

Guidelines for Greening Healthcare Spaces

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Abstract

Biophilic Design is a concept used in the interior design sector to increase the connection of users to the natural environment. Used at both the building and city level, this technique is claimed to have health, environmental, and economic benefits for space occupants and urban environments. The biophilic design focuses on human well-being to improve physical and mental health, performance, and wellness. All this opens the way to an understanding of the solutions that the use of biophilic design in healthcare spaces could bring. Indeed, through this research and based on the analysis of health spaces whose use of biophilic design has been ubiquitous, we will develop the notion of biophilic health care design and how this new way of space design will affect positively mental health, and subsequently, physical health of the person concerned by the health care in these health centers, hence its impact on the acceleration of healing. Upon concluding our comprehensive investigation into the prevalent application of biophilic design within healthcare settings, this study endeavors to provide a comprehensive set of directives tailored for designers. These guidelines are formulated to serve as a lucid roadmap, facilitating the seamless integration of biophilic principles into the architectural blueprint of hospitals. This undertaking is driven by the overarching objective of augmenting the favorable impacts on both mental and physical well-being, ultimately speeding up recuperation and instigating a revolutionary transformation in the domain of healthcare environments.

Keywords: Biophilic Design; Green; health care; mental health; physical health; healing.

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1. Introduction

The hospital environment, while essential for the process of healing, can often be a source of inherent stress for patients, their families, and healthcare professionals alike. Extensive research has unequivocally established a direct correlation between patient stress levels and the trajectory of their recovery, underscoring the pivotal role played by the physical environment in determining health outcomes. Furthermore, the stress experienced within the hospital setting can exert a substantial influence on a patient's overall state of well-being and the course of their recuperation. In this regard, the overarching

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ambiance of a hospital emerges as a critical determinant in alleviating the stress associated with the hospitalization experience.

The integration of biophilic design, a methodology increasingly embraced within healthcare facilities, offers a promising avenue for enhancing the well-being of all parties involved. The primary objective of employing biophilic design in hospitals is to create spaces that are not only aesthetically inviting but also exude a calming aura conducive to the healing process. This approach is finely attuned to addressing the emotional and physical needs of patients, as well as accommodating the comfort of visitors and medical staff.

This article is dedicated to delving into the concept of biophilia and its profound implications for the healing journey of patients in a hospital setting. It will elucidate how the integration of biophilic architectural principles can significantly elevate the well-being of patients within hospital environments. Ultimately, the culmination of this study will manifest in the form of a comprehensive guideline meticulously crafted for designers and architects in Tunisia. This guideline will ardently advocate for the integration of biophilic architecture in hospital design, with the overarching goal of optimizing the healing potential of these critical spaces and ultimately enhancing the overall healthcare experience for all parties involved.

2. Literature Review

The term biophilia is commonly associated with the American biologist Edward Osborne Wilson. It was his book *Biophilia*, written in 1984, that made the concept popular. He used the term biophilia to describe an experience of deep communion with Nature. originates from the Greek word is formed from “bio” (life) and the suffix “philia” (love of), the term biophilia designates the fundamental love of humans for the living. (Cambridge Dictionary, n.d.) Wilson defined biophilia as “the innate tendency to focus on life and lifelike processes.” (Wilson, 1984, Kurazumi et al., 2017) So it is the innate tendency of man to focus his attention on life forms and all vital processes.

The term biophilia, which means "love for life", was first introduced in 1964 by Erich Fromm, a German psychoanalyst, and philosopher. He used this term to describe the psychological orientation that drives man to be attracted to all that is living and vital. Fromm pointed out the necessary conditions for biophilia to develop adequately in human beings, concluding that living meaningful experiences and being in contact with people who love life, therefore biophilic people, favors the development of love for life.

Biophilic design is a process that offers a sustainable design strategy aiming to establish an interconnection between individuals and nature, relying on three distinct experiences and twenty-four design attributes. This approach seeks to seamlessly integrate elements of the natural world into living, working, and caregiving spaces, thus fostering environments that facilitate a profound connection with nature. The three fundamental experiences central to biophilia encompass the direct presence of nature, the evocation of natural elements, and immersion in natural spaces. Complementing these experiences are twenty-four design attributes, which include elements such as the utilization of natural materials, the integration of abundant natural light, the incorporation of nature-centric views, the inclusion of vegetation, and the creation of inviting outdoor spaces. This holistic approach to design not only enhances the aesthetic appeal of spaces but also nurtures the physical and psychological well-being of their inhabitants.

By implementing biophilic design principles, the aim is to enhance the well-being, productivity, health, and happiness of individuals by creating environments that support our innate connection with nature. This approach has significant implications for architectural design, promoting a reconnection between humans and their built environment.

Architects are increasingly recognizing the fundamental need for human connection with nature and are incorporating features like green roofs and walls into their designs. These elements not only positively impact human well-being but also contribute to environmental sustainability by improving thermal insulation and air quality (Table 1): (Terrapin Bright Green, 2015).

Table 1: Biophilic Experiences and Corresponding Design Attributes.

Biophilic Experiences	Design Attributes
Nature in the Space: Incorporate plants, water, and animals in the build environment. It includes seven biophilic design patterns:	Visual connection with nature: A view of natural elements, living systems and natural processes.
	Invisible link with nature: Auditory, tactile, olfactory, or gustatory stimuli that deliberately and positively refer to nature, living systems or natural processes.
	Non-rhythmic sensory stimulation: Stochastic and ephemeral links with nature that can be analyzed statistically but are not necessarily precisely predictable.
	Thermal variability and air renewal: Subtle changes in temperature, humidity, airflow over the skin and surface temperatures that mimic natural environments.
	Presence of water: A condition that enhances the perception of a place through the sight, sound, or touch of water.
Natural Analogues: materials and patterns that evoke nature and are characterized by four broad types: representational artwork, ornamentation, biomorphic forms, and the use of natural materials. It includes three patterns of biophilic design:	Dynamic and diffuse light: Variations in the intensity of lights and shadows that change over time can create nature-like conditions.
	Link to natural systems: Awareness of natural processes, the seasonal and temporal changes characteristic of a healthy ecosystem
	Biomorphic shapes and patterns: Symbolic references to traced, patterned, textured, or numeric layouts that are common in nature.
Nature of the Space: the way humans respond psychologically and physiologically to different spatial configurations. It includes four patterns of biophilic design.	Material connection with nature: Materials and elements of nature which, through minimal transformation, reflect the natural environment or local geology and create a different feeling of place.
	Complexity and order: Rich sensory information that adheres to a spatial hierarchy like what can be encountered in nature.
	Perspective: An unobstructed view, for monitoring and forecasting.
	Refuge: A place to withdraw from environmental conditions or the flow of activity, in which the individual is protected behind and above it.
	Mystery: The promise of a wealth of information, through partially obscured views or other sensory dispositions that prompt the individual to travel deeper into the environment
	Risk: An identifiable threat coupled with reliable security.

Architects have become aware of the fundamental need that human have to be in contact with nature. Architects and designers are integrating and insisting more and more on designing buildings with green roofs and walls.... In addition to the effects on humans, plants also have effects on the building itself. Green roofs contribute to improving the thermal insulation of roofs, which reduces energy in heating and air conditioning, while interior living green walls contribute to better air quality. All these elements Have a positive effect on the environment, the planet, and its inhabitants.

The six criteria for designing an architecture that adopts the principles of biophilia according to Jason McLennan (McLennan, 2004):

Allow the perception of seasonal and daily cyclical variations in light and thermal conditions.

Connect people to outdoor conditions by providing access to views and natural light.

Giving the occupant control over the management of their thermal comfort, ventilation, and natural light.

Use natural light as the main source of lighting.

Use healthy and durable materials that require little maintenance.

Adopt passive natural ventilation and heating strategies.

From the above it can be said that biophilia, considering air quality, thermal and acoustic comfort, represents an essential element of environmental quality that goes beyond daylight, the toxicity of materials, air, water, and soil quality, to include human biological health and well-being.

Environmental psychology studies in the most objective way possible certain effects of the built and natural environment on humans. Indeed, the built environment influences our experience and our behavior in many ways. The psychology of architecture has been a well-established discipline of psychology since the 1970s. During this period, in Anglo-Saxon countries, environmental psychology was established as an autonomous discipline distinguished by research focused on the interaction of the person with his environment. The main objective of the investigations carried out was to understand how the characteristics of the environment interact with the psychological characteristics of individuals in determining their behavior and their representations. It is inspired by psychological theories and knowledge relating to perception, attention, motor skills, interaction, etc., (Evans & McCoy, 1998, Joye, 2007)

The scientific literature of environmental psychology mainly mentions five dimensions related to design and which have a primary impact on individual well-being: Simulation, coherence, affordance, the feeling of control and the restorative effect.

The Figure 1 below summarizes the five dimensions mentioned.

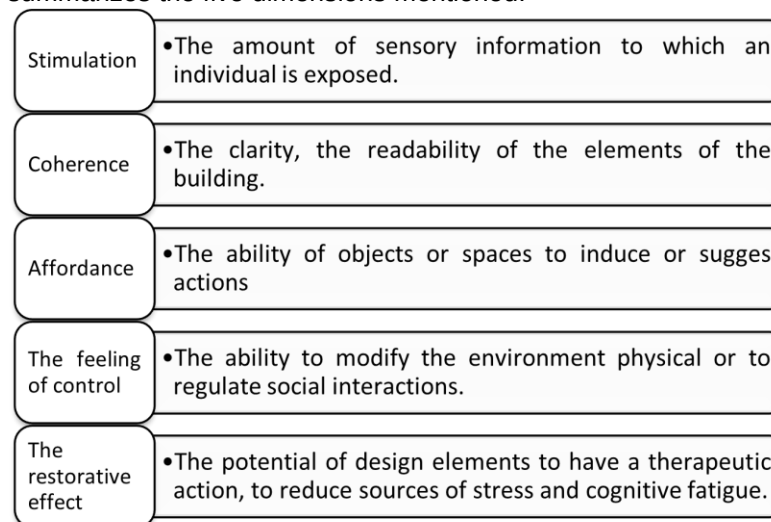


Figure 1. The five dimensions related to design, and which have a primary impact on individual well-being.

In environmental psychology, three categories of theories have been developed according to the factor considered dominant in the interaction of man with the environment. (Morval, 2007)

These theories are:

The individual as a dominant factor: This theory considers that the individual's personality is dominant.

The environment as dominant factors: This theory considers that the environment is the dominant and the person is a part of it.

The balance between the individual and the environment: This theory is based on the continuous exchanges that take place between man and the environment.

For our research we rely on this last theory. Indeed, the relationship between the person and his environment is materialized by the perception he has, the evaluation he makes of this environment and the manifestations of his behaviors and attitudes. The concept of balance between the individual and the environment emphasizes the ongoing interactions and exchanges between human beings and their surroundings. It recognizes the reciprocal relationship between individuals and the environment, highlighting the influence that each has on the other. This perspective acknowledges that humans are both influenced by and have an impact on their surrounding environment, and that maintaining a harmonious balance is crucial for overall well-being and sustainability.

Many studies confirm the positive effects of nature on physical and mental well-being. Trees, flowers, and green spaces near a living room allow the individual to experience seasonal changes and climatic variations. For example, looking out the window can arouse enthusiasm. Thus, the presence of greenery inside spaces will also have a positive impact on human psychology. It has a positive impact on improving moods and reducing stress.

Exposure to representations and images of nature can help speed up the healing and recovery process, increase positive feelings and reduce negative ones. Conversely, indoor environments that are cold, sterile, and deprived of life can adversely affect our mood and overall state of mind. From this one can recognize the importance of creating an interior environment that strengthens the connection between man and nature.

Several studies have examined different biophilic interventions in hospital spaces, ranging from simple exposure to images of nature to the design of green spaces and therapeutic gardens. The results suggest that biophilia can have a positive impact on the health and well-being of patients in hospitals. These studies have shown that patients recover faster in healthcare environments that incorporate natural elements such as natural light and views of nature. Therapeutic gardens are also increasingly being used in hospitals to help improve mood, reduce anxiety, and improve quality of life for patients.

The study "A review of the research literature on evidence-based healthcare design" carried out by Ulrich and al. in 2008 (Ulrich et al., 2008), is a review of the scientific literature on the design of health care spaces based on evidence. Researchers review different studies and research articles to assess the impact of design on patient health and wellness outcomes. Incorporating elements such as natural light, nature views, the presence of greenery, and indoor air quality into healthcare spaces can help reduce patient stress levels and promote a feeling of comfort. These positive environmental factors can also help speed up the healing process. We can refer also to Totaforti, S., in his study "Applying the benefits of biophilic theory to hospital design." (Totaforti, 2018).

This study highlights the positive impact of biophilic design on patient well-being in healthcare spaces. By integrating nature into these environments, researchers notice that there is a reduction in stress, pain, and an improvement in the mood of patients. This requires a cultural shift in the design of health spaces, with an emphasis on reconnecting people with nature. The results of the studies underline the importance of considering human needs, beyond the strict therapeutic aspect. This approach promotes holistic healing and empowers patients. In conclusion, biophilic design offers opportunities to improve patient experience and well-being in healthcare environments.

Another literature review by Maghlakelidze, Mariami, and Lola Ben Alon, titled 'Biophilic Daylight Design in Healthcare Environments: A Critical Review' (Maghlakelidze & Ben Alon, 2021). This study examines the impact of biophilic daylight design in healthcare environments. It highlights the association between exposure to natural light and positive outcomes such as reduced hospitalization duration, decreased medication intake, lower stress levels, and improved task performance. The study emphasizes that design guidelines and simulation tools to assess the effect of biophilic design on patient recovery and well-being are insufficiently developed. Current healthcare spaces fail to provide environments that foster a connection with nature. The objective of this review is to propose design guidelines for biophilic daylight in healthcare environments. It analyzes biophilic design parameters and their potential impact on patients and medical staff, including recovery rates, hospitalization days, medication intake, stress levels, task performance, and job satisfaction. Preliminary results highlight the importance of direct exposure to morning sunlight, space orientation, and views of nature in reducing hospitalization length. However, more advanced simulation tools are needed to assess the health outcomes of different biophilic daylight strategies more accurately. To conclude, this study underscores the significance of integrating biophilic daylight design in healthcare environments to enhance patient recovery, reduce stress, and promote well-being. More precise guidelines and advanced simulation tools are necessary to guide practitioners in designing these spaces.

As a conclusion, literature reviews highlight the importance of biophilic design in healthcare environments. Incorporating natural elements such as natural light, nature views, and natural materials can improve patient well-being, reduce stress, and promote healing. This requires a holistic approach to the design of care spaces, considering the physical, emotional, and psychological needs of patients. Biophilic design offers real opportunities to create more humane and healing care environments.

3. Material and Methods

Few people like going to the hospital because it is a place dedicated to people who are going through difficult times.

Studies have shown that patients recover more quickly in healthcare environments that incorporate natural elements such as natural light and nature views. Therapeutic gardens are also increasingly used in hospitals to help improve mood, reduce anxiety, and enhance patients' quality of life.

Biophilic design can also improve indoor air quality in hospitals by introducing plants and other natural elements that absorb pollutants and toxins.

Aiming to answer the question in the article "How the integration of biophilic design in hospital can stimulate healing?" This paper develops an exploratory, analytical study of two examples of hospitals integrating in its architecture the notion of biophilia followed by a presentation of qualitative results, and qualitative interpretation.

The hospital whose analysis is put under the spectrum are:

Maggie's Leeds Hospital, located in Leeds, England, is a healthcare center that is part of the Maggie's Network, which supports people with cancer and their loved ones. Designed by architect Thomas Heatherwick, this property takes an innovative, biophilic approach to incorporating natural elements to create a calming and welcoming environment.

Maggie's Leeds Hospital is surrounded by landscaped gardens offering panoramic views of nature. Its interior spaces are bathed in natural light thanks to large bay windows and a central atrium (Figure 2-A). Natural materials such as wood and stone are used to create a warm and organic atmosphere (Figure 2-B).



A. Maggie's Leeds Hospital Exterior



B. Maggie's Leeds Hospital Interior

Figure 2. Maggie's Leeds Hospital, located in Leeds, England. (Hufton+Crow, 2021).

This biophilic design concept helps create a therapeutic environment for cancer patients and their loved ones. It promotes their emotional and psychological well-being by offering relaxation areas, consultation, and therapy rooms, as well as places to meet and social support. Maggie's Leeds Hospital demonstrates how biophilic design can positively influence the patient experience and aid in their healing process.

One of the key design goals for the hospital was to create a calm and soothing healing environment for cancer patients. To achieve this, the design team integrated many elements of nature into the design of the building, including an interior garden, a green wall, a greenhouse, and other nature elements. These elements are concluded as:

1. The presence of an interior garden: the interior garden is a key element of the design of the hospital, which provides a calming view from all parts of the hospital and creates an environment of nature and serenity (Figure 3-A).
2. The use of a green wall: the green wall located in the reception area creates an effect of freshness and nature in the space and reinforces the soothing effect of the environment.
3. The Greenhouse: The Greenhouse provides gardening and horticultural therapy space for patients, as well as a meeting place for support groups. The greenhouse is designed in glass, which allows natural light to enter the space and creates a warm and welcoming atmosphere (Figure 3-B).
4. The use of sustainable materials: the materials used in the construction of the hospital are chosen for their durability and their respect for the environment.
5. The use of soothing colors: the colors used in the hospital are mainly shades of white and green, which enhance the effect of nature and serenity of the environment.
6. Lighting: The lighting in the hospital is designed to provide natural and soothing light, thus enhancing the effect of nature and the serenity of the environment.

By integrating nature into its care environment, Maggie's Leeds Hospital creates a place of refuge and solace, providing patients and their loved ones with a space for hope, connection with nature and mutual solidarity.



A. Maggie's Leeds Hospital interior garden



B. Maggie's Leeds Hospital Plans

Figure 3. Plans and Interior, Maggie's Leeds Hospital. (Hufton+Crow, 2021).

The second example is KTPH Hospital, also known as Khoo Teck Puat Hospital, is a hospital located in Singapore (Figure 4-A). The architects used the concept of “hospital in a garden, garden in a hospital”. The use of biophilic design at KTPH Hospital is supported by research and studies that demonstrate the beneficial effects of nature on the health and well-being of individuals. Incorporating these principles into hospital design seeks to create an environment that promotes healing, reduces stress, and improves the overall patient experience.

One of the highlights of the biophilic design of KTPH Hospital is the presence of a large central atrium, called “The Village”. This six-story space is designed to resemble a tree-lined street and offers views of an interior landscaped garden. It is also equipped with comfortable seats and charging stations for mobile phones, providing a relaxation space for patients and visitors.

He has taken an innovative approach in creating a healing space that emphasizes connecting with nature. Elements such as therapeutic gardens (Figure 4-B), green areas and the use of abundant natural light have been integrated into the design of the hospital. These elements create a soothing, revitalizing and aesthetically pleasing environment for patients.

The structure of the hospital is characterized by its abundant use of natural light, open space, and green spaces. The large glass windows allow daylight to penetrate deep into the interior spaces, creating a bright and pleasant atmosphere. Therapeutic gardens and green spaces are present throughout the hospital, providing calming views and opportunities to connect with nature.



A. KTPH Hospital exterior



B. KTPH Hospital Garden

Figure 4. Facade and Interior, Maggie's Leeds Hospital. (Williams, 2020).

Khoo Teck Puat Hospital (KTPH) stands out for its innovative and successful approach to biophilic design.

1. Natural Light: KTPH's interior spaces are designed to maximize the entry of natural light. The large bay windows and judiciously placed openings allow daylight to penetrate deep into the spaces, creating a bright and warm atmosphere. This promotes better visibility, reduces dependence on artificial lighting and improves perception of the environment.

2. Smooth and intuitive circulation: KTPH is designed to provide smooth and intuitive circulation for patients, visitors, and staff. The spaces are well laid out, with clear directions and a layout that makes it easy to navigate through the hospital. This helps reduce the stress of navigating a complex medical environment.

3. Inclusion of water features: KTPH incorporates water features such as ponds, fountains, and streams, (Figure 5). creating a calming and refreshing atmosphere. The visual and sound effects of the water contribute to creating a relaxing atmosphere, promoting the relaxation and well-being of the occupants.

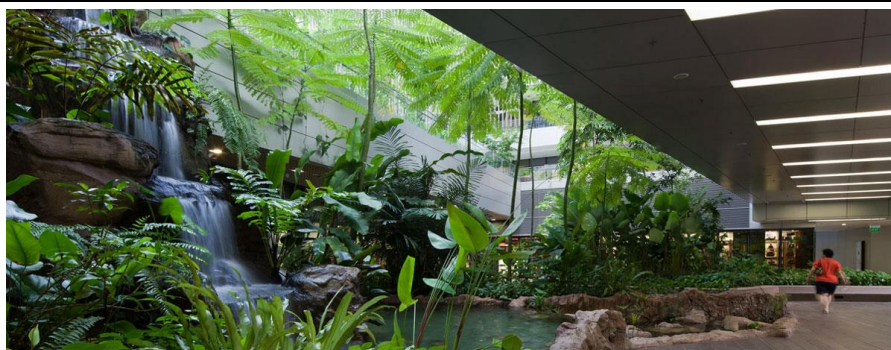


Figure 5. KTH Hospital waterfall. (Williams, 2020).

Integration of art and culture: KTH's biophilic design also incorporates artistic and cultural elements, creating an inspiring and engaging atmosphere. Works of art, sculptures and cultural elements are scattered throughout the hospital, providing occupants with visual points of interest and opportunities for cultural appreciation.

These features help to create a welcoming, calming and healing hospital environment, enhancing the experience and well-being of patients, visitors, and staff.

There are indeed studies that show the positive effect of biophilia on the healing of patients in the two hospitals we have mentioned, Maggie's Leeds Hospital and Khoo Teck Puat Hospital (KTH).

For example, a study by Tekin, B.H., et al published in 2023 titled "The impact of biophilic design in Maggie's Centres: A meta-synthesis analysis." (Tekin, Corcoran, & Gutiérrez, 2023) This study examines the impact of biophilic design on patients in the Maggie's centers. The results show that the presence of natural elements in indoor and outdoor spaces promotes the healing and well-being of cancer patients. The biophilic design creates a therapeutic environment where patients feel supported and comfortable. These results highlight the importance of considering human-nature interactions in the design of healthcare spaces.

Similarly, a study conducted by the Built Environment Research Center carried out by EDLASIA SAVIA MAVOVA FILIPE in 2020, titled "An exploration of the interior design process focusing on the intrusion of Biophilic Design in the interiors of a healthcare facility to promote patient wellbeing: A case study" (Filipe ESM, 2020) examined the effects of the biophilic design of KTH Hospital on patient healing. The results showed that patients who had a view of the hospital's therapeutic gardens recovered faster and were less likely to experience pain than those who did not have this view.

By incorporating biophilic elements such as indoor gardens, green walls, natural materials, soothing colors, and nature images, hospital spaces can become warmer, more welcoming, and therapeutic environments.

4. Results and Discussion

This analysis aims to showcase the successful integration of biophilic design in healthcare environments, using Maggie's Leeds Hospital and KTH Hospital as exemplary cases. Going beyond a traditional literature review, this exploration emphasizes the pivotal role played by natural elements in enhancing the well-being of patients, visitors, and healthcare professionals. These hospitals not only contribute to physical recovery but also provide emotional support, highlighting the profound positive influence of biophilic design in healthcare settings.

Maggie's Leeds Hospital, a part of the esteemed Maggie's Network, stands as a prime example of how nature can be seamlessly woven into healthcare architecture. Designed by the visionary architect Thomas Heatherwick, this hospital embodies a biophilic ethos, creating a serene atmosphere with lush gardens and expansive views of nature. Abundant natural light floods the interior spaces through expansive bay windows and a central atrium, while the use of organic materials like wood and stone adds warmth and authenticity. Khoo Teck Puat Hospital, known as the "hospital in a garden, garden in a hospital," exemplifies the deliberate integration of nature in healing spaces. Beyond aesthetics, this approach enhances healing, reduces stress, and elevates the overall patient experience. "The Village," a central atrium, resembles a tree-lined street and offers views of a meticulously landscaped garden. This space provides a sanctuary for both patients and visitors, complete with comfortable seating and convenient mobile charging stations.

Both hospitals share key design elements that define biophilic excellence:

Abundant Natural Light: Maximizing natural light penetration creates bright and inviting atmospheres, improving visibility, and reducing reliance on artificial lighting.

Thoughtful Circulation: Meticulously planned layouts facilitate easy navigation, alleviating the stress associated with complex medical environments.

Water Features: Incorporating elements like ponds, fountains, and streams creates a calming ambiance, with visual and auditory effects promoting relaxation.

Integration of Art and Culture: Both hospitals incorporate artistic and cultural elements, enhancing the overall experience of occupants.

Maggie's Leeds Hospital and KTPH Hospital demonstrate the transformative potential of biophilic design in healthcare. They offer not only physical healing but also serve as havens of emotional comfort and solace. The integration of natural elements stands as a testament to the profound influence of biophilic design on the well-being of patients, visitors, and healthcare professionals, marking a significant advancement in healthcare architecture.

In conclusion, it is important to note that biophilic design in healthcare settings is not limited to aesthetics alone but also focuses on optimizing functionality and creating safe and hygienic environments. The materials used should be durable, easy to clean, and resistant to infections.

This biophilic approach Hospitals goes beyond the physical aspects of healing. It fosters a therapeutic environment that addresses the emotional and psychological well-being of cancer patients. The incorporation of natural elements, such as the interior garden and greenery, provides a soothing backdrop that encourages emotional healing. Patients have dedicated spaces for relaxation, allowing them to find moments of respite from the challenges they face.

Moreover, the design facilitates consultations and therapy sessions in a serene setting. This not only enhances the effectiveness of medical interventions but also creates a more comfortable and supportive atmosphere for patients and their families. Additionally, the layout encourages social interaction and support among patients, further strengthening their emotional well-being.

4.1 Discussion

In Tunisia, there are a few examples of biophilic design initiatives where nature is integrated into healthcare environments to support patient healing: For example, the therapeutic garden of Razi Hospital in Tunis, designed in collaboration with the association "Les amis de SP Razi" where patients can enjoy a peaceful outdoor space with plants, flowers, and benches for relax. This garden provides an environment conducive to relaxation and reflection, thus promoting the well-being of patients. Patients can stroll the aisles, enjoy the greenery, smell the flowers, or sit down to relax. These activities stimulate the senses, promote relaxation, and create a connection with nature, which can be beneficial for the healing process. Thus, the Gafsa Regional Hospital project plans to incorporate indoor green spaces to provide a soothing healing environment for patients. The project also foresees the use of natural materials such as stone and wood to create a comfortable and warm environment. this is why from the literature review and according to the analysis of the two international examples and the results obtained we have tried to propose a guide for the integration of biophilic design in hospital spaces in Tunisia (Table 2).

Table 2: A guide for the integration of biophilic design in hospital spaces in Tunisia.

Recommendation:		Explication
Incorporate Nature into the Space:		Include elements such as plants, water features, and animals in the built environment. Facilitate visual connections with nature through views of natural elements, living systems, and natural processes. Integrate invisible links with nature, like auditory, tactile, olfactory, or gustatory stimuli that positively refer to nature.
Utilize Natural Analogues:		Employ materials and patterns that evoke nature, such as representational artwork, ornamentation, biomorphic forms, and natural materials.
Consider the Nature of the Space:		Design spaces to facilitate psychological and physiological well-being. Provide perspectives that offer unobstructed views for monitoring and forecasting. Include areas of refuge for withdrawal from environmental conditions, ensuring individuals feel protected.
Incorporate Elements of Nature:		Integrate elements like interior gardens, green walls, greenhouses, and natural materials. Utilize sustainable materials that reflect the natural environment or local geology: Raising awareness of environmental sustainability in hospital spaces by encouraging waste reduction, use of sustainable materials, and efficient energy and water management. use local materials and plants in the design of biophilic spaces. This supports the local economy and adds a cultural dimension to the care environment

Maximize Light:	Natural	Design spaces to allow the entry of abundant natural light, reducing reliance on artificial lighting.
Foster Circulation:	Smooth	Create intuitive layouts with clear directions to reduce stress associated with navigating a complex medical environment. Ergonomics and consideration for people with reduced mobility
Include Features:	Water	Integrate water elements like ponds, fountains, and streams to create a calming and refreshing atmosphere.
Integrate Culture:	Art and	Scatter works of art, sculptures, and cultural elements throughout the space to provide visual interest and opportunities for cultural appreciation.
Consider Nature Interactions:	Human-	Recognize the reciprocal relationship between individuals and their environment, acknowledging the influence each has on the other.
Promote Healing and Well-being:	Healing and	Provide spaces that offer hope, connection with nature, and mutual solidarity for patients and their loved ones. Create environments that nurture physical, emotional, and psychological well-being.
Utilize Evidence-Based Design:		Base design decisions on scientific research and studies that demonstrate the beneficial effects of nature on health and well-being.
Prioritize Experience:	Patient	Design spaces with the aim of enhancing the well-being, productivity, health, and happiness of individuals by creating environments that support their innate connection with nature. Consider cultural and local aspects in integrating biophilic design. Explore natural elements and aesthetic patterns specific to Tunisian culture to create hospitable spaces that reflect local cultural identity and values.
Adaptability flexibility	and	Designing biophilic spaces to be adaptable and flexible to future needs and changes in the healthcare facility. It is preferable to provide modular systems, reversible layouts, and customization options to adapt to organizational changes or new scientific discoveries.
Certification and labels		it will be preferable to opt for certifications or labels linked to biophilic design, such as the WELL Building Standard or the LEED label, to guide and support the design of hospital spaces. These certifications ensure that biophilic design principles are properly applied and can help build credibility for healthcare spaces.

By following these steps, it is possible to integrate biophilic design into hospital spaces in Tunisia. It is important to tailor recommendations to the specific needs of each healthcare facility and to work closely with relevant stakeholders to achieve optimal results.

A diagram evaluation of the use of biophilia in space will be the tool to measure and visualize the degree of integration of biophilia. It will quantify, compare, and track the integration of biophilia into a space, which facilitates informed decision-making and communication of results to stakeholders. 10 criteria will be assessed, namely:

- ✓ Presence of vegetation
- ✓ Natural light
- ✓ The sustainability of space and the use of natural materials
- ✓ Integration of water and indoor air quality
- ✓ Visual connection with nature and accessibility to outdoor spaces
- ✓ Ergonomics and consideration for people with reduced mobility
- ✓ the use of natural colors and the integration of nature into art
- ✓ Adaptability and flexibility
- ✓ Consideration of culture (and plant culture) in design
- ✓ Certification and labeling

The rating scale will help quantify the degree of use of biophilia in space. we opt to use it on a scale of 0 to 100%, Each criterion represents 10% of the scale. Indeed, 0% represents the complete absence of biophilia and 100% indicates complete and optimal integration of biophilia (Figure 6).

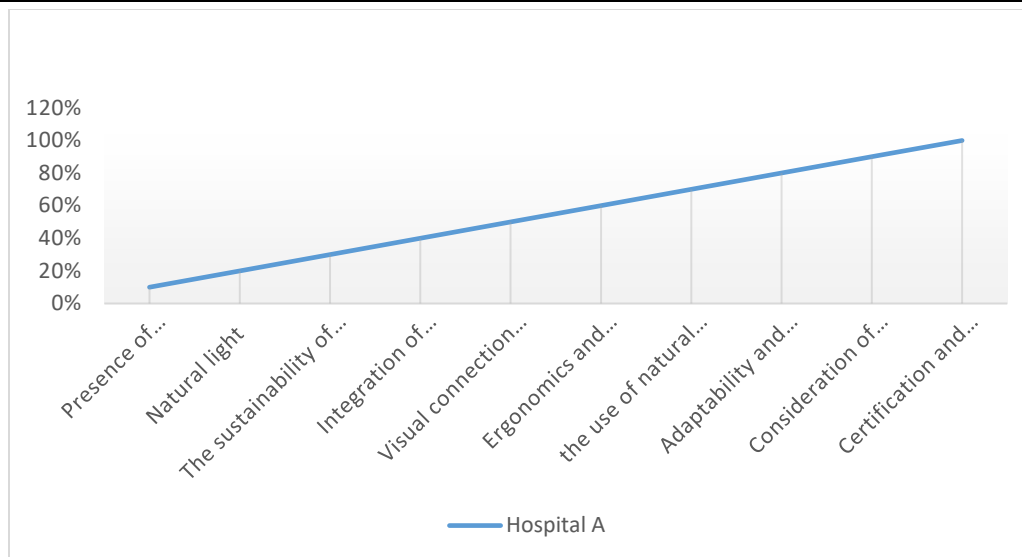


Figure 6. Evaluation diagram of biophilia in a hospital project.

This diagram will make it possible to evaluate in an objective and measurable way the degree of integration of biophilia in the hospital space to quantify and visualize the aspects of biophilia present in the environment. Also, it will propose to compare several spaces or projects with each other to determine which one best uses the principles of biophilia, which makes it possible to identify the strengths and weaknesses of each project and to make decisions to improve the design (Figure 7).

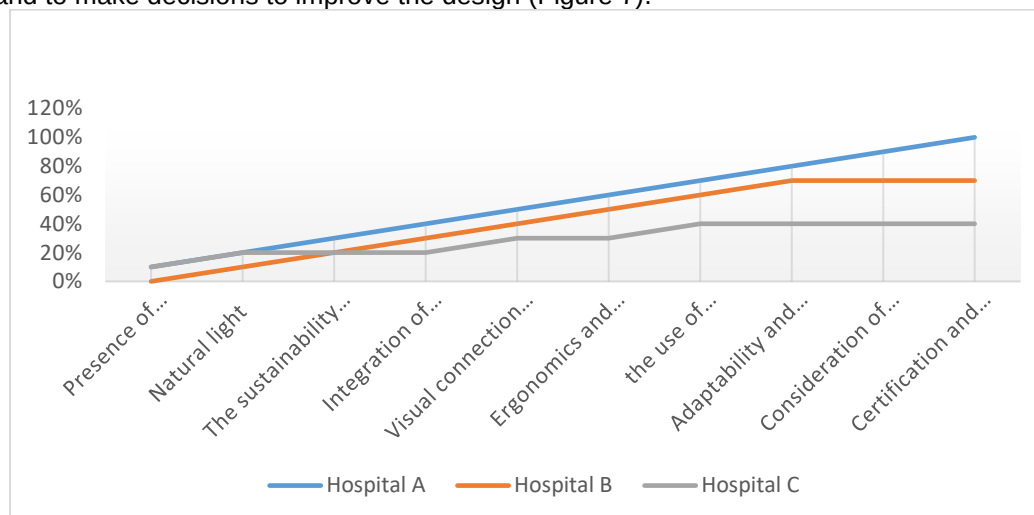


Figure 7. Comparing the evaluation of biophilia in 3 hospitals projects.

In addition, the diagram allows information on the use of biophilia in space to be communicated quickly and efficiently, whether to customers or other stakeholders. It can also serve as a reference for other design projects, providing a template or guidelines on how to effectively incorporate biophilia into a space.

5. Conclusions

In summary, this study has extensively explored the profound influence of biophilic design on healthcare environments. By recognizing the intrinsic bond between humans and nature, this design approach holds immense potential for enhancing the well-being of patients, visitors, and healthcare professionals. The research commenced by acknowledging the inherently stressful nature of hospital settings and the pivotal role of physical surroundings in patient recovery. It introduced biophilic design as an environmentally sustainable strategy that seamlessly integrates natural elements into healthcare spaces. The investigation aimed to elucidate how biophilic design can promote healing and elevate the overall hospital experience. Through the analysis of exemplar healthcare facilities, namely Maggie's Leeds Hospital and KTHP Hospital, the study exemplified how biophilic principles were harmoniously integrated into their architectural designs. These hospitals emerged as epitomes of biophilic excellence, crafting environments that not only foster physical convalescence but also provide emotional solace and comfort. The study identified pivotal design

elements that characterize biophilic excellence, encompassing ample natural light, considerate circulation, water features, integration of art and nature imagery, ergonomic considerations, and a commitment to environmental sustainability. These elements collectively contribute to the creation of spaces that nurture the well-being and recovery of occupants.

To facilitate the integration of biophilic design in hospitals, a comprehensive set of recommendations was furnished. These encompassed various facets, ranging from conducting a feasibility study and analyzing specific needs to integrating specific design elements such as natural light, water features, and greenery. Furthermore, the study proposed the adoption of a rating scale to quantitatively gauge the extent of biophilic integration in a given space. This tool provides a systematic approach to evaluate and visualize the incorporation of biophilia, streamlining informed decision-making and results communication.

It is imperative to recognize that biophilic design is a dynamic field, continuously evolving with new research findings and innovations emerging regularly. Therefore, it is crucial to stay abreast of current trends, best practices, and novel discoveries to consistently enhance and refine biophilic spaces. Exploring the potential afforded by cutting-edge technologies is advisable to enrich biophilic hospital environments. For instance, leveraging intelligent natural lighting systems, automated green walls, air quality monitoring systems, or mobile applications that enable patient interaction with virtual biophilic elements can further optimize the biophilic experience and augment its impact on health.

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Conflicts of interests

The Author(s) declare(s) that there is no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s.

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