

## Healing Spaces: Elements of Environmental Design That Make an Impact on Health

MARC SCHWEITZER, M.Arch.,<sup>1</sup> LAURA GILPIN, M.F.A., R.N.,<sup>2</sup> and SUSAN FRAMPTON, Ph.D.<sup>3</sup>

### ABSTRACT

The “ambiance” of a space has an effect on people using the space. In recent years, design for health care environments has begun to include esthetic enhancements in an attempt to reduce stress and anxiety, increase patient satisfaction, and promote health and healing. In this paper, the authors survey the existing research on those elements of the built and natural environment most often asserted by proponents as being inherently healing or promoting health. We postulate a hierarchy of effect of environmental elements ranging from simply nontoxic to safe (both physically and psychologically) to “providing a positive context” to being actively salutogenic. Most relevant research has been concentrated on a limited number of settings and is inadequate to inform the creation of design guidelines for the physical elements of an optimal healing environment. Opportunities exist to make meaningful contributions in this area that are likely to make a significant impact on health outcomes of human beings.

### INTRODUCTION

Since the beginning of humankind, it is likely that people have been seeking safe shelter in which to heal. When little could be done to treat the physical causes of illness or injury, a safe, supportive environment where natural or supernatural forces could aid the recuperative process to help the patient heal was vital. Now we can design, build, and adapt healing spaces and measure their restorative effects. But we must first understand the elements of a space or environment most likely to optimize physical, mental, emotional, and spiritual healing for the individual needs of patients from a variety of backgrounds and cultures and with vastly different beliefs and attitudes about illness and health.

The positive effects of space and the environment were well known in the era before science. For many centuries in ancient Greece, temples to the God Asklepios, such as the one at Epidaurus, were designed to surround patients with nature, music, and art, to restore harmony and promote healing in the absence of other treatment modalities.<sup>1</sup> In the nine-

teenth century, Florence Nightingale recognized the negative effects of hospitals by observing differences in survival rates at various facilities. She attributed this difference to the hospitals’ design and construction, particularly regarding crowding, light, and ventilation.<sup>2</sup>

While physicians are taught the principle of “first do no harm,” schools of architecture rarely educate students in elements of design that promote or impede healing. Hospitals are designed to deliver state-of-the-art medical treatment in the most efficient way possible. While it is well-documented that stress, depression, and anxiety have a deleterious effect on health,<sup>3</sup> modern hospitals, with their emphasis on diagnosing, curing, and treating, have become noisy, cluttered, institutional environments with little regard for the potentially detrimental effects these environments have on the patients’ physical or psychologic well-being. In recent years, hospital design has begun to include esthetic aspects but for the purpose of enhancing patient satisfaction as a means of attracting consumers.

In this paper, we (1) discuss how the design of the envi-

---

<sup>1</sup>The Design Partnership, San Francisco, CA.

<sup>2</sup>Planetree Alliance, Fairhope, AL.

<sup>3</sup>Planetree, Derby, CT.

ronment influences behaviors, actions, and interactions; (2) present several models and approaches that have made impacts on design in health settings; and (3) review elements of space and the environment that have shown to be inherently healing.

### THE ROLE OF THE ENVIRONMENT ON BEHAVIORS, ACTIONS, AND INTERACTIONS

The physical environment, while being a dimension of healing in its own right, is intertwined with all other dimensions of an optimal healing environment (OHE). Some elements of environmental design may, in themselves, help or hinder healing. But the environment may also make an impact on health by influencing the behaviors, actions, and interactions of patients and their families as well as the staff members who provide the care. In hospitals, the link between the environment and behaviors is powerful and pervasive: Restrictive visiting policies, for example, are often blamed on lack of space for families.

There is a growing body of research examining how the environment makes an impact on patient safety.<sup>4,5</sup> Private rooms in intensive care units have been shown to decrease infection rates. Widening doors to patient bathrooms to accommodate a staff person ambulating with the patient can decrease patient falls. Rooms that offer flexible patient acuity can minimize transfers, thereby reducing medication errors.<sup>6</sup> A design that encourages physical activity may reduce depression.<sup>7</sup> The environment may also influence behaviors in more subtle ways by communicating through images, symbols, and metaphors.<sup>8,9</sup> But the question is: Which messages are most conducive to health and healing? Can a home-like environment, with a fireplace, plants, carpeting, a kitchen, and smells of fresh-baked bread convey a sense of familiarity and comfort?<sup>10</sup> In a home-like environment, are staff members more likely to treat patients as guests?

Although there are more questions than answers, the following is an exploration of how environmental design influences other dimensions of health and healing, reflecting the components in the OHE graphic depicted by Jonas and Chez in this supplement (see Optimal Healing Environments graphic).\*

#### *Intention and awareness*

Numerous studies show that stress, anxiety, depression, and loss of control are detrimental to health.<sup>3,11</sup> Low socioeconomic status is also linked to negative health outcomes.<sup>12</sup> Even during a brief hospital stay, presurgical anxiety has been shown to increase postoperative pain.<sup>13</sup>

However, optimism, hardiness, self-efficacy, coherence,

and a sense of control are linked to good health.<sup>14–16</sup> Though these are often considered to be personality traits, they are also skills that can be learned and practiced.<sup>16</sup> Greater perceived control over recovery has been associated with shorter hospital stays.<sup>17</sup>

Many hospitals are stark, cluttered, intimidating institutions with multiple entrances, unclear signage, and disorienting corridors. In large facilities, frail but ambulatory patients may require wheelchairs to cover long distances to their destinations, necessitating dependence on others. A logical building design and adequate parking and way finding, using signage, artwork, and other visual clues, can help patients navigate their surroundings without getting lost or having to depend on others.<sup>18</sup> Giving patients an opportunity to personalize their environments by bringing comforting items from home may help give patients a sense of control and familiarity. “Artcarts” can give patients choices regarding artwork.<sup>19</sup> A free-standing power column permits a flexible room design, giving patients (and nurses) control over room design.<sup>6</sup>

#### *Wholeness and energy*

Health care has a long history of being intertwined with spirituality. From the temples of Asklepios, to the monastic hospitals of the Middle Ages,<sup>1</sup> to the spiritual calling of Nightingale nurses,<sup>2,20</sup> health and spirituality have been closely linked. Yet, most hospitals today are designed to meet the needs of technology more than spiritual needs of patients, families, or staff. Even hospitals with religious affiliations rarely differ in design from nonreligious institutions other than statues in lobbies or crosses, for example, in patient rooms.

For some patients, illness is not only a physical and emotional crisis, but a spiritual one as well. Patients may be faced with their own mortality, life-changing diagnoses, or feel they have been punished or betrayed by God.<sup>21</sup> Prayer and religious affiliation are associated with health benefits.<sup>22</sup> Yet, except for a chapel, there are few spaces in most hospitals reflecting the spiritual needs of patients, families, and staff. Thus, hospitals are challenged to meet the needs of religiously diverse populations who may not differentiate spirituality and religion.

Nature may be the most universal image of spirituality.<sup>23</sup> A number of hospitals are adding outdoor labyrinths in gardens as a focus for spirituality.<sup>24</sup> Nature may also be useful in providing images of lifecycles such as birth, death, and the renewal of life.

#### *Healing relationships*

There is extensive research on the importance of social support,<sup>3,25</sup> yet, hospitals have a long history of separating patients from families. It is only within the past several decades that fathers have been permitted in delivery rooms during the birth of their children. Some hospitals still have restrictive visiting hours, especially in critical care areas

\*By the Samuelli Institute. Diagram created in 2003. See Jonas and Chez paper in this Supplement, pages S-1–S-6.

such as emergency rooms, intensive care units, and recovery rooms, areas where families may most want to be near their loved ones. Poor design contributes to restrictive family access as a result of insufficient space in patient rooms and waiting areas and lack of confidentiality when only curtains separate patients.

Buildings can be designed to encourage social connectedness by providing opportunities for social contact and engagement. Research has indicated that family and friends made longer visits to rehabilitation patients in carpeted patient rooms, as opposed to patient rooms with hard surface flooring.<sup>†</sup> Furniture arrangements have been shown to have an effect on social interactions. Much work has been done looking at waiting areas, day rooms, and lounges in health care settings.<sup>26,27</sup>

The relationships among patients and physicians, nurses, and other caregivers is also affected by design. Centrally located nursing stations and glass partitions may limit patients' access to staff. In addition to the importance of family and friends, studies show that contact with caring individuals during stressful situations is beneficial to health.<sup>28,29</sup> Hospital design that provides opportunities for patient/staff interactions, such as decentralized nursing stations, may be useful. Private patient rooms, rather than semiprivate ones, as well as adequate consultation rooms, provide opportunities for confidential discussions.

Nurses cite relationships among staff members and between nurses and physicians as reasons for leaving current jobs and the profession.<sup>30</sup> Design that encourages positive interactions among staff, such as gardens and lounges, could promote greater job satisfaction. Incorporating day care facilities and sick-child day care into the design supports family relationships of staff members.

There is also growing research regarding the health benefits of animal therapy. For some people, pets are part of their social support network.<sup>31,32</sup> While animal therapy is becoming more accepted in hospitals, visits by the patients' own pets are still uncommon. Rarely does design consider the presence of animals. A variety of outdoor spaces would facilitate visits by companion animals.

### *Health promotion*

Many hospitals are teaching institutions for physicians, nurses, and other staff members, but their importance in providing learning opportunities for patients and families may be underutilized.<sup>33,34</sup> Low health literacy is a risk factor for poor health.<sup>35</sup> Design that incorporates libraries near each unit, Internet access in and near patient rooms, and community health resource centers, can help transform hospitals into educational resources. Placement of the patient's med-

ical records to maintain confidentiality while giving the patient access<sup>36</sup> may encourage active participation. The hospital can also focus on teaching stress reduction and health promotion by including community meeting spaces, wellness centers, and indoor and outdoor walking paths for staff members and members of the community. Cafeterias designed as restaurants encourage community use, giving consumers access to nutritionists and other hospital educators.

### *Collaborative treatments*

Hospitals have been designed around the needs of Western medicine. With the integration of various complementary healing traditions, the need arises to integrate these practices into hospital design as well. Massage is useful in relieving stress for patients as well as staff.<sup>37,38</sup> Rooms for massage, acupuncture and stress reduction can be incorporated into a variety of hospital settings. Community rooms for *tai chi*, yoga, journaling, drumming, and other modalities may eventually become mainstream. In time, architecture itself may be seen as a complementary healing modality.

## **EXISTING RESEARCH: PHYSICAL PARAMETERS**

The authors performed a MEDLINE<sup>®</sup> and associated literature survey in an attempt to ascertain the state of the research. The survey was organized by those elements of a physical environment that are (a) popularly considered; (b) researched; or (c) identified by the healing design systems discussed in this paper as important to a healing environment. Interesting and relevant findings from related research fields are included, but the focus is on the health care setting.

### *Personal space*

Single-bed rooms are preferable for operational benefits of better communication with staff, minimization of transfers (due to roommate conflicts), fewer medication errors, decreased infection rates, and comfortable inclusion of the family.<sup>6</sup> Orthopaedic and psychiatric patients treated in single rooms were more satisfied with their care than those treated in multiple-bed wards.<sup>39</sup>

Data from a 2002 Press Ganey survey of patient satisfaction in labor and delivery units found an across-the-board preference for single rooms on measures of perceived pleasantness of room décor, cleanliness, courtesy of housekeepers, temperature, noise, and "how well things worked."<sup>40</sup> Furthermore, Press Ganey national data for 1999–2002 show a consistent preference for single rooms with much greater patient satisfaction in overall care resulting.

### *The sensory environment*

*Smells.* Claims are made that pleasing aromas can reduce blood pressure, slow respiration, and lower pain-perception

<sup>†</sup>Harris D. Environmental Quality and Healing Environments: A Study of Flooring Materials in a Healthcare Telemetry Unit [dissertation]. Department of Architecture, Texas A&M University, College Station, TX, 2000.

levels. There is some research that fragrance perceived as moderately to extremely pleasant lowered patient-rated anxiety during magnetic resonance imaging.<sup>41</sup> However, odors (“negative smells”) are observed to stimulate anxiety, fear, and stress.

*Sound/noise.* It is often asserted that noise in a hospital is a highly negative environmental characteristic that increases patients’ perception of pain, increases the use of pain medications, contributes to sleep deprivation, and may cause patient confusion and disorientation. There is some evidence that noise may even contribute to increased lengths of hospital stay.<sup>42</sup> One of the most common complaints by recently hospitalized patients is that health care, and particularly hospital environments, are distressingly noisy.<sup>42</sup> Patients commonly complain of a lack of sleep or say that they are sleeping poorly.<sup>43</sup>

Staff members often cite high noise levels as a cause of increased stress.<sup>44</sup> Correlations between noise and increased frequency of headaches and symptoms of “burnout” in coronary-care unit (CCU) nurses have been made.<sup>42</sup> Tile surfaces, metal equipment, alarms, beepers, and overhead paging contribute to disruptive noise levels.<sup>42,45</sup>

Most findings suggest that noise is harmful to at least some health outcomes by disrupting sleep, worsening sleep quality, increasing blood pressure, elevating heart rate, and reducing patient satisfaction.<sup>46†</sup> Among the many effects of a noisy environment listed are: people become less interpersonally engaged, less caring, and less reflective; cognition is impeded; and there is a loss of perseverance in addressing complex tasks and a tendency to seek simple solutions.<sup>42</sup>

Recent research shows even low noise levels of 40 dB–58 dB can worsen health outcomes. The U.S. Environmental Protection Agency (EPA) in 1974 recommended that hospital noise levels not exceed 45 dB during the day and 35 dB at night. The International Noise Council has suggested a maximum of 45 dB, on average, in acute-care areas during daytime, 40 dB in the evening, and 20 dB (a soft whisper) at night. But studies have shown noise levels ranging from 60 dB to 84 dB over a 24-hour period in the intensive-care unit and an average night-time noise level of 67 dB in acute-care and general medical units.<sup>42</sup>

Patients perceive that they sleep poorly in the intensive-care unit and CCU, and indications are that the main factors are noise, pain, and environmental temperature.<sup>47†</sup> Some research shows that the number of disturbances at night is significantly greater in the hospital than at home. However, the cause of sleep disruption is multifactorial and the significance of noise may be overstated in the popular literature.<sup>48†</sup> A study of healthy women in a sleep labora-

tory with simulated noises of a CCU did show a disruptive effect on rapid eye movement sleep.<sup>49</sup>

The problem of noise in double rooms is problematic. Noise made by a roommate, their visitors, or attending staff can be particularly stressful because the patient has no control and feels victimized. A 2002 Press Ganey survey of patient satisfaction in labor and delivery units found the greatest decrease in satisfaction with patients’ rooms was caused by noise in a double room.<sup>40</sup>

The research into the positive effect of sounds is less extensive. The research on the similar effect of music may be relevant. The assumption that natural sounds have a calming, relaxing effect that improves sleep quality has been shown in a study of surgery patients.<sup>50</sup>

*Temperature.* There is inadequate research reported on the relationship of temperature to health outcomes. One survey of sleep of inpatients did identify uncomfortable ambient temperature (either too hot or too cold) as a cause of sleep disruption.<sup>†</sup>

### *Environmental complexity*

There is an anecdotal suggestion that a variety of “thermal environments” are beneficial to mood and function.<sup>51</sup> Davidson’s research has shown that an environment with greater complexity was correlated with greater cognitive functioning and beneficial physical activity in the elderly.<sup>52</sup> Variation in environment is associated with reduced depression, social withdrawal, misidentification, and hallucinations in patients with Alzheimer’s disease.<sup>53,54</sup> Similarly, sensory variation in ambient conditions (light levels, temperature) between spaces and over time is preferred by building occupants.<sup>55</sup>

There is some evidence that a variety of spaces (visually accessible versus visually enclosed) and “multiple sensory retreats” in a building are important for emotional and cognitive functioning and may affect immune-system function.<sup>56</sup> Smith<sup>57</sup> has found that patients could “rest better in a hospital environment with varied patterns of auditory input (music or stories) than with quiet ambience.”

### *Fresh air and ventilation*

Claims are made for the health benefits of fresh air. Additionally, the proponents of building energy efficiency and sustainable design (“green architecture”) argue that natural ventilation can increase energy efficiency of buildings as well as improving indoor environmental conditions. The EPA estimates that indoor air pollution is one of the top five environmental risks to public health. The EPA states further that indoor air pollutants can cause eye, nose, and throat irritation; headaches; loss of coordination; nausea; cancer; and damage to the liver, kidneys, and central nervous system.<sup>58</sup>

The current surprising reality is “that indoor air contains more pollutants, and often at higher concentrations, than outdoor air.”<sup>59</sup> The Green Guidelines for Healthcare Construc-

<sup>†</sup>Closs SJ. Study of Sleep on Surgical Wards [dissertation]. Department of Nursing Studies, University of Edinburgh. Edinburgh, 1998.

tion state that a strategy for good indoor air quality (IAQ) is to “develop ventilation strategies that support operable windows, where appropriate” (EQ Prerequisite 1). Operable windows also avail the occupant of ambient smells, breezes, and all the sensory stimuli of an “open” environment. While “appropriate ventilation” is desirable, there is an argument to be made that allowing immediate air flow directly from outdoors (e.g., operable windows) may actually bring in “dirtier” outside air and increase the risk of hospital-acquired infections. Obviously, this is of particular concern in intensive or critical patient care units and other areas with immune-suppressed populations.

A study of student performance found that students in classrooms with operable windows progressed 7%–8% faster on standard tests in 1 year than students in rooms with fixed windows.<sup>60</sup> The authors have not found any research on the effect on health outcomes in hospitals with operable windows.

### *Light (natural and artificial)*

The two accepted pathways for light’s biologic effect are the skin and the eyes. Skin exposure is related to vitamin D production by the body. Visible light has an effect on both systemic physiologic responses and mood,<sup>61</sup> as well as on visual needs. Research on the effect of light on autonomous physiology has been concentrated on circadian rhythms. Per a 1993 survey, there existed “over 3000 references to research on light’s affect on human chronobiology” including seasonal affective disorder (SAD), sleep disorders, and work disruptions.<sup>60</sup> A natural circadian rhythm of light exposure influences health by regulating melatonin production, and influencing biochemical and hormonal body rhythms.

A shorter period of daylight, naturally occurring during winter, has been shown to trigger SAD with symptoms of depression, irritability, and fatigue.<sup>61</sup> Regular exposure to either full-spectrum lighting (or increased intensity of light) has been demonstrated to improve the condition by increasing the amount of melatonin produced in the brain.<sup>62</sup> Sleep deprivation has been described as a treatment for depression for more than 30 years, and approximately 50%–60% of patients with depression respond to this approach.<sup>63</sup>

Infants exposed to diurnally cycled lighting while in intensive care experience both physical and behavioral developmental benefits. Mimicking the circadian rhythm of light and noise in a newborn nursery increases the time preterm infants spend sleeping and improves their weight gain.<sup>64–66</sup> The more typical condition of aperiodic lighting patterns with light pulses of variable frequency, intensity, and duration associated with providing intensive care in the modern neonatal nursery may have adverse effects on infant development.<sup>67</sup>

The differences between natural and artificial light are significant, including levels of illuminance, uniformity, and diffusion of the light, variation of time, color, and amount of ultraviolet radiation.<sup>61</sup> The importance of natural sunlight to healing has been explored in a number of strong studies. Depressed patients in a psychiatric unit recovered faster in

rooms with brighter light.<sup>68</sup> Neonates in the obstetric ward of a tropical hospital exhibited a significant increase in the rate of neonatal jaundice from 0.5% to 17% when the amount of sunlight entering the ward was decreased by the installation of exterior awnings.<sup>69</sup>

Daylighting was found to have a uniformly positive and statistically significant effect on student performance as evidenced by better test scores.<sup>70</sup> Insufficient light exposure has been implied as a cause of sleep fragmentation. The results of studies of nursing-home patients, the hospitalized and healthy youths suggest that increased daytime light exposure, measured by duration and intensity, has an impact on night-time sleep quality and consolidation.<sup>71,72</sup>

The negative impact of poorly designed or maintained indoor lighting resulting in source glare and flicker are documented. These intensify existing vision problems, add to eye fatigue and headaches, and contribute to a loss of concentration, especially in the elderly.<sup>73</sup>

### *Color*

The premise is that different colors affect moods and behaviors. Certain colors are said to encourage activity, while others promote passive behavior. How visible light affects mood requires more research. Claims for the effects of ambient colors in indoor environments (e.g., pink walls calming prisoners) are largely anecdotal. The Coalition for Health Environments Research, with sponsorship of the AIA Academy of Architecture for Health, is conducting a survey of color research, which is due to be published in 2004 ([www.chereseach.org/res\\_color.shtml](http://www.chereseach.org/res_color.shtml)).

Use of colored light as a treatment modality is a rapidly growing area of experimentation for many acupuncturists. Esoteric colorpuncture is a complete system of therapy developed by Mandel for treatment of migraines, childhood insomnia, bronchitis, attention-deficit disorder (ADD), learning disorders and uterine fibroids.

Ocular light therapy, in which light is projected through colored filters into the eyes, is claimed to “enhance brain activity, increase brain energy and open up neural pathways . . . [and] improve intellectual capacity as well as mental, emotional and physical well-being and performance.” Ocular light therapy is being used to treat stress/anxiety, insomnia/fatigue, headaches, and depression.

### *Viewing nature*

Ulrich’s “Theory of Supportive Healthcare Design” includes a design guideline to “Provide Access to Nature and other Positive Distractions.”<sup>74</sup> A working definition of “positive distractions” is “environmental-social conditions marked by a capacity to improve mood and effectively promote restoration from stress.”<sup>75–77</sup> Ulrich pays particular attention to views of nature in his research, but identifies comedy or laughter, caring or smiling human faces, music, and companion animals as others.<sup>19,76</sup>

Both workers and patients rate having a window as very desirable, preferably with a view of a natural setting.<sup>76</sup> Furthermore, studies of students and office workers on behalf of the California Energy Commission's Public Interest Energy Research program find that for both groups an "ample and pleasant view" improved performance.<sup>60,78</sup> Employees with a window view of nature report less stress, better health status, and higher job satisfaction.<sup>79</sup>

Studies on hospital inpatients have concentrated on critical or intensive care units. Such studies have linked the lack of windows with high rates of anxiety, depression and delirium.<sup>80,81</sup> A view of nature has been correlated with shorter postoperative hospital stays, higher satisfaction with nursing care, and decreased use of potent analgesics in cholecystectomy patients compared to patients with obstructed views.<sup>82</sup>

Ulrich postulates that the lack of a window may act negatively by reducing positive stimulation and aggravating the negative effects of sensory deprivation, particularly in a clinical environment with such conditions as repetitive sounds of respirators.<sup>75</sup> In addition, he has found that views of nature can reduce anxiety and pain and have a restorative effect on patients as well as staff (e.g., mood improvement, lower blood pressure, and reduced heart rates). He postulates an evolutionary theory predisposing humans to find scenes of nature restorative.<sup>19</sup>

Office workers with access to natural light and views of greenery are more productive and have higher job satisfaction.<sup>83</sup> National Aeronautics and Space Administration studies have found that a sense of perceptual distance and expansiveness, either with distant views, internal view corridors with interesting focal points, or even the design of vertical surfaces, promote "cognitive tranquility," which aids mental functioning.<sup>84</sup>

Providing patients, families and staff with access to nature by providing indoor and outdoor gardens, views of nature through windows, and artwork of nature scenes can relieve stress.<sup>19</sup> In one study, surgical patients in postoperative units with no windows to the outside developed twice as many cases of postoperative delirium during a 72-hour period as those with windows.<sup>85</sup> In addition, patients in units without windows developed more symptoms of depression.

### *Experiencing nature*

The healing effects of experiencing natural environments are largely taken for granted. The research supporting this supposition is limited to self-reported evidence of lowered stress and muscle tension.<sup>86</sup> A study of children with ADD found they function better after activity in natural settings, and that the "greener" the play area, the less severe the ADD symptoms.<sup>87</sup> Similar positive indications with fewer occurrences of aggression and violence have been reported in inner-city urban public housing residents.<sup>88</sup>

Buildings with natural characteristics and visual features, including daylight, nature views and indoor plants, are more highly preferred by occupants.<sup>55</sup> Indoor plants have also

been shown to increase work efficiency and attentiveness as well as decreasing perceived stress, lowering blood pressure, and reducing physical discomfort.<sup>89,90</sup>

### *Arts, esthetics, and entertainment*

The mechanism for the impact of the arts is assumed to be a lowering of stress and anxiety levels, promotion of restoration from stress and improvement in mood.

*Visual arts (sight).* Patients with nature images have less anxiety and require fewer strong pain medication doses.<sup>91</sup> However, too much stimulation will have the negative impact of raising anxiety levels. Abstract art may contribute to less favorable recovery outcomes than viewing no pictures at all and is consistently disliked by patients.<sup>75,76,91</sup> All visual art (paintings, prints, photographs) displayed in patient areas should have unambiguously positive subject matter and convey a sense of security or safety.

When selecting art for stressed patients, Ulrich suggests the following characteristics should be avoided: ambiguity or uncertainty; emotionally negative or provocative subject matter; surreal qualities; closely spaced repeating edges; forms that are optically unstable or appear to move; restricted depth or claustrophobic-like qualities; close-up animals staring directly at the viewer; and outdoor scenes with overcast or foreboding weather. Most pictures selected should depict landscapes during warmer seasons when vegetation is verdant and flowers may be visible; avoid landscapes conveying bleakness; include scenes with positive cultural artifacts, such as barns and older houses, and garden scenes with some openness in the immediate foreground. Figurative art should include emotionally positive facial expressions; group scenes that depict friendly, caring, or nurturing relationships among people, or scenes of people at leisure in places with prominent nature.<sup>19</sup>

*Music.* There exists a considerable body of strong research in the area of the positive effect of music on health outcomes in Western medicine. For example, as early as 1948 at the University of Chicago hospital, music was used in surgical suites for patients who went under local, regional, and spinal anesthesia. The National Endowment for the Arts has a provocative summary of Arts in Healthcare Research at its Web site at [www.nea.gov/news/news03/AIHRresearch.html](http://www.nea.gov/news/news03/AIHRresearch.html) Research highlighted there indicates the effectiveness of music in mitigating nausea and emesis in chemotherapy patients, decreasing preoperative anxiety in infants, improving physiologic and behavioral measures of premature infants in the intensive care unit, and reducing stress of visitors in hospital waiting rooms.

It has been shown that music "administered" at times of high stress (e.g., outpatient surgery and recovery) has an anxiolytic effect resulting in increases in patient comfort and endorphin levels, lowering of heart rate and anxiety, and re-

duction of the need for anesthesia.<sup>92–98</sup> Music also decreased the use of analgesics and hastened recovery from surgery in a study of 90 hysterectomy patients.<sup>99</sup> The use of music programs timed to the surgical procedure (e.g., central nerve block) was associated with a significant reduction in the amount of perceived pain and decrease in the level of stress hormones in the blood.<sup>100</sup> Studies of neonates also provide strong evidence for the benefits of music to promote weight gain and reduce stress, resulting in a shorter length of hospital stay.<sup>101</sup>

#### *Positive distractions: humor and entertainment*

The “classic” work in psychoneuroimmunology is Norman Cousins’ self-medication regime of humorous movies and books. Studies since then have documented the health benefits of “a good laugh,” as including greater optimism, socialization and cooperation among patients; decreased dependence on tranquilizers and pain-relieving medication; and less burnout among health professionals.<sup>102</sup>

One study of “stress chemicals” in the bloodstream after exposure to a humorous video found decreased levels of epinephrine (adrenaline), a hormone that causes vasoconstriction and raises the heart rate and blood pressure. The levels of cortisol, which is involved with suppression of the immune system, were also significantly decreased.

Virtual reality intervention therapy is being used to alleviate the effects of classically conditioned responses such as anticipatory nausea and vomiting in chemotherapy patients, anxiety disorders, phobias, eating disorders, and post-traumatic stress disorder, as well as to improve the mood of cancer inpatients.<sup>103</sup>

## SURVEY OF HEALING ENVIRONMENT DESIGN MODELS

Models and philosophies informing healing environmental design, particularly in health care settings, provide elements for consideration. The following constitute some of the better-known examples that have affected hospital and health center design over the past half century.

### *Feng Shui*

Feng Shui is the ancient Chinese study of the natural environment. Literally translated as “wind and water,” it is used by practitioners to determine the most favorable location for both people and things in a particular environment. Feng Shui is used to promote the creation of an optimally productive and harmonious environment that supports the people in that environment. Design recommendations are generally based on elemental aspects of the environment and the individuals in the environment as well as on movements of the solar system. Every building is believed to have

unique energy characteristics and the physical relationship between the natural environment and magnetic fields is taken into account.

A Feng Shui practitioner uses a special compass known as a *Lo-pan* to determine the energy characteristics of a building and the consequent effects on the building’s occupants. Calculations are done according to basic principles and remedies may then be prescribed where necessary to balance the energy so it will have a positive effect. Especially important are the entrances to the building, offices, patient rooms and treatment areas. Promoting good *chi* or energy flow in these areas is believed to have a strong impact on the health and peace of mind of occupants. Using Feng Shui principles in laying out these spaces and the arrangement and orientation of furniture is said to affect this energy flow. Some general guidelines include the following:

- Provide direct views to entrances, so that patients and employees do not have their backs to doorways.
- Avoid placing patients or employees in the direct line of a door in order to protect privacy and avoid the feeling of always being watched. Being in the direct line of a doorway reportedly puts an individual directly in the rush of *chi*, with resulting negative effects on health and productivity.
- Utilize warm lighting, as opposed to glaring florescent lighting; overly bright light is believed to irritate people and result in headaches.

### *Anthroposophic medicine*

Anthroposophic medicine is practiced at numerous hospitals and clinics throughout Germany, England, Holland, Sweden, and France. Based on the work of Steiner, anthroposophic medicine is an extension of medical practice that incorporates a holistic view of the human being provided by spiritual science. Steiner elaborated the relationships among the senses, intellect, life, and spiritual awareness, and suggested that, through our common evolution, human beings and nature are related in potentially healing ways.

The healing relationship between humans and nature is reflected in medical approaches to pharmacy and therapy dependent on what realm of the human is in need of attention. Recognized realms include “material” (the physical body), “life” (the etheric body), “soul” (the astral body or consciousness), and “spirit” (the ego or self-consciousness). In the anthroposophic view of humans, each of these bodies correlates with specific bodily systems.

In addition to medicine, Steiner applied his philosophy to other aspects of life, including architecture, art, and education. He inspired the Waldorf School movement from which Assmussen developed his architectural ideas. The most significant example is the village-like cluster of buildings in Jarna, Sweden, which includes an anthroposophic healing center (Vidar clinic), along with a college, Waldorf school, performing arts center, gardens, housing, and mill and bakery.<sup>104</sup>

### *Color therapy*

Colors and color therapy to promote health may involve the use of a variety of modalities, from the exposure of individuals to colored lights and body work such as massage utilizing color-saturated oils, to visualizations focused on color and the eating of certain colored foods. The use of color in health care environments reaches back into ancient Egypt and the temple of Heliopolis where patients were treated in rooms designed to separate the sun's rays into various colors of the spectrum. Pilgrimages made to the Hanging Gardens of Babylon for healing purposes focused on exposure to the healing colors of the plants and flowers propagated there.

With Newton's experiments adding to the intuitive body of beliefs around the healing power of color, physicians began using color to treat everything from smallpox to behavioral problems in the eighteenth and nineteenth centuries. This focus was accentuated with the publication of Babbitt's work in chromatotherapy in the late 1800s that indicated color treatments for a broad range of illnesses of the day. Based on this work, some of the most extensive research on colored light therapy was done in the early 1900s by Ghadiali, who researched the effects of color on disease and, by 1920, was producing and distributing "Spectro-Crome" lamps, promoted to treat a variety of chronic ailments, including diabetes and tuberculosis. Ghadiali's work remains controversial, in contrast to that of Luscher, who developed the Luscher Color Test, in which observations are made of patients and their reactions to different colors. Therapy is in part based on aversions and preferences expressed during the testing procedure. And, as described previously, the research on SAD and its treatment with full-spectrum light has spurred additional interest in color and light applications in healing.

### *Sacred geometry*

There is little or no research on this topic. However, belief systems including a focus on sacred geometry are widespread worldwide. Examples include the selection of building orientation according to Sthapatya Ved. Based on the client's relationship with the cosmos, the orientation is chosen in a way that benefits the owner's health, prosperity, and spiritual growth. When a building is designed with this knowledge, a cosmic blueprint (*mandala*) is created and by placing a building (*Vastu*) over it, pure consciousness (*Purusa*) is manifested in it while remaining in contact with the cosmos. When the building is in a perfectly ordered state, it is conceived to be in the likeness of *Purusa* ([www.adsvastu.com/whatissthatyaved.html](http://www.adsvastu.com/whatissthatyaved.html))

Religions have processional rituals that are related to the compass, and buildings of worship are often oriented to certain directions. For example, in Islam, an orientation toward the east and Mecca is dominant. In many Native American belief systems, each of the four directions has specific mean-

ings attached that affect health and healing and therefore figure into the physical environment and its directional orientation.

### *The Planetree hospital model*

Established by a patient in 1978 as a nonprofit organization, in this model, everything in the hospital and health care setting is continuously evaluated from the perspective of the patient, incorporating this perspective into both the culture of the organization and the facility over time. Access to information, involvement of family, and fostering positive human interactions are the foundations of these efforts. The actual design of the health care environment is one of ten core components that make up the Planetree philosophy of care, which seeks to personalize, humanize, and demystify the patient experience.

*Intention and awareness.* The focus of this approach has less to do with a specific type of architecture or interior design and everything to do with intention and awareness. Patients often enter typical hospital environments in a state of anxiety and fear and during their time there may feel lonely and isolated from family and friends. In this state, they are not likely to benefit from even the most beautiful surroundings. The design deemphasizes the rigid hierarchy present in medicine among patients, families, and providers and increases patient participation and control while in the health care environment. The principles used include:

- Welcome the patient's family and friends.
- Value human beings over technology.
- Enable patients to fully participate as partners in their care.
- Provide flexibility to personalize the care of each patient.
- Encourage caregivers to be responsive to patients.
- Foster a connection to nature and beauty.<sup>11</sup>

*Healing relationships.* It is extremely important for patients and their significant others to feel connected with the staff in an environment that supports such connection and interaction. Yet, it is not uncommon to find large centralized nursing stations on a typical patient unit, set apart from patients by half-walls or glass partitions and at significant distances from most patient rooms. These elements clearly distance staff members from patients, sending the message that they are busy and inaccessible.

An alternative is a decentralized nursing work station that is small, open and located outside clusters of 4–6 patient rooms, with the main nursing station completely open to patients. The open and inclusive designs of these spaces suggest that healing is a collaborative process, and not something exclusively under the purview of "professionals." Professional staff members are both physically and emotionally closer and more accessible; they are there to collaborate with each patient and family members about the

health care experience. An indirect benefit of this accessibility has been the decrease in frequency of call-light use by patients, which was reduced by up to 40% (Susan Frampton, Ph.D., Derby, CT) personal communication). Data have been published on the significant impact on patient satisfaction with the transformation of the predominantly high-technology, sterile, provider-focused institution to warm, home-like, person-centered environments.<sup>105</sup>

*Health promotion.* The auditory landscape created in and by the patient's environment has particular impact on a patient's well-being. From the piercing overhead pages to the electronic beeping of cardiac monitors, hospital sounds can be frightening and disturbing for patients who have no recourse but to listen to them day and night. Solutions include carpeting in corridors to lessen the impact of footsteps, rolling carts, and staff member conversations; thoughtful location of storage areas, staff lounges, and utility rooms away from patient rooms; and internal corridors located between storage and utility rooms allowing clinical and support staff to conduct necessary tasks without disturbing patients.<sup>106</sup>

Music can be used to mask distressing environmental noise that cannot be eliminated. Similarly, appropriate artwork included throughout the facility provides additional positive distraction and promotion of positive responses.

### ELEMENTS OF SPACES AND ENVIRONMENT THAT INHERENTLY AFFECT HEALTH

It is generally accepted as common knowledge that the "ambiance" of a "space" has an effect on people using the space. The perceived habitability of a space is critical to the overall feeling of a space. A "positive toned mood" affects how occupants feel in a space and affects physiologic restoration (healing).

Users of health care settings value the physical environmental context in which care occurs. In a recent survey by the CABE/ICM in Great Britain, 91% of all nurses—and 100% of directors of nursing—believe that a well-designed environment is significantly related to patient recovery rates. In addition, 90% of directors of nursing say that patients behave better toward staff in well-designed wards and rooms and that 74% of nurse managers and 64% of staff registered nurses also agree with this statement. The survey also revealed that 79% of nurses believe that the design of a hospital makes a difference to staff morale.<sup>107</sup>

Improvements in the physical environment have been suggested to improve patients' perceptions of physician and nursing care, as well as hospital services.<sup>108</sup> There is some indication that physical improvements shorten length of patient stay and that patients require fewer analgesics.<sup>39</sup> However, a limited number of rigorous studies on health care environments exist.

A review of research demonstrating a relationship between the environment and health outcomes<sup>5</sup> found only 84 of 78,761 published studies used adequate methodologies. However, as Ulrich states, "it is encouraging that the report indicated that an impressively high percentage (80%) of the most rigorous studies found positive links between environmental characteristics and patient health outcomes."<sup>77</sup>

A broader literature review focusing on pediatric environments also found little rigorous research on the effects of environmental design on health and healing. In a review of 185 journals from the 1950s thru mid-1997, 109 studies were judged as having sufficient methodology. The recurring themes in this research, as identified by the review authors, were largely of a psychosocial nature, including the need for (a) privacy and personalization of space; (b) distractions (nature, music, play, mother's voice); (c) staff supervision; (d) age-appropriate environments; and (e) family supportive spaces. However, the physical aspects of "healing sensory dimensions (sound, light, humidity, temperature, and color)" were also researched.<sup>109</sup>

Research reviews in 1991 and 2000<sup>74,75,77</sup> reported that "it is evident that, although the amount of research is steadily growing, there is no sound, directly relevant research yet available for many health care environmental design questions."

We can postulate a hierarchy of environmental effects in the following sequence: Nontoxic ⇒ safe (physical and psychologic) ⇒ positive context ⇒ salutogenic.

#### *Nontoxic*

The Green Guidelines for Healthcare Construction (GGHC) are designed to provide the health care sector with a quantifiable tool to guide facility planning, design, construction, and operation toward enhanced environmental and health performance. The Guidelines use a scoring system modeled after the U.S. Green Building Council's LEED™ rating system but is self-certifying. The GGHC is built upon the Green Healthcare Construction Guidance Statement developed by the American Society of Healthcare Engineering. It addresses the particular structural, usage, and regulatory challenges of health care buildings, and emphasizes environmental and public health issues.

An essential part of the "green" process is to limit exposures to harmful chemicals and other substances throughout the entire building process, starting with how basic building materials are extracted or obtained (i.e., gypsum mining and sustainable forestry practices) through building construction practices on-site (i.e., contaminated wastewater runoff containment), what materials are put into an interior environment (i.e., low-volatile organic compound paints and carpets), to building operations (i.e., heating and cooling), and, finally, disposal (i.e., recycling scrap materials, safe disposal of mercury from light balasts, and medical equipment).

Another growing toxicity concern is over exposure to electromagnetic (EM) fields. Attention has become so pronounced that governmental agencies are pursuing research and making recommendations. An example is The California Electric and Magnetic Fields (EMF) Program ([www.dhs.ca.gov/ehib/emf/](http://www.dhs.ca.gov/ehib/emf/)). These guidelines for school construction include recommendations for site planning, building design and space layout, electrical system design, and fluorescent lighting. For instance, fluorescent lights are an important source of EM fields in classrooms. It is recommended that electronic ballasts will minimize EMF from fluorescent-light fixtures.

### *Safe*

The positive provision of a safe place, both physically and psychologically, is essential. For instance, designers have been encouraged to create a domestic esthetic in their interiors based on extensive patient input collected from ongoing focus groups conducted nationally.<sup>105,110</sup> Rehabilitation in the care of patients with Alzheimer's disease includes the treatment domain of a "naturally mapped" physical environment "in which the environment itself contains the knowledge necessary for its correct use" to promote safety and feelings of security, mastery, and belonging, while reducing fear.<sup>111</sup> It is interesting that both of these examples have revealed that the use of carpeting is linked to an increased perception of walking security and comfort by patients, particularly the elderly.<sup>112,\*</sup>

### *Salutogenesis*

Salutogenic environmental parameters are suggested in the literature but sometimes it is only by investigations into their negative impact (disease causation) that the correlative positive enhancing action can be surmised. Ulrich postulates an evidence-based "Theory of Supportive Design."<sup>79</sup> His guidelines begin by eliminating environmental characteristics known to be stressful or to have direct negative impacts on health outcomes. Emphasis is additionally placed on the inclusion of characteristics and opportunities that calm patients, reduce stress, and strengthen coping resources and healthful processes. The general guidelines are to foster control, including privacy, promote social support, and provide access to nature and other positive distractions.

## **APPLICABLE RESEARCH**

Relevant research can be categorized by a typology of building use. Health care organizations include hospital inpatient units, outpatient surgery, Alzheimer's disease special-care units, and emergency departments. Nonhealth care units include primary schools, workplaces, gardens, and space habitats (e.g., space stations).

## **OUTCOME MEASURES**

Research in health care settings specifically uses outcomes of:

- Medication use (especially pain medications)
- Length of hospital stay
- Patient satisfaction
- Provider satisfaction
- Well-being, mental status, anxiety, and depression scale scores
- Pain self-rating
- Sleep questionnaire, sleep scores
- Hospital-acquired infection rate
- Stress behaviors
- Weight and weight gain (especially in newborns)
- Patient comfort (self-rating)
- Physiologic indicators such as heart rate, blood pressure, and respirations.

Environmental research in the workplace setting has outcomes measures of: "well being," "performance," "positive functioning," "workplace productivity," "healthiness," "emotional and cognitive functioning," and "positive mood."<sup>84</sup> Other measures include performance on standardized tests.

## **CONCLUSIONS**

While a great deal of attention has been paid over time to the design and creation of healing environments, much of the data informing these efforts are anecdotal or under-researched. Opportunities exist to make meaningful contributions in this area that will make significant impacts on the health outcomes of human beings.

## **REFERENCES**

1. Lyons AS, Petrucelli RJ. *Medicine, An Illustrated History*. New York: Harry N. Abrams, 1987.
2. Nightingale F. *Sick nursing and health nursing*. Summary. Chicago: The International Congress of Charities, Correction and Philanthropy, 1893.
3. Taylor S, Repetti R, Seeman T. Health psychology: What is an unhealthy environment and how does it get under the skin? *Ann Rev Psychology* 1997;48:411-417.
4. Reiling J. Designing around patient safety. *Healthcare Design* 2003;3:18-14.
5. Rubin H, Owens A, Golden G. Status report: An investigation to determine whether the built environment affects patients' medical outcomes. Concord, CA: Center for Health Design, 1998.
6. Page A. *Keeping Patients Safe: Transforming the Work Environment of Nurses*. Washington, DC: National Academy of Sciences, 2004.

7. Jackson RJ. Physical spaces, physical health. *AIA J Arch* 2003;1:1–2.
8. Astorino LD. Enhancing the design process through visual metaphor. *Healthcare Des* 2003;3:12–17.
9. Lakoff G, Johnson, M. *Metaphors We Live By*. Chicago: University of Chicago Press, 1980.
10. Csikszentmihaly, M, Rochberg-Halton E. *The Meaning of Things: Domestic Symbols and The Self*. Cambridge: Cambridge University Press, 1981.
11. Lindheim R, Syme L. Environments, people and health. *Ann Rev Pub Health* 1983;4:335–359.
12. Adler NE, Boyce T, Chesney MA, Cohen FS, Kahn RL, Syme SK. Socioeconomic status and health: The challenge of the gradient. *Am Psychologist* 1994;49:15–24.
13. Ozalp G, Sarioglu R, Tuncel G, Aslan K, Kadiogullari N. Preoperative emotional states in patients with breast cancer and postoperative pain. *Acta Anesthesiol Scand* 2003;47:1, 26–29.
14. Sobel D. Rethinking medicine: Improving health outcomes with cost-effective psychosocial interventions. *Psychosomatic Med* 1995;57:234–244.
15. Lorig KR, Sobel DS, Steward AL, et al. Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalization: A randomized trial. *Med Care* 1999;37:5–14.
16. Seligman M. *Learned Optimism*. New York: AA Knopf, 1991.
17. Mahler HI, Kulick JA. Preferences for health care involvement, perceived control and surgical recovery. *Soc Sci Med* 1990;31:743–751.
18. Carpmann JR, Grant MA. *Design That Cares*. San Francisco: Jossey Bass, 1993.
19. Ulrich R, Gilpin L. Healing arts—nutrition for the soul. In: Charmel PM, Frampton SB, Gilpin L, eds. *Putting Patients First—Designing and Practicing Patient-Centered Care*. San Francisco: Jossey-Bass, 2003;117–146.
20. O'Brien ME. *Spirituality in Nursing*. Sudbury, CT: Jones and Bartlett, 2003.
21. Handzo G, Wilson JC. Spirituality—inner resources for healing. In: Charmel P, Frampton SB, Gilpin L, eds. *Putting Patients First—Designing and Practicing Patient-Centered Care*. San Francisco: Jossey-Bass, 2003:89–104.
22. Townsend M, Kladder V, Ayele H, Mulligan T. Systematic review of clinical trials examining the effects of religion on health. *Southern Med J* 2002;95:1429–1424.
23. Cooper-Marus C, Barnes M. *Healing Gardens: Therapeutic Benefits and Design Recommendations*. New York: John Wiley and Sons, 1999.
24. Artress L. *Walking a Spiritual Path: Rediscovering the Labyrinth as a Spiritual Tool*. New York: Putman Publishing Group, 1995.
25. Reynolds P, Kaplan GA. Social connections and risk for cancer: Prospective evidence from the Alameda County Study. *Behav Med* 1990;16:101–110.
26. Melin L, Gotestam KG. The effects of rearranging ward routines on communication and eating behaviors of psychogeriatric patients. *J Appl Behav Anal* 1981;14:47–51.
27. Peterson R, Knapp T, Rosen J, et al. The effects of furniture arrangement on the behavior of geriatric patients. *Behav Ther* 1977;8:464–467.
28. Lepore S, Mata AK, Evans G. Social support lowers cardiovascular reactivity in an acute stressor. *Psychosomatic Med* 1993;55:518–524.
29. Komarck T, Manuck S, Jennings JR. Social support reduces cardiovascular reactivity to psychological challenge: A laboratory model. *Psychosomatic Med* 1990;52:42–58.
30. Larrabee JH, Janney MA, Ostrow CL, Withrow ML, Hobbs GR Jr, Burant CK. Predicting registered nursing job satisfaction and intent to leave. *J Nurs Admin* 2003;33:271–283.
31. Allen K, Blascovich J, Tomaka J, Kelsey R. Presence of human friends and pet dogs as moderators of autonomic responses to stress in women. *J Pers Soc Psychol* 1991;61:682–689.
32. Berry D, Pennebaker J. Nonverbal and verbal emotional expression and health. *Psychother Psychosomatics* 1993;59:11–19.
33. Webber G. Patient education: A review of the issues. *Med Care* 1990;28:1089–1103.
34. Giloth BE. Promoting patient involvement: Educational, organizational and environmental strategies. *Patient Educ Couns* 1990;15:29–38.
35. National Academy on an Aging Society. *Low Health Literacy Skills Contribute to Higher Utilization of Health Care Services*. Online document at: [www.agingsociety.org/agingsociety/publications/fact/fact\\_low.html](http://www.agingsociety.org/agingsociety/publications/fact/fact_low.html)
36. Grange A, Renvoize D, Pinder J. Patients rights to access their healthcare records. *Nurs Standard* 1998;13:41–42.
37. Richards KC, Gibson R, Overton-McCoy AL. Effects of massage in acute and critical care. *AACN Clin Issues* 2000;11:77–96.
38. Katz J, Wowk A, Culp D, Wakeling H. Pain and tension are reduced among hospital nurses after on-site massage treatments: A pilot study. *J Perianesthes Nurs* 1999;14:128–133.
39. Lawson B, Phiri M. Hospital design: Room for improvement. *Health Serv J* 2000;110:24–26.
40. Kaldenberg D.O. The influence of having a roommate on patient satisfaction. *Satisfaction Monitor*. South Bend, IN: Press Ganey Associates. Jan/Feb 1999.
41. Redd WH, Manne SL, Peters B, Jacobsen PB, Schmidt H. Fragrance administration to reduce anxiety during MR imaging. *J Magn Reson Imag* 1994;4:623–626.
42. Grumet G. Pandemonium in the modern hospital. *NEMJ* 1993;328:433–437.
43. Kuivalainen L, Ryhanen A, Isola A, Merilainen P. Sleep disturbances affecting hospital patients [in Finnish]. *Hoitotiede* 1998;10:134–143.
44. Bayo MV, Garcia AM, Garcia A. Noise levels in an urban hospital and workers' subjective responses. *Arch Environ Health* 1995;50:247–251.
45. Pattison HM, Robertson CE. Effect of ward design on the well-being of post-operative patients. *J Adv Nurs* 1996;23:820–826.
46. Yinnon AM, Ilan Y, Tadmor B, Altarescu G, Hershko C. Quality of sleep in the medical department. *Br J Clin Pract* 1992;46:88–91.
47. Topf M, Bookman M, Arand D. Effects of critical care unit noise on the subjective quality of sleep. *J Adv Nurs* 1996;24:545–551.
48. Freedman N, Kotzer N, Schwab RJ. Patient perception of sleep quality and etiology of sleep disruption in the inten-

- sive care unit. *Am J Respir Crit Care Med* 1999;159:1155–1162.
49. Topf M, Davis JE. Critical care unit noise and rapid eye movement (REM) sleep. *Heart Lung* 1993;22:252–258.
  50. Williamson J. The effects of ocean sounds on sleep after coronary artery bypass graft surgery. *Am J Crit Care* 1992;1:91–97.
  51. Heschong L. *Thermal delight in architecture*. Cambridge, MA: The MIT Press, 1990.
  52. Davidson AW, Bar-Yam Y. *Environmental Complexity: Information for Human–Environment Well-Being*. New England Complex System Institute. Online document at: <http://nesci.org/projects/yaneer/envcomp/html>
  53. Brawley E. *Designing for Alzheimer's Disease: Strategies for Creating Better Care Environments*. New York: John Wiley & Sons, 1997.
  54. Brawley E. Alzheimer's disease: Designing the physical environment. *Am J Alzheimer's Care Related Dis Res* 1992;2:3–8.
  55. Orians GH, Heerwagen JH. Evolved responses to landscapes. In: Barkow J, Cosmides L, Tooby J, eds. *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*. Oxford & New York: Oxford University Press, 1992:98–121.
  56. Parsons R. The potential influences of environmental perception on human health. *J Environ Psychol* 1991;11:1–23.
  57. Smith MJ. Human–environment process: A test of Rogers' Principle of Integrality. *Adv Nurs Sci* 1986;8:21–28.
  58. *Green Guidelines for Healthcare Construction: Creating High Performance Healing Environments*. Center for Maximum Potential Building Systems. Dec 2003. Online document at: [www.GGHC.org](http://www.GGHC.org)
  59. Stolwijk JAJ. Shelter and indoor air. *Environ Health Perspect* 1990;86:271–274.
  60. Heschong L. *Windows and Classrooms*. Fair Oaks, CA: Heschong Mahone Group. 2003.
  61. Zilber S. Review of health effects of indoor lighting. *Architronic* 1993;2(3). Online document at: <http://architronic.saed.kent.edu/v2n3/v2n3.06.html>
  62. Terman M, Lewy AJ, Dijk DJ, Boulos Z, Eastman CI, Campbell SS. Light treatment for sleep disorders: Consensus report. IV—sleep phase and duration disturbances. *J Biol Rhythms* 1995;10:135–147.
  63. Boivin DB. Influence of sleep–wake and circadian rhythm disturbances in psychiatric disorders. *J Psychiatry Neurosci* 2000;25:446–458.
  64. Mann NP, Haddow R, Stokes L., et al. Effect of night and day on preterm infants in a newborn nursery: Randomized trial. *BMJ (Clin Res Ed)* 1986;293:1265–1267.
  65. Miller CL, White R, Whitman TL, O'Callaghan MF, Maxwell SE. The effects of cycled versus noncycled lighting on growth and development in preterm infants. *Infant Behav Devel* 1995;18:87–85.
  66. Brandon DH, Holditch-Davis D, Belyea M. Preterm infants born at less than 31 weeks' gestation have improved growth in cycled light compared with continuous near darkness. *J Pediatr* 2002;140:192–199.
  67. Glotzbach SF, Rowlett EA, Edgar DM, Moffat RJ, Ariagno RL. Light variability in the modern neonatal nursery: Chronobiologic issues. *Med Hypoth* 1993;41:217–224.
  68. Beauchemin KM, Hays P. Sunny hospital rooms expedite recovery from severe and refractory depressions. *J Affective Dis* 1996;40:49–51.
  69. Barss P, Comfort K. Ward design and neonatal jaundice in the tropics: report of an epidemic. *BMJ (Clin Res Ed)* 1985;291:400–401.
  70. Heschong L. *Daylighting in schools: An investigation into the relationship between daylighting and human performance*. Summary for the Pacific Gas and Electric Company on behalf of the California Board for Energy Efficiency Third Party Program, August 1999.
  71. Shochat T, Martin J, Marler M, Ancoli-Israel S. Illumination levels in nursing home patients: Effects on sleep and activity rhythms. *J Sleep Res* 2000;9:373–379.
  72. Wakamura T, Hiromi T. Influence of bright light during daytime on sleep parameters in hospitalized elderly patients. *J Physiol Anthropol* 2001;20:345–351.
  73. Arneill B, Frasca-Beaulieu K. *Healing environments: architecture and design conducive to health*. In: Charnel P, Frampton SB, Gilpin L, eds. *Putting Patients First—Designing and Practicing Patient-Centered Care*. San Francisco: Jossey-Bass, 2003:163.
  74. Ulrich R. Effects of healthcare environmental design on medical outcomes. In: *Design & Health—The Therapeutic Benefits of Design*. Proceedings of 2nd International Congress on Design and Health. Karolinska Institute Stockholm, Sweden, June 2000:49–59.
  75. Ulrich RS. Effects of health facility interior design on wellness: Theory and recent scientific research. *J Health Care Des* 1991;3:97–109. Reprinted in Marberry SO, ed. *Innovations in Healthcare Design*. New York: Van Nostrand Reinhold, 1995.
  76. Ulrich RS. Effects of gardens on health outcomes: Theory and research. In: Marcus CC, Barnes M, eds. *Healing Gardens: Therapeutic Benefits and Design Recommendations*. New York: John Wiley & Sons, 1999:27–86.
  77. Ulrich RS. Evidence based environmental design for improving medical outcomes. Proceedings of the Healing by Design: Building for Health Care in the 21st Century Conference. Montreal, Quebec, Canada, March 1–10, 2000.
  78. Heschong L. *Windows and Offices*. Fair Oaks, CA: Heschong Mahone Group, 2003.
  79. Leather P, Pyrgas M, Beale D, Lawrence C. Windows in the workplace: Sunlight, view, and occupational stress. *Environ Behav* 1997;30:739–762.
  80. Keep PJ, James J, Inman M. Windows in the intensive therapy unit. *Anesthesia* 1980;35:257–262.
  81. Parker DL, Hodge JR. Delirium in a coronary care unit. *JAMA* 1967;201:702–703.
  82. Ulrich RS. Benefits of nature: View from a hospital bed. *Science* 1984;224:420–421.
  83. Clay RA. Green is good for you. *Monitor on Psychology*. 2001;32:1–16.
  84. Heerwagen JH, Johnson JA, Brothers P, Little R, Rosenfeld A. *Energy Effectiveness and the Ecology of Work: Links to Productivity and Well-Being*, 1998. Online document at: [www.sustainableportland.org/grn\\_rethink\\_heerwagen\\_5-9-03.pdf](http://www.sustainableportland.org/grn_rethink_heerwagen_5-9-03.pdf)
  85. Wilson LM. Intensive care delirium: The effect of outside deprivation in a windowless unit. *Arch Intern Med* 1972;130:225–226.

86. Cooper-Marus C. Gardens and health. In: Design & Health—The Therapeutic Benefits of Design. 2nd International Congress on Design and Health. Karolinska Institute Stockholm, Sweden, June 2000: 461–471.
87. Taylor FA, Kuo F, Sullivan C. Coping with ADD: The surprising connection to green play settings. *Environ Behav* 2001;33:54–77.
88. Kuo FE, Sullivan WC. Aggression and violence in the inner city: Effects of environment via mental fatigue. *Environ Behav* 2001;33:543–571.
89. Lohr VI, Pearson-Mims CH. Impact of interior plants on human stress and productivity. *J Environ Horticulture* 1996;14:97–100.
90. Lohr VI, Pearson-Mims CH. Physical discomfort may be reduced in the presence of interior plants. *Horticulture Technol* 2000;10:53–58.
91. Ulrich RS. Effects of exposure to nature and abstract pictures on patients recovering from open heart surgery. *J Soc Psychophysiol Res* 1993;30:204–221.
92. Aldridge D. The therapeutic effects of music. In: Jonas W, Crawford C, eds. *Healing Intentions and Energy Medicine*. Edinburgh: Churchill Livingstone, 2003.
93. Dubois J, Bartter T, Pratter M. Music improves patient comfort level during outpatient bronchoscopy. *Chest* 1997; 108:129–130.
94. Menegazzi JJ, Paris P, Kersteen C. et al. A randomized controlled trial of the use of music during laceration repair. *Ann Emerg Med* 1991;20:348–350.
95. Moss VA. Music and the surgical patient: The effect of music on anxiety. *AORN J* 1988;48:64–69.
96. Yilmaz E, Ozcan S, Basar M, Basar H, Batislam E, Ferhat M. Music decreases anxiety and provides sedation in extracorporeal shock wave lithotripsy. *Urology* 2003;61:282–286.
97. Knight WE, Rickard NS. Relaxing music prevents stress-induced increases in subjective anxiety, systolic blood pressure, and heart rate in healthy males and females. *J Music Ther* 2001;38:254–272.
98. Wang SM, Kulkarni L, Dolev J, Kain ZN. Music and pre-operative anxiety: A randomized, controlled study. *Anesthesiol Analg* 2002;94:1489–1494.
99. Nilsson U, Rawal N, Unestahl LE, Zetterberg C, Unosson M. Improved recovery after music and therapeutic suggestions during general anaesthesia: A double-blind randomized controlled trial. *Acta Anaesthesiol Scand* 2001;45:812–817.
100. Robertson P. Music and health. Design & Health—The Therapeutic Benefits of Design. Proceedings of the 2nd International Congress on Design and Health, Karolinska Institute, Stockholm, Sweden, June 2001:78.
101. Caine J. The effects of music on the selected stress behaviors, weight, caloric and formula intake, and length of hospital stay of premature and low birth weight neonates in a newborn intensive care unit. *J Music Ther* 1991;28:180–192.
102. Fry WF. The physiological effects of humor, mirth, and laughter. *JAMA* 1992;267:11857–11858.
103. Kaneda M, Oyama H, Katsumata, N. Summary—VR Intervention Therapy for Emotion Related Cancer Chemotherapy Side Effects. ICAT '99, The Virtual Reality Society of Japan. Waseda University, Tokyo, Japan. Dec 16–18, 1999:16–18.
104. Coates GJ. Seven principles of life-enhancing design: The architecture of Erik Asmussen. In: Design & Health—The Therapeutic Benefits of Design. 2nd International Congress on Design and Health. Karolinska Institute, Stockholm, Sweden, June 2001:73–79.
105. Martin D, Diehr P, Conrad D, et al. Randomized trial of a patient-centered hospital unit. *Patient Educ Couns* 1998;34: 125–133.
106. Malkin J. Hospital interior architecture: Creating healing environments for special patient populations. New York: Van Nostrand Reinhold, 1992.
107. Commission for Architecture and the Built Environment, CABE/ICM. Attitudes towards hospitals. Aug 2003: Online document at: [www.healthyhospitals.org.uk/news/news.html](http://www.healthyhospitals.org.uk/news/news.html)
108. Swan JE, Richardson LD, Hutton JD. Do appealing hospital rooms increase patient evaluations of physicians, nurses, and hospital services? *Health Care Manage Rev* 2003;28(3): 254–264.
109. Shepley M, Fournier M, McDougal K. *Healthcare Environments for Children and Their Families*. Dubuque, IA: Kendall-Ward, 1998.
110. Frampton S. Patient satisfaction: Focus group results. *Plane-Talk Newsletter*, Summer 2002:1–2.
111. Zeisel J, Silverstein NM, Hyde J, et al. Environmental correlates to behavioral health outcomes in Alzheimer's special care units. *Gerontologist* 2003;43:697–711.
112. Wilmott M. The effect of a vinyl floor surface and a carpeted floor surface upon walking in elderly hospital in-patients. *Age Ageing* 1986;15:119–120.

Address reprint requests to:  
*Marc Schweitzer, M.Arch.*  
*The Design Partnership*  
*1412 Van Ness Avenue*  
*San Francisco, CA 94109*

*E-mail:* marc@dpsf.com

