

العنوان:	Interior Design in Improving Smart and Sustainable Healthcare: A Case Study on Pediatrics Clinics
المصدر:	مجلة التصميم الدولية
الناشر:	الجمعية العلمية للمصممين
المؤلف الرئيسي:	Abdel-Maksoud, Asmaa Hamed
المجلد/العدد:	مج 7, ع 3
محكمة:	نعم
التاريخ الميلادي:	2017
الشهر:	يوليو
الصفحات:	15 - 36
رقم MD:	984475
نوع المحتوى:	بحوث ومقالات
اللغة:	English
قواعد المعلومات:	HumanIndex
مواضيع:	التصميم الداخلي، الرعاية الصحية المستدامة، تصميم المستشفيات الذكية، تصميم المستشفيات الخضراء
رابط:	<a href="http://search.mandumah.com/Record/984475">http://search.mandumah.com/Record/984475</a>

## Interior Design in Improving Smart and Sustainable Healthcare A Case study on Pediatrics Clinics

**Asmaa Hamed Abdel-Maksoud**

Assistant Professor in, Faculty of Applied Arts, Helwan University

### Abstract:

Since the advent of the internet more than two decades ago, the pace of technological advancement has been exponential in a countless number of fields. Despite significant early gains, Egyptian hospitals continue to be late adopters both of healthcare technology and modern industrial engineering concepts. Medical technology for diagnostics and treatment have improved in leaps and bounds, but almost all health services are still stuck on paper. People expect the health system to keep up and we're seeing some exciting emerging technologies that will make a big difference over coming years. Intelligent buildings use integrated and intelligent systems to provide a rewarding experience for the building owners, property managers, occupants and visitors to achieve their goals. These goals include lifespan, high energy efficiency, environmental-friendly built environment with substantial safety, security, well-being and convenience, a lower life-cycle cost, and long-term flexibility and marketability that lead to achieve a high-level of buildings that have the highest social, environmental and economic values. Green hospital concepts will play an important part in the curative process in time to come. Instead of being referred to as a place that houses healthcare amenities, hospitals of tomorrow will now focus on wellness and be transformed into welcoming spaces to get well. Over the last few decades, a deeper understanding of the role that early education plays in improving a child's future academic performance, health and quality of life has emerged. Within the spectrum of elements that create excellent child care, the quality of this environment has a profound influence – especially given that many children spend close to half their waking hours in a child care setting. Learning from direct experience, children are attuned to and affected by their surroundings. The child care is a place where children experience the world and through which caregivers and the community gain support. Children are usually discouraged from moving around in hospital environments lest they disturb the health-care workers or patients; there should be spaces set apart for them where they can move as freely as they need or wish to, as they need to engage in imaginative play regardless of the condition of their health. Children need to feel they can create and make changes by interacting with their environment and moving objects and parts; as a result, flexible play areas should be designed to stimulate their imaginations and give them the pleasure and therapeutic benefit of creative activity. While gardens had been used in the service of health care for centuries, modern medicine, it is important to note that the level of architectural achievement and the illumination of these forms and spaces was a result of a team and goal oriented collaboration between the owner group, design team and construction team. There is a growing acceptance that the healthcare environment can have a significant impact on a patient's perception of their medical care and, in some cases, on their actual recovery. Here we explore the psychology of color and how well-chosen hues on walls, floors and furniture can have a positive, or indeed negative, effect on a person's health.

### Keywords:

- *Smart Hospital*
- *Intelligent Building*
- *Sustainable Development*
- *Green Hospital*
- *Interactive Hospital*
- *Children's Hospital*
- *Colored Light*
- *Healing Garden*

Paper received 10<sup>th</sup> February 2017, Accepted 19<sup>th</sup> May 2017, Published 15<sup>st</sup> of July 2017

### 1- Introduction:

An intelligent building is the one that provides a productive and cost-effective environment through optimizations based on its three basic elements: people (owners, occupants, visitors); products (materials, fabric, structure, facilities, equipments, services); and processes (automation, control, systems, maintenance, performance evaluation); and the interrelationships between them. Through these networks services systems are automatically

controlled to respond using an approach similar to the sensor system of human beings, guided by predictions based upon knowledge of the past situations of the building and usage, and maintained in an integrated data base. Thus, intelligent buildings should be sustainable, healthy and technologically aware, meet the needs of occupants and business, and should be flexible and adaptable to deal with change. Most architects today are already familiar with green building

concepts, as both the public sector and private businesses are increasingly committed to an array of environment-friendly principles. "Green Hospital" concepts, which focus on sustainable designs specifically for hospitals, are also gaining an increased interest and awareness. This shift to sustainable healthcare facilities is primarily centered around reducing the carbon footprint of hospitals and the incorporation of modern "Green Building" design elements into the healthcare environment to improve patient care and allow hospital occupants to feel more at ease.

Children's hospitals often include the latest in medical technology, as well as dynamic, kinetic, soothing and engaging designs that support the emotional needs of patients, their families and care staff. Children deal with a wide range of fears and anxiety during a hospital stay: fear of separation from their family.

stay in the hospital can be frightening for kids, and they're often comforted by only one thing: their families. This is why we've incorporated family-style conveniences in every aspect of hospital. From private patient rooms to expanded sibling child rooms feature color changing LED lights that can be changed by patients for a dramatic effect. Patients have been enthusiastic about the choice of colored lighting. Even in this seemingly small way, having choices and allowing the child to have control over their physical environment can boost self-esteem and outlook. When colored light is not desired, the LED fixtures shift to emit white light. In addition to providing engagement and distraction for patients and visitors. (. New Lighting Strategies Promote Healthier Patient Experiences).

### 1.1 Statement of the Problem

- Increased numbers of patients on the capacity and efficiency of the performance of traditional hospitals and the difficulty of accurate diagnosis and maintain a satisfactory record of each patient containing data and medical records
- Frequent human errors due to the manual recording of the medical record, analyzes and medical laboratories, which in turn give false results to determine the efficiency of the performance.

### 1.2 Significance:

- Improve administrative performance using modern management methods in the organization and management of sustainable hospitals
- The use of digital technologies to close the health care gap in remote communities, as well as the availability of equipment and services

for the diagnosis of patients and remote training, as well as providing emergency medical care to enhance their ability to adapt for a number of possible scenarios

- Availability of hospitals with the ability to serve future generations and achieve the principle of sustainability or the ability to adapt throughout the life cycle of the building and the protection of land and natural resources. Activation of strategies to control energy efficiency from the environmental side and work to achieve acceptable rates and appropriate in dealing with energy consumption

### 1.3 Objectives

- Highlight the importance of sustainable development in hospitals and the role of the internal designer in the development of modern management systems in children's hospitals and the flexibility of design modification according to the changing needs of the design of an environment that positively affects the patient and help to speed recovery and response to treatment
- The vital role played by smart or digital hospitals in the easy diagnosis of the disease and the introduction of a culture of continuous improvement on the administrative performance in hospitals, and the optimal utilization of the basic components of the structure of systems and services and management and mutual relations between them, enables modern technology management of hospitals to collect data in a system accurate and easy. And easy to access through the data recorded to the information required easily and very pleased and accurate.
- Designing health care buildings requires a careful balance of a wide range of variables, careful use of analytical systems and integration of digital technology into patient rooms to obtain the required comfort for the patient
- Increase the level of preparedness for disasters and increase the efficiency of the hospital in the reception of a larger number of patients

### 1.4 Methodology:

- The descriptive and analytical, and data and information collection for smart hospital and intelligent building and sustainable development advantage available for children's hospital from sources and processed scientifically objective to reach the expected results of the search.

### 1.5 Hypotheses:

- In the smart hospital patients can diagnose and

- train remotely, especially in remote areas
- Improve the quality of administrative performance and apply the methodology of continuous evaluation of administrative performance and the built environment and the establishment of healing gardens as a compensatory environment for children during their treatment in the hospital
  - Design healing gardens where they lead to stress relief, relieve physical and psychological symptoms, and enhance the positive feeling of hospital staff and patients.

**Green Guide for Health Care:** First released in 2003, The Green Guide for Health Care filled a need in the marketplace for green building tools specifically for health care. According to its website, The Green Guide for Health Care is “the healthcare sector’s first quantifiable sustainable design toolkit integrating enhanced environmental and health principles and practices into the

planning, design, construction, operations and maintenance of their facilities. This guide provides the healthcare sector with a voluntary, self-certifying metric toolkit of best practices that designers, owners, and operators can use to guide and evaluate their progress toward high performance healing environments . The document has an explicit health-based focus. Before this connection, healthcare administrators often dismissed green building as having no relevance to health, viewing it as purely about saving the environment. In 2002, the American Society for Healthcare Engineering (ASHE) developed the Green Healthcare Construction Guidance Statement, which articulated the need to protect health on three scales: building occupants, the surrounding local community, and the global community and resources .



**Figure 1: Shanghai International Hospital- The undulating landscape form and building envelope provide a great healing connection green hospital**

**Green healthcare principles** can be implemented on many scales, from physicians’ offices, clinics, and community hospitals to vast medical centers that occupy several city blocks. At the workshop, most discussion focused on large hospitals and academic medical centers, not only because these are the venues in which many Institute of Medicine (IOM) members work, but also because data are most plentiful from such settings. Moreover, large institutions offer strategic advantages: health science students are trained there, so effective green healthcare principles can be modeled and disseminated. Also, many large institutions are currently undertaking building programs, offering opportunities for far-reaching impact. Even so, participants noted that there is an important role for environmentally friendly

practices at every level of the healthcare system. Designing, constructing, and operating buildings require careful balancing of a vast array of variables. Careful analysis using systems thinking is essential. Craig Zimring of the Georgia Institute of Technology, during his presentation, warned of the “fallacy of generalized goodness”; not all green decisions are all good. For example, although wide hallways, large rooms, and oversize windows that provide natural daylighting may create pleasant environments for staff and patients, they may also increase energy demand and costs. The presence of plants may pose challenges for infection control. Thoughtful analysis, supported by empirical data and a culture of continuous improvement, is necessary (<https://www.ncbi.nlm.nih.gov/books/NBK>



**Figure 2: Community Hospitals and Wellness Centers (CHWC), Bryan Hospital, Bryan, Ohio.**

### **Role of the Physical Environment in Green**

**Building and Health:** there is a large and growing body of evidence demonstrating the role of the physical environment in achieving healthcare quality and safety. For example, a recent meta-analysis of more than 600 primarily peer-reviewed studies found associations between the physical environment and patient and staff outcomes in four areas: reduced staff stress and fatigue and increased effectiveness in delivering care; improved patient safety; reduced patient stress and improved health outcomes; and improved overall healthcare quality. For example, access to views and natural light in healthcare facilities can have important stress-reducing effects, as well as reduce pain and the length of stay at the hospital. In their meta-analysis review, hospitals are complex systems in which it is difficult to isolate the impacts of individual factors and suggest that design-based evidence parallels evidence-based medicine for improving health care.

### **Sustainable hospital Design.**

Designers must incorporate sustainable hospital design in the selection of materials and in the promotion of interior environmental quality. hospital must achieve designated LEED ratings. Consider sustainable or “green” design elements on all projects. Designers will evaluate furnishings and finish materials containing recycled product and materials that can be recycled at the “end of their useful life”. Whenever possible, use sustainable principles when choosing interior finishes and materials, furnishings and equipment, especially on hospital slated as Sustainable Showcases.

A hospital’s mission is inextricably tied to the issue of sustainability. After all, without a sustainable operation, there is no hospital. Sustainability goals usually refer to money saved, energy conserved, waste diverted, water recycled, or any other easily understood metric. But a clear connection between sustainability and a hospital’s mission, in an understandable language and with a factual basis, rarely occurs. The connection between sustainability and mission must extend to effective management of the healthcare environment, social interaction between patient and healthcare provider, community-based healthcare approaches, and the utilization of current technology. The mission must have measurable goals and objectives that support sustainability, and the ability of the health system to thrive in its ecological, social, and economic environment. Many hospitals in existence are nearing the end of their life span and will undergo renovation or replacement. The management of

these buildings and properties in a sustainable manner is an obvious next step. Renewable energy, energy conservation, access to mass transportation, recycling, building reuse, and green building design and construction are but a few of the sustainability issues that the healthcare industry can directly impact.

### **Steps to Environmental Sustainability**

Hospitals and care systems should make environmental sustainability a priority and create a culture of change to achieve lasting results.

The first step toward any change is making a commitment. Hospital and care system executives and trustees should consider the drivers behind their decision to pursue environmental sustainability. Reasons for deciding to implement sustainability initiatives include:

- Saving money
- Demonstrating corporate social responsibility
- Contributing to community health by reducing pollution Making facility operations more efficient
- Increasing employee satisfaction, engagement and retention
- Fostering a positive public image
- Meeting compliance or regulatory requirements
- Improving the patient experience

**Sustainability means:**Sustainability means many things to different organizations — from attaining a heightened level of energy efficiency for long-term savings, to meeting carbon reduction mandates, to global responsibility (<https://buildingsolutions.honeywell.com/en-US/solutions/energy/Pages/default.aspx>).

**Energy :**Energy is a complex issue that touches every aspect of a building and presents many simultaneous challenges — energy costs, occupant comfort, and energy security and reliability, using a responsible and sustainable approach, while maintaining the integrity of operating budget. to develop and implement a comprehensive energy strategy's goals: Increase energy efficiency - Decrease costs -Increase reliability and security - Improve facility management and optimization through data and analytics Meet carbon footprint and sustainability goals -Turn energy into education.

### **Leadership in Energy and Environmental**

**Design:** In the past two decades, the link between buildings and health has received considerable attention. Many media reports have highlighted the problem of indoor air toxins in sealed buildings green buildings are defined as “the practice of increasing the efficiency with which buildings and their sites use energy, water, and



materials, and reducing building impacts on human health and the environment through better siting, design, construction, operation, maintenance, and removal—the complete building life cycle”The U.S. Green Building Council developed Leadership in Energy and Environmental Design (LEED) as “a nationally accepted benchmark for the design, construction, and operation of high performance green buildings. The LEED rating system is the current best practice standard for the building sector.

LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings’ performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality”



**Figure 3:** Cedars-Sinai Advanced Health Sciences Pavilion ,Los Angeles, California, USA the hospital’s commitment to creating a state-of-the-art environment that would support a new model of collaborative practice only strengthened

**Lighting Design Goals in Healthcare :** Hospitals are complex, task intensive facilities. Many of the spaces in a typical healthcare facility such as corridors, offices, restaurants, conference rooms, and lobbies, are also found in other public facilities. The lighting requirements for these spaces are fairly straightforward and similar. Others space are entirely unique to the healthcare

segment: patient rooms, examination rooms, emergency rooms, operating rooms, nursing stations, monitoring and observation rooms, intensive and acute care units, etc.(  
<https://www.sylvania.com/en-us/applications/healthcare/Pages/lighting-design-goals.aspx>)



**Figure 4 :** Lighting design in a healthcare.

Lighting in a healthcare facility should compensate for the fact that many of the patients may have limitations in mobility and vision. Any improvements in illumination will aid in navigating the facility and reduce the possibility of accidents. Some of the visual factors to consider are: direct glare, reflected glare, harsh shadows and poorly lit visual cues to hazards. Even visual fatigue can be a factor; the delay in adapting one’s eyes from dark to brightly lit areas and vice versa. In the design of healthcare facilities, medical professionals and architects are increasingly realising the importance of creating a 'healing environment' that addresses the totality of patient and staff needs. This more holistic approach is driven by the recognition that a patient's perception of the physical environment in a hospital can affect his or her sense of wellbeing

and, potentially, health. In an effort to create this environment in modern hospitals, considerable attention is paid to detail, colour, form, light and shade. Factors such as fresh air, light and peaceful surroundings are key design drivers. From a lighting design point of view, two developments offer new possibilities for using lighting to address wellbeing in hospital areas: the advent of LED technology, and new advances in the understanding of the non-image-forming (NIF), or biological, effects of light. In the past, lighting designs focused primarily on the visual aspects of light. The main purpose of lighting was to enable people to see. A large number of lighting parameters played an important role and requirements were application- and task-dependent. The visual aspects of light have a significant effect on our performance in a given

environment.

### **Intelligent Buildings**

The concept of intelligent buildings appeared initially in the early 1980s. Since then, the definition of intelligent building has been evolving with different emphasis, mainly driven by the development of relevant technologies and the changing needs for the built environment. Two typical definitions of intelligent buildings are: "One that incorporates the best available concepts, materials, systems and technologies integrating these to achieve a building which meets or exceeds the performance requirements of the building stakeholders, which include the owners, managers and users, as well as the local and global community . and One that provides a productive and cost-effective environment through optimization of its four basic components: structure, systems, services and management and the interrelationships between them. For the

purpose of developing an evaluation methodology and tool, and in order to take account of building use and operation, the intelligent building is defined as one that (Rabee, M. Reffat 2007);

- provides a productive and cost-effective built environment through optimization of its four basic components - structure, systems, services and management - and the interrelationships between them .
- maximizes the efficiency of its occupants .
- permits effective resource management of resources with minimum life costs (focusing on the benefit of the environment, i.e. through minimum environmental impacts whilst maximizing economic impacts). The evaluation methodology and tool takes into account the following basic elements:
- facilitates the provision of productive, safe, healthy, thermally, aurally and visually comfortable built environment.



**Figure 8:Ng Teng Fong General Hospital provides built environment that has the potential to serve future generations: sustainability, or adaptability over the life cycle of the building and safeguarding the earth and environment resources.**

**The intelligent hospital** An intelligent hospital is based on a combination of existing technologies that are designed, set up, and integrated to share data back and forth, and ultimately to provide an enhanced level of clinical information, to enable diagnosis, to monitor treatment, and to provide metrics to see how your hospital is performing (Frisch, Paul 2016 )

### **Hospital intelligent building system integration**

of science, technology, information, and social development, technological progress, people's living standards and quality of life improved signs? Hospital building intelligent information technology in order to improve the level of medical information. Provide better services to the hospital's medical career, while meeting the

requirements of the hospital integrated business, building a new, modern, stable, high-speed intelligent information systems Hospital intelligent building system integration to provide an efficient, reliable information platform for the hospital, in the sharing of resources within the hospital for medical treatment, teaching, scientific research, management services. And to provide a higher level between hospital, medical, social, family and communication entrance. Realization of medical information, to achieve the combination of hospitals, community, family (http://www.enjoyor.net)

### **The Hospital building intelligent systems**

- **System integration:** Weak systems integration.

- **Building Automation System:** Automatic fire alarm and fire linkage system, public broadcasting and the Emergency Broadcast System, Floor word automation systems, patrol management systems, security systems, card systems.
- **Hospital-specific weak system:** Surgical teaching system, health care intercom systems, electronic calling system.
- **Communication and Network Systems:** Integrated wiring system, computer network system, cable and satellite TV reception system, cell phone coverage, wireless paging system.
- **Integrated Hospital Information Management System:** Comprehensive medical information management system, touch-screen information system, electronic bulletin board systems, computer workstations, remote consultation, television and telephone conference.

**Smart Hospital** The fundamental challenge is that most advanced healthcare technologies reside in very disparate systems. The blind application of these technologies results in a significant amount of manual coordination that actually reduces workflow efficiency. Organizations need to adopt both technology and process improvement strategies to enable secure access, exchange and analyze patient information, and create greater efficiencies in both business and clinical processes

**Technology-Driven Productivity** Technology is becoming an integral part of overall business strategy, implement a scalable, modular design with robust systems technology integration to improve processes, enhance safety and improve the quality of care (<https://buildingsolutions.honeywell.com>). This focus on digital health technology goes beyond advanced clinical systems and promotes many goals, including:

- Real-time health information management
- End-to-end approach from design, planning, procurement and installation
- Holistic support of a patient-centered environment
- Integration of technologies to enable more automated logistics and assist with workflow management, patient experience and satisfaction, operational efficiencies, and the mobility and accessibility of equipment
- Enterprise integration between IT, medical, communication and building technologies to create more intelligent buildings and improved clinical management
- Convergence of data flow from medical and

non-medical equipment, as well as intelligent clinical and non-clinical solutions, into and out of electronic medical records

- Economically-friendly infrastructure

#### **benefits of an intelligent, digital hospital.**

1. **Improve patient satisfaction.** Mobile applications from a bedside tablet can be tied into the building management system to give patients control over their own room temperature and lighting, as well as the ability to call the nurse, view noise levels, and control their smart TV. A patient recovering in a more friendly environment may be discharged an average of 2.5 days earlier, according to the American Society for Healthcare Engineering .
2. **Protect patient health.** Proper air movement can reduce the transmission of healthcare-acquired infections (HAIs) and can be an effective measure to promote patient safety and healing, according to the World Health Organization (WHO). The normal air flow design is based on air changes an hour (ACH); however, WHO suggests that in order to reduce infections, air flow should be designed per patient. This WHO guideline recommends 60 liters per second per patient in general wards and outpatient departments. That figure is easier to achieve with intelligent infrastructure automating the process.
3. **Stay current.** Technology is evolving so fast and hospitals are notoriously slow in adopting the latest and greatest. And that's because it's no small challenge to incorporate new technology, as hospitals are complex facilities (second only to nuclear power plants in that regard). A digital infrastructure is built to be open, flexible, and scalable so that it can accommodate future technologies and expansions.
4. **Enhance productivity.** A digital infrastructure utilizes forward thinking network connectivity to enhance wireless communication and transfer of digital data such as electronic medical records and digital imaging. Being able to access patient information remotely through smartphones and tablets enables hospital staff to react efficiently and quickly, improving not on productivity, but also patient care.
5. **Protect them like they are your own.** With a digital, intelligent infrastructure, hospital security teams can integrate video surveillance, access control, intercom, intruder detection, fire safety, RTLS, among other security systems to provide real-time data and alarms. In addition, in the event a security incident



occurs, actionable reports with traceability are available for forensic analysis

We see smart hospital systems as the solution. It has been estimated that there will be approximately 50 billion devices connected to the internet and, therefore, to each other by 2020 (Cisco 2013). These devices are already all around us, and are fundamentally changing the way in which we interact with each other and with our environment. Smart devices, which are capable of semi-autonomous interaction, are trickling into every corner of our lives, from phones and watches, to cars, appliances, and the healthcare IT marketplace. The transition from an internet of computers, to an internet of devices is referred to as the Internet of Things.

In a hospital, the Internet of Things is made up of IP addressable communications and medical devices, sensor systems, building systems, and

hospital information systems such as the electronic medical record. These are all integrated through an enterprise service bus that allows all of these disparate systems to exchange information with each other, and with patients, healthcare providers, and staff. At Mackenzie Health, we refer to this as the Internet of Healthcare Things. The Internet of Healthcare Things is fundamentally changing the delivery of health care by unifying communications and information exchange in unprecedented ways, and delivering the right information and resources at the right time to the point of care. The combination of bidirectional communication between clinical, business, and building systems, the implementation of smart, semi-autonomous devices or sensor networks, and the use of analytics within a hospital creates endless possibilities for the development of smart, efficient, and effective hospital processes.

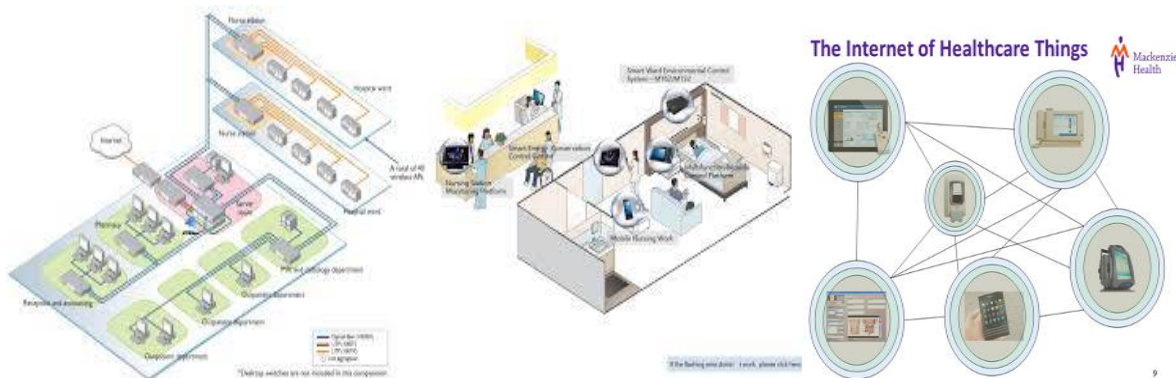


Figure 9: Comprehensive smart hospital solutions [www.healthtrainingcentre.com](http://www.healthtrainingcentre.com).

**Smart Hospital Vision**

The objectives of our smart hospital vision are:

- Patient Centred – To facilitate and improve patient care, satisfaction, safety, and experience.
- Staff Centred – To facilitate and improve staff satisfaction, productivity and efficiency
- Hospital Centred – To facilitate and improve resource utilization, efficiency, and financial performance.
- System Centred – To embrace and integrate with local community, LHIN, provincial and federal initiatives to improve patient health and safety through more integrated population based approach to health care delivery and

preventative medicine.

- Innovation Centred – To encourage, facilitate and lead the development of innovations in health care delivery, hospital process redesign, efficiency, and financial performance.

**The key features of our smart hospital are:**

Systems will be interoperable – People, systems and processes are connected and will work together seamlessly to ensure effective sharing of data, to support seamless integration of diagnostic, treatment, management and business decisions. It is imperative to deliver the right information and resources at the right time to the point of care.



Figure 10 : Exterior of Winthrop University Hospital Research and Academic Center. Courtesy of Perkins

### Eastman.

People, equipment, technology will be mobile. Our mobile health (mHealth) strategy will focus on narrowing the point of care.

All information will be digital –Reengineered (CQI) clinical and business processes will be used to create paperless, more automated work flows. Wherever possible, information will be stored in discrete and structured formats (as opposed to scanned print records), so that it is available for reporting and analysis.

Communication will be unified. Integration of audio, video, and data will allow for seamless and secure communication between patients and their caregivers, families, staff, and external healthcare providers and consultants.

High speed, reliable networking, identification technologies, sensor networks and embedded systems will interconnect the services of the facility, and provide the core infrastructure for the smart hospital, and for all future innovation projects.

#### **Interactive features**

Technology can entertain and stimulate while it educates—a critical tool in the planning and design of pediatric healthcare environments,

especially. Offering a specialty area for pediatric diabetes, the design of the new Research and Academic Center aims to capture the attention of young patients through an interactive wall in the pediatric waiting area. The overall goal of the installation is to promote movement, an important prevention method for pediatric diabetes patients, through custom-designed interactive games that will be simultaneously entertaining and educational.

#### **Future forward**

The rapid advancement and pervasive influence of technology has created the opportunity to re-imagine the delivery of healthcare. As designers, we're tasked with the challenge of integrating known technology that will enhance the patient experience in current time while strategizing future technological advancements and possibilities. Our insights, resourcefulness, and ability to visualize physical space with emerging technology will help shape the future patient experience and care model.

technology's role in improving care, the need for smart and sustainable hospital



**Figure 11: new Prebys Cardiovascular Institute supports patient- and family-centered care -Interior spaces support advanced medical treatment, patient care, research, clinical trials and graduate medical education within an environment supportive of patient and family-centered care.**

#### **The interactive hospital**

The introduction of IT in hospitals has made the use of the electronic patient record (EPR) far from unproblematic. For years the purpose of the desktop computer has been to support office work, but the problem is that hospital work is very different from office work. It involves human contact, physical work, mobile work and above all cooperation.

In short, focus of this research project was on how to adapt technology to the type of work that characterizes hospitals but also in other areas with similar characteristics.

In specific, the project focused on the surgical department in a hospital and how IT could support e.g. the work in a surgery room, and between the surgery room, the surgical ward and the rest of the hospital. In terms of research, the project has dealt with three fundamental concepts of pervasive computing and user interface design, and has

produced research results in all of them. Firstly, the project has worked with the 'context-awareness' concept, i.e. to give the computer an understanding of the use context in which it is. A result of this work is a general Java-based framework for design and implementation of context-aware technologies called "The Java Context-Awareness Framework", abbreviated JCAF. Several papers have been written on JCAF and on the use of context-awareness in general in a hospital. JCAF has been downloaded by nearly 50 other scientists and is being used today several places, also by researchers in the US, China, Japan, Europe and in Denmark. Secondly, the project has dealt with 'capture-and-access' applications, with focus on the capture-and-access during operations. This work has resulted in the prototype - "ActiveTheatre" - which shows how a surgeon can access the relevant clinical data during surgery by use of multi-modal interaction

and furthermore he can capture parts of the operation through pictures, video and voice recognition. Later, these recordings are stored in the PACS or EHR systems. An article about ActiveTheatre was presented at the UbiComp conference in Japan in 2005. Thirdly, the project has worked with social awareness, particularly to give the clinical staff a sense of what is happening around them, where the colleagues and patients are and what they are doing. This research has led to three important technological results: a general infrastructure for the mediation of awareness, called the AWARE infrastructure, a mobile phone (called AwarePhone) which can be used by the clinical staff to locate people, get information about what they are doing and to send messages, and a planning tool for surgeries that has been extended with information about what is happening in each operating ward, where people

(including patients) are situated and what they are doing. This prototype is called AwareMedia. These three technologies have been running in pilot project at Horsens Hospital since January 2006. In 2006 this field featured new research in the form of a series of articles presented at leading international conferences and journals, but also national media have covered research intensively. In addition to this, we have held a series of lectures in Denmark and abroad (<https://alexandra.dk/uk/cases/interactive-hospital>)

### Deliverable Hospital

Designer Kukil Han imagines a go-anywhere solution for providing aid to victims of natural disasters such as floods, earthquakes, tsunamis and storms. The Mobile Hospital could be delivered to any part of the world (including hard to reach areas) in a matter of hours via helicopter, or be



Figure 12: Deliverable Hospital the interactive design

transported on a larger scale by ship, providing emergency medical attention to those in need. This thoughtful design can also be customized to provide support to specific needs with relative ease, furthering its adaptability to a number of scenarios (<http://www.yankodesign.com>)

**Children's Hospital:** A big misconception about pediatric facility design is that smaller patients need smaller spaces. In fact, it means we need even greater spaces. With patients ranging from neonates to young adults, pediatric facilities have to stock a variety of sizes of medical equipment and other items used for patient care. Bed storage, for example, must handle everything from isolettes to adult-sized beds. Support services, like the pharmacy, must accommodate a broad range of body weights and physical development. Pediatric patients have a variety of accessibility needs. In addition, pediatric facilities include space for child life services, like schoolrooms, playrooms and teen lounges. Family support spaces also are essential. (Innovative Strategies for Pediatric Care Design -2015) Pediatric patients don't come to or stay in the hospital or the clinic by themselves.

Their families are an integral part of their care. Whatever we design should support the family unit as they move through the process together. In the inpatient environment, this can mean family respite or education areas on the patient unit and amenities within the patient room that support parenting other siblings; running the household from the hospital, if necessary; and continuing to work. Good sleeping accommodations, space to store personal items, a work surface and Internet access can be vital for parents. A small table for family dining or activities like coloring or playing games together can make a hospital room feel a little more like home. Benches in the exam rooms provide comfortable seating for multiple people. The exam rooms are decorated with silhouettes comprising small pictures, like animals and musical instruments, to help keep children occupied with storytelling and I-spy games. Additional interactive games and artwork are located on each floor, and parents a convenient place to share electronic health information. Designing a space that allows for two-way dialogue between the parent and the provider is really important.





Figure 13: The Buerger Center for Advanced Pediatric Care -Lobby-Ramp-Axon www.architecturescope.com

### **Impact on Children Hospital design:**

Planning for change in anticipation of future care models and technologies to provide long-term economic value has become standard practice. One strategy for addressing this is through standards and modularity, which can accommodate future growth and allow flexibility in use via scheduling or without disruptive renovation in occupied spaces (Pediatric Hospital Design 2005).

**patient rooms Design:** Designer use endless options related to configuration and aesthetics of patient rooms, nursing units, diagnostic and treatment areas, and public and outdoor spaces. The important thing is that you are able to decipher between what you need, what you want, and what you feel pressured to adopt. Not every

design solution will be right for your hospital, your staff, or your patients. As we review the five trends that we are seeing most commonly in facility design projects at children's hospitals, the hope is that we can begin to separate the trends into those that will be remembered as trends and those that will prove beneficial enough to become tomorrow's standards of care. The five overarching trends in today's children's hospital replacement or renovation projects are : ( Pediatric Hospital Design 2005)

1. Flexibility
2. Patient Safety
3. Optimal Healing Environment
4. Technology Integration
5. Security and Disaster Preparedness



Figure 14: Proposed Private NICU of Central Texas Dell Children's Medical Center Austin, TX



Figure 15: The Children's Hospital of Philadelphia

### **Designing for flexibility**

The space within a hospital that has seen the greatest changes over the past decade is without question the patient room. With patients staying days instead of weeks, nursing ratios forcing less face time between the caregiver and the patient, and most parents opting to remain beside the child 24 hours per day, the patient room is facing new demands. Increasing the flexibility of these rooms is of paramount importance, and for many

hospitals is key to maintaining occupancy rate goals and ensuring efficient patient throughput. The transition from semi-private to private patient rooms is the most obvious way to increase bed flexibility and your occupancy rate. This will raise your patient satisfaction rates (semi-private patient rooms are the strongest driver of patient dissatisfaction), support HIPAA compliance, and may lower rates of hospital-acquired infections. There is also ample evidence that private rooms



(in contrast to semi-private rooms) reduce noise, allow for higher-quality uninterrupted sleep, and ultimately result in lower average lengths of stay for some patients. Private rooms also enable a more efficient and more comfortable arrangement through the creation of three distinct zones – the caregiver zone, the patient zone, and the family zone.

Allowing for three distinct zones provides opportunities to focus on and enhance the experience for each zone’s occupants by creating design elements that respond to the likely needs of each group. The patient zone may provide views of nature, room temperature and lighting controls that the patient can control, and direct and real-time access to media choices (music, TV, internet, video). The patient bed should be located in close proximity to the bathroom (proven to reduce falls) and at an angle that provides privacy from the public corridor. The caregiver zone must have a handwashing sink, a small area on which to set something or write, access to the workstation (if

wired), and bedside supplies. The family zone usually includes sitting and sleeping spaces, internet access or laptop ports, and in some cases, a separate television in addition to the patient’s television. Spaces that allow for personalization are increasingly popular, such as photo frames and displays, artwork, or special items from home. Overall, the desire to improve patient room conditions and technological capability is evident and the new standard for private pediatric patient rooms is a generous 340-400 sq. ft., up from about 150-180 sq. ft. just a decade ago.

**Designing for patient safety**

A great deal of innovation has taken place in the patient room and hospital-wide related to the integration of technology for the purpose of reducing medical errors. A recent Hospitals & Health Networks / American Hospital Association survey of the 100 “most wired” hospitals in the United States showed that the overall patient mortality rate at



Figures 16 : Oncology infusion bays and borrowed daylight and view in waiting area.

“wired” hospitals is 7.2% lower than the rate at those hospitals that did not make the list. Though the direct correlation was reportedly unknown at this point, the study created a buzz by announcing a clear distinction between those hospitals that have made the significant upfront investment in an integrated approach to IT and those who have not enjoyed such widespread adoption. In the patient room, the early integration of technology at the bedside consisted of bar coded patient identification bracelets that can be scanned to ensure matches with personalized, automated

medication, lab, and equipment bar code labels that are brought to the patient. Today, the move toward RFID (Radio Frequency Identification) is beginning, allowing hospitals to track the status and exact location of patients, staff, and essential equipment. RFID tags are used that can be detected by tag readers throughout the facility, from a distance of up to 600 feet. Hospitals to date have used RFID mostly for the purposes of tracking supply and equipment inventory, but use of the tags for medication and patients is increasing.

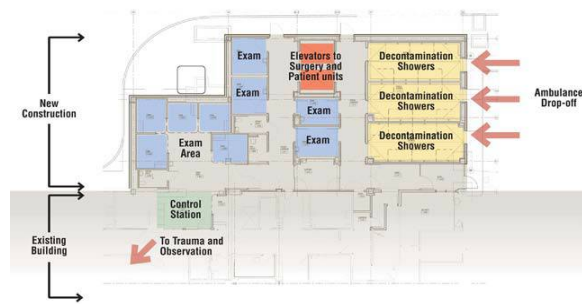


Figure 18 The level of disaster preparedness and mass-casualty readiness



Figure 17: patients and visitors expect a wireless Proposed Main Entry, Dell Children’s Medical Center of Central Texas Austin, TX Current Trends in Pediatric Hospital Design

### **Other parameters to consider in a child's space**

**Anthropometrics/Scale:** Equipment and facilities used in any of the spaces should fit the child's anthropometrics, the likes of furniture, play materials, beds, cabinets and bathroom equipment. **Textures:** Quite a different approach to interior design and furnishing is needed for children facilities. The setting should promote a "kindergarten environment", however not at the expense of medical efficiency. **Finishes:** Walls could be finished in claddings of soft materials like chip board finished in bright colours of careful combination of primary colours. Floors could be carpeted and not too slippery. **Edge Treatment:** Sharp and rough edges usually are to be rounded to reduce injuries for example in the play areas, and classroom. Dell Children's Medical Center in Austin, Texas, is a LEED-registered project that is pursuing certification at the Platinum level. A redevelopment located at the old Austin Municipal Airport, it is pursuing green strategies across the board; most notably, the integration of a combined heat and power facility that doubles the efficiency of electricity generation by utilizing waste heat for thermal energy. It is scheduled for occupancy in late 2007.

**Healthcare Daylighting** The lack of adequate natural light, the lack of the full spectrum of light, and the lack of darkness have a negative effect on physical and emotional health as well as behavior and performance. Various studies noted by Ulrich and Zimring, as well as Edelstein show that inadequate lighting levels can result in diminished immune and endocrine function, which may contribute to problems such as Seasonal Affective Disorder (SAD), diabetes, reproductive and growth disturbances, and symptoms associated with premature aging, as well as affecting working

memory and cognitive activation. Further study of this research has demonstrated that appropriate lighting conditions are important to human health and well being. There is research that shows shorter length of stays for patients in brightly lit rooms, compared to darker rooms, and that exposure to bright light improves sleep and circadian rhythms<sup>1,27</sup>. In one study noted by Ulrich and Zimring, patients exposed to an increased intensity of sunlight needed 22% less pain medication and had 20% less pain medication costs because they perceived less stress and less pain. Edelstein emphasizes the need for healthcare to have 24-hour design considerations. Day and night shift caregivers need access to daylight and darkness, as well as control of task lighting levels and glare. Patients require individual control of the lighting environment; to be able to darken a room completely for better quality of healing sleep, both day and night, and for adequate access to natural light<sup>27</sup>. The functional drivers for adjacencies and modularity also suggest a large floor plate, and healthcare facilities are challenged to bring natural light into staff work areas and Diagnostic and Treatment areas, as patient rooms typically fill the perimeter to provide daylight to patient rooms. New, sustainable recommendations require a higher percentage of access to daylight for all staff, reintroducing features such as courtyards, light wells to accomplish this. In addition to the advantages of daylighting itself, patients with views to nature require less pain medication and heal faster<sup>1,2</sup>. There is a trend towards making nature and views to nature accessible to patients, families and care givers. Planning can be organized around opportunities to provide natural views in waiting and respite areas, and especially in patient rooms.



**Figures 19: Healthcare Daylighting in patient rooms**

### **Lighting Options by Space or Area**

**Patient Rooms** : Nowhere is the accommodation of multiple lighting needs more evident than in

patient rooms. The environment needs to be welcoming and homelike for the patient and family, while providing the illuminance levels

required by the medical, nursing and support staff to perform tasks efficiently. The lighting must be provided in a way that is not distracting to other patients sharing the same space. The patient room lighting systems must provide for:

- Nursing and patient care
- Patient observation and monitoring
- Patient activities: e.g. reading,

- watching TV, resting
- Sleep (night lighting)
- Examination
- Simple medical procedures
- Visitation and socializing
- Patient mobility (safe passage to restroom and corridor)

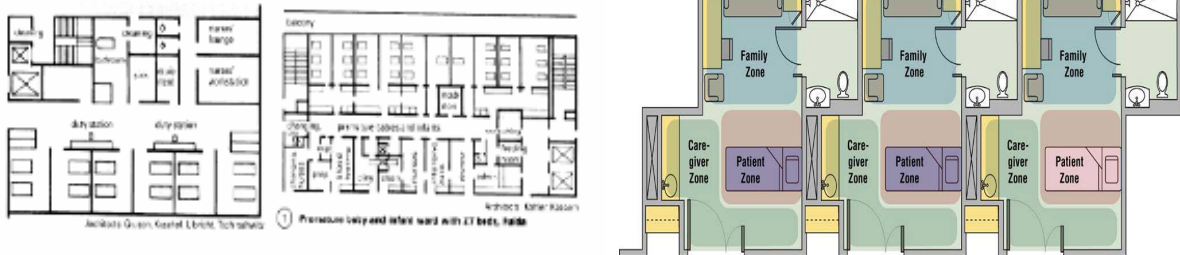


Figure 20: shows different arrangement of beds

**Coloured light: Responses to coloured light**

Thanks to the advent of LEDs, coloured light is easier to use today, and coloured lighting solutions – fluorescent or LED – are increasingly popular. New, more sophisticated lighting control systems have made it easier to use dynamic coloured lighting. If designed well, coloured light can be used effectively to influence emotion, mood and wellbeing. We experience colour on a conscious level, but also on a subconscious level, as categorised in Frank H Mahnke's 'colour experience' pyramid, which describes the effects of coloured lighting on mood and wellbeing. These effects range from conscious, personal and

temporary to more subconscious, biological and long-term. If the application of colour is not based on aesthetic impressions, it is the influence of trends, styles and associations that form the basis for colour selection. Every colour has its own properties that can evoke emotions. There are, for example, some universally valid colour associations. Warm colours such as red, orange and yellow are associated with sun and fire. Red is seen as an activating colour. Cool colours such as blue and violet, are associated with air, sky and water, while green tends to be associated with nature. Blue is described as having a calming effect.



Figure 21:- Stanley Beaman -Medical University of South Carolina

Our emotional response to colour is a response that is triggered immediately. A colour is perceived and the impression, association, response is formed. But colour has a long-term effect as well. It is a form of energy, a bandwidth of wavelengths. When it is experienced for a longer period of time – minutes, hours or days – this energy affects bodily functions, like brain activity and the production of hormones, just as it influences our mood and emotions 5 . It is assumed that pulse, heartbeat, blood pressure, EEG or galvanic skin response are physiological indices for the level of arousal – one of the biological responses to light. Literature indicates, with anecdotal evidence, that blood pressure rises

and pulse quickens in red light. Red also makes body temperature rise, and people experience a feeling of warmth. It stimulates the nervous system.

Furthermore, it has been suggested that blue rooms have a calming effect on the senses, helping people to calm down, and boosting a person's ability to concentrate. Previous research 6,7,8 worked specifically with coloured light, and showed that light of a long wavelength generates a high level of arousal and light of a short wavelength induces a low level of arousal. In the experiments carried out by Swirnowff, in which highly saturated colours were used, the red room was perceived as aggressive and the dark blue



room was found to calm the senses. Other research 9 supports the claim that blue light can be used to induce physiological rest, but it does not support the idea that red light has a stimulating effect, and still further research 10 failed to reproduce any of the effects of coloured light on physiological indices. In one experiment 11 , blood pressure

increased with blue light and decreased under red light. A number of aspects could be the cause of this discrepancy 12.

Coloured lighting used in the waiting room (left) and the patient room (right) has a positive impact on patients' sense of wellbeing Architects

Using coloured light in scan rooms



Figure 22: Phoenix Children's Hospital / HKS Architects

Taking into consideration the ambiguity of biological responses to coloured light, the use of coloured light in scan rooms will focus on the emotional responses of the patients. We split the use of (variable) coloured light in scan rooms into the three scenarios, all based on the symbolic content of colour: Coloured light to communicate signals: because in an MR room the staff and the patient are in different rooms for a large percentage of the procedure, coloured light signals can be used to communicate with the patient. For instance, a few seconds of red light might indicate to the patient to hold their breath, and green light could tell them to continue breathing again. This reduces communication barriers, especially for those who are emotionally distressed, hard of hearing and/or speak a foreign language. Coloured

light to underline a specific theme: if the decor of the space is based on a specific theme (summer, winter, spring or autumn, underwater, sky) they can be enhanced by choosing the right light colours. For a summer theme, bright and warm light colours such as red, orange and yellow can be used. For a winter theme, cool colours such as blue, green and purple are better. Coloured light for emotional association: colour can evoke emotions, and thus create an emotional state of mind. Some colour associations that are universally valid can be identified: red and orange are generally assumed to suggest warmth and cosiness; blue is considered cooler and more cheerless; a wild mixture of colours suggests cheerful and festive; and purple is thought to evoke a sad, sombre atmosphere.



Figure 23 Interior Design of Golisano Children's Hospital

**Children and Colour –Its Effects on them:** Colour schemes for children facilities include the predominant use of the three primary colours of red, blue and green. The careful selection of these colours can be used to paint the wards, the reception, and other areas where necessary. The selection can be made from combination of colours of the colour wheel or chart. Red: It is

known as a sociable and lively colour which best stimulates excitement in children. It could be used in children's play room with a combination of yellow, orange or purple. It should never be used in a baby's bedroom.

Green: This is the colour of concentration and intellect, calming in a neutral, positive sense and the most restful colour to the eye. It promotes



feelings of well-being and harmony, nature, security, stability and balance. It is best used for children's learning areas (libraries and classrooms).

**Blue:** Correct shade of blue is best used for welcoming area of hospitals. It slows the pulse rate, lower body temperature, relieve headaches, migraines and muscle cramps. Due to its soothing and calming nature, it could be used for a child's bedroom and bathroom.

**Yellow:** This colour heightens energy levels, creativity and stimulates the intellect. It cancels out feelings of heaviness or oppression and brings feelings of warmth and joy. It is one of the most appropriate colours for a child's play area because of its friendly and inviting nature. It promotes socialization among children. It should not be used for bedrooms as it is not a very restful colour.

#### Radiography & Scanning

Radiation, MRI, and CAT scanning suites include a variety of viewing tasks. Two key areas are the equipment and scanning room and the imaging and viewing room. Generally, the equipment and hardware operates in a vertical or horizontal plane so placement and shielding of luminaires is critical to avoid glare to the patient's eyes. Use high (>85) CRI general light sources to provide high quality flattering light for patient comfort and appearance. Dimming and switching controls are



Figure24: Using coloured light in scan rooms

As a result of this new, holistic approach to medicine which entails alleviating the fears and disorientation of patients that may hinder medical treatment, the hospital has come to be seen today as a necessarily comforting and stress-free environment, created with a broader, patient-oriented sense that encompasses both master planning and landscaping.

#### Noise in hospitals and staff outcomes

Studies show that noise is strongly related to stress and annoyance among nurses, and that noise-induced stress is related to emotional exhaustion and burnout among critical-care nurses (Joseph, Anjali- Mahbub Rashid - 2007). Healthcare staff reports that the excessively high noise levels at work interfere with their work and impact patient comfort and recovery. Blomkvist and colleagues examined the effects of changing the acoustic conditions (using sound absorbing

needed to adjust illuminance levels for patient transfer and prep, equipment operation and room cleaning and servicing. Portable task lighting may be needed for catheterization. Backlit ceiling graphics or patterns of light projected on ceiling create visual interest and distraction. Viewing room lighting should follow the guidelines for visual display screens in offices (IES RP-1-04 American National Standard Practice for Office Lighting).

**Hospital Outdoor Landscape Design:** Among public institutions, the large buildings and complicated intervening and surrounding areas of hospitals usually tend to be seen by the public as removed from the urban context, as spaces to be feared, which one only accesses in emergencies or out of necessity. However, this psychological perception of their distance and separation can be decreased by today's more hospitable approaches to their content and design. With a growing understanding of the importance of the physical environment for the quality of hospital care and the health and safety of patients and staff, the outdoor spaces of hospitals are beginning to be considered, particularly in scenic and more green areas, as a productive complement to the interior areas which are reserved for patient treatment and have traditionally been prioritized. (Yücel, Gökçen Firdevs - Hospital Outdoor Landscape Design).

versus sound reflecting ceiling tiles) on the same group of nurses in a coronary intensive-care unit. During the periods of improved acoustic conditions, many positive outcomes were observed among staff including improved speech intelligibility, reduced perceived work

#### The child care environment:

The purpose of the section is to illustrate both the function and the intent of each area of a child care facility. By referencing design ideas regarding circulation, spatial organization and room layout, this section provides guidelines for designing safe, functional and inspiring spaces that support child development and encourage learning. This section is organized by room and outlines

**Designing Healing Gardens :healing garden:** Gardens which serve as safe and meditative environments for healing and recuperation date back to the medieval period, and

have traditionally been features of hospitals, hospices, rehabilitation centers, and nursing homes. The wide range of activities related to healing gardens may be passive or active: looking at the garden from a window, sitting, eating reading, doing paperwork or taking a nap in the garden, prayer and meditation, walking to a preferred spot, gardening, exercise and sports, and children's play. The gardens are conducive to stress relief,

relieving physical symptoms, and enhancing the feeling of well-being of hospital staff and patients. When designing healing gardens, the same considerations are used as in designing any other garden. However, these considerations take on special meaning in healing environment. (Betty ,Ansabah Sawyerr Bsc- PAEDIATRIC CENTRE 2010)



Figure 25 :The Crown Sky Garden: Ann & Robert H. Lurie Children's Hospital of Chicago

### **Successful healing gardens make use of certain fundamental design principles .:**

**Enhance feelings of control:** People should be aware that there is a garden and be able to find, enter and use its space. The garden should have private areas which cannot be seen from overlooking windows, and different kinds of spaces so users can feel they are making choices; if users are also consulted in designing the garden, this will also add to their feeling of control. All or some of the five senses can be chosen as focal stimuli in the garden's construction. Have a prevalence of green material and areas: Patients' sense of well-being is enhanced by soft landscapes, so plant material should be dominant and hardscaping reduced to a minimum: trees, shrubs and flowers should make up about 70% of the garden, with 30% in walkways and plazas (Yücel,Gkçen Firdevs - Hospital Outdoor Landscape Design)

**Sustainability:**Resources should be allocated intelligently when designing outdoor spaces: every material used does not have to be green, and some hard surfaces like concrete can help prevent storm water run-off. Wild grasses and Sedum spp. create ground cover which reduces domestic grass, decreasing the cost of maintaining lawns. Xeriscaping (designing with low water-use plants) together with native vegetation also helps reduce water use and maintenance. Nature trails enable users to have exercise, education and a natural aesthetic at a minimal cost; and solar-powered lights and water features that recycle rainwater can also be cost effective and sustainable.

### **Case study:Nemours Children's Hospital**

Nemours is an internationally recognized children's health system that owns and operates the

Nemours/Alfred I. duPont Hospital for Children in Wilmington, Del., and Nemours Children's Hospital in Orlando, along with major pediatric specialty clinics in Delaware, Florida, Pennsylvania and New Jersey.

### **Nemours/Alfred I. duPont Hospital for Children:**

The A.I duPont Hospital for Children expansion provides a dramatic new experience for patients and visitors of the children's hospital. The shimmery glass towers and 5 story atrium daylight into the main public space and patient areas and offer views to the historic Nemours Mansion site. The atrium's directional accent lighting mounted at the edge of the balcony overlooks mimic the effect of sunlight. Uplights mounted above projecting balconies provide reflected fill light to emphasize the volume of the space. All lighting is positioned to allow easy access for maintenance. TLP's scope includes exterior lighting for the children's garden, site roadways, parking areas and entry canopy, all designed to reinforce the soft welcoming forms in the building architecture and landscape.

the Nemours expansion project is a six-story, 423,000-sq-ft freestanding pediatric bed tower, designed to focus on enhancing the health care experience for patients and their families. The \$233.6-million project was constructed in 38 months, The facility includes 144 patient rooms, a shelled floor for 44 more rooms, an emergency and imaging department, food service and dining and a five-story atrium with retail space. The team devised a prefabrication strategy to help save time on the project schedule, eliminate waste, enhance quality and improve safety. Crews built bathrooms, overhead MEP and patient headwalls



at an offsite warehouse, approximately 10 miles from the jobsite. Building information modeling was used for digital layout in the field and helped coordinate the installation of prefabricated modules. The strategy cut site rough-in time while maintaining quality standards. The team estimates that it was able to reduce the construction schedule with prefabrication by 10% to 20% compared with traditional methods.

The emergency department will nearly double in size, moving from 24 bays to 44 bays. The design emphasizes light and natural elements to improve healing. This includes the soaring 5 story Anthony N. Fusco Sr. Atrium and the rooftop healing garden. The Discovery Zone presented by DuPont is an interactive wall that uses the latest technology to create a living garden,



**Figure 26: the Discovery Zone's interactive wall his company created for Nemours/Alfred I. duPont Hospital for Children's new atrium.**

complete with changing seasons and weather patterns .

The Lighting Practice designed a system that would support the natural daylight and continue the effect into the evening. TLP incorporated directional accent lighting mounted at the edge of balcony in the atrium to mimic the effect of sunlight. Up lights mounted above projecting balconies provide reflected fill light to emphasize the volume of the space. TLP also designed the exterior lighting for the children's garden, site

roadways, parking areas and entry canopy. Each space was designed to reinforce the soft welcoming forms in the building architecture and landscape. Inspired by the gardens on the mansion grounds next to the hospital, the project team wanted to create a bold statement on the building façade. The team came up with an arbor-patterned skin that features multicolored glazing in a diagonal pattern, metal panels, and a solar shade pipe system. `



**Figure 27:the diagonal pattern and the triangular colors suggest that the glass is modular in that way, they're really rectangular sections of glass that have been twisted with battens on the outside of the building to create the diamond grid.**

**Nemours Children's Hospital Orlando, Florida**  
Square Footage: 600,000 ,LEED NC Gold .Inspired conceptual planning of programmed elements along with integration with the surrounding gardens and landscape helped create a truly remarkable building. Low-scaled and campus-like in appearance, the facility relates to children's sensibilities. Playful accents, such as the hedge-like benches that surround "picnic blankets on the grass," dot the waiting areas. The

Habitable Wall offers fun, comfortable seating options for children to enjoy with their families. The bright colors of the furniture and accent walls provide a full spectrum of color against a neutral field, like flowers in a garden. Upon arrival, children and their families are greeted by an illuminated reception desk that functions like a porch light to create a welcoming, comforting environment. It is enhanced by sparkling spotlights that twinkle in the airy space below rich

wood ceilings. Each patient room offers floor-to-ceiling windows for plenty of sunshine and healing landscape views as well as furniture that allows for family comfort. The Paint Your Room concept lets children customize their own space. They can modify their environment by painting the space with colored LED lights. This choice of color translates to the exterior and creates a mosaic of patient personalities at night (<https://perkinswill.com/type/healthcare-interior-design>) the children's hospital experience, from arrival to bedside, is designed to help balance a child's emotional needs in the face of the challenges that come with illness and hospitalization—unexplained terrors, sense of

guilt, fright, worry. The children's hospital is a place where families remain intact, where children feel "normal" and connected with the familiar and their everyday lives. It stimulates life and learning and, in the process, teaches kids of all ages about their bodies and their health. It is a place that holds optimism and resignation with equal grace. The planning and design of children's facilities with dedication, attention to detail, and the desire to create a healing environment for this special patient population. Clinical Spaces : Within the clinical spaces we used a gradation and layering of light levels dependent on different tasks: talking to the



Figure 28: Nemours Children's Hospital- Orlando, Florida

doctor, been treated, sleeping, watching tv, reading, and homework. Our aim was to create functional yet non-hospital-like lighting that is calming, reassuring, even entertaining. (New Lighting Strategies Promote Healthier Patient Experiences) The layering of light at the nurses' stations was achieved by using a mix of decorative pendant mounted fixtures, direct illumination from downlights, furniture integrated LED task illumination and perimeter lighting on walls behind the stations. This layered lighting allows for visual comfort for the nurses, and allows for tiered controls to suit a brighter daytime and lower nighttime illumination, all the while preserving the aesthetic intent. Patient Rooms: Red, green, blue, purple, yellow? Which color would you choose? Nemours' 95 patient rooms feature color changing LED lights that can be changed by patients for a dramatic effect and can be seen by as many as million visitors coming to the Orlando Airport every year. According to Michael Cluff, staff architect with Nemours, patients have been

enthusiastic about the choice of colored lighting, even noting it in satisfaction surveys. The lights are 1PXL Cove Light XR RGB fixtures and installed over the beds in a ceiling cove, washing the ceiling and walls with dynamic color controlled by each patient through an interactive television. Even in this seemingly small way, having choices and allowing the child to have control over their physical environment can boost self-esteem and outlook. When colored light is not desired, the LED fixtures shift to emit white light. In addition to providing engagement and distraction for patients and visitors, the innovative lighting display adds inspirational content that supports Nemours' mission to create a healthcare facility 100 percent focused on the needs of children and their families.

Sustainability and Cost Considerations : The design of the Nemours facility followed the latest findings in patient-centric and sustainability criteria. The lighting design of the facility follows the principles of sustainability through the use of



controllable layers of illumination, efficacious lamps and ballasts for restricted connected loads, and an intuitive control system and strategy to manage life cycle costs associated with maintenance and operation of the systems. Daylight response, occupancy response and clock settings are employed for automated lighting adjustments, while in private spaces personal controls allow occupants to adjust their local illumination. The project was designed and specified at a juncture when LEDs were emerging as a viable technology for very limited ambient lighting applications, and still very expensive when compared to conventional technologies. The design of the systems therefore applied LEDs to all applications that involved accent lighting, decorative lighting, color-changing, and video applications. The design and sustainability criteria dovetailed with cost criteria as well. The lighting systems were specified with an eye on procurement synergies in the local market, and by encouraging competition amongst vendors.

#### **King Abdullah Specialty Children's Hospital**

National Guard Health Affairs .Riyadh, Saudi Arabia .Completion Date: June 2014.Square Footage: 2 millionThe King Abdullah Specialty Children's Hospital is located in Riyadh, Saudi Arabia within one of the largest Academic Medical Districts of the region. The hospital includes a 200-bed Adult Specialty Hospital, a 350-bed Children's Hospital and a series of outpatient clinics. Pedestrian bridges and covered drop-offs link an elevated landscaped medical plaza atop public parking to the medical complex entry lobbies

(<https://perkinswill.com/work/king-abdullah-specialty-childrens-hospital-kasch>)

Circulation, both horizontally and vertically, establishes the template for the design and building configuration. The first four floors of the hospital form the diagnostic and treatment chassis

that support the three upper bed tower floors. Sensitive to the hot desert climate, the architecture massing is organized with the perimeter of the lower floors expressed as a solid skin with a rhythm of punched openings. The upper floors pull apart, forming the towers, which allow for pockets of space and natural light to filter down to the lower levels. The three towers read as a series of soft curving forms, reflecting the movement of the wind that is so prevalent at the site.

The design is respectful of the culture and context, interlacing indigenous patterning into the flooring and glazing, incorporating a rich color palette, and providing for the privacy needs of the population. The design team identified and incorporated local materials and approaches to construction that are familiar to the region and celebrate the exquisite craft of the local expert installers. This is celebrated in the complex stone patterning, polished plaster work, and local specialty glass. The interiors invoke a subtle childlike aesthetic to reach children from infant to teen as well as adults. The lobby features a three-story spiral stair anchored to a star patterned stone floor at the entry level. The celestial pattern is reinforced by the back lit ceiling panels of the lobby and the centered child-friendly light sculpture that travels down through the center of the staircase. Brightly patterned play rooms are adjacent to infusion areas and patient areas to provide much needed play during somewhat stressful times. Way finding is enhanced with the use of brightly colored walls and millwork within the patient floors. The patient rooms utilize a patient selected LED color ceiling that can be directed with the time of day to utilize optimal circadian rhythms or be turned to neutral when required. At night, the colored LED lighting in the patient rooms paint a subtle pattern of color on the tower face, visible from one wing of the tower to the next.



**Figure29: King Abdullah Specialty Children's Hospital**

### 1.6 Results and Recommendations:

- Lighting solutions, and lighting installations for healing environments in particular, should take into account all three aspects of light – visual, emotional and biological. The right balance depends on the function of the space and the activities that are performed.
- Ambient Experience is an interactive, human-centred healthcare environment that combines design and technology to create a more comfortable experience for patients and staff, improve workflow and increase operational effectiveness.
- Integrating architecture, design and enabling technologies (dynamic coloured lighting, sound, projection, RFID), Ambient Experience creates environments that the patient can personalise, embracing them within a relaxing ambience.
- The goal of our smart hospital vision is to improve patient care, patient satisfaction and safety, optimize workflow, and reduce operating costs
- Designers must consider interior design compatibility with the local environment, functional requirements, ergonomics, and economy of construction, energy conservation, interior details, sustainable design and life cycle costs.
- facilities must be designed in harmony with the architectural character of existing facilities that are to remain, especially those that are considered historically or architecturally significant
- Systems will be automated – automation technologies will be used to improve interoperability, safety, availability, efficiencies, increase productivity and, more importantly, contribute to an improved patient care experience.
- planning for telemedicine must go beyond current uses to anticipate future applications, such as traveling nurses connecting to doctors in real-time or “robot doctor” specialists incorporated into care facilities.
- Through the utilization of state-of-the art healthcare technologies in a facility designed on the principles of the Internet of Healthcare Things, and leveraging experience in continuous quality improvement Mackenzie Health will be at the forefront of innovation in smart hospital design.
- intelligent buildings use advanced information and communication technologies to develop embedded data collection and information networks.
- Aspects of hospital design such as air quality, lighting, patient room design and other interior design elements can directly impact safety outcomes
- Pediatric facility design must enable excellent medical care while also offering playful features that engage, calm and delight young patients.
- The patients may be small, but spaces must be big enough to accommodate family stays and large medical equipment.
- Technology is a way of life for young people and rooms must allow them to access social media, online games and the like.
- Wayfaring is especially important in pediatric facilities and can be achieved in a number of simple but fun and colorful ways.
- As the children react to these spaces with their sight, their psychological and emotional needs are taken care of. Creation of the gardens within takes nature into the building.
- design active and passive hospital landscapes enhance patients’ interaction with nature and so reduce stress, facilitating interaction with others in ways compatible with and complementary to those found in the urban environment.
- Lighting design should emphasize the needs of the patient. Choice of light sources and luminaires should cater to patients whose primary field of view may often be the ceiling.
- Green areas outside hospitals are today seen as both beneficial and necessary, and specialized gardens have now been designed to meet the needs of particular patient groups.

### REFERENCES

1. Betty ,Ansabah Sawyerr Bsc- PAEDIATRIC CENTRE – A NEW DESIGN APPROACH- MASTER OF ARCHITECTURE -Faculty of Architecture and Building Technology, - College of Architecture and Planning- November 2010
2. Frisch, Paul , Designing the Smart Hospital:Creating the Hospitals of the Future- January 20-22, 2016 • Dallas, TX
3. Joseph,Anjali- Rashid ,Mahbub - The Architecture of Safety: Hospital Design - Current Opinion in Critical Care 13 (2007 )
4. Rabee, M. Reffat- A Knowledge-Based Tool for Contextual-based Assessment of Intelligent Buildings- Architecture Department, KFUPM - November 3, 2007
5. Weremeychik, Evan How To Design A ‘Smart’ Hospital -December 17, 2014
6. Yücel,Gökçen Firdevs - Hospital Outdoor Landscape Design-

- <http://dx.doi.org/10.5772/55766>
7. Pediatric Hospital Design: Are they right for your organization? -Karlsberger Knowledge Paper Series –Karlsberger - Volume 1, Number 1. October 2005
  8. New Lighting Strategies Promote Healthier Patient Experiences: Nemours Children's Hospital in Orlando  
<http://stanleybeamsears.com/new-lighting-strategies-promote-healthier-patient-experiences-nemours-childrens-hospital-orlando/>
  9. Environmental sustainability in hospitals: The value of efficiency. Chicago, IL: Health Research & Educational Trust-Health Research & Educational Trust. (2014, May -). Accessed at [www.hpoe.org](http://www.hpoe.org)
  10. Transcending Project Type - Principles for High Performance Interior Design-- INTERIOR DESIGN: High Performance Interiors- PERKINS+WILL RESEARCH JOURNAL / VOL 01.02
  11. Innovative Strategies for Pediatric Care Design -2015 <http://www.hhnmag.com>
  12. Green Healthcare Institutions Health, Environment, and Economics Workshop Summary Institute of Medicine (US) Roundtable on Environmental Health Sciences, Research, and Medicine.  
<https://www.ncbi.nlm.nih.gov/books/NBK54147>
  13. Institute of Medicine (US) Roundtable on Environmental Health Sciences, Research, and Medicine. Green Healthcare Institutions: Health, Environment, and Economics: Workshop Summary. Washington (DC): National Academies Press (US); 2007.-  
<file:///books/NBK54143/figure/ch2.fl1/?report=objectonly>
  14. About Our Hospital on Anschutz Medical Campus- Children's Hospital Colorado -  
<https://www.childrenscolorado.org/your-visit/our-hospital>  
<http://www.healthcaredesignmagazine.com/article/how-design-smart-hospital>
  15. Smart Hospital Vision - Mackenzie Health  
<http://mackenziehealth.ca/ioht.php?id=598>
  16. <https://www.sylvania.com/en-us/applications/healthcare/lighting-options-by-space-or-area/Pages/critical-care-areas.aspx>
  17. <https://buildingsolutions.honeywell.com/enUS/industries/healthcare/Pages/default.aspx>
  18. <https://www.urmc.rochester.edu/childrens-hospital/giving.aspx>
  19. <https://alexandra.dk/uk/cases/interactive-hospital>
  20. <https://perkinswill.com/type/healthcare-interior-design>
  21. [www.architecturescope.com](http://www.architecturescope.com)
  22. <https://www.ncbi.nlm.nih.gov/books/NBK54151/>
  23. <http://www.healthcaredesignmagazine.com/article/how-design-smart-hospital>
  24. <http://www.australianmanufacturing.com.au/14715/csiro-report-reveals-robots-and-smart-apps-will-transform-australian-health-system>
  25. <http://www.healthcaredesignmagazine.com/article/take-5-mary-frazier?page=2>
  26. <https://practicalanalytics.co/tag/wellness>
  27. [www.healthtraining.centre](http://www.healthtraining.centre).
  28. <https://www.sylvania.com/enus/applications/healthcare/Pages/lighting-design-goals.aspx>
  29. <http://www.middleeasthealthmag.com/nov2014/feature7.htm>
  30. <http://www.enjoyor.net/en/productdetail.asp?cagid=LDMwOSwzMTksMzQ5&id=MTAzMg>
  31. <http://blog.schneider-electric.com/healthcare/2016/03/08/smart-hospital-5-benefits-intelligence/>