The Role of Sustainable Environmental Design in Enhancing the Efficiency of Healthcare Buildings in Egypt

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ABSTRACT:

The focus on sustainability in the design and construction of buildings has gained significant attention in recent years. Healthcare facilities, in particular, represent a critical sector where sustainable design can have far-reaching benefits, considering their large energy consumption, waste generation, and impact on human health. This research study aims to explore the principles and strategies for sustainable environmental design in healthcare buildings, considering energy efficiency, water conservation, material selection, indoor environmental quality, and overall environmental impact. The findings of this research will contribute to the development of guidelines and best practices for designing healthcare facilities that prioritize environmental sustainability while also supporting the health and well-being of patients, staff, and the community, Furthermore, it underscores the potential for healthcare buildings to act as exemplars of sustainability, fostering healthier environments for patients, staff, and the surrounding community.

It calls for increased collaboration among architects, engineers, healthcare providers, policymakers, and other stakeholders to promote and prioritize sustainable practices in the design, construction, and operation of .healthcare buildings

KEY WORDS: sustainable design, healthcare buildings, environmental impact, energy efficiency, water conservation, material selection, indoor environmental quality.

INTRODUCTION

Healthcare buildings, such as hospitals and medical clinics, are critical infrastructure that provide essential medical services to communities. However, these facilities are also known for their high energy consumption, extensive waste generation, and significant environmental impact. Traditional healthcare buildings often prioritize functionality and patient care over environmental considerations, resulting in inefficient resource use and harmful emissions.

In recent years, there has been a growing recognition of the need to integrate sustainability into the design and operation of healthcare buildings. Sustainable design aims to minimize the negative environmental impacts of buildings while optimizing energy efficiency, water conservation, waste management, and indoor environmental quality. By adopting sustainable practices, healthcare facilities can reduce their ecological footprint, improve operational efficiency, and promote the health and well-being of patients, staff, and the surrounding community. Careful consideration should be given to design decisions that impact the long-term operating costs throughout the life cycle. Failure to do so can result in significant increases in operating costs that surpass the initial construction costs. This is particularly true for energy costs, which have become a significant portion of operational expenses. Therefore, it is necessary to comply with environmental protection laws and regulations aimed at minimizing adverse environmental impacts on neighboring areas, such as noise pollution, air pollution, traffic impact, and more. Additionally, the selection of the healthcare building's location should not have any undesirable negative effects in this regard.

The research problem

The design process of healthcare buildings often prioritizes the functional needs of medical sciences, while the environmental considerations associated with the design process are neglected. Consequently, sustainability is not adequately considered in architectural applications when designing healthcare buildings. As a result, there is a gap between the design process and the implementation of sustainability concepts in the design of healthcare buildings, particularly in meeting sustainability standards in existing healthcare building designs in Egypt.

Objectives:

The research aims to develop sustainable design standards for healthcare buildings in order to promote the integration of environmental and health principles in application and practice. These standards aim to achieve a certain level of sustainable architecture and test its efficiency for high-performance healing environments by applying sustainable environmental design principles. The study seeks to establish a connection between sustainability and comprehensive design of healthcare buildings through a balanced methodology that includes design cost, significant flexibility, functional efficiency, and human experience throughout the design process.

- Provide a strong foundation for further studies and research in the field of health and design.
- Provide knowledge on how design can impact human health, as well as the economic impact of environmental design on health and stress in the surrounding community.
- Discuss and analyze existing global examples of healthcare buildings that implement green standards.

• Provide recommendations for the development of existing healthcare buildings in Egypt

Research Methodology

The study focuses on examining the development of compatible design standards for healthcare buildings using global assessment systems such as the Green Guide for Healthcare and Leadership in Energy and Environmental Design (LEED) program. This will be achieved through the following:

• Presenting a theoretical background on the evolution of the design concept for healthcare buildings and its transition to sustainable design.

• Discussing and analyzing global and local assessment systems for healthcare buildings.

• Analyzing international examples of healthcare buildings that apply sustainable concepts.

• Attempting to propose local sustainability design standards for healthcare buildings that align with global systems and develop an assessment form for healthcare buildings before, during, and after design and occupancy.

Design concepts for healthcare buildings

The increased interest in providing necessary healthcare services and programs at all levels reflects contemporary society's recognition of the importance of individual and community well-being in contributing to societal development. According to the World Health Organization (WHO), health is an integration of physical, psychological, and social elements, and it goes beyond the absence of diseases or any form of disability. The concept of comfort has recently been introduced in the context of hospitals, and therefore it should hold a respected value in the hospital environment to achieve psychological, spiritual, material, intellectual, and mental comfort.

In the past, the idea behind healthcare facilities and hospitals relied on the services they provided. However, the modern paradigm is based on patient requirements and comfort. In the new model of healthcare buildings, there is an interaction and integration of social aspects and technological methods for climate control by architects on one hand, and healthcare service providers, hospital administrators, specialists, and health insurance officials on the other hand. They collaborate to create hospitals with facilities that consider sufficient efficiency and flexibility to align with the requirements of the 21st century.

The architectural trend in healthcare projects is a fundamental factor in achieving healthy buildings that consider environmental, economic, and social aspects while achieving higher performance efficiency throughout the building's lifespan. Hence, the concept of sustainable hospitals emerged, which relies on advanced technology in healthcare industry and the selection of products and applications that work towards reducing environmental and occupational risks while maintaining patient health efficiency and lowering treatment costs.

The most important features of healthcare buildings in the classical period

The hospital separated as a building from the church while retaining the characteristics of wards. Each ward had a high ceiling and a large capacity (40 beds per ward). However, these wards did not consider the patients' human needs in terms of privacy, noise prevention, and infection control (Figure 1). Horizontally extended hospitals were prevalent during that period, where the structural system, such as load-bearing walls, imposed a maximum height of three or four floors at most. Expansions focused on limited clinical service areas provided by the hospital during this period, such as the operating room and delivery rooms.

The prevailing architectural trend in the mid-19th century and early 20th century tended to use decorations and amplify them as a way of expressing wealth and influence. This trend was reflected in hospital design, where there was an immersion in attention to decorations.

(Figure 1) "Manteno State Hospital 2-story Cottage plan, 1920". http://www.mantenostatehospital.com/architec-ture.html

The details and collecting various architectural styles (the eclectic approach) led to the uniform and similar features being applied to all types of buildings without distinguishing their functions. Facades became indistinguishable and no longer expressed their purpose (Figure 2). As a result, there was no specific interaction in hospital design, as the same principles applied to any other structure. Consequently, hospitals were constructed resembling palaces and public buildings in Europe (Figure 3).

Figure 2Greenwich Hospital England, 1696 to 1715.
http://www.sandiegohistory.org/journal

Figure 3
Miami city Hospital
l 1917.
http://www.flickr.com/photos/imagemd/144.

Hospital design Modernism

The architectural movement of that period did not touch upon religious aspects and did not provoke intercultural or interreligious tensions. Modern architecture did not prioritize the social, aesthetic, and heritage values of the population. This period was associated with the expressive and planning concepts of hospitals, with each expressing the prevailing function and technology of that period. The idea of modernity in architecture emerged at the beginning of the 20th century and continued to dominate the architectural movement, spreading worldwide until the end of the 1970s. Modernist ideas emphasized simplicity and a departure from decorations (Figures 3), as well as the use of modular units and standardization, making construction easier due to The use of modern technology and materials played a significant role in the widespread adoption of modern architecture worldwide. For this reason, it was named Universal Architecture. There was a strong connection between architects, thinkers, and artists in establishing the global modern design movement. Buildings started to adopt a new style that prioritized function. Healthcare facilities built in the 1920s, especially hospitals, embraced the language of modernity (Figures 5). During this period, many architects emerged who overlooked the principles of modernism in hospital design, such as architect Alvar Aalto, who designed the Paimio Sanatorium.
Note: Due to the incomplete sentence regarding Alvar Aalto, I provided a general explanation. If you need a more specific translation or additional information, please let me know.


Figure 3
"Freemason's Hospital, East Melbourne 1936".
http://www.sydneyarchitecture.com/INW/INW07.html

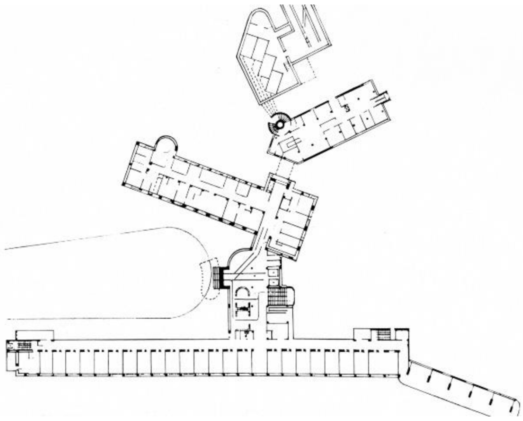
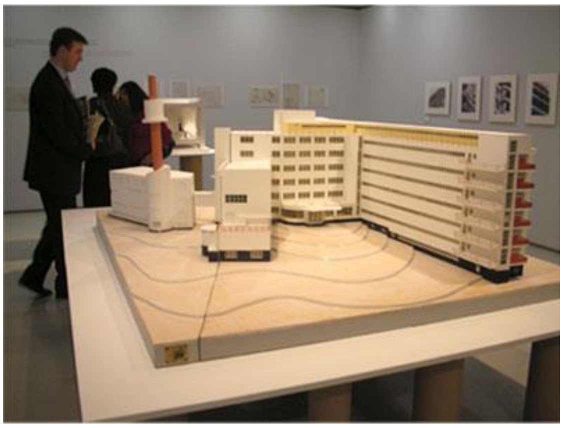



Figure 4
Alvar Aalto's Tuberculosis Sanatorium 1929-1933
http://www.designboom.com/history/aalto/paimio.html

Hospital design Post Modernism

Post-modern architecture emerged as a reaction to modern architecture. It reintroduced decorative and ornamental elements into building designs, often with vibrant colors and illogical arrangements. It selectively borrowed historical details from various periods, creating a collage of symbols and aesthetic details. This style predominantly employed free geometric shapes in deliberate contrast to scale (Figure 5). This approach evolved in the latter years of the 20th century, where the language of the period involved the use of high technology, known as High Tech. Architects shaped it according to their direction to represent the language of the era and express culture, place, and the public. This international style is characterized by the diversity of its elements, combining local, regional, and international influences. It disregarded individual human requirements. There were negative effects of the application of modernism in various countries, as architecture and architectural formations became confined to a single template, leading to uniformity

Figure 5
Health Central, West Orange Hospital, Ocoee, Florida,1993.
Hospital Building from the temple to the mall concept, UIA Congress 2005, Istanbul, Turkey.

and similarity in urban development.

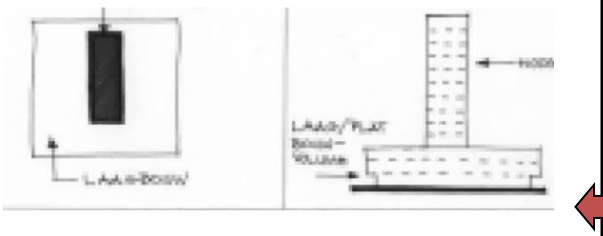
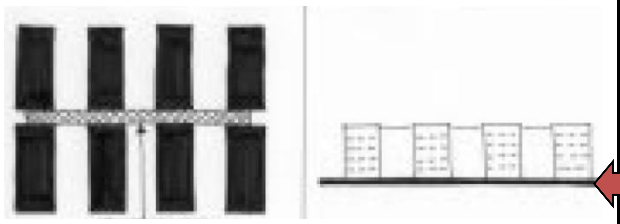
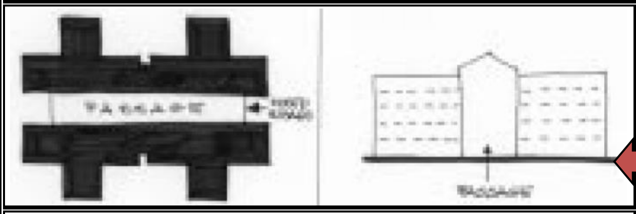
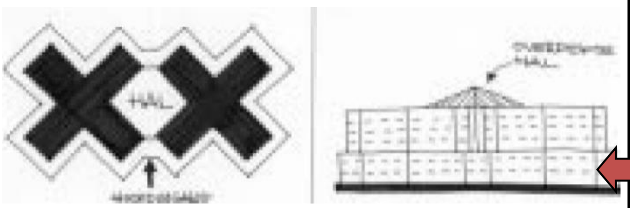
Post-modern architecture was characterized by its uniqueness in form, deviating from simple geometric shapes. Pluralism and diverse creative approaches emerged (Figure 6). There was a renewed focus on aesthetic and formal elements, colors, and the reintroduction of decorations, drawing inspiration from heritage, historical forms, and local popular architecture. The open plan emerged, and interior walls became movable, giving rise to the free plan and undulating, curved walls, emphasizing continuity and freedom in the relationship between the interior and exterior .(Figure 7)

Figure 6
Augusta Medical Centre Fishersville, Virginia, 1994.
The American institute of architecture press, 1996, Health Facilities, Rockport publishers Inc Washington. D.C

Furthermore, post-modern architecture demonstrated an interest in local culture and human aspects, which influenced the new design concept for hospitals. Specialists in this field shifted their focus to patient care, whereas in the past, the emphasis was largely on doctors and nursing staff.

<table>
<tr><th colspan="2">The Hospital Design Development In 20th Century</th></tr>
<tr><td colspan="2">The evolution of hospital design throughout the 20th century can be summarized as follows:

1. Shift of nursing units from the center and heart of the hospital to its outer periphery. Diagnostic and therapeutic services were centralized.
2. Increased flexibility leading to the development of the cluster model. The main functional groups such as nursing units, outpatient clinics, diagnostic departments, and treatment departments were arranged in close proximity, allowing for independent changes in each area.

This evolution signifies a shift towards patient-centered design and efficient organization of healthcare services within hospitals. The cluster model promotes better coordination and accessibility of different departments, enhancing the overall functionality and adaptability of hospital design</td></tr>
<tr><td></td><td>The Old breitfuss-type
The model of the 1960s in the twentieth century featured a vertical arrangement where the service area was located below and above it were the nursing units.</td></tr>
<tr><td></td><td>The comb-type
The model of the 1970s in the twentieth century was characterized by the comb-shaped design, allowing for both horizontal and vertical expansion.</td></tr>
<tr><td></td><td>The passage-type
The model of the 1980s in the twentieth century was characterized by the vertical corridor design.</td></tr>
<tr><td></td><td>The atrium-type
The model of the 1990s in the twentieth century was characterized by the internal courtyard design.</td></tr>
</table>

Green architecture

Figure 7 Green architecture

http://www.livingspacearchitects.com/sustainable-development.

The process of designing buildings in an environmentally respectful manner, taking into consideration the reduction of energy, material, and resource consumption, while minimizing the environmental impacts of construction and usage, and maximizing harmony with nature. The relationship between the environment and architecture is interactive, as humans strive to understand the impact of each on the other in order to achieve their comfort and utilitarian needs. The forms of interaction with the environment have evolved according to climatic and environmental conditions and individual requirements. Sustainability is a comprehensive concept that encompasses the material and moral aspects of human life, ensuring its continuity for future generations. Therefore, sustainable architecture is in harmony with the surroundings and the environment, preserving its natural or economic resources Reducing the use of non-renewable resources.

Enhancing the natural environment

Minimizing pollution.

Ensuring that the building is compatible with the spatial and human context of the surroundings to meet individuals' needs in an environment constructed with minimal possible harm to the environment. Achieving sustainable design requires attention to several elements, as shown in (Figure 7): renewable resources, respect for ecological value, use of sustainable materials, adoption of positive design strategies, consideration of transportation impact, cost-effectiveness throughout the building's operational period, and achieving health and well-being.

The main aspects that make the design compatible with sustainability

• Reducing the use of petroleum-derived energy in energy-consuming aspects, including transportation, construction, manufacturing, installation, and energy used throughout the building's lifespan.
• Using materials that are reusable and recyclable.
• Avoiding the use of alternatives that contain volatile organic compounds.

• Maximizing the use of natural lighting in the design process.
• Ensuring building management simplicity, avoiding complexity in forms and management methods.
• Relying on natural ventilation and its impact on the space to reduce energy consumption and achieve thermal comfort.
• Utilizing solar energy in heating and cooling systems while employing efficient machinery.
• Harnessing opportunities for on-site renewable electricity generation.
• Utilizing geothermal energy for heating and cooling purposes.
• Conserving water through rainwater collection, greywater treatment, and reuse.
• Reducing stormwater runoff by implementing collection tanks.
• Creating an outdoor environment that provides visual comfort and environmental benefits, such as shading with trees and cooling through evaporative elements.
• Ensuring that the design adheres to the highest specialized standards with aesthetic excellence.

Standards and strategies for designing sustainable health care globally

There are five primary branches that determine the plans and strategies of sustainable construction, and based on which sustainable design tools and standards are developed. They are:

1. Site Planning: This involves considering the site's location, orientation, and surrounding environment to optimize energy efficiency, minimize environmental impact, and promote ecological balance.
2. Energy Use: This branch focuses on reducing energy consumption and maximizing the use of renewable energy sources, such as solar, wind, or geothermal energy, to power the building and its systems.

Site Planning and Access to Nature
Clean Transportation
Energy Efficiency
Water Conservation
Indoor Environmental Quality
Healthy Material Selection

3. Water Conservation: The goal here is to minimize water usage through efficient plumbing fixtures, rainwater harvesting, water recycling, and implementing strategies for responsible water management.
4. Materials Used: This branch emphasizes the selection of sustainable and environmentally friendly materials, including recycled

or recyclable materials, low-impact materials, and those with a reduced carbon footprint.

5. Indoor Environmental Quality: This branch aims to create a healthy and comfortable indoor environment by incorporating proper ventilation, natural lighting, and utilizing non-toxic materials that promote air quality and occupant well-being.

These five branches form the basis for sustainable building plans and strategies, and they guide the development of sustainable design tools and standards.

Strategies and components of sustainable design for healthcare buildings

The research reviews several key components of sustainable design for healthcare facilities, including the following:

Indoor Air Quality Strategy: This involves implementing measures to maintain clean and healthy indoor air, such as proper ventilation systems, air filtration, and the use of non-toxic materials that minimize off-gassing and indoor pollutants.

Materials and Resources Selection Strategy: This strategy focuses on choosing sustainable materials and resources for construction and operation, including recycled content, locally sourced materials, and products with low environmental impact.

Natural Lighting Methods Strategy: This strategy emphasizes the use of natural light to illuminate interior spaces, promoting energy efficiency and creating a visually appealing and comfortable environment for patients and staff.

Connection with Nature Strategy: This strategy highlights the importance of incorporating elements of nature, such as views of green spaces, access to natural light, and the integration of healing gardens, to enhance the well-being and healing process of patients.

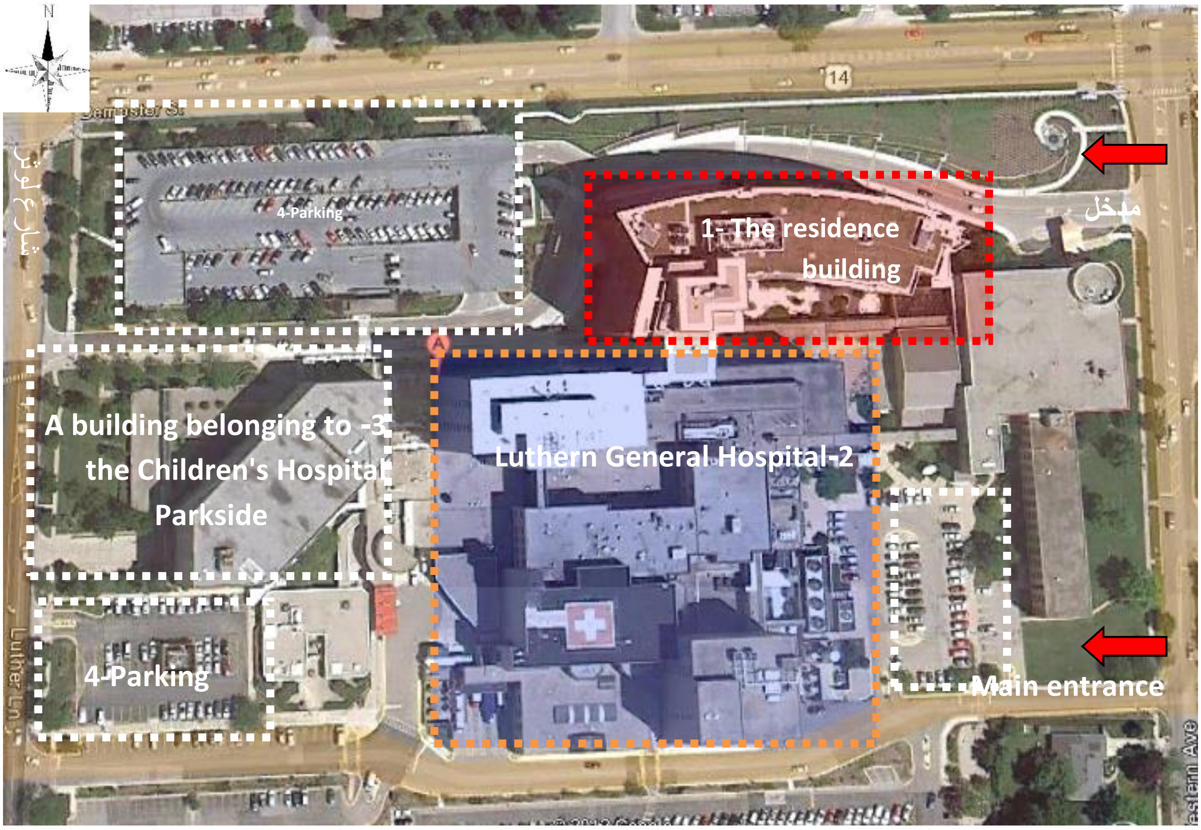
Clean Practices Strategy: This strategy involves implementing effective cleanliness practices and infection control measures to ensure a safe and hygienic environment for patients, staff, and visitors.

These components play a crucial role in designing sustainable healthcare buildings that prioritize indoor air quality, material selection, natural lighting, connection with nature, and cleanliness practices.

After explaining the main green assessment systems and highlighting the key criteria on which they can be evaluated, some buildings that have achieved high environmental performance will be discussed. This will demonstrate the importance of achieving these assessment systems in buildings to reinforce the research's objective, which aims to develop a methodology for creating healthcare facilities with exceptional environmental performance that aligns with the criteria of green assessment systems.

Advocate Lutheran General Hospital, Children’s Hospital Patient Tower

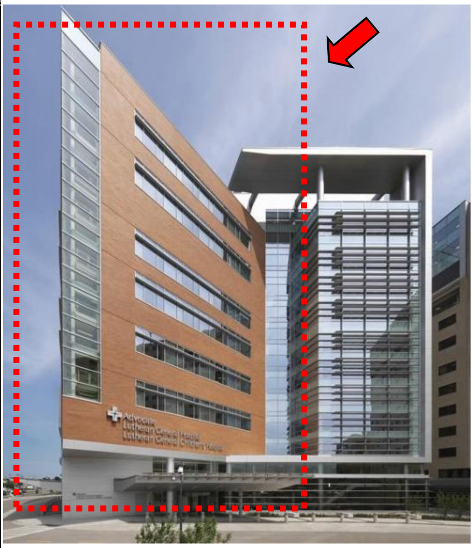
The aim of constructing this new building was to increase the number of individual accommodation rooms and provide healthcare services to individuals, families, and the community. This idea stems from a comprehensive philosophical concept based on our belief in the existence of humans in the way that God intended. The new residential building represents a new addition to the Lutheran General Hospital, serving as a new entrance and holding significant importance in providing and improving a healthy environment for patients, families, and the healthcare team.Patient safety, building efficiency, performance, and improving the quality of life for patients and staff were among the key motivations for the design team when conceptualizing the building. The new residential building is the first to achieve LEED Gold certification in the city of Illinois, USA, and one of the few buildings worldwide to attain this rating. It works towards reducing energy consumption by more than 50% of the total consumption volume.



A general site plan illustrates the location of the new building in relation to the other buildings within the campus of Advocate Lutheran General Hospital in Illinois, USA:

1- New Residential Building at Advocate Lutheran Children's Hospital
2- Advocate Lutheran General Hospital Main Building
3- Parkside Pediatrics Building (Affiliated with the hospital)
4- Dedicated Parking Lot.

	**Advocate Lutheran General Hospital Patient Tower**	
	OWP/P and Cannon Design, Chicago	designer
	Dempster Street, Park Ridge, Illinois	site
	consists of 8 floors, 59,855 m2	area
	It is considered the first green building in the region to obtain a LEED Gold certificate	Reason for selection

Basic data for the new residence hall, Lutheran Advocate General Hospital ALGH		
	LEED Gold 2010	
	The total area is 35,675 square meters, with a renovation area of 4,180 square meters. The building has 8 floors and accommodates 192 beds as follows: 102 beds for medical surgery, 22 beds for intensive care, 15 beds for pediatric intensive care, and 28 beds for the maternity ward. The construction cost of the building is $200 million.	
	2009	
	Advocate Health Care	
	Conservation Design Forum, Inc.	
	Gewalt Hamilton Associates, Inc.	
	Electrical, mechanical, plumbing and energy consulting works	
	Grumman/ Butkus Associates and Dickerson Engineering, Inc.	
	Power Construction	
	CB Richard Ellis	

Strategies and features of integrated design

The project was approved and achieved LEED Gold environmental certification in July 2010. The design accreditation was carried out by the designers "OWPP / Cannon Design" based on the following essential requirements that must be met in the design, represented by the following criteria:

1. Sustainable Sites: The project focused on minimizing the environmental impact of the building site, including site selection, water efficiency, and stormwater management.
2. Water Efficiency: Strategies were implemented to reduce water consumption within the building, such as efficient fixtures, landscaping techniques, and water recycling systems.
3. Energy and Atmosphere: The design incorporated energy-efficient systems and technologies to minimize energy usage and greenhouse gas emissions, including efficient HVAC systems, lighting, and renewable energy sources.
4. Materials and Resources: The project prioritized sustainable material selection, waste reduction, and recycling practices, aiming to minimize the environmental impact during construction and operation.
5. Indoor Environmental Quality: Measures were taken to ensure a healthy and comfortable indoor environment, including proper ventilation, indoor air quality management, and the use of low-emitting materials.

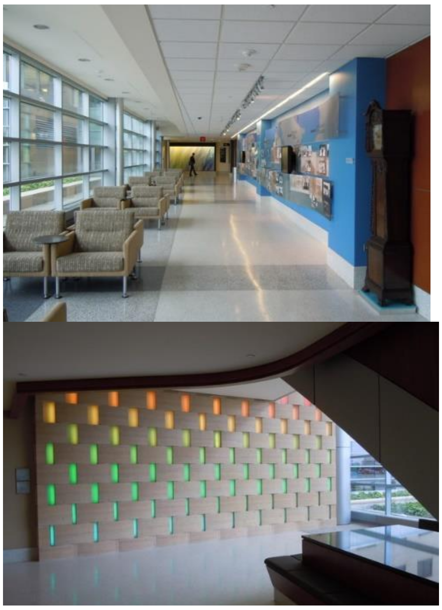


Figure 8

Use appropriate materials and raw materials.

These criteria served as the foundation for the design accreditation process and contributed to the project's achievement of LEED Gold certification.

Water conservation: The additional cost of achieving LEED Gold certification for the project represents 2% of the total project cost. Although these certifications add value to the project through their significant sustainability capabilities, there is still a desire to make such investments clear and tangible. Unfortunately, many sustainable features are buried within different systems, materials, and project resources. The key site features, especially the stormwater management structure, provide the best opportunities to achieve clear and visible sustainability for the community.

Green roofs, rain gardens, and the main park represent very few components of the green concept. Therefore, the design team attempted to add other green applications, focusing on rainwater treatment, utilization, and effective utilization by illustrating the path from the roof to its designated use, making it a step forward towards sustainability. The transportation of water from one surface to another involves the use of covered drains and a series of open channels.

Figure 9
Water conservation

The quality of the plants used was also taken into consideration, selecting plants that require a limited amount of water for preservation and conservation. The gardens are irrigated with treated rainwater, and specific types of plants that are suitable for the site's climate were chosen. The flow rate of water is controlled through connections, and temporary water taps are used only when needed to control the amount of water flowing and to restrict the use of drinking water to its designated purposes.

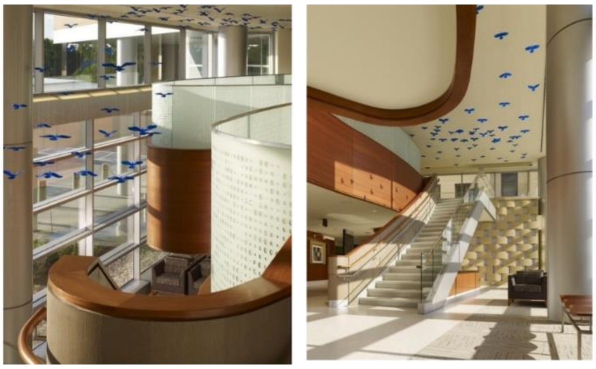


Figure 10
Indoor environmental efficiency

Site sustainability: The site sustainability element relied on easy access to the building through the main roads surrounding the project site. It also involved allocating parking spaces and creating gardens at the main entrance of the project, as well as green roofs to reduce rainwater runoff and utilize natural site resources. The gardens were paved with non-permeable materials, and there were plans in place to manage the water. Additionally, provisions were made for bicycle parking and changing rooms.
Special finishing materials and roof materials were used to minimize the impact of heat island

LEED Education room

Figure 11
Energy saving, recycling and air efficiency

Healthcare and education must always go hand in hand. Many hospitals feel a responsibility to protect public health, and focusing on sustainability is as important to the community as food, health, and well-being. One of the roles of the building is to facilitate dialogue between health and the environment. To showcase the green and sustainable aspects of the building and its educational mission, Lutheran Advocate Hospital has established a LEED Gold learning hall. This hall highlights the achieved LEED Gold features of the new building and how to maintain those important characteristics for the community. Located at the main entrance, the hall helps educate the public about the project's advancements and the hospital's commitment to achieving green standards that drive the hospital forward.

The hall also demonstrates how rainwater drainage is managed and made available to visitors, allowing individuals to calculate their carbon emissions. It emphasizes the hospital's historical contribution to environmental preservation since the establishment of the main hospital building and its current role in achieving sustainability. The founders of Advocate Lutheran Healthcare believe in comprehensive patient care, which includes healing, social improvement, and spiritual well-being. With this approach, the hospital not only raises awareness but also establishes a new connection between the community and the building as a place of healing.

The LEED certification features implemented in the new residential building include energy conservation, recycling, air efficiency, and many other aspects that improve the building's impact and performance. However, all of this is considered minor compared to the potential returns and outcomes of the project when it comes to educating people about sustainable green ideas. If the hospital can make even a slight change in the awareness of visitors, its impact can extend far beyond the hospital campus.

Daylighting: refers to the entry of natural daylight into interior spaces by increasing the dimensions of external openings such as windows, proposed inner courtyards in the design, and the use of skylights and reflective surfaces. This works to improve the

Figure 12
Interior courtyards proposed in the design.

performance of work inside the building and enhance patient healing rates while achieving significant energy savings.

When designing patient rooms, careful consideration is given to maximizing the entry of natural daylight into the room and corridors simultaneously. This is achieved by relatively high floor heights and the presence of overhead openings on both sides of the room to allow light to enter from one side and the other on the internal corridor, enabling the maximum amount of illumination to enter

Green roofs: At the top of the building, there is an extended rooftop garden equipped with filters, drains, and channels to transport rainwater and gradually release it through internal pipes within the building to irrigate the interior gardens. This is known as the "rain garden system." The green gardens cover 70% of the building's surface, creating a natural insulation layer that improves the quality of the indoor environment.

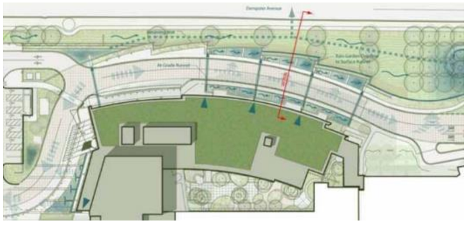
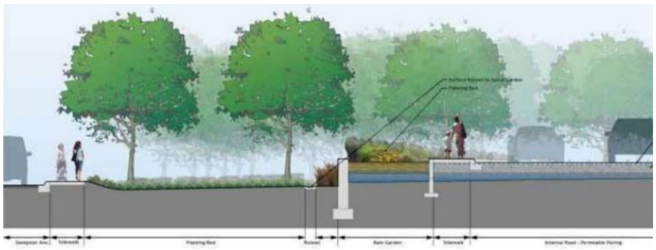


Figure 13
To the rainwater collection network, green roofs



This example was presented by introducing the basic information about the residential building and its main components and then clarifying the strategies and features of the integrated design, which include energy efficiency, waste and resource management, water conservation, site sustainability, indoor environmental quality, daylighting, creativity and innovation in design, and site coordination. This was achieved through green roofs, permeable external pathways, rain gardens, and rainwater storage. Finally, a plan was developed to illustrate the key determinants implemented in the example, based on the project's nature and the priorities set by healthcare authorities in each building.

LEED rating degrees obtained by the building
The LEED standards implemented in the Health and Healing Center focused on sustainability aspects in site development, water and energy consumption efficiency, and innovative

methods of conservation. They also considered the quality of resources and materials required for construction and finishing, as well as ensuring the indoor environmental quality of the center. The center received 55 points out of a total of 69 points, qualifying it for the Platinum certification issued by the U.S. Green Building Council. These points were accumulated through the assessment outlined in the following table (Table 1):

The new residence building at Lutheran Advocate General Hospital	LEED	Sustainability aspects	n
13	14	Site sustainability	1
5	5	Efficient water use rationalization	2
14	17	Energy efficiency and saving	3
8	13	Rationalization of materials and resources	4
10	15	Indoor environmental quality	5
5	5	Design and creativity	6
55	69	total	

Basic elements of sustainable design

First: Early Decision Making

Where planning and design are deeply studied and filled with innovative decisions that have a clear impact on energy sustainability and utilization of solar design, as well as lighting and natural ventilation.

Second: More of a Philosophical Approach than a Building Style

Sustainable design leans towards a philosophy of construction rather than just looking at a specific architectural style. Sustainable design does not have a distinct appearance or building style as much as it has visible or hidden effects on the environment, humans, and costs.

Third: Design without Additional Costs or Design Complications

Sustainable design does not entail any additional costs as commonly believed. It always aims to reduce costs, especially during the operation phase. Furthermore, it does not introduce any design, human, or implementation complexities compared to traditional designs.

Fourth: Considered as an Integrated Design

The most distinguishing feature of sustainable design is the integration between system components. Each system considers the goals and strategies of other systems and deals with them sensitively and accurately to ensure the successful achievement of sustainable design objectives.

Fifth: Lower Energy Consumption and a Healthier Environment

Sustainable design helps reduce energy consumption and achieves better human health through the use of energy-saving architectural elements, energy-conserving building envelopes, electrical, mechanical, and sanitary systems with greater energy efficiency, ensuring a high level of human health.

Providing an evaluation form for the proposed methodology

In this proposal, the life cycle of the building has been addressed as consisting of three stages, as outlined in the proposed methodology. These stages include the pre-design stage, the design and construction stage, and finally the post-occupancy stage. Therefore, the three stages were considered, and an evaluation checklist (CHECK-LIST) was developed for each stage, with key indicators. Each indicator includes a set of constituent elements based on the study of chapters three and four, resulting in such a checklist. The indicators included in the checklist are the same as those in the proposed methodology. The following are the indicators

presentation of the proposed system

The checklist serves as an entry point for the Egyptian-specific assessment of healthcare buildings expected to be constructed in the coming years. Therefore, the adopted approach in dividing the assessment levels follows the Egyptian GPRS system, which was previously introduced in Chapter Three. The evaluation checklist consists of three levels:

1. Silver Pyramid (the lowest level, ranging from 80 to 99 points)
2. Golden Pyramid (the average level for green building certification, ranging from 100 to 129 points)
3. Green Pyramid (the highest level for green building certification, starting from 130 points and above)

The highest assessment level is Green, not Platinum as in other systems, because the nominal and desired goal is to achieve the Green level, as practiced in the Egyptian Green Building Assessment system. Additionally, another assessment level can be added, which is the Pyramid Certified level, ranging from 65 to 79 points.
Determinants of assessment: The system includes several indicators, specifically targeting a segment of buildings, which are sustainable healthcare buildings. These indicators highlight the environmental factors that impact the green performance of the building, as shown in Table 2. The most important proposed indicators to be included in the system, along with the number of points assigned to each indicator's elements, are as follows:

Table 2: The most important determinants that were covered in the evaluation form. (Source: researcher)

Post-occupancy determinants		Design and construction parameters		Pre-design parameters	
15	Waste and waste management	6	Building design	5	Integrated design
10	Catering services	23	energy	10	Site sustainability
15	Costs and savings	23	Indoor environmental quality	5	Alternative means of transportation
8	Environmentally friendly purchases	15	Materials and resources	3	Zone priority

5	**Social Responsibility**	**10**	**Water use efficiency**		
4	**Applying sustainability thought**	**5**	**Innovation and creativity in design**		
57	**total**	**82**	**total**	**23**	**total**

As shown in the previous table, the total sum of the indicators is 162 points. This is divided into 23 points for pre-design indicators, 82 points for design and construction indicators, and 57 points for operation indicators. The following is a presentation of the proposed evaluation checklist:

Pre-design evaluation form				
Yes: Yes the item can be fulfilled				
Possibly: Unsure of ability to achieve item, but try to achieve				
No: It cannot be achieved at the present time due to cost or other justifications				
عدد النقاط = 5	**Integrated design**	No	Possibly	Yes
1	• Integration of various building processes.			
1	• Establishing comprehensive sustainable construction plans.			
1	• Implementing building management plans from the start of operation.			
1	• Forming the project team from the beginning.			
1	• Considering the building as a whole.			
عدد النقاط = 10	**Site sustainability**	No	Possibly	Yes
1	• Site selection, planning, and utilization.			
1	• Environmental assessment of the site.			
1	• Site and neighboring building management.			
1	• Area development and mitigation of disturbances and incidental erosion on site.			
1	• Reduction of existing emissions on site.			
1	• Parking management.			
1	• Provision of rest areas.			
1	• Minimization of incidental pollution from construction activities.			
1	• Stormwater management.			
1	• Impact of heat islands.			
عدد النقاط = 5	**Alternative means of transportation**	No	Possibly	Yes

1	• Dependence on alternative transportation methods.			
1	• Low-emission vehicles.			
1	• Energy-efficient and energy-saving vehicles.			
1	• Accessibility of public transportation to the site.			
1	• Provision of parking spaces for cars and bicycles.			
عدد النقاط = 3	**Zone priority**	No	Possibly	Yes
1	• Priority of the area for project establishment.			
1	• Research and studies.			
1	• Success of the project in the chosen location.			

A proposed sustainable methodology for designing healthcare buildings in Egypt has been developed after reviewing the most prominent healthcare building assessment systems worldwide, such as the Green Guide for Health Care (GGHC) and the U.S. Green Building Council's LEED for Healthcare (LEED-HC). The study also examined the indicators and requirements of each system. Additionally, the Egyptian Green Pyramid Rating System (GPRS) and its indicators and levels were presented in Chapter Three.

The research further analyzed two global examples of healthcare buildings that received LEED-HC certification, identifying the applied indicators during these examples. Based on this analysis, the research aimed to establish a sustainable methodology for designing healthcare buildings in Egypt, incorporating the latest global design concepts. The focus was on relevant indicators throughout various stages, including site selection, design, operation, and cost considerations.

The research concludes that these indicators, along with their elements, can effectively control the building's performance, enhance productivity among the staff, and ultimately improve the health and well-being of patients.

Three stages were identified to achieve the main sustainable methodology throughout the building's life cycle: pre-design stage, building design stage, and post-occupancy stage. Each stage encompasses a set of indicators that contribute to implementing the methodology through their respective elements. An evaluation checklist was developed for each of these three stages.

First: The Results

1. Evolution of Design Concepts: The research identified the development of design concepts for healthcare buildings in the 20th century through three

main axes: firstly, the evolution of design concepts for healthcare buildings in line with architectural advancements, secondly, the design evolution based on scientific and medical discoveries, and thirdly, the design concept evolution based on human needs.

2. Sustainable Design Strategies and Components: The study identified a set of determinants for sustainable design strategies and components for healthcare buildings, including indoor air quality strategies, improving indoor environmental quality, material selection strategies, resource strategies, natural lighting strategies, and cleanliness practices and food services strategies.
3. Obstacles to Sustainable Design: The research highlighted several obstacles that affect sustainable design for healthcare buildings, such as cost, leadership, and infrastructure challenges.
4. Research on Green Building Assessment Systems: The research aimed to monitor and analyze the most important green building assessment systems for healthcare buildings to assist designers and implementers in improving building performance through various environmental determinants, including energy, water, site, materials, resources, and elements that contribute to achieving an appropriate environment for treatment and healing.
5. Green Building Assessment Systems' Determinants: Green building assessment systems consist of a set of determinants that include multiple elements, allowing for comprehensive performance assessment based on the improvement of elements' performance. This differs from traditional buildings that focus on performance in specific determinants rather than all the determinants covered by the assessment system.
6. Global Trend and the Egyptian Approach: The global trend towards achieving green building assessment systems has influenced Egypt's direction in adopting a performance assessment system for buildings to improve their performance and deal with the surrounding environment. The Egyptian system includes fixed determinants and defines grading for evaluating the elements of those determinants. However, the Egyptian system is still a general system, not specific to building types. Due to the significant importance of healthcare buildings, the study attempted to propose a methodology specifically for designing healthcare buildings.
7. Proposed Methodology: The proposed methodology applies the concept of sustainability throughout the building's life cycle, consisting of three stages: pre-design stage, building design stage, and post-occupancy stage. Each stage includes a set of determinants that can be applied to buildings.
8. Evaluation Form: To realistically implement this methodology, an evaluation form was created to assist in implementing the proposed determinants with their various elements. The form includes a set of points for each determinant, allowing for an assessment of the building's sustainability based on the evaluation form.

Second: Recommendations

Previous studies have yielded several recommendations that can help in the development of sustainable design for healthcare buildings, meeting the needs of patients, medical staff, and visitors, and facilitating the healing process. These recommendations include:

1. The importance of the government adopting a green building assessment system specifically for healthcare buildings in Egypt, taking into account the surrounding environment and climatic conditions in Egypt, and defining appropriate determinants and associated elements.
2. The research recommends incorporating sustainable design determinants for healthcare buildings into the design standards of the Egyptian code specifically for designing such buildings. The upcoming part of the code should address sustainable design for healthcare facilities.
3. The research also recommends the continuation of studies in this regard, with a focus on each determinant and emphasizing its achievement to reach ideal determinants that can be included in the Egyptian code as a rule to be followed during the various design stages.
4. It is important to study and explore the proposed determinants and how to implement them through the elements listed under each determinant. This should be applied to healthcare buildings in Egypt, and further experiments should be conducted in this field to establish a consistent formula that can be referred to during the design stages.
5. Special attention should be given to studying the architecture of sustainable healthcare buildings in colleges and architectural institutes. Libraries should be equipped with up-to-date references on the architecture of such buildings. This is to activate the principle of evidence-based design and research

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