Effects of Healthcare Environmental Design on Medical Outcomes

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The goal of DCHP 2000 is to create a multidisciplinary scientific forum for presenting research and new ideas toward improving the quality of hospital design and care. A premise motivating the conference is that the quality of the design of physical environments can affect patient medical outcomes and care quality. An important impetus for the growing international awareness of healthcare facility design has been mounting scientific evidence that certain environmental design strategies can promote improved outcomes whereas other approaches can worsen patient health.

The theme of DCHP 2000 reflects the shift in the scientific or mainstream medical community away from a narrow pathogenic conception of disease and health towards an expanded perspective that includes emphasis on health-promoting experiences and processes. Accordingly, conditions or experiences shown by medical researchers to be healthful, such as social support and pleasant distraction or entertainment, now become much more important considerations in creating new healthcare facilities and organizational models for delivering care. By contrast, the traditional pathogenic perspective implied that the main requirement placed on healthcare facilities should be construed narrowly as the reduction of infection or disease risk exposure. Also, decades of advances in medical science conditioned many healthcare designers and administrators to concentrate on creating buildings that succeeded as functionally efficient delivery platforms for new medical technology. The emphasis on functional efficiency, together with the pathogenic conception of disease and health, has often produced healthcare facilities with environments now considered starkly institutional, stressful, and detrimental to care quality (Ulrich, 1991, 1992; Horsburgh, 1995). In spite of the major stress caused by illness and traumatizing hospital experiences, comparatively little emphasis has been given to creating surroundings that calm patients, strengthen their coping resources, or otherwise address psychological and social needs.

The new broader perspective in medicine requires that the psychological and social needs of patients be strongly emphasized along with traditional economic and biomedical concerns, including disease risk exposure and functional efficiency, in governing the care activities and design of healthcare buildings. *DCHP 2000* was planned with the goal of stimulating progress in identifying and understanding aspects of the physical

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environment able to support patients' psychological and social needs and to improve medical outcomes.

Healthcare Changes that Form the Backdrop for DCHP 2000

Several important healthcare trends and changes form the background or context for the conference. Most of the trends hold across "modern" healthcare systems internationally, regardless of whether systems provide care universally to all residents through government insurance or entitlement (Sweden or Canada, for example), or whether care is supported by a mix of private and government means, and is not universally available (as in the United States). These trends have produced challenges and forces that are propelling significant changes in healthcare, and creating pressures for new types of healthcare buildings, improved building design, and for patient-centred care philosophies. These diverse healthcare trends and changes include the following:

- Strong pressures to reduce costs yet improve quality
- Growing numbers of elderly
- Shifts in healthcare demand and facility use patterns
  - Examples: increased need for outpatient/ambulatory and long-term care, shorter inpatient stays for acute care, yet greater demand for critical care
- Need to adopt effective but costly new medical technologies and treatments that often require new facility designs
- Mounting demands to increase patient *satisfaction*
- Growing stresses, work demands for healthcare staff
  - Declining staff/patient ratios
  - Related problems such as attracting and retaining quality employees
- Advances in mind/body medicine that have convinced the mainstream medical community that stress and psychosocial factors affect health
- Increasing adoption of patient-centred or family-centred care philosophies requiring new types of buildings and organizations
- Mounting scientific research linking well-designed healthcare environments to improved outcomes, poorly designed facilities to worsened outcomes
  - Criticism internationally of much hospital design as stark, unpleasant, stressful.

Objectives of Paper

Against the background of the above developments which have made improving healthcare design a major priority, the next sections will focus on the last of these, environmental design research. The discussion will concisely review the limited amount of scientific research linking healthcare environmental characteristics to improved health outcomes. It will become evident that, although the amount of research is steadily growing, there is no sound, directly relevant research yet available for many healthcare environmental design questions. To suggest promising design approaches in situations when gaps exist in research knowledge, the discussion will outline a Theory of Supportive Healthcare Design that generates design guidelines that can be flexibly applied to a wide range of healthcare environmental questions. Finally, advantages will be summarized, such as improved outcomes and cost savings, that healthcare administrators concerned with quality and costs can reasonably expect to achieve through evidence-based supportive design of a new healthcare facility.

General state of scientific knowledge

The status of research on environmental design/health relationships has been evaluated by Dr. Haya Rubin and her associates at the Johns Hopkins Medical School (Rubin et al., 1998). The investigators located upwards of 85 published studies, which met criteria for scientific rigor such as using an experimental design with random assignment. (In the three years since the

Johns Hopkins report was prepared, the number of such scientific studies may have grown to approximately 100.) Rubin and her colleagues observed that this amount of research is small by the standards of established medical fields, but enough quality research has appeared to justify the conclusion that "there is suggestive evidence that aspects of the designed environment exerts significant effects on clinical outcomes for patients" (Rubin et al., 1998). When forming an assessment of an emerging research field, scientists pay particular attention to the success rate with respect to positive findings of the portion of studies that uses the strongest, most rigorous methods. It is encouraging, therefore, that the Johns Hopkins report indicated that an impressively high percentage (80%) of the most rigorous studies found positive links between environmental characteristics and patient health outcomes.

The next section lists and briefly discusses several types of environmental characteristics that studies indicate can affect outcomes. The review is selective and does not include all environmental factors that may influence patient health. The discussion draws on the report by Rubin and her associates (Rubin et al., 1998) and especially on reviews by the author (Ulrich, 1991, 2000a, 2000b).

Environmental characteristics found to influence health outcomes

Noise. Several studies have found that hospital noise levels are often high (65–85 dB), and produce widespread annoyance among patients and perceived stress in staff (Hilton, 1985; Bayo, Garcia, and Garcia, 1995). A limited amount of research has investigated the effects of noise on outcomes, particularly in critical or intensive care units. Most findings suggest that noise detrimentally affects at least some outcomes, for example, producing sleeplessness and elevating heart rate (e.g., Yinnon et al., 1992; Hilton, 1985). Recent evidence indicates that even when sound intensity levels are kept at relatively low levels (27–58 dB), differences in room reverberation times or echo/liveliness characteristics are associated with variations in sleep quality (Berg, in press). In this regard, Berg (in press) found that hospital rooms with shorter reverberation times produced by sound-absorbing ceiling tiles reduced sleep fragmentation as measured by EEG. Berg's findings raise the possibility that relatively low noise levels that do not consciously awaken patients nonetheless worsen sleep quality in rooms with poor acoustic properties.

Windows Versus No Windows. Notable evidence of negative effects of windowless healthcare environments on outcomes has emerged from studies of critical-care patients. Studies have linked the absence of windows in critical or intensive care with high rates of anxiety, depression, and delirium relative to rates for similar units with windows (Keep et al., 1980; Parker and Hodge, 1976). It is thought that lack of windows may worsen outcomes by reducing positive stimulation and aggravating the negative effects of sensory deprivation associated with such conditions as repetitive sounds of respirators (Ulrich, 1991). Diverse patient groups accord high importance to having a window view of nature (e.g. Verderber, 1986). Regarding employees, those with window views of nature report less stress, better health status, and higher job satisfaction in a variety of workplaces than do comparable groups with views of built environments, and especially compared to employees lacking windows (e.g. Leather et al., 1997). A later section dealing with natural and other positive distractions will survey studies indicating that nature views can also reduce patient stress and improve other health outcomes.

Sunny Rooms. Findings from two studies raise the possibility that patient rooms looking out on sunshine, rather than cloudy or drab conditions, foster more favourable outcomes (Beauchemin and Hays, 1996, 1998). Both studies, it should be noted, were performed in a Canadian hospital in a northern latitude location having long winters with relatively few hours of daylight. The investigators found in the first study that patients hospitalized for severe depression had shorter

stays if assigned to a sunny rather than a "dull" room overlooking spaces in shadow. In the second investigation, myocardial infarction patients in coronary critical care had lower mortality when assigned rooms overlooking sunny spaces rather than north-facing rooms overlooking spaces in shadow (Beauchemin and Hays, 1998). Based on the first finding that sunny rooms appear to alleviate depression, the researchers speculated that a mechanism accounting for reduced mortality among myocardial infarction patients assigned sunny views likewise was depression mitigation. Regarding employees, questionnaire studies across a variety of workplaces have shown that staff like window views of spaces illuminated by sunshine rather than cloudy conditions. Both employees and patients, however, may respond negatively if windows are exposed directly to the sun and create bright glare patches in room interiors (Boubekri, Hull and Boyer, 1991).

Multiple Occupancy Versus Single Patient Rooms. Mounting concern for controlling infection from antibiotic resistant pathogens has become an important consideration favouring single- over multiple-occupancy patient rooms, especially for intensive or critical care (Ognibene, 2000). This point is bolstered by limited evidence that infection rates in critical care units can be lower in single rooms than open wards (Shirani et al., 1986).

There is inadequate research on acute-care patients to clarify definitively whether single- versus multiple- occupancy rooms are better from the standpoint of supportive environmental characteristics and improved outcomes (Ulrich, 2000b). Advocates of multiple occupancy point out that initial construction costs per bed are lower for multiple- than single-occupancy acute care units. They may further argue that anecdotal evidence suggests that acute patients sharing a room provide each other with healthful social support. Single-room proponents, on the other hand, claim that incompatibility or conflict among roommates leads to costly room changes and patient moves that may outweigh initial construction cost advantages for multiple occupancy. This argument receives indirect yet persuasive support from several scientific studies performed in different countries that have identified the presence of other patients in multiple-occupancy rooms as a major source of perceived stressors such as loss of privacy (e.g. Van der Ploeg, 1988). Moreover, noise research clearly indicates that sounds stemming from the presence other patients in multiple occupancy rooms (patient sounds, equipment, staff talking) are often the single most important factor negatively impacting sleep in both acute care and intensive care (Yinnon et al., 1992; Southwell and Wistow, 1995). Notwithstanding these and other findings, more research is needed to shed light on questions such as the extent to which beneficial and stressful psychosocial aspects of multiple- versus single-occupancy rooms might vary according to culture.

Flooring Materials. A small but growing body of research has compared the advantages for patients of different types of flooring materials, including carpet and hard or glossy materials such as vinyl composition and linoleum. There are increasing indications that carpet is superior from the standpoint of certain patient-centred considerations (Ulrich, 2000b). Elderly patients walk more efficiently (longer steps, greater speed) and feel more secure on carpeted compared to vinyl surfaces (Wilmott, 1986). Harris (2000) found that family and friends made longer visits to rehabilitation patients when patient rooms were carpeted rather than covered with vinyl composition flooring. Her finding justifies the speculation that carpet in patient rooms, and possibly waiting areas, might promote improved patient outcomes via an effect of heightening social support from visitors. Harris' work also showed that the great majority of patients preferred carpet to vinyl composition flooring for reasons such as slip resistance and perceived comfort. Employees, however, overwhelmingly favored vinyl composition (83%) mainly because of greater ease in cleaning up spills (Harris, 2000).

Furniture Arrangements. Much research focusing on waiting areas, day rooms, and lounges

has demonstrated that the widespread practice of arranging seating side-by-side along the walls of a room markedly inhibits social interaction among patients or other users (e.g. Sommer and Ross, 1958; Holahan, 1972). These studies also indicate that levels of social interaction can be increased – and presumably beneficial social support enhanced as well – by providing in day rooms and other spaces comfortable movable furniture arranged in small flexible groupings. Other research on psychiatric wards and nursing homes strongly suggests that appropriate arrangement of movable seating in dining areas not only enhances social interaction but can have important positive effects on eating behaviours, such as increasing the amount of food consumed by geriatric patients (Melin and Gotestam, 1981; Peterson et al., 1977).

Other Environmental Factors. In addition to the environmental characteristics discussed above, certain other factors have been the focus of multiple studies, including music, art, nature, and air quality (Ulrich, 2000a, 2000b). Concerning air quality, much research indicates that ventilation and filter systems that produce ultraclean air in areas such as intensive care, procedure rooms, and acute care units, are very important for reducing infection occurrence and improving other outcomes (e.g. Everett and Kipp, 1991; deSilva and Rissing, 1984). Hospital renovation and nearby construction, however, can worsen air quality in patient care and treatment areas, and may negatively impact outcomes unless mitigating steps are taken (Loo et al., 1996).

Several studies have shown across a variety of patient groups that pleasant music, especially when controllable by patients, often can reduce anxiety or stress and help some patients cope with pain (e.g. Standley, 1986; Menegazzi et al., 1991). Research on art and nature will be discussed as part of a later section on positive distractions.

A theory of supportive healthcare design

The foregoing sections surveyed examples of the limited amount of scientific research on the links between environmental characteristics and outcomes. As was earlier pointed out, the volume of studies is growing but there is no sound directly relevant research yet available for many healthcare design questions. The Theory of Supportive Design now outlined proposes broad design guidelines that can generate design directions in situations where gaps exist in knowledge. The Theory and guidelines are underpinned by a large amount of "indirectly" relevant research in health psychology, environmental psychology, behavioral medicine, and other health-related fields (Ulrich, 1991, 1999, 2000a). Because the guidelines suggest comparatively evidence-informed directions for design solutions, the design approaches seem likely to prove successful in promoting improved patient outcomes.

The Theory of Supportive Design proposes that the capability of healthcare environments to foster improved outcomes is linked to their effectiveness in promoting stress reduction, buffering, and coping (Ulrich, 1991, 1999, 2000b). Stress is a documented problem for the great majority of patients, for families and visitors as well, and is pervasive among healthcare employees. Alleviating patient stress is a significant clinical goal because stress is both an important negative health outcome in itself and has a variety of detrimental psychological, physical, and behavioural effects that worsen other outcomes (Gatchel et al., 1989; Cohen et al. 1991).

Supportive Design Defined

The term *supportive* here refers to environmental characteristics that support or facilitate coping and restoration with respect to the stress that accompanies illness and hospitalization. By having restorative and buffering effects on stress, and by enhancing coping and other healthful resources, supportively designed healthcare environments

can foster gains in numerous other patient health outcomes (Ulrich, 1991, 1999).

At a general level, the process of supportive healthcare design begins by eliminating environmental characteristics that are known to be stressful or can have direct negative impacts on outcomes (loud noise, for instance). Additionally, supportive design goes a major step further by emphasizing the inclusion of characteristics and opportunities in the environment that research indicates can calm patients, reduce stress, and strengthen coping resources and healthful processes (Ulrich, 1991, 1999, 2000a). To aid in identifying evidence-informed design strategies that should tend to be successful in reducing stress and improving outcomes, a multidisciplinary review was undertaken of theory and scientific research in the behavioural sciences and health-related fields. On the basis of the review, the following general guidelines are proposed for creating supportive healthcare environments:

- Foster *control,* including *privacy*
- Promote *social support*
- Provide access to *nature* and other *positive distractions*.

Design Guideline: Foster Control and Privacy

Control refers to an individual's real or perceived to influence their situations and determine what others do to them (Gatchel et al., 1989). A great deal of research has indicated that people who feel they have some control over their circumstances deal better with stress and have better health than persons who lack a sense of control (Evans and Cohen, 1987). Loss of control is a major problem for patients that produces stress and adversely affects outcomes (Taylor, 1979; Ulrich, 1991, 1999). Aspects of illness and hospitalization that erode feelings of control include, for instance, painful and unavoidable medical procedures, impaired physical capabilities, lack of information, and loss of control over eating and sleeping times (Taylor, 1979). Control is further undermined by poorly designed, unsupportive healthcare environments that, for example, are noisy, deny visual privacy, force bedridden patients to stare at glaring ceiling lights, and present way-finding difficulties (Ulrich, 1991, 1999). Importantly, provision of actual or perceived control over stressors or unpleasant situations usually alleviates stress (Evans and Cohen, 1987). Healthcare design characteristics that enhance feelings of control, therefore, should tend to mitigate stress and improve other outcomes. Examples of design approaches for promoting feelings of control for patients include providing: bedside dimmers that enable control over lighting; privacy in imaging areas; televisions controllable by individual patients (Ulrich et al., in press); headphones that allow personal choice of music; gardens accessible to patients in wheelchairs; and architectural design and signs that make wayfinding easy in large hospitals (Ulrich, 1991, 1992, 2000b).

In addition to plaguing patients, loss of control is an important problem for healthcare employees because their jobs often combine an overload of demanding responsibilities with low decision latitude or authority (Teikari, 1995; Shumaker and Pequegnat, 1989). Examples of design approaches for promoting employee feelings of control include providing comfortable break rooms that give staff a sense they can escape briefly from workplace demands and stressors (Ulrich, 1991, 2000b), and easily adjustable workstations (O'Neill and Evans, 2000).

Design Guideline: Foster Social Support

Social support refers to emotional support and tangible assistance that a person receives from others. Much research has shown across a wide variety of situations that persons who receive higher social support generally experience less stress and have better health than those who are more socially isolated (Shumaker and Czajkowski, 1994). Studies of several different categories of patients have indicated that social support improves, for example, recovery outcomes in myocardial infarction patients, and survival length in patients with metastatic cancer (e.g. Spiegel et al. 1989). Despite a shortage of research focusing directly on healthcare facility design, the

evidence showing benefits of social support across other health-relevant contexts is so convincing that it seems clearly justified to suggest that design promoting social support for patients should tend to mitigate stress and improve other outcomes (Ulrich, 1991, 2000a, 2000b).

Examples of the many possible design approaches for increasing social support for patients include providing the following features to encourage and support the presence of family and friends: comfortable waiting areas with movable seating; convenient access to food, telephones, and rest rooms; attractive gardens with sitting areas that facilitate socializing with patients; and convenient overnight accommodations (Ulrich, 1991, 2000b). Design approaches for fostering healthful social support for employees include, for instance, providing pleasant gardens that facilitate social interaction among staff (Marcus and Barnes, 1999), and comfortable break areas with flexible movable seating.

Design Guideline: Provide Access to Nature and other Positive Distractions

Positive distractions refer here to a subset of environmental-social conditions marked by a capacity to improve mood and effectively promote restoration from stress (Ulrich, 1991,1999, 2000b). It has been theorized that these phenomena have been associated with critical advantages for humans during more than a million years of evolution. Accordingly modern humans as a genetic remnant of evolution might have a predisposition to react positively and pay attention to the following types of features or environmental-social content: comedy or laughter, caring or smiling human faces, music, companion animals, and nature such as trees, flowers, and water (Ulrich, 1999; Ulrich et al., 1991). This section will concentrate on the last, nature, and briefly survey research that has examined the effects of *viewing* nature on stress and other health outcomes.

Findings from several studies of nonpatient groups (such as university students) as well as patients have converged in indicating that simply viewing certain types of nature can significantly ameliorate stress within only five minutes or less. (For a review of studies see Ulrich, 1999). When persons experience stress or anxiety, looking at particular kinds of nature scenes rather quickly produces mood improvement and elicits beneficial physiological changes such as lower blood pressure and reduced heart rate (e.g. Ulrich et al., 1991). Further, a limited amount of research has found that prolonged exposure to nature views not only helps to calm patients, but can also have positive effects on other health outcomes. A study of surgery patients, for example, found that those with a bedside window overlooking trees had more favourable recovery courses than patients overlooking a brick building wall (Ulrich, 1984). The patients with the nature window view, compared to the wall view group, had shorter hospital stays, tended to have fewer minor post-surgical complications, and needed fewer doses of strong pain drugs. In other research, Ulrich and colleagues (1993) used an experimental design to investigate whether exposure to a nature picture in intensive care improved recovery outcomes in heart surgery patients. Compared to patients assigned abstract pictures and control groups given no pictures, patients exposed to a nature view of water and trees less anxiety and required fewer strong pain doses (Ulrich, Lunden, and Eltinge, 1993). In the same study, findings suggested that patients had less favourable recovery outcomes if they were assigned an abstract picture dominated by rectilinear forms than if they were assigned to control groups with no pictures.

Additional evidence of positive influences of nature comes from a small body of research on patient emotional reactions to different types of art (Ulrich, 1999, 2000b). The great majority of patients prefer realistic art depicting serene natural environments having scattered trees and/or non-turbulent water features (Carpman and Grant, 1993; Ulrich, 1991). Abstract art, and particularly emotionally challenging or provocative works, are consistently disliked by patients (Ulrich, 1991, 1999). Although environmental designers, artists, and some healthcare staff react positively to

abstract or challenging images, there is mounting evidence that such content or styles in pictures can increase stress and worsen other outcomes in many patients. (Ulrich, 1991, 1992, 1999). Caution should be exercised before displaying ambiguous, challenging art in patient spaces or high-stress waiting and treatment areas (Ulrich, 1999, 2000bb).

A growing but limited amount of research on *gardens* in healthcare facilities (Marcus and Barnes, 1999) suggests that gardens will tend to alleviate stress effectively if they contain green or relatively verdant foliage, flowers, non-turbulent water, park-like qualities (grassy spaces with scattered trees), and compatible nature sound (birds, water, breezes) (Ulrich, 1999). Apart from providing soothing gardens that can be easily accessed by family, patients, and staff, examples of other design approaches for fostering access to nature include providing: nature window views for patient rooms, waiting areas, and staff spaces; an aquarium in a high-stress waiting area; an atrium with greenery and a fountain; and calming nature art mounted where bedridden patients can readily see it (Ulrich 1992, 2000b).

Advantages and costs of evidence-based supportive design

One way to summarize the emerging field of evidence-based design is by addressing the question: What advantages can healthcare administrators, medical professionals, designers, and the general public reasonably expect to achieve by including supportive design criteria in the objectives for a new facility? The list of advantages below was identified on the basis of a broad yet reasonably cautious assessment of the available scientific research (Ulrich, 2000a, 2000b). The advantages are stated in terms of improved outcomes that seem realistically attainable assuming that a facility is well designed given current research knowledge (Ulrich, 2000b).

- **Reduced stress/anxiety for patients and family**
  – Likelihood of achieving given current research: *very high*
- **Reduced pain**
  – Likelihood of achieving: *moderately high* for some patient categories
- **Improved sleep quality**
  – Likelihood: *high*
- **Lower infection occurrence**
  – Likelihood: *moderately high,* especially for intensive or critical care
- **Improved patient satisfaction**
  – Likelihood: *very high*
- **Benefits for employees** (reduced workplace stress, improved satisfaction, possibility of reduced turnover, improved capability of workplace to attract and retain qualified employees)
  – Likelihood: *high* that at least some will be attained
- **Cost savings** by improving medical outcomes (examples: reduced infection occurrence; reduced intake of costly strong analgesics; some patients might be moved sooner from intensive or acute care to less costly care)
  – Likelihood: *moderate to moderately high,* depending on extent to which hospital is well designed throughout

Finally, healthcare administrators, medical professionals, and politicians might ask whether an emphasis on evidence-based supportive design would increase construction costs for a major facility. Both to reduce costs and greatly increase the potential advantages of such design, it is very important that evidence-informed design goals and approaches be included early rather than late in the process of facility programming and design (Ulrich, 1992, 2000b). Involvement in the initial stages is important because supportive considerations can potentially affect the architectural form and internal configuration of a facility, as well as interior design. If such objectives are introduced at a late stage, major opportunities tied to larger-scale architectural, planning, and possibly siting decisions will be lost (Ulrich, 1992).

When evidence-informed goals are included in the beginning project stages, most strategies

probably cost no more than poorly conceived or traditional unsupportive approaches, and many cost less (Ulrich, 2000b). It is common to find healthcare facilities built in recent years that were costly to construct on a square-metre basis yet have major inadequacies when assessed according to evidence-based environmental criteria such as noise levels, access to privacy, or facilitation of social support. Considering costs over a period of several years, facility design and construction costs are usually low (less than 10%) compared to expenses for facility operation, employee salaries, and the day-to-day delivery of healthcare (Ulrich, 1991, 1992).

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