Chapter 28. The Impact of Facility Design on Patient Safety

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Background

Recent attention in health care has been on the actual architectural design of a hospital facility, including its technology and equipment, and its effect on patient safety. To address the problems of errors in health care and serious safety issues, fundamental changes of health care processes, culture, and the physical environment are necessary and need to be aligned, so that the caregivers and the resources that support them are set up for enabling safe care. The facility design of the hospital, with its equipment and technology, has not historically considered the impact on the quality and safety of patients, yet billions of dollars are and will be invested annually in health care facilities. This provides a unique opportunity to use current and emerging evidence to improve the physical environment in which nurses and other caregivers work, and thus improve both nurse and patient outcomes.

Human Error and Cognitive Functioning by Design

Cognitive psychologists have identified the physical environment as having a significant impact on safety and human performance.[1, 2] Understanding "the interrelationships between humans, the tools they use, and the environment in which they live and work"[3] is basic to any study of the design a health care facility and its effect on the performance of the nurses and other caregivers who interface with the facility and its fixed (e.g., oxygen and suctioning ports on the wall of a patient room) and moveable (e.g., a patient bed) equipment and technology. Humans do not always behave clumsily and humans do not always err, but they are more likely to do so when they work in a badly conceived and designed[4] health care setting.

Organizational/system factors that can potentially create the conditions conducive for errors are called latent conditions. According to Reason,[1] latent conditions are the inevitable "resident pathogens" that "may lie dormant within the system for a long time, only becoming evident when they combine with other factors to breach the system's defenses. Latent conditions can be identified and remedied before an adverse event occurs." Examples of latent conditions are: poorly designed facilities, including the location of technology and equipment; confusing procedures; training gaps; staff shortages or improper staffing patterns; and poor safety culture. A specific example of a latent condition effecting patient safety would be the impact of low lighting levels in the medication dispensing areas that are associated with some medication errors but not others.[5] These and other conditions occur at what Reason describes as the "blunt end," where administrators, the work environment, and resources determine the processes of care delivery. Latent conditions are present in all organizations and can be unintentionally created by those who are responsible for designing systems, ensuring adequate staffing, creating and enforcing policies, and so on.

The design of a facility/structure with its fixed and moveable components can have a significant impact on human performance, especially on the health and safety of employees,

patients, and families.[6] In a review of more than 600 articles, researchers found that there was a link between the physical environment (i.e., single-bed or multiple-bed patient rooms) and patient (e.g., fewer adverse events and better health care quality) and staff outcomes (e.g., reduced stress and fatigue and increased effectiveness in delivering care).[7] Efforts to improve patient and staff outcomes can target latent conditions for clinicians by using evidence-based designs to decrease distractions, standardize locations of equipment and supplies, and ensure adequate space for documentation and work areas. The research done by Reason[1] and Leape[2] describes the value of practices based on principles designed to compensate for human cognitive failings. Thus, when applied to the health care field, human factors research (i.e., an area of research that includes human performance, technology design, and human-computer interaction; this topic is covered in chapter 5, "A Human Factors Framework," by Henriksen and colleagues), which has emphasized the need for standardization, simplification, and use of protocols and checklists, can be used to improve health care outcomes.

By targeting human factors through facility design and ensuring that latent conditions and cognitive failures that lead to adverse events are minimized, patient safety will improve. This requires a multifaceted approach, including developing a strong safety culture, redesigning systems or facilities with their equipment and technology, focusing on eliminating the conditions of cognitive errors, and helping caregivers correct/stop an error before it leads to harm or mitigate it if it occurs.[1, 2]

Factors Influencing the Built Environment

With human factors in mind, there are several aspects of the built environment that should be considered. In a review of the literature by Henriksen and colleagues,[8] the following design elements were identified as critical in ensuring patient safety and quality care, based on the six quality aims of the Institute of Medicine's report, *Crossing the Quality Chasm: A New Health System for the 21st Century*:[9]

- *Patient-centeredness*, including
  - using variable-acuity rooms and single-bed rooms
  - ensuring sufficient space to accommodate family members
  - enabling access to health care information
  - having clearly marked signs to navigate the hospital
- *Safety*, including
  - applying the design and improving the availability of assistive devices to avert patient falls
  - using ventilation and filtration systems to control and prevent the spread of infections
  - using surfaces that can be easily decontaminated
  - facilitating hand washing with the availability of sinks and alcohol hand rubs
  - preventing patient and provider injury
  - addressing the sensitivities associated with the interdependencies of care, including work spaces and work processes
- *Effectiveness*, including
  - use of lighting to enable visual performance
  - use of natural lighting
  - controlling the effects of noise

- *Efficiency*, including
  - standardizing room layout, location of supplies and medical equipment
  - minimizing potential safety threats and improving patient satisfaction by minimizing patient transfers with variable-acuity rooms
- *Timeliness*, by
  - ensuring rapid response to patient needs
  - eliminating inefficiencies in the processes of care delivery
  - facilitating the clinical work of nurses
- *Equity*, by
  - ensuring the size, layout, and functions of the structure meet the diverse care needs of patients

There have been five other significant reviews of the literature relating to the physical environment and patient outcomes. Nelson and colleagues[10] identified the need to reduce noise pollution and enhance factors that can shorten a patient's length of stay (e.g., natural lighting, care in new/remodeled units, and access to music and views of nature); according to their study, patients can benefit from the skillful utilization of music and artwork. Ulrich and colleagues[7] found research that demonstrated that the design of a hospital can significantly improve patient safety by decreasing health care associated infections and medical errors. They also found that facility design can have a direct impact on patient and staff satisfaction, a patient's stress experience, and organization performance metrics. Three other reviews found that hospital design, particularly when single-bed rooms are employed, can enhance patient safety and create environments that are healthier for patients, families, and staff by preventing injury from falls, infections, and medical errors; minimizing environmental stressors associated with noise and inefficient room and unit layout; and using nature, color, light, and sound to control potential stressors.[11–13]

Nurse staffing levels. Preventable adverse events such as falls and complications have been found to be related to both the design of health care facilities and nurse staffing levels. Patient falls in acute care settings can result from slippery floors, poor placement of handrails, inappropriate door openings, furniture heights,[14] and inadequate nurse staffing.[15, 16] Infection rates have been found to be lower in patients, particularly critically ill patients, when there are higher staffing levels.[17, 18, 19] High rates of postoperative infections, especially related to wounds among patients ages 65 to 70, have been found to be associated with facilities that were overcrowded, had few private rooms, lacked individual bathrooms and toilets, had no isolation facilities, and had deficient ventilation systems.[16] Without effective ventilation systems, efforts to avoid ventilator-associated pneumonia—such as patient positioning, oral health, and airway management[20, 21]—have a greater potential of not being as beneficial. Then again, the greater risk for health care associated infections may be associated with nurses not implementing evidence-based practices,[22] such as aseptic technique or washing hands appropriately[18] to prevent infections, as well as nurse understaffing;[23–26] how much is not known. These are only some of the examples that indicate that there are fewer adverse events when appropriate nurse staffing levels are met, and operational costs are lower because the rates of adverse events are lowered.[27] Thus, adequate staffing must be addressed to enable the benefits of well-designed health care facilities.

Structural obstacles and the nature of work for nurses. Several factors have been identified as physically being in the way of the work of nurses. An assessment of the organization of nurses in medical and surgical units in hospitals in France found that the work of

nurses was dependent upon the spatial configuration of the unit. For purposes of this study, nurses' work areas were divided into four categories: the patients' rooms, the nurses' area, the corridor, and other specialized areas such as a storage room. Nurses were found to have generally followed three paths in their trips: different points of the nurses' area, trips between the patients' rooms and nurses' area, and trips between the patients' rooms. Trips were organized according to spatial and functional logic. The majority of the activities performed by nurses were found to last less than 2 minutes. On the surgical unit, nurses during one shift were found to perform 3,855 trips that lasted approximately 3 minutes and 25 seconds each; this was fewer than the 4,521 trips performed by nurses on the medical units, each lasting approximately 3 minutes and 9 seconds. The constant movement by nurses varied based on the spatial organization of the unit as well as the temporal structure of the tasks. On the surgical unit, nurses were interrupted, an average of once every 20 minutes; on the medical unit, nurses were interrupted an average of once every 12 minutes.[28]

One approach to address these obstacles and to better meet patients' needs is to not have one central nursing station. Instead, there would be several decentralized nursing work stations throughout the unit with supplies, linens, and equipment areas. Appropriately distributed supplies and equipment could reduce fatigue and improve efficiency of nurses[29] by minimizing the time associated with finding supplies and equipment and moving from one location to another. Patients could benefit from more time with nurses and increased surveillance opportunities that require nurses to visually monitor patients—a benefit enhanced further by using single-bed rooms in hospital design.[30]

Single-bed and variable-acuity rooms. Debate continues as to whether hospitals should have single-bed rooms or semiprivate rooms for patients. Research over the past 10 years has compared single to semiprivate rooms and, in so doing, has provided greater insight into cost implications, patient satisfaction, and impact on patient care and outcomes. Several reviews of the literature found that single-bed rooms were more conducive for infection control and patient care,[7, 31, 32] were associated with reduced stress and improved outcomes for patients,[33] and increased privacy and accessibility for patients and families.[34] Noise levels and catheter-related infections have been found to be lower for critically ill infants in single-bed rooms.[35] Comparatively, environmental risk factors for patients in multiple occupancy include lack of privacy[36] and higher noise levels that can affect their comfort and recovery.[37] Environmental noise and light as well as patient interruptions can cause sleep disturbance,[36] especially in intensive care unit patients.[38]

Patients and families tend to be more satisfied with single-bed rooms. In one study, patient satisfaction among low-risk maternity patients was found to be higher with single rooms because of having their privacy respected; patients felt they were in a comfortable environment and felt that they received more support and education.[39] Clinicians have also been found to prefer single rooms for maternity patients[40] and neonatal intensive care patients.[35]

The availability of single-patient rooms has been found to control the spread of infection from patients infected with methicillin-resistant Staphylococcus aureus,[41–43] gram-negative bacteremia in burn patients,[44] and respiratory and enteric infections requiring contact isolation in pediatric units.[45] Single-bed isolation rooms, intended to prevent the spread of infectious agents by using pressure differentials to contain them, are effective only if the room is tightly sealed.[46] Thus, in terms of controlling infection in isolation rooms and other patient rooms, the greater risk may be associated with nurses not implementing evidence-based practices regarding hand washing and aseptic technique to prevent infections.[18]

The design of a patient room that allows flexibility and can be adapted to meet changing acuity and care needs of patients has been found in some institutions to contribute to decreased medication errors and falls.[47, 48] A well-designed patient room has also been found to be a factor in improving care delivery processes for clinicians by providing more private patient consultations,[36] improving patient and clinician satisfaction,[48] decreasing length of stay,[29] and facilitating continuity of care during a hospital stay.[39]

Traditionally, the bed charge has been higher for single rooms and the capital investment greater. Yet research has found that single rooms and flexible/adaptable rooms for maternity care and intermediate and intensive care offered cost savings, particularly because of shorter lengths of stay and a decrease in the number of transfers within the hospital.[40, 49] Such rooms are more likely to be filled[47] and can avoid the costs of transfers when the room is acuity adaptable.[36]

Lessons From Best-Practice Designs

There are several examples of the impact of evidence-based design in acute care settings; a few will be discussed here. Research in the early 1970s found that unit efficiency was determined by the design of the unit, not room size or occupancy.[50] Research conducted since then has continued to emphasize the importance of designs. One study[51] began with a systematic evaluation of best practices in 19 intensive care units (ICUs), built between 1993 and 2003, that received a design award from the Society of Critical Care Medicine, the American Association of Critical Care Nurses, and the American Institute of Architects. The reviewer found positive characteristics of the ICUs to include single-bed rooms for improved patient care, safety, privacy, and comfort; bed locations that provided easy access for clinicians; hand-washing sinks and waste disposal in the patient rooms; and use of natural lighting. Negative characteristics were found to be renovation projects that posed health and safety hazards during the construction; mixed-service units with safety and staffing problems; overall layout—and layout of work areas for staff—that lacked a common design solution; and family space that was often located outside the unit and provided the family with limited access.

The Pebble Project, supported by the Center for Health Design and funded by the Robert Wood Johnson Foundation, includes several hospitals across the country. As part of this project, evidence-based designs are used and empirical evidence is assessed to measure outcomes such as safety (visit the Center for Health Design's Web site at www.healthdesign.org). Findings from the Pebble Project are expected to advance the evidence base by increasing our knowledge of design features that can ensure a safe healing environment where the best quality of care can be provided. The project is intended to have a ripple effect and influence other health care facilities nationwide.[52]

There are several examples of hospitals involved in the Pebble Project, such as Children's Hospital in San Diego, which opened a long-term, convalescent hospital designed to promote the care needs for permanently disabled children. The design included out-of-sight wheelchair storage in patients' rooms, private spaces outside the patient rooms for parents to hold their children, and an improved ventilation system to decrease respiratory infections. The Methodist Hospital in Indianapolis opened a 56-bed cardiovascular critical care unit where patients are admitted directly to their rooms from the emergency room, admitting, physicians' offices, or the Lifeline helicopter. Patient rooms are private and patients are in control of the temperature and light. Each room also has an interior window that can become opaque to increase privacy. The design also enabled nurses to observe patients better, resulting in half as many patient falls, and the need for patient transfers has decreased substantially from 200 per month to an average of 20

per month. Bronson Methodist Hospital in Michigan opened a new facility with private patient rooms and increased patient access to nature (e.g., indoor gardens, natural light, and landscape views) and decreased patient stress using of positive distractions such as music, water sounds, artwork, and daylight. The Barbara Ann Karmanos Cancer Institute renovated several hospital areas to be patient-centered and to provide a more pleasant environment, where patient rooms were made larger and an emphasis was placed on lighting and acoustics. In doing so, administrators and clinicians have seen a decrease in the use of pain medication and medication errors on these units. Thus, by incorporating private rooms into their designs, these four hospitals and patients they have served have experienced successful outcomes in their new and renovated facilities.[53]

Research Evidence

There were 10 original articles that met the inclusion criteria for this review. Four articles described investigations with nurses in relation to the work and built environment, five were about patient's perspectives, and two were about specific built environment projects; one study investigated both staff and patient perceptions of the built environment.

Nurses' Perspective

Four studies assessed hospital nurses' perspectives on factors associated with the built environment using cross-sectional surveys. Two surveys intended to assess the work environment and challenges prior to moving forward with specific changes.[54, 55] When asked about performance obstacles, nurses reported: work environments; distractions from families; hectic and crowded work environments; delays in getting medications from the pharmacy; amount of time spent teaching families; equipment not being available; patient rooms not well stocked; insufficient workspace for completing paperwork; time spent seeking supplies or patients' charts; receiving many phone calls from families; delays in seeing new medical orders; and misplaced equipment.[54] When asked about what physical changes were problematic in the layout of the current unit, including patients' rooms, pediatric nurses reported that they were not satisfied with: the size of residents' closets, showers, and activity room; the actual size, aesthetics, and location of the break room and dining room; the available space for medical equipment; the available space for charting; and the outdoor recreation area. Not only did nurses share similar concerns with parents, the facility aesthetics and work environment were found to be associated with higher satisfaction and better coworker relationships among nurses.[55]

The other two surveys assessed the perceptions of nurses about single versus multiple bed rooms. A very small sample of nurse managers and unit directors (n = 7) in best-practice ICUs reported the benefits of single-bed rooms as enhanced patient safety, ensured privacy for patients, increased access to patient status information, and more space for family members.[56] In the other survey, administrative and nursing staff (n = 77) reported that they favored single-occupancy rooms because of their flexibility, being more appropriate for patient examination, improved quality of patient monitoring and scope of patient surveillance, and improved patient comfort level and patient recovery rate. Helpful characteristics of single-occupancy rooms were reported as: the more favorable layout of the room, including the availability of extra space in the room making arrangement of furniture easier and providing storage for clean and dirty supplies in the room; better privacy for patients and more space for family members; and better lighting

and temperature control and lower noise levels. A little over half of the respondents believed that health care acquired infections were low or very low in single-occupancy rooms, but that there was no difference in the number of patient falls or the need for pain-reducing or sleep-inducing medications between the two types of rooms. Conversely, helpful characteristics of double-occupancy rooms included proximity to the nursing station. However, being able to see patients for monitoring purposes was reported as problematic for both single and multiple occupancy rooms.[57]

Patients' Perspective and Impact

Five of the identified studies assessed the perspective of patients who received care in a purposefully built environment within hospitals. Two studies used focus groups to assess the patients' perspective, one with hospital inpatients,[58] and the other with patients and family members in ambulatory care, acute care, and long-term care settings.[59] A consistent theme among these studies was the preference for an environment that offered quality and comfortable personal space, rather than an environment that addressed only medical needs, but none were without some aspect that was not favorable.

Three studies assessed the perspectives of patients and family members in the United States and the United Kingdom. Patients and family members in the United States, across various settings, reported wanting a health care environment that facilitates connections to clinicians; fosters a sense of well-being; and is not dissociated from the world outside the hospital, outpatient setting, or long-term care setting.[59] Patients in the United Kingdom, hospitalized patients in various units (n = 51) reported feeling a loss of independence and control while hospitalized, but felt safer and at home when they had the TV close by, and were able to walk around. For these patients, the most important factors about the built environment were privacy, a homely environment, considerations for disabilities, and being able to see outside and get outside.[58] Patients in another study in the United Kingdom reported a relationship between the environment and internal areas of the hospital and how that made them feel comfortable, able to keep a sense of normalcy, and as having a positive affect on their feelings of well-being. Patients further reported that they felt that it was important to have good signage, controllable lighting and temperature, privacy, reduced noise levels, access to the natural environment, safety and security in internal and external areas, internal and external children's play areas, accommodations for visitors, shops and personal services, good 24-7 catering facilities, and good landscape designs with seating and garden areas.[60]

Patient perceptions were assessed after implementation of a built environment in a hospital. In one study, there were fewer patients who left against medical advice, aggression levels in patients decreased, and levels of benzodiazepine dosing decreased compared to measured occurrences before the new unit opened. It is not known if there was any assessment of patients' perceptions.[61] Parents (n = 40) in a children's hospital reported more satisfaction with the structure and facility aesthetics**,** but were not satisfied with space for showers/baths, the amount of closet space in the patient room, lack of sufficient private areas to be with their child or for outdoor recreation, location of the nurses station, and the low level of natural lighting.[55]

Acuity-Adaptable Rooms

One study investigated the impact of an evidence-based design of 56 new acuity-adaptable rooms for a combined coronary critical care and step-down unit.[62] Researchers found that two

different levels of acute care (intensive care and step-down care) could effectively be merged together into a single patient room by making the room acuity adaptable to accommodate the changing needs of patients. Once in the new single-bed acuity-adaptable unit, researchers found: a large reduction in clinician handoffs and transfers; a 70 percent reduction in medication errors; a reduction in patient falls; improvements in patient satisfaction; decreases in budgeted nursing hours per patient day; and increases in available nursing time for direct care without additional cost. Yet, clinicians felt more isolated by the increased size of the unit and with decentralized nursing stations; then again, the "isolation" gave nurses greater opportunity for autonomous decisionmaking.

Designed ICU

The implementation of a new neonatal intensive care unit, designed to have a more efficient floor plan, provide space for supportive family-centered care, and to use of natural light, used was assessed using multiple methods.[63] On this new unit, the majority of nurses were positive about the design features. Nurses reported the new unit as enabling efficiency, in part attributable to being able to move about the unit at a greater velocity, enabling them to spend more time with the infants and less time needed to walk about the unit in the course of their work. The nurses also reported that the new unit was more comforting, clean and quieter, and the new lighting was thought to have a positive impact on the patients. Additionally, nurses reported that they felt that families were utilizing the majority of space designated to them.

Addressing the Problem: A Case Study

One new 80-bed community hospital in Wisconsin has been designed to improve patient safety through research-based design. Following the report of the Institute of Medicine (IOM), *To Err Is Human: Designing a Safer Health System*,[64] the management and medical staff at St. Joseph's initially believed that adverse events applied to other institutions and not their own. When it became apparent that St. Joseph's, too, had preventable adverse events, top management authorized the design of a facility with the equipment and technology to lower or eliminate preventable adverse events—a design that could possibly be used as an example by other health care organizations that were building new facilities, remodeling, or expanding existing facilities.

The process began in April 2002, when leadership from SynergyHealth St. Joseph's Hospital met with national leaders representing health care administration, health services research, hospital quality improvement and accreditation, hospital architecture, systems engineering, medicine, nursing, and pharmacy.[65] Using personal experience, human factors principles, health care research, and research from other industries, it was agreed that a National Learning Lab, would be used to develop recommendations for facility design, define and create a roadmap for safety by design, including safe design principles, make recommendations for changes in care processes, and enhance safety culture for hospitals through facility design focused on patient safety. The specific safety design principles, intended to specifically address both latent conditions and active failures, included the following:

1. Automate where possible.
2. Design to prevent adverse events (e.g., patient falls, operative/postoperative complications and infections, and deaths associated with restraint use).
3. Design for scalability, adaptability, and flexibility.

4. Place accessibility of information in close proximity to the patient.
5. Improve visibility of patients to staff.
6. Involve patients in their care.
7. Minimize fatigue of staff.
8. Minimize patient transfers/handoffs.
9. Reduce noise.
10. Standardize.

These principles were substantiated by using failure mode and effects analysis throughout the design process, involving patients/families, and instituting an organizational culture of safety, these principles would enable designs that would support the anticipation, identification, and prevention of adverse events.[65]

Designing for Nursing Care

The first step for the National Learning Lab was an educational program about human error and its causes associated with latent conditions and active failures. The goal of this education was to gain commitment to the need for nurses to be active in the design phase. Then representatives of nursing were elected to a facility design committee. Design teams of nurses were also formed to assure formal input into the design. Mock-ups were also an important feature and prompted more input from the nurses. Many rooms were mocked up, and the medical-surgical room was modified multiple times by the involvement of nurses reviewing every detail to assure a safe design. Nurses' involvement in equipment and technology planning started immediately with the mock-ups. The interplay between the facility (with its equipment and technology) and nurses and patients creates safe or unsafe interactions, and the result is affected in large part by the facility design.

Once the National Learning Lab was over, St. Joseph's Hospital began the important process of implementing the Lab's recommendations. For St. Joseph's to implement the National Learning Lab's recommendations, senior leadership knew they needed to involve nurses in the facility design process because of nursing's essential role in caring for patients, and because nurses interface with all the systems of a hospital at the "sharp end," including equipment, technology, facilities, and patients—more so then any other care provider in a hospital. Not discounting the role of physicians, other clinicians, and health care staff, nurses provide care 24 hours a day, 7 days a week. As such, nurses providing care are most aware of the best way to design a patient room (for example) so the room design minimizes the potential for human error and harm to patients. St. Joseph's organized the design process to maximize the involvement of nurses.

Single-Patient Room

In many instances, including the need for patient isolation measures, double or multiple-occupancy rooms were viewed as not being conducive to patient safety and quality care. The floor plan shown in Figure 1 illustrates how a series of standardized single-patient rooms were laid out on both sides of a hallway in St. Joseph's Hospital. This perspective allows various features of the room to be seen in relation to each other. There are two entrances to the room, one from the hallway (along the lower edge of the picture), and one from the alcove on the right. In that alcove, also entered from the hallway, a desk, computer, and chair are provided for use by

staff. The alcove also contains a standardized storage area, so staff can find everything they need for the care of the patient adjacent to the patient room.

The interior of a single-patient room incorporates many of the recommendations relating to latent conditions and active failures in the design for safety (see Figure 2). The family area of the room is in the right corner of the room, by the window, and includes a couch/pull-out bed, chair, desk with Internet connection, and good natural lighting. The treatment area of the room is on the left side of the bed, with room all around the bed for patient care. It is intentional, also, that the patient is on the nurses' and other caregivers' right as that person enters the room from either door, so care can be more efficiently provided. Note that the bathroom is at the head of the patient's bed, allowing the patient to get to and from the bathroom without impediments, holding onto a rail all the way if necessary. At the head of the bed is the headwall with connections for various gases such as oxygen; on the wall to the left of the bed is a pull-down table the caregiver can use when it is needed. Although it is not shown in the illustration, there will also be a portable cart in each room, with a computer on it. Last but not least, in the lower right-hand corner of the room, between the two doorways, easily visible to the patient, there is a sink—an ever-present and convenient reminder to nurses, all staff, and visitors to wash their hands.

Figure 1. Floor Layout of Single-Patient Rooms in St. Joseph's Hospital

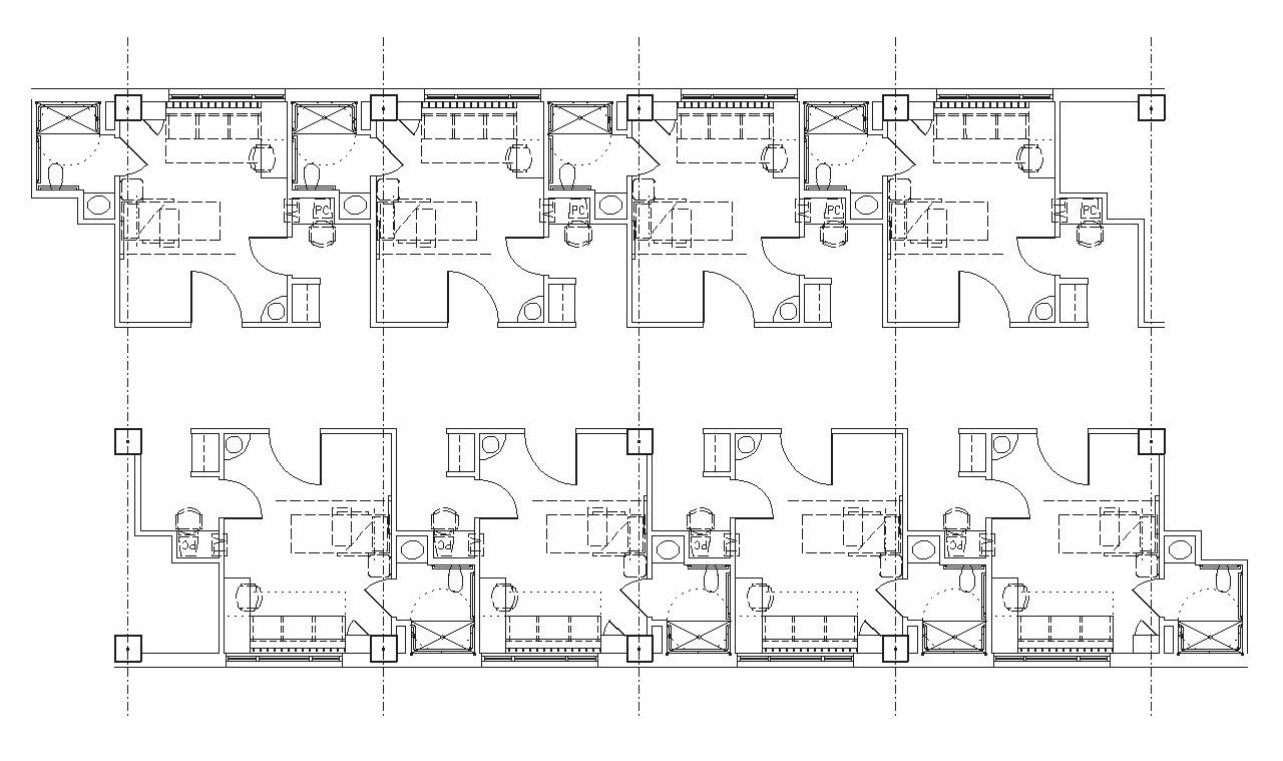

Figure 2. Single-Patient Room in St. Joseph's Hospital

Applying Knowledge of Active Failures and Latent Conditions to Room Design

The design process for St. Joseph's Hospital focused on safety, employing broad participation, including nurses, physicians, board members, administration, National Learning Lab participants, expert consultants, other health systems, health care writers, and design teams. The patient room was selected as a good example of how the design plan for the hospital came together in one location. To show how the room design was reached, each of the applicable latent conditions and active failures will be discussed, to explain how they relate to the plan for a single-patient room.

Noise reduction: Noise interferes with communication, creates distractions, affects cognitive performance and concentration, and contributes to stress and fatigue.[66] Particularly sensitive are mental activities involving working memory.[67] Noise can also adversely impact healing, alter quality of sleep, and reduce overall perceived patient satisfaction, yet the evidence at present is equivocal.[68] Since a standardized patient room has a material effect on noise, the bed in each single room in St. Joseph's is in the same location as the next room. In the traditional patient room style, called back-to-back, patient beds are on the same wall. Back-to-back plans create major transfer noise between rooms, and their use of the same oxygen, compressed room air, and

suction intensifies the transfer noise and vibration. In a truly standardized room, this does not occur. In addition, the walls between rooms are separated and insulated with airspace, minimizing transfer noise. This was designed into the structure early in the building design. In addition, vibration noise between floors and within a floor was minimized through design. The mechanical, electrical, and plumbing systems were designed to use the optimum materials for minimizing noise. This included using vibration isolation/dampening devices wherever vibration could be a factor.

The flooring in the patient room is rubber, second to carpet in sound reduction qualities. The reason carpet was not chosen (it was mocked up and tested) is because spills and mishaps needed to be cleaned up immediately. Carpet requires housekeeping to bring a carpet cleaner, which could take time and also could be embarrassing for the patient. Carpet was chosen, however, for the alcoves and hallways, with a low-nap, special carpet for hospital application. Special ceiling tiles that absorb noise better than regular ceiling tiles were chosen. Triple glazed windows were specified to minimize outside noises. No overhead paging system is used (except for public emergencies such as a tornado warning), and nurse call systems use minimal tone with vibrating features. As specific equipment and technologies were needed, manufacturers of that piece of equipment or technology were contacted and asked how they reduced noise in their products. That became one important criterion for selecting which company's equipment to use.

Scalability, adaptability, flexibility: Many design and construction concepts can be applied to achieve a scalable (e.g., the ability to expand or remodel easily) or adaptable (e.g., the ability to adapt space for different or evolving services) health care facility. At St. Joseph's, all rooms have higher-than-normal ceilings to allow changes to be incorporated in the future. Space around the bed is sized so procedures (e.g., colonoscopies) could be performed in the room in the future.

Visibility of patients to staff: The importance of being able to see patients is inherent to nursing care, a concept that was recognized early by Florence Nightingale, who advocated the design of open, long hospital wards to see all patients. The design of units and patient rooms should allow caregivers to be in visual proximity to patients; a pod structure can allow close proximity and enable quality care by improving efficiency and effectiveness. At St. Joseph's, each alcove door has a glass window with a blind so nurses can work in the alcoves and see the patient or check on the patient. The nurse can also check on the patient in the evening without opening the door and waking the patient. Each room is wired for cameras for observation. All materials, such as medication, linens, IV poles, and a rough-in for icemakers, are delivered to the alcove to allow nurses to spend more time with the patient. The chart will initially be in the room, but shortly after the new hospital opens, it will be replaced by electronic medical records with a workspace so nurses and other caregivers can spend more time with the patient. Furthermore, visibility also means lighting to see the patient. Natural light is maximized by large windows in every patient room. Light sources after hours are as close to natural light as can be achieved cost effectively. Canned lights are located over the patient for assessment. A total of 15 lights are located in every room, including the bathroom and alcoves.

Involving patients in their care: The IOM[9] found that many patients have expressed frustration with their inability to participate in decisionmaking, to obtain information they need, to be heard, and to participate in systems of care that are responsive to their needs. The availability of information for patients increases their knowledge regarding their illness and treatment options, and being informed gives patients the opportunity to participate in shared decisionmaking with clinicians and may help patients better articulate their individual views and preferences.[69–71] This reflects several dimensions of patient-centered care, including respect for

patients' values, preferences, and expressed needs, as well as providing information, communication, and education.[72]

At St. Joseph's, the patient room is designed with a treatment section near the door and a family section near the window. A couch folds outs into a bed; a desk with an Internet connection encourages family members or friends to stay with patients. This is intended to help patients to be more active with their care and better able to protect themselves from errors. A portable computer on a cart (same one used by staff) is located in each room so patients can have appropriate access to their chart.

Standardization: Standardization has been documented as an important human factors-based design strategy [4, 64] that can help lessen the number of errors. Standardization reduces reliance on short-term memory and allows those unfamiliar with a specific process or design to use it safely.[64] With a focus on improving the human-system interface by designing better processes and systems, standardization of patient rooms, treatment areas, equipment, and procedures can substantially reduce errors.[64]

There were many design elements that incorporated standardization as a physical attribute. The patient rooms in St. Joseph's may be the first patient rooms in the country to be standardized. The headwalls are standardized throughout the facility; a seven-drawer configuration was designed into every patient room or alcove to provide consistency of supply locations and to simplify the restocking of those supplies. This provides staff with a known constant, regardless of where they may be caring for a patient throughout the facility due to floating, a patient resuscitation, or some other emergent situation. The electronic medical record, use of bar-coding, computerized provider order entry, and other technologies will be standardized eventually, assisting in the development of standardized protocols and order sets. The facility materials distribution and routine nurse functions can also be standardized to match the facility.

Equipment is not fully standardized yet, but that is the goal, since fully standardized equipment provides the highest level of safety. The complexity and variety in equipment vendors and models is immense, and this complexity creates more errors. This weakness—the lack of equipment standardization—was pointed out continually in using failure and effects mode analysis. So St. Joseph's is evolving toward equipment standardization. The hospital was able to purchase limited new patient monitoring equipment, and took care to assure that new and existing equipment were from the same vendor to give the user a similar feel and functionality, regardless of which equipment they were using. The hospital will continue to utilize this process to guarantee long-term equipment standardization within the facility.

Automation where possible: The IOM identified health information technology solutions as a necessary component to improving patient safety.[9] As discussed in the chapter on health information technology, technologies such as electronic medical records can improve communication and information dissemination between providers.

At St. Joseph's, electronic medical records, bar-coding, physician order entry, a pneumatic tube system, two computers in every room (one in the alcove and one on a cart in the room), a sophisticated nurse call system, new patient beds, and patients lifts for every room are examples of automation. These applications are intended to allow caregivers to give care more efficiently and rely less on short-term memory. Many design features and technology applications have affected multiple latent conditions. This was one of the important criteria used at the matrix exercise to determine which design features to include. Technology applications were deemed to be a critical part of allowing St. Joseph's to design for safety.

Immediate accessibility of information, close to the point of service: In order to provide patients with the most accurate diagnosis and treatment possible, clinicians need to have complete, real-time information about the patient, care needs, and treatment options. Technologies such as the Internet, electronic medical records, and clinical decision-support systems can accomplish this. At St. Joseph's, electronic medical records were seen as the most useful way of making information accessible quickly at the point of service. When the hospital opened, the patient chart was 100 percent paper based. In traditional hospital environments, the patient chart changes location without regard to patient activities. Early mornings, a physician may come around and take the chart to a quiet dictation area to write notes and orders. The chart is often left there until another care provider requires the chart. Or, the chart may be left with the unit secretary to input/transcribe orders.

A transitional plan was developed to meet this guiding principle: When the hospital opened, a mandate was incorporated into the physician and staff orientation that the chart on the medical/surgical unit never leaves the alcove unless the patient leaves. This was surprisingly effective and compliance was unusually high. When an order is written, the physician uses a wall-mounted button labeled "New Order" or "Stat Order" to alert the unit clerk. The unit clerk then transcribes the order and does any necessary computer order entry in the alcove. The chart never leaves the alcove. Anecdotally, the physicians find this process useful to them. They can make rounds more efficiently, since they never have to look for a chart to write their notes or orders. They never have to "batch" their rounding and then look for all of the charts to document. Verbal orders are also reduced. For obvious reasons, this process will cease to be relevant when the electronic medical record is implemented.

Minimizing fatigue: Fatigue has been identified as a contributing factor to human error.[73, 74] While the effects of fatigue on patient safety is not known, fatigue has been found to have a negative impact on alertness, mood, and psychomotor and cognitive performance, which can have an impact on patient safety.[74–76] Some of the effects of long work hours and increasing workload can be mitigated by minimizing the distances staff must travel between patient rooms, and by using health information technology at the bedside to reduce reliance on short-term memory and thought processes. Other considerations in the design of St. Joseph's to minimize fatigue are carpeting and rubber flooring, a chair in the alcove, single rooms, keeping all materials in the alcove so nurses have to take fewer steps, less reliance on short-term memory, less noise, natural light, and strong lighting sources.

Minimizing patient transfers/handoffs: Transferring patients from one unit, room, or floor to another puts both the patient and staff at risk of harm, and it is disruptive to both patients and clinicians. Often these transfers involve handoffs, which, as described in another chapter in this book, also place the patient and clinician at risk for errors. Minimizing patient transfers and handoffs has design implications. Private single rooms with appropriate space around the beds, lifts, and other safety mechanisms allow more procedures to be performed in the room. This is similar to the model in obstetrics with Labor Delivery Recovery Post-Partum (LDRP) rooms, where the mother delivers the child and the child can remain with the mother in the same room for the entire stay. Another example is the physical therapy gym located on the med-surg unit—the patient never leaves the unit to obtain therapy, and their nurse is always in close proximity should a change in patient condition occur. Electronic medical records are another important tool. Bar-coding helps with continually and accurately identifying the patient.

Addressing the Root Causes of Precarious Events

The approaches used by St. Joseph's to address root causes for other types of at risk areas are described as follows:

Operative/postoperative complications and infections: Among the design features that will contribute to the reduction in operative/postoperative complications and infections are private rooms; a sink at the entrance to the medical/surgical patient rooms, which you must pass going in either door (to encourage hand washing); internal window blinds (to reduce accumulation of dust); a housewide air filtration system that includes central HEPA filters; ultraviolet lights in all clinical areas; airflow systems in which clean air passes the patient and is recycled and filtered again; and a radiant heat panel above or below every patient window to eliminate condensation. These are all features that minimize infection. Air supply and return grates that need cleaning have been upgraded to stainless steel so cleaning is more effective. However, the most important design element is the location of the sink, since lack of hand washing is the number one reason for hospital-acquired infections.

Inpatient suicides: Data from the Joint Commission indicate that out of the approximately 1,500 to 1,800 suicides that occur annually in hospitals, about 50 percent of those occur in medical/surgical units. The two most common methods are jumping and hanging. In a medical/surgical room, there are many things patients can use to hang themselves, such as bathroom curtain rods, showerheads, television brackets, or lights. Thus, St. Joseph's decided to use breakaway shower curtain rods and minimize other hanging risks by choosing lights and brackets that met the design needs of the room but would be less likely to be used for a suicide attempt. To minimize jumping, windows cannot be opened, and they are triple-paned, making them much harder to break through. If a suicide-risk patient is identified, that patient is transferred to the mental health unit, but increased visibility in all patient rooms helps staff keep a closer watch, which helps minimize the risk of suicides.

Death of patients in restraints, patient falls: St. Joseph's, like most hospitals, has minimized restraints. The new beds ordered for the hospital have eliminated many of the risks of deaths due to restraints. With less and less restraints, however, the risk of falls rises. Most patients fall at night or while walking with a nurse or other caregiver. Design elements that help reduce falls include fixed night lights in every room, beds that drop down to sixteen inches above the floor, locating the bathroom at the head of the bed with railings to the stool and shower, and utilizing bathroom lights that automatically turn on when anyone enters the bathroom. Besides the above-mentioned strategies, a bed-exit system is being explored using infrared technology. If a patient is identified as he is trying to get out of bed, then lights could turn on, an emergency call to the pager could occur, or a voice could ask the patient to wait for a caregiver. Such a system is in design at St. Joseph's.

Correct tube—correct connector—correct hole placement events, oxygen cylinder hazards: All connectors are a different size for different gases and color-coded. Storage and identification of portable gases employ the same identification program. All gases are in standardized locations to further minimize the risk of a gas-connecting error.

Wrong-site surgery: Operating room suites were standardized, using proper lighting and cable access to digital images and photographs of the surgery site.

Medication and transfusion-related adverse events: Bar-coding, unit doses at point of service, electronic medical records, and physician order entry are critical elements for medication

error reduction. Private rooms with alcoves that include medical records allow nurses to concentrate on one patient and document those efforts, before moving on to the next patient.

Bringing It All Together at St. Joseph's Community Hospital

The use of failure mode and effects analysis, patient focus groups, mock-ups with employee evaluation, and checklist safety design principles (latent conditions and active failures) helped St. Joseph's create the safest room they could envision. The patient room evolved over months of design. Over 27 different designs or refinements were made on the patient room. This room is not the only way a patient room can be designed for safety, but it is believed to be a good way, and it exhibits efficient, thoughtful features that meet National Learning Lab expectations.

The 2002 National Learning Lab had a powerful effect on St. Joseph's and is beginning to influence hospital facility development nationally. St. Joseph's Hospital implemented the recommendations of the Learning Lab, designing around latent conditions and active failures, and enhancing or creating a safety culture through facility design with its technology and equipment. The importance of nursing leadership in the whole process cannot be overstated. Without the commitment, knowledge, and perseverance of the nursing leadership, along with the chief executive officer, board, medical staff, architects, and the rest of the design teams, a safe design would not have occurred.

The effort of St. Joseph's is just the tip of the iceberg of the potential for improving safety of patients in hospitals as a result of facility development. The impact of the National Learning Lab recommendations on processes also offers an immense opportunity to improve the safety of patients in hospitals. The work of St. Joseph's should serve as a model for those health care leaders who share the vision that facilities, including equipment and technology, focused on safety will improve the health and well-being of the patients whom they serve.

The building of the new hospital was completed in 2005, and investigators are currently evaluating the impact of their designs on the frequency of adverse events and patient outcomes. Using innovative architectural and design features to enhance patient safety together with institutionalizing a nonpunitive safety culture can potentially have a greater impact than design features alone. Over the past few years, the National Learning Lab changed St. Joseph's Hospital and has begun to influence hospitals and health care throughout the country.

Leaders and clinicians at St. Joseph's found that the project, with its many safety enhancements, resulted in capital expenditures under budget—an important consideration in the business case. The National Learning Lab's process of identifying and addressing latent conditions was correlated with the Toyota Lean Principles. Standardization, visibility, continuous flow, value stream, minimizing handoffs/transfers will be created as a result of a safely designed facility. This should lead to less human error and potential harm and more efficient operations (process). Yet, one of the major difficulties of translating this efficiency and better outcomes into improved net income is the basic misalignment of financial incentives. Both the fee-for-service and the DRG (diagnosis-related group) introduce perverse incentives. Hospital revenues can actually be reduced as a result of improved safety, and savings can accrue to the insurance companies and not the institutions creating the improvements. Although there is some evidence of changes to improve these misaligned incentives, more dramatic changes are needed to encourage safe process redesign.

Practice Implications

The evidence base is growing in support of evidence-based design for renovations and new building. The new field of evidence-based design has emerged at a time when there is a health care construction boom.[77] There are many factors in the workplace that impact care delivery and work satisfaction, and they should be incorporated into designs. Based on the Gurses and Carayon study,[54] care processes will need to be modified to address inefficiencies caused by distractions (e.g., by family members), overly busy working conditions, delays in getting access to required resources (e.g., medications, patient medical records, supplies, and medical equipment), delays in seeing new medical orders, and misplaced equipment.[54]

Nurses need to be involved and have an active role in evaluating, planning, and testing the layout of patient units and patient rooms to ensure a healing and comfortable environment for both patients and clinicians. Lessons learned should be shared with others to enable improvements across the country, not just on one facility. Current laws and regulations will need to be modified to support new hospital standards and building codes.[10] As single-bed patient rooms are now considered the minimum standard for maternity/postpartum and intensive care units in general hospitals,[78] nurses will need to be involved in planning for transitions and assessing environmental and structural features that will improve the quality of care afforded patient.

Research Implications

The impact of the built environment will most likely be magnified by concurrent efforts to change organization culture and functionality as well as processes of care delivery, but future research would need to so demonstrate. Since the majority of the research on the impact of the built environment has been conducted in specific units in hospital settings, it will be important to investigate whether similar effects can be realized in general medical-surgical units and outpatient settings, including clinics and offices.

In a 2004 report commissioned by the Agency for Healthcare Research and Quality, *The Hospital Built Environment: What Role Might Funders of Health Services Research Play*,[10] the following gaps in the literature were identified: What are the effects of the built environment on the quality of communication and information sharing between clinicians, patients, and families? What is the relationship between environmental factors and the working conditions for clinicians? What are the best mechanisms and designs for facilitating effective hand washing? What is the effect of elements in the built environment that reduce staff fatigue, distractions, and stress? And what is the role of the built environment in decreasing infection rates across patient types? Nurses can have a critical role in addressing these and other research gaps. In this relatively new and exciting area of research in health care, nurses need to and should be actively involved throughout the research and quality improvement processes involving the design of the work environment space.

Conclusions

In the next few years, hospital leaders will be involved in new hospital construction projects to meet the changing marketplace demands associated with the growing demand of an aging population. Many clinicians, architects, and hospital administrators believe that the hospital built

environment can benefit the satisfaction of health care providers as well as patient satisfaction and outcomes. There is some evidence that the built environment may influence patient and family perceptions of the quality of and satisfaction with care received during a hospitalization. There is also some evidence that nurse satisfaction with the built environment was related to general well-being and job satisfaction, two factors that are critical because of their impact on patient care.

The evidence-base is emerging to support the business case that designing for safety and quality can improve patient outcomes and safety, promote healing, increase patient satisfaction, and reduce costs. It is thought that the cost of building or remodeling projects based on design evidence conducive to patient safety can result in organizational savings over time, without adversely impacting revenues.[8] Investigators with the Center for Health Design have been assessing hospitals involved in the Pebbles Project, and have found that the financial incentive for investing in evidence-based design using therapeutic design elements such as single-bed rooms and decentralized nursing stations added close to $12 million in costs to hospital reconstruction—but those costs would be recouped within one year of being operational.[79]

Those building new or remodeling current facilities should consider beginning with transitioning to a culture of safety, then using a safe design as a matter of focusing on maximizing the safety features without expending additional capital resources. While relatively new, evidence is growing in objective assessments of the impact of built environments, particularly around the issue of infection control. Some safety features will cost more than traditionally designed facilities (e.g., HEPA filters and ultraviolet lighting to improve air quality) while other safety features will cost less than a traditionally designed facility, most notably standardization. In all, most of the safety features of a built environment involve a reordering of functions in most "traditionally" designed facilities, minimally affecting capital costs, to improve the quality of care and patient outcomes.

Search Strategy

PubMed® was searched to locate studies and related literature on the built environment. Most of the articles identified in the literature search were primarily descriptive. Search terms included "built," "environment," "hospital design and construction," "interior design and furnishings," "patients' rooms," and "health care." Excluded from the review were articles published before 1999, non-English language articles, expert opinions, case reports, and letters. Three hundred abstracts were obtained. To be considered evidence in this review, the research had to involve nurses or patients in clinical settings, reported findings related to patient safety, and not be specific only to health information technology.

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Evidence Table

Source	Safety Issue Related to Clinical Practice	Design Type	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Chaudhury 2006[57]	Single-occupancy rooms in acute care	Cross-sectional study	Survey of nurses about patient care, management, and infection control issues (Level 4).	77 administrative and staff nurses in 3 hospitals in Washington and 1 in Oregon	None	Nurses favor single-occupancy rooms because of their flexibility, being more appropriate for patient examination, quality of patient monitoring, improved patient comfort level, improved patient recovery rate, and scope of patient surveillance. 57 percent believed that health care acquired infections were low or very low in single-occupancy rooms. There was no difference in the number of patient falls, need for pain-reducing or sleep-inducing medications between the two types of rooms. Helpful characteristics of single-occupancy rooms were layout of the room; availability of space in the room; the arrangement of furniture; privacy; space for family members; storage for clean and dirty supplies; and the location of the sink, bathroom, door, and window; lighting; temperature control; and lower noise levels. Helpful characteristics of double-occupancy rooms were proximity to nursing station; visibility of patients for monitoring purposes; and the location of the sink, bathroom, door, and window.

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Douglas 2005[60]	Built environment Patient-centered care	Cross-sectional study	Multiple methods, including 50 personal interviews, autophotographic study with 35 patients, novice-expert cohort of patients and clinicians, and a survey of past patients (Level 4).		None	Patients viewed the environment and internal areas of the hospital that made them feel comfortable and able to keep a sense of normalcy as having a positive effect on their feelings of well-being. Novices and experts considered the following important: good signage; controllable lighting and temperature; privacy; reduced noise levels; access to the natural environment; safety and security in internal and external areas; internal and external children's play areas; accommodations for visitors; shops and personal services; good 24-7 catering facilities; and good landscape designs with seating and garden areas. Patients reported the general atmosphere (e.g., feel of the environment, feeling safe and at home, having the TV close by, and being able to walk around) as important. Patients felt a loss of independence and control.
Douglas 2004[58]	Built environment	Cross-sectional study	Face-to-face interviews with hospital inpatients (Level 4).	21 patients in surgery, medicine, care of the elderly, and maternity in 1 hospital in the UK	None	Patients reported the general atmosphere (e.g., feel of the environment, feeling safe and at home, having the TV close by, and being able to walk around) as important. Patients interviewed felt a loss of independence and control Most important factors about the built environment were privacy, a homely environment, considerations for disabilities, being able to see outside, and to get outside.
Feeney 2007[61]	Built environment	Cross-sectional study	Assess the impact of a new, purpose-built acute unit on patients' behaviors and care needs (Level 4).	1 psychiatric unit in a hospital in Ireland	Implementation of a purpose-built acute psychiatric unit in a hospital in Ireland	After the new unit opened, there were fewer patients that left against medical advice, aggression levels in patients decreased, and levels of benzodiazepine dosing decreased.

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Fowler 1999[59]	Built environment	Cross-sectional study	Conducted 9 focus groups with patients (Level 4).	Patients in ambulatory, acute care, and long-term care settings	None	Patients and family members look for an environment that facilitates a connection to staff and caregivers, is conducive to a sense of well-being, and facilitates a connection to the outside world.
Gurses 2007[54]	Effects of physical environment	Cross-sectional study	Survey of nurses in intensive care units (ICUs) (Level 4).	272 nurses in 17 ICUs in 7 hospitals in Wisconsin	None	Reported performance obstacles included noisy work environment, distractions from families, hectic and crowded work environments, delay in getting medications from pharmacy, amount of time teaching families, equipment not being available, patient rooms not well stocked, insufficient workspace for completing paperwork, time spent seeking supplies or patient's charts, receiving many phone calls from families, delay in seeing new medical orders, and misplaced equipment.
Hendrich 2004[62]	Acuity-adaptable rooms	Pretest, post-test	Implementation of new acuity-adaptable rooms (Level 3).	A coronary critical care unit and its step-down medical unit at 1 hospital in Indiana	Evidence-based design of 56 new acuity-adaptable rooms for the combined coronary critical care and step-down unit.	After the move, there was a large reduction in clinician handoffs and transfers; a 70 percent reduction in medication errors; a reduction in patient falls; improvements in patient satisfaction; decrease in budgeted nursing hours per patient day; increased available nursing time for direct care without additional cost.
Rashid 2007[56]	Effects of physical environment	Cross-sectional study	Development of a survey instrument about underlying effects of environmental features on staff perception of patient comfort, patient safety, patient privacy, family integration, and working conditions (Level 4).	Nurse managers/directors in 7 adult ICUs built between 1993 and 2003	None	Respondents reported that private patient rooms enabled patient safety; ensured privacy of patients; access to patient status information and space for family was important; and flexible patient charting locations and adequate work surface/space were important.

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Shepley 2002[63]	Built environment	Pretest, post-test design	A multi-method approach using behavioral mapping; interviews; questionnaires; and calibrated measures of walking, noise, and temperature (Level 3).	21 nurses were observed, 10 completed the questionnaire, and 8 nurses were interviewed in a neonatal ICU in 1 hospital.	Implementation of a new neonatal ICU, where the new design focused on the development of a more efficient floor plan, the provision of space for supportive family-centered care, and the use of natural light	On the new unit, nurses were found to spend most of their time in active baby care, followed by walking, conversations, passive baby care, and charting. More time was spent taking care of the babies on the new unit than on the old unit. Those responding to the questionnaires perceived the new unit as comforting and clean but less secure than the old unit. Family-centered care was perceived as supportive of babies and their families, though its ratings were lower for the supportiveness of nurses and physicians. The unit was rated as generally being efficient and the new lighting was thought to have a positive impact on the patients. Those who were interviewed felt that families were utilizing the majority of space designated to them. They felt the design was efficient, lighting was improved, and noise levels were lower.
Varni 2004[55]	Built environment	Cross-sectional study	Development of a measurement instrument about the built environment (Level 4).	Parents and staff in a children's convalescent hospital	None	Parent satisfaction with the structure and facility aesthetics was associated with higher satisfaction with care. Staff satisfaction with the facility aesthetics and work environment was associated with higher satisfaction and coworker relationships.