

Sustainable Healthcare Architecture; Designing a healing environment

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Sustainable healthcare architecture: designing a healthy environment

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Sustainable Healthcare Architecture

Healthcare facility design is a complex endeavor that forces function to follow both form and quality. Healthcare facilities serve a wide range of functions from medical applications (i.e. diagnostic, treatment, emergency rooms, clinics, etc.) to functional programs (i.e. food services, housekeeping, waiting rooms, meeting areas, office space, etc.). Designers of a healthcare facility are required to look at every aspect of human life. These facilities are spaces people live (temporarily) and work in, where they are born and die. With the reliance on technology with modern medicine and demanding building program requirements of healthcare facilities, designers of modern hospitals may view healthcare architecture as incompatible with the principles of sustainable design. However, sustainability is not only a moral obligation for the healthcare field, it is beneficial to the patient and fosters a healing environment. Sustainable practices should be adopted for future

constructions and renovations of healthcare facilities. These practices will not only save money during the lifespan of most healthcare facilities, they will also make spaces more effective for healing.

Sustainable Architecture

Sustainable Architecture looks further than the building ecology or energy efficiency, and towards the end user's experience, placing people at the center of the design process. Sustainability is not about sacrificing comfort or lifestyle for environmental benefit, but to find design solutions that increase quality of life today without sacrificing tomorrow. The sustainable design process focuses on the people who will utilize the project, and for this reason, sustainability applied to healthcare architecture has the most potential to benefit building users. The medical field is only starting to now accept sustainability into the building practices. Medicine is not a place of risk, because at the core

of a healthcare facility the mission is medical treatment for the patient. Out of the box thinking is not a chance that medical professionals want to take. In general, changes in medical environment happens slower than in other parts of the economy (Butler et al., 1996). For these reasons sustainability has not been widely adopted in healthcare designs.

Health Challenges for the 21st Century

Many of the upcoming problems in health that will have to be treated in the healthcare facilities are problems that can be linked to the built environment that people have created. The way that we live and the places and spaces that we live in have made a unique environment that does not promote healthiness. The current generation of the industrialized world is projected to be the first not to live longer than the previous ones (Daniels, 2006).

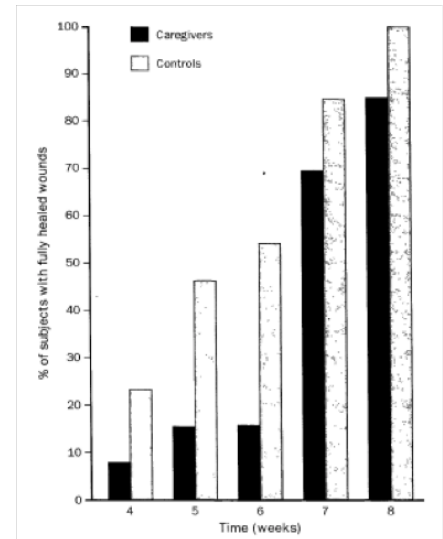
Health challenges that the youth will face in their life are asthma, developmental disabilities, diabetes, obesity, reduced fertility, cancer, and heart disease. These health impacts have significant linkages to the technology advancements. Changes with indoor/outdoor environment and changes in the lifestyle that has resulted from the modern lifestyles that are unsustainable for public health. In addition, lifestyles have further isolated people from interactions with others and added stresses to life with increased productivity requirements at work. The lifestyles currently lived by Americans is unsustainable, and the hospitals that will treat the problems associated with this should be models of a sustainable and health

lifestyle.

Mind-Body Connection

Even though changes happen slowly in the medical field, the new sub-discipline of integrative medicine is showing promise of changing the way medical doctors look at their patients. Integrative medicine is a holistic movement in the medical field, which looks at treatment of the whole person not just the illness or sickness. The mind body and soul is treated to increase probabilities of success. This movement is based on the idea that pain and suffering is not felt in a particular part of the body, but is interpreted in the mind. A healthy mind and psychology offers the body greater support in the healing process.

There is evidence that psychological stress adversely affects the immune system (Kiecolt-Glaser et al., 1995). In a study performed on the effects of wound healing, Kiecolt-Glaser et al. took a group of patients with Alzheimer's disease and a control group inflicting them with a punch biopsy (a low-risk technique used extensively in dermatological research), and then monitored the healing process of the wound. People inflicted with Alzheimer's disease are known to have stress levels substantial higher than normal. The results of the study were profound showing a linkage between the stress levels of a patient and healing time (are shown in Figure 1). About half of the control group with normal stress levels healed within 5 weeks, while it took over 6 weeks to see healing comparable from the patient's with Alzheimer's disease.



Stress levels inhibit recovery, but positive thinking and determination has helped patients beat such diseases as cancer. The Livestrong foundation is an example of using healthy mindsets to promote healing during the very invasive treatments of chemotherapy. Many patients undergoing cancer treatments credit the programs outlined by the Livestrong foundation for successful outcomes.

This mind-body connection has lead doctors to have group therapy sessions where patients talk about struggles of their disease to support each other. Doctors practicing in integrative medicine have also incorporated hypnosis and meditation into normal pain relief therapy. These practices are currently being researched, and preliminary findings are showing promising results of increased success rates and quicker recovery times (Kligler & Lee, 2004). This type of medicine does not only make hospitals more productive but also make them more profitable.

Achieving a high performance hospital with principles of sustainable design is following a similar route of adoption as integrative medicine. Today new building constructions and renovations are demonstrating that green building principles are not only ecologically and environmentally responsible, but in the end create spaces that are of higher quality and more productive. This paper will explore the building-mind-body connection that can be fostered through sustainable development of healthcare to produce healing environments.

Healthcare and Sustainability

Healthcare is the preservation of mental and physical health by preventing or treating illness. A healthy person is not one with just the absence of disease, but health is a state of physical, mental, and social well-being. In general, healthcare is not practiced with this idea, modern healthcare systems treat people like machinery. Modern healthcare facilities fix parts as if the person is a collection of mechanical systems. People though are more complex than machinery. The mind is not only the central control on conscience but also the place where all pain is felt, all healing is commanded, and where people perceive their environment.

If the mind has the power to heal, fostering an environment that promotes mental wellness should translate to the physical healing of the body. Architecture has shown that the environment that people create has profound impacts on the human psyche. Sustainable designs of workplaces have shown that productivity levels increase (Heschong, 1990). Sustainable designs

of schools have shown that student performance increases (Heschong, 1990). Healthcare facilities have only recently adopted sustainable practices, however some components of sustainable design can be found in healthcare facilities of the past. These include natural ventilation and day lighting. The cases that are outlined in this paper show that sustainability has the power to create a healing environment.

Indoor Environment Quality

Today in industrial countries people spend about 90 percent of their days indoor. The human body is not adapted to life in these artificial environments (i.e. artificial lighting, cooling, and ventilation) cut off from the external environment. While shelter is a natural and instinctive aspect of people, artificial environments of the past 40 years have led to the sick building syndrome.

In the same ways that architecture has moved from very different building in different regions of the world towards a uniform international design style, the indoor environment has also changed towards an average comfort style. Humidity levels are controlled, temperature is at a constant 21 degree Celsius, and lighting environments are artificially lite. This has been the definition of comfort in our modern world, however inflexibility is not comfort. True comfort is a flexible environment that gives people the ability to control it.

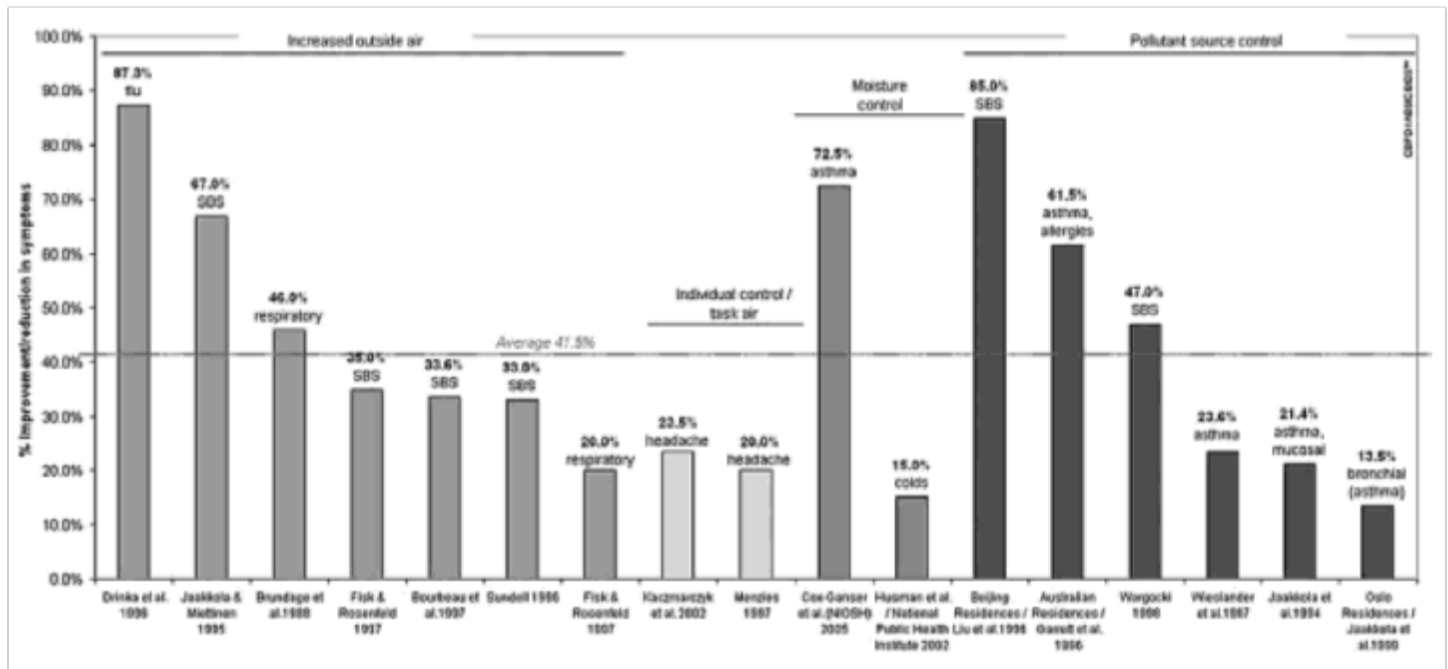
Sick Building Syndrome

Sick building syndrome is well researched by the medical field and architects (Brede-Weisflog, 1996; Burge, 2004; Burge, et al., 1987;

Finnegan et al., 1984; Lyles et al., 1991; Redlich et al., 1997; Singh, 1999; Stolwijk, 1991). Effects of sick building syndrome are seen through uncomfortable feeling of sickness through headaches, dizziness, wheezing, eye irritation, respiratory infections, and fatigue. Most of the effects of sick building syndrome are attributed to air quality problems. It is estimated that about 20 percent of the American workforce is impacted by sick building syndrome (Levin, 1989). The Environmental Protection Agency lists the key factors of sick building syndrome as:

- Inadequate ventilation
- Pollutants emitted inside buildings
- Contaminations from outside sources
- Biological Contamination (i.e. mold growth due to excess humidity)
- Inadequate temperatures
- Excess humidity
- Poor Lighting

The impacts of sick-building syndrome are documented as reducing productivity, performance, and well-being of building occupants. Currently many hospitals in the industrialized world can be characterized as prone to sick building syndrome. These impacts are extreme in hospitals where the spread of diseases are possible. In Germany, about 1,500 people die annually from diseases they contract in the hospital (Stolze, 2005). The underlying motivations for healthcare facilities to pursue sustainable building designs are moral, but they should also be seen as financial or as part of health treatment (Houghton et al, 2010). A hospital should not be a place that people go and get sick in.



In general, green buildings have measurably better IEQ than traditional buildings, with associated positive impacts on health (Kats, 2010). Figure # shows a survey of studies on green buildings' positive impacts on health due to the air quality. The health benefits of green building design have shown linkage with patient recoveries, in part because of the better air quality (Kats, 2010).

Day lighting

Day lighting also plays an important role in the healing process through the regulation of the circadian system. The circadian system is the regulation of body function based on the day-night cycle. The body is adapted to daylight and uses it as an internal clock, regulating all aspects of physiology. The human body's digestive system, sleeping patterns, and even body temperature show measurable differences throughout the day (See Figure 2). Through this system day lighting aids in healing

through reducing depression, shortening hospital Stays, and improving sleep (Joesph, 2006). Patients in day lite rooms have less pain, less stress, and are calmer. This translates to a body in harmony with nature, which aids the healing process. In addition, worker performance and job satisfaction is increased, creating a work environment where doctors and nurses are more effective. With the power of day lighting in the regulation of bodies, it is immoral to create hospital spaces like patient rooms that do not incorporate daylight.

Comparing French and British Hospital Systems

A study comparing French and British hospital systems preformed by the Building Design Partnership, (a firm of architects, engineers, and designers), showed substantial differences in effectiveness of the healthcare systems (BDP, 2004). They drew conclusions that each bed in a French hospital outperforms the

British hospitals, which drives down costs. The key findings of the report were:

1. French hospitals deliver more benefit for less cost than UK hospitals.
2. The French use single bed wards to assist faster recovery.
3. Day lit plans and good amenities aid staff wellbeing
4. Good architecture in France fosters community pride and user morale.
5. French hospitals cost between half and two thirds of the cost of UK hospitals per m².
6. Building servicing costs in France are less than half those of the UK with little artificial ventilation used.

BDP's report attributed the difference to the building designs of the healthcare facilities. The French Healthcare Architecture regulations adopt many of the characteristics common to sustainable design prac-

tices. The regulations require that hospitals are to be designed with daylight in all occupied areas. They also mandate single room floor plans that accommodate overnight stays by families. Also impose requirements on building:operation:staff costs are set to 1:5:200. These limits require a low cost construction and operation, with daylight, natural ventilation, and social sustainability. Although they are not called sustainable, the practices employed in France are close to the ideas of sustainable design.

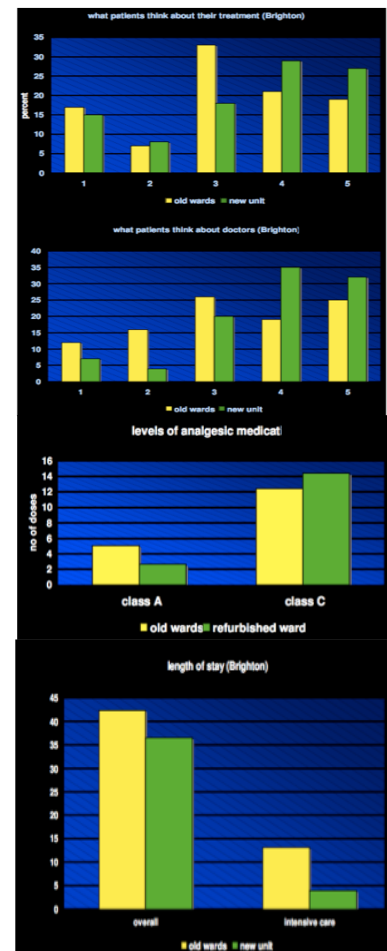
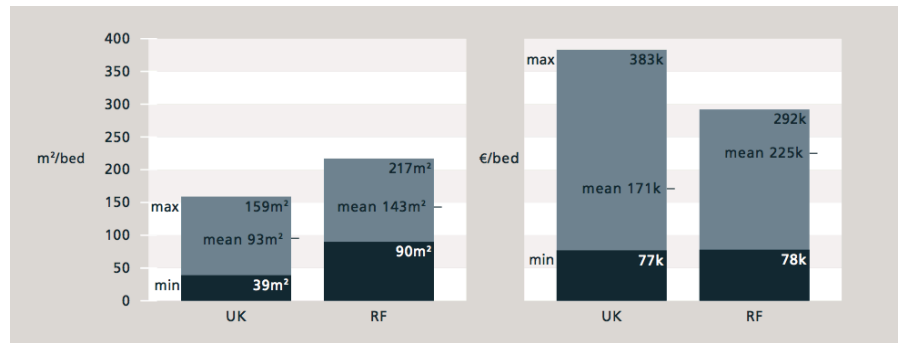
The resulting buildings have large surface area to volume ratios, insuring day-lighting to all part of the building, providing views from the patients rooms of the outside, and having better air quality with natural ventilation techniques. The benefits of this approach resulted in better health rate from hospitals in France than those in the UK and higher morale among the patients and doctors.

Sustainable Versus Traditional Hospital Wards

Building extension projects have offered a great opportunity for researchers to study the impacts of new building design compared to older sections of the buildings. Professor Bryon Lawson researched the impacts of a building extension project at Brighton Hospital. The hospital served the same populations of patients and the rooms were used for the same types of treatments in the older and newer sections of the hospital. The Doctors and staff also came from the same pool. This case study offered a unique opportunity to study the differences in patient outcomes in new building design. The new building regulations in effect were closer to sustainable concepts in green design.

The results showed a positive gain in patient care in the new section of the hospital. Figure 3 shows the results of patient survey on satisfaction of the medical treatment and the doctors' performance. The patients in the new units rated both the treatment and the doctors higher when having treatment in the newer section of the hospital. In addition to the perception of the patient, the outcomes were measured both in overnight stays and types of drugs taken. These results are shown in Figure 4. The overnight stays were lower showing that the patients felt well enough after treatment to go home. The types of medications also differed, in that less powerful class C drugs were prescribed as opposed to the more powerful class A. Since class A drugs are made up of powerful pain relievers this result can be interpreted as the patients did not complain as much about pain, and less powerful drugs were strong enough.

Reduction in hospitalization stays and less drugs is the equivalent of money savings in the healthcare industry. The average hospital night stay costs \$1,200 in the United States. In addition, the Class A drugs are generally more expensive than Class C drugs. Green hospital design could even lead to stronger results, but future studies are needed.





Klinikum Großhadern, DE

Operated by: Fachkliniken Nordfriesland GmbH

Beds: 1,418

Total Cost: 367 Million Euros

Date: 1977

Website: www.klinikum.uni-muenchen.de

The Klinikum Großhadern of the Ludwig Maximilians University is the largest hospital in Munich and the fourth largest in Germany. It has 1,418 beds and offers the widest range of services of all the hospitals in the city. The building features an aluminum façade that acts as a secondary façade shading the actual façade of the building. The students attending LMU medical program refer to the building as 'the toaster' because of its rectangular long shape and metal exterior. The hospital is known for its innovative equipment and is designed to accommodate testing for numerous patients in the region. The building has about 500,000 patients per year with over 1,800 doctors.

The layout of the hospital is much like an airport. When entering the hospital there is a lack of information and greeting services. Most information is delivered by signage marking off different sections of the hospital

with letter and color codes. Navigating the hospital takes place through a central corridor that encompasses the length of the building. The hospital is generally cold and lacks views of the natural garden surrounding the campus. Many views from windows are of other windows in the adjacent buildings.

The building is large and mostly empty of people. It is not uncommon to look down a long corridor and find no one. Also there is a general lack of community in the hospital. Most hospital staff walk looking down at the ground, with little eye contact. There is a lack of congregation and talking amongst the building users. Often in very public parts of the hospital patients in their gown walk through, lost, looking for their next office.

The hospital is built like a machine and is made to process as many people as possible. There is ample space left empty. The hospital systems works like a factory, with carts pulling wagons. Much of the feel in the hospital is that of a factory for medical care. The hall also lacks natural light and the artificial lighting is not strong enough, often leaving the interior of the building dark. The humidity levels of the building are high and the temperature is cold. Windows have condensation forming on them.

The surrounding gardens of the hospital are very pleasant and are often visited by patients for recuperations. This serves as an escape from the cold inside of the building.

Overall, this building is made for maximum output, and does not create a welcoming healing space. The building interiors are not comfortable and most people visiting the hospital remain outside in gardens and public benches. Future studies should look at the success rates and compare this hospital to its downtown branch, which occupies a historic building. Given that the two hospitals have similar functions and the same administration, patient surveys of quality of care could result in useful studies on the healing environment.



Klinikum Neuperlach

Architect: Beed – Geiselbrecht – Lernke Architekten GmbH

Operated By: Stadtische Kliniken Munich GmbH

Located at: Oskar-Maria-Graf-Ring 51, 81737, Munich, Germany

Reinnovation: 2005

Beds: 594

Area: 8,074 square meters

Cost: 20.5 Million Euros

The Klinikum Neuperlach, constructed in the 1970s, represents the typical clinic design of the era. The building was very commercial and was designed for efficiency. The original building contained 765 beds and the design was not made flexible for future medical advancements. After 30 years of use, the building outlived its usefulness and required complete renovations to provide modern medical procedures. The redesign of the hospital required larger floor space, in which the only solution was to add additional floors to the top of the flat structure. Through the renovations, the new design corrected many mistakes that the older design had. The numbers of beds were reduced to 594 making spacious rooms for patients. The most important element of the new design, was constructing an air space through the center of the building. This space adds air volume to the building, greatly improving indoor air quality. The top of the air

space features a glass roof that allows for direct sunlight to enter the building, warming it and giving a pleasant lighting effect throughout the corridors surrounding this central courtyard on every level of the building. The courtyard serves multiple purposes; air ventilation, natural lighting, and a central area for patients to orient themselves when navigating the building. Patient waiting rooms on every level are located next to the central courtyard, lined with potted plants and comfortable furniture. Families wait in these areas also. In addition, a covered area was created in front of the entrance of the building, which serves as the entrance, pavilion, and sidewalk café. When entering the building the lower floor is well lit, and the air smells fresh. Geothermal cooling is used to bring fresh air into the building. Finally, the façade of the building was ornamented with multi-color glass giving it a modern look. This building is an example of how to correct the mistakes of the old building design, where the hospital was a functional machine. The designer brought sustainability into the hospital, which greatly improved the look and feel of the place.



Rotkreuz-Krankenhaus

Munich, Germany

Architect: RRP

Architekten+Ingenieure

Operated by: Bayerisches Rotes Kreuz

Located: Rotkreuzplatz 8 80634 Munich, Germany

Refurbishment: 2009

Beds: 324

Area: 6,544 square meters

Total Cost: 81.7 Million Euros

The Rotkreuz-Krankenhaus located in the inner city of Munich is owned and operated by the Red Cross of Bavaria. The buildings have a rich history spanning over 135 years. This history as well as the Red Cross culture of caring for the well being of the patients makes this hospital the leading one in comfort and care in Munich.

The building has been in a constant state of renovation since the late 1980's with plans to continue to modernize the grounds to support innovative treatments. The build-

ing's history is complex with many construction periods, 70 percent of the building was destroyed in World War II. Reconstruction of the building took until the mid-1960s. Later in the 1980's the high-rise tower was added to the building to add a modern look, serve as a landmark, and close off the inner courtyard from the street. The modern renovations brought in natural lighting, natural ventilation, and additional wings for specialized treatments.

The renovations were planned in 1979, but the realizations of these plans are still not fully met. The original plan was to have the building renovated over 10 years in 3 phases. The renovations have taken now over 20 years with 5 out of the 6 phases completed. The plans were lengthened because of the complex situation of constructing in a fully operating hospital in the inner city. This is an example of the need for a flexible and long-term thinking design plans to make renovations easier.

The main design concepts surround the idea of the garden hospital, where green and natural spaces are provided for both visual effect and physical experience. The gardens are visible from a majority of the patients' rooms. The access to the garden areas is private for the patients of the hospitals. The gardens do not only heal the patients, but also heal the building from the negative effects of the inner city. The thick trees provide sound protection and a buffer from the noisy streets. These gardens serve as an island of calmness in the heart of the building grounds. The main hall of the building is lit by 4 x 4 meter mirrors that are bringing in warm natural lighting to the main hall. The building has underground parking in order to preserve both the architectural look of the structures and the green space created between the buildings.



Dell Children's Hospital

Austin, Texas, USA

Architect:

Operated by: Seaton Hospitals

Located: 4900 Mueller Boulevard,
Austin, TX 78723

Construction: 2007

Beds:

Area:

Total Cost: 200 Million Dollars

The Dell Children's Hospital is the first Hospital in world to achieve Platinum LEED. This hospital embraced the concepts of sustainability to create a healing environment.

Costs to Incorporate Sustainability to the Hospital:

- 5% additional construction cost (of total)
- 6% additional design cost (of total)
- 11% total additional costs
- Total Costs: 200 Million Dollars
- 22 Million Dollars additional costs

The additional costs will be quickly

recuperated with the lower operation costs of the hospital. The hospital has lower water usage and lower heating/cooling costs. It also uses 50% less electricity than comparable hospitals of its size, and generates most electricity on site through coupled heat and power plant.

The operation of the facilities also allow for costs savings. The administration has an easier take to recruit medical staff, which also has high retention rates. The hospital is able to retain the top talent of the country, because the building provides a space that creates a corporate culture of doing good. Preliminary studies are showing that there are faster patient recovery times (still in study), however more studies must be done to determine the exact cost savings. Seaton claims that the hospital has gave them an overall competitiveness and advantage in the marketplace. The sustainability features act as marketing tools that encourage people to choose their hospital over other hospitals throughout the region.

Medical Treatment and Good Design: Key Design Factors in Sustainable Architecture

Much like air conditioning is an active solution for the problems of hot indoor temperature, medical treatment is an active way to help heal a patient. Passive systems such as natural ventilation also help control indoor environments with a fraction of the cost and benefits to the indoor environment. Well-designed hospitals can foster an environment that does not require as much medicine to heal a patient.

The key factors in designing a heal-

ing environment are to think of the patient, medical staff, and visitors of the hospital first. When designing a hospital that heals, the architects must think of the user. Patients must have privacy, dignity, and the ability to have company. Sharing a room with a stranger in a time of sickness is not comfortable for the end user. Being able to ensure social interactions with family by accommodating over night stays is very important for the well being of the patients. This gives the patient the possibility to control how and when they share spaces (acoustically as well as visually). This requires single room facilities that are constructed well to provide sound insulation. These patient rooms should have a connection with nature through operable windows that view the outside. These windows will provide the day lighting that helps regulate the internal clock of the patient, greatly reducing healing time. Windows will also help improve the air quality of the rooms. The indoor environment has to provide both comfort and control (temperature, lighting, ventilation, sound etc.). In a time of sickness, people lose control of themselves. Bringing them to a hospital should not make them loose control of their environment as well. These principles in room design foster a connection between the patient and the room. In addition to the room design, patients must have outdoor access to garden areas. These areas act as an escape from the medical treatments. In addition, the grounds of the hospital and the inside plan should be spatially legible and easy to navigate in.

Although this healing environment does not require the building to be green, sustainable architecture is a

framework that would meet all these objectives. The Hippocratic Oath is an oath historically taken by doctors swearing to practice medicine ethically. It can be best characterized by the common saying "First do no harm." This oath should be also applied to the environment that medicine is practiced in. The environments of current healthcare facilities are places, in which people get sick, do not feel comfortable being in, and avoid. The outcomes of research show that bad hospital design harms the patients. Hospitals must take into account the holistic thinking during renovation and building process. The best way to achieve this is through sustainable architecture practices. Natural lighting, ventilation, user controls, and clean indoor/outdoor environment can help solve the problems of current healthcare practices.

References

- Butler, C., Rollnick, S., & Stott, N. (1996). The practitioner, the patient and resistance to change: recent ideas on compliance. *CMAJ: Canadian Medical Association Journal*, 154(9), 1357.
- Braman, J., James, M., & Kats, G. (2010). Greening our built world: Costs, benefits, and strategies. Washington, DC: Island Press.
- Brede-Weisflog, B. (1996). Sick building syndrome. *Versicherungsmedizin/herausgegeben von Verband der Lebensversicherungs-Unternehmen eV und Verband der Privaten Krankenversicherung eV*, 48(5), 170.
- Burge, P. S. (2004). Sick building syndrome. *Occupational and environmental medicine*, 61(2), 185.
- Burge, S., Hedge, A., Wilson, S., Bass, J. O., & Robertson, A. (1987). Sick building syndrome: a study of 4373 office workers. *Annals of Occupational Hygiene*, 31(4A), 493.
- Building Design Partnership 'BDP' (2004), "Learning from French Hospital Design", www.bdp.co.uk
- Daniels, S. R. (2006). The Consequences of Childhood Overweight and Obesity. *The Future of Children*, 16(1), 47-67.
- DH Estates and Facilities (2009) Achieving Excellence Design Evaluation Toolkit (AEDET Evolution), NHS of the UK.
- Finnegan, M. J., Pickering, C. A., & Burge, P. S. (1984). The sick building syndrome: prevalence studies. *British Medical Journal*, 289(6458), 1573.
- Heschong, L. (1990). Thermal delight in architecture. Cambridge, Mass: MIT Press.
- Joesph, A. (2006). The Impact of Light on Outcomes in Healthcare Settings, The Center for Health Design, <http://www.healthdesign.org/research/reports/light.php>
- Kiecolt-Glaser, J. K., Marucha, P. T., Mercado, A. M., Malarkey, W. B., & Glaser, R. (1995). Slowing of wound healing by psychological stress. *The Lancet*, 346(8984), 1194-1196. doi:doi: DOI: 10.1016/S0140-6736(95)92899-5
- Kligler, B., & Lee, R. A. (2004). Integrative medicine: Principles for practice. New York: McGraw-Hill, Medical Pub. Div.
- Lawson, B. (2002). Healing architecture. *Architectural Review*.
- Lenin, H. 1989. "Sick Building Syndrome: Review and Exploration of Causation Hypotheses and Control Methods." The Human Equation: Health and Comfort, ASHRAE/SOEG Conference IAQ 89, April 12-20, 1989, San Diego, California. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
- Lyles, W. B., GREVE, K. W., BAUER, R. M., WARE, M. R., SCHRAMKE, C. J., CROUCH, J., & HICKS, A. (1991). Sick building syndrome. *Southern medical journal*, 84(1), 65.
- Mösle, P., Schwarz, M., & Bauer, M. (2010). Green building: Guidebook for sustainable architecture. Heidelberg: Springer.
- Redlich, C. A., Sparer, J., & Cullen, M. R. (1997). Sick-building syndrome. *The Lancet*, 349(9057), 1013-1016.
- Saxon, R., Sutcliffe, M. (2004) Learning from French Hospital Design. BDP Publications <http://www.bdp.com/News/2004/Learning-from-French-Hospital-Design/>
- Singh, J. (1999). Sick building syndrome. *Facilities Management, Health and Safety*, 12-15.
- Stolwijk, J. A. (1991). Sick-building syndrome. *Environmental health perspectives*, 95, 99.
- Stolze, C. (2005): Erst waschen. In deutschen Kliniken grassieren gefährliche Keime. *Die Zeit* 17/2005
- Vittori, G., & Guenther, R. (2008). Sustainable healthcare architecture. Hoboken, N.J: John Wiley & Sons.

