

The Role of the Physical Environment in Crossing the Quality Chasm

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Shortly following release of the *To Err is Human*¹ report exposing serious threats to patient safety, the Institute of Medicine (IOM) released a second report, *Crossing the Quality Chasm*,² which revealed other problems in our health care system. Not only was the health care system shown to be *unsafe*, with needless numbers of patient deaths and injuries, it was found to be *ineffective*, with an overuse of unnecessary tests and underuse of necessary services; *inefficient*, with considerable waste of supplies, equipment, and human effort; *untimely*, with respect to prolonged wait times and harmful delays; *not patient-centered*, because patient preferences and values go unrecognized; and *not equitable*, given the disparities of care that exist for minority groups and other subsets of the population. Taken collectively, these disturbing departures from quality led the IOM to conclude that separating the health care we have and the health care we should be receiving is not just a gap but a chasm.

Concurrent with efforts to identify and bring under control the most prevalent and serious departures from quality has been a less recognized yet exceedingly relevant area of research that focuses on the physical environment and how its design can serve to facilitate or impede the quality of care that patients receive as well as the quality of work life for their providers. Many of the existing hospitals in the United States, spawned by the Hill-Burton program after World War II to support a growing and shifting population, are showing their age. With advances in technology and heightened patient expectations, acute med-

Article-at-a-Glance

Background: Evidence-based design findings are available to help inform hospital decision makers of opportunities for ensuring that quality and safety are designed into new and refurbished facilities.

Framework for the Evidence: The Institute of Medicine's six quality aims of patient centeredness, safety, effectiveness, efficiency, timeliness, and equity provide an organizing framework for introducing a representative portion of the evidence. Design improvements include single-bed and variable-acuity rooms; electronic access to medical records; greater accommodation for families and visitors; handrails to prevent patient falls; standardization (room layout, equipment, and supplies for improved efficiencies); improved work process flow to reduce delays and wait times; and better assessment of changing demographics, disease conditions, and community needs for appropriately targeted health care services.

The Business Case: A recent analysis of the business case suggests that a slight, one-time incremental cost for ensuring safety and quality would be paid back in two to three years in the form of operational savings and increased revenues. Hospitals leaders anticipating new construction projects should take advantage of evidence-based design findings that have the potential of raising the quality of acute care for decades to come.

Six Institute of Medicine (IOM) Quality Aims

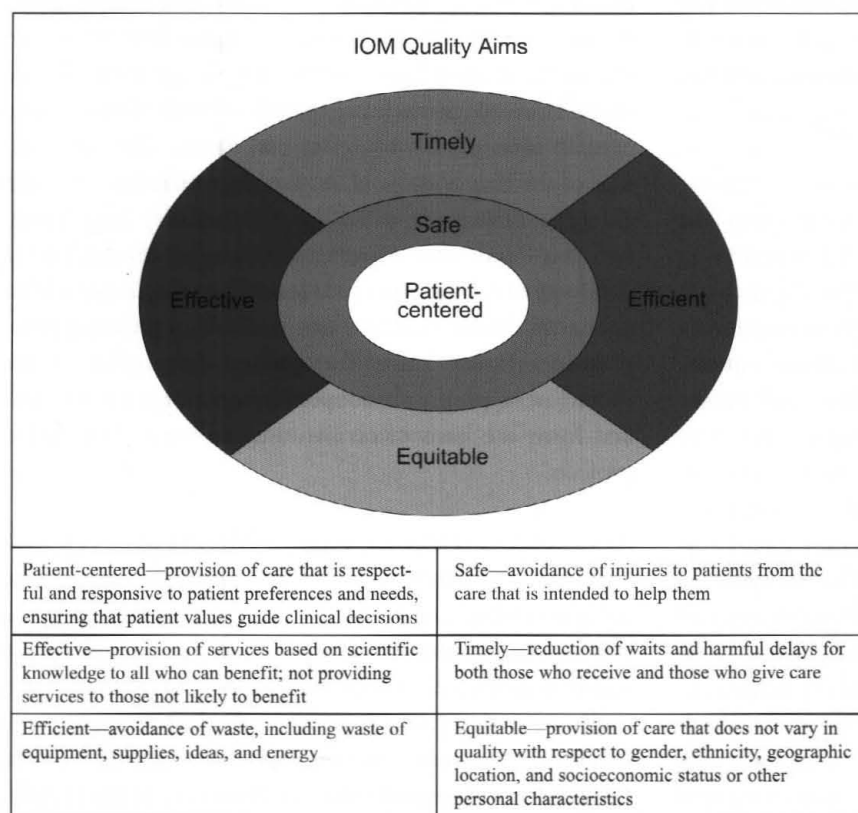


Figure 1. The figure represents the six IOM quality aims, with patient-centeredness as the foremost central aim. Adapted from Institute of Medicine: *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academy Press, 2001.

ical care no longer resembles that of the 1950s and 1960s. As a result, the hospital industry is in the middle of a major building boom, with some \$100 billion in inflation-adjusted dollars spent on new construction in the past five years.³ There is an emerging evidence base from health care architecture, health design, environmental psychology, human factors, and industrial engineering that collectively reinforces the expectation that safety and quality of care should and can be designed into the construction of new facilities. In parallel fashion to evidence-based medicine, evidence-based design⁴ strives to use the best available information from credible research to construct patient rooms, improve air quality, improve lighting, reduce noise, encourage hand hygiene, reduce walking distances, improve way-finding, incorporate

nature, and accommodate family needs. Researchers from Texas A&M University, the Georgia Institute of Technology, Simon Fraser University, and the Center for Health Design have compiled a diverse range of studies in the form of literature reviews that address the impact of hospital design and environmental factors on clinical outcomes and the work-life quality of providers.⁵⁻¹¹

Given that the physical environment is relatively permanent and will shape the work environment and quality of care provided for decades to come, a rare opportunity currently exists amid the current hospital building boom for chief executive officers (CEOs), their boards of trustees, and design teams to take advantage of evidence-based design that can inform their decision making. This article provides some of this evidence base by describing design features that have the potential to facilitate achievement of the six IOM quality aims familiar to many health care practitioners. Some of these physical features affect patients

directly and others indirectly by their mediated effects on the caregiver work environment.

Figure 1 (above) provides a schematic of the six IOM quality aims, with patient-centeredness as the foremost central aim.¹² It enables us to consider the ways that a health care facility designed to be patient-centric would be different from provider-centric facilities of the past.

Patient-Centeredness

Care is patient-centered when it revolves around the patient, respect for patient needs and concerns is evident, credible information is tailored to the individual, physical comfort is assured, emotional support is provided, and family and friends are active partners in the cycle of care.^{2,13} In brief, the goal of patient-centeredness is to

adjust the delivery of care to the patient's needs, preferences, and values. Rather than clinical autonomy driving variability, patients' needs drive the variability. Care is modified to adapt to the individual, not the individual to the care.²

VARIABLE-ACUITY ROOMS

Patient-centeredness can be viewed as bringing the right level of care to the patient rather than transferring the patient to different levels of acuity care during an average four- to five-day hospital stay. A lot goes wrong during patient transfers—communication breakdowns among staff, missing or incorrect information, delays, and incompatibilities between separate record-keeping systems. The consequences are medical errors, diminished quality of care, wasted staff time, reduced satisfaction, and increased costs.³ In a study that will be discussed subsequently in greater detail, a team at Clarian Methodist Hospital in Indianapolis demonstrated that different levels of comprehensive cardiac critical care can be brought to single patient rooms by making the headwalls “acuity adaptable” to accommodate the different gases and equipment needed and by decentralizing nurses' stations, with additional workstations positioned outside patient rooms.^{1*} Several hospitals have adopted various aspects of this strategy to limit patient moves and improve patient safety.

As illustrated above, new designs of the physical environment frequently cut across the quality aims. Variable-acuity rooms are a good example of likely favorable impacts on safety and efficiency, as well as patient-centeredness.

SINGLE-BED ROOMS

The movement in hospital design and construction to single-bed rooms is a significant step towards achieving patient-centeredness while simultaneously helping to achieve the aims of safety, effectiveness, and efficiency. The emerging evidence suggests that single-bed rooms have several advantages over double rooms and open bays.⁴⁻⁹ These advantages frequently include lower nosocomial infection rates, standardization in room layout, fewer patient transfers and associated disruptions of care, shorter lengths of stay, reduced noise levels, better patient-staff communication, better privacy for patients and families, oversized windows for natural light, and greater satisfac-

tion with overall quality of care. Avoidance of preventable infections and the physical discomfort and complications that such infections bring is very compatible with the aim of patient-centeredness. Single-bed versus multiple-bed rooms leave patients less exposed to both airborne and contact transmission routes of pathogens. The 2006 edition of the *Guidelines for Design and Construction of Health Care Facilities*, compiled by the Facility Guidelines Institute and the American Institute of Architects Academy of Architecture for Health, lists single-bed rooms as the minimum standard for medical/surgical and postpartum nursing units for general hospitals.¹⁵ These Guidelines typically are adopted by a majority of the states and form the basis of civilian and military construction projects.

ACCOMMODATION OF FAMILY MEMBERS

If design efforts indeed are to be patient-centric, then persons serving in a design role need to consider how the patient's immediate environment can best accommodate family members and friends who are in a position to understand the patient's needs and provide appropriate forms of emotional support. Patient rooms can be designed with designated family areas that make it easier for family members and patients alike to articulate their views and be actively involved in shared decision making and the care provided.

The recently constructed St. Joseph's Community Hospital in West Bend, Wisconsin, serves as an example.¹⁶ The family area, as distinct from the caregiver area, includes a couch that folds out to a bed, a desk with access to the Internet, and storage closets for the belongings of the patient and family members. Emory University (Atlanta) and MCG Health (Augusta, Georgia) have extended the family accommodation concept to intensive care units (ICUs). Nurses and families in both settings report that the presence of family members does not interfere with provider activities but has facilitated the supportive role that families can serve.

ACCESS TO INFORMATION

Given the numerous procedures, test results, and consultations that patients undergo throughout their cycle of care, it is important for accurate and timely information to reach those that need it in a reliable fashion.²

Well-coordinated transfer of information and transitions of care remain major hurdles for many facilities. When patients and family members receive information that is tailored to their needs and in a manner that can be understood, they can serve as key quality control allies in the quest for smooth and uneventful transitions of care. Informed decision making and self-managed care are facilitated when rooms are equipped electronically for giving patients and families access to the Internet, and when their medical records, medication regimens, and care plan following discharge are easily accessible. Similarly, navigating the facility's physical environment can be made less bewildering for patients and families with improved way-finding features and signage in the concourses, hallways, and intersections.

Safety

The distinction made by Reason between *active errors* and *latent conditions* is very important for understanding the ways the built environment can undermine patient and provider safety.^{18,19} Active errors are those slips and lapses likely to be made by providers responding to patient needs at the *sharp end*, while *latent conditions* refer to potential contributing factors that are less recognizable and lie dormant in the health care delivery system. The latter originate upstream in design and organizational contexts and take the form of questionable space layouts, clumsy devices and equipment, stressful working conditions, and organizational policies that do not make sense for the nature of the work performed. These are the system defects that are present in the system long before the mishap. They have been dubbed the *blunt end* because they are far removed from the activities of the sharp end, yet they can combine in unique ways, create awkward work environments, and compromise the safety of patients and providers alike. Providers are actually the last line of defense, for it is they who inherit the sins of commission and omission of everyone else who has played a role in the design of the delivery system.

PATIENT FALLS

The design, layout, physical structures, and equipment in patient rooms are latent conditions that have a direct bearing on patient falls. It has been observed that the majority of falls of hospitalized patients occurs in their

rooms as patients attempt to make their way from the bed to the bathroom.²⁰⁻²² Although there is a host of risk factors associated with falls (for example, altered mental status, impaired mobility, incontinence, age²³), there also are ways of redesigning patient rooms that make getting to the bathroom less of a hazardous activity. In the design of patient rooms at Saint Joseph's Community Hospital, the bathroom is located behind the headwall to minimize distance to the bathroom, and handrails are provided along the route for patient support.^{16,21} Use of infrared technology that notifies caregivers immediately when the patient sits up or moves to the end of the bed also is used to reduce patient falls. Another design consideration with potential to prevent falls stems from the location of staff. Feedback from care-provider personnel and iterative mock-ups and evaluations led the Saint Joseph's design team to include a small charting alcove adjacent to each room, enabling nurses to have greater visibility of patients without disturbing them but with the ability to assist them when needed. The alcove also contains storage for needed supplies, patient information, and bar-coded medication, potentially realizing efficiency gains as well in terms of reduction of unnecessary steps and greater contact time with patients.

CONTROL AND PREVENTION OF INFECTIONS

Hospital-acquired infections continue to serve as a very serious threat to patients in the United States and elsewhere, especially to elderly patients with compromised immune systems. By examining the environmental routes for the transmission of infections—air, surface contact, and water—preventive control measures can be put into place to drastically limit their spread.⁹ Airborne spread of pathogens occurs with faulty and contaminated ventilation systems and from the fungal spores that are released with the disturbance of dust and moisture from new construction activities.^{25,26} Properly maintaining air filtration and ventilation systems is necessary for ensuring good air quality. High-efficiency particulate air (HEPA) filtration systems, while increasing original and operating costs, are extremely efficient in removing airborne particulates from hospital units and in allowing recirculation of conditioned air. Single-bed rooms where patients can be isolated and HEPA filtration provided offer clear advantages to multiple-bed rooms for preventing the spread of pathogens

from patient to patient.⁵ A lower incidence of infection has been reported for high-acuity and immunocompromised patients when housed in isolation rooms with HEPA filtration systems.²⁷ Once reserved for areas requiring special air handling, such as operating rooms, a growing number of hospitals such as Northwestern Memorial Hospital in Chicago are choosing to install HEPA filters extensively throughout their facilities to potentially reduce the impact of infections.²⁸

With respect to infections acquired by contact, many surfaces in patient rooms serve as receptive hosts for pathogens through contact with patients and staff. Although the surfaces are not thought to play a direct role in transmission of pathogens, the hands of health care staff that come into contact with surfaces serve as the contact route for transmission from staff to patient.^{29,30} After a patient is discharged, single-bed rooms, with their easier access to surfaces, are less difficult to decontaminate than multiple-bed rooms.

Despite what is known about the importance of hand washing for reducing hospital-acquired infections and educational programs that have done their best to inform providers, compliance rates among staff and physicians remains low, often in the 20%–40% range.⁵ Simply informing providers is not sufficient; design-based strategies are needed that will change provider behavior. In efforts to increase compliance, design-minded investigators have tried to make hand washing a very easy and convenient thing to do through placement of alcohol hand rubs or sinks close by and within sight along the path to the patient.⁵ There is evidence to suggest that installing alcohol hand-rub dispensers at bedside in conjunction with posters reminding staff to wash their hands significantly improves compliance.^{31,32}

The spread of waterborne infections occurs through direct contact, ingestion of contaminated water, indirect contact, and from inhalation of aerosols dispersed from water sources.⁹ To prevent such spread, a regular inspection and maintenance regimen to minimize stagnation and backflow and to ensure appropriate temperature control is essential. To prevent and control *Legionella*, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers recommends regular cleaning and disinfection of faucet aerators, especially in areas with immunocompromised patients.^{9,33}

PREVENTING PATIENT AND PROVIDER INJURY

Just as providers who work excessive hours in a fatigued state pose a risk to patients and to themselves, so do providers who work with musculoskeletal injuries. Providers and their assistants who work with lower-back, hand, or arm injuries can harm patients during lifting and transporting tasks. Of course, they run the risk of further injury to themselves because much of their daily work involves lifting and laterally transferring heavy loads from less than ideal positions. Musculoskeletal injury in the workplace is recognized as a serious problem—approximately one million people miss some work each year³⁴—yet greater recognition is needed about the role that good ergonomic design can play in enabling good body mechanics and reducing these injuries. The best time to address the problem is during the early design phases of new facilities.

In response to the pervasive problem of patient-handling injuries, PeaceHealth's Sacred Heart Medical Center in Eugene, Oregon, installed ceiling lifts in patient rooms in their ICU and neurology units in an effort to move toward a "no manual lift" environment. A Center for Health Design Pebble Project study tracked the number of injuries associated with patient handling and their costs during a five-year period.³⁵ In the ICU, 10 injuries were related to patient handling in the two years before installation, with an annual cost of \$142,500. Three years after the installation, two such injuries occurred, with an annual cost of zero dollars. In the neurology unit, 15 such injuries occurred during a three-year period before the installation, for an annual cost of \$222,645. During a two-year period after installation, the 6 injuries accounted for an annual claims cost of \$54,660. In terms of the bottom line, it was reported that annual costs for patient-handling injuries in the two units was 83% lower than before the ceiling lifts were installed. Despite the impressive reductions in patient-handling injuries, the study's investigators underscore the importance of reinforcing and supporting the "no manual lift" policy through educational efforts because there was still some resistance among staff to using the lifts. In a new replacement hospital that PeaceHealth currently is building, it will be making 309 rooms "lift ready."

SENSITIVITY TO THE INTERDEPENDENCIES OF CARE

Safety is an emergent property of systems.³⁶ It does not

reside in a person, device, department, or physical structure, but comes from the intricate interactions that occur among a system's components. Weick has referred to safety as a "dynamic non-event."³⁷ It takes a lot of work, attention to operations, and resiliency for nothing bad to happen in complex settings. Too frequently, the multiple and dynamic interdependencies among the physical structures, technologies, personnel, clinical processes, supplies, and equipment are not well aligned, resulting in cumbersome work environments for providers and substandard care for patients. A study of hospital work-process failures (for example, incomplete information, missing supplies, malfunctioning equipment, unavailable personnel) nicely illustrates the need for the interdependencies of care to be better designed and managed.³⁸ Failures elicited "work-arounds" and "quick fixes" by nurses 93% of the time, yet reports to those who might be able to do something about the failure occurred only 7% of the time.³⁸ Neglect by those who play a role in the design and management of clinical work environments and processes is one way of ensuring that such failures reoccur.^{39,40} To promote safety and overall system performance, design efforts need to integrate as seamlessly as possible the interdependencies among work spaces, technologies, work processes, and people.⁴¹ This is best accomplished when design teams are interdisciplinary.

Effectiveness

As noted in Figure 1, *effectiveness* refers to the appropriate use of a service or intervention that is derived from relevant scientific knowledge. In delivering care on the basis of the best available evidence, providers need to do so consistently, ensuring that underuse of effective care and overuse of ineffective care are not dual threats to the patient.⁴² To realize and sustain a desired level of effective care, hospitals need to track their own care patterns and interventions and follow up their patients systematically after discharge—as advocated by Codman nearly a century ago⁴³—to determine whether the interventions have the intended effect.² In clinical practice settings, the outcomes realized are likely to be a function of a number of relevant environmental variables, and some variables may manifest their effects only at particular levels of other variables, as illustrated next.

LIGHTING AND VISUAL PERFORMANCE

The ability to perform tasks effectively depends, in part, on the amount, spectrum, and distribution of light available in the immediate work environment.

Medication-dispensing error rates among pharmacists were lower when work-surface lights were at high illumination levels (at 1,500 lux compared with 450 and 1,100 lux).⁴⁴ Visual performance also depends on the nature of the tasks. For example, performance can suffer when providers are executing tasks that involve small visual elements and when contrast between figure and background is low, as would be the case in dimly lit patient rooms. Increasing the level of illumination can help for certain tasks; however, the relationships between size, contrast, and illumination can affect performance in less than obvious ways.⁴⁵ Although performance generally improves with increases in illumination, the improvements may progressively diminish with subsequent increases until a point is reached where further increases are no longer beneficial.

Visual performance also depends on changes that take place in our eyes as we age. As we reach 40 years of age and beyond, changes in the lens and optic pathways reduce the amount of light that reaches the retina.⁴⁶ At the time of writing, the average age of registered nurses in hospitals in the United States is greater than 45 years; other key staff members are aging as well.²² Quite informative are the results of a study on the relationship between illumination and performance for young and aged subjects performing easy (good print quality) and difficult (poor print quality) versions of the same proofreading task.⁴⁶ Although increases in illumination had a positive impact on performance and younger subjects overall outperformed older subjects, the difference between the two age groups was most pronounced for the poor print quality condition and considerably reduced for the good print quality condition. Older subjects performed almost as well as younger subjects across the four illumination conditions when print quality conditions were good. In addition to demonstrating the effects of illumination, the study shows how a seemingly simple workplace feature such as the quality of written material, as can be found on medication labels and instructions to infusions pumps, can have a significant impact on the performance of older workers. The lesson for designers is that particular design features do not always have uniform effects and that it is important to

know something about lighting requirements for various workforce tasks and about the capabilities of different groups in the workforce.

DIVERSE EFFECTS FROM EXPOSURE TO LIGHT¹

Although the use of bright artificial light for reducing depression among patients with bipolar disorder and seasonal affective disorder is generally well known, there is evidence that suggests bright natural light also plays a role in reducing depression.^{17,18} In east-facing rooms where exposure to bright natural light was greatest in the morning, bipolar depressed patients stayed an average of 3.67 days less in the hospital compared with patients staying in west-facing rooms. Similarly, there is evidence that exposure to bright light in the morning is more effective in reducing depression than bright light in the evening.¹⁸⁻²¹ Agitation among elderly dementia patients also has been shown to lessen with exposure to bright light in the morning.²¹ Other studies suggest that timed exposure to artificial bright light might be helpful in improving sleep quality among older adults and in stabilizing circadian rhythms among nursing home dementia patients.^{19,22-25}

The relationship between the amount of sunlight in a hospital setting and the amount of analgesic medication used, the cost encumbered for analgesic medication, and patients' psychosocial health has been examined.²⁶ Compared with the less well-lit side, patients who stayed on the bright side of the hospital and who were exposed to more intense sunlight experienced less perceived stress, took 22% less medication for pain per hour, and had 21% less medication costs. When given a choice, people seem to prefer daylight to artificial sources of light given different work attributes (for example, psychologic comfort, color appearance, work requiring fine discriminations) and prefer to be close to windows.²⁶ Contrary to expectations, the link between the presence of windows and improved mood and performance outcomes has not received unequivocal empirical support. Factors such as glare and thermal discomfort stemming from windows can affect mood and task performance adversely and thus require some form of control by room occupants.² Although daylight-enhancing features such as atriums and windows in patient rooms receive high staff satisfaction ratings in surveys, nurses' stations and break rooms where staff currently spend much of their time typically do not

have these daylight-enhancing features.^{10,28}

What one views through the window can make a difference.^{5,50-61} Bedridden patients show a strong preference for having a hospital window with a view of nature.⁵⁰ Abdominal-surgery patients recover faster and require less pain medication when they have windows with views of nature (looking out over trees) compared with looking out at a brick wall.⁶⁰

Heart-surgery patients in ICUs who are assigned a landscape scene with trees and water report less stress and need less pain medication compared with a control group with no pictorial views of nature.⁶¹ One interpretation is that patients' exposure to real or simulated views of nature provides a "positive distraction," diverting attention from the patient's perceived suffering and distress.^{5,61}

Although the multidimensional nature of light will keep researchers busy for some time to come, what is already known should enable facility designers to more adequately respond to the needs of patients and providers for an appropriate lighted environment. Thus far, the evidence informs us that patients are well served by windows for gaining access to natural light and by the capability to control glare and temperature. Providers, in turn, are well served by sufficiently high illumination levels when performing complex visual tasks and by windows in break rooms for enabling access to natural light.

THE EFFECTS OF NOISE

Reviews of experimental laboratory studies on the effects of noise on performance disclose a wide range of effects, some of which are counterintuitive (for example, noise can enhance performance on certain tasks).^{62,63} Generalizing the findings from such studies to applied work settings is a bit risky, however, because of differences in the subject populations and tasks performed.⁶⁴ Nevertheless, hospitals are noisy places, stemming from discordant sounds from numerous sources—paging systems, alarms, rolling carts, bedrails, staff voices, other patients, and the hard, sound-reflecting surfaces that cause the noise to reverberate and travel along considerable distances.⁶⁵ Much of the applied research conducted in hospitals on noise underscores its detrimental effects. For example, noise has been found to be a major cause of awakenings and sleep loss in patients.^{66,67} Noise also has been implicated in physiologic stress experienced by adult

patients in the form of increased blood pressure and heart rate.^{68,69} In a study of patients with acute myocardial infarction in coronary ICUs, a higher frequency of rehospitalization following discharge occurred when patients experienced noisy, poor acoustical conditions during their hospital stays.⁷⁰ By changing the sound-reflecting tiles to sound-absorbing tiles in the coronary ICU, the same investigators were able to decrease noise, improve sleep, and lower the incidence of rehospitalization. Noise also impairs infant sleep in neonatal ICUs, decreases oxygen saturation, and raises blood pressure, heart rate, and respiration.⁷¹⁻⁷² Although less is known about the effects of noise on task performance of providers, higher noise levels among staff have been associated with greater perceived stress, annoyance, work interference, and emotional exhaustion.^{68, 73-75} Clearly, well-designed studies that determine the impact of noise on specific task performances of providers are needed.

Strategies for reducing noise need to do more than simply encourage hospital staff to be quieter in the performance of their daily tasks. The greatest gains in noise reduction come from elimination of unnecessary sources of noise, appropriate design of the physical facilities to curtail the travel of noise and judicious use of sound-absorbing materials.⁶⁸ The creation of single-patient rooms is a big step in the right direction because noise is much worse in multi-patient rather than single-patient rooms, where one has no control over the noise generated by other patients. Patient satisfaction survey data from over two million patients in 2003 unquestionably showed a wide pattern of higher satisfaction across all categories of patients with respect to the lesser noise levels experienced in single-bed rooms.⁷⁶ The installation of sound-absorbing ceiling tiles has been demonstrated as an effective way to reduce significantly noise reverberation and propagation.^{68,69,77} Other sound-absorbing techniques include use of bio-safe and cleanable cork partitions around noisy equipment; rubber flooring that is acoustically absorbent; sound-absorbent wrapping around ducts, pipes and pneumatic tubing; noise-absorbing wall boards; and when appropriate, electronic sound masking.⁷⁷ Finally, eliminating noisy systems such as overhead paging and replacing them with noiseless systems—especially when making purchasing decisions during new construction or reconstruction projects—is yet another strategy for reducing noise.

Efficiency

Concerns about efficiency usually take the form of assessing whether the resources used are providing the best value or outcomes for the efforts expended. In health care, the ultimate outcome is improved health as the end value, with the delivery of health care services as the intermediate steps or means to the end value.⁷⁸ The design of health care facilities does not play a neutral role with respect to the intermediate steps that are performed or to the final health outcome. Inefficient facility designs that affect way-finding routes, patient care units, and provider work spaces can encumber considerable resources and energy, day in and day out, but without additional benefit to patients, providers, and visitors alike.

THE VALUE OF STANDARDIZATION

As has been demonstrated in many industries, efficiencies and economies of scale can be realized by greater standardization. On entering patient rooms, providers should not have to waste time and effort in rediscovering the locations of needed equipment, controls, outlets, supplies, and patient information. Patient rooms can be standardized with respect to size and layout to enable quick access to supplies and equipment, to facilitate proper hand hygiene, to increase patient visibility, to allow more natural light, to reduce noise, to decrease patient falls, to allow easier access to records and care regimens, and to accommodate family members.^{16,79} The combined intent of the standardized functionality is an environment that is safer for patients, more efficient for providers, and more accommodating for family members. In addition to patient rooms, other aspects of the physical environment that represent opportunities for gains in efficiency include standardization of emergency exam rooms, postrecovery rooms, diagnostic exam rooms, access to gases throughout the facility, and equipment (for example, monitors, infusion pumps, beds, medication systems, intravenous devices, and assorted connecting devices). When like-kind items are purchased from different vendors, it only adds to the “learning curve” burden placed on time-pressured providers.

MINIMIZING INEFFICIENT TRANSFERS

Patient transfers from one acuity level or room in a hospital to another serve as powerful magnets for inefficiencies. Both the amount of time that nursing personnel

spend preparing patients for transfers and the percentage of patients undergoing transfers are quite high.^{14,79} The same inefficiencies get repeated day after day—foraging for missing information, supplies, and equipment; waiting for or looking for test results; searching for other staff members; trying to clarify failed communications; trying to recover from interruptions that disrupt completion of ongoing tasks; and making duplicative requests for patient information.^{8,32,79,80} These inefficiencies converge to add to the nonproductive work load of staff and increase overall costs, and over time, can have the accumulative, debilitating effect of lowering the quality of care and fostering a culture of low expectations.

As noted earlier, an innovative demonstration project to minimize the need for patient transfers as acuity level changes was conducted in cardiac comprehensive critical care at Clarian Methodist Hospital.¹⁴ Rather than transfer patients, the patient rooms were designed so that different levels of acuity care could be provided to patients in a single room. By outfitting the headwalls with the necessary gases and equipment, adaptable acuity care was possible for a range of patient acuity conditions in a newly designed 56-bed unit. Other changes to the physical environment included decentralized nurses' stations and workstations outside patients' rooms. Changes in the physical environment to improve efficiency necessitated changes in the culture-of-work model with which it interacted.^{8,14,72} To respond to patients with varying acuity levels, the existing model of how nurses carried out their work changed. To work on the adaptable acuity care unit, nurses received training so they would be prepared to respond to a more diverse range of patient care needs. Comparison of two-year baseline data with three-year postintervention data showed a 90% decrease in patient transfers, a 70% reduction of medical errors, and a reduction in the number of falls.¹⁴ Although these findings are encouraging, further study of acuity-adaptable rooms is needed to gain a better understanding of how the physical environment and the culture-of-work variables (for example, staffing, work flow, training) interact to bring about improved care processes and improved care outcomes.⁸

Timeliness

As an essential characteristic of quality, timeliness refers to the ability to provide health care services in a time-sensi-

tive manner once a need is recognized. A timely response to a patient's suddenly deteriorating condition can be the difference between recovery, permanent injury, or death. Measures of timeliness have included wait times in doctors' offices and emergency departments (EDs), visits in which the patient left the ED without receiving attention, and time from arrival to initiation of thrombolytic therapy for heart attack patients.⁸¹ A general trend in recent years is an increase in wait times. A delay in receipt of test results and diagnoses can result in preventable complications and a more advanced staging of disease. Long delays not only have the potential to adversely affect patients left on gurneys in hallways awaiting transfer, but also nurses and physicians and other specialists who have to disrupt their own schedules to attend to patients who are left in a standby mode.

Timeliness of needed services is influenced by a host of interdependent factors—design of patient care units, work processes, competing distractions and interruptions, extent of patient handoffs and information transfer, communication exchanges, and health information technologies—that frequently converge in unanticipated ways and preclude meeting of critical time windows. The size and shape of patient care units have a major influence on the overall design of the hospital structure. Patient care units take various geometric forms (for example, open ward, racetrack, triangle), each with its advantages and disadvantages contingent on the perspective considered—the patient, caregiver, or hospital.^{22,82} In maximizing observation and staffing efficiencies with an open-ward design, patients' privacy can suffer; maximize the number of beds on a unit, as in the racetrack design, and nurse travel time increases while timeliness declines; create shorter travel distances for nurses, as with the triangle design, and less square footage is available for patient rooms and for interactions with family members. In addition to taking into account the evidence base, much of design involves the art of compromise. As these trade-offs are considered, it is best to remember the IOM aim of patient-centeredness. Amidst the cacophony of competing interests and activity, whose interests should the design efforts serve?

Nurses spend a significant amount of their time in mundane activities. Tending to housekeeping chores, delivering and retrieving food trays, transporting patients, checking in deliveries, and looking for needed supplies can

undermine timeliness and minimize the time spent in direct patient care.^{22,83} The vast majority of these activities do not require performance by a licensed nurse.^{84,85} Yet nurses are called on to fill the gaps when process failures and staff shortages occur.^{86,87} Failures and inefficiencies in the execution of daily work processes are a very common experience that providers have come to accept as part of hospital working life, which again reinforces a culture of resignation and low expectations. In satisfying assigned paperwork and documentation requirements that can lessen time spent in contact with patients, providers typically are not in a good position to do much about the diversions that are a reflection of poor design of commonplace work processes. Rather than perpetuate inefficiencies of the past, nurse managers, administrators, and hospital leaders are in a better position to do something about flawed work processes.⁸⁹ An opportune time to address them is during the design phases of reconstruction and new construction efforts, when designers and the care team collaborate to ensure that patient and providers' needs are met and that design features support improved patient-care work processes.

Equity

The aim of equity is to provide high-quality health care to the entire population of the United States. Unfortunately, departures from equity occur at the level of the individual and at the level of the population.² At the individual level, departures from quality care sometimes occur on the basis of personal characteristics such as gender, race, age, ethnicity, and sexual orientation. At the population level, departures from quality exist at a subgroup level, which can be the uninsured, racial and ethnic minorities, women, the elderly, and residents of rural areas, among other groupings. The Agency for Healthcare Research and Quality releases annually a National Healthcare Disparities Report, which tracks disparities among these groups and priority populations.⁸⁶

One way that those involved in the design of new facilities can help reduce some of the disparities is by being sensitive to the needs and changing demographics of the communities they serve. By assessing health care use data, demographic information, and community survey data, designers and their clients can gain a better understanding of care services needed and the disease conditions likely to

be prevalent.⁷⁷ The size, space layouts, and functions of the new facility are then based on those needs. For example, 3.2 million or 13.3% of all blacks 20 years of age or older have diabetes.⁸⁹ Newly designed health care facilities in communities with large representations of blacks would do well to ensure that the space layout and adjacencies (for example, wait areas, exam rooms), patient flow patterns, and services are appropriate for the volume of diabetic patients that can be expected.⁷⁷

An aging baby-boomer generation with a host of chronic and acute care conditions is starting to populate our health care facilities in greater numbers.⁷⁴ Not every patient requires an office visit or hospital stay. For some patients, alternative electronic communication channels can be used. Many patients can be treated in outpatient facilities. However, a sicker segment of the older population will require inpatient care, likely placing increasing capacity demands on ICUs.⁷⁷ Projections of who will need health care services and for what conditions need to be considered at the earliest stages of planning for new facilities. Increasing health care costs and other factors have led to a greater uninsured population, which makes the ED the primary and only source of care for approximately 45 million individuals. Overcrowding, long waits, and missed opportunities to provide a basic modicum of care are the conditions that beg for new design ideas and improved patient flow, triage, and treatment. Likewise, a sizable segment of the population has become obese, creating a need for up-to-date specifications for wider chairs and beds and heavier-duty lift and transport systems. Design efforts also will need to accommodate an increasingly culturally diverse population. The need for improved religious and language sensitivity in the design of facilities should be receiving greater attention.⁷⁷

The Business Case for Better Buildings

For decision makers who need to focus on the financial impact of construction projects, an essential issue is the cost-effectiveness of these improvements. Is evidence-based design cost-effective? It is only recently that the business case has been analyzed. An interdisciplinary team systemically analyzed and estimated the incremental capital costs of many of the design improvements discussed in this article.⁹⁰ The project created a new hypothetical hos-

pital, given the name Fable Hospital to convey the power of a story with a useful truth, which modeled 300 beds with a cost \$240 million. The analysis derived a one-time incremental cost of \$12 million for the improvements. Using the most relevant cost data available, the team analyzed the cost savings that could reasonably be assumed to be achieved from each improvement. The total cost savings realized came to \$7 million. The team also concluded the new facility and its design improvements would generate \$4 million in additional revenue as a result of increased market share and philanthropic donations. Because these cost savings and revenue increases are repeated every year, a most conservative estimate leads to the conclusion that the initial incremental cost would be paid back in two to three years. Building a better hospital makes good business sense. The take-home lesson for hospitals in planning any new construction or major remodeling project is the desirability of examining the one-time capital costs in view of the ongoing operational savings.^{91,92}

Concluding Comment

Among health care professionals who take a keen interest in the quality and safety of patient care, there is no argument with the principal findings of the *Crossing the Quality Chasm* report that health care is not as patient-centered, safe, effective, efficient, timely, and equitable as it should be.³ Less well recognized, but in complementary fashion to evidence-based medicine, are the findings stemming from evidence-based design that address the impact of the physical environment on different dimensions of quality and safety for patients and providers alike. Although there is a need for further, well-executed research regarding the insertion of design improvements in clinical settings, the consensus among a growing number of architects, health designers, environmental researchers, providers, and administrators is that much is already known that will enable quality and safety to be designed into newly constructed and reconstructed facilities. To be sure, the evidence-based design process will continue to provide the empirical foundation for design improvements in the physical environment, and cost-effectiveness analyses can help ensure their financial viability.

Either positively or negatively, the design of the physical environment will have its impact on providers and patients. No environment is neutral. Rather than relying

solely on traditional quality improvement efforts after the hospital is built (when operating budgets are typically limited) to enhance quality, a more proactive approach is to build quality into the physical structure at the very beginning of the design process. Maximum benefit can be realized by using evidence-based design principles to inform the capital budget decision-making process. Once these principles become part of the design of the new facilities, it is not unreasonable to expect that the daily savings that are reaped in terms of quality and safety will accrue for decades and decades. ■

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