "Birth Unit Design Spatial Evaluation Tool" for the assessment of hospital birthing units in Australia. Corridor spaces, as previously mentioned, were considered in their research. Four dimensions of each unit were measured including (1) characteristics affecting what the researchers described as the "fear cascade," (2) the unit's physical attributes, (3) aesthetic aspects of the unit, and (4) the presence (absence) of adequate essential support provisions for women and their families while on the unit. It was concluded that the facilitation of effective navigational behaviors and the presence of a welcoming care environment reduced patient anxiety. "Long corridors can be frightening and cause anxiety for first-time arrivals, especially those who are not sure how far it might be and whether help is nearby" (Foureur et al., 2010, p. 49). Other fear-inducing features related to counter therapeutic corridor zones included poor lighting conditions and the absence of windows and views to the outdoors. One additional key element of

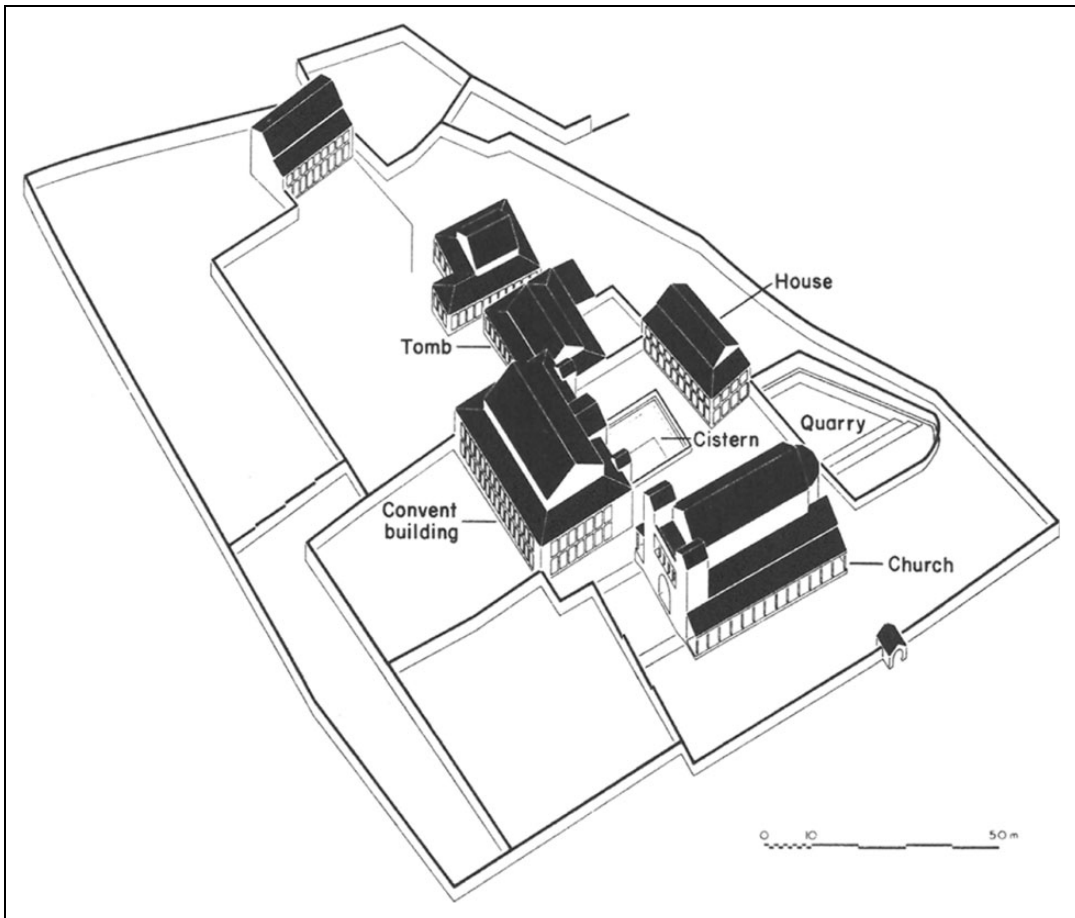


Figure 2. Site plan of the monastery of Turmanin, Syria, about 475 AD. Adapted from Thompson and Goldin (1975).

therapeutic health facility design in this regard was having a connection with nature and easy access to gardens and courtyards, “Moving to another environment, especially a garden or outdoor setting, can reduce fear and restore the production of oxytocin (i.e., the hormone responsible for initiating labor) to support strong contractions” (Foureur et al., 2010, p. 49).

Discussion

Circulation zones and adjacent public spaces have been a fundamental and essential spatial feature of healthcare environments since the Asclepiad of Ancient Greece, with their open spaces and interior side corridors that ran along

the entire inner side length of the adapted stoa-patient wards surrounding a large open-air central courtyard. Later, the Bimaristans of the ancient Middle East in Baghdad, Cairo, and Damascus featured large open-air courtyards and adjoining patient wards with corridors that ran continuously at the perimeter (Montague, 1984). Later, the Roman valetudinarium was a military hospital, featuring a racetrack circulation system, with the first double-loaded corridors in Western hospitals. After the fall of Rome in the 4th century, the massive monastic medical complexes of the Middle Ages across Europe were operated by religious orders (Thompson & Goldin, 1975; Verderber, 2003). These places featured large chapel-wards surrounded by an array of secular

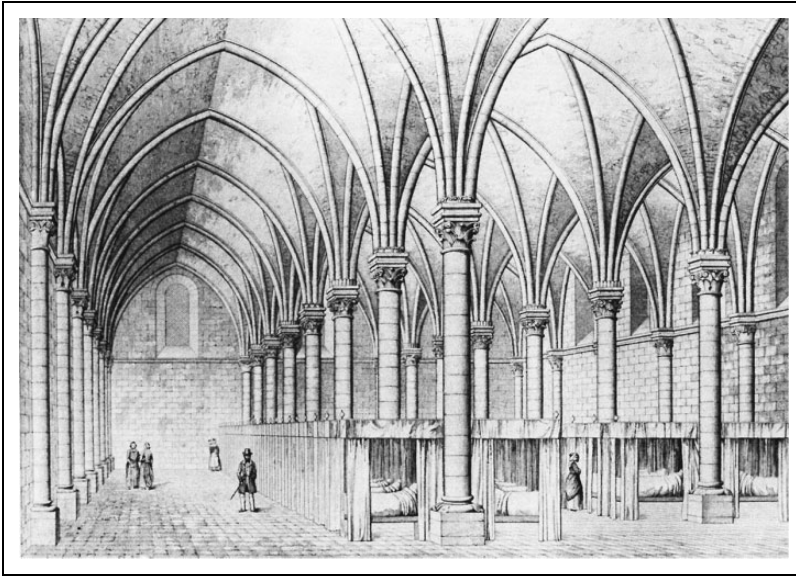


Figure 3. Interior of the Hotel Dieu of St. Jean in Angers, France (founded 1153) as depicted in the 19th century. Adapted from Thompson and Goldin (1975).

support structures. The circulation arteries linking these various out-building secular support structures with the sacred space of the chapel-ward were outdoors, typically, although far from randomly configured (Figure 2). By contrast, the generous circulation aisles of the chapel-ward infirmary were the principal means of interior circulation for everything, as they were shared by people, equipment, and supplies (Goldin, 1994). There was no distinction between public (direct caregiver and patient use) and back-of-house circulation arteries in this regard (Thompson & Goldin, 1975; Verderber, 2010). The massive chapel-ward infirmaries that dominated the European healthcare landscape in the 12th through 15th centuries were characterized by immense ceilings, wide circulation zones, and spatial undifferentiation, since in times of plague even these spaces became filled with patient beds (Figure 3).

In the classic Nightingale nursing ward, 16 beds were arrayed on each side of a central circulation zone, connecting all portions of the ward. Each ward, in turn, was connected to a central circulation artery linking multiple open wards on the hospital campus. Many of the earliest hospitals built by the Veterans' Administration in the

United States, dating from the agency's founding in 1930, were still using this same ward footprint well into the 1970s, a footprint developed more than a century earlier (Verderber & Fine, 2000). After 1945, in the era of the modernist megahospital, the size of the building envelope increased exponentially in size and its sheer complexity. This resulted in myriad interior—undifferentiated interior circulation zones linking dozens of specialized units and departments—departments dedicated to the advancement of medical science by means of highly sophisticated medical technologies for the diagnosis and treatment of illness and disease.

By the 1990s, in the most progressive instances, the pendulum had begun to swing away from these excessively oppressive building envelopes and their attendant Spartan circulation zones, toward a facility planning and design strategy that sought a greater connectivity with nature and greater sense of visual/sensory transparency with the outdoor milieu. One early outcome of this contemporary trend was the rise of the “healing garden” and more recently, therapeutic gardens. Most recently, in a very positive development internationally, many other manifestations of this movement toward the blurring

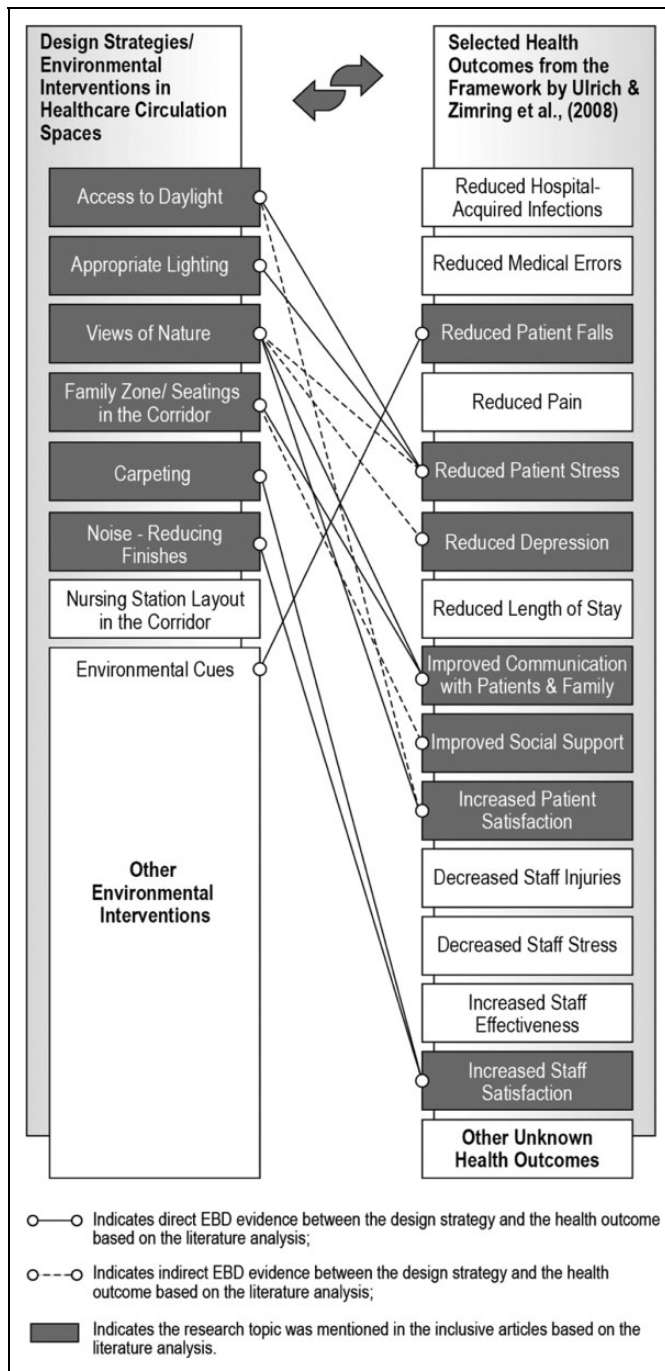


Figure 4. Evidence-based knowledge gaps identified with respect to hospital circulation zones and health-related outcomes. Courtesy of the authors.



Figure 5. The inpatient unit and corridors at Helsingor Psychiatric Hospital in Denmark (2006). Courtesy of JDS/Julien DeSmedt Architects.

of the lines between architecture and landscape architecture are occurring in hospitals and allied healthcare settings including the injection of landscape architecture from the earliest phases of site/facility planning and design (Jiang & Verderber, 2016).

Best practices in the planning and design of healthcare circulation zones and their relationship to their users' well-being and health status must continually evolve to reflect the state of the art. Somewhat surprisingly, a paucity of systematic research exists on this topic compared to the large volume of research that has been conducted and published on many other facets of the healthcare environment relative to occupants' safety, well-being, and health status. In this regard, current research gaps on this facet of the total built environment are discernable as are environmental *interventions* to enhance the efficacy of these zones and their positive impact on health outcomes (Ulrich et al., 2008). As such, and as depicted in Figure 4, the knowledge gaps cited in the previous discussion warrant further exploration using evidence-based methodologies.

One particular research finding in the preceding analysis is natural views in hospital circulation zones afford potential therapeutic benefits in relation to hospital spatial navigation behavior. As discussed by Allison (2007), views to the outside world can provide a vista to various external landmarks, enhancing internal

cognitive spatial orientation. It has been hypothesized that single-loaded corridors with windows views looking onto nature were inherently more legible than double-loaded corridors with monotonous, institutional interior conditions. As Allison stated, "locating pathways along the edges of courtyards can also help—even small courtyards placed along public corridors can assist in wayfinding" (p. 64). A greater degree of transparency between the interior and exterior realms of a healing setting can break down barriers that have persisted in hospitals in the West for hundreds of years (Jiang & Verderber, 2016). The concept of *theraserialization* is apropos, defined by the interior and exterior realms of a healthcare setting, in effect, being consciously planned and designed to dematerialize many of the myriad walls and barriers that tend to overcompartmentalize, segregate, and otherwise excessively wall off internal elements within the typical hospital. In so doing, alternatively, they are able to become "layered" with one another, where interior-to-exterior spatial sequences are more interconnected and internal functionality expressed more transparently—interwoven—in a completely new way. This strategy is promising at this time, as it can yield positive outcomes for building inhabitants from a therapeutic standpoint (Jiang, 2015; Jiang & Verderber, 2016; Verderber, 2010). The Helsingor Psychiatric Hospital, in Denmark (2006), by JDS/Julien DeSmedt Architects,

inventively uses a corridor intersection node to activate a powerful view into an adjacent outdoor garden (Figure 5). Thoughtful facility planning and design strategies such as this warrant further investigation beyond the scope of the present discussion.

The internal circulation zones within hospitals warrant reappraisal as arteries not unlike coral reefs—containing continuous interesting natural views, with multivalent atrium gardens, seating nodes, and light wells and vegetated-wall apertures—places judiciously situated along primary and secondary corridors and between various departmental units. This affords connectivity with nature and the outdoor milieu. Correspondingly, seating areas and water elements should be integrated, hierarchically, providing a vibrant palette of discrete viewing places (e.g., perches and outlooks). This interwoven vocabulary of circulation arteries, windows, views, and seating nodes function collectively as “landmarking devices,” as essential aids in the spatial and sensory navigation of otherwise uninspiring, and cognitively, if not physically challenging circulation realms. Collectively, these amenities can significantly aid the occupant in constructing a sustainable, flexible cognitive map of a healthcare setting. These and related hypotheses/concepts call for further exploration using evidence-based research as a basis for articulating campus master

planning, facility planning, and architectural design strategies.

Implications for Practice

This study will inform healthcare design professionals and administrators on these points:

- Hospital circulation zones are critical, essential components of a healthcare delivery system and significantly impact users’ perceptions and experiences from the perspective of multiple stakeholders.
- Hospital circulation zones are associated with various essential health-related outcomes including wayfinding and spatial orientation, interpersonal communications and socialization, the effects of excessive noise, incidents of patient fall, and occupants’ stress and level of satisfaction.
- It is recommended that circulation zones in healthcare facilities be viewed as integral elements in campus and building planning processes from both a functional and psychological standpoint. They hold the power to foster a sense of psychological respite and positive distraction from the rigors of one’s daily routine while simultaneously providing essential functional support on a 24/7 basis.

Appendix A

Table A I. Summary of Primary Resources in the Design of Hospital Circulation Zones.

Authors (Year)	Type of Facility/Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
Allison (2007)	General hospitals in the United States	Theoretical assumptions	N/A	A clear hierarchy of circulation spaces (e.g., major thoroughfares, secondary stress, and back alleys) promotes exceptional wayfinding behavior	In healthcare design, systematic consideration of paths, nodes, landmarks, edges, and districts contribute to effective wayfinding and enhance users' overall experience Urban planning and design principles are applicable to medical planning and hospital design, e.g., Lynch's five elements on the image of the city (1960) Hospital corridors are important to the functioning of multidisciplinary clinical teams and quality of care delivery. Inflexibly reducing corridor spaces may be a false economy. A "nook" in a corridor for benches or ledges is preferred, as shown in the diagram:
Carthey (2008)	General healthcare facilities in Australia	Literature review; Theoretical assumptions	N/A	Hospital corridors (1) serve as "neutral zones" in healthcare facilities for clinical care and interaction by multidisciplinary care teams, (2) provide spaces for informal interpersonal behaviors, and (3) facilitate wayfinding	
Edgerton, Ritchie, and	A psychiatric hospital in Scotland	Comparison of a corridor before-and-after design interventions	Behavioral mapping; Questionnaire on 10 aspects of the	Certain positive design interventions to the hospital corridor	Findings support the value of variability in architectural arrangement of circulation spaces and in "breaking-up" long corridors. Findings

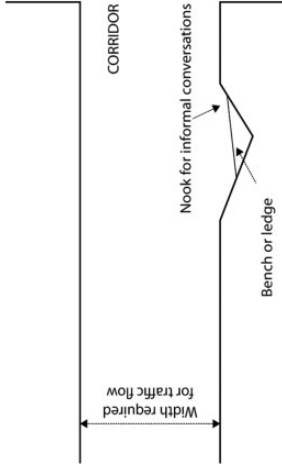


Table A1. (continued)

Authors (Year)	Type of Facility/Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
McKechnie (2010)		Observational study: behavioral mapping Survey: dementia patients ($n = 100$; preintervention = 53, postintervention = 47), and staff ($n = 55$; preintervention = 30; postintervention = 25)	corridor environment and users' perceptions	(1) positively impact patients' behaviors; (2) make patients feel more relaxed, and (3) improve patient–nurse communications	also support, for dementia patients, architectural edge spaces/exterior walls with windows/views of nature and as settings for social interaction Positive design interventions in hospital corridors include (1) removing obtrusive “institutional” features and instead introducing views of gardens and landscape features; (2) using opaque glass to accentuate the daylight while blocking out unsatisfactory external views; (3) changing the color/pattern of the ceiling, wall, and floor coverings to interject representations of nature; (4) reducing the width of corridors to a less institutional, more welcoming scale; (5) introducing ergonomically designed timber beams to act as informal seating elements; (6) planting trees outside, adjacent to the circulation artery and viewable from within; and (7) installing site-specific artworks at key intervals
Wang et al. (2013)	Adult-cardiac ICU in an academic medical center in the United States	Survey: nursing staff ($n = 118$) On-site observation Quasi-experimental, before-and-after comparison of noise levels in two ICUs	Acoustical measures of noise; Assessment of staff stress and satisfaction	A dedicated service corridor can (1) reduce overall and daytime noise levels in the unit, (2) reduce service traffic and amount of crash cart activity in the patient corridors, (3) improve the usage of patient corridors for patients walking/	The addition of a dedicated service corridor in a new ICU improved noise control, reduced staff stress, and improved staff satisfaction. The dimension of the measured service corridor is 8'6" (approximately 2.6 m) in ceiling height and 6' (approximately 1.8 m) in width

(continued)

Table A I. (continued)

Authors (Year)	Type of Facility/Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
Lau and Roy (2014)	Palomar Pomerado Health (PPH) in the United States	Comparison of noise levels: two corridors and adjacent public spaces Survey to patients and staff (sample size not known)	Acoustical measures of noise; assessment of users' perception of noise (various sources)	ambulation, (4) reduce staff stress, and (5) improve staff satisfaction Carpeting and high-performance acoustical ceiling in the hospital corridor and the adjacent spaces (1) reduce overall noise levels and (2) reduce users' perceptions of annoyance and distraction caused by excessive noise	Replacement of excessively hard surface flooring materials, i.e., carpets and high-performance acoustical ceiling, reduces "corridor activity noise" and enhances users' overall experience

Note. Courtesy of the authors.

Appendix B

Table B I. Summary of Secondary Resources in the Design of Hospital Circulation Zones.

Authors (Year)	Type of Facility/ Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
Foureur et al. (2010)	Birth/Labor and Delivery Room (LDR) birth units in Australia	Literature review; interviews with key informants (10 midwife clinicians and researchers and 3 healthcare architects); expert panel (experts from midwifery and architecture)	Development of the Birth Unit Design Spatial Evaluation Tool (BUDSET)	Certain conditions for corridors in birth units can be frightening and cause anxiety, including (1) excessively long corridor arteries, (2) corridors with insufficient natural lighting, (3) and windowless corridors that lack visual connectivity with the world beyond	To facilitate and support the physiology of natural childbirth, BUDSET identified four fundamental design principles, including (1) characteristics affecting the Fear Cascade, (2) facility characteristics, (3) aesthetic aspects of the unit, and (4) essential support elements preferred by women and family members. For corridor arteries, it is fear reducing to provide connectivity with nature in a manner that allows patients, family, and visitors to circulate with relative ease into gardens and courtyards on-site
Topo, Kotilainen, and Eloniemi-Sulkava (2012)	Special Care Units for patients with dementia in Finland (N = 10)	Randomized controlled intervention using a qualitative assessment tool; On-site observation	Residential Care Environment Assessment (RCEA) tool developed by research team	The presence of windows in spatially dead-end corridors invited residents to obtain sensory respite. Excessively narrow corridors, corridor arteries bisecting or traversing dining or living areas, or an absence of landmarks coupled with a monotonous or excessively	Five environmental/spatial affordances were identified vis-à-vis the RCEA diagnostic tool. These corridor-related items influence overall environmental quality: (1) Layout and Building Configuration: spatial movement patterns and direct accessibility to natural

(continued)

Table BI. (continued)

Authors (Year)	Type of Facility/ Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
				<p>long corridor configuration were perceived as perceptually and spatially restrictive. Sufficient lighting in circulation arteries and adjacent public spaces was found to support spatial orientation, and establishes a quasi-residential ambience</p>	<p>daylight sources, views to the immediate outdoor environment vis-à-vis windows, balconies, and gardens and (2) Attached Objects: corridor arteries and/or vestibular spaces sufficiently spacious enough and equipped with electronic surveillance amenities, and sufficient natural and artificial lighting.</p>
					<p>Suggestions for the improvement of corridor and associated circulation arteries in special care units include the interjection of (1) furnishings, color palettes, and works of art such as paintings to visually demarcate the end points of corridors; (2) removal of extraneous equipment and furnishings from corridors to enhance fire safety preparedness, wayfinding, and spatial amenity; (3) incorporate furnishing at the end points of corridors, where feasible, to double function their use as nodes</p>

(continued)

Table B1. (continued)

Authors (Year)	Type of Facility/ Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
Pangrazio (2013)	General hospitals in the United States	Theoretical assumptions	N/A	Public spaces (e.g., circulation systems, identified as one of the five typologies) enhance patients' overall experience. Six attributes should be considered when designing supportive healthcare public spaces including (1) environmental factors, (2) user characteristics, (3) public and private interpersonal relationships, (4) patients' physical health status and functional capabilities, (5) the function of time, and (6) patients' emotional disposition	for social interaction; and (4) provide effective lighting yet in a manner that controls for excessive glare at the end points of corridor arteries Public spaces in hospitals can promote memorable, positive experiences, contributing to the healing process through the provision of well-designed spatial orientation cues. Second, from a cost/benefit perspective, rethinking the functions of occupant-attuned design in public spaces in hospitals enhances the overall patient, visitor and staff experience
Wood-Nartker, Guerin, and Beuschel (2014)	Assisted living facilities in the United States (N = 140)	On-site interviews with sensory cue checklist	3-Point scale/presence of sensory cueing devices	An inverse relationship occurred between the incidence of patient falls and the presence of sensory cues in corridor arteries: the greater the number of environmental cues, the lower the number of falls. Facility size and room type	Environmental sensory cue recommendations for common spaces in assisted living facilities included (1) provide high contrast between surface finishes and furnishings; (2) employ aesthetically attractive finishes; (3) use color,

(continued)

Table B1. (continued)

Authors (Year)	Type of Facility/ Site	Research Design; Sample	Measures of Health Outcome	Impacts of Healthcare Circulation Spaces on Well-Being	Conclusions/Design Suggestions
Andersson, Ryd, and Malmqvist (2014)	Assisted living facilities in Sweden (N = 14)	Observation: residents and unit staff (n = 302); group interviews: unit staff (n = 24); individual interviews: residents (n = 10), relatives (n = 4), and planners and architects (n = 7); Questionnaire: unit staff (n = 177) and unit heads (n = 16)	Assessment of space utilization patterns and perceptions of facilities by multiple users and stakeholders	Residents, staff, and related stakeholders hold different views about the demarcation of home and work place and the role of common spaces as venues for social interaction. The physical environment of common spaces within assisted living facilities, corridors included, have an impact on patient socialization patterns	Lighting use routines within common spaces varied considerably; existing lighting conditions in a subset of public circulation arteries were assessed as inadequate
Xie and Deng (2014)	Cardiology department at a general hospital in China	Observational study: behavior patterns of noise sources and the recording of noise levels	Acoustical measurements: noise levels	Noise levels in cardiology corridor arteries were found to greatly exceed World Health Organization guidelines. Four typical noise sources were identified: obtrusive talking, loud door closings, coughing, and footsteps	N/A

Note. Courtesy of the authors.

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Notes

1. According to Latimer, Gutknecht, and Hardest (2008), departmental grossing factor, also known as net-to-gross multiplier, “is applied to the sum of all departmental NSF that calculates DGSF. These multipliers are empirical and based upon national norms as well as the experience of this healthcare consulting firm experienced in the programming of space requirements. They vary by department depending on the intensity of small rooms and the required widths of corridors (p. 73).” In the current practices, the departmental grossing factor of a typical 32-bed acute care unit ranges from 1.5 to 1.6 (Latimer et al., 2008). Given the definition of grossing factor mentioned above, it is unfeasible to isolate circulation spaces alone out from the miscellaneous spaces, such as wall spaces and building infrastructure facilities (e.g., electric and IT closets). In this case, it is only possible to speculate the circulation allowance and determine the upper limit. The above estimate is comparable to the recommendation by U.S. General Services Administration (2012) that the circulation multiplier for institutional buildings ranges from 1.4 to 1.6, the average is 1.5, and the average proportion of circulation spaces is 33%.
2. There is a trend to implement “Walking for Wellness” program at general hospitals (e.g., Piedmont Hospital, Atlanta, GA, and University of Wisconsin Hospital, Madison, WI). This program was designed to prevent the functional decline and mobility in older patients results from hospitalization. The program included the use of trained escorts to assist with walking in the hospital hallways

several times a day and educating patients and families about the importance of staying mobility (Callen et al., 2004).

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