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chapter 6

Biophilic Theory and Research for Healthcare Design

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This is an era of vast investment internationally in new healthcare buildings. More than $40 billion was spent in the United States in 2006 on new healthcare construction, and annual U.S. spending is projected to reach $61 billion by 2010 (Jones 2007). The United Kingdom has begun a program to create upwards of 100 hospitals and thousands of clinics. This surge of construction provides a major opportunity to use biophilia research to inform the design of better, more healing healthcare environments. There are more than 50 rigorous studies relevant to understanding the influences of such biophilic elements as nature views and daylight in healthcare settings on patients, family, and staff. This growing literature indicates that evidence-based biophilic design can have a positive impact by reducing stress, improving emotional well-being, alleviating pain, and fostering improvements in other outcomes.

This chapter describes biophilia theory and selectively reviews scientific research pertinent to designing healthcare settings that reduce stress and promote better health outcomes. Patients and other users of healthcare facilities can potentially derive benefits from widely different types of encounters with biophilic elements or nature including physically active experiences such as horticultural therapy (Wichrowski et al. 2005); less physically active contacts, for instance, sitting and talking in a garden; and passive interactions such as looking at nature through a window (Ulrich 1999). The discussion concentrates mainly on the effects of passive visual experiences with nature and exposure to sunlight on patient outcomes. Although the amount of research relevant to healthcare design is limited, there are a growing number of scientifically rigorous studies, making this one of the most rapidly developing and coalescing areas of biophilia/design research.

The next section defines two key terms that are important throughout the chapter, ***health outcome*** and *stress*. The following discussion covers biophilia theory relating to the proposition that exposure to nature and sunlight helps to mitigate stress, reduce pain, and improve other outcomes. Later sections survey research findings and list evidence-based biophilic design recommendations for hospitals and clinics.

WHAT ARE HEALTH OUTCOMES?

Health outcome broadly refers to an indicator or measure of healthcare quality. There are many different types of health or medical outcomes, including

- Observable signs and symptoms relating to patients' conditions (examples: intake of pain medication, blood pressure, length of hospital stay)
- Satisfaction and other reported outcomes (examples: patient satisfaction, health-related quality of life, staff satisfaction)
- Safety outcomes (examples: infection rate, medical errors, falls)
- Economic outcomes (examples: cost of patient care, recruitment or hiring costs due to staff turnover, revenue from patients choosing a facility)

Outcome studies have major importance in healthcare because they provide the most sound and credible basis for evaluating whether a particular medical intervention, treatment, or service is medically effective and cost-efficient. An important related point is that outcome research methods can be adapted to evaluate to what extent biophilic design measures in healthcare facilities are beneficial and cost-effective compared to creating conventional hospitals and clinics designed without biophilic features. Healthcare providers everywhere are under strong pressures to control costs yet increase care quality, and they face mounting financial demands such as paying for costly imaging technology and recruiting employees with key skills. Intuitive or qualitative arguments in favor of biophilic design carry little weight with administrators forced to pay close attention to the bottom line. There can be no question that the resources accorded to biophilic design in the healthcare sector will be heavily affected by the extent to which sound studies demonstrate that biophilic measures provide actual gains through improving outcomes and reducing costs compared to alternatives such as not providing nature (Ulrich 2002).

The priority of specific health outcomes used for measuring the effects of biophilic design can vary in different categories of patients. Suppose, for example, that a hospital is considering whether to install a garden designed to benefit patients recovering from cardiac surgery. Here, administrators would be more likely to allocate space and funding for the project if credible research showed that a well-designed garden would improve outcomes relevant for the surgery patients, such as reducing intake of pain drugs, lowering anxiety or stress, increasing satisfaction with the care experience, improving the capacity to move or walk independently at time of discharge, and reducing the length of hospital stay. By contrast, the selection of outcomes would be different for gauging the effects of a garden, for instance, on terminally ill persons in a hospice, and could focus on an evaluation of whether garden exposure improved reported quality of life and reduced depression, pain, and family stress. As another example, assessing the effects of a hospital garden designed for use by nurses and other staff would measure such outcomes as absenteeism, turnover, work stress, and satisfaction (Ulrich 1999, 2002).

STRESS: A MAJOR PROBLEM IN HEALTHCARE

Stress is defined here as a process of responding to events, environmental features, or situations that are challenging, exceed coping resources, or threaten well-being. Stress is central to understanding how biophilic design, and healthcare physical environments more generally, can influence outcomes (Ulrich 1991, 1999, 2006). A vast body of research has documented that patients experience stress, and that a large proportion suffer acute stress. Examples of the many stressful aspects of hospitalization include fear about impending surgery, lack of information, painful medical procedures, reduced physical capabilities, depersonalization, loss of control, and disruption of social relationships. Much added stress, unfortunately, stems from poorly designed healthcare environments that are noisy, hinder the presence of family and friends, deny privacy, prevent patients from seeing out windows, or force bedridden persons to stare directly at glaring ceiling lights (Ulrich 1991; Ulrich et al. 2006).

In addition to afflicting patients, stress is also a burden for families of patients and visitors, and a pervasive problem among healthcare staff. Occupations such as nursing are stressful because they often involve high work demands, low sense of control, stressful events such as the death of a patient, noise, fatigue, inadequately designed work and care settings that force nurses to spend much of their time walking up and down halls engaged in wasteful fetching, and a lack of break rooms or respite spaces (Ulrich et al. 2006).

The stress experienced by a patient is an important negative outcome in itself, and directly and adversely affects many other outcomes (Ulrich 1991). These unhealthy effects stem from detrimental psychological, physiological, neuroendocrine, and behavioral changes linked to stress. Examples of psychological manifestations of patient stress responses include feelings of fear or anxiety, sadness, and a sense of helplessness. Physiological accompaniments often include, for instance, elevated blood pressure and heart rate. The neuroendocrine component produces increased levels of a steroid (cortisol) and stress hormones (such as epinephrine) that tax the heart and other major organs. Much research has shown that stress-related neuroendocrine and physiological mobilization suppresses immune system functioning, thereby decreasing resistance to infection and worsening recovery indicators such as wound healing (Kiecolt-Glaser et al. 1998; Kiecolt-Glaser et al. 1995). Behavioral effects of stress range from social withdrawal, verbal outbursts, and sleeplessness to a failure to take medications. Given these findings, the contention is justified that biophilic design should foster improved outcomes to the extent that the presence of nature and other biophilic elements in healthcare environments is effective in reducing stress.

BIOPHILIA THEORY: WHY NATURE SHOULD FOSTER RESTORATION FROM STRESS

The intuitive belief that contact with nature promotes psychological well-being and physical health dates back at least two thousand years and has appeared widely in Western and Asian cultures (Ulrich et al. 1991). Until recent years, many writers ascribed this belief to culture and individual learning, often asserting that societies inculcate their inhabitants to like nature but associate cities with stress (e.g., Tuan 1974). It can also be argued that people learn positive and restorative associations with nature through personal experiences such as vacations in rural environments, but acquire negative associations with cities because of work pressures, noise, crime, and other urban stressors.

These interpretations based on learning or culture fail to explain adequately, however, evidence from a large scientific literature showing that diverse cultures and socioeconomic groups show high similarity in responding positively to nature views (Ulrich 1993). Evolutionary theory more easily accounts for this widespread agreement by proposing that millions of years of evolution have left modern humans with a partly genetic predisposition for responding positively to nature (Appleton 1975; Orians 1986; Kaplan and Kaplan 1989; Ulrich 1983). In this vein Wilson's biophilia hypothesis (1984) holds that humans have a partly genetic tendency to pay attention to, affiliate with, and otherwise respond positively to nature. The notion that biophilia is represented in the human gene pool carries with it the proposition that certain types of positive responses were adaptive for early humans and increased fitness or chances for survival (Ulrich 1993).

Considerable evolutionary writing has discussed survival-related benefits of preferences or aesthetic liking for nature (Appleton 1975; Coss 2003). Orians and Heerwagen have convincingly argued that savanna-like views should be preferred by modern humans because savannas were superior during evolution to other habitats for providing primary necessities such as food, water, and security (Orians 1980, 1986; Heerwagen and Orians 1993). Apart from preferences, evolutionary theory is also important for explaining why certain types of nature views and content (vegetation, water, sunlight) should have stress-reducing and healthful influences.

Detailed conceptual arguments have been developed elsewhere as to why a capability for fast recovery from stress following a demanding episode was so vital for the survival of early humans as to favor the selection of individuals with a biologically prepared capacity for responding restoratively to many nature settings (Ulrich et al. 1991; Ulrich 1993). Daily living for premodern people was demanding and stressful, and involved encounters with threats or risks. Acquiring a partly genetic capability for faster recuperation from stress would have had several key advantages, including faster replenishment of energy expended in the physiological arousal and behavior involved in stress responding to threats ("flight-or-fight") and other challenging situations. Other health-related benefits should include rapid declines in stress-related negative emotions such as fear and anger, increases in positive feelings, and salutary changes in bodily systems indicative of lessened physiological and neuroendocrine mobilization (lower blood pressure, reduced levels of stress hormones, enhanced immune function). Physiological restoration should be expected to include prominent reduction of fatigue and deleterious autonomic/sympathetic nervous system activity, because sympathetic mobilization is centrally involved in stress responses for dealing with taxing situations and threats (Ulrich et al. 1991; Ulrich 1993, 1999). A testable hypothesis that follows from this evolutionary-functional reasoning is that restorative responses to nature should occur rapidly, usually within minutes—or even as fast as several seconds in certain bodily systems—rather than in several hours or days (Ulrich et al. 1991; Ulrich 1993). The theory also expressly contends that reductions in stress should directly and indirectly promote improved health outcomes, such as lessened pain and faster wound healing in connection with enhanced immune function (Parsons 1991; Ulrich 1991, 1999).

This restoration theory further holds that modern humans, as a genetic remnant of evolution, have a capacity for acquiring stress-reducing responses to certain nature settings and content (vegetation, water), but have no such disposition for most built or artifact-dominated environments and materials (concrete, glass, metal, plastic) (Ulrich 1993, 1999). Properties of nature settings that should be effective in producing restoration include security linked to spatial openness that fosters visual surveillance; sunshine or good light in contrast to poor light or threatening weather; and qualities linked with high habitability and food availability, including calm or slowly moving water, verdant vegetation, flowers, savanna-like or parklike properties (scattered trees, grassy understory), and unthreatening wildlife such as birds (Ulrich 1993, 1999; Ulrich and Gilpin 2003). These conceptual arguments have a practical implication, which is that designing healthcare buildings to incorporate nature features such as those listed can harness therapeutic responses and influences that are carryovers from evolution, resulting in more restorative and healing patient care settings.

Evolutionary theory is also useful for identifying specific types of nature features and configurations that should be *avoided* when designing healthcare environments to reduce stress and foster better outcomes (Ulrich and Gilpin 2003). It has been proposed elsewhere that people have a partly genetic disposition not only for biophilic or positive responses to nature features that were advantageous during evolution, but also for negative/avoidance responses to certain nature stimuli that signaled *threats or dangers* for early humans (Öhman 1986; Ulrich 1993; Coss 2003). These stressful and potentially dangerous stimuli included shadowy enclosed spaces, snakes and spiders, reptilian-like tessellated scale patterns, pointed or piercing forms, and angry and fearful human faces (Öhman 1986; Coss 2003; Ulrich 1993). Findings from scores of conditioning experiments, and behavior-genetic investigations and other research on human twins, leave no doubt that genetic factors play a major role in fear and stress responses to certain visual features such as snakes and angry faces (Ulrich 1993). The partly genetic underpinning of negative responses emphasizes the importance of excluding views or images of such phenomena from healthcare settings where stress is a problem (Ulrich and Gilpin 2003).

Theory: Daylight, Restoration, and Health

Another carryover of evolution is that modern humans are psychologically and biologically attuned to light and changing cycles of light and darkness. Daylight and sun exposure were critically important for the day-to-day well-being and survival of premodern people. In line with earlier conceptual arguments regarding nature scenes, it is proposed that positive responses to nature settings should be enhanced during good lighting or sunny conditions. Daylight and sunshine enabled visual surveillance of surroundings, finding food and water, locating and pursuing game, and avoiding threats such as predators that would be concealed in darkness. Clear or sunny conditions, compared to overcast conditions or dark clouds with thunder, signaled less short-term risk from adverse weather.

Further, human physiology evolved to require sun exposure for metabolism of vitamin D, which is vital for overall health. Vitamin D is important for the development of a healthy musculoskeletal system, preventing rickets and osteoporosis, maintaining muscle strength, and preventing chronic diseases such as type 1 diabetes and rheumatoid arthritis (Holick 2005). Also, daylight is the main environmental stimulus for regulating circadian or body clock rhythms that cycle approximately every 24 hours, and synchronize the sleep and awake cycle with night and day. Daylight exposure affects levels of the hormone melatonin, which influences levels of energy, alertness, and activity. When exposure to daylight or artificial light is inadequate, melatonin levels increase and cause drowsiness and depression. In sum, an evolutionary conceptual perspective predicts that well-lighted or sunny nature settings should be more effective than dark or overcast nature scenes in eliciting positive responses, improving emotional well-being, fostering restoration, and promoting health. The least effective scenes should be built or artifact-dominated spaces in shadow or overcast conditions.

RESEARCH: NATURE VIEWS AND RESTORATION

Consistent with the evolutionary restoration theory outlined above, several studies of nonpatient groups using prospective experimental designs indicate that even briefly viewing nature settings can produce substantial and rapid psychological and physiological restoration from stress (Ulrich 1979; Ulrich et al. 1991; Hartig et al. 1995; Parsons et al. 1998; Parsons and Hartig 2000; Hartig et al. 2003; Van den Berg et al. 2003). Restorative or stress-reducing effects of looking at nature are manifested as a constellation of beneficial changes that include reduced levels of negatively toned emotions (fear, anger), elevated positive emotions (pleasantness), and changes in physiological systems indicative of diminished stress mobilization or arousal (autonomic/sympathetic, electrocortical, neuroendocrine, musculoskeletal) (Ulrich et al. 1991). Studies in both laboratories and real environments have consistently found that viewing nature produces significant physiological restoration within three to five minutes at most, as evidenced, for example, in brain electrical activity, blood pressure, heart activity, and muscle tension (Ulrich 1983; Ulrich et al. 1991; Parsons et al. 1998; Hartig et al. 2003; Laumann et al. 2003). (See Figures 6-1 to 6-3.) Fredrickson and Levenson (1998) exposed participants to a fear-eliciting film, and reported that those persons assigned randomly to view a nature film (water) exhibited significant recovery from cardiovascular stress in only 20 seconds. These rapid and beneficial psychological and physiological changes can be accompanied by sustained yet nontaxing or nonvigilant attention and perceptual intake with respect to the nature setting, as indicated by heart rate deceleration and reduced autonomic/sympathetic nervous system activity (Ulrich et al. 1991; Laumann et al. 2003). Although most nature views are stress reducing, most built or urban settings lacking nature (streets, parking lots, building exteriors without nature, parking lots, windowless rooms) are unsuccessful in producing restoration, and in some instances worsen stress (Ulrich 1979; Van den Berg et al. 2003).

Research: Effects of Viewing Nature on Patient Stress

Survey research on bedridden hospital patients suggests that they assign high preference and importance to having a bedside window view of nature (Verderber 1986). A study of elderly in urban long-term care facilities has similarly found that residents attach considerable importance to having access to window views of outdoor

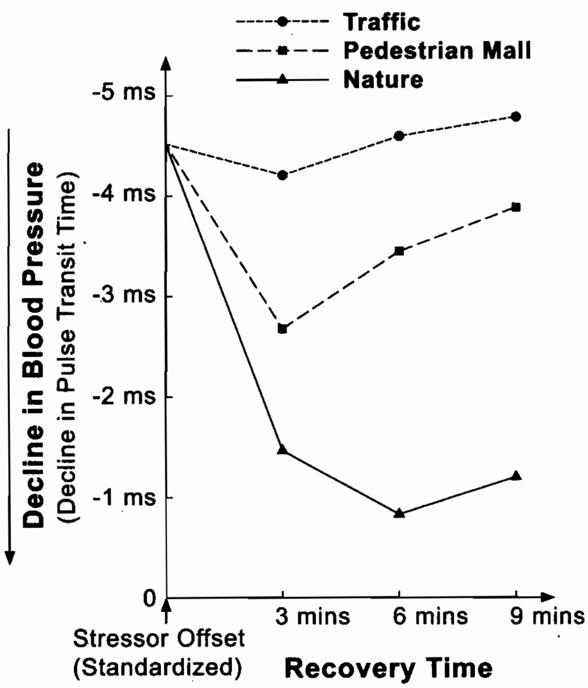

Figure 6-1: Systolic blood pressure (via pulse transit time) during recovery from stress in persons exposed to nature settings or urban settings lacking nature.

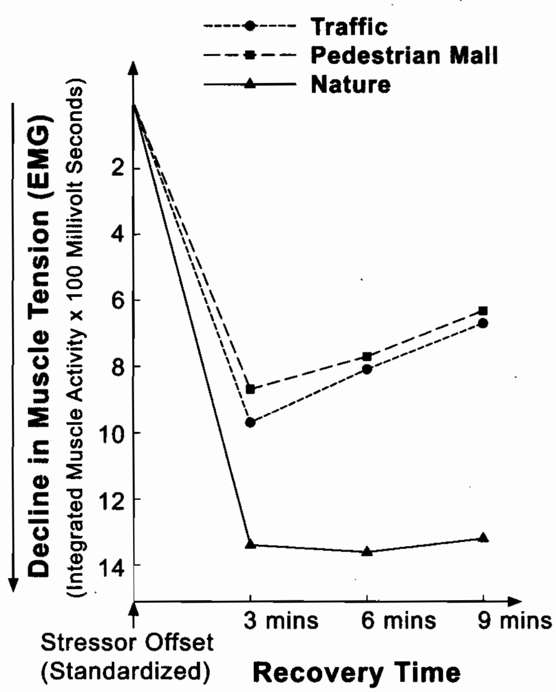

Figure 6-2: Muscle tension (forehead) during recovery from stress in persons exposed to nature settings or urban settings lacking nature.

spaces with prominent nature such as plants, gardens, and birds (Kearney and Winterbottom 2005). In the same study, long-term care elderly expressed dislike for window views of built content lacking nature, such as rooftops and building walls.

In view of the earlier discussion of restoration, it is worth emphasizing that a few studies in healthcare settings have found that visual exposure to nature can effectively lower stress. An early investigation by Katcher and his associates measured restoration from anxiety in patients waiting to undergo dental surgery in a room with or without an aquarium with fish (Katcher et al. 1984). They found that anxiety was lower on days when the aquarium was present, and scores for patient compliance during surgery were higher. A study by Heerwagen (1990) suggested that patients in a dental clinic were less stressed on days when a large nature mural was hung in the waiting room, in contrast to days when there was no nature scene. A prospective randomized experiment focusing on stressed blood donors found that participants had lower blood pressure and pulse rates when a wall-mounted television displayed a nature videotape, compared to when the television showed either an urban videotape or daytime television programs such as game or talk shows (Ulrich et al. 2003). A quasi-experimental study of patients with dementia, including Alzheimer's disease, suggested that adding large color nature pictures and recorded nature sounds (birds, brook) to a shower room lessened stress and cut incidents of agitated aggressive behavior such as hitting, kicking, and biting (Whall et al. 1997). (See Figure 6-4.)

A growing body of research suggests that visual exposure to nature not only reduces patient stress but also improves other important outcomes such as pain. Before reviewing these studies, it is useful to digress briefly and examine theory relevant to understanding why nature exposure could be expected to decrease pain.

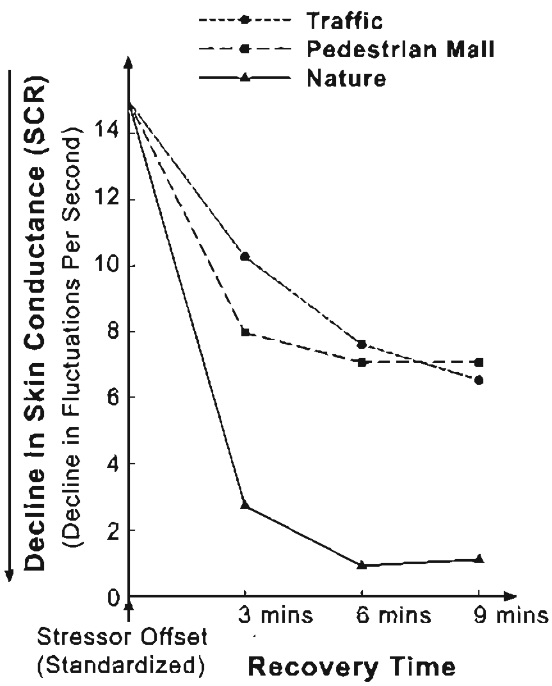

Figure 6-3: Changes in skin conductance (SCR) during recovery from stress in persons exposed to nature settings or urban settings lacking nature. Skin conductance activity is controlled by the autonomic nervous system. Greater decline of autonomic activity indicates larger reduction in physiological stress mobilization.

Figure 6-4: Waiting area to calm stressed patients and family. Doernbecher Children's Hospital, Portland, Oregon.

BIOPHILIA THEORY: WHY NATURE EXPOSURE SHOULD REDUCE PAIN

It is reasonable to propose that nature exposure should mitigate pain in patients through different mechanisms, including stress reduction and distraction. The most influential model in medicine and health psychology for explaining pain is *gate control* theory (Melzack and Wall 1965, 1982). According to this theory, neural structures or mechanisms in the spinal cord act as a gate in the transmission of sensory input or pain impulses through the spinal cord to the brain. When the gate is open, impulses flow to the brain and pain is experienced. When the gate is closed, pain impulses are inhibited from reaching the brain and pain is diminished or not felt. A key premise of gate control theory is that the gate can be closed by messages that descend from the brain and are influenced by psychological or emotional factors (Melzack and Wall 1965, 1982). Negative emotions such as anxiety and depression, and focusing on an injury, can open the gate and thereby increase pain. Positive feelings such as relaxation, or distracting the patient's focus away from an injury, close the gate and thus reduce pain.

Studies were reviewed earlier indicating that viewing nature reliably produces restoration from stress, as manifested by declines in negative emotions such as anxiety, enhanced positive feelings, and physiological changes indicative of diminished stress mobilization. These positive changes, according to gate control theory, should close the gate and inhibit pain impulses from reaching the brain, thereby alleviating pain. Furthermore, restorative psychological and physiological effects of viewing nature can be accompanied by sustained yet nontaxing attention and perceptual intake that should reduce pain via distraction. To the extent a nature view holds the patient's focus and attention, and diverts their focus away from pain, gate control theory predicts that nature distraction will tend to close the gate and reduce pain. Accordingly, gate control theory suggests that a nature view can close the gate and alleviate pain by distracting the patient, reducing stress, and increasing positive emotions.

In addition to gate control theory, another prominent pain perspective, *distraction* theory, offers a rather different explanation for pain-reducing effects of viewing nature (Ulrich et al. 2006). Distraction is defined as concentrating on aspects of the environment that are outside oneself (Brewer and Karoly 1989). According to distraction theory, persons have a limited amount of available conscious attention (McCaul and Malott 1984). Pain requires considerable conscious attention and draws upon much of the limited amount available. Distraction theory proposes that as the amount of conscious attention directed to pain increases, the intensity of experienced pain will correspondingly rise (Brewer and Karoly 1989). However, if patients become engrossed in an external pleasant distraction such as a nature scene, they will have less conscious attention to direct to their bodily sensations of pain, and experienced pain therefore will diminish. The theory explicitly predicts that the more engrossing and diverting a distraction, the greater the pain reduction (McCaul and Malott 1984). Traditional distraction theory implies that both emotionally positive and negative distractions, if highly engrossing, should be effective in alleviating pain. However, findings from one strong study suggest that emotionally pleasant picture distractions are more effective than unpleasant visual stimuli in increasing tolerance for pain (Wied and Verbaten 2001). This implies that many nature views may be effective in reducing pain because they are emotionally pleasant distractions as well as capable of eliciting sustained attention and perceptual intake.

Research Findings: Effects of Nature Exposure on Pain

Several studies using experimental or quasi-experimental designs have shown convincingly that nature distraction can produce substantial and clinically important alleviation of pain. A study of patients recovering from abdominal surgery found that those assigned to rooms with a bedside view of nature (trees) had better postoperative recovery courses than matched patients assigned to identical rooms with windows overlooking a brick building wall (Ulrich 1984). Patients with the nature window view, compared to those with the wall view, suffered significantly less pain, as indicated by needing far fewer doses of strong narcotic pain medications than their matched counterparts with the wall view. Furthermore, the nature view patients had shorter postsurgery stays, better emotional well-being, and fewer minor complications such as persistent nausea or headache (Ulrich 1984). (See Figures 6-5 to 6-7.)

In another study (Ulrich et al. 1993) patients who had undergone heart surgery were assigned to view color photos mounted directly in their line of vision. Patients shown a picture of a spatially open, well-lighted view of trees and water required fewer doses of strong pain drugs and suffered less anxiety than groups exposed to abstract images or patients assigned to a control group with no picture (Ulrich et al. 1993). A picture of a spatially enclosed and shadowy forest setting, however, did not significantly lessen pain or anxiety. In the same study, patients assigned an abstract picture with straight-edged or rectilinear forms had worse outcomes than the control group with no pictures. A well-controlled experiment in a hospital by Tse and colleagues found that volunteers had much greater pain tolerance and a higher threshold for detecting pain

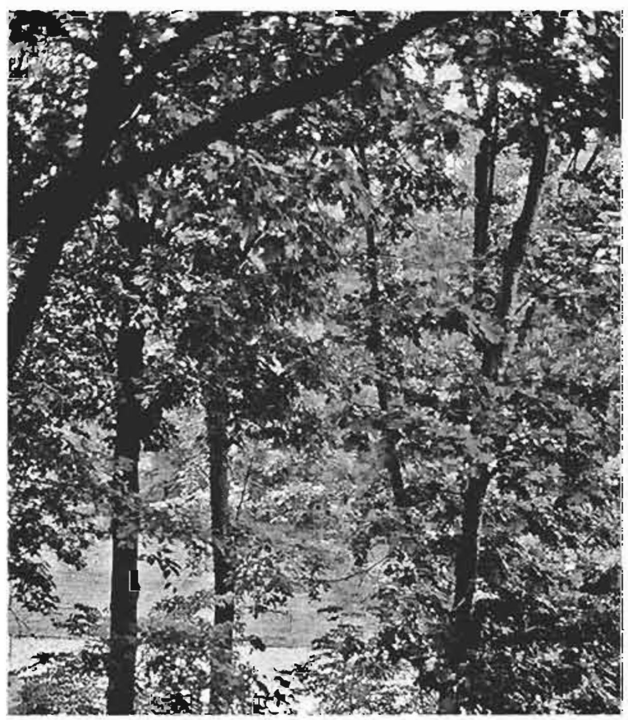

Figure 6-5: Hospital window view of trees.

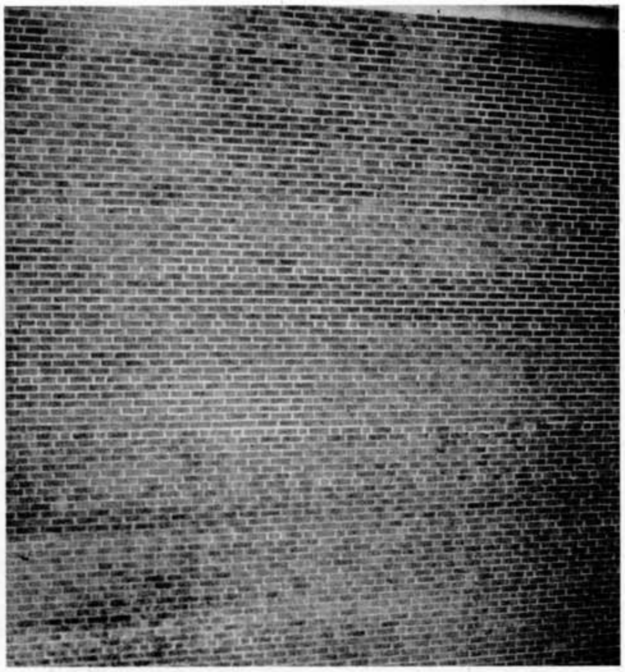

Figure 6-6: Hospital window view of brick wall.

when assigned to view a nature videotape on an eyeglass display (waterfall, mountains, landscapes) in contrast to looking at a blank display (Tse et al. 2002).

As noted, distraction and gate control theory predict that the more engrossing a nature distraction, the greater the pain alleviation. This implies that nature exposures may tend to be more diverting and hence pain reducing if they involve sound as well as visual stimulation, and are high in realism and "immersion" (Wismeijer and Vingerhoets 2005). A study of burn patients suffering acute pain showed that distracting patients during burn dressings with a bedside television screen displaying nature scenes (forest, flowers, waterfalls, ocean, wildlife) accompanied by music lessened both pain and anxiety/stress (Miller et al. 1992). A randomized prospective trial of patients undergoing painful bronchoscopy found that compared to a control group who looked at a blank ceiling during the procedure, pain was lower when patients were assigned to look at a ceiling-mounted nature scene and listen to sounds recorded at the nature setting (moving water, birds, breezes through wildflowers and grass) (Diette et al. 2003).

Lee and colleagues carried out a randomized controlled trial of the effects of nature distraction on pain and patient-controlled sedation during colonoscopy (Lee et al. 2004). They reported that visual distraction alone lowered pain but did not reduce intake of sedative medication during colonoscopy. However, a more engrossing combination of visual and audio distraction (nature scenery with classical music) significantly lowered both pain and self-administered sedation during colonoscopy, a finding consistent with the predictions of distraction and gate control theory (Lee et al. 2004). Kozarek and colleagues (1997) investigated the effects of seeing and listening to a travelogue with nature scenes on patients undergoing unpleasant gastric laboratory procedures. Patient reports and nurse observations were in accord in suggesting that the audiovisual distraction improved comfort and tolerance for the procedures, compared to when the patients previously had the procedures without distraction (Kozarek et al. 1997).

It is evident from this review that the majority of pain studies to date have simulated nature using equipment such as television screens, eyeglass displays, or virtual reality, rather than exposing patients to real nature, for instance, a garden or window view of trees. One reason is that simulations make it easier to carry out

	Number of Pain Drug Doses (days 2-5 after surgery)	
Analgesic Strength	**Nature** View Patients	**Wall** View Patients
Strong	0.96	2.48
Moderate	1.74	3.65
Weak	5.39	2.57

after Ulrich, 1984

Figure 6-7: Pain drug intake of patients with window view of nature versus brick wall. Examples in the strong analgesic category were potent narcotics administered by injection. The weak category consisted of oral doses of drugs such as acetaminophen.

prospective randomized clinical trials that achieve the rigor required in medical research. Also, there are certain highly stressful medical settings where it is not feasible to provide visual contact with real nature even through windows, such as an underground shielded room for radiation therapy or the tight confines of an MRI scanner, and simulations may be the only viable option for exposing patients to nature. These exceptions notwithstanding, creative evidence-based designers have demonstrated in many healthcare projects that window views of gardens and other real nature can be successfully provided for challenging and restrictive medical environments, for instance, treatment spaces where measures such as pressurized air, HEPA filtration, and sealed windows are needed to protect immunocompromised and other acutely vulnerable patients from infection.

There is a clear need for controlled experimental studies to evaluate the extent to which real nature environments may outperform simulations in reducing pain and stress. Do simulations, compared to real nature settings, lose much of their effectiveness in distracting and calming patients during longer hospital stays? It seems likely that over long-term healthcare exposures, real nature should be more effective than simulations in sustaining distraction and positive responding owing to greater authenticity, immersiveness, and the multisensory stimulation and ongoing visual change inherent in real nature settings (Ulrich 1993). It is important that additional rigorous research be conducted to clarify how integrating nature into healthcare buildings is medically beneficial and cost-effective compared to conventional design approaches that tend to omit nature, so that administrators are equipped to make well-informed decisions benefiting their patients, staff, and budgets.

NATURE ART IN HEALTHCARE SETTINGS

There has been considerable research on people's responses to art, but most has examined the art preference of nonpatient adults, rather than art's effects on patient stress, recovery, pain, or other outcomes. Although the relationship between preference responses and restoration effects is not well understood, preference studies are nonetheless useful for identifying types of art that are most liked by patients, family members, and staff in healthcare facilities (Ulrich and Gilpin 2003). Limited research using path analysis suggests that emotional components of restoration drive or strongly influence preferences, raising the possibility that art preferences are linked to and reflect restorative responses (Van den Berg et al. 2003).

Studies have shown that the vast majority of adults across different cultures prefer nature over other art subject matter (Wypijewski 1997; Kettlewell 1988; Winston and Cupchik 1992). Adults internationally also reflect strong similarity in *disliking* abstract art (Wypijewski 1997). A few studies of patient art preferences have produced results that closely parallel those for the nonpatient public (Ulrich and Gilpin 2003). Carpman and Grant (1993) studied 300 randomly selected hospital inpatients and found they overwhelmingly preferred realistic nature art and disliked abstract images. Hathorn and Ulrich surveyed small samples of black and white Americans in a large urban hospital to determine their preferences for a highly varied collection of several hundred art images. Consistent with the prediction from evolutionary theory that nature scenes should be liked across different groups, both blacks and whites accorded high preference to paintings of nature landscapes, and judged nature as the most appropriate subject matter for art in patient rooms (Ulrich and Gilpin 2003). Blacks and whites were also similar in especially liking nature paintings depicting spatially open settings in sunny or well-lighted conditions, with green vegetation and water features. Art depicting gardens with flowers also received consistently high preference scores (Ulrich and Gilpin 2003). A study of adults in a Scandinavian mental health facility found that patients reported positive emotional responses to nature paintings and prints, but consistently evidenced negative, stressful reactions to abstract artworks in which the content was ambiguous and disordered (Ulrich 1991).

A recent study by Eisen (2006) is among the first to investigate scientifically the art preferences of schoolchildren and hospitalized pediatric patients. The research compared the art preferences of children across four different age groups: 5–7, 8–10, 11–13, and 14–17. Findings suggested that across all age groups and both genders, the great majority of schoolchildren (n=129) and hospitalized pediatric patients (n=79) were similar in preferring nature art over abstract arrays that varied in complexity, color brightness, and presence versus absence of a cartoonlike image. In the case of the schoolchildren, for example, a total of nearly 75 percent accorded highest preference either to a representational nature artwork (forest with lake and deer) or an impressionistic nature scene (beach with waves) (Eisen 2006). These findings are broadly consistent with biophilia or evolutionary theory, but run counter to traditional intuition-based design guidelines that often recommend abstract or cartoonlike images for healthcare spaces for children.

GARDENS IN HEALTHCARE FACILITIES

Evidence from a few studies suggests that well-designed gardens can be efficacious settings in healthcare facilities for fostering restoration among stressed patients, family, and staff (Ulrich 1999; Marcus and Barnes 1999). Gardens not only provide restorative and pleasant nature views, but can also reduce stress and improve outcomes through other established mechanisms, such as fostering access to privacy and social support, creating opportunities for restorative escape (and control) with respect to stressful clinical environments, and providing settings that enable physically active pursuits in pleasant nature surroundings ranging from active play to physical rehabilitation (Ulrich 1999; Marcus and Barnes 1995; Whitehouse et al. 2001; Hartig and Marcus 2006). If viewing a garden produces restoration and improved mood in patients, they may be more likely to engage in other healthy and stress-reducing activities such as walking in the garden or talking with a friend (Ulrich 1999). The assumption that pleasant gardens help to motivate patients to engage in physical activity, as well as alleviate their emotional stress, has led some hospitals to design rehabilitation gardens that enable physiotherapists to treat specific categories of patients, such as those recovering from stroke, fractures, and burns. Notable examples of such gardens include those at Legacy Health in Portland, Oregon, and the Rusk Institute of Rehabilitation Medicine in New York City. (See Figure 6-8.)

Marcus and Barnes (1995) used a combination of behavioral observation and interview methods in postoccupancy studies of four hospital gardens in California. Their findings suggested that recovery from stress was the most important category of benefits realized by nearly all users of the gardens. Similarly, a postoccupancy evaluation of a garden in a children's hospital identified restoration from stress and improved emotional well-being as the primary benefits for users (Whitehouse et al. 2001). This finding was supported by convergent evidence from observation of users, interviews with on-site users, and a hospital-wide questionnaire survey of staff and patients' parents. Another investigation of three gardens in a pediatric cancer center found that emotional stress was lower for all types of users when they were in the gardens rather than inside

Figure 6-8: Children's Garden at Legacy Good Samaritan Hospital, Portland, Oregon. The garden was designed to be restorative and promote improvements in specific health outcomes for pediatric patients and their families. The participatory design process involved nurses and physicians, a landscape architect, horticultural therapists, and artists. The garden provides a variety of spaces and features to support active play by children in addition to restorative sedentary activities (viewing nature, socializing) by adult family and staff. Other spaces support rehabilitation activities such as horticultural therapy. The design creates easy access to shade, as the medical conditions and treatments of some patients make them negatively sensitive to direct sun exposure.

the hospital (Sherman et al. 2005). A recurring finding across these studies is that adult garden users, including family and staff, engage mostly in sedentary activities such as passive relaxation, socializing, and eating. By contrast, children interact actively with garden features much more than adults (Sherman et al. 2005). The research implies that designers can create healthcare gardens that benefit both adults and children by providing a variety of spaces, ranging from active play features and spaces for children to calm refuges for adults. Concerning the latter, restorative refuges, the limited research suggests that gardens will tend to mitigate stress effectively for adult users when spaces contain verdant foliage, flowers, water, grassy spaces with trees or large shrubs and a modicum of spatial openness, compatible pleasant nature sounds (birds, breezes, water), and comfortable movable seating (Ulrich et al. 2006; Ulrich 1999; Marcus and Barnes 1995, 1999; Rodiek 2005).

Broadly similar findings have emerged from research on gardens and other outdoor spaces in assisted living facilities for elderly residents. Based on studies of fourteen assisted living facilities, Rodiek (2005) reported that elderly residents preferred outdoor spaces with abundant greenery, flowers, birds, water features, and fresh air. In contrast to these positive characteristics, research on hospital gardens suggests that the following environmental qualities can elicit negative responses in patients and other users, and may hinder restoration or even worsen stress: predominance of hardscape rather than nature (concrete, for example); intrusive urban or mechanical sounds (such as traffic or an air-conditioning compressor); crowding; and ambiguous or abstract art and design features that are readily interpreted in multiple ways and may elicit negative reactions in some stressed patients (Ulrich 1991, 1999; Ulrich and Gilpin 2003).

Other research suggests that gardens can also be important for reducing stress in healthcare workers and increasing job satisfaction (Marcus and Barnes 1995; Whitehouse et al. 2001; Sherman et al. 2005). Although staff research is limited, the findings are noteworthy in light of the serious and widespread problems in healthcare of mounting work demands and pressures, high staff stress, low job satisfaction, and high turnover. Findings from other research on stressed employees in non-healthcare workplaces appear relevant to healthcare workers such as nurses and physicians. A study of European white-collar and blue-collar employees in different non-health work settings found that window views of nature buffered job stress and enhanced health-related well-being (Leather et al. 1998). Research by Kaplan (1993) found that office workers with a window view of nature reported lower frustration and higher life satisfaction and overall health.

EFFECTS OF DAYLIGHT EXPOSURE IN HEALTHCARE FACILITIES

As mentioned in an earlier theory section, daylight and sun exposure were vital for the well-being, health and survival of early humans. As a legacy of evolution, modern humans are psychologically and physiologically attuned to full-spectrum light and changing cycles of light and darkness. Consistent with evolutionary arguments, studies across a variety of environments (hospitals and workplaces) suggest patients and other groups accord even higher preference and importance to a nature window view when the outdoor setting is illuminated by clear light conditions or sunlight rather than shade (Verderber 1986; Leather et al. 1998; Ulrich et al. 2006). In healthcare facilities, evolutionary carryover arguably is also evident in beneficial effects of daylight and sun exposure on patient and staff outcomes, including facilitation of critical chemical reactions within the body, influences on circadian or body clock rhythms, and positive effects on emotional well-being and pain (Boyce et al. 2003; Joseph 2006; Ulrich et al. 2006).

A well-documented effect of daylight in healthcare facilities is preventing jaundice in newborns by fostering excretion of bilirubin. The potentially harmful impact of depriving infants in hospitals of light is evident in research showing that incidence of jaundice increases when windows in maternity units are covered or shaded and no full-spectrum artificial light exposure is provided (Barss and Comfort 1985; Giunta and Rath 1969). Also, light radiation absorbed through the skin stimulates other beneficial chemical reactions such as metabolism of vitamin D, which is important for preventing osteoporosis and certain chronic diseases in groups such as elderly in long-term care facilities (Holick 2005). Additionally, research on residents in Alzheimer's disease care units has linked facilities designed for higher light exposure with lower patient agitation levels (Sloane et al. 1998). This finding is reinforced by results from a prospective study of dementia patients showing that two 10-day periods of exposure to bright morning light reduced agitation (Lovell et al. 1995). The same patients became significantly more agitated on nontreatment days.

As previously noted, exposure to daylight is important for regulating circadian or body clock rhythms, and synchronizing the sleep and awake cycle. Limited research suggests that exposure to higher levels of daylight or white artificial light may improve sleep in community-dwelling older adults and persons in dementia facilities (Van Someren et al. 1997). At least three studies of preterm infants have found that exposure to daylight and night, or cycled artificial light, improves sleep and weight gain (Mann et al. 1986; Blackburn and Patteson 1991; Miller et al. 1995). For day-shift healthcare staff, morning daylight exposure is the primary environmental stimulus for entraining or regulating circadian rhythms, thereby fostering daytime alertness, cognitive performance, and nighttime sleep quality (Rea 2004). The key role of daylight for regulating body clock rhythms implies the importance of providing windows in healthcare workspaces and break areas for nurses and other staff. Tinted windows that attenuate daylight exposure for staff, however, may hinder circadian entrainment and erode alertness and sleep quality (Rea 2004). A study of staff in a Turkish hospital suggested that nurses who were exposed to daylight for three or more hours a day experienced less work stress and had higher job satisfaction (Alimoglu and Donmez 2005).

Research: Effects of Daylight on Depression and Pain

Findings from several rigorous studies indicate that exposure to light—daylight or bright artificial light—is effective in reducing depression and improving mood, even for patients hospitalized with severe depression. The mechanisms of action of light treatment on depression are partly but not fully understood. Light falling on the retina influences activity of the pineal gland and by this pathway suppresses or delays secretion of melatonin, thereby reducing depression, increasing daytime alertness, and fostering sleep quality (Martiny 2004).

A meta-analysis of randomized controlled studies published in the *American Journal of Psychiatry* concluded that light treatment for nonseasonal and seasonal depression is "efficacious, with effect sizes equivalent to those in most antidepressant pharmacotherapy trials" (Golden et al. 2005, 656). Compared to antidepressant drugs, light exposure offers the advantage of being faster acting. In this regard, several studies have found that light can significantly alleviate depression after approximately two weeks of treatment, while antidepressant drugs have a delayed onset of at least four to six weeks. Some studies suggest that exposure to morning light is more effective than afternoon or evening light, although light exposure occurring in the middle of the day or afternoon also significantly reduces depression (Martiny, 2004).

Although artificial light is often used to treat depression, a few studies suggest that architectural design and siting decisions for healthcare facilities can affect depression levels and other outcomes by influencing the amount of daylight exposure patients receive. Beauchemin and Hays (1996) reported that adult patients hospitalized for severe depression in a Canadian hospital had substantially shorter stays if they were assigned to sunny rooms rather than rooms that were always in shade. Similarly, a study in an Italian facility found that adult patients hospitalized for bipolar depression stayed an average of 3.7 days less if they were assigned east-facing rooms exposed to bright morning light, compared to similar patients in west-facing rooms with less sunlight (Benedetti et al. 2001). Apart from mental health patients, depression is a serious problem across several other categories of patients, such as those with cardiovascular disease and cancer. A retrospective study of myocardial infarction patients in an intensive care unit in a Canadian hospital suggested that female patients had shorter stays if their rooms had sunny versus shaded or dim window exposures (Beauchemin and Hays 1998). In the same study, mortality in both sexes was lower in sunny rooms than in north-facing shaded rooms.

In addition to reducing depression and shortening length of stay, there is some evidence that higher daylight exposure alleviates pain. The presumed mechanism for pain reduction is that higher sunlight exposure influences levels of serotonin, a neurotransmitter known to inhibit pain pathways. Walch and colleagues (2005) carried out a strong prospective study focusing on patients undergoing lumbar spinal or cervical surgeries who were admitted postoperatively to rooms either on the bright or shaded side of an inpatient surgical ward. Patients in the bright rooms, compared to those in the more shaded rooms, were exposed on average to 46 percent higher sunlight intensity. Findings indicated that patients in rooms with more sunlight reported less pain and stress, took 22 percent less analgesic medication and had 21 percent lower medication costs. It should be mentioned that the shaded patient rooms—and heightened pain—resulted from construction of a new building 25 meters away that blocked sunlight on one side of the older building with surgical wards. This episode underscores for architects and healthcare administrators the importance of paying close attention to building orientation in new projects, and avoiding site plans where some buildings block light from others (Ulrich et al. 2006). (See Figure 6-9.)

Figure 6-9: Hospital rooftop garden at Legacy Health, Salmon Creek, Washington. The garden enables users to be exposed to sun and engage in sedentary restorative activities such as viewing distant hills and forests. A meditation room juts into the garden (right center). The garden provides restorative garden window views for bedridden patients, and the berm prevents persons in the garden from looking into patient rooms and violating privacy (patient rooms are out of picture to right).

SUMMARY AND DESIGN IMPLICATIONS

The chapter discusses evolutionary or biophilia theory proposing that exposure to nature and sunlight in healthcare settings should reduce stress, lessen pain, and foster improvements in other health outcomes. The conceptual arguments have a practical implication, which is that designing healthcare environments to incorporate nature and daylight can harness therapeutic influences that are carryovers from evolution, resulting in more restorative and healing settings for patients, family, and staff.

The theory contends that a capability for fast recovery from stress following demanding episodes was so critical for enhancing survival chances of early humans as to favor individuals with a partly genetic predisposition for restorative responding to many nature settings. Such stress reduction should directly and indirectly promote improvements in other health outcomes, such as enhanced immune function and reduced pain. Regarding pain, evolutionary theory is integrated with gate control and distraction theory from medicine to explain why nature exposure can be expected to alleviate pain in patients. The evolutionary framework holds that modern humans, as a genetic remnant of evolution, have a capacity for readily acquiring restorative and other healthful responses to certain nature scenes and content (vegetation, water), but have no such predisposition for most built or artifact-dominated environments and materials (concrete, glass, metal, for example).

In addition to nature, daylight and sun exposure also were critical for the well-being, health, and survival of early humans. As a legacy of this importance, modern humans are psychologically and biologically attuned to sunlight and changing cycles of light and darkness. The evolutionary framework predicts that exposure to sunny or well-lighted nature in healthcare buildings should be more effective than dark or overcast nature scenes in fostering restoration, improving emotional well-being, and promoting health. The least effective physical settings should be built or artifact-dominated spaces that lack nature and have overcast or dim light conditions.

In accord with the conceptual position regarding nature, empirical studies of nonpatient groups using prospective experimental designs have shown that even briefly viewing nature can produce rapid and substantial psychological and physiological recovery from stress. Rigorous studies in laboratories and real environments have reliably found that viewing nature produces significant physiological restoration within a few minutes. Limited research in healthcare settings has similarly found that viewing nature fosters restoration in stressed patients. Importantly, several well-controlled prospective investigations of patients have shown convincingly that nature distraction can produce substantial and clinically important pain reduction.

Findings from a few studies suggest that well-designed gardens in healthcare facilities can be efficacious restorative settings for stressed patients, family and staff. Limited research suggests the possibility that well-designed gardens are important for reducing stress and increasing job satisfaction in nurses and other healthcare workers. Regarding art, empirical studies have shown that adults across cultures prefer nature over other art subject matter, a finding broadly consistent with biophilia or evolutionary theory. Recent research on art preferences of children across different age groups suggests the great majority of hospitalized pediatric patients and nonpatient schoolchildren likewise prefer nature art.

A growing amount of research has shown that daylight or sun exposure in healthcare settings has beneficial influences on patient and staff. Daylight stimulates metabolism of vitamin D, and plays a central role in regulating body clock rhythms and synchronizing sleep and awake cycles. Exposure to daylight and night, or cycled artificial light, improves sleep and weight gain in preterm infants and appears to reduce agitation and improve sleep in persons with Alzheimer's disease. For day-shift healthcare staff, morning daylight helps regulate circadian rhythms, and thereby may foster daytime alertness, better cognitive performance, and improved nighttime sleep. Higher daylight exposure levels in healthcare buildings may lessen work stress and increase job satisfaction among nurses.

Several well-controlled studies of patients have produced strong evidence that exposure to light—bright artificial light or daylight—is effective in reducing depression and improving mood, even in persons suffering severe depression. A few investigations suggest that architectural design and siting decisions for healthcare buildings, by influencing the amount of daylight exposure patients receive, can impact depression levels and outcomes such as length of stay and pain. Concerning the last, pain, a strong study found that surgical patients assigned to bright rooms, compared to those with rooms in shade, reported less pain and required fewer analgesic medications.

The priority and resources accorded to biophilic healthcare design will be heavily influenced by the extent to which rigorous research demonstrates that biophilic measures improve outcomes and are cost-effective. Although the amount of biophilia/health research is steadily increasing, and several sound studies already are available on issues such as reduction of stress, pain and depression, there is a clear need for additional research to address gaps in knowledge. Rigorous prospective investigations are needed to deepen understanding of such topics as the effectiveness of daylight exposure and real nature views in alleviating pain across diverse categories of patients, the impacts of physically active and passive garden experiences on outcomes, and the extent to which real nature environments may outperform simulations in fostering gains in clinical outcomes. A priority need is for research to develop the business or financial case for biophilic healthcare design. Optimism seems warranted for pursuing this key direction, as some credible research already implies that by designing hospitals to provide nature views and daylight exposure, substantial cost savings can be achieved because, for instance, intake of costly pain drugs is reduced, and stays are shortened for some categories of patients (Berry et al. 2004).

Implications for Evidence-Based Biophilic Design of Healthcare Buildings

Despite the research needs just noted, there is now enough sound evidence available to support the following biophilic design recommendations for healthcare environments:

- Architectural siting and design should provide restorative window views of nature and gardens from patient rooms, waiting areas, staff work spaces, and other interior areas where stress is a problem. Patient rooms and windows should be designed to make it possible for bedridden persons to view outdoor nature. Affording nature window views in treatment and procedure spaces where stress and pain are problems warrants high priority.
- Provide nature views with characteristics identified by research as effective in alleviating stress and improving outcomes, including green foliage, flowers, water, savanna-like or parklike characteristics (trees with grassy understory, some visual depth), unthreatening wildlife such as birds, and sunshine or good light in contrast to dim light or shadow. Avoid window views of outdoor spaces with the following properties, which can hinder restoration or even aggravate stress in some patients: spaces dominated by hardscape or starkly built content (such as concrete); roof tops and parking lots lacking vegetation; walls of other buildings; and abstract or ambiguous sculpture that can be interpreted in multiple ways by stressed patients (Ulrich 1999).
- The evidence linking higher daylight or sun exposure to reduced patient depression, pain, and other improved outcomes underscores the importance of giving careful consideration to healthcare building orientation and site planning in new healthcare projects (Ulrich et al. 2006). Avoid site plans where some buildings block light from others. Hospitals and mental health facilities should be sited and designed to ensure that depressed patients have abundant natural light.
- Avoid deep plan building layouts and floor plans—with a large proportion of windowless rooms—as these may tend to worsen patient and staff outcomes. Also, hospitals should not be designed with patient windows looking out into an enclosed and roofed atrium with few skylights and little natural light, as this architectural approach virtually eliminates natural light exposure in patient rooms. Atrium-facing patient rooms can have the additional drawback of requiring that patient windows be heavily tinted to prevent persons in the atrium from looking into rooms and violating privacy—a possible infringement of federal patient privacy regulations.
- Larger windows should be provided to permit more exposure to daylight and restorative nature views in patient rooms and other spaces where depression, pain, and stress are problems. Avoid designs, however, that create sun glare patches. Biophilic considerations favor patient rooms designed with the bathroom located on the hallway or headwall sides, rather than the window or outboard wall, to facilitate larger exterior windows, greater daylight exposure, and better visual access to nature or gardens for bedridden patients.
- Provide well-designed outdoor gardens for patients, family, and staff. Evidence-based design characteristics for successful healthcare gardens include prominent real nature content (such as verdant vegetation, water); convenient way-finding to the garden; accessibility; movable seating that facilitates social interaction; access to privacy; congruent nature sounds (birds, water, breezes) rather than intrusive urban or machine sounds (traffic, air-conditioning compressors); and opportunities for physical activity, movement, or exercise (Marcus and Barnes 1995; Ulrich 1999). Gardens should provide users with easy access to shade, as some patients' medical conditions or treatments make them negatively sensitive to direct sun exposure. Garden spaces intended for adult family members and staff should support restorative sedentary activities such as viewing nature and socializing. In the case of gardens for children, it is important to include active play features and spaces in addition to calm refuges for adults. In large healthcare facilities, provide a number of decentralized gardens located conve-

niently close to patient care units, waiting areas, and staff work spaces, to increase garden usage and benefits.

- It is recommended that visual art (paintings, prints, and photographs) displayed in patient rooms and other healthcare spaces where stress and pain are problems give priority to representational nature subject matter with unambiguously positive content. Designers should consult the evidence-based guidelines for selecting healthcare art used by several hospitals and university medical centers (Ulrich 1991; Ulrich and Gilpin 2003). The following are examples of subject matter categories recommended by these guidelines: waterscapes with calm or nonturbulent water; landscapes with visual depth or openness in the immediate foreground; nature settings depicted during warmer seasons when vegetation is verdant and flowers are visible; scenes with positive cultural artifacts such as barns and older houses in nature surroundings; garden scenes; people at leisure in places with prominent nature; and outdoor scenes in sunny conditions, not overcast or foreboding weather (Ulrich and Gilpin 2003, 134–136). Designers and healthcare administrators should avoid abstract, emotionally negative, or surreal artwork, as it can aggravate stress in some patients.
- Consider providing technology to enable patients to experience simulated nature (television screens, eyeglass displays, virtual reality) in highly stressful medical settings where it is not feasible to provide visual contact with real nature, including shielded rooms for radiation therapy, imaging, or procedures such as cardiac catheterization. Nature simulations that involve both visual stimulation and sound may tend to be more engrossing and hence more effective for alleviating severe pain.

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