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Evaluating Biophilic Design Strategies in Hospital Interior Environments: A Comparative Case Study Between Iraq and Singapore

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ABSTRACT

Biophilic design research standards and methods have been widely published to evaluate how hospitals can shift from sterile environments to healing places using nature-inspired elements. This research aims to evaluate biophilic design with respect to healing environments at Samarra General Hospital (SGH) in Iraq as a local conventional case study and Khoo Teck Puat Hospital (KTPH) in Singapore as an international exemplary case study. Five categories formed the basis of our assessment protocol: Natural lighting, natural elements, materials and colors, stress reduction, and overall satisfaction. By focusing on these metrics and attributes, this research explores how biophilic design can improve healing hospital environments through perceived environmental quality, comfort, stress reduction, and overall satisfaction. The case studies utilized were SGH in Iraq and KTPH in Singapore, with primary data collected from SGH through photographic observation, semi-structured interviews, and questionnaires, while KTPH was examined using published documents and post-occupancy evaluation (POE) literature. Statistical analysis was performed only on the SGH questionnaire data. A descriptive–analytical approach was used to analyze the collected SGH data, followed by descriptive statistics and statistical analysis. Findings indicated significant contrasts between the studied hospitals. SGH suffered from a lack of daylight, synthetic finishes, and an almost complete absence of natural elements that created a sterile and monotonous environment (visually and psychologically). On the other hand, KTPH implemented biophilic strategies through daylight, landscaped courtyards, water features, and the use of natural finishes. It created a calming environment that supports its users. The SGH interviews and questionnaire analysis indicated that participants had favorable comments towards biophilic attributes and associated them with feeling comfortable, less stressed, and greater satisfaction. The results indicated that better implementation of biophilic attributes is more closely related to environmental quality, psychological comfort, and user satisfaction. It can be concluded that bioclimatic design strategies have great potential to enhance hospital interior environments for the Iraqi climate.

1. INTRODUCTION

Hospital architecture has changed considerably over the last century. Traditionally, hospitals were designed primarily as sterile and highly functional environments, with an emphasis on operational efficiency and infection control. In many cases, this approach placed less emphasis on psychological comfort and users' connection with nature [1, 2]. More recent approaches to hospital design have increasingly shifted toward healing environments that address not only clinical requirements but also the physical and psychological needs of patients and healthcare providers.

In a similar study, a rapid review by Du et al. [3] found that biophilic design elements incorporating natural elements into the healthcare environment may improve patient recovery and reduce stress of the healthcare staff. Other positive effects on healthcare staff and the patient recovery process were reported. Exposure to nature during the hospital stay may improve various patient outcomes and provide emotional and psychological benefits [4]. The incorporation of biophilic elements and natural materials has also been reported to provide positive perceptions of the healthcare environment and improve the quality of the healthcare space [5].

Recent research has further demonstrated the value of biophilic strategies in healthcare settings. A systematic review by Al Khatib et al. [6] found that therapeutic biophilic interventions, including indoor vegetation, natural daylight, healing gardens, and views of nature, can enhance stress recovery, support emotional well-being, reduce perceived pain, and improve patient satisfaction.

Despite progress in the field, many healthcare environments are still clinically sterile, with long, enclosed, light-starved corridors and basic interior finishes. Such environments may cause anxiety and discomfort for patients rather than calmness

[5, 7]. These conditions increase interest in the use of biophilic design to create more supportive and restorative healing environments. Incorporating design features based on the principles of biophilic design will support healing for patients in clinically defined environments [5, 8, 9].

One of the challenges associated with applying biophilic design to healthcare environments in Iraq is the lack of direct or indirect connections with the outdoors or nature. The existing evidence suggests that incorporating living plants or greenery in a building improves the emotional and psychological health of patients and staff, lowers the stress response of patients and improves their satisfaction, and alleviates anxiety and fatigue. Healing gardens, natural materials, and other biophilic design elements are effective in improving the assessment of the quality and safety of the healthcare environment. Although studies on the application of biophilic design in healthcare environments in Iraq are limited, studies on the application of biophilic design and indoor green spaces in the region confirm the positive effects of the application of biophilic design on wellbeing and restoration [3, 9, 10].

However, studies on biophilic design have focused on health and psychological benefits, and its use and assessment in other Iraqi health facilities is very scant. Moreover, few studies assess traditional Iraqi hospitals by incorporating architectural assessment and the perceptions of the users. To fill this gap, the present study uses a multiple case design strategy, incorporating architectural assessment, questionnaires, and semi-structured interviews, at Samarra General Hospital (SGH), and uses Khoo Teck Puat Hospital (KTPH) as an international case. For this study, KTPH is used as a contextual reference, based on published works and the post-occupancy evaluation (POE) done on the hospital [11].

By focusing on the Iraqi healthcare context, this study assesses biophilic design conditions in a conventional hospital and identifies design considerations that may be adapted to local conditions. KTPH provides a contextual reference for interpreting the findings rather than serving as a basis for direct statistical comparison.

2. LITERATURE REVIEW

2.1 Climate-responsive and passive design strategies in hot-arid healthcare environments

Hot-arid climates mean high solar exposure and high evaporative cooling demands. Understanding design concepts to moderate climate conditions, maintain indoor comfort, and reduce energy use is critical. Passive strategies include site, orientation, and the placement of the building to take advantage of solar exposures. Shading and controlled openings can reduce the impact of solar heat gain. Natural ventilation and the use of Courtyards can reduce the need for mechanical cooling. Thermal mass can help reduce indoor temperatures and improve comfort by storing heat at night and releasing it during the day [12].

As noted above, solar shading and design can incorporate the use of vision glazing to promote useful daylight in patient rooms. Natural ventilation, if controlled, can promote thermal comfort [13]. Consideration of other strategies to moderate indoor climate, such as the use of insulation and appropriate building materials and the incorporation of vegetation to provide shading and evapotranspiration, can contribute to the reduction of energy use [14].

Ventilation may also support thermal comfort when outdoor conditions permit, although it must be coordinated with indoor air-quality and healthcare requirements [14].

Thermal mass, insulation, and suitable building materials can help moderate indoor temperature fluctuations and reduce cooling demand. Vegetation can provide additional shading and contribute to local microclimatic improvement through evapotranspiration. However, plant selection in arid regions should consider water availability, maintenance, and climatic suitability [15].

In Iraqi healthcare environments, these principles suggest that biophilic strategies should be adapted to local climatic conditions rather than transferred directly from other regions. Measures such as filtered daylight, external shading, suitable vegetation, thermally efficient materials, and water-conscious landscape design can support both environmental performance and the integration of natural elements into hospital interiors [16].

2.2 Theoretical basis for the assessment dimensions

The five assessment dimensions of our design framework are drawn from biophilic and healthcare design frameworks. Natural lighting is the role of daylight and light variation. Natural Elements are the direct connections with nature through vegetation and water, and other aspects of the surrounding environment. The remaining two, Stress Reduction and Overall Satisfaction, refer to the effect the hospital environment has on patients. Together, these five dimensions of design capture the relationship between the design elements and the perceived effects on users. Our goal is to provide an improved hospital environment that lessens the detrimental effects of the traditional hospital setting on the patient [17, 18].

3. METHODOLOGY

The study used a descriptive-analytical approach. The assessment instrument was developed with five dimensions of assessment based on the theoretical framework and previous research in the field of design of healthcare facilities. The dimensions were natural lighting, natural elements, materials and colors, stress recovery, and overall satisfaction [6, 19]. Previous research related to the use of biophilic design in healing environments of healthcare facilities covers both the environmental characteristics of design elements and the perceived responses of users, including environmental quality and stress reduction, as well as overall satisfaction [6, 20]. Related architectural components to the design of natural elements in the dimension assessment of the study were vegetation, interior gardens and courtyards, and water elements [6, 19]. A structured questionnaire was used to assess the perceptions of the interior environment of the SGH. One item of the questionnaire was dedicated to representing each assessment dimension. A five-point Likert scale was applied: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. No reverse scoring was performed. The mean of each dimension was calculated as the mean of the related items. The internal consistency of the questionnaire was good; Cronbach's alpha was 0.850. Mean scores were interpreted considering equal intervals of the Likert scale. The interval width was 0.8. Five-point Likert scale: 1.00–1.80 =

Very Low, 1.81–2.60 = Low, 2.61–3.40 = Moderate, 3.41–4.20 = High, and 4.21–5.00 = Very High (Table 1). The interval width was calculated as (5-1)/5 = 0.80.

Table 1. Mean score interpretation criteria for the five-point Likert scale

Mean Range	Impact Level
1.00–1.80	Very Low
1.81–2.60	Low
2.61–3.40	Moderate
3.41–4.20	High
4.21–5.00	Very High

A comparative case-study method was employed involving SGH in Iraq and KTPH in Singapore, which is internationally recognized as a benchmark for biophilic healthcare design [21]. Data collection included direct visual observations, photographic documentation, semi-structured interviews, and questionnaire surveys conducted at SGH. The interviews explored users' perceptions of daylight, natural elements, environmental comfort, and psychological well-being within the hospital environment. The two hospitals were considered differently in the analysis. SGH was the primary field case, where data were collected through site observation, photographic documentation, semi-structured interviews, and questionnaires. KTPH was considered an international reference case using published POEs, architectural studies, sustainability reports, and institutional documents. Therefore, the two cases were used for contextual comparison rather than direct statistical comparison [21].

A total of 63 valid questionnaires were obtained from SGH, including 30 patients (47.6%), 15 visitors (23.8%), and 18 healthcare staff (28.6%). Participants were recruited using convenience sampling, including patients, visitors, and healthcare staff who were available during the data-collection period and agreed to participate. Data collection took place at SGH between 9 and 12 June 2026. Age and gender were not included in the questionnaire and were therefore not considered in the analysis.

NVivo (QSR International) was used to organize and analyze the qualitative data [22, 23]. Twelve semi-structured interviews were conducted at SGH, with each interview lasting approximately 15 minutes. The interviews were transcribed and coded in NVivo together with relevant field observation notes. Initial codes were assigned to recurring comments concerning daylight, natural elements, materials and finishes, the institutional atmosphere, and users' psychological responses. Related codes were then grouped into broader themes. The number of NVivo references associated with each theme was recorded. Illustrative or representative quotations from the coded data were selected to show the main themes. These quotations were also used to illustrate and interpret participants' views.

Quantitative data were analyzed using IBM SPSS Statistics [24]. Frequencies, percentages, means, and standard deviations were calculated to summarize questionnaire responses, and Cronbach's alpha was used to assess internal consistency. Prior to correlation analysis, data distribution was examined using the Shapiro–Wilk test, and potential outliers were assessed using the interquartile range (IQR) method. As the Likert-based assessment dimensions did not meet the normality assumption, Spearman's rank correlation was used to examine associations among the five dimensions. Because ten pairwise correlations were tested, a Bonferroni correction was applied, resulting in an adjusted significance level of $p < 0.005$. Because each dimension consisted of one item, the mean reported for each dimension represented the mean response to that item across the 63 valid respondents. Cronbach's alpha coefficient was 0.850. Statistical analysis was performed only on the questionnaire data collected from SGH; no statistical analysis was conducted on the published KTPH data.

Lastly, qualitative data gathered from NVivo and quantitative data created from SPSS were triangulated with observational data and benchmarked against existing published post-occupancy data from KTPH to better determine successful biophilic design implementation within healthcare settings [6, 10]. Statistical analysis was performed only on the questionnaire data collected from SGH. No statistical analysis was conducted on the published KTPH data.

4. CASE STUDY

4.1 Samarra General Hospital (Iraq)

4.1.1 Description

Site visit observations were made at SGH and found that the design layout was made of rectangular blocks connected to corridors used for services such as ventilation. In regard to finishes, painted walls and ceramic tiles were used indoors; corridors were painted and elongated, with small windows providing little natural light. Site visits showed little evidence of nature and demonstrated a very functional space lacking biophilic design qualities (Figure 1). Few aspects of nature are used throughout SGH. There are no indoor plants, green walls, or nature-themed art. The hospital looks very monotone with painted concrete, vinyl floors, and metal doors. The interior design focused on function over providing a humanistic and healing space [8, 9].

4.1.2 Natural lighting

Site analysis revealed there was not much natural daylight at SGH. The windows provided natural light to patient rooms, and hallways were relatively small, with most windows being shaded. Large portions of the day are lit by fluorescent light indoors. Research has linked daylight exposure to better circadian health, sleep, and patient experience in healthcare settings [6]. There may not be enough natural daylight to expose users to those benefits and promote healing. Unlike biophilic design standards, SGH doesn't appear to make much use of daylighting.

4.1.3 Materials

Inspection of the hospital and photographic analysis revealed that materials used throughout the interior of SGH are primarily functional for sanitation and ease of cleaning. Flooring is primarily comprised of ceramic tiles, and walls are either painted plaster or ceramic tiles. Standard drop acoustic ceilings and metal doors/fixtures complete the sterile, industrial look of the interiors (Figure 2). Incorporation of natural materials like wood or stone adds sensory richness and warmth that is currently not present in SGH. Studies indicate that natural elements used throughout healthcare facilities can decrease stress levels and increase psychosocial comfort while connecting occupants to the healing philosophy of biophilic design [1, 21]. Due to material choices used throughout SGH, function took priority over restorative qualities.

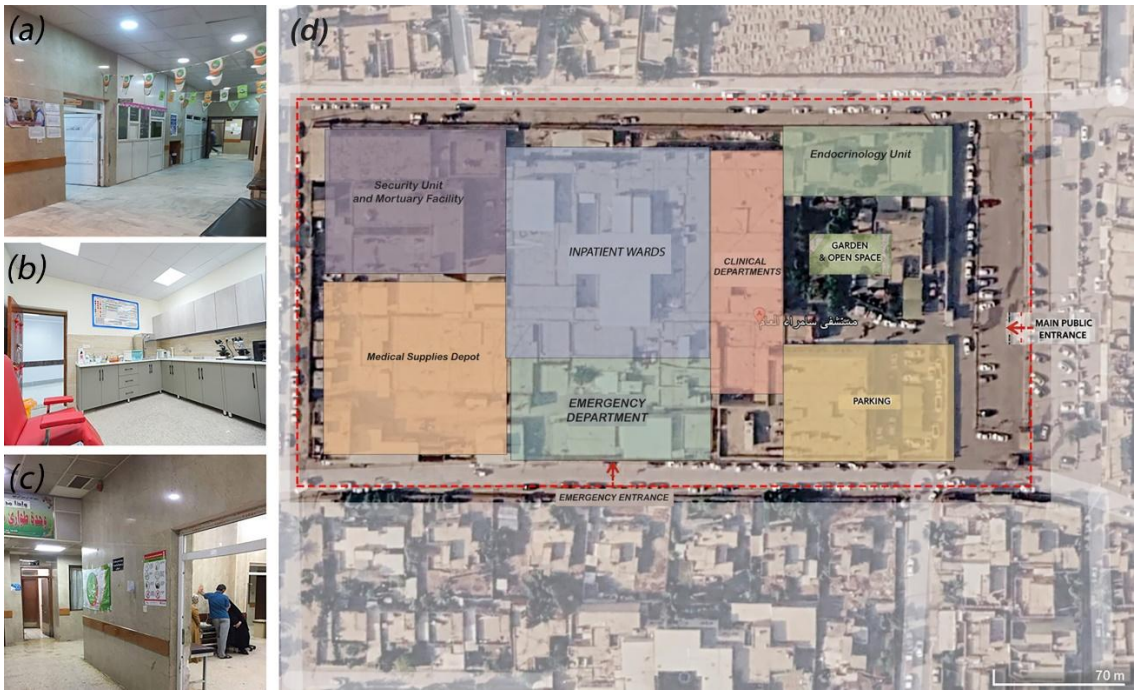

Figure 1. The general site for Samarra General Hospital: (a) Corridor leading to the Emergency Department; (b) laboratory interior showing work surfaces, storage units, and interior finishes; (c) internal circulation and transition area; and (d) aerial-based functional layout illustrating the distribution of hospital departments, supporting facilities, garden and open space, parking areas, and public and emergency entrances

Note: The scale bar represents 70 m.



Figure 2. Exterior views, internal circulation spaces, and site context of Samarra General Hospital: (a) exterior façade; (b) corridors leading to outpatient clinics; (c) internal circulation corridors; (d) covered circulation corridor; and (e) aerial view of the hospital site and surrounding urban context

Note: A view of the interior hallways and means of circulation.

4.1.4 Presence of natural elements

Outdoor environments were not applicable to field data collection as there was no vegetation, water fountain, or other biophilic elements observed indoors at the hospital. Windows, planted pots, living walls, or other natural elements were not found in waiting rooms or hallways where there may be opportunities to observe nature. Studies have shown indoor plants can help decrease stress and anxiety while increasing comfort for users in a healthcare environment [9]. Therefore, there may be fewer opportunities for positive distraction throughout the hospital.

4.1.5 Biophilic design assessment

In conclusion, SGH's interior can be described as a mundane space that lacks healing character and focuses more on its functionality. As noted earlier in the interior appraisal scorecard, there is a lack of natural daylight, which forces occupants to use artificial lighting. The hospital's interior consists of hard, cold materials such as ceramics and synthetic textures. The hospital lacks access to indoor plants as well as other natural elements [6]. As a result, SGH doesn't create a comforting or supportive environment for its users (Figure 2, SGH view of Interior Hallways and Pathways. Notice the simplicity of the design. There is no plant life or natural

features indoors).

4.2 Khoo Teck Puat Hospital (Singapore)

KTPH in Singapore was intentionally chosen as an international exemplar rather than a matched control case. Its analysis drew solely from publicly available post-occupancy reports, architectural critiques, sustainability documents, and organizational releases.

4.2.1 Description

KTPH (opened in 2010; capacity of 550 beds) was chosen as the international case study because it was one of the few healthcare facilities where biophilic design concepts and passive design strategies were widely documented. Built adjacently to Yishun Pond, its unique V-shape promotes cross-ventilation, natural daylighting, and views to green open spaces, facilitating restorative elements in healthcare settings [25].

The hospital layout encloses a landscaped courtyard with ponds and waterfalls running down from Yishun Pond. Natural ventilation techniques utilize predominant winds which flow through the inpatient wards. Shading devices such as overhangs and fins help to mitigate heat gain whilst maintaining daylight illumination (Figure 3) [26].

Exceeding 700 species of indigenous flora are integrated within rooftop gardens, terraces, balconies and courtyard gardens which support birds and butterflies and promote occupants' visual and physical connection with nature [25, 26]. As this review was conducted through published POEs, architectural case reviews, sustainability assessment documents and institutional reports, no field observations, questionnaires, interviews or ethical clearance was needed [25, 27]. KTPH is internationally referred to as a benchmark for assessing biophilic design strategies and passive design strategies within healthcare design [27].

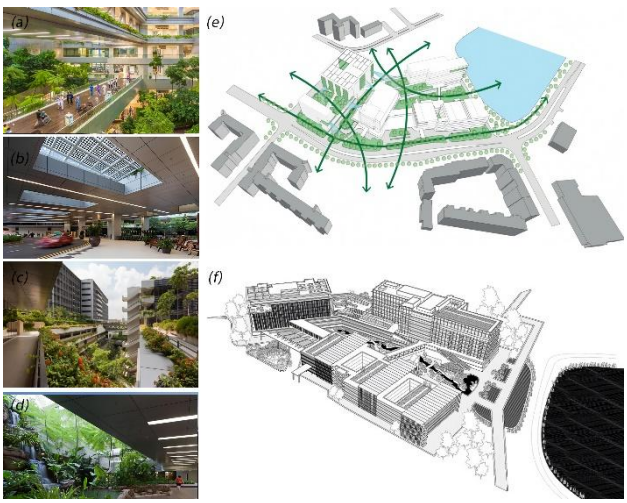

Figure 3. Layout and pictures from Khoo Teck Puat Hospital (KTPH)

4.2.2 Indoor gardens and greenery

Greenery indoors is abundantly used at KTPH. Vegetation forms one of the main strategies of the biophilic design concept. Plantings were applied on as many surfaces as possible at KTPH to enhance visual and physical connections with nature throughout the facility [26]. A canopy garden bridging the ward towers across a tropical courtyard helped to strengthen the connectivity of the space and connected users to nature [26].

The rooftop gardens feature an urban farm that grows over 100 varieties of fruits, vegetables, and herbs, contributing even further to the hospital's green efforts, education, and therapy [28]. A dementia garden can also be found on the fourth floor, adjacent to the geriatric clinic. It allows patients easy access to an outdoor-feeling environment with sensory vegetation they can interact with to relax and receive therapy [9].

Integration of greenery continues into circulation spaces, waiting areas, and interior courtyards through use of planted alcoves, green walls, and landscaped terraces. The building design dedicates over 40% of total floor area to blue and green open spaces such as courtyards, rooftop gardens, and planted terraces [26, 28]. User satisfaction surveys indicated that landscape elements increased connectivity to nature, psychological comfort, and overall environmental satisfaction [9, 26].

4.2.3 Natural lighting

Natural daylight is another environmental feature embedded into the design of KTPH. Daylight enters the building through its open central courtyard, illuminating parts of the lower floors as well as the inner atria naturally [26]. In fact, its landscaped basement level was designed with consideration to allow daylight and natural ventilation to filter down from the upper floors [26]. Daylight also reaches into all of its inpatient rooms through large windows. Beds in patient rooms are also strategically placed to allow patients to view nearby vegetation and landscaped areas [9]. Installation of glazed corridors and light wells also allows more daylight into interior areas.

Prior research has shown that daylight availability inside hospitals allows people to have better circadian lighting and sleep conditions, as well as satisfaction levels [6]. Thus, KTPH's daylighting design allows it to have a brighter and more restorative interior atmosphere. At the same time, daylighting emphasizes the biophilic intent of the hospital.

4.2.4 Water elements

Water features form another important biophilic design strategy employed at KTPH. By cascading water features, courtyard ponds, and fountains, KTPH connects the adjacent pond called Yishun Pond to the garden. Visual and sensory connection with water is designed into almost every area in the hospital [26]. Water features also promote passive environmental performance strategies. By incorporating water bodies that evaporate into the surrounding air, they create a cooler microclimate. Outdoor spaces like the landscaped courtyard have been recorded as being about 2° cooler than ambient outdoor temperatures [1].

Research has shown that the presence of water in healthcare settings not only lowers stress levels but also contributes to improved psychological health and perception towards environmental quality [6, 9]. In line with previous studies, post-occupancy surveys conducted in KTPH also revealed that the occupants experience greater levels of beauty and perceived environmental satisfaction with the inclusion of water features and plants around the hospital premises [21].

4.2.5 Materials

Selection of materials palette at KTPH mirrors the implementation of biophilic design principles. Natural materials such as timber, stone and bamboo were used widely throughout the hospital along with concrete finishes [28]. This

was evident in features found along walkways, in public areas and waiting rooms, which aimed to warm up the spaces visually and made them less institutional, more homely for visitors. Research conducted previously has found that utilizing natural materials promotes stress reduction, psychological comfort and connectedness to nature among users [21]. Thus, materials used at KTPH helped to support the creation of restorative interiors.

4.2.6 Impact on users

Feedback received through POEs suggests the biophilic hospital design is linked to increased user satisfaction. In a survey conducted with 200 patients, visitors, and healthcare workers, perceived ratings of beauty, psychological well-being, and connection to nature were significantly higher than those from users of a traditional hospital [26]. Over 80% of participants surveyed recognized integrated vegetation as being an attribute of therapeutically significant healthcare spaces; KHOTP demonstrated increased community involvement and patient satisfaction as well [26].

This study supports other research which shows that using elements of biophilic design in healthcare environments may decrease stress and anxiety levels and increase psychological well-being and user satisfaction. [21, 28]. Also, the vegetation and biodiversity on the hospital grounds provide a restorative environment and connect users to nature, thus improving perceived environmental quality [26].

5. RESULTS

This paper attempts a contextual comparison of the two hospitals: SGH and KTPH. Primary data were gathered from field visits, and interviews were conducted in Samarra, while published data were obtained for KTPH. The hospitals were compared based on the biophilic design strategies deployed, the attributes of the facilities, and the reported experiences of the users. Comparisons based on numbers were avoided. A total of 63 respondents were sampled and completed the questionnaires. The sample comprised 30 patients (47.6%), 15 visitors (23.8%), and 18 (28.6%) health workers. A reliability test for the questionnaires yielded an excellent internal consistency (Cronbach's $\alpha = 0.850$; $n = 63$). Descriptive statistics are presented in Table 2.

5.1 Biophilic design assessment dimensions

Table 2 presents the descriptive statistics and ratings for each of the five biophilic design dimensions. Natural lighting ($M = 2.48$, $SD = 1.216$) was the highest, while stress reduction ($M = 2.00$, $SD = 1.308$) was the lowest. Overall satisfaction ($M = 1.90$, $SD = 0.911$), natural elements ($M = 1.90$, $SD = 1.241$), and stress reduction ($M = 2.00$, $SD = 1.308$) were the other lowest mean scores. Based on the predefined 5-point Likert scale criteria, all five dimensions were rated low.

Table 2. Descriptive statistics of the biophilic design assessment dimensions (N = 63)

Assessment Dimension	Mean	Std. Deviation	Perception Level
Natural Lighting	2.48	1.216	Low
Natural Elements	1.90	1.241	Low
Materials and Colors	2.27	1.298	Low
Stress Reduction	2.00	1.308	Low
Overall Satisfaction	1.90	0.911	Low

The data show that SGH patients, on the whole, have low impressions of the assessed biophilic and environmental elements.

Frequency data showed further detail. Regarding natural elements, 63% (48 of 63) of the respondents selected either Disagree or Strongly Disagree. Regarding stress reduction, 74.6% (47 of 63) of the respondents selected either Disagree or Strongly Disagree. Lastly, regarding overall satisfaction, 79.4% (50 of 63) of the respondents selected either Disagree or Strongly Disagree.

Table 3 compares biophilic design indicators at SGH and KTPH.

Table 3. Contextual comparison of biophilic design indicators between Samarra General Hospital (SGH) and Khoo Teck Puat Hospital (KTPH)

Design Indicator	SGH (Baseline Case)	KTPH (International Reference Case)
Architectural Design Approach	Conventional functional design characterized by linear circulation systems, enclosed corridors, and block-based spatial organization.	Biophilic planning strategy based on V-shaped building blocks surrounding a central landscaped courtyard, facilitating continuous interaction with nature.
Natural Lighting	Limited daylight access due to small window openings and heavy reliance on artificial lighting systems.	Maximized daylight penetration through large windows, open courtyards, skylights, and naturally ventilated circulation spaces [28].
Natural Elements	Minimal incorporation of natural elements; absence of indoor vegetation, therapeutic gardens, and water features.	Extensive integration of greenery through healing gardens, green roofs, indoor planting systems, ponds, and cascading water features [28].
Materiality and Finishes	Predominantly synthetic and institutional materials, including painted concrete, ceramic tiles, metal, and plastic finishes.	Use of natural materials such as timber, stone, and bamboo, enhancing environmental warmth and visual comfort [20, 28].
User Experience and Psychological Impact	Users' questionnaire and interview responses indicated limited environmental comfort and low satisfaction with several assessed attributes.	Published post-occupancy evaluation (POE) evidence reports favourable perceptions of environmental quality, well-being, and connection with nature.

Natural lighting showed a clear concern in the SGH findings. Field observations, questionnaire responses, and interview data indicated limited daylight availability, particularly in internal corridors and waiting areas. NVivo coding also showed more negative than positive comments related to daylight availability (Figure 4), supporting the observed limitation in visual access to natural light. contrast, published evidence from KTPH describes the use of windows, landscaped courtyards, atria, and naturally ventilated circulation areas to increase access to daylight and nature [28].

Another important aspect of the SGH findings was the presence of Natural Elements. Limited indoor vegetation, healing gardens, and water features were found in on-site visits. Findings were supported by the questionnaires, and the mean score (M = 1.90, SD = 1.241) was the second lowest score of all assessed aspects. The interviews confirmed the presence of a "cold," "stressful," and "institutional" environment. The participants said that the researcher was "free to interpret as he wishes". Some positive aspects were found in KTPH [28], which include the use of vegetables and healing gardens.

Case differences were evident in Materiality and finishes. SGH extensively uses ceramic tiles, painted concrete, metal doors, and other synthetic materials. Materials and Colors received a mean score of 2.27 (SD = 1.298), which falls within the Low category of the predefined interpretation criteria of the study. KTPH, on the other hand, used timber, stone, bamboo, and other natural materials [20] to enhance environmental quality and visual comfort.

Mean scores for the SGH questionnaire range from 1.90 to 2.48 and are depicted in Figure 5 for the five dimensions of assessment. The interviews confirmed the survey findings about inadequate daylight, inadequate vegetation, crowded circulation, and limited visual comfort. Evidence published about KTPH is useful to provide context and indicates more advanced integration of daylight, vegetation, water features, and other biophilic elements.

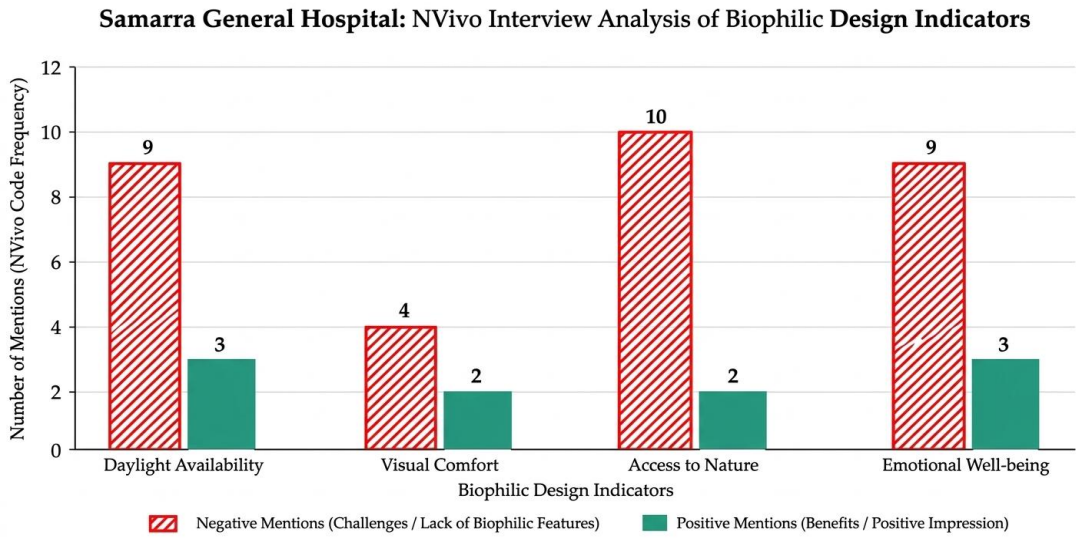

Figure 4. Frequency of interview code mentions associated with selected biophilic design patterns at Samarra General Hospital (SGH)

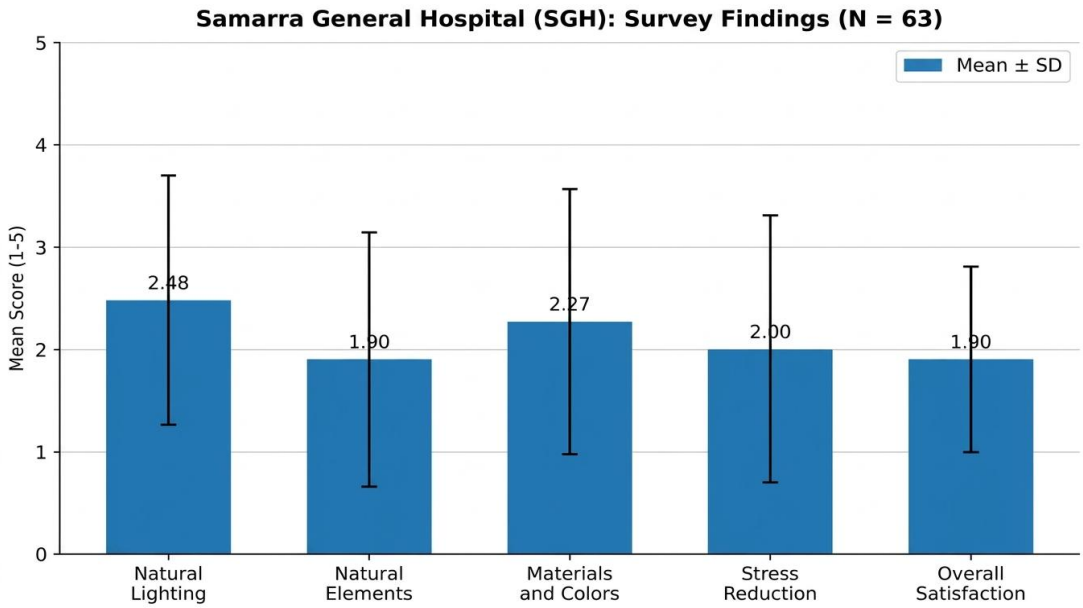

Figure 5. Mean scores of biophilic design assessment dimensions at Samarra General Hospital (SGH) (N = 63)

5.2 Correlation analysis of biophilic design indicators

Prior to the correlation analysis, the distribution of the five assessment dimensions was checked. The Shapiro-Wilk test showed that $p \approx 0.001$, meaning normality was not distributed. The IQR was used to check for potential outliers. Some questionnaire responses were flagged as potential outliers, but since they were completed responses using the 5-point Likert

scale, they were kept. Spearman's rank correlation was performed to determine the correlation of the assessment dimensions. As ten correlations were conducted, the significance level was adjusted using the Bonferroni method to $p < 0.005$.

Stress Reduction had a low mean score ($M = 2.00$, $SD = 1.308$), indicating generally low perceived support for stress reduction within the hospital environment. Spearman's correlation showed a positive association between Natural Elements and Stress Reduction ($\rho = 0.627$, $p < 0.001$) and between Materials and Colors and Stress Reduction ($\rho = 0.722$, $p < 0.001$). Both associations remained statistically significant after the Bonferroni adjustment ($p < 0.005$).

The results suggest that participants who gave more favorable ratings to natural elements and to materials and colors also tended to report more favorable perceptions of stress reduction. These correlations describe an association between the variables and should not be taken as evidence of a causal effect of biophilic design on stress reduction.

6. DISCUSSION

Results revealed that specific biophilic conditions were related to healthcare users' perceptions of their environment. SGH scored low on Natural Elements ($M = 1.90$), Stress Reduction ($M = 2.00$), and Overall Satisfaction ($M = 1.90$), which suggests that this hospital offered limited restorative qualities within the assessed interior environment. A lack of vegetation, limited daylight, and the predominance of institutional materials may lead to a sterile and visually uninteresting atmosphere.

Correlation results were also consistent with these findings. Natural Elements were positively associated with Stress Reduction ($\rho = 0.627$, $p < 0.001$). Materials and Colors were positively associated with Stress Reduction ($\rho = 0.722$, $p < 0.001$). These findings are consistent with the restorative perspective of Stress Recovery Theory and with previous healthcare studies [7, 29, 30]. However, the observed associations do not establish a causal relationship between biophilic attributes and stress reduction.

The qualitative results supported the quantitative findings. Respondents described the hospital as having a "cold" and "institutional" atmosphere and referred to higher levels of stress, together with the lack of daylight and greenery. Taken together, these findings suggest that occupants perceived the interior environment as lacking restorative elements.

In comparison, KTPH incorporates lush greenery, landscaped green spaces, water features, daylight, natural ventilation, and natural materials. Published findings reported favorable perceptions of environmental quality and psychological well-being. KTPH was not treated as a statistically equivalent case but as an international reference case, since primary data were collected at Samarra whereas KTPH was examined through published literature and post-occupancy evidence.

The comparison between the two cases highlights the importance of adapting biophilic design strategies to local conditions rather than directly replicating approaches used elsewhere. Instead of imitating the Singaporean example, Iraqi hospitals could consider context-sensitive strategies such as daylight modulation, filtered solar exposure through vegetation, natural materials, and appropriately selected green spaces that respond to local climatic conditions. Overall, the findings suggest that more favorable perceptions of biophilic attributes were associated with greater overall satisfaction and psychological comfort.

7. LIMITATIONS

This study has several limitations. It adopted a descriptive–analytical approach based on architectural observation, document analysis, and users' perceptions. The survey was conducted at a single time point with 63 respondents selected through convenience sampling. These factors may limit the generalisability of the findings.

The comparison between SGH and KTPH in Singapore relied on non-equivalent data sources. Primary data were collected at SGH while KTPH was assessed using published studies and available documentation. Therefore, the comparison should be interpreted as descriptive and contextual rather than as a direct quantitative evaluation.

Direct on-site measurements of indoor environmental conditions such as temperature, relative humidity and illuminance were not conducted. Quantitative architectural indicators including window-to-wall ratio and sunlight exposure duration were also not measured because they required additional data collection beyond the scope of this study. Furthermore, age and gender were not included in the analysis, which prevented the examination of demographic differences in respondents' perceptions. Future research should use larger and more diverse samples and apply standardised comparative methods. It should also incorporate objective environmental measurements and relevant demographic variables.

8. CONCLUSIONS

The findings of this study suggest that biophilic attributes were associated with users' perceptions of indoor environmental quality, psychological comfort, and satisfaction with hospital interiors. At SGH, the low scores for Natural Elements, Stress Reduction, and Overall Satisfaction indicated limited restorative qualities within the assessed environment. Positive associations were also observed between Natural Elements and Stress Reduction, as well as between Materials and Colors and Stress Reduction.

The KTPH case provided a contextual reference for understanding how daylight, vegetation, water features, natural materials, and views of nature can be incorporated into hospital environments. Since KTPH was not assessed using the present questionnaire and its evidence was obtained from published studies and POEs, the two cases were not subjected to direct statistical comparison. The findings suggest that biophilic strategies adapted to Iraq's hot-arid conditions, including filtered daylight, shaded vegetation, natural materials, and appropriately scaled green spaces, may provide practical options for improving hospital interior environments in Iraq. Future research should examine these relationships using larger samples across multiple hospitals and longitudinal or intervention-based designs to provide stronger evidence regarding changes over time and potential causal effects on users.

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