

The Application of the Biophilic Design in Healthcare Buildings

- Outpatient clinics -

Dr. Rania Khalifa

Architectural Engineering Department, Higher Institute of Engineering, Shorouk Academy, Cairo, Egypt

Dr. Engy Metwally

Architectural Engineering Department, Higher Institute of Engineering, Shorouk Academy, Cairo, Egypt

Dr. Amna Nassar

Architectural Engineering Department, Higher Institute of Engineering, Shorouk Academy, Cairo, Egypt

a.abdelhafeez@sha.edu.eg

Abstract

In the last ten years, due to the growing environmental challenges, biophilic design has become one of the trending topics to increase the quality of life in addition to achieve sustainability in buildings. Since Egypt is one of the countries suffering from many environmental problems, studies have been directed towards maintaining sustainability in different types of buildings with lack of consideration towards healthcare buildings. Biophilic design is known to maintain quality of life in addition to sustainability. Thus applying biophilic design in healthcare buildings controls the spread of infection and increases the healing rates of patients.

This study will illustrate the biophilic design patterns and their role in healthcare buildings to maintain sustainability and quality of life. It will consist of a literature review on the biophilic design patterns and their importance in providing a healthy environment to increase the healing rates of patients. It will also consist of the analyses on global hospitals that applied biophilic design patterns in them highlighting the positive results that may be applied in the case study hospital in Egypt to improve the healthcare services.

The study will end up with the conclusions and recommendations that will help in maintaining sustainability, quality of life and increasing the healing rates of patients in healthcare buildings in Egypt.

KEYWORDS:

sustainability, biophilic design patterns, healthcare, quality of life

1. Introduction:

Biophilic design can be applied to many different manmade environments, different buildings and spaces including healthcare buildings and hospitals.

Sometimes hospitals are unable to satisfy the needs of their guests. Negative effects on patients' health could result from the use of neon lights or even lighting from above, as well as from interior spaces, corridors and seating areas lacking an outdoor view.

Adding plants inside the hospital or placing windows with outdoor views are not the only examples of biophilic design. It also offers a number of tools and applications that could help people feel better emotionally, manage stress, and improve their mental health. It might also boost employees' productivity and general well-being along with raising the organization's level of service and efficiency.

By applying the biophilic design of the healthcare buildings there will be a better understanding of how to incorporate the human's experience into the process of design and there will also be an illustration of the advantages that result from it. The healthcare sector in Egypt lags both quantitatively and qualitatively behind MENA. Reformation is happening quickly, and Egypt needs to coop with the change as soon as possible. Egypt's healthcare sector needs to adopt with new ideas and technologies built up on global research to improve and develop successfully in the long run. [1]

Applying the biophilic design (which achieves sustainability and the quality of life) in hospitals in Egypt may speed up the improvement and development required to be achieved in the healthcare services.

2. Methodology:

1. Recognizing the connection between humans and the manmade environment of healthcare and applying bio-based techniques to accelerate the patient's recovery.

2. Classification of vital materials that can be used in health care buildings, as hospitals are considered one of the most prominent places for the movement of green buildings because they are exposed to viruses, and they are also an environment that helps the spread of infection.

3. Including the biophilic patterns that are most suitable for use in Egyptian healthcare buildings. The effectiveness of medical therapy is correlated with the quality of healthcare spaces.

4. The facilities of the hospital and the needs of its occupants are extremely compatible with the natural elements and health benefits that biophilic design may bring to the spatial environment of a healthcare building.

5. Use of appropriate biomaterials in the case study hospital to observe the improvement in energy consumption. The quality of life of the internal environment in the hospital in general and in outpatient clinics in particular.

This study will illustrate the 14 life-loving design patterns and incorporate the patterns that are most appropriate for the hospital.

3. Biophilic Design

The global application of biophilic design is heavily influenced by geography for a variety of reasons, including socioeconomic status, cultural norms, and regional development. The official start of biophilia in the field of eco-friendly design began in 2006 with a conference held in Rhode Island, USA. The conference explored the benefits and tactics for integrating biophilia into buildings and cities [2]. The phrase "biophilic design" was formally identified and established in 2008 with the release of *Biophilic Design: Bringing Buildings to Life*.

The goal of biophilic design is to recreate, use, model, and extract elements of nature in order to create manmade environments that sustain and revitalize human natural design. [3]. In the same year, Kellert et al. offered four fundamental ideas for biophilic design: first, the significance of regular and ongoing interaction with nature; second, an emphasis on how humans have adapted to their natural environment; third, fostering an emotional connection to particular locations and environments; fourth, encouraging constructive interactions with nature and a broader understanding of the connection and accountability between the human and natural societies; and fifth, fostering architectural solutions that are interconnected, integrated, and mutually reinforcing [2].

In Table 1, there are 14 biophilic design patterns that William Browning presented in 2014 (Browning, Ryan, and Clancy 2014) [4], while in Table 2, there are 24 biophilic design strategies that Stephen Kellert and Elizabeth Calabrese proposed in 2015 [2]. Three distinct ways that the design approach develops are shown by a comparative investigation of the two: the usage of actual elements from the nature or traits, and the derivation and modification of the nature-human interaction. William Browning adds the qualities of "mystery" and "adventure" to the third two elements and groups the first two according to their uniformity, which reflects a more straightforward outcome.

By today, biophilic design has gained popularity as a standard design methodology in the field of architecture. It is even incorporated in the metrics used to assess the built environment. The application of the natural elements that have positive impact on human in the built environment is known as the biophilic design.

3.1 The Biophilic Design Patterns:

The fourteen patterns that make up biophilic design fall into three groups: nature of space, nature in space, and natural parallels. The patterns, as per Browning et al., are as shown in the following table:

The biophilic design methods from William Browning in 2014 [4].

The design methods	The elements of design
The application of natural elements	(1) Visual connections with nature; (2) nonvisual connections with nature; (3) Non-Rhythmic Sensory Stimuli; (4) Thermal and Airflow Variability; (5) Presence of water; (6) Dynamic & Diffuse light; (7) Connection with natural systems
The imitation of natural analogs	(8) Biomorphic forms & Patterns; (9) natural materials; (10) complexity and order
The construction of the connection between human and nature	(11) Prospect; (12) refuge; (13) mystery; (14) Risk

Table 1: The biophilic design methods from William Browning

Regarding biophilic design techniques, Stephen Kellert published a list of 24 patterns in 2015 [2], which fall into three categories: The sense of place and space, as well as direct and indirect experiences with nature. The patterns are:

The design methods	The elements of design
Direct use of natural elements	(1) light; (2) air; (3) water; (4) plants; (5) animals; (6) weather; (7) natural systems; (8) fire
Indirect use of natural elements	(9) natural patterns; (10) natural materials; (11) natural colors; (12) simulated natural light and natural ventilation; (13) natural shapes or forms; (14) natural associations; (15) information richness; (16) change of time; (17) natural geometry; (18) bionics
The relationship between the space and the place	(19) foresight-shelter; (20) organize complexity; (21) integration; (22) transitional spaces; (23) mobility and wayfinding; (24) emotional connection of place

Table 2: The biophilic design methods from Stephen Kellert

3.2. Biophilic Design in Healthcare Spaces

In the 1980s, Ulrich carried out some of the first studies on the use of biophilic design in hospitals. According to his research, patients who had rooms with views of green spaces spent less time in the hospital after surgery and took less painkillers than those who had equivalent rooms with views of the constructed environment. 95% of patients and their families that were exposed to nature had reduced pressure levels, better attitudes, and higher surviving skills, according to international investigations.

In 2006, Biederman and Vessel proposed in therapeutic psychology that incorporating plants into healthcare environments and roof gardens could alleviate pain and nervousness in patients. A study by Eisen et al. on the preferences of pediatric inpatients for art revealed that there was little difference in the artwork that children of different ages and genders chose. Nearly 75% of them favored impressionistic nature images as beaches with waves or nature art depicting woods with lakes and deer over abstract art [5]. Famous German explorer and

geographer Alexander von Humboldt highlighted the therapeutic value of gardens and recommended that design should be in harmony with the natural world to improve the quality of the surrounding area.

The biophilic-inspired "restorative healthcare environment design" by Dushkova and Maria from 2020 "extends from the exterior landscape to the interior architectural space." A wealth of experimental evidence demonstrated the beneficial effects of biophilic design, including natural light, vegetation, green windows, spaces view the nature, sounds from the nature, scents, water features, actual aquatic life, visual ease, and the sense of self control, on causing positive feelings and speeding the healing process [6].

Natural materials can enhance how well individuals recover from illness and perceive their environment. This is due to the fact that natural materials enhance visual effects (by capturing more light than they reflect) and benefit the immune system, general health, creativity, and olfactory comfort (via essential oils). In response to patients' light sensitivity, the chemotherapy area at the Sir Robert Ogden Macmillan Cancer Centre was designed as a lengthy, relaxing view of the patient's faintness.

The primary setting for rehabilitation is a healthcare facility, so researching the biophilic design of these spaces can benefit patients' overall health. The medical space biophilic design study is not yet flawless, and more practice-oriented standards and procedures for the incorporation of natural elements are required.

3.3. Biophilic design patterns and biological responses:

Using biophilic design patterns has lots of advantages for human health and well-being, including reducing stress, improving cognitive function, enhancing emotion and mood, and promoting healing. While more research is needed on some patterns, the existing evidence is strong enough to support the incorporation of biophilic design principles into a wide range of built environments especially health care building to improve mental health which plays an important role in physical healing. When people are stressed, depressed or anxious, their ability to heal from illness can be impaired. Stress can also increase the risk of chronic diseases.

MATURE IN THE SPACE	14 Patterns	Stress Reduction	Cognitive Performance	Emotion, Mood & Preference
	Visual Connection with Nature	Reduced blood pressure and heart beats (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	Better mental health and attention (Biederman & Vessel, 2006)	Better attitude and overall happiness (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	Reduced blood pressure and stress hormones	Positive impact on mental health (Mehta, Zhu & Cheema, 2012;	Tranquility and an observed improvement in mental health

		(Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	Ljungberg, Neely, & Lundström, 2004)	(Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	Positive impact on heart beats, blood pressure and the activity of the sympathetic nervous system (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	Attention and exploration have been observed and measured (Windhager et al., 2011)	
	Thermal & Airflow Variability	Comfort and positive impact on the wellbeing and productivity (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	Better concentration (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	Improved awareness of special and temporal pleasure (alliesthesia) (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Hescong, 1979)
	Presence of Water	Lowered stress, heart beats, blood pressure and increased calmness (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	Better concentration and memory recovery (Alvarsson et al., 2010; Biederman & Vessel, 2006) Enhanced perception and psychological responsiveness (Alvarsson et al., 2010; Hunter et al., 2010)	Observed better emotional reactions (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso &

				Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	Better circadian system performance (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) Increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems			Enhanced better health reactions; Awareness of the surroundings (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns			Observed view preference (Vessel, 2012; Joye, 2007
	Material Connection with Nature		Reduced diastolic blood pressure (Tsunetsugu, Miyazaki & Sato, 2007) Improved creative performance (Lichtenfeld et al., 2012	Enhance well-being (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	Improved perception and physiological reactions to stress (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		Preference for the observed view (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURAL OF THE	Prospect	Less stress (Grahn & Stigsdotter, 2010)	Less tiredness and anger (Clearwater & Coss, 1991)	Enhance wellbeing and sense of security (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000
	Refuge		Enhanced focus, awareness, and sense of security	

			(Grahm & Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery			Encouraged strong preference reaction (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril			Produced powerful dopamine or joy reactions (Kohn et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

Table 3: The biophilic design patterns and research findings on human biological response [7]

Biophilic Design Pattern	Biological Response		
	Stress Relief	Cognitive Skills	Sensitivity Atmosphere and Preference & effort
Visual Connection with Nature	-Reducing heart beats and blood pressure	<ul style="list-style-type: none"> -Enhancing concentration -Improving productivity 	-Better responses
Non-Visual Connection with Nature	-Reducing systolic blood pressure and stress	-Better effect on mental health.	-Encouraging mental well-being and calmness.
Connection with Natural Systems	-Releasing stress		-Influencing the awareness of the environment and advancing health.
Dynamic & Diffuse Light	-Improving contentment, comfort, and output.	-Better attention	-Enhancing sense and liking for space.

Biomorphic Forms & Patterns			-Enhancing the sense of liking the view.
Material Connection with Nature		-Reducing diastolic pressure	-Encouraging the sense of comfort.
Complexity & Order	-Releasing psychological stress.		-Enhancing the sense of liking the view.
Prospect	-Releasing stress.	-Decreasing tiredness.	-Enhancing the sense of security and relaxation.
Refuge		-Better attention and ability to sense security.	Enhancing perception of safety and stability.

Table 4: The biophilic design patterns needed in healthcare buildings and biological response [8]

From the previous tables and the list of biophilic design patterns it is observed how biophilic design patterns may have positive impact on the users of the healthcare buildings which may achieve sustainability and quality of life. The study will focus on the connection with nature, presence of water elements, natural lighting and ventilation.

As a conclusion, biophilic design in architecture started early and developed internationally. The research and application of biophilic design have been somewhat sparked by economically developed cities, indicating that biophilic design has grown in importance as a trend in architectural design. Even though sustainable development and green ecology are being progressively incorporated into urban building designs worldwide, many of these creations still fall short of being truly biophilic. Learning from cutting-edge global concepts and experiences is essential, as is researching biophilic design techniques that are appropriate for the particular climatic and environmental constraints of each location.


3.5. Analyses for an example of biophilic design in hospitals and healthcare spaces:





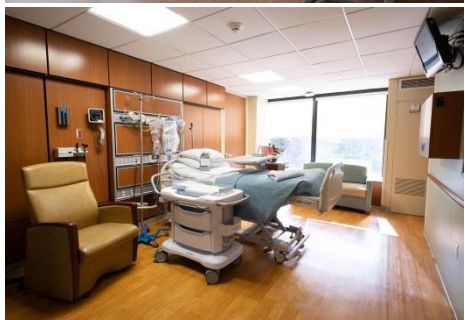
Hospitals were selected from various nations to examine how biophilic design trends were implemented there. The LEED certification of the hospitals and their proximity to a climate zone comparable to Egypt's were the deciding factors in selecting the sample of hospitals with biophilic design applications. The goal of the analyses conducted was to enumerate the benefits of these already-operational hospitals, highlight the environmentally friendly measures taken in them, and pinpoint the key components of biophilic design for medical facilities.


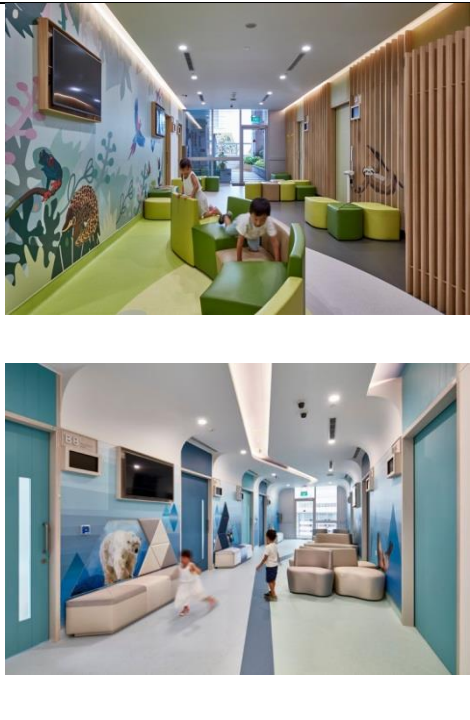

In order to improve the efficiency and quality of hospitals and healthcare facilities to a level commensurate with architectural development and the global trend toward sustainability and quality of life, analyses were conducted in order to create a standardized model for biophilic design that can be applied in hospitals and healthcare facilities in Egypt in particular as well as in other Arab countries. According to the analyses, KhooTeck Puat Hospital (KTPH) is the best example to use as a model because it is situated in a climate similar to Egypt, has applied the

majority of biophilic design patterns, and obtained a LEED gold certificate. It is also widely regarded as one of the best healing environments worldwide.

Name	KhooTeck Puat Hospital (KTPH)		
Basic Information	<ul style="list-style-type: none"> •Opened: 2010 •No. of beds: 591 •Gross floor area (GFA): ~110,000 m² •Acute hospital with: operating theatres, ICUs, emergency, wards and specialist outpatient clinics to serve the northern region of Singapore •Under National Healthcare Group (NHG), Public Healthcare Cluster of Singapore 		
Biophilic Design Pattern	Visual Connection with Nature	<p>A space merging view and experience: the reception serves as a welcoming area where the natural world is observed. The interior and exterior environments of the hospital merge together giving a close relationship with the nature bringing calmness and speed healing.</p>	 
	Non-Visual Connection with Nature	<p>A feast for the senses: engages guests in a multi-sensory experience by adding a central water feature that offers the gentle murmur of falling water, the coolness of mist on the skin and a visual sight of tumbling beauty.</p>	 

	<p>Non-Rhythmic Sensory Stimuli</p>	<ul style="list-style-type: none"> • Sky gardens: wide rooftop gardens like the healing garden and heritage garden offer patients, staff and visitors calm escapes into nature. These green havens boast diverse vegetation, walking paths, and seating areas, providing opportunities to soak up the sun, breathe fresh air and reconnect with nature. • Vertical greenery: living walls adorn various internal and external facades, adding vibrancy and natural elements to the built environment. These vertical gardens not only enhance aesthetics but also improve air quality and reduce stress levels. 	
	<p>Thermal & Airflow Variability</p>	<p>Natural ventilation: in response to the tropical climate, natural ventilation is enhanced to increase patient comfort. In order to minimize the need for artificial ventilation and energy consumption, public rooms were planned with optimal natural ventilation in mind. An ideal wind speed is reached by positioning the tower to "capture" the dominant north and south-east breezes, giving the patients enough thermal comfort. Energy savings can be realized by lowering the hospital's dependency on mechanical ventilation by about 60%. The building's walls were adorned with aluminum fins, often known as "wing walls," which were intended to increase the build-up of wind pressure on the façade and direct the prevailing winds inside the</p>	 

		structure. The National University of Singapore (NUS) conducted wind tunnel studies and discovered that these fins would produce a 20–30% increase in air flow.	
	Presence of Water	Water features: calming water features like fountains and ponds add a calming ambiance to the space. The gentle sounds of flowing water further promote relaxation and create a sense of peace.	 
	Dynamic & Diffuse Light	Natural light: large windows and open spaces maximize natural light penetration, reducing reliance on artificial light and promoting circadian rhythm regulation. This can positively impact sleep patterns, mood, and overall well-being	  

	<p>Connection with Natural Systems</p>	<p>Spaces designed to be in contact with nature: the walls breathe with open facades, the courtyards intersect sunlight and rain, and the architecture is a canvas for nature</p>	
	<p>Biomorphic Forms & Patterns</p>	<p>Shaping playing facilities and areas with sculptures symbolizing nature as flowers which add a touch of beauty and nature to the space as a source of inspiration and fun for children and adults</p>	
	<p>Material Connection with Nature</p>	<ul style="list-style-type: none"> • Wood, stone, and bamboo: these materials are used in furniture, flooring and decorative elements throughout the hospital. Their natural textures and colors evoke a sense of warmth and connection to nature. 	




	Complexity & Order	Creating an environment in nature-focused outdoor spaces, like landscapes and green walkways, where people can experience a variety of natural sensory information.	
	Prospect	Providing a space from the food court's interior to observe, view, and monitor the main entrance and the surrounding outside area.	
	Refuge	Forming moving, linked hiding spots that facilitate mass education and physical activity.	

Table 5: The biophilic patterns applied in KhooTeck Puat Hospital (KTPH)

3.6. Conclusions from the analyses of the biophilic design example:

1. Biophilic design emphasizes the interdependence of humans and environment. In addition to making people feel more at ease, this connection improves social interactions and lets people appreciate the beauty of nature. Thus, incorporating biophilic design into healthcare buildings can aid patients in recovering from a range of illnesses.
2. Adding plants, green walls, or green roofs is not the only way that biophilic design may be used in healthcare architecture. It's a thorough strategy that calls for fresh perspectives in order to produce creative ways to incorporate nature into healthcare buildings.
3. A design does not have to use every biophilic design pattern in order to qualify as biophilic.

3.7. Case study selection:

The case study hospital is The Specialized Air Force Hospital which is located in The New Cairo City in the fifth settlement. The hospital provides highly specialized medical services with international quality standards. It includes 400 beds, private suites, 41 intensive care beds, isolation beds, 11 operation rooms, and 100 clinics. The vision of this hospital is to achieve leadership in the medical field at the local and regional levels, targeting all sectors of the society. Biophilic design emphasizes the interdependence of humans and environment. In addition to making people feel more at ease, this connection improves social interactions and lets people appreciate the beauty of nature. Thus, incorporating biophilic design into healthcare buildings can aid patients in recovering from a range of illnesses. Its goal is to provide complete healthcare in compliance with the most recent international standards while enlisting the help of all hospital employees and making the best use of the resources at hand. It will overcome all obstacles in the process of achieving the highest standards of quality and safety for patients, their families, and hospital personnel.

The study was done to apply various suitable biophilic patterns to the hospital to support it to successfully achieve its vision and mission.

3.8. Case study site analyses:



Figure 1: The land uses surrounding the site

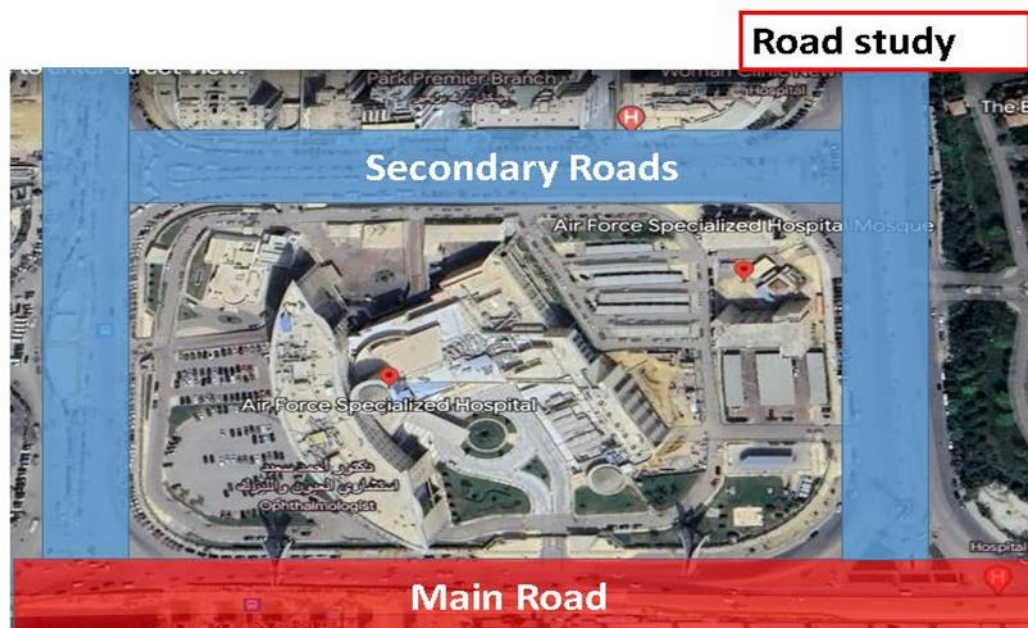


Figure 2: The roads surrounding the site

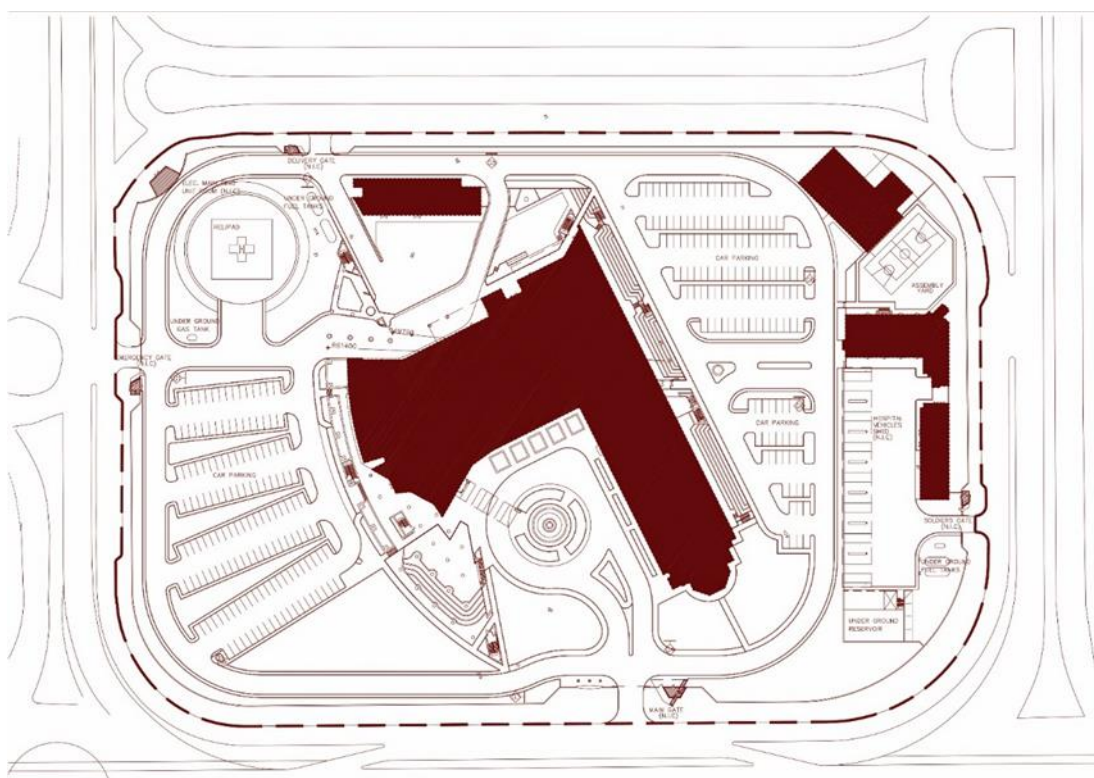


Figure 3: The orientation of the hospital in the site

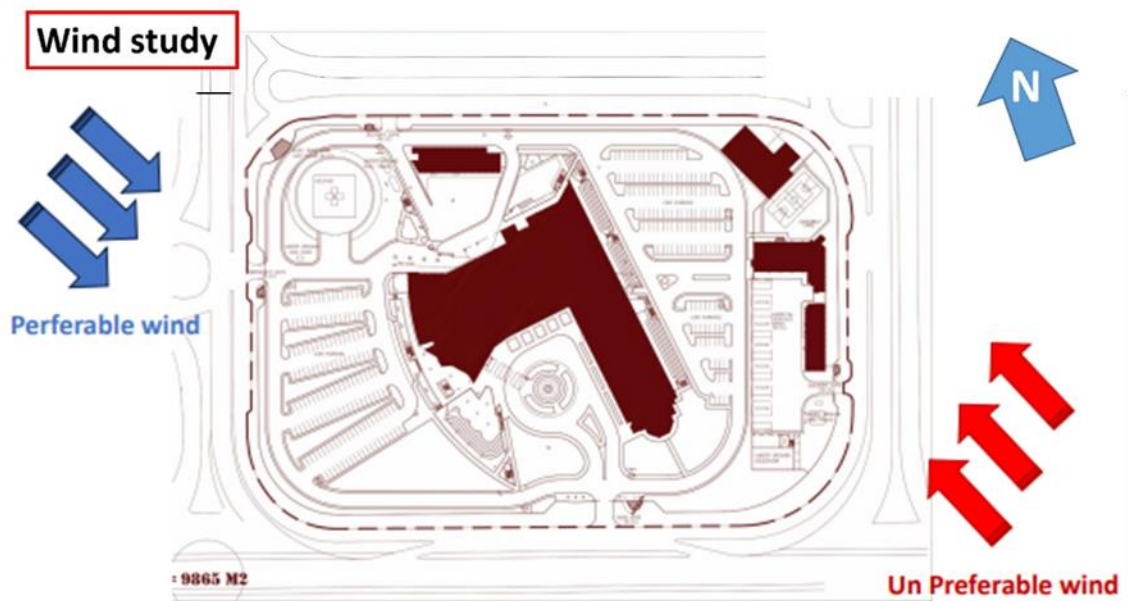


Figure 4: Environmental site analyses

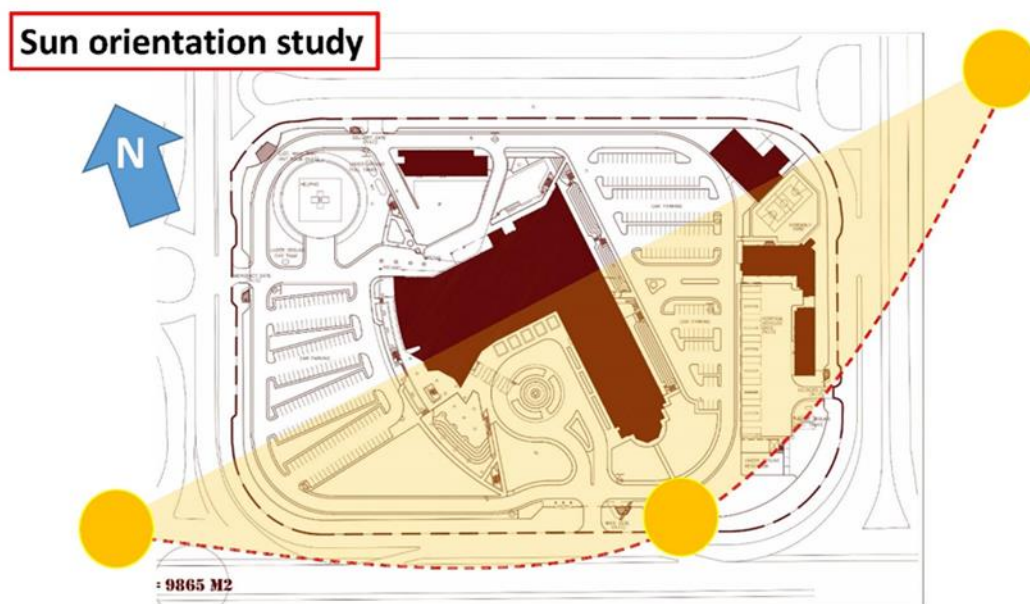


Figure 5: Sun path in site

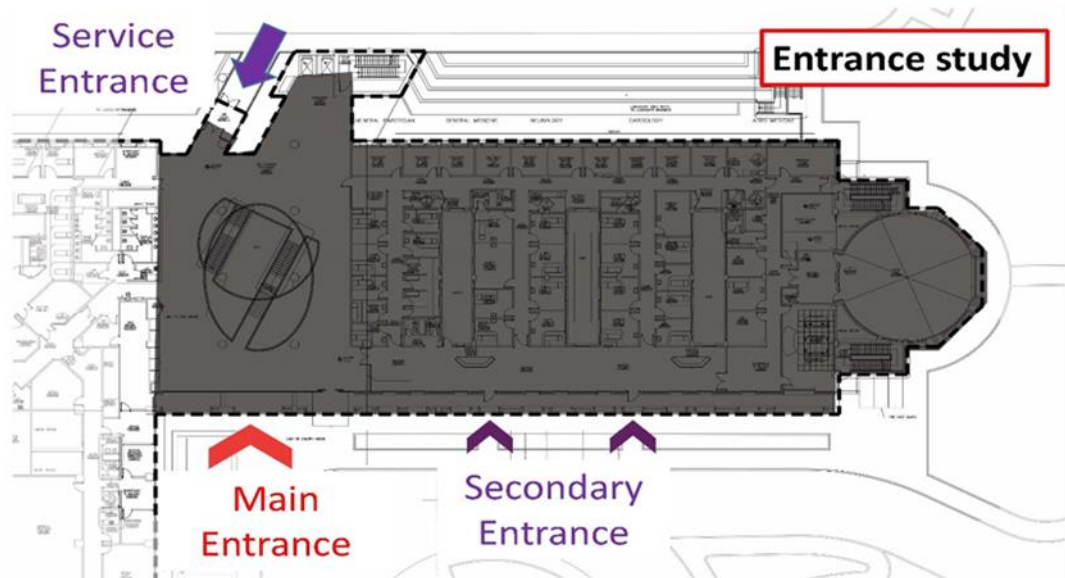


Figure 6: Entrances for the outpatient clinics

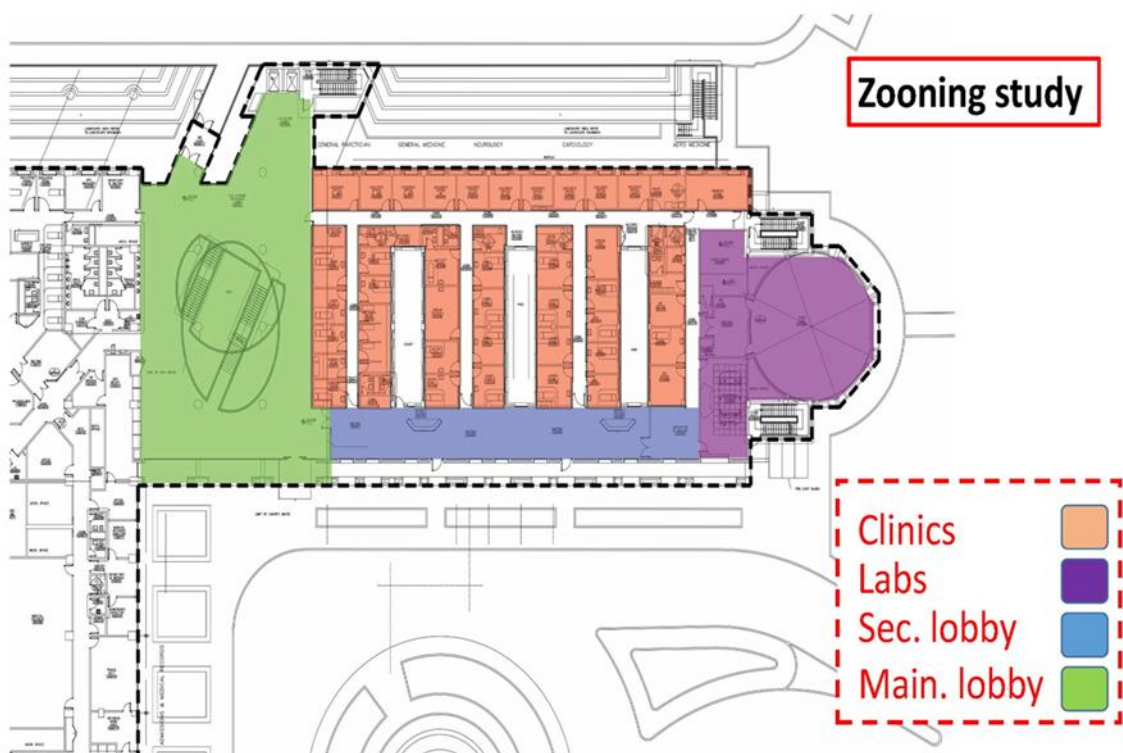











Figure 7: Outpatient clinics zoning

3.9. Analyses for biophilic design solutions in the case study:

Name	Specialized Air Force Hospital		
Basic Information's	<p>Specialized Air Force Hospital</p> <ul style="list-style-type: none"> •Opened: 20's •No. of beds: 400 beds •Acute hospital with: 400 beds, private suites, 41 intensive care beds, isolation beds, 11 operation theatres and 100 outpatient clinics Located in: Cairo, Egypt 		
Biophilic Design Pattern	Visual Connection with Nature	<p>A space merging view and experience: connecting the reception area with the nature outside using skylight or wide openings. This could improve the well-being and efficiency of hospital staff as well as speed patients' recovery.</p>	
	Non-Visual Connection with Nature	<p>A feast for the senses: by decorating interior spaces with natural materials, features, or aspects, one can create an indirect link to nature. utilizing water features, such as fountains and waterfalls. Patients, staff, and visitors can all feel more connected to nature when natural materials like marble, wood, and other materials are used in hospital interior areas.</p>	

	<p>Non-Rhythmic Sensory Stimuli</p>	<p>Sky gardens: adding roof gardens accessible for the hospital staff and patients provide them with an outside space where they may enjoy nature without being surrounded by the air and noise pollution caused by nearby traffic.</p> <p>Vertical greenery: covering internal walls with greenery may be a good option to improve air quality and reduce stress levels.</p>	
	<p>Thermal & Airflow Variability</p>	<p>Natural ventilation: To improve patient comfort, natural ventilation is maximized in response to the tropical climate. Public spaces may be planned with the best possible natural ventilation in mind, which would require less energy and mechanical ventilation. The hospital's layout permits it to take use of the dominant north-west breezes, which would give the patients enough thermal comfort. The air flow entering the hospital may be directed by a number of features utilized at the west and north elevations.</p>	
	<p>Presence of Water</p>	<p>Water Features: adding water features like fountains, ponds or waterfalls achieve a calming ambiance to the spaces of the hospital. The gentle sounds of flowing water further promote relaxation and create a sense of peace.</p>	<p>Lack of water features.</p>

	Dynamic & Diffuse Light	Natural lighting: wide windows and open spaces allow ample natural light to penetrate the building thus reduce the dependence on artificial light. This can positively impact mood, sleep patterns, and overall well-being of hospital users.	
	Connection with Natural Systems	Spaces designed to be in contact with nature: windows and courtyards capture sunlight and maintain natural ventilation.	 <p>There is no contact with nature except in few public spaces.</p>
	Biomorphic Forms & Patterns	Shaping playing facilities and areas with sculptures symbolizing nature as flowers which add a touch of beauty and nature to the space as a source of inspiration and fun for children and adults.	 <p>There are no playing facilities in public spaces.</p>
	Material Connection with Nature	<ul style="list-style-type: none"> • Wood, stone, and bamboo: using these materials in furniture, flooring and decorative elements throughout the hospital with their various natural textures and colors evoke a sense of warmth and connection to nature. 	 <p>The wood was used in administrative spaces' doors only.</p>



	Complexity & Order	Creating an environment in a nature-focused outdoor space, like a landscape or green walkway, that allows for the reception of various types of sensory input from the natural world.	 <p>Not enough outdoor landscape.</p>
	Prospect	Providing a space from the inside to watch, view, and monitor the main entrance and the surrounding outside area.	
	Refuge	Establishing moving, linked hiding spots that facilitate mass education and physical activity.	Lack of refuge.

Table 6: The biophilic patterns applied in The Specialized Air Force Hospital

4. Conclusions from the case study analyses:

1. The Specialized Air Force Hospital applied most of the biophilic patterns that enhance the healing process, increase the recovery rates and reduce the patients stay in addition to maintaining a suitable environment for the staff to increase their health and productivity.
2. The hospital lacks the presence of water features.
3. The spaces of the hospital have poor contact with the nature except in few public spaces.
4. The absences of any children and adult entertaining facilities in the hospital.
5. Poor presence of natural materials as wood, stone and bamboo in the hospital.
6. The presence of the landscape and green footpath in the hospital's outdoor is not enough.
7. Lack of the safe spaces that enable physical activities and learning.

5. Recommendations for the case study:

1. The hospital needs some water features to be added in its different public spaces to achieve a calming ambience, promote relaxation and create a sense of peace to the spaces of the hospital.
2. The spaces of the hospital need more contact with the nature through more wide windows and skylights to achieve natural lighting and ventilation.
3. The hospital needs entertaining facilities as source of inspiration and fun for children and adults.
4. To create a feeling of coziness and a connection to the natural world, natural materials such as wood, stone, and bamboo, with their diverse hues and textures, must be included into the furnishings and medical rooms.
5. Enlarge the outdoor landscape and green walkway at the hospital to allow for a variety of natural sensory experiences.
6. The hospital need safe areas for staff and patients to walk around in order to facilitate learning and physical activity.

6. Recommendations for the hospitals and healthcare buildings in general:

- 1- To aid patients in recovering from a range of illnesses, biophilic design should be incorporated into Egyptian healthcare facilities.
- 2- Using biophilic design is simple, but it takes original thinking to come up with novel ways to incorporate nature into Egyptian healthcare buildings.
- 3- A design does not have to use every biophilic design pattern in order to qualify as biophilic.
- 4- To put it simply, biophilic design emphasizes the link between nature and humans. In addition to making people feel more at ease, this connection improves social interactions and lets people appreciate the beauty of nature. Thus, incorporating biophilic design into healthcare buildings can aid patients in recovering from a range of illnesses.
- 5- To aid patients in recovering from a range of illnesses, biophilic design should be incorporated into Egyptian healthcare facilities. The application of biophilic design in hospital architecture extends beyond the use of green walls, roofs, and plants. It's a thorough strategy that calls for fresh perspectives in order to produce creative ways to incorporate nature into healthcare buildings.

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