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Sustainable Design in the Healthcare Environment

An Honors Thesis submitted in partial fulfillment of the requirements for Honors in Interior Design.

By
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Under the mentorship of Mrs. Amy Boyett

ABSTRACT
From creating an efficient business to helping people heal, there are various and difficult goals in a healthcare project. There are significant issues in healthcare design that can be harmful to the people that inhabit the spaces and to the environment. Through evidence-based research, this paper will outline the latest developments in sustainable design and how they can be implemented to solve the current building-related issues in healthcare facilities. Lastly, the solutions will be put into practice in a Healthcare Design Capstone Project utilizing the elements of sustainable design to achieve the goal of sustaining the health of occupants, the environment, and building operations.

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Honors Director: ________________________  Dr. Steven Engel

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Sustainable Design in the Healthcare Environment

Sustainable Design is a relatively new branch of the building and development industry. It can also be referred to as Environmental Design, but it encompasses the social, economic, and environmental facets of any development project. Through evidence-based research, this paper will outline the latest developments in sustainable design and how they can be implemented to solve the current building-related issues in healthcare facilities. Lastly, the solutions will be applied in the student’s Healthcare Design Capstone Project utilizing the elements of sustainable design to achieve the goal of sustaining the health of occupants, the environment, and building operations.

Sustainable Design strives to create responsible spaces by looking at the three facets and determining the best practices for each project. Responsible decisions for design include looking at the location of the project and not disturbing natural processes or ecosystems. It also includes how a development project uses energy, water, and other resources throughout the life cycle of the building. There are many certification systems, such as LEED and the Living Building Challenge, that rate buildings on the efficiency of sustainable principles and practices.

Sustainable Design is preferred on the social level because it puts the welfare of occupants on the forefront of design discussions - both for the present and the future generations (Russ, 2010). Sustainable Design is seen as "best practices" because it minimizes the life cycle and maintenance costs of a building, and it also reduces the negative impact of a building on the natural environment, and some new buildings are
even striving to create a positive effect on the environment (Living Building Challenge, 2014).

Healthcare is one branch of the Design Industry that is slow to change on the environmental front. Because healthcare is such a vital industry, healthcare spaces cannot take the time and money to make new changes. According to the American Hospital Association, there are several factors that account for the slow change. The factors include a lack of funds, underfunded operation and maintenance budgets, other priorities of administration, lack of management commitment and support, or the assumed long wait on the return of investment for such changes (American Hospital Association, 2015).

When sustainable solutions are not implemented in healthcare spaces, there are health problems related to unsustainable building practices; problems include carbon emissions that can lead to cancer or other illnesses, sick building syndrome, respiratory illnesses, anxiety, moodiness, depression, and allergies (American Hospital Association, 2015). It creates a sort of irony because the one place that people go to heal is the place that is slowly killing them through emissions and toxic materials. A study by Dr. Wieslander et. al. in 1999 studied the nasal and ocular health of workers and patients in a healthcare facility and how it is related to the design of the building and indoor air pollution. They concluded that inadequate building ventilation and poor indoor air quality negatively impacted the care and wellness of the workers and patients in the four healthcare facilities they studied (Wieslander et. al. 1999). Interior design can have
a positive impact on the issues when considering indoor air quality and occupant comfort.

Another issue in healthcare buildings is the rising costs to run and operate the facility. According to the American Hospital Association, hospitals consume two-and-a-half times more energy than other commercial buildings and produce 30 pounds of Carbon Dioxide per square foot (American Hospital Association, 2015). “Since 1970, health care spending has grown at an average annual rate of 9.8%, ....and is projected to be 20% of (the United States’) GDP in 2015,” (Kaiser Foundation, 2007). Because of advances in technology and the sheer span of the healthcare industry, a lot of energy is required (Kaiser Foundation, 2007), but if careful planning went into how a facility received (or even created) its energy, healthcare costs could be lowered significantly (American Hospital Association, 2015).

Healthcare buildings are notorious for high energy bills, inefficiency, and poor worker satisfaction; they also are known to create anxiety or unease in patients. The problems of healthcare design can be alleviated by utilizing evidence-based design to research and develop sustainable design solutions that not only promote the wellness of people, but also consider the environment and the business of a healthcare facility (Berry et. al., 2004).

In light of all of the issues associated with healthcare design, the good news is that there are many varied and successful solutions that can be implemented in the healthcare setting. Due to research and the social push for more sustainable practices, it is proven that an integrative and sustainable design will improve the health, the
environmental impact, and the operational costs of a healthcare facility Berry et. al., 2004). One of the top complaints in the healthcare setting is the lack of a quiet, healing environment (Centers for Medicare and Medicaid Services, 2012). People use healthcare facilities in some of the most stressful and fearful times of their life. They usually are questioning the health and longevity of themselves or loved ones. Healthcare facilities are also one of the most stressful workplaces because the staff daily takes other people’s lives into their hands. Whether administering medication or suturing a trauma patient, all workers experience the heightened sense of urgency that their roles require. Designing for this level of stress, urgency, and uncertainty can prove a challenge for many designers and architects, but sustainable design addresses all of the questions and provides viable solutions to the varied psychological and physical needs of the healthcare environment.

To address the various psychological needs of patients and staff in the healthcare setting, sustainable designers look to nature and the human response to the natural environment. Biophilia is defined as “the humankind’s innate biological connection with nature.” (Browning et. al., 2014). Biophilia is not a new phenomenon; in fact, E.O. Wilson asserts that it is based on evolution and that contact with nature is a basic human need (Heerwagen, 2009). Dr. Judith Heerwagen, an environmental psychologist and affiliate faculty member at the University of Washington, explains human affinity for nature as a universal primary need (2009). Historically, cultures worked, played, socialized, and worshipped in the natural “outside” environments (Heerwagen, 2009). For the majority of human existence, nature provided everything
that humans needed for survival. The sun provided warmth and light, shelter was found high in trees or in caves, animals and plants provided food and medicine, and water gave cleanliness and early forms of travel (Heerwagen, 2009). Thus, biologically, humans associate nature with survival, life, and wellbeing.

Nature has an inseparable link to health and wellness. Common vacation destinations, such as hiking in the mountains, sunbathing on the beach, or rock climbing in an exotic location, are all proof of the restorative and healing effect of the natural environment (Heerwagen, 2009). Dr. Heerwagen states, “Even small spots of nature – a flower pot, tree, or a small garden – also delight” (2009).

The measured benefits of nature on a person relate to improved mood (happiness) and reduced stress levels. This has been measured in field studies of various environments and in the laboratory, and results are consistent (Heerwagen, 2009). Dr. Heerwagen goes on to explain:

“Furthermore, contact with nature can be purely visual or multi-sensory, active engagement (walking, running, gardening) or passive (viewing only). Benefits are found in multiple settings, multiple cultures, and across the age-span, from early childhood to late adulthood” (2009).

The first test to verify the supposed health benefits of nature on a person was done by Roger Ulrich in 1984 (Heerwagen, 2009). In a well-documented and controlled hospital setting, Ulrich tested the effect of window views on hospital patient outcomes. All patients had the same procedure, and two groups were made with the same ages,
genders, and general health conditions in both groups. The first group had a window that had a view of a brick wall, and the second group had a window with a view of trees and landscaping. The group with the nature view used less narcotics and milder analgesics (showing lower amounts of pain), and they also had a more positive recovery and left the hospital 75% faster than the group with the view of the brick wall. (Berry et. al., 2004). Again, according to Heerwagen, results can be duplicated with real or simulated views of nature (Heerwagen, 2009).

There are six Biophilia Principles that Dr. Heerwagen outlines in the article *Biophilia, Health, and Well-being*, and the principles help designers incorporate biological processes in the biophilic design of their projects. The first principle is Motion (Heerwagen, 2009). Nature is always moving; it is like a rhythm that water, clouds, leaves, and the sun can hear. Constant, steady movement indicates consistency and security (Heerwagen, 2009). Movement can be incorporated in an interior space by showcasing the sunlight’s path as it moves through the space, or with visual patterns and lines that keep the eye moving throughout the space.

The second principle of biophilic design is Resilience. Every living thing (and even non-living) shows a pattern of change and evolution to meet new challenges. There are cycles of new life and death, winter and summer, day and night, even with storms and diseases, nature has a profound way of bouncing back (Heerwagen, 2009). Buildings can be created to have the same type of resilience if the entire life of the building is considered. Old and derelict buildings’ parts can be reused in new construction to limit the amount of waste it produces (Heerwagen, 2009). New buildings can be made to last
a long time and then created to be reused in a different way when their useful life is
over. Examining the life-cycle of a building is a vital component to sustainable design,
and it must be considered when designing for ecological and social responsibility
(McDonough & Braungart, 2009).

The third principle is Variation. Variation creates interest, but it must also be
balanced with similarity (Heerwagen, 2009). Referred to as “rhyming,” variation finds
the balance of what is known with what is different – such as a vase of roses (the same),
with three colors of roses (different). Variation can be incorporated in an interior space
by various textures and colors to relate way-finding or other communication to
occupants (Heerwagen, 2009).

The fourth principle of biophilic design is Complexity, and it is not seen as hard to
understand, but as a deeper layer than what is only on the surface (Heerwagen, 2009).
In any insect, rock, or other natural element, one can learn something new by taking a
closer look and exploring. If an interior incorporated this element, it would encourage
users to keep coming back because they would constantly discover something new.
Practical ways to apply the fourth principle would be in the detailing of different finishes
on walls, panels, floors, and ceilings. Complexity could also be utilized in the way a space
responds to certain times of day or seasons of the year. Sustainable buildings, through
passive solar design, can respond to temperature changes to heat and cool a space as
needed (Steven Winter Associates, 1998). Complexity creates a new appreciation every
time something is studied, and that is what all designers should strive for in a space
(Heerwagen, 2009).
The next principle is Transformability (Heerwagen, 2009). Nature readily transforms into a quiet sanctuary or a social gathering place, as seen when children imagine and play outdoors (Heerwagen, 2009). Also known as “design for multi-use,” transformability allows spaces to be flexible and adaptable to all users for any function. Transformability strongly relates to universal design and the fact that quality spaces should be accessible by all, no matter the socio-economic class or disability (Heerwagen, 2009). By designing interior spaces for multiple uses, designers can lengthen the useful life of any building.

The last principle is Multi-Sensory (Heerwagen, 2009). The natural environment affects every sense of the human body. From sight and hearing to smell and touch, nature impacts every facet of our senses. Heerwagen describes a growing movement in the design world that emphasizes an emotional experience in the design of interior environments (2009). Currently, in healthcare, many hospitals and physicians’ offices feel like an institution, and hallways are seas of grey or beige— as if separating emotion from the spaces where people spend many hours of their time. In a study done by the Centers for Medicare and Medicaid Services (2012), a more comfortable and relaxing environment was a top concern for patient satisfaction in the healthcare setting, and many facilities do not accurately address the need for emotional and sensory experience of a space.

Paula Melton, a professor at Boston Architectural College and a major contributor of the online periodical BuildingGreen.com, agrees that spaces should be a pleasant and sensory experience: “The green building community is trying to bring joy
back to architecture – with design solutions that also enhance the durability and performance of buildings and neighborhoods” (2014). Beauty is a major requirement of The Living Building Challenge, the world’s most stringent and rigorous green building certification system. The Living Building Challenge challenges all of humanity to “reconcile the built environment with the natural environment,” with the goal of every act of design and construction becoming an act to make the world a better place (Living Building Challenge, 2014).

The Living Building Challenge says the beauty requirement is to “recognize the need for beauty as a precursor to caring enough to preserve, conserve, and serve the greater good…. When we accept billboards, parking lots, freeways, and strip malls as being aesthetically acceptable, in the same breath we accept clear-cuts, factory farms, and strip mines” (Living Building Challenge, 2014). Beauty is incorporated into a design project through use of features that delight humanity and celebrate culture and place (Living Building Challenge, 2014).

With the recent changes in the healthcare system, beauty will help to change the perspective of care. There is a shift for facilities to focus on the promotion of wellness, instead of the prevention of sickness (Melton, 2014). Facilities should become more beautiful, comfortable, and a place the public can come to stay well, not just get better. Melton says that buildings must be designed for people first, not automobiles or technology: “If it doesn’t work for people, it’s never going to work for the planet” (2014). To promote occupant comfort, designers plan for areas that give occupants a sense of control over their environments (Melton, 2014).
A sense of control is especially important in the healthcare environment because, often, patients may feel out of control and anxious in their surroundings (Berry et al., 2004). The key to giving occupants the sense of control is to give them choices (Melton, 2014). Melton suggests providing multiple levels of social interaction for occupants, so that they can choose the amount of interaction they have. Areas of quiet and refuge are helpful for people who need space, and areas of collaboration and social engagement are important for people who crave interaction and community (Melton, 2014).

Control of systems is another important facet of occupant comfort. Because everyone is different, individuals should have access to heating and cooling controls. Whether personal heaters and fans, or personal thermostats, patients and workers will benefit from control they have over their comfort levels (Melton, 2014). Lighting is another system that users should have control over, and by incorporating dimmable, energy-efficient lighting in spaces and adjustable shades on daylighting windows, occupants can determine the amount of light they need in a space (Melton, 2014). By providing occupants a sense of control of their environment, designers are giving them dignity and reminding them that they have autonomy and independence. Self-esteem and independence are major contributors to a sense of wellbeing, and they promote recovery in a hospital setting (Heerwagen, 2009).

Acoustics are a major concern in the healthcare environment, first because of proprietary information and patient privacy, and second because noise that is carried can create discomfort and dissatisfaction in patients. A study by Busch-Vishniac et al.
concluded that noise levels are rising significantly in healthcare environments (2005).

Rising sound levels inhibit effective communication between healthcare providers and can also create anxiety and distrust in the patient (Pasha et. al., 2012). Poor acoustics in healthcare facility is dangerous because it can potentially hinder the concentration of healthcare workers (CISCA, 2010). In several case studies performed by the Ceiling and Interior Systems Construction Association (CISCA), acoustic panels in the ceiling or on the walls significantly reduced the stress, distractions, discomfort associated with sound reverberation (CISCA, 2010). CISCA suggests utilizing a ceiling with a Ceiling Attenuation Class (CAC) of 35 or greater for a good sound barrier (2010).

Daylight may be the most important biophilic element as it affects all biological processes (Heerwagen, 2009). Sunlight controls the circadian rhythms that run a person’s biological clock; sunlight also is linked directly to enhanced mood, neurological health, and alertness (Heerwagen, 2009). According to Helmut F. O. Mueller, an environmental architect, daylight “defines the range of brightness and color composition for our vision, it gives us orientation in time and space, and it is a precondition for our perception for and evaluation of the built environment” (Mueller, 2014). Daylight also promotes sustainability by reducing the heat gain of artificial lights and the amount of electricity they need to light a space (Mueller, 2014).

Daylight has quantitative and measurable effects on human health and wellbeing. Dr. Ihab M.K. Elzeyadi (2011) researched the health effects of daylighting in the workplace and quantified the benefits of natural lighting on human health and productivity. Dr. Elzeyadi found that workers without access to daylighting or workers
that only had a view of an urban landscape complained of discomfort and missed work more often than employees with daylighting and views of nature (2011). The group with no daylighting reported two times the instances of eyestrain and six times the amount of work absences (Elzeyadi, 2011). The group with no daylighting reported higher instances of headache, nausea, fatigue, muscular pain, and discomfort (Elzeyadi, 2011). The group with daylighting and views reported a higher satisfaction with quality and amount of lighting in their workspace (Elzeyadi, 2011).

Sunlight also dictates space planning and can help to heat and cool a building in passive solar design. Passive solar design is defined as the heating and cooling of spaces using the sun’s energy (Sustainable Sources, 2015). Passive solar design utilizes natural processes to collect heat through the use of masonry and controlled heat gain and loss (Steven Winter Associates, 1998). Brick, mortar, concrete, and other natural heat-retaining elements can be used in interior spaces to maximize heat gain in the winter, and to cool spaces in the summer. Through careful planning, intelligent design, and good organization of spaces in healthcare facilities, passive solar design can be used to offset heating and cooling costs of a building (Steven Winter Associates, 1998).

Many naturalists promote the use of healing gardens in and around healthcare facilities to promote calmness and positive distractions in users of the space. Many individuals find peace and solace when looking near a natural environment (Schroeder, 1996). In healthcare, healing gardens can be utilized on the interior or exterior to facilitate ease and relief from the stressors of the environment. Green space in an urban
area is shown to aid stress recovery, improve mood, and build community ties (Heerwagen, 2009).

In order to keep patients and workers healthy and safe, designers must ensure good indoor air quality throughout the space. Many healthcare facilities have poor indoor air quality because of the chemicals in the air from toxic products. Interior designers can limit exposure to toxic products by choosing safe materials and buying from companies that are transparent about what chemicals they use in their products (EPA, 2007).

The Environmental Protection Agency says that the population in the healthcare environment is more susceptible to the dangers of indoor air pollution that come from volatile organic compounds (VOCs) and poor air circulation because their immune systems are already compromised (2007). Young and elderly patients are at a higher risk to be affected by toxic chemicals in the indoor environment. It is imperative that designers ensure that the products they use are beneficial to all occupants, and that the materials they specify promote the health of the user (EPA, 2007).

The best way to promote good indoor air quality is through prevention in limiting the amount of toxins that enter a building. This is done through the selection of harmless materials, trapping dirt and debris before it enters the building, and by controlling the openings of a building and the location that air enters the space (Southface Energy Institute, 2007). One way to control the amount of air entering the building is through mechanical ventilation of a tight building envelope. A device, known as an Energy Recovery Ventilator (ERV), allows the controlled exchange of air in the
healthcare facility. An Energy Recovery Ventilator exchanges unconditioned, humid, indoor air for conditioned, dehumidified, fresh air. ERVs and HRVs (Heat Recovery Ventilators) control the temperature, humidity, cleanliness, and amount of fresh air coming into a building (Southface Energy Institute, 2007).

Another way that a designer can improve indoor air quality is to have optimally-sized mechanical equipment. A mechanical system that is the right size for the healthcare facility will use less energy than one that is bigger than necessary or smaller than needed. Mechanical systems with capacities more closely matched to actual loads also provide greater comfort for the users of the space (Southface Energy Institute, 2007).

Ductwork sealing is a big part of improving energy efficiency in a healthcare space (Southface Energy Institute, 2007). Sealing the ductwork with mastic will also provide better air flow and improved comfort to the occupants. When there are return leaks, conditioned air will blow out into unconditioned space, which will increase energy costs. When there are supply leaks, unconditioned air is sucked into the building and throughout the ductwork, which will negatively impact the indoor air quality of the healthcare facility (Southface Energy Institute, 2007).

To promote energy efficiency, heating and cooling ducts can be located in the conditioned space instead of an unconditioned attic or basement. Placing the ductwork in a conditioned space will reduce the heat loss to or from the natural environment. It will also minimize the effects of energy loss through openings or leaks in the ductwork because the ducts can be sealed to prevent the loss of conditioned air to unconditioned
air (Southface Energy Institute, 2007). Energy use can also be minimized through the use of energy-efficient Light-Emitting Diode (LED) bulbs in light fixtures, automated controls of lighting and cooling systems, and energy-star rated appliances and computers (Berry et al., 2004).

One major issue in the healthcare industry is the high amounts of waste that is produced in the building. According to the American Hospital Association, hospitals generate close to 7,000 tons of waste per day. Much of the waste is carefully regulated and expensive to dispose, not to mention hazardous to human health and the environment. Medical waste incinerators are a major source of mercury in the outdoor environment (American Hospital Association, 2015). Healthcare facilities could cut up to $7 Billion if they would implement responsible waste management strategies. Just by changing the way facilities handle waste, healthcare costs could be significantly reduced (American Hospital Association, 2015).

The waste stream from a hospital includes cardboard, and cardboard is recyclable (American Hospital Association, 2015). A responsible recycling program in a healthcare facility would collect cardboard, confidential paper (HIPAA), mixed fibers (magazines, newspapers, non-confidential mixed office paper, boxboard), beverage containers, metal, recyclable construction/building materials, and some non-traditional mixed plastics. A program such as that would reduce waste by 30%-40% (American Hospital Association, 2015).

In new construction and demolition, waste can be minimized if planned for early in the process. Most materials can be reused in another way, and there are many
businesses now that focus on storing and selling recycled building materials; one example is the Life-Cycle Building Center in Atlanta, Ga. Designers can plan for waste management by locating recycle bins and composting bins in convenient locations. Designers can cut back on raw materials used by specifying recycled materials and reusing resources.

Water is another waste issue of healthcare facilities, and it may be the most pressing. Just hospitals use an unprecedented 139,214 gallons a day (American Hospital Association, 2015). There are many measures that can be incorporated to manage water use sustainably (Hospital Checklist, 1997).

The first point of defense against water overuse is the collection of rainwater that falls on a building site (Hospital Checklist, 1997). Instead of letting the water become run-off in a storm drain, rain screens and cisterns can filter and store the grey water to be reused in toilets, and as irrigation of landscaping (Hospital Checklist, 1997). Next, using water-saving plumbing fixtures, water use can be reduced significantly. Plumbing fixtures such dual-flush or composting toilets and WaterSense® rated fixtures will lower water use. Perhaps the most important way to reduce water use is through sustainable operational and organizational practices, such as cleaning and maintenance usage (Hospital Checklist, 1997).

Lastly, research included a case study that implemented many of the design suggestions to report on the efficiency, profitability, and success of sustainable design in the healthcare setting. The case study (2004) was performed by Leonard L. Berry et. al. who studied multiple healthcare facilities that utilized sustainable design in their
buildings and practices. Berry et. al. found that one time up-front costs were quickly repaid through operational savings – such as energy and water use reduction. Up-front costs were also quickly repaid through increased revenue created by the sustainable design (Berry et. al., 2004). Beautiful environments that calm and heal keep workers and patients coming back. Natural elements that help to fight fatigue also raise productivity and efficiency of workers, so that they get more done in less time (Berry et. al., 2004).

Berry also reports that the benefits are not just a one-time payback, but that the benefits are indeed sustaining and substantial, and the benefits have a direct financial payoff (2004). In the hospital, 5% of the budget went to sustainable design initiatives, and after the first year of operation, they already had a 95% return on investment, and the return will continue for years to come.

In the Healthcare Design Studio of Georgia Southern University, the student’s Senior Studio Capstone Project shows an interpretation and creative ways that sustainable design can be used in the healthcare setting. In a 19,334 sq. ft. treatment and diagnostic center for individuals with cerebral palsy, the client wanted a fully accessible health facility that met the social, medical, and emotional needs of the client. Figure 1.1 shows the Floor Plan and the entire scope of the student’s Healthcare Capstone Project.
Figure 1.1 Universal Access Center Floor Plan

Universal Access Center – Islip, NY.

A 19,334 multi-purpose diagnostic and rehab center for individuals with cerebral palsy. Areas include Dental Offices, Primary Care Offices, Ophthalmology Office, Audiology Office, A Mental Health Center, Rehabilitation Center, Mobility and Assisted Technology Training Center, Hydro-Therapy and Occupational Therapy Offices, and A Medical Training and Meeting Room. The student designed all spaces for the Capstone Project.

To welcome clients and guests to the facility, the General Lobby (Figure 1.2) utilizes natural daylight and views to help clients and workers feel relaxed, and to also save energy in lighting. The Lobby also utilizes the principles of Biophilia to help the psychological and health of the occupants.
The movement of rain water throughout the space adds visual interest and natural, soothing elements. The use of natural textures, colors, and elements bring lowered stress levels in the healthcare setting.

Daylighting is maximized through the use of clerestory windows, reflective copper surfaces, and a light ceiling.

Textiles, materials, and finishes were chosen based on their high recycled content, recyclability, and low amounts of harmful chemicals, such as volatile organic compounds (VOCs).

Living plants help to purify the air, and they add an important aesthetic quality while contributing to improved mood of workers and patients.
The Exam Room (Figure 1.3) focuses on creating a space where individuals feel safe and able to talk to their care provider in a healthy and wholesome environment.

Figure 1.3 Exam Room

The Exam Room also utilizes daylight to reduce electricity use. Outdoor views help patients and guests to relax, and all finishes in the space were chosen to improve the health of all users of the space.

The Exam Room also uses low-flow fixtures and Energy-Star Rated appliances.
As shown through the student’s Healthcare Studio, sustainability can be incorporated in the healthcare space in beautiful, cost-effective, and creative ways. By incorporating Biophilia in spaces, designers can improve both patient and worker mood and satisfaction. Energy can be saved by efficient use of mechanical and lighting systems, and water use can be minimized by selecting low-flow fixtures and incorporating sustainable practices in the design. As the earlier case-study showed, sustainability measures have a very fast return on investment and continually add value and benefits to the facility. Sustainable practices are truly “Best Practices,” and they improve the social, environmental, and economic facets of all healthcare projects.
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