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BIOPHILIC DESIGN FOR SENSORY AND EMOTIONAL WELLNESS IN HEALTHCARE FACILITIES

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Abstract

The spaces we inhabit shape our experiences, emotions, and well-being—perhaps nowhere more so than in healthcare environments. While patient-centered design has long been a focus in medical settings, less attention has been given to how the built environment impacts visitors, caregivers, and therapists—those who provide emotional and physical support but often navigate these spaces under stress. This study explores the potential of biophilic design, the integration of natural elements into architecture, to foster sensory and emotional well-being for these non-patient users in healthcare facilities.

Grounded in Florence Nightingale's Environmental Theory, this research examines how elements such as natural light, greenery, soundscapes, biomimicry, and tactile pathways contribute to reducing stress, enhancing emotional resilience, and encouraging social interaction. Through a systematic literature review and a quantitative survey, the study gathers insights from a diverse participant group to assess perceptions of biophilic design features in public spaces within healthcare environments.

The findings provide evidence-based recommendations for designing more restorative and inclusive healthcare spaces that go beyond patient care. By prioritizing the experiences of visitors, caregivers, and therapists, this research advocates for a more holistic approach to healthcare design—one that acknowledges the profound impact of space on mental and emotional well-being.

This study contributes to the growing discourse on human-centered, sustainable, and emotionally responsive architecture, offering practical insights for designers, architects, and healthcare administrators looking to create healing environments for all who enter them.

Keywords: Biophilic Design, Sensory Well-being, Emotional Wellness, Healthcare Environments, Environmental Psychology, Human-Centered Design

Definition of Key Terms

Aesthetics: The visual appeal or beauty of a space or element often influencing how comforting or engaging it feels.

Biomimicry: A design approach that imitates patterns, forms, or systems found in nature to create spaces that feel familiar, calming, and supportive.

Biophilia: The innate human inclination to connect with nature and natural forms.

Biophilic Design: The practice of integrating natural elements—such as light, greenery, textures, water, and sounds—into built environments to promote human well-being.

Caregivers: Individuals who provide emotional or physical support to patients, often in informal or family-based roles, within healthcare environments.

Comfort (Perceived): The feeling of ease and relaxation experienced by individuals within space; includes both physical and emotional dimensions.

Daylight / Natural Light: Sunlight entering a space through windows or openings, influencing mood, visibility, and circadian rhythms.

Emotional Well-being: A state of mental and emotional health characterized by calmness, positive mood, reduced anxiety, and psychological resilience.

Environmental Psychology: A field of study exploring how built environments influence human behavior, emotions, and health.

Greenery: Plants, green walls, gardens, or other vegetation incorporated into indoor or outdoor spaces.

Healing Environment: A built setting designed intentionally to support recovery, reduce stress, and promote holistic well-being.

Indoor Plants: Live vegetation placed inside buildings, used as a biophilic element to improve air quality, aesthetics, and mental clarity.

Multi-sensory Design: Design that engages more than one of the five senses—sight, sound, touch, smell, and hearing—for a more immersive user experience.

Natural Elements: Components of the built environment that reflect or include nature, such as sunlight, plants, water, textures, and organic patterns.

Public Healthcare Spaces: Non-clinical areas within healthcare settings that are accessible to the public, such as waiting areas, lobbies, and corridors.

Restorative Environment: A space that facilitates psychological recovery from stress or mental fatigue through sensory stimuli, typically involving nature.

Sensory Experience: The overall perception and feeling generated through environmental stimuli including sights, sounds, textures, and smells.

Social Interaction: Interpersonal engagement and communication within a space, often influenced by environmental comfort and layout.

Soundscape: The auditory environment, particularly natural or ambient sounds (like water, wind, birdsong) are used to enhance emotional and sensory well-being.

Stress Reduction: A decrease in mental or emotional tension resulting from calming environmental features or stimuli.

Survey Instrument: A structured tool used to collect responses from participants, typically using a mix of scaled questions and demographic items.

Tactile Pathway / Tactile Elements: Textured surfaces or materials designed to be felt and interacted with, contributing to sensory stimulation and user comfort.

Therapists: Healthcare professionals offering mental or physical therapy, who may also interact with healthcare public spaces in their roles.

Visitors: Non-patient users of healthcare spaces, often accompanying or visiting someone receiving care.

Well-being: A holistic measure of health encompassing physical comfort, mental clarity, emotional resilience, and social harmony.

Chapter 1: Introduction

In this chapter, the foundation of this research is established by exploring the broader context, significance, and key aspects of the study. It begins with the background and problem statement, highlighting the need for a deeper understanding of how healthcare environments impact visitors, caregivers, and therapists. The purpose statement and research questions define the study's focus, while the research objectives outline what this study aims to achieve. The chapter also details the research strategy and methodology, explaining how data will be collected and analyzed, along with the expected outcomes. Finally, the research limitations acknowledge potential challenges and constraints, providing a well-rounded overview of the study's scope.

1.1. Background Information

The design of healthcare environments has evolved significantly over the years, with a strong emphasis on evidence-based design (EBD) principles that prioritize functionality, efficiency, and patient-centered care (Ulrich, 2001; Hamilton & Watkins, 2009). However, beyond clinical spaces, public and transitional areas such as waiting rooms, lobbies, and corridors play a crucial role in shaping the overall experience of visitors, caregivers, and healthcare staff. Despite the high emotional and cognitive demands placed on these non-patient users, design guidelines and healthcare facility standards primarily address patient recovery and operational efficiency, often neglecting the psychological and sensory needs of those who support and interact within these spaces.

Current healthcare design standards, such as the Facility Guidelines Institute (FGI) Guidelines for Design and Construction of Hospitals (2022) and the American Institute of

Architects (AIA) Guidelines for Healthcare Design, focus primarily on clinical safety, infection control, and accessibility. While these guidelines include provisions for lighting, acoustics, and spatial arrangements, their emphasis remains on patient care rather than holistic environmental comfort. Similarly, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) sets performance standards for healthcare environments yet lacks specific recommendations for integrating nature-based design strategies that could enhance overall well-being for all users.

Furthermore, international frameworks like the WELL Building Standard and LEED for Healthcare have introduced concepts related to indoor environmental quality (IEQ), daylight access, and biophilic design elements, yet their implementation within non-clinical healthcare spaces remains inconsistent (International WELL Building Institute, 2020; U.S. Green Building Council, 2019). Research suggests that elements such as dynamic and diffused lighting, views to nature, controlled acoustics, and natural materials can reduce anxiety, improve cognitive focus, and promote relaxation—benefits that extend beyond patients to visitors and healthcare providers (Ching et al., 2014; Sadek & Willis, 2020).

Table 1. *Limitations of Existing Healthcare Design Guidelines in Addressing Non-Patient User Needs*

Guideline/Standard	Focus Areas	Limitations for Non-Patient Users
FGI Guidelines for Design and Construction (2022)	Space planning, safety, infection control, patient-centered design	Minimal consideration for emotional and sensory well-being of visitors & caregivers
AIA Guidelines for Healthcare Design	Accessibility, operational efficiency, lighting, HVAC	Lacks recommendations for biophilic or sensory-enhancing design

WELL Building Standard (Healthcare)	Indoor air quality, daylight access, stress reduction	Primarily voluntary, not mandatory for all facilities
LEED for Healthcare	Sustainable materials, energy efficiency, wellness integration	Limited emphasis on psychological comfort in public spaces
Joint Commission (JCAHO)	Performance standards for patient safety and healthcare quality	Limited emphasis on psychological comfort in public spaces

Despite these insights, healthcare architects and designers often struggle to balance regulatory requirements with user-centered approaches due to constraints in budget, space, and institutional priorities. The integration of sensory-based and psychological comfort factors into code-compliant designs remains a key challenge. Therefore, this study seeks to explore how design strategies can enhance the quality of experience for all healthcare users while aligning with existing regulatory frameworks and best practices.

1.2. Problem Statement

Current healthcare design standards prioritize patient care, often overlooking the needs of visitors, caregivers, and therapists, who frequently occupy waiting areas, lobbies, and transitional spaces. While guidelines such as the FGI Healthcare Guidelines (2022) and AIA Healthcare Design Standards ensure safety, functionality, and efficiency, they lack specific provisions addressing the psychological and sensory well-being of non-patient users (Hamilton & Watkins, 2009). As a result, these spaces remain sterile, impersonal, and acoustically harsh, contributing to stress and emotional fatigue (Ulrich et al., 2018).

Although studies indicate that natural elements—such as greenery, natural light, and acoustic control—can reduce anxiety and enhance comfort (Russo & Andreucci, 2023), their

application in non-clinical healthcare spaces remains limited. Additionally, existing research lacks a structured approach to integrating biophilic design within regulatory constraints (Edwards, 2023).

This study aims to evaluate the impact of biophilic design on stress reduction, emotional well-being, perceived comfort, and social interaction in healthcare public spaces, providing evidence-based design recommendations that align with both healthcare regulations and well-being principles.

1.3. Research Questions

To explore this issue, the study is guided by the following research questions:

1. How do biophilic design elements influence the sensory and emotional experiences of non-patient users in healthcare public spaces?
2. What environmental preferences are expressed by different user groups?
3. What design insights can be drawn from users' responses to biophilic elements in healthcare public spaces?

These questions aim to bridge the gap between healthcare regulations and user-centered design, ensuring that public spaces within healthcare settings are both functional and emotionally supportive.

1.4. Research Objectives

To effectively address the research questions, this study establishes key objectives that focus on evaluating, analyzing, and applying biophilic design principles in non-clinical healthcare spaces.

The specific objectives of this research are:

1. To examine the influence of biophilic design elements—such as natural light, greenery, soundscapes, and tactile materials—on the emotional and sensory responses of non-patient users in healthcare public spaces.
2. To analyze and compare the environmental preferences of different user groups, specifically visitors and caregivers, based on their perceptions of biophilic features.
3. To identify key patterns in user feedback that can inform inclusive and emotionally supportive design strategies for healthcare environments.

These objectives provide a clear roadmap for exploring how nature-inspired design can create healthcare spaces that support not only patients but all users, balancing regulatory constraints with human-centered design solutions.

1.5. Significance for the study

This study contributes to a growing body of research that recognizes the importance of user-centered healthcare environments. While much of the existing literature and design standards prioritize patient care, there is limited attention given to the emotional and sensory needs of non-patient users—such as visitors, caregivers, and therapists—who regularly occupy public spaces within healthcare settings.

By exploring how biophilic design elements influence stress reduction, emotional well-being, comfort, and social interaction, this research highlights the broader impact of environmental design on diverse user groups. The findings not only help bridge a critical gap in healthcare design but also offer evidence-based recommendations for creating more inclusive, calming, and supportive spaces that benefit all users, beyond the clinical patient population.

1.6. Research Strategy

To achieve the research objectives, this study adopted a mixed-methods research strategy, integrating both quantitative and qualitative data collection to explore the sensory and emotional impact of biophilic design on non-patient users in healthcare settings. The mixed-methods approach allowed for both measurable patterns and contextual understanding, offering a more complete picture of user experiences.

1. Phase 1: Systematic Literature Review:

   A detailed review of 50 peer-reviewed academic sources helped to build a theoretical and empirical foundation. This process identified core variables, trends in user-focused design, and existing gaps—especially around the needs of non-patient users like visitors and caregivers.
2. Phase 2: Online Survey (Primary Data Collection):

   Insights from the literature review directly shaped the survey design. The survey was structured to collect responses on specific biophilic features—natural light, greenery, soundscapes, and tactile materials—and their effect on four outcome variables: stress reduction, emotional well-being, perceived comfort, and social interaction.
3. Phase 3: Evaluated the impact of biophilic design on stress, comfort, and social interaction.

Later, the findings were compared with existing healthcare design standards and developed evidence-based recommendations for improving non-clinical healthcare spaces. This strategy ensured a comprehensive and practical assessment of biophilic design in healthcare environments.

1.7. Research Methodology and Outcome

1. This research followed a mixed-methods methodology, combining secondary research (literature review) with primary research (online survey) to evaluate user experiences in healthcare public spaces.
2. Secondary Data Collection:

   The literature review synthesized knowledge from 2010 to 2024, focusing on biophilic design in healthcare and its emotional, psychological, and functional implications. Key findings helped define the outcome variables and supported the application of Florence Nightingale's Environmental Theory as a framework.
3. Primary Data Collection:

   A structured survey was developed and shared online using platforms like Qualtrics and distributed via university mailing lists, social media, and snowball sampling. The survey included Closed-ended questions rated on a Likert scale to quantify user experiences with biophilic elements.
4. Participants:

   Data was collected from 141 valid responses, primarily from two user groups: visitors (n=99) and caregivers (n=36). These groups were selected to reflect real users of healthcare spaces who often experience emotional strain without the support provided to patients.
5. Outcome of the Study: The data analysis showed clear trends:

- Visitors consistently preferred natural light, especially for emotional well-being and social ease.

- Caregivers leaned toward greenery and tactile features, which provided emotional grounding and sensory relief.

The finalized survey tool used in this study is available in *Appendix I*, and summarized findings from the literature review that informed the tool are provided in *Appendix II*.

Table 2. *Data Collection Overview*

Component	Description
Research Method	Mixed methods (Quantitative + Qualitative)
Secondary Data	Systematic Literature Review (50 peer-reviewed articles)
Primary Data	Online Survey (Quantitative + Open-ended questions)
Sample Size	143 valid responses
Target Groups	Visitors (n = 99), Caregivers (n = 36) Others (n=8)
Key Outcome Variables	Stress Reduction, Emotional Well-being, Perceived Comfort, Social Interaction

These results support the idea that biophilic elements play a vital role in shaping user experience, and that preferences can differ based on the user's role and time spent in the space. The inclusion of qualitative feedback helped explain why certain features mattered more to each group—validating the decision to use a mixed-methods approach.

1.8. Research Limitations

While the study was thoughtfully designed, several limitations should be acknowledged:

1. The number of visitor responses (n=99) was significantly higher than caregiver responses (n=36). While the analysis accounted for this through percentage-based comparisons, the imbalance may have affected the weight of certain findings.
2. All data was collected through self-reports, which are inherently subjective. Responses may have been influenced by current mood, memory bias, or participants trying to give socially desirable answers.
3. Some participants were friends and family from India. While this added diversity to the sample, it also introduced possible bias due to different healthcare environments, cultural expectations, and design standards compared to U.S.-based facilities.
4. Due to time and access constraints, the study did not include direct observation of healthcare spaces or interviews with professionals. This limited the study's ability to assess how users physically interact with the design features discussed.

Table 3. *Summary Table of Limitations*

Limitation	Description	Impact
Uneven Group Size	More visitors than caregivers	May skew comparative analysis
Self-Reported Data	Responses influenced by bias or mood	May affect accuracy
Contextual Differences	Inclusion of India-based participants	May limit U.S. applicability
Lack of Observational Data	No in-person site visits or case studies	Limits spatial behavior insight

Despite these limitations, the study makes a valuable contribution by focusing on underrepresented user groups and offering practical insights that can inform more inclusive, emotionally supportive design strategies in healthcare settings.

1.9. Scope for Future Research

While this study focuses on visitors and caregivers as non-patient users in healthcare environments, future research could expand to include a broader range of participants such as healthcare staff, therapists, and even administrative personnel. Their perspectives would offer a more comprehensive understanding of how biophilic design affects various user groups within the same setting. Additionally, observational studies, post-occupancy evaluations, or case studies involving built environments could enrich the findings by exploring actual user behavior in context, beyond self-reported perceptions.

Further exploration into cultural and regional interpretations of biophilic elements could also be valuable, especially considering the contextual differences noted in this study. This could help develop localized or culturally responsive biophilic design guidelines for healthcare spaces around the world.

1.10. Conclusion

This chapter established the foundation of the study by introducing the research topic, defining the problem, and outlining the purpose, questions, and objectives. It also presented the mixed-methods strategy and methodology adopted for investigating how biophilic elements shape sensory and emotional experiences in healthcare public spaces.

The next chapter builds on this foundation by reviewing the existing literature on biophilic design in healthcare settings, emphasizing its emotional and psychological impact on diverse user groups. The literature review also helps position this study within the broader context of environmental design research and identifies the gaps this study aims to address.

Chapter 2: Literature review

This chapter explores the evolution of healthcare design, the impact of natural elements on well-being, and the current gaps in design standards for non-patient users. By reviewing previous studies, healthcare guidelines, and sustainability frameworks, this section establishes the foundation for the study. It also highlights the benefits and challenges of integrating biophilic design in public healthcare spaces. The insights from this literature review provide context and validation for the research findings and recommendations.

2.1. Search Strategy

This review aimed to gather relevant and credible sources that examine the role of natural elements in healthcare settings, particularly in relation to emotional and sensory well-being. The search strategy was developed to identify peer-reviewed, evidence-based studies aligned with the objectives of this research.

2.1.1. Keywords Used

A combination of broad and specific search terms was used to capture literature on both design elements and user experiences in healthcare contexts. These included:

- “Biophilic design in healthcare”
- “Natural elements in healthcare environments”
- “Impact of greenery and natural light in healthcare”
- “Soundscapes in healthcare facilities”
- “Tactile pathways and biomimicry in healthcare settings”
- “Stress reduction and emotional well-being in healthcare spaces”

To ensure a systematic approach, search terms were grouped into the following categories:

Table 4. *Thematic Grouping of Search Terms for Systematic Literature Search*

Search Concept	Search Terms
Biophilic Design Elements	Biophilia, greenery, indoor plants, green walls, natural light, soundscapes, biomimicry, tactile pathways, water features, healing gardens
Healthcare Settings	Healthcare, hospital, medical facility, outpatient center, inpatient unit, ward, clinic, mental health facility, waiting area, lobby, reception area
Public Spaces	Public spaces, shared spaces, communal areas, lobbies, corridors, waiting rooms, atriums, break rooms
Health and Emotional Outcomes	Well-being, emotional health, comfort, stress reduction, relaxation, mood improvement, anxiety reduction, social interaction, emotional resilience
User Groups	Visitors, caregivers, therapists, public, healthcare staff, non-patient users
Design Features	Natural elements, greenery, natural light, water elements, soundscapes, textures, tactile experiences, biophilic patterns

2.1.2. Databases Searched

The literature search was conducted using reputable academic databases, including:

- PubMed
- ScienceDirect
- Google Scholar

- ResearchGate
- University of Oklahoma Library databases

These platforms provided access to peer-reviewed journals, conference papers, and academic publications relevant to biophilic design, environmental psychology, and healthcare design.

2.1.3. Inclusion Criteria

To maintain the relevance and quality of the literature, the following criteria were applied:

- Articles published between 2010 and 2024
- Peer-reviewed sources in English
- Studies conducted in healthcare or analogous settings
- Research focusing on non-patient users (e.g., visitors, caregivers, healthcare staff)
- Studies reporting measurable outcomes such as stress reduction, comfort, or emotional well-being

2.1.4. Exclusion Criteria

The following were excluded from the review:

- Articles focused solely on energy efficiency or structural engineering unrelated to user experience
- Studies examining patient-only outcomes without relevance to other user groups
- Non-empirical publications lacking measurable or observable outcomes

All selected literature was then organized and analyzed thematically, based on common topics such as biophilic elements, user groups, and emotional outcomes. This process ensured that the review remained focused and relevant to the goals of the study.

2.2. Design Overview

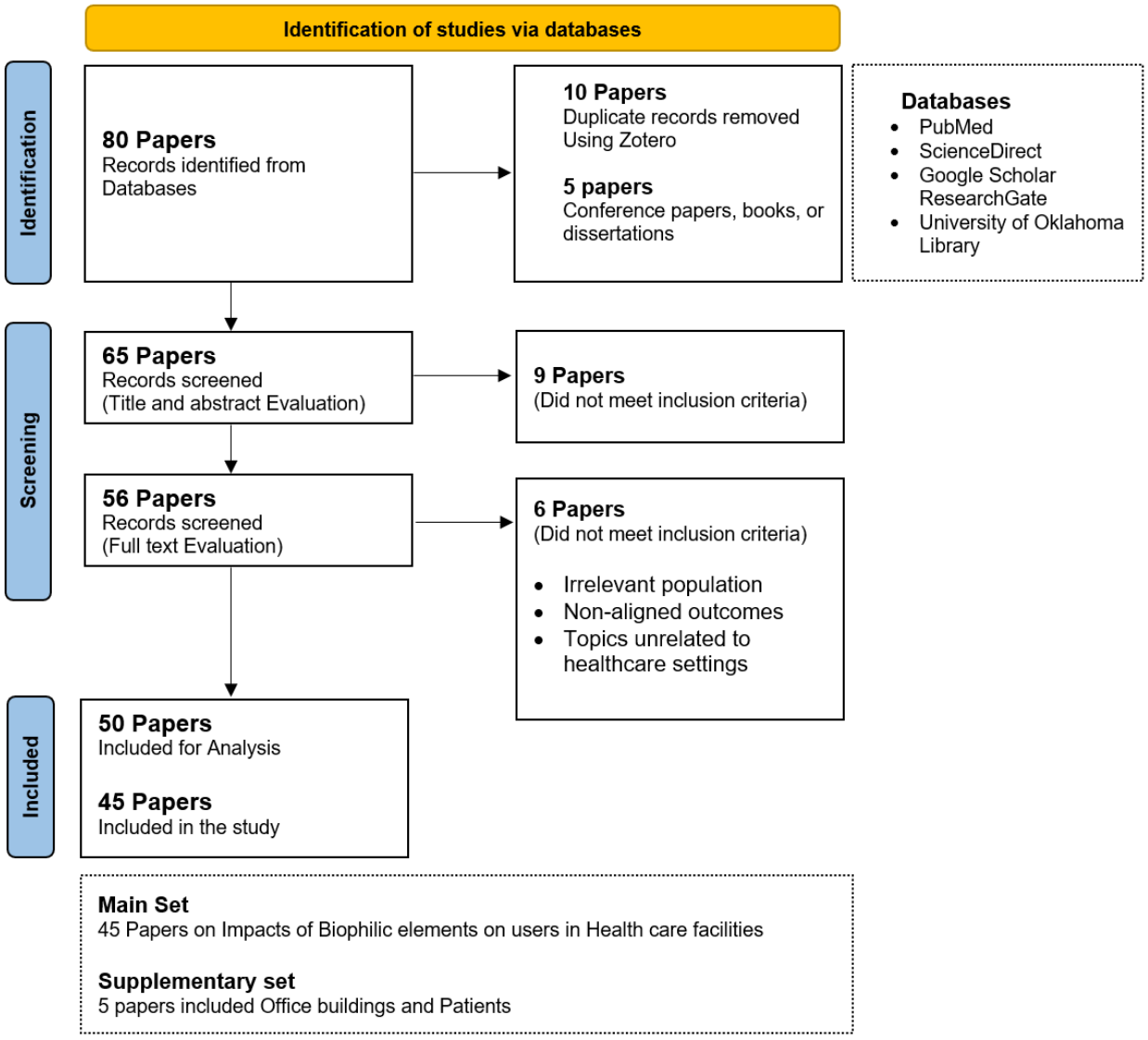

Figure 1. *PRISMA Flow Diagram of Study Selection Process*

Biophilic design—the intentional integration of nature into the built environment—has emerged as a powerful design strategy in healthcare settings. Grounded in the idea that humans have an innate affinity for nature, biophilic design has been widely associated with reduced stress, improved emotional well-being, and enhanced user satisfaction. A systematic review of 50 peer-reviewed studies was conducted to explore the role of biophilic elements in healthcare spaces, focusing on how these features affect a range of user groups and outcomes. This section categorizes key findings based on biophilic components, target populations, and reported psychological or physiological benefits, offering a comprehensive overview of the current evidence base.

Numerous studies have consistently highlighted the therapeutic potential of natural elements in healthcare environments. For instance, El Messeidy (2019) emphasized how the presence of natural light, greenery, and water features significantly improves recovery and reduces stress. Similarly, Russo and Andreucci (2023) examined the value of green spaces in pediatric settings, showing how access to outdoor gardens and natural light supports children's emotional development. These findings are echoed by Kyrkou (2023), who reported both psychological and physiological benefits from incorporating healing gardens and natural views in pediatric healthcare environments.

Biophilic strategies have also proven valuable in inpatient settings, where regulatory and spatial constraints often limit design flexibility. Simarmata (2023) showcased creative inpatient room designs that maintain patient privacy while promoting comfort through biophilic elements. Ekpo (2023) similarly noted improvements in patient mood and satisfaction in orthopedic hospitals enhanced with natural light and indoor vegetation. These studies emphasize that, even

within tightly regulated environments, nature-based interventions can be adapted in meaningful ways.

Beyond patient-centered outcomes, there is growing evidence that biophilic design also benefits healthcare staff and non-patient users. Untaru et al. (2023) found that emotional well-being, job satisfaction, and workplace attachment were significantly higher among professionals working in biophilic environments, particularly in hospice settings. Further, Fouda & Fouda (2024) developed an assessment tool to measure the degree of biophilic integration, suggesting the potential for more structured evaluation and implementation in therapeutic spaces. Al Khatib et al. (2024) called for expanded research to investigate how individual biophilic features may reduce caregiver stress and absenteeism, highlighting a key gap in current literature.

In addition, urban green infrastructure within hospital campuses is gaining recognition for its dual role in supporting staff wellness and patient recovery. Arora Mathur & Ashtt (2023) demonstrated that outdoor gardens and water features contribute to greater satisfaction and improved emotional balance. Wichrowski et al. (2021) further supported this by documenting stress reduction among rehabilitation patients exposed to nature imagery and dynamic green spaces. Martin et al. (2021) focused on visitors, showing that rooftop gardens and other modest green features significantly enhanced the perception of care environments.

Design elements such as color psychology and lighting also emerged as subtle but impactful tools in healthcare design. Edwards (2023) found that yellow, often associated with hope, positively influenced emotional well-being in clinical environments. Makram & Abdelrazek (2020) similarly emphasized the importance of natural light and shared social spaces in fostering supportive, emotionally uplifting environments. Sayed et al. (2021) provided a

holistic framework of biophilic design patterns, showcasing their collective potential to support stress recovery, cognitive clarity, and emotional restoration.

There is also a growing push toward integrating biophilic and salutogenic principles to design spaces that not only heal but actively build resilience. Totaforti (2018) and Mazuch (2017) explored how natural sensory stimulation, communal areas, and nature-inspired aesthetics can promote emotional stability and social engagement in long-term healthcare settings. Tekin et al. (2023) proposed a systematic framework that addresses both patient and staff needs through biophilic spatial programming.

In alignment with sustainability goals, several studies highlight how biophilic design can intersect with environmentally responsible architecture. Abeysinghe (2024) explored the use of rammed earth as a sustainable material that provides both tactile and thermal comfort. Zhao et al. (2022) examined the integration of natural light, greenery, and eco-conscious materials in Chinese healthcare facilities, demonstrating that biophilic design can support both human and environmental health.

Together, these findings illustrate the broad and adaptable nature of biophilic design across a range of healthcare settings and user groups. While a significant portion of the literature focuses on patient outcomes, there remains a notable gap in research targeting visitors, caregivers, and staff. This study aims to address that gap by evaluating how biophilic features—especially soundscapes, tactile pathways, and biomimicry—influence emotional comfort, stress reduction, and social engagement in public and shared healthcare spaces.

Ultimately, this review reinforces the idea that biophilic design is not a one-size-fits-all solution, but rather a flexible, evidence-informed strategy. Its potential lies in its ability to

humanize healthcare environments, making them not only efficient and code-compliant but also emotionally supportive and inclusive for all who use them.

2.3. Impact of Biophilic Design Elements on Health and Well-being

In healthcare settings, the physical environment plays a powerful role in shaping users' experiences and emotional responses. Among the many design strategies explored in recent years, biophilic design has emerged as a meaningful approach to support mental, emotional, and even physical well-being. When thoughtfully integrated, natural elements such as light, greenery, sound, and texture help transform otherwise sterile environments into places that feel more calm, restorative, and human centered.

Natural light is consistently cited as one of the most impactful design features in healthcare spaces. Studies show that daylight not only reduces stress and enhances mood but also accelerates healing and improves overall satisfaction with the space (Simarmata, 2023; Russo & Andreucci, 2023; Totaforti, 2018). Its presence contributes to a sense of openness and emotional ease—not only for patients but for staff, caregivers, and visitors as well.

Greenery—whether in the form of indoor plants, green walls, or healing gardens—has also been shown to reduce stress, promote relaxation, and enhance cognitive clarity. In pediatric healthcare, for example, greenery supports both emotional and physiological healing (Kyrkou, 2023). Waiting rooms enriched with plant life have been associated with improved mood and a stronger sense of connection to nature, benefiting everyone who interacts with space (Moslehian et al., 2023; Mathur, 2023).

Water features and natural sounds further support emotional regulation. The gentle sound of flowing water or other ambient nature sounds can help reduce anxiety, improve focus, and contribute to a more tranquil environment (Simarmata, 2023; Ekpo, 2023). These features are especially appreciated in larger public areas such as atriums, where their calming effect extends to visitors as well (Martin et al., 2021).

Finally, the use of natural materials, including wood and stone, introduces warmth and texture into a space—counteracting the coldness often associated with clinical design. Such elements create a sense of comfort and familiarity, contributing to both psychological relief and improved social interaction (Puren et al., 2021; Sayed et al., 2021). When combined, these biophilic elements offer a synergistic experience that supports a wide range of users—emotionally, psychologically, and even behaviorally.

2.4. Biophilic Design Patterns

Biophilic design patterns provide a structured approach to integrating nature into the built environment, offering both sensory stimulation and psychological support. According to *Terrapin Bright Green (2014)*, the 14 biophilic patterns are grouped into three main categories. Each of these patterns evokes different emotional or cognitive responses and can be directly linked to user outcomes such as stress reduction, comfort, and social interaction—key themes in this study.

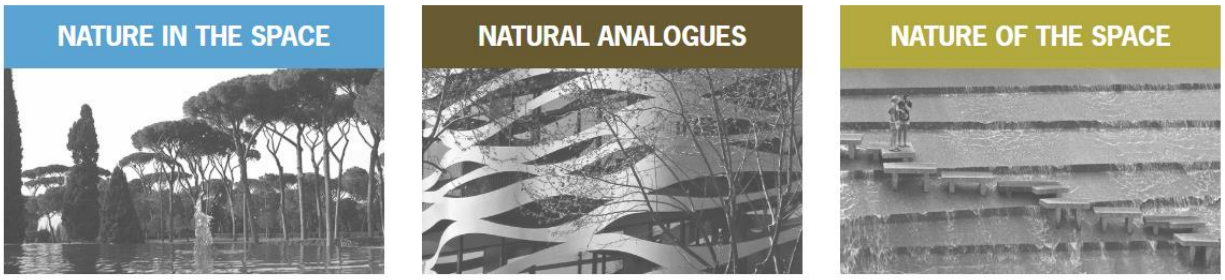

Figure 2. *The Three Categories of Biophilic Design Patterns (Terrapin Bright Green, 2014)*

2.3.1. Nature in the Space

These patterns involve direct experiences of nature—bringing natural elements physically into the environment.

1. Visual Connection with Nature

Figure 3. *Kikugetu-tei, Takamatsu, Japan. Image © wakiiii/Flickr. (Terrapin Bright Green, 2014)*

The most common and intuitive biophilic feature involves views of greenery, daylight, or natural landscapes through windows or indoor gardens. In healthcare settings, exposure to nature—even through a window—has been linked to reduced stress, improved mood, and shorter recovery times.

2. Non-Visual Connection with Nature

Figure 4. *Morske Orgulje (sea organ), Zadar, Croatia. Image © Bohringer Friedrich. (Terrapin Bright Green, 2014)*

This includes sensory elements such as natural sounds (e.g., water, birdsong), pleasant natural scents (e.g., plants or herbs), and tactile cues (like rough stone or smooth wood). These can calm the nervous system, particularly in shared spaces like waiting rooms or corridors.

3. Non-Rhythmic Sensory Stimuli

Figure 5. *Kinetic membrane of the Brisbane Domestic Terminal Airport Carpark by Ned Kahn. (Terrapin Bright Green, 2014)*

Refers to subtle, momentary experiences like light dancing on a surface, a breeze passing through a corridor, or the sound of trickling water. These unpredictable but gentle sensations help people feel attuned to their environment.

4. Thermal & Airflow Variability

Figure 6. *Cloisters at San Juan de Los Reyes, Toledo, Spain. Image © Ben Leto/Flickr. (Terrapin Bright Green, 2014)*

Slight shifts in air movement, temperature, or humidity simulate outdoor conditions. For instance, operable windows or ceiling fans can offer users a more dynamic experience compared to a fully climate-controlled environment.

5. Presence of Water

Figure 7. *Rice Univeristy, TX. Image courtesy of archdaily.com. (Terrapin Bright Green, 2014)*

Incorporating water features—like fountains or indoor water walls—can create a calming ambiance. In healthcare environments, water sounds are associated with reduced anxiety and improved emotional balance.

6. Dynamic & Diffuse Light

Figure 8. *Visionaire, New York, NY. Pelli Clarke Pelli Architects. Image courtesy of Bill Browning. (Terrapin Bright Green, 2014)*

Varying light intensities, shadows, and reflections—especially natural daylight—support circadian rhythms and reduce fatigue. Sunlight through windows or skylights can significantly improve users' emotional state.

7. Connection with Natural Systems

Figure 9. *Tanner Springs, Portland, Oregon. Atelier Dreiseitl, architect. Image courtesy of GreenWorkSpc. (Terrapin Bright Green, 2014)*

This includes design elements that reflect natural cycles, such as daylight progression, seasonal planting, or green walls that change over time. These dynamic cues foster a sense of orientation and temporal rhythm.

2.3.2. Natural Analogues

These patterns use materials, shapes, or textures that resemble natural forms but aren’t made from actual natural elements.

1. Biomorphic Forms & Patterns

Figure 10. *Façade of Manuel Gea González Hospital in Mexico City. Image © misia-nov-dom. (Terrapin Bright Green, 2014)*

Using organic shapes and flowing curves (e.g., leaf-like structures or wave patterns) in flooring, ceiling design, or furnishings. These evoke a natural rhythm and can soften the clinical feel of healthcare interiors.

2. Material Connection with Nature

Figure 11.*Bamboo pavilion by WOHA architects. Image courtesy of WOHA Architects. (Terrapin Bright Green, 2014)*

Involves using natural materials like wood, stone, cork, or natural fibers. These materials offer tactile warmth and sensory comfort, reducing feelings of sterility or anxiety in public areas.

3. Complexity & Order

Figure 12.*Summer Palace, Beijing, China. Image courtesy of Bill Browning. (Terrapin Bright Green, 2014)*

Refers to designs that reflect the richness and variety of nature, such as fractals, mosaics, or natural pattern repetition. These create visual interest and can reduce cognitive fatigue by mimicking how we process information in natural environments.

2.3.3. Nature of the Space

This category focuses on spatial configurations that influence psychological safety, curiosity, and exploration.

1. Prospect

Figure 13.*Gardens at the baroque Château de Vaux-le-Vicomte in Maincy, France. Image © Mark B. Schlemmer/Flickr. (Terrapin Bright Green, 2014)*

The opportunity for an unobstructed view across a space, such as open-plan waiting areas or windows overlooking courtyards. Prospect allows users to feel secure and oriented in unfamiliar environments.

2. Refuge

Figure 14. *Cliff Palace, Mesa Verde, CO. Image © Terry Feuerborn/Flickr. (Terrapin Bright Green, 2014)*

Small, protected areas that offer a sense of shelter—like seating alcoves, corners, or booths. These allow users to retreat while still being visually connected to the rest of the space, fostering a sense of calm.

3. Mystery

Figure 15. *Lan Su Chinese Garden, Portland, OR. Image courtesy of Catie Ryan. (Terrapin Bright Green, 2014)*

Design elements that suggest more to be discovered, such as a curved hallway, filtered light through a screen, or partial views. This stimulates curiosity and encourages gentle exploration without overwhelming the user.

4. Risk/Peril

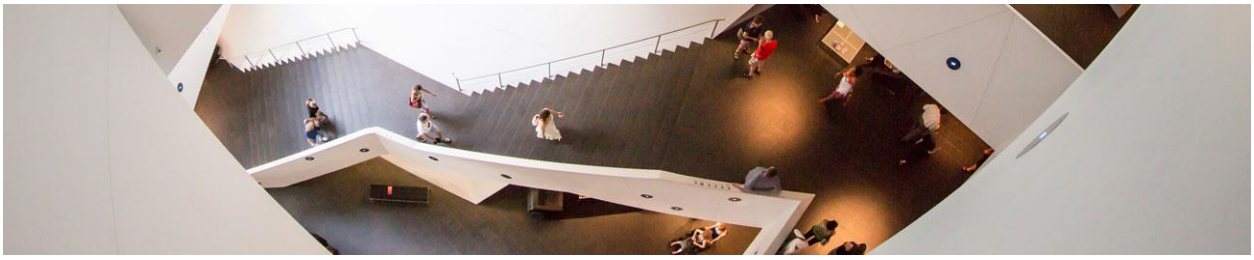

Figure 16. *Denver Art Museum by Daniel Libeskind, Denver, CO. Image © Thomas Hawk/Flickr.. (Terrapin Bright Green, 2014)*

Incorporates a safe sense of risk, like a glass floor, a suspended bridge, or a dramatic overlook—though rarely used in healthcare, this pattern can add excitement and novelty in limited ways, such as viewing galleries or suspended artwork.

Table 5. *Biophilic design patterns & biological responses (Terrapin Bright Green, 2014)*

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	* * *	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	* *	**Reduced systolic blood pressure and stress hormones** (Park et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith et al., 2004; Ulrich et al., 1991)	**Positively impacted cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	* *	**Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2010; Park et al., 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
	Thermal & Airflow Variability	* *	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	* *	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	* *	**Positively impacted circadian system functioning** (Figueiro et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	* *	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	* * *	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	* * *		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Ulrich et al., 1991; Wang & Taylor, 2006; Petherick, 2000)	
	Mystery	* *			**Induced strong pleasure response** (Biederman, 2011; Salimpoor et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

2.5. Impact on Different User Groups

While biophilic design is often studied in the context of patient outcomes, its benefits extend to many other individuals who regularly navigate healthcare spaces. These include

visitors, caregivers, and healthcare staff—groups whose emotional needs are just as valid, though less frequently addressed in the design process.

For patients, natural light, green views, and healing gardens have been shown to ease anxiety, promote relaxation, and support faster recovery (Kyrkou, 2023; Totaforti, 2018). However, these benefits are not isolated to patients alone.

Healthcare staff, often under high stress and long working hours, experience significant psychological benefits in environments that incorporate natural features. Access to greenery, views of nature, and designated restorative spaces have been linked to improved mental clarity, reduced burnout, and increased job satisfaction (Untaru et al., 2023; Puren et al., 2021).

Caregivers and visitors—who typically spend long periods waiting or supporting loved ones—benefit from calm, welcoming spaces that feel less clinical. Natural light and communal green areas have been shown to improve comfort and encourage social interaction, helping reduce emotional fatigue and promote moments of reprieve (Martin et al., 2021; Makram & Abdelrazek, 2020).

These examples show that biophilic design is not just a visual strategy, but a holistic one—capable of improving how people feel, behave, and interact in emotionally charged environments like healthcare facilities.

2.6. Gaps in Literature

Despite growing interest in biophilic design, certain key gaps remain in the literature—particularly concerning non-patient users. Many existing studies focus on short-term effects on patient recovery, with limited exploration of how biophilic elements impact staff, caregivers, or

visitors over longer periods (Untaru et al., 2023; Puren et al., 2021). This leaves open questions about how these features influence broader outcomes such as emotional resilience, social behavior, or environmental satisfaction.

Another gap lies in the limited user diversity explored in current research. Most findings are generalized or patient-specific, with few studies focusing directly on caregivers, therapists, and family visitors, whose emotional experiences are deeply shaped by their surroundings. This lack of attention makes it difficult to design spaces that truly reflect the needs of all users. A summary table of key findings from the literature is included in *Appendix II* for reference.

This study responds to these gaps by focusing specifically on the non-clinical, shared spaces within healthcare facilities—areas often overlooked in both design and research. By investigating how biophilic elements influence stress, comfort, emotional well-being, and social interaction, the study offers a broader and more inclusive perspective on wellness-centered healthcare design.

2.7. Relevance to My Study

Building on existing research, this study shifts the lens toward public and transitional spaces like waiting areas, lobbies, and corridors—where visitors, caregivers, and therapists often spend meaningful time. Unlike much of the current literature, which centers on patients or inpatient rooms, this study aimed to explore how biophilic design elements shape non-patient experiences.

To capture diverse perspectives, the study gathered input from members of the general population, including university students and community members. While not all participants

were healthcare professionals, their insights reflect the real-world diversity of individuals who engage with healthcare spaces. This broader view offers valuable understanding of how nature-based design is perceived and experienced by everyday users.

Although the study did not include observational case studies due to access limitations, it utilized a structured online survey incorporating validated scales and carefully designed Likert-based questions. While tools like the Perceived Restorativeness Scale (PRS), Perceived Stress Scale (PSS), and State-Trait Anxiety Inventory (STAI) informed the development of the questionnaire, they were not directly implemented, and the final instrument was customized to suit the study's focus and feasibility. This approach allowed for the collection of relevant and meaningful data within the project's timeline, ensuring the core research objectives were effectively addressed.

By bridging theory, prior research, and user feedback, this study aims to contribute practical, actionable recommendations that support more inclusive and emotionally responsive healthcare environments.

2.8. Tools and Frameworks Used in Literature

During the literature review, it became clear that there is no universally standardized method for measuring the impact of biophilic design in healthcare settings. However, several commonly used tools and strategies were identified, which informed the design of this study's data collection approach.

2.8.1. Tools Used in This Study:

For this research, a custom Likert-scale questionnaire was developed. The questions were designed based on insights from existing literature but adapted to fit the context of non-patient users in public healthcare spaces, such as visitors, caregivers, and therapists.

This approach allowed participants to reflect on their perceptions of biophilic elements—like greenery, natural light, and textures—and report how these elements influenced their emotional and sensory experiences in healthcare environments.

2.8.2. Data Analysis Tools:

Survey responses were analyzed using SPSS and Microsoft Excel. These tools enabled:

- Descriptive statistical analysis
- Identification of trends and patterns

2.8.3. Rationale for Approach:

Although this study did not utilize multiple validated instruments or observational tools, the selected method provided a practical and focused approach suitable for the scope and timeline of the research. It also allowed for efficient data collection from a broader, diverse participant group while maintaining clarity and relevance to the study objectives.

2.9. Conclusion

The literature reviewed in this chapter highlights the growing relevance of biophilic design in healthcare settings, particularly for enhancing emotional and sensory well-being. While past studies have largely centered on patient outcomes, emerging research underscores the

importance of addressing the needs of non-patient users—visitors, caregivers, and staff—who frequently engage with public spaces in healthcare facilities. The review also revealed that while various guidelines and standards exist for healthcare design, few directly address the psychological and sensory needs of these user groups.

The exploration of biophilic design patterns—ranging from visual connections with nature to spatial configurations like refuge and prospect—offers a structured lens through which these needs can be understood and met. However, significant gaps remain in applying these patterns consistently and inclusively across healthcare environments. This study aims to fill that gap by examining how different user groups perceive biophilic elements and identifying which design strategies promote comfort, stress reduction, emotional well-being, and social interaction.

Building on the insights gathered here, the next chapter outlines the theoretical foundation and research methodology used to investigate these relationships through a mixed-methods approach.

Chapter 3: Theoretical Framework

3.2. Florence Nightingale: Environmental Theory

This study draws on Florence Nightingale's Environmental Theory, which highlights the vital connection between the physical environment and human health. Although developed in the 19th century, the theory remains highly relevant, reminding us that our surroundings play a key role in how we feel, heal, and interact.

In her work, Nightingale emphasized the importance of elements like fresh air, natural light, quiet, and cleanliness as essential to recovery and comfort. These ideas closely mirror the principles of biophilic design, which also focuses on integrating nature into the built environment to support well-being and emotional balance (Davies, 2012).

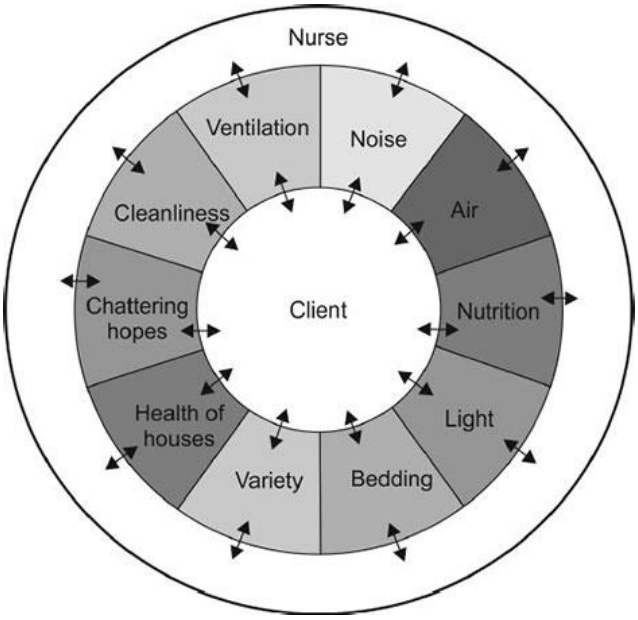

Figure 17. *Florence Nightingale's Environmental Theory Framework (Nurselabs, 2024)*

This visual representation reinforces Nightingale's belief that health is not just a medical outcome but a response to the total environment. Each factor—air, light, noise, nutrition,

cleanliness, and so on—is a sensory or spatial experience that parallels the biophilic design elements explored in this study.

While the original framework was created with patients in mind, its relevance extends beyond that. In modern healthcare settings, these same environmental qualities influence visitors and caregivers as well. By recognizing this connection, the study adapts Nightingale's environmental focus to a broader user base, emphasizing the emotional and psychological impact of well-designed public spaces.

By applying this framework, the study examines how biophilic design elements—such as natural light, greenery, soundscapes, and tactile materials—relate to stress reduction, emotional well-being, perceived comfort, and social interaction. These four variables help assess how design affects users' emotional and sensory experiences, especially in shared, non-clinical spaces.

Using Nightingale's theory as a foundation ensures that the study remains grounded in healthcare design philosophy, while also adapting it to modern needs—creating more inclusive and supportive environments for everyone who interacts with a healthcare facility.

3.2. Dependent and Independent Variables

Building on Florence Nightingale's Environmental Theory, this study recognizes that specific environmental factors can directly influence emotional, sensory, and social outcomes. Nightingale emphasized that surroundings—light, air, sound, and cleanliness—have a tangible effect on health and comfort. These foundational ideas helped shape the core focus areas of this

research, particularly in terms of how modern design features can support well-being in non-clinical healthcare spaces.

Additionally, insights from the literature review revealed recurring themes related to the influence of natural light, greenery, soundscapes, textures, and nature-inspired patterns on user experience (Totaforti, 2018; Simarmata, 2023; Puren et al., 2021). These elements were consistently associated with benefits like reduced stress, improved emotional states, increased comfort, and enhanced social connection.

Independent Variables (Biophilic Design Elements):

- Greenery and Plant Life
- Natural Light
- Soundscapes
- Tactile Pathways

Dependent Variables (User Experience Outcomes):

- Stress Reduction
- Emotional Well-being
- Perceived Comfort
- Social Interaction

Table 6. *Independent and Dependent Variables of the Study*

Type of Variable	Category	Description
Independent Variables	Greenery and Plant Life	Indoor plants, green walls, outdoor gardens
	Natural Light	Sunlight through windows, skylights, and reflective surfaces
	Soundscapes	Natural sounds like water, birdsong, or soft ambient noise
	Tactile Pathways	Materials and textures that engage touch and enhance sensory awareness
Dependent Variables	Stress Reduction	Self-reported relaxation and decreased tension
	Emotional Well-being	Mood enhancement, reduced anxiety, feelings of calm
	Perceived Comfort	Emotional and physical ease in the environment
	Social Interaction	Quality and frequency of interactions in shared public spaces

Together, Nightingale's theory and existing research informed the selection of both the independent and dependent variables for this study. The biophilic design elements represent the environmental inputs, while the emotional and behavioral responses of users form the outcome measures. This structure supports a clear evaluation of how design decisions affect human experience in shared healthcare environments.

Chapter 4: Methodology

This chapter outlines the research approach used to investigate how biophilic design elements influence the experiences of non-patient users in healthcare environments. It explains the research design, participant profile, and recruitment strategy, and details how data was collected and analyzed. The methodology was developed to align with the study's theoretical framework and objectives, ensuring that findings are both relevant and grounded in evidence.

4.1. Research Design

This study followed a quantitative research design to examine the impact of biophilic design elements on user experiences in public areas of healthcare facilities. The focus was on understanding how design features influenced stress reduction, emotional well-being, perceived comfort, and social interaction among visitors, caregivers, and therapists.

The research began with a systematic review of 50 peer-reviewed articles, which helped identify key themes, design elements, and gaps in existing studies. These findings, along with the principles of Florence Nightingale's Environmental Theory, formed the foundation for developing the survey instrument and guiding the structure of the study.

Primary data was collected through an online survey targeting individuals from the general population. Instead of standardized psychological scales like the PRS, PSS, or STAI, the survey was structured around core concepts from Nightingale's theory, emphasizing environmental factors such as light, air quality, quietness, connection to nature, and comfort. The questions focused on user perceptions of biophilic design features—including greenery, natural

light, soundscapes, biomimicry, and tactile experiences—and their effects on the four key outcome variables.

This approach allowed the study to remain grounded in a theoretical framework while still being flexible and accessible to a broader, non-clinical audience. The resulting data offered valuable insights into how public healthcare spaces can better support emotional and sensory wellness for all users.

4.2. Participants

The study included participants from a variety of demographic backgrounds, ensuring a well-rounded understanding of how different individuals experience public spaces within healthcare environments. Participants were primarily located in the United States, with a large portion of responses collected from Oklahoma, while others were distributed across different regions via online platforms.

4.2.1. Demographic Overview:

- Age: 18 years and older, covering a range of life stages from young adults to older adults
- Gender: Open to all gender identities
- Education: Participants were eligible if they were 18 years or older and had prior experience visiting or spending time in a healthcare facility, regardless of their educational background.

Participants represented a wide range of individuals who might spend time in public or shared areas of healthcare settings—such as waiting rooms, lobbies, or break areas. While they

were not required to have medical or professional expertise, their experiences and perceptions reflected the diversity of real-world users of these spaces.

4.3. Recruiting Strategy

Participants were recruited using digital outreach methods designed to ensure accessibility and a broad demographic reach. Multiple platforms and networks were used to invite participation in the study:

- University Networks:

  Invitations were sent through university mailing lists, along with flyers and social media posts targeting students, faculty, and staff.
- Social Media Platforms:

  Posts were created on Instagram, LinkedIn, Facebook, and Twitter, sharing a brief overview of the study and a link to the survey.
- Professional and Community Forums:

  The survey was also distributed through professional groups and local community channels to reach beyond student populations.
- Snowball Sampling:

  Participants were encouraged to share the survey link within their networks, helping expand the sample organically.

Before beginning the survey, all participants were provided with an informed consent statement outlining the purpose of the study, estimated time commitment, and their rights as voluntary participants. Consent was documented via an acknowledgment checkbox prior to starting the survey.

4.4. Survey Instrument / Data Collection Tool

The survey used in this study was created and administered through Qualtrics, a secure online platform. It consisted of 20 closed-ended questions, all measured using a 5-point Likert scale ranging from *Strongly Disagree (1)* to *Strongly Agree (5)*. The complete set of survey questions is provided in *Appendix I*.

Survey Link: https://ousurvey.qualtrics.com/jfe/form/SV_5ulHDIoywUaKbtk

The 5-point Likert scale was selected for its simplicity and clarity, making it accessible for a broad audience. It allowed participants to express varying degrees of agreement or disagreement while minimizing response fatigue. This format offered a balanced level of nuance without overwhelming complexity, especially important for capturing subjective perceptions in a consistent, analyzable way.

The survey questions were grouped into four thematic categories, each aligned with the core outcome variables derived from Florence Nightingale's Environmental Theory and Each section focused on user perceptions of specific biophilic design elements.

Table 7. *Survey Question Distribution*

Biophilic Element	Stress	Well-being	Comfort	Usability/Social Interaction
Greenery	Q5, Q4	Q12	Q13	Q17
Natural Light	Q2	Q7, Q9	Q14	Q18
Soundscapes	Q3	Q8	Q15, Q16	Q19
Tactile Pathways	Q6	Q10	Q11	Q21, Q20

The survey was designed to be user-friendly and accessible, with a completion time of approximately 10–15 minutes. Questions were written in plain, inclusive language to ensure clarity and broad participation across different backgrounds. See Appendix I for the full questionnaire.

To enhance participant understanding, the survey incorporated annotated images of hospital public spaces that visually illustrated biophilic elements. These images provided context and helped ensure that participants could accurately interpret the design features referenced in the questions.

Additionally, a glossary of key terms was included at the end of the survey. This section provided simple definitions of technical or unfamiliar terms (e.g., “biophilia,” “tactile pathway,” “soundscape”) to ensure clarity and accessibility for participants from diverse backgrounds.

Demographic data was also collected, including gender and prior experience with healthcare spaces, such as roles as visitors, caregivers, or therapists. No personally identifiable information was linked to the responses, except for optional email addresses submitted for gift card compensation, which were stored separately and deleted after distribution.

Responses were numerically coded from 1 to 5, corresponding to the Likert-scale options (1 = *Strongly Disagree*, 5 = *Strongly Agree*). Average scores were calculated for each of the four main categories—stress reduction, emotional well-being, perceived comfort, and social interaction—to identify overall trends and patterns in participant perceptions.

This tool allowed for the systematic and focused collection of data on how biophilic features are perceived by users in public healthcare settings, and how those perceptions relate to the emotional and sensory impact of the built environment.

4.5. Data Analysis Procedure

Once the survey responses were collected through Qualtrics, the data was exported into SPSS for analysis. The dataset was first reviewed to ensure completeness and accuracy, and incomplete or invalid responses were removed before proceeding.

The analysis focused on descriptive statistics, with mean values calculated for each survey item related to the key variables: stress reduction, emotional well-being, perceived comfort, and social interaction. Each biophilic design element—greenery, natural light, soundscapes, biomimicry, and tactile pathways—was analyzed to evaluate how it was perceived in relation to these outcomes.

To support visual interpretation of the results, graphs and charts were created using Microsoft Excel, representing average response values and patterns across variables. This helped highlight which design features were perceived most positively and how consistently they contributed to the intended emotional and sensory effects.

Although the analysis remained primarily descriptive, it offered meaningful insights into trends and preferences, helping to inform recommendations for user-centered design in healthcare public spaces.

4.6. Ethical Considerations

4.6.1. IRB Approval

Ethical approval for this study was obtained from the University of Oklahoma's Institutional Review Board (IRB) under expedited review. This ensured that the research met all institutional and federal guidelines for working with human participants.

IRB protocol number: 18163

4.6.2. Informed Consent

Before beginning the survey, participants were provided with an informed consent form, which clearly outlined:

- The purpose of the study
- The estimated time commitment (~8–10 minutes)
- The voluntary nature of participation
- Their right to withdraw at any time without penalty
- Assurance that responses would remain anonymous and confidential

Consent was confirmed via an acknowledgment checkbox before participants could proceed to the survey questions.

4.6.3. Confidentiality and Data Protection

Participants were not asked to provide any personally identifiable information, and all responses were collected anonymously. Participants were given the option to provide their email address to be entered into a gift card drawing. It was explicitly stated that email addresses were

collected solely for incentive purposes and were not linked to individual survey responses in any way. This ensured that all survey data remained anonymous The collected data was stored securely on a password-protected device and backed up in secure cloud storage, accessible only to the researcher and academic advisor.

4.6.4. Risk to Participants

Participation in the study posed minimal to no risk, as the questions focused on perceptions of design elements in general healthcare environments. No sensitive or intrusive topics were included. Participants were free to skip any question they did not feel comfortable answering.

4.7. Limitations of Methodology

While the study was designed to be inclusive and aligned with real-world user experiences, several limitations were acknowledged:

1. Sampling Limitations:

   The survey was conducted entirely online, which restricted participation to individuals with internet access and basic digital literacy. As a result, certain demographic groups may have been unintentionally excluded.

2. Participant Representation:

   Most participants were members of the public rather than healthcare professionals or therapists. This limits the applicability of the findings to those who work within healthcare environments on a daily basis.

3. Self-Reported Data Bias:

   All responses were self-reported, which may be influenced by personal bias, momentary emotion, or recall inaccuracies. These factors may affect the objectivity of the data.

4. Survey Instrument Constraints:

   While the survey was structured using concepts from Florence Nightingale's Environmental Theory, it did not use standardized psychological scales. This limits direct comparison with other similar studies.

5. Lack of Observational Data:

   Due to time and resource constraints, the study did not include observational or site-specific analysis. Such data could have provided richer, context-driven insights into user behavior and environmental interaction.

6. Generalizability:

   The findings are based on perceptions and preferences of a specific sample and may not be fully generalizable across all healthcare settings or cultural contexts.

Despite these limitations, the study offers valuable insights into how biophilic design is perceived by everyday users and provides a strong foundation for further research in inclusive, emotionally supportive healthcare environments.

Chapter 5: Data Analysis and Findings

This chapter presents the results of the survey, offering insights into how participants perceived biophilic design elements in healthcare public spaces. The data is analyzed in relation to the study's key variables. Findings are organized to highlight participant demographics, individual variable responses, and emerging trends across the dataset.

5.1. Overview of Data Collected

The online survey was published on February 25, 2025, and remained open until March 12, 2025. During this period, a total of 156 responses were received from participants with diverse demographic and experiential backgrounds.

After an initial review of the dataset, 13 responses were excluded due to incompleteness or response inconsistency (e.g., skipping multiple questions or selecting the same rating throughout). This resulted in 143 valid and usable responses included in the final analysis.

The data collected reflected participants' perceptions of biophilic design elements—including natural light, greenery, soundscapes, tactile pathways, and biomimicry—in relation to their experiences within healthcare public spaces. The cleaned dataset provided a strong basis for descriptive analysis, allowing key insights to be drawn about how these design features influenced stress reduction, emotional well-being, perceived comfort, and social interaction from the perspective of everyday users

5.2. Demographic Profile of Participants

5.2.1 Gender Distribution

Among the respondents, 55.3% identified as male and 42.7% as female, with a small percentage identifying as non-binary or third gender (1.3%) and 0.7% choosing not to disclose their gender. This near-balanced gender representation supports a well-rounded exploration of environmental preferences and perceived emotional responses across identities.

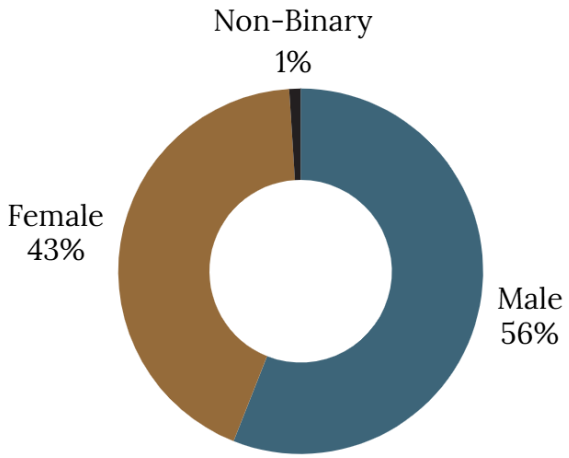

Figure 18. *Breakdown of Participant Types by Gender*

5.2.2. Experience with Healthcare Spaces

Participants were asked to indicate their level of engagement with healthcare environments. The pie chart below visually depicts this distribution. The results showed that:

- 69% (99 participants) had visited a healthcare facility as a visitor
- 25% (36 participants) had served as caregivers
- 4% (3 participants) were therapists or healthcare professionals
- 2% (5 participants) had used healthcare spaces for other non-professional purposes

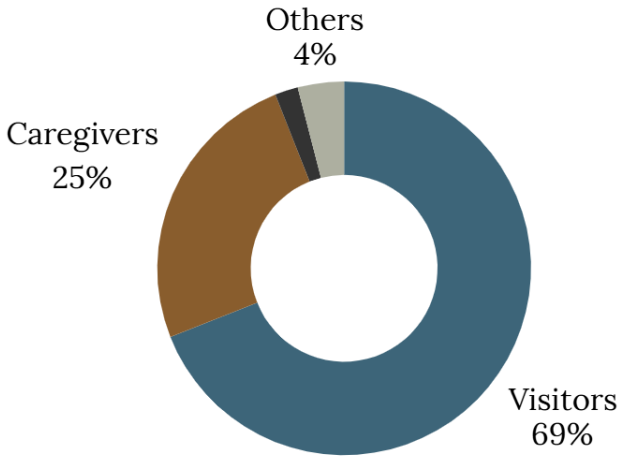

Figure 19. *Breakdown of Participant Types by Role*

This spread indicates that most respondents had firsthand experience with public healthcare environments, primarily in a supportive or observational role, rather than as staff. These insights are particularly valuable for understanding how public spaces are perceived by non-patient users.

For the purpose of this study, focused insights were drawn from the two most substantial participant categories:

- Visitors (n = 99)
- Caregivers (n = 36)

These two groups represented 95.7% of the total sample, offering rich and diverse feedback from non-patient users who interact with public areas of healthcare facilities. Other participant types (e.g., therapists or other roles) were excluded from group-specific analysis due to their small representation.

Table 8. *Participant Demographics (n = 143)*

Category	Option	Count	Percentage
Gender	Male	83	55.3%
	Female	64	42.7%
	Non-binary / Third Gender	2	1.3%
	Prefer not to say	1	0.7%
Experience with Healthcare Spaces	Visitor	99	69%
	Caregiver	36	25%
	Therapist / Healthcare Professional	3	2.0%
	Other	5	3.3%

While this study includes both visitors and caregivers as key participant groups, it is important to note that the number of visitor responses (n = 99) was substantially higher than that of caregivers (n = 36). As a result, comparative interpretations between the two groups should be viewed with some caution, as differences in group size may influence the weight of the findings. However, both groups were analyzed proportionally to reflect meaningful insights based on their respective experiences in healthcare settings.

5.3. Mean Ratings Overview of Biophilic Elements

After understanding who the participants were, it was important to look at how they responded to the different biophilic design elements presented in the survey. While individuals came from varied backgrounds, their experiences and perceptions shared some common

themes—especially around what made a healthcare space feel more calming, comfortable, or emotionally supportive.

Among visitors, who formed the largest participant group (n = 99), natural light emerged as the most positively rated element, with a mean score of 4.29. This suggests that daylight was strongly associated with a more comfortable and emotionally supportive environment. Indoor plants followed with a mean of 4.16, indicating that greenery also contributed meaningfully to the visitor experience. Soundscapes (M = 4.15) and tactile features (M = 4.13) were rated nearly equally, both reflecting a favorable response and suggesting that non-visual cues, such as texture and ambient sound, played an important yet slightly subtler role in shaping visitors' emotional and sensory perceptions.

Table 9. *Descriptive Statistics of Biophilic Design Element Ratings Among Visitor Participants*

	N	Minimum	Maximum	Mean	Std. Deviation
IndoorPlants_Avg	99	1.00	5.00	4.1616	0.59842
Natural Light_ Avg	99	1.00	5.00	4.2929	0.57734
Soundscape_ Avg	99	1.00	5.00	4.1535	0.63170
Tactile_ Avg	96	3.20	5.00	4.1313	0.44940
Total Responses, N			**99**		

In contrast, caregivers (n = 36) showed a slightly different pattern in their responses. Indoor plants received the highest mean rating from this group (M = 4.09), followed closely by tactile features (M = 4.09), soundscapes (M = 4.05), and natural light (M = 3.95). While caregivers also reported a generally positive response across all biophilic elements, their scores

were slightly lower than those of visitors. Notably, their ratings appeared more evenly distributed across the four elements, suggesting a more balanced sensory preference.

When comparing the two groups, visitors consistently rated all biophilic features slightly higher than caregivers. The most notable difference appeared in the perception of natural light, where visitors gave the highest score, while caregivers rated it the lowest among the four. This variation could reflect differences in how each group interacts with and interprets their environment. For visitors, natural light might symbolize openness and ease, while caregivers—often more focused on caregiving tasks—may prioritize comfort through tactile support or plant-rich spaces.

Table 10. *Descriptive Statistics of Biophilic Design Element Ratings Among Caregiver Participants*

	N	Minimum	Maximum	Mean	Std. Deviation
IndoorPlants_ Avg	36	3.00	5.00	4.0944	0.48163
Natural Light_ Avg	36	2.00	5.00	3.9500	0.59785
Soundscape_ Avg	36	2.60	5.00	4.0500	0.50906
Tactile_ Avg	36	2.80	5.00	4.0889	0.44707
Total Responses, N			**36**		

Overall, both groups expressed generally favorable views toward biophilic elements, but with distinct patterns in preference. Visitors leaned more toward visual and auditory cues, whereas caregivers showed a stronger response to tactile and plant-based features. These differences highlight the importance of designing healthcare environments that offer a multi-sensory experience, accommodating the diverse needs of various user groups.

5.4. Analysis by Outcome Variable

To better understand how biophilic design elements influenced user experiences in healthcare settings, responses were analyzed across four key outcome variables: stress reduction, emotional well-being, perceived comfort, and social interaction. Each section highlights which elements were perceived as most impactful, while also offering comparisons between elements.

5.4.1. Stress Reduction

For visitors, natural light received the highest rating for stress reduction (87.8%), followed closely by soundscapes and tactile features (both 83.8%), and indoor plants (79.7%). These results suggest that visual and auditory stimuli—particularly natural light and calming sounds—were perceived as effective in creating a soothing and emotionally regulated environment.

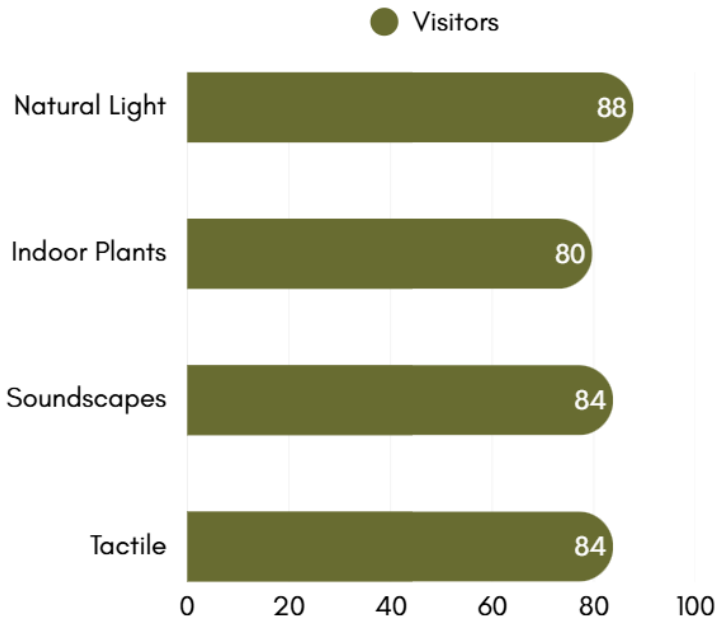

Figure 20. *Perceived Impact of Biophilic Elements on Stress Reduction Among Visitor Participants*

Among caregivers, however, natural light and indoor plants were equally rated for stress relief (both 77.7%), while soundscapes and tactile features followed closely (75%). The ratings are positive overall but slightly lower compared to visitors, possibly due to caregivers' longer exposure to the space or differing functional priorities.

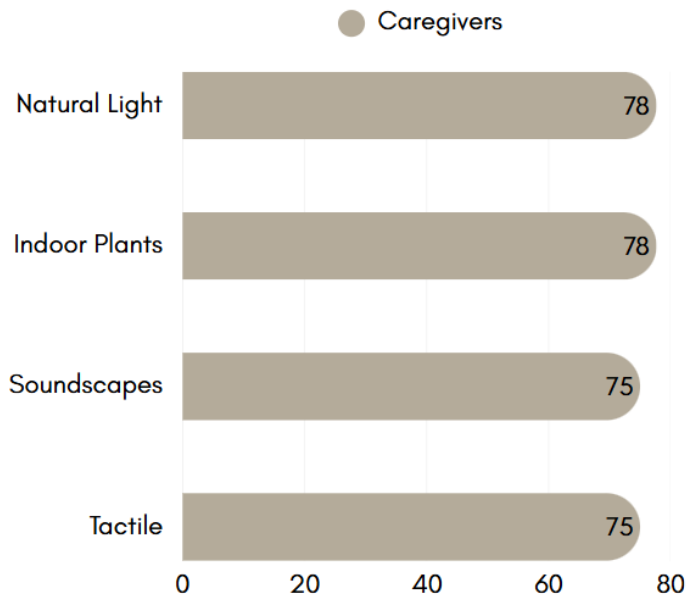

Figure 21. *Perceived Impact of Biophilic Elements on Stress Reduction Among Caregiver Participants*

The clear difference lies in the higher sensitivity of visitors to natural light for emotional regulation, whereas caregivers demonstrated a more balanced response across all four elements.

5.4.2. Emotional Well-being

In terms of emotional well-being, both visitors and caregivers reported generally positive associations with biophilic features, but with slight differences in preference. For visitors, natural light was rated the highest at 87.8%, followed by soundscapes (83.8%) and tactile features (83.8%). Indoor plants, while still positively viewed, received a slightly lower score of 79.7%. This suggests that visitors found light, sound, and tactile features equally uplifting, likely due to their immersive and multi-sensory quality, with natural light offering the most emotional clarity.

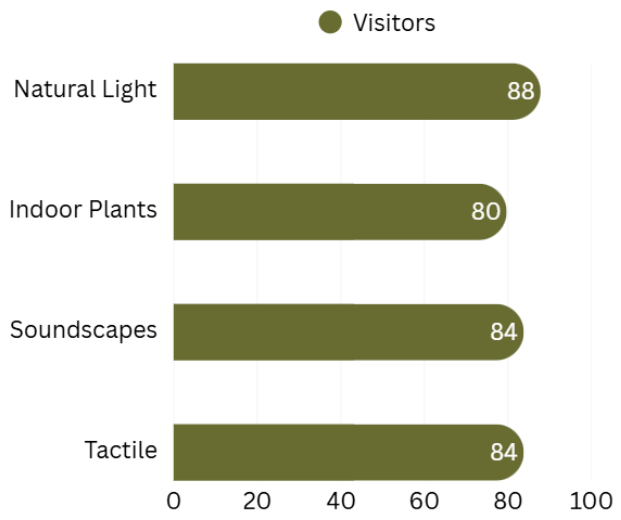

Figure 22.*Perceived Impact of Biophilic Elements on Emotional well-being Among Visitor Participants*

Among caregivers, Natural light and indoor plants were equally rated highest at 77.7%, while soundscapes and tactile features followed closely at 75% each. This reflects a consistent appreciation across all features, without a single dominant element. It may indicate that caregivers, often engaged in more active or demanding roles within healthcare environments, value emotional support through a blend of sensory experiences, rather than relying on any one element.

Together, these patterns highlight how emotional well-being can be supported through different sensory strategies depending on the user's role. Visitors leaned more toward visual and ambient sensory input, while caregivers preferred a balanced sensory environment that integrates visual, tactile, and auditory cues.

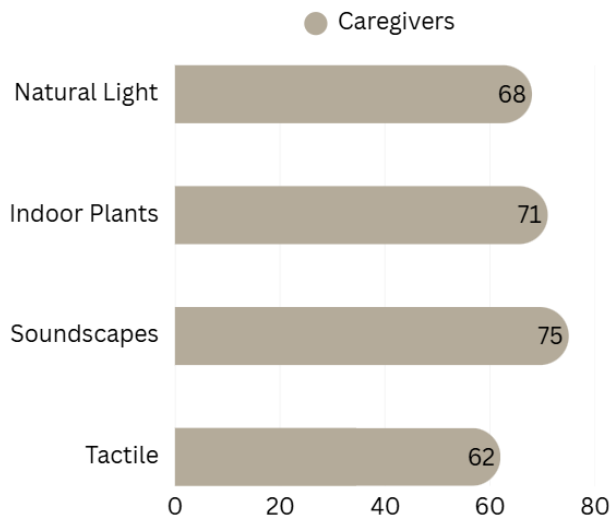

Figure 23.*Perceived Impact of Biophilic Elements on Emotional well-being Among Caregiver Participants*

5.4.3. Perceived Comfort

When considering physical and emotional comfort in the space, visitors rated indoor plants highest (87.8%), followed closely by natural light (83.8%). Tactile features and soundscapes scored slightly lower at 75.7%, though still within a positive range. These findings suggest that visual softness and plant life were key contributors to creating a welcoming atmosphere for visitors. The sharp difference in greenery ratings between visitors and caregivers could point to differences in emotional focus versus task-oriented engagement.

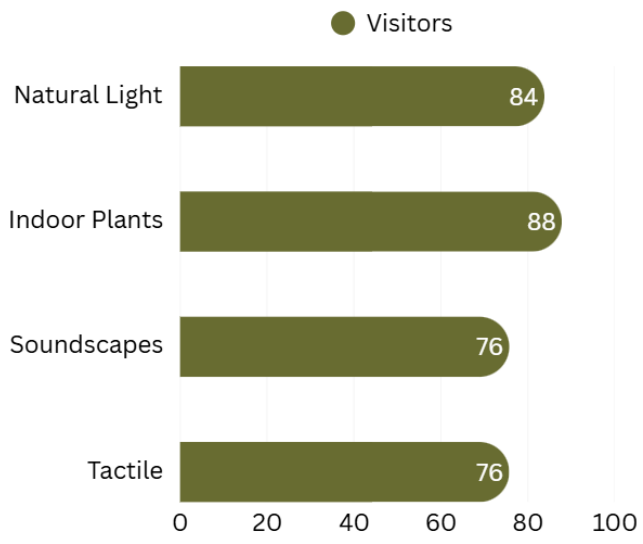

Figure 24.*Perceived Impact of Biophilic Elements on Perceived Comfort Among Visitor Participants*

For caregivers, the ratings showed more variation. Soundscapes and tactile features were both rated at 72.2%, while indoor plants received a notably lower score (63.8%), and natural light was rated at 69%. This contrast may reflect the more functional focus of caregivers, who may prioritize sensory and material comfort—like sound management and textures—over visual aesthetics.

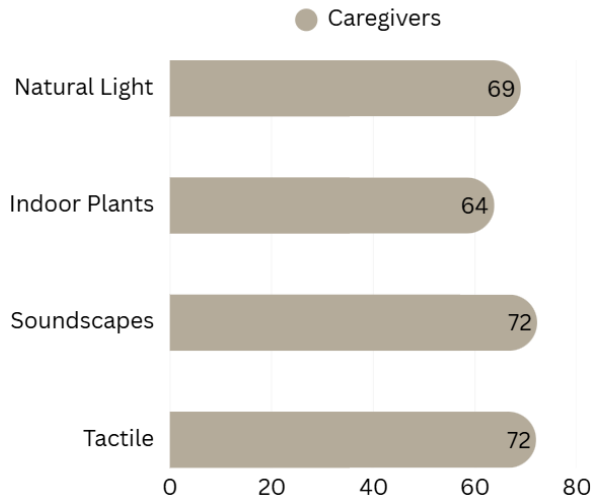

Figure 25.*Perceived Impact of Biophilic Elements on Perceived Comfort Among Caregiver Participants*

5.4.4. Social Interaction

Social interaction showed some of the most aligned scores between groups. Visitors rated natural light highest (87.8%), followed closely by soundscapes and tactile features (82.8%). Indoor plants were slightly lower at 76.7%. These results suggest that well-lit and acoustically soothing environments were perceived as most conducive to relaxed social engagement.

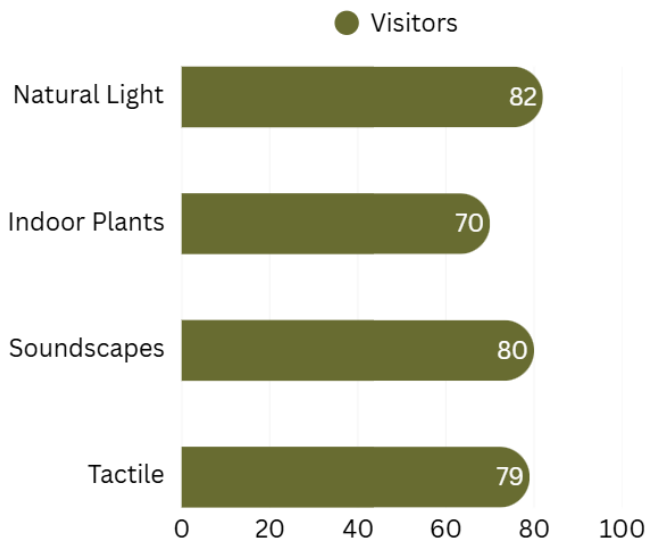

Figure 26.*Perceived Impact of Biophilic Elements on Social interaction Among Visitor Participants*

Among caregivers, tactile and soundscape elements were rated slightly higher (both 77.7%) than natural light and indoor plants (both 69–72.2%). This pattern suggests caregivers valued environments that reduced sensory barriers and supported ease of communication and movement through touch and auditory cues more than visual openness.

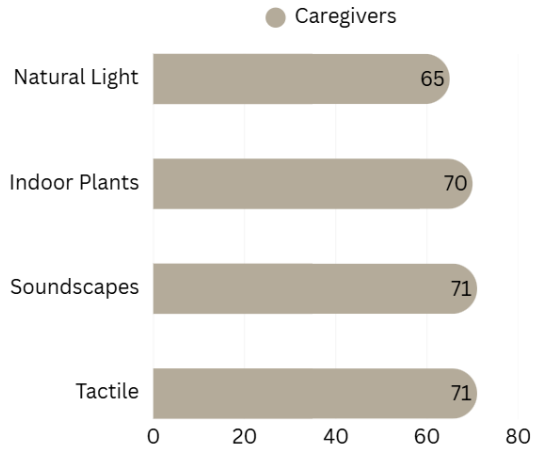

Figure 27.*Perceived Impact of Biophilic Elements on Social interaction Among Caregiver Participants*

Overall, while both groups agreed that biophilic design supported social interaction, they differed in how. Visitors responded to openness and brightness, while caregivers favored materiality and soundscapes that eased environmental strain during interaction.

5.5. Cross-Variable Insights or Emerging Themes

Bringing together the findings from all four outcome variables—stress reduction, emotional well-being, perceived comfort, and social interaction—several consistent patterns and meaningful contrasts emerged across the two primary user groups: visitors and caregivers.

For visitors, natural light consistently stood out as the most valued biophilic element. It received the highest ratings across multiple outcomes, particularly for stress reduction, emotional well-being, and social interaction. This suggests that for individuals entering healthcare

environments in a temporary, supportive role, visual openness and access to daylight serve as key anchors for emotional regulation and comfort.

Soundscapes and tactile features also maintained strong and steady ratings across outcomes, especially among visitors. Their consistent presence across emotional and comfort-related dimensions points to the value of multi-sensory design in fostering a calm, welcoming atmosphere. Although indoor plants received slightly lower scores compared to other features in the visitor group, they were still perceived positively, particularly in enhancing the sense of comfort.

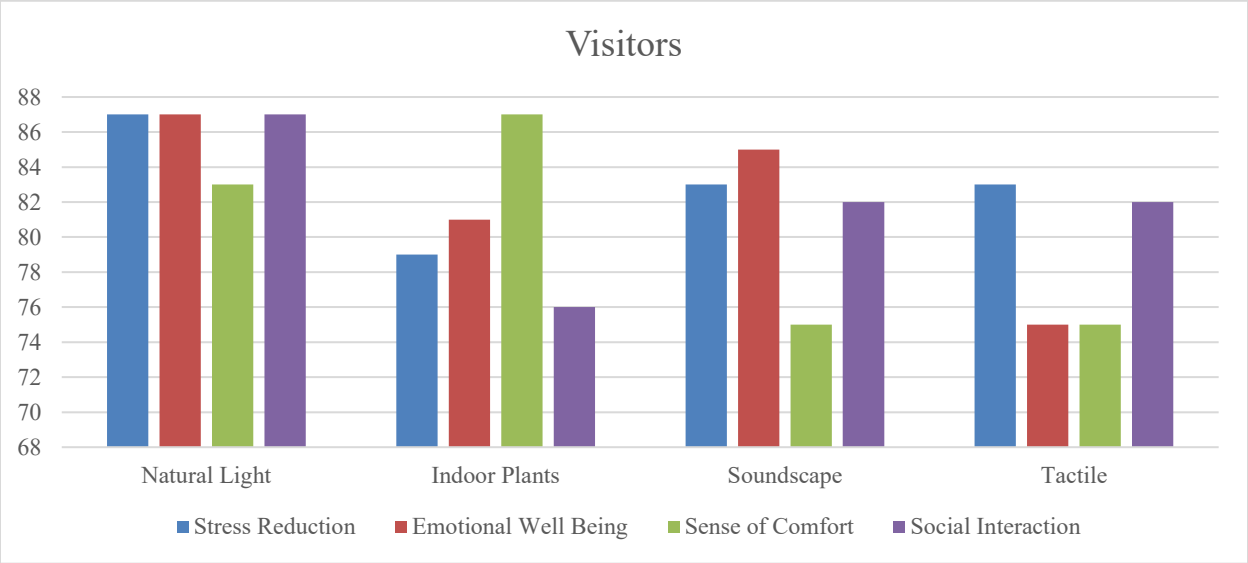

Figure 28.*Frequency Distribution of Perceived Well-being of Visitors from Biophilic Design Features*

In contrast, caregivers displayed a more balanced and uniform appreciation across all four biophilic elements. Rather than favoring one element over the others, their ratings remained close in value—indoor plants and natural light often tied as the most appreciated, with soundscapes and tactile features trailing closely behind. This pattern suggests that caregivers,

likely spending more extended and task-oriented time in these spaces, benefit most from holistic sensory support rather than isolated environmental features.

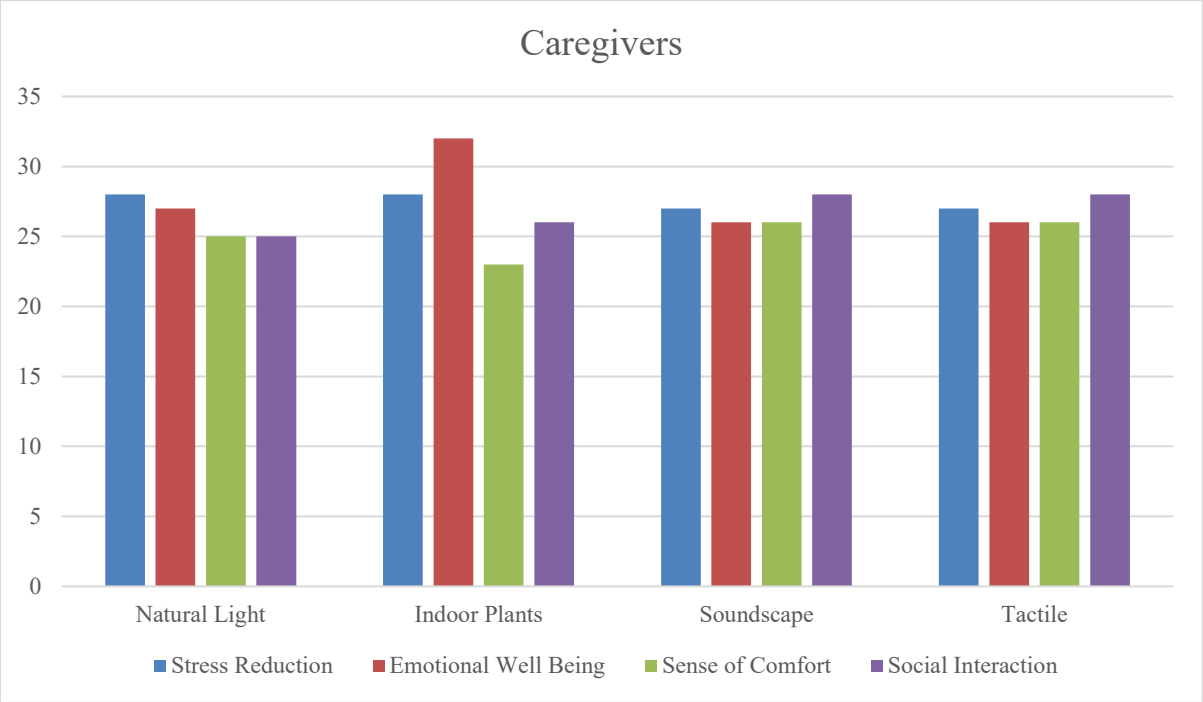

Figure 29.*Frequency Distribution of Perceived Well-being of Caregivers from Biophilic Design Features*

One notable contrast lies in how the two groups experienced greenery. While visitors perceived plants as supportive but secondary to light and sound, caregivers rated indoor plants just as highly as natural light—particularly for emotional well-being. This could reflect the grounding effect of greenery during extended, high-responsibility visits.

An overarching theme across both groups is the strong positive response to multi-sensory biophilic design. Even where preferences differed slightly, all four elements consistently scored above neutral. This reinforces the idea that no single feature works in isolation. Instead, the integration of visual, tactile, and auditory elements creates an environment that feels emotionally balanced, physically comfortable, and socially inviting.

5.6. Conclusion

The findings revealed that natural light consistently emerged as the most impactful feature for visitors, particularly in reducing stress and encouraging social interaction. For caregivers, indoor plants held slightly more significance, especially for supporting emotional well-being and comfort. Across both groups, soundscapes and tactile elements played steady, supportive roles, contributing to calming environments and reinforcing the value of multi-sensory design.

One of the most important takeaways from this research is that users do not respond to a single feature in isolation. Instead, the data points to the importance of sensory layering—the thoughtful combination of visual, auditory, and tactile inputs—which fosters a more inclusive and restorative experience for everyone who enters a healthcare setting.

By centering non-patient perspectives, this study highlights a critical dimension of healthcare design that is often overlooked. Visitors and caregivers bring with them emotional vulnerability, yet they are also essential to the healing ecosystem. Supporting their well-being through biophilic strategies can help create environments that are not only functional but also deeply human-centered.

Chapter 6: Discussion

This chapter interprets the findings presented in the previous section by addressing the research questions and examining the broader implications of the results.

6.1. Addressing the Research Questions

Each question is addressed using the data collected from both visitors and caregivers, offering insight into how biophilic elements influenced their emotional and sensory experiences.

RQ1: How do biophilic design elements influence the sensory and emotional experiences of non-patient users in healthcare public spaces?

The data revealed a strong positive perception of biophilic elements across both participant groups. Visitors showed a high response to natural light across all outcomes—87 participants consistently selected it as impactful for stress reduction, emotional well-being, and social interaction. Soundscapes and tactile features were also highly rated for stress relief (83 responses each), while indoor plants were most strongly associated with comfort (87 responses).

Caregivers showed a more balanced response across elements, though slightly lower in frequency due to a smaller group size. Indoor plants (32 responses) stood out as the most significant for emotional well-being, while tactile features and soundscapes were more associated with comfort and social interaction (28 responses each). This shows that biophilic design fosters emotional and sensory support but varies slightly depending on the user's role and engagement with the space.

RQ2: What environmental preferences are expressed by different user groups?

Visitors preferred natural light, which consistently topped the chart for all four outcomes (with 87 responses each for stress reduction, emotional well-being, and social interaction). Their preference suggests a strong inclination toward visual clarity and open, bright environments, which likely contribute to their sense of calm and connection in temporary or brief stays within healthcare spaces.

Caregivers showed stronger preference for indoor plants (32 responses for emotional well-being), tactile features, and soundscapes, which may reflect their need for sensory grounding and emotional regulation during longer or more intense visits. These patterns suggest that caregivers may benefit more from multi-sensory engagement, while visitors respond more to visual and ambient comfort.

RQ3: What design insights can be drawn from users' responses to biophilic elements in healthcare public spaces?

This data supports the following design insights:

- Incorporate abundant natural light in areas frequented by visitors to support emotional clarity and reduce stress.
- Design plant-integrated spaces, especially in waiting and transitional areas, to foster emotional connection and relief, especially for caregivers.
- Use tactile materials (wood, stone, textured fabrics) in furniture and finishes to create warmth and comfort.

- Implement nature-based soundscapes to soften the clinical environment and reduce background noise, supporting both stress reduction and social ease.

6.2. Comparison with Previous Studies

The results of this study closely align with much of the existing literature that highlights the positive influence of biophilic design on human well-being in healthcare settings. However, by focusing on non-patient user groups, this research adds a new layer to the discussion—highlighting how visitors and caregivers respond differently to sensory elements based on their roles and emotional context.

Many findings reinforce prior studies. For instance, the consistent value placed on natural light by visitors supports conclusions from Simarmata (2023), Russo & Andreucci (2023), and Totaforti (2018), who link daylight with stress relief, emotional balance, and psychological clarity. Likewise, the strong association caregivers had with indoor plants mirrors the restorative benefits of greenery found in research by Kyrkou (2023) and Puren et al. (2021).

Table 11. *Key Findings That Align with Previous Research*

Biophilic Element	What This Study Found	Matches With	Why It Matters
Natural Light	Visitors rated it highest across all outcomes (stress, well-being, interaction, comfort).	Simarmata (2023), Totaforti (2018), Russo & Andreucci (2023)	Confirms that daylight isn't just healing for patients—it positively impacts non-patient users as well.
Indoor Plants	Caregivers strongly linked greenery to emotional comfort and stress relief.	Kyrkou (2023), Puren et al. (2021), Moslehian et al. (2023)	Extends known healing benefits of greenery to caregivers—often under-addressed in design.

Soundscapes (Visitors)	Visitors found soundscapes calming, especially for stress and emotional balance.	Martin et al. (2021), Simarmata (2023)	Reinforces value of acoustic design for non-patient user experiences in shared spaces.
Greenery & Comfort	Visitors associated greenery with increased physical and emotional comfort.	Totaforti (2018), Mathur (2023)	Emphasizes greenery's role beyond aesthetics—offering comfort to those in transitional roles.

However, some contrasts emerged. While soundscapes are often highlighted as effective in reducing anxiety and promoting relaxation (Martin et al., 2021), caregivers in this study rated soundscapes lower than other elements. This suggests that the auditory environment may not hold the same value for all user types—possibly due to noise fatigue, attentional demand, or different sensory sensitivities. Another unique insight is the consistently high rating for tactile features by caregivers, an area that receives less emphasis in existing literature but was shown here to support both emotional and physical comfort.

Table 12. *Novel Insights or Divergences from Previous Research*

Biophilic Element	What This Study Found	How It Differs or Adds to Existing Research	Implication for Design
Soundscapes (Caregivers)	Rated lowest among all elements by caregivers, despite known restorative value.	Contrasts with Martin et al. (2021), who highlight calming audio in clinical settings.	Suggests sound design should be context-specific; may be less effective for users under cognitive load.
Tactile Features	Caregivers consistently rated textures/materials highly for comfort and emotional support.	Rarely emphasized in prior biophilic studies focused more on sight/sound/greenery.	Adds new dimension to biophilic design—highlighting importance

			of sensory grounding via materiality.
Balanced Sensory Ratings (Caregivers)	Caregivers did not show a dominant preference—valued all elements fairly equally.	Literature often emphasizes a top-rated element (e.g., greenery or light).	Supports multi-sensory layering for users with prolonged presence and higher emotional load.

6.3. Design Strategies Informed by the Study

The findings of this study provide practical, user-centered insights that can inform the design of emotionally supportive and sensory-rich healthcare environments. Given the distinct yet overlapping preferences expressed by visitors and caregivers, the following strategies aim to enhance non-patient user experience in public healthcare spaces such as waiting areas, lobbies, and transition zones.

1. Prioritize Natural Light in Visitor Areas

Visitors consistently rated natural light as the most emotionally uplifting and stress-relieving element. To enhance this benefit:

- Maximize access to daylight through large windows, clerestories, and skylights.
- Use reflective surfaces and light-toned materials to diffuse natural light throughout public areas.
- Orient seating and circulation to face or frame outdoor views when possible.

2. Integrate Greenery Beyond Decoration

Both user groups responded positively to indoor plants, with caregivers especially valuing them for emotional comfort.

- Use living walls, potted plants, and indoor gardens in waiting areas.
- Incorporate viewable green courtyards or atrium gardens to serve as calming visual anchors.
- Ensure that plants are well-maintained and integrated into the space, not treated as afterthoughts.

3. Create Acoustic Comfort Through Natural Soundscapes

Visitors responded well to soundscapes, especially for emotional well-being and stress relief.

- Introduce subtle, nature-based sound systems (e.g., water features, soft bird sounds).
- Use acoustic zoning to reduce mechanical or clinical noise in shared areas.
- Ensure volume and frequency are adjustable to avoid overwhelming caregivers or users in emotional distress.

4. Enhance Comfort with Tactile Materials

Caregivers rated tactile features highly for comfort and emotional ease—suggesting a need for multisensory material engagement.

- Use natural textures like wood, stone, bamboo, or cork in surfaces and finishes.
- Incorporate textured upholstery and furniture to break away from clinical sterility.
- Apply materials that offer both visual and tactile warmth, especially in long-stay areas.

5. Design for Sensory Layering, Not Isolation

Rather than relying on a single element, the findings support the integration of multi-sensory design:

- Combine light, greenery, sound, and materiality in the same space for a holistic experience.
- Allow flexibility in how users interact with spaces—some may need quiet zones, others may seek vibrant, engaging corners.
- Offer choice and control: lighting dimmers, moveable furniture, varied textures.

6. Consider Role-Based Needs in Layout and Programming

The differences between caregivers and visitors suggest that their emotional needs vary by role and duration of stay.

- Design zones that serve both short-term comfort (e.g., soft seating near windows for visitors) and long-term support (e.g., restorative garden views and sensory-rich lounges for caregivers).
- Incorporate restorative micro-environments within large waiting areas to offer emotional relief.

6.4. Validity and Reliability

To ensure the credibility and relevance of the study findings, careful attention was given to both validity and reliability throughout the research process.

Content validity was established through a strong foundation in literature and theoretical grounding. The survey questions were directly informed by Florence Nightingale's Environmental Theory and structured around well-documented biophilic design elements—natural light, greenery, soundscapes, tactile features, and biomimicry. Each question group targeted specific emotional and sensory outcomes such as stress reduction, emotional well-being,

comfort, and social interaction. This alignment ensured that the content of the instrument was conceptually appropriate and relevant to the research objectives.

While the study did not employ previously standardized tools such as the Perceived Restorativeness Scale (PRS) or the Perceived Stress Scale (PSS), the custom questionnaire was developed with reference to similar constructs and supported by a comprehensive literature review. The use of simple, clearly worded questions helped reduce ambiguity and improved the likelihood of honest, reflective responses.

Reliability was enhanced through consistent data collection procedures. The survey remained open for a fixed period, and the participant recruitment strategy ensured diverse representation while maintaining focus on the two key user groups—visitors and caregivers. The use of descriptive statistics and frequency distribution helped identify consistent response trends across different variables, supporting the internal consistency of the data.

Despite not including formal reliability tests such as Cronbach's alpha due to the non-scale-based nature of the questions, the pattern of responses across user groups demonstrated a high degree of logical consistency. This suggests that participants understood and interpreted the questions as intended.

Overall, the study demonstrates reasonable validity and reliability given its scope and structure. Still, future research could benefit from integrating standardized scales and performing psychometric testing to further strengthen the methodological framework.

6.5. Study Limitations

While the study was carefully designed to explore how biophilic design elements affect non-patient users in healthcare public spaces, several limitations should be acknowledged:

1. The sample included significantly more visitors (n = 99) than caregivers (n = 36), which may have skewed comparative analysis. Although percentages were used to normalize comparisons, the difference in group size may affect the weight of conclusions.
2. All data was collected through self-reported online surveys. While this method allowed for broader reach, responses may have been influenced by mood, memory, or social desirability at the time of participation.
3. The study relied solely on perceptions gathered through surveys. Observational or real-time engagement within healthcare environments could have provided richer, context-specific insights about how biophilic elements were actually experienced.
4. A portion of the survey respondents included friends and family from India. While their input offered valuable perspectives, the cultural and contextual differences in healthcare environments between India and the U.S. may have introduced bias or influenced preferences differently than the intended American healthcare context.
5. The study focused on visitors and caregivers, excluding healthcare professionals and patients due to scope and permissions. Including a broader user base could provide a more comprehensive view of how biophilic design impacts all individuals within healthcare spaces.

Despite these limitations, the study provides a meaningful contribution by centering the experiences of everyday, non-clinical users—groups that are frequently underrepresented in healthcare design research.

Chapter 7: Conclusion

This study explored how biophilic design elements—such as natural light, greenery, soundscapes, and tactile materials—affect the sensory and emotional experiences of non-patient users in healthcare public spaces. Guided by Florence Nightingale's Environmental Theory and a mixed-methods approach, the research examined four key outcomes: stress reduction, emotional well-being, perceived comfort, and social interaction. The findings revealed distinct preferences between visitors and caregivers, with natural light rated highest by visitors for its calming effect, while caregivers responded more strongly to indoor plants and tactile features for emotional support and grounding. Across both groups, there was a clear appreciation for multi-sensory environments, reinforcing the value of holistic, layered design strategies.

By focusing on non-patient users—an often overlooked group in healthcare design—this study fills an important gap in the literature and provides practical insights for more inclusive, emotionally supportive spaces. It demonstrates that healthcare environments should not only meet clinical and functional standards but also prioritize the sensory and psychological needs of everyone who interacts with them. While the study was limited by sample diversity and reliance on self-reported data, it opens the door for future research that includes broader user groups and observational methods. In doing so, it encourages a shift toward design practices that view wellness as a shared experience, shaped not only by medicine but also by space.

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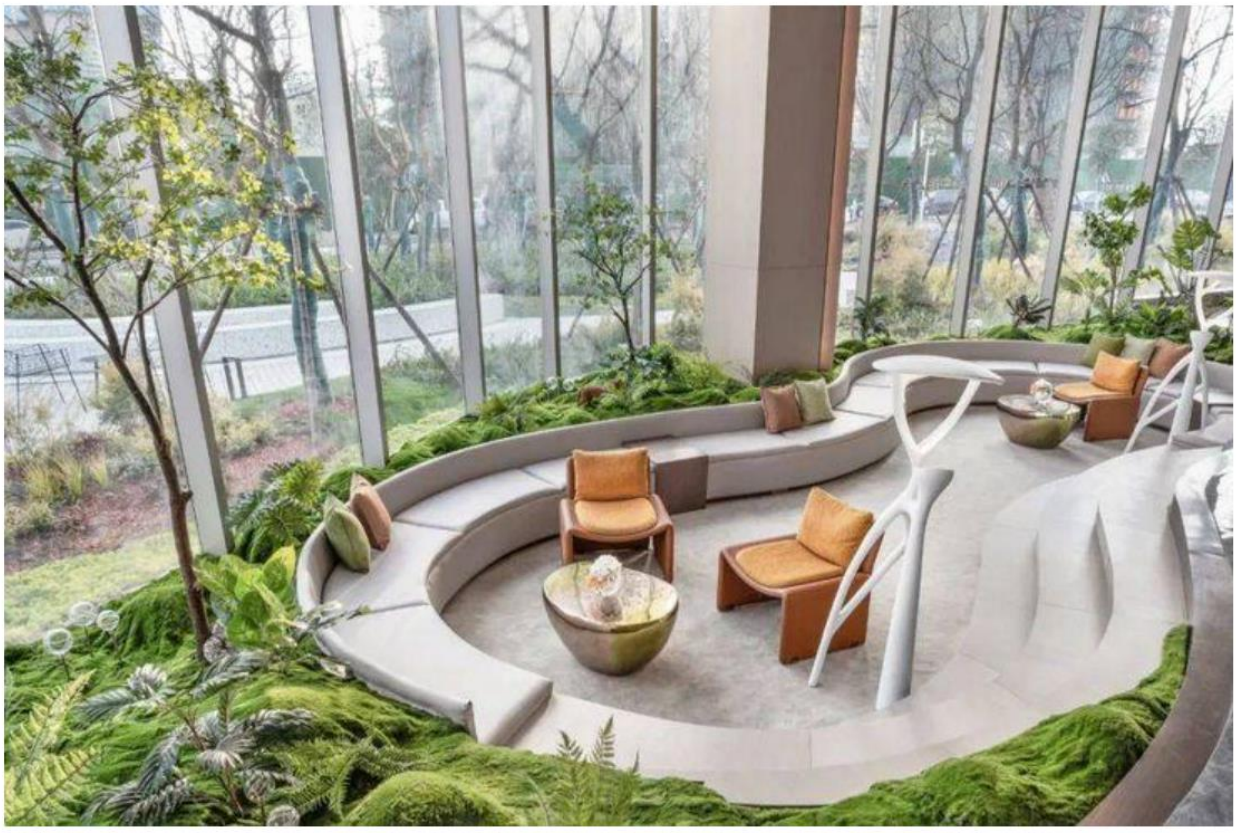
Appendix I – Survey Questionnaire

The UNIVERSITY of OKLAHOMA



PURPOSE OF THE RESEARCH:

You are invited to participate in this research study, which aims to explore how biophilic design elements (such as indoor plants, green walls, natural light, and nature-inspired patterns) influence perceptions of healthcare environments. Your participation will help improve the understanding of how these design elements impact user experience in healthcare spaces.

PROCEDURES:

If you agree to participate, you will complete a 10–15-minute online survey through Qualtrics. The survey consists of questions about your perceptions of natural design features in healthcare spaces. Your responses will be confidential, and you may skip any question you do not wish to answer.

RISKS AND BENEFIT:

- Risks: This study poses no more than minimal risk, like those encountered in daily life. However, since the survey is conducted online, there is a small risk of data breach. Qualtrics follow strict security protocols to protect data privacy.

  Additionally, since email addresses are collected for compensation purposes, there is a social risk of deductive identification. However, this information will be stored separately from survey responses, kept confidential, and deleted after gift card distribution.

- Benefits: While there are no direct benefits to you as a participant, your responses will contribute to research that may help improve the design of healthcare environments, potentially making them more comfortable and stress-reducing for future visitors.

DATA PRIVACY AND SECURITY:

This survey is conducted using Qualtrics, a secure third-party platform. The research team will collect email addresses only for gift card distribution, but this information will be stored separately from survey responses to maintain confidentiality.

The only demographic information collected is gender. Your responses will be held confidential, and data will be reported in aggregate form to protect participant privacy.

COMPENSATION:

As a token of appreciation for your time, you will receive a $5 Target gift card upon completing the survey.

- Compensation is limited to the first 80 participants.
- Only fully completed surveys will be eligible for compensation.
  Gift cards will be distributed via email within two weeks after survey completion.
- Email addresses collected for compensation purposes will be deleted after distribution is complete.

CONFIDENTIALITY:

Your participation is voluntary, and your responses will be confidential. The research team will collect email addresses only for compensation purposes, but this information will be stored securely and not linked to survey responses.

We will not share your data or use it in future research beyond this study. All responses will be analyzed and reported in aggregate form to maintain participant privacy. Even if you choose to participate now, you may stop participating at any time and for any reason.

CONTACT INFORMATION:

If you have any questions about this study or your participation, please contact:

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You can also contact the University of Oklahoma – Norman Campus Institutional Review Board at 405-325-8110 or irb@ou.edu with questions, concerns or complaints about your rights as a research participant, or if you don't want to talk to the researcher.

Please print this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

Are you 18 years of age or older? (If no- cannot participate)

- ◯ Yes
- ◯ No

Have you used public spaces in a healthcare facility, such as waiting areas, lobbies, or communal spaces?

- ◯ Yes
- ◯ No

Gender:

- ◯ Male
- ◯ Female
- ◯ Non-binary / third gender
- ◯ Prefer not to say

Which of the following best describes your experience with healthcare facility spaces? (Select all that apply)

- ◯ I have visited a healthcare facility as a visitor (e.g., family, friend of a patient).
- ◯ I have been a caregiver in a healthcare facility (e.g., assisting a patient).
- ◯ I am a therapist or healthcare professional who works in a healthcare facility.
- ◯ I have used healthcare facility spaces for other reasons.

How often do you feel stressed or anxious during visits to healthcare spaces?

- ◯ Always
- ◯ Most of the time
- ◯ Sometimes
- ◯ Never

Figure 1 : *Biophilic design elements*

Participants' views on the biophilic elements in the environment.

Indoor plants and green walls improve my perception of the healthcare facility's environment.

- ○ Strongly Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Large windows or skylights enhance my sense of openness and connection to nature within the space

- ○ Strongly Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Natural sounds, such as water features or birdsong, create a more pleasant and calming atmosphere in the environment

- ○ Strongly Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Nature-inspired patterns or textures positively influence my overall impression of the healthcare facility

- ○ Strongly Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

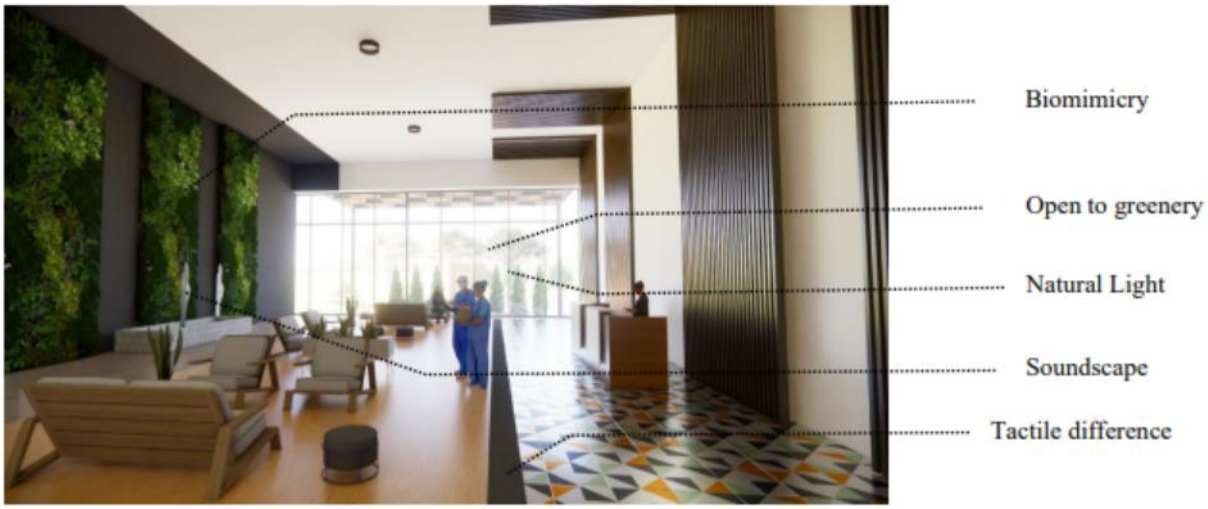

Figure 2 : *Healthcare Lobby with Biophilic Design Elements (Designed by the Author)*

How biophilic elements support emotional well-being and reduce stress

Green spaces or indoor plants help in reducing my stress levels during visits to healthcare facilities.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Exposure to natural daylight improves my mood and reduces feelings of anxiety.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Soundscapes with natural elements (e.g., wind, water sounds) create a calming atmosphere for me.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Tactile pathways contribute to my sense of emotional stability and relaxation.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Figure 3 : *Healthcare Lounge with Integrated Biophilic Elements (Designed by the Author)*

Participants' sense of physical and emotional comfort in the space.

Spending time in areas featuring greenery or gardens makes me feel physically and emotionally comfortable.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

I feel more physically at ease in spaces with abundant natural light compared to those with artificial lighting

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Spaces with natural soundscapes (e.g., water features) provide a sense of safety and comfort

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Walking on textured pathways or nature-inspired surfaces enhances my sense of safety and comfort in the environment.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

How biophilic design features enhance the practical use of the space.

Green walls or indoor plants improve my ability to focus or navigate the space.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Natural lighting enhances visibility and usability for different activities in space.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Natural sounds make it easier for me to concentrate or communicate with others in shared spaces.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Nature-inspired design features improve the functionality and layout of healthcare spaces.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Overall perceptions of the environment's ability to promote health and wellness.

Biophilic elements like gardens and indoor greenery enhance my overall experience in healthcare spaces.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

The presence of natural light throughout space contributes to my sense of wellness.

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree

Soothing natural soundscapes create a holistic and restorative healthcare environment.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Design elements inspired by nature support my overall well-being and satisfaction with the space.

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Would you like to receive a gift card via email?

- ○ Yes
- ○ No

Please enter your email address to receive your $5 gift card. (This is optional. If you do not wish to receive a gift card, you may leave this blank.)

We thank you for your time spent taking this survey.
Your response has been recorded.

Appendix II – Literature Review Findings

		Research Paper	Findings	Design Strategies
1	Totaforti, S. (2018)	Exploring the relationship between biophilic design and meditation facilities	The study found that biophilic elements such as natural light, natural materials (e.g., wood), and views of nature positively impacted meditation quality. Acoustics, specifically nature sounds, were also important for creating a conducive meditation environment.	Incorporate biophilic design elements such as natural materials, views to nature, dynamic lighting, and natural soundscapes. Design for acoustic comfort and privacy to enhance the meditation experience.
2	Tekin, B.H., Corcoran, R., & Gutiérrez, R.U. (2022)	Application of Biophilic Patterns in Health Care Environments to Enhance Healing	Biophilic design elements significantly reduce patient stress levels, improve mood, and accelerate recovery times. Hospitals incorporating natural light, greenery, and open spaces reported improved patient satisfaction and well-being.	Design hospitals with direct access to natural light, views of nature, and water features. Utilize materials and forms derived from nature, integrate green spaces within and around the hospital, and ensure patients have visual and sensory access to natural elements.
3	Edwards, T.M. (2023)	Understanding the effects of biophilic design in healthcare environments through the use of VR	There was no significant effect of biophilic design on cognitive load, but participants reported higher satisfaction and lower stress in environments with biophilic elements. The study found a strong correlation between cognitive load and valence	Incorporate natural elements such as plants, natural materials, and views of nature to improve patient satisfaction and reduce stress.
4	Untaru, E.N., Han, H., David, A., & Chi, X. (2024)	Design Considerations of Biophilic Design to Improve Human Health and Well-being in Indoor Spaces	Biophilic design improves cognitive performance, reduces stress, and promotes emotional restoration. It has been shown to improve productivity, learning outcomes, and patient recovery in healthcare environments.	Incorporate natural elements like plants, natural light, water features, and materials that mimic nature. Design environments that promote sensory engagement and connection to the natural world.

5	Sofiana, Y., Yulia, Y., & Indahyani, T. (2021)	Applying the benefits of biophilic theory to hospital design	Patients exposed to natural environments showed faster recovery times, reduced stress, and improved emotional well-being. Elements like natural light, plants, and views of nature had significant positive impacts on health outcomes.	Natural light: Maximize windows and skylights. Green spaces: Include indoor plants, rooftop gardens, and courtyards. Water features: Add elements like fountains or streams to enhance tranquility. Natural materials
6	Zhao, Y., Zhan, Q., & Xu, T. (2022)	Biophilic Design as an Important Bridge for Sustainable Interaction between Humans and the Environment: Based on Practice in Chinese Healthcare Space	The most valued biophilic design elements were natural light, greenery, and real plants. Indirect natural elements like natural colors, materials, and patterns also contributed to positive experiences.	Incorporate natural light, plants, and water features in waiting rooms and wards. Create visual and physical connections to nature (e.g., gardens). Provide quiet spaces with greenery to reduce stress.Use natural materials (wood, stone), improve access to natural light, and employ multisensory stimuli (sound, sight, touch).
7	Khan, A. (2023)	Biophilic Design as Sustainable Approach for Interior Hospice Care	Biophilic design elements such as natural light, access to outdoor spaces, and the use of natural materials like wood and stone were found to create positive healing environments for pediatric patients. These elements helped reduce stress, improved mood, and provided a sense of comfort.	Create child-friendly, nature-inspired interiors with calming colors and natural materials. Include outdoor spaces for therapy and relaxation. Incorporate flexible, multi-functional rooms that cater to both private and communal activities like art and music therapy. Use natural textures and elements to create a home-like, comforting environment.
8	Alvaro, C., Wilkinson, A.J., Gallant, S.N., Kostovski, D., & Gardner, P. (2016)	Biophilic Design and Its Effectiveness in Creating Emotional Well-Being, Green Satisfaction, and Workplace	Biophilic design, especially open spaces with natural light, natural decor, and views of nature, positively impacted emotional well-being and satisfaction. Emotional well-being was a key mediator between biophilic design and workplace attachment.	Incorporate natural light, green spaces, and natural decor

		Attachment Among Healthcare Professionals: The Hospice Context		
9	Alkali, I.A. (2023)	Designing for Hope: Biophilic Color Associations and Their Relevance to Clinical Settings	Yellow evoked the strongest experience of hope among participants. The depth of yellow color increased the emotional response of hope.	yellow - oncology, rehabilitation, and mental health settings. calming green or blue - high-stress areas like emergency rooms or maternity wards. red - to capture attention or signal urgency.
10	Edwards, T.M. (2023)	A Systematic Review and Conceptual Framework of Biophilic Design Parameters in Clinical Environments	Key biophilic design parameters for patients include light-daylight, thermal comfort, view, and refuge. For staff, privacy, refuge, and quietness were the most valued features. Both groups benefit from natural light, access to views, and calming environmental elements.	For patients: Maximize views, daylight, and access to outdoor spaces; provide refuge and protection. For staff: Create private, quiet spaces with access to outdoor areas for relaxation. For both: Use natural materials, ensure thermal comfort, and create a welcoming, non-clinical environment.
11	Gong, Y., Zoltán, E.S., & János, G. (2023)	Potential risks and beneficial impacts of using indoor plants in the biophilic design of healthcare facilities: A scoping review	Indoor plants were found to reduce emotional stress, improve subjective well-being, and enhance cognitive performance. The risks of microbial infection from indoor plants were minimal when properly maintained, and the benefits outweighed the risks in non-clinical areas.	Use indoor plants in non-clinical areas such as waiting rooms and corridors. Focus on low-maintenance plants that improve air quality and provide visual and psychological comfort to patients and staff.
12	Khanzadeh, M. (2024)	Human-centred health-care environments: a new framework for biophilic design		

13	Wichrowski, M.J., Corcoran, J.R., Haas, F., Sweeney, G., & Mcgee, A. (2021)	Perceived Restoration of Hotel Lobbies: An Examination of Biophilic Design Attribute Organized Complexity and Attention Restoration Theory	The study found that perceived environmental complexity positively correlated with attention restoration, though the relationship between organized complexity and attention restoration was not statistically significant.	Incorporate elements that increase perceived complexity (e.g., varied textures, intricate patterns) while maintaining organization. Focus on natural elements like lighting and materials to foster a restorative environment.
14	Mazuch, R. (2017)	Healthy Dwelling: Design of Biophilic Interior Environments Fostering Self-Care Practices for People Living withMigraines, Chronic Pain, and Depression	Biophilic design elements such as exposure to natural light, plants, aromatherapy, and soundscapes can improve relaxation, reduce stress, alleviate pain, and promote emotional well-being	For migraines: Incorporate dynamic lighting, green LED light therapy, and aromatherapy with lavender to reduce headaches and stress. For chronic pain: Use natural light, indoor plants, and spaces for physical activity (e.g., yoga mats). For depression: Include bright light therapy, access to nature views, and music therapy to promote emotional regulation.
15	El Messeidy, R. (2019)	Healthy Dwelling: The Perspective of Biophilic Design in the Design of the Living Space Yu Gong	green spaces, access to nature, and better spatial organization, contribute significantly to improving residents' quality of life in high-density urban environments.	Increase greenery in public spaces, design for better ventilation and sunlight, and create multi-level green spaces (e.g., rooftop gardens). Use natural materials, maximize access to natural light, and incorporate green plants.

16	Abdelaal, M.S., & Soebarto, V. (2019)	Effects of Biophilic Nature Imagery on Indexes of Satisfaction in Medically Complex Physical Rehabilitation Patients: An Exploratory Study	Patients in rooms with nature imagery rated their rooms significantly higher ($p = .0071$) compared to those in standard rooms. Positive comments focused on brightness, pleasantness, and cleanliness of rooms with nature imagery.	Incorporate nature imagery, such as posters and bed curtains with biophilic themes, in patient rooms to improve satisfaction. Consider multi-sensory experiences (visual, auditory, olfactory) for further enhancing the therapeutic effects.
17	Aristizabal, S., Byun, K., Porter, P., Clements, N., & others. (2021)	Biophilia and Salutogenesis as restorative design approaches in healthcare architecture	The study found that incorporating biophilic elements, such as access to natural light, green spaces, and views of nature, significantly improved patient recovery times, reduced stress, and enhanced emotional well-being. It also found that salutogenic design principles, such as spaces for social interaction and meditation gardens, contributed to a stronger sense of coherence among patients and staff.	Incorporate visual and non-visual connections to nature (e.g., windows with views of greenery, natural light), spaces for social interaction (e.g., communal areas), and calming features like water elements to reduce stress and promote well-being.
18	Kanu, B.C. (2021)	Biophilic office design: Exploring the impact of a multisensory approach on human well-being	Multisensory conditions showed the greatest reduction in stress, as indicated by skin conductance levels, and improved cognitive performance, particularly in working memory. Auditory elements enhanced task-switching abilities. Visual elements alone improved environmental satisfaction and reduced stress but had a lesser impact on cognitive performance compared to multisensory conditions.	Incorporate both visual (e.g., plants, nature imagery) and auditory (e.g., nature sounds) biophilic elements to maximize stress reduction and improve cognitive performance. Multisensory environments lead to better outcomes than single-sensory biophilic designs.

19	Russo, A., & Andreucci, M.B. (2023)	Raising Healthy Children: Promoting the Multiple Benefits of Green Open Spaces through Biophilic Design	Green spaces significantly improve children's physical activity, cognitive performance, and emotional well-being. Schools with green grounds or access to nature show better academic and developmental outcomes. Biophilic design elements, such as vegetation and water features, reduce stress and promote relaxation.	Incorporate diverse green spaces such as parks, school gardens, and playgrounds with natural elements (trees, water, vegetation) to promote physical activity and cognitive development.
20	Mathur, C.A.		Healthcare facilities with well-designed urban green spaces reported faster recovery times, reduced stress levels in patients and staff, and overall improved mental and emotional well-being. Access to gardens, natural light, and water features was found to have a calming and restorative effect.	Incorporate accessible green spaces, such as gardens and courtyards, within healthcare facilities. Ensure that patient rooms have views of nature, natural light, and biophilic elements like water features to promote healing.
21	Simarmata, A. (2023)	The Creativity in the Design of Hospital Inpatient Rooms with Biophilic Criteria	Most of the designs focused on "nature in the space," incorporating natural elements like plants, natural light, and organic materials. While effective in enhancing well-being, these designs faced challenges with hospital hygiene standards. Some projects successfully integrated technology to mitigate risks, such as using artificial plants or LED screens simulating natural environments.	Use natural materials and textures, maximize natural light, and integrate visual connections to nature. Consider incorporating technological solutions, like dynamic lighting or digital nature screens, to overcome regulatory constraints on live plants.
22	Kyrkou, A. (2023)	THE ROLE OF GREENERY IN HEALTHCARE FACILITIES FOR CHILDREN	Incorporating natural elements into healthcare facilities has a positive impact on pediatric patients, reducing stress, promoting relaxation, and fostering faster recovery. Biophilic elements, such as green walls, healing gardens, and views of nature, help create a calming environment for children.	Include healing gardens, sensory gardens, green walls, and large windows with views of nature. Use natural materials in interiors and create green spaces that are accessible for both patients and staff.

23	Ekpo, N. (2023)	Exploring The Incorporation Of Biophilic Design Features In Orthopedic Hospitals To Accelerate Recovery	Incorporating biophilic elements such as natural light, greenery, and views of nature can improve patient outcomes, reduce stress, and create a more conducive healing environment. Natural materials and water features also contribute to a calming atmosphere, improving patient satisfaction and reducing recovery times.	Implementing large windows to maximize natural light, incorporating indoor plants and greenery, using natural materials in interiors, and providing views of nature to create a healing environment.
24	Avinç, G.M., & Selçuk, S.A. (2021)	AN EVALUATION OF BIOPHILIC DESIGN PARAMETERS IN HOSPITAL BUILDINGS	Hospitals with successful biophilic designs incorporated elements like natural light, views of nature, and green spaces, which contributed to reduced stress and improved patient outcomes. The study also found that hospitals using biophilic design principles had better environmental quality and supported healing processes more effectively.	Incorporate elements such as natural materials, large windows for natural light, indoor gardens, and sensory elements like water features to create healing environments that support patient recovery and staff well-being.
25	Al Khatib, I., Samara, F., & Ndiaye, M. (2024)	A systematic review of the impact of therapeutical biophilic design on health and wellbeing of patients and care providers in healthcare services settings	Biophilic design positively affects both patients and care providers by reducing stress, improving recovery times, and enhancing mental health. Hospitals that implemented biophilic features, such as natural light and greenery, reported better patient outcomes and reduced caregiver burnout.	Incorporate natural elements like light, greenery, and water features to reduce stress and create healing environments. Prioritize patient rooms with views of nature, as well as biophilic elements in common areas such as waiting rooms and staff break rooms.

26	Barnaby, J.,N.A		The study found that incorporating biophilic design elements, such as natural light, gardens, and water features, can significantly improve the well-being of elderly priests. These elements promote relaxation, reduce stress, and create a more comfortable and spiritually fulfilling environment.	Integrate natural elements such as indoor plants, courtyards, gardens, and large windows to enhance natural light. Design common areas and individual rooms with views of nature to promote mental and emotional well-being.
27	Ayuso Sanchez, J., Ikaga, T., & Vega Sanchez, S. (2018)	Quantitative improvement in workplace performance through biophilic design: A pilot experiment case study	The presence of daylight and greenery improved participants' well-being, reduced stress, and enhanced creativity. Performance improvements were particularly noticeable in creative tasks, and participants reported feeling less fatigued in environments with natural elements.	Incorporate large windows to maximize natural light, introduce greenery such as indoor plants, and use biophilic elements like water features to create a calming and productive environment.
28	Puren, N., Eddy, F., & Abdillah, W. (2021)	Biophilic Design in the Built Environment to Improve Well-Being: A Systematic Review of Practices	Biophilic design improves mental and physical well-being in indoor environments. Key elements include natural light, plants, water features, natural materials, and access to views of nature. Positive outcomes: reduced stress, increased productivity, improved mood, and enhanced creativity.	Focus on integrating natural elements like light, air, plants, and water into buildings. Design to foster connection to nature, promoting well-being. The concept of biophilic interior design linked to sustainable practices.
29	Sachs, N. A. (2018)	DESIGN OF MENTAL HEALTH CENTER WITH BIOPHILIC ARCHITECTURE APPROACH IN MEDAN CITY	Incorporating natural elements like plants, water features, and natural light significantly improves patient comfort, reduces stress, and enhances recovery. Key design features include visual and non-visual connections with nature, dynamic light patterns, natural ventilation, and the use of natural materials.	visual connection with nature, non-visual sensory stimuli, airflow variability, and the presence of water are integrated into the design of the Mental Health Center.

30	Fouda, S. M., & Fouda, M. A. (2024)	Designing for Public Health With Healthcare Design Part II: Design	green roofs, healing gardens, and daylight exposure contribute to better health outcomes. These designs foster a sense of calm, improve air quality, and encourage social interaction	Integration of nature within indoor and outdoor spaces. Use of materials that reflect natural systems, such as wood and stone, to create a calming atmosphere. Designing for safety and comfort while incorporating environmental sustainability measures.
31	Peters, T., & D'Penna, K. (2020)	Establishing a Quantitative Assessment Tool for Biophilia in Healthcare Facilities	The developed tool successfully quantified the integration of biophilia in Khoo Teck Puat Hospital, showing a high level of biophilic design that contributed to patient well-being and mental health improvements.	Incorporate natural elements (green spaces, natural light, water features) to improve health outcomes. Use WELL features such as operable windows, air quality management, and access to nature to enhance the biophilic experience.
32	Zhong, W., Schröder, T., & Bekkering, J. (2022)	Biophilic Design for Restorative University Learning Environments: A Critical Review of Literature and Design Recommendations	Biophilic design improves attention restoration, stress reduction, and cognitive function in students. Incorporating natural elements such as green views, daylight, and indoor plants enhances students' learning environments.	Enhance learning environments with nature views, indoor plants, daylight access, and natural materials to improve mental well-being and focus. Consideration of biophilic patterns like "Prospect and Refuge" and "Connection with Natural Systems" in design strategies.
33	Sabila, Y.R., Fatimah, I.S., & Anggraeni, D. (2024)	Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review	Biophilic design has substantial benefits for health and well-being, such as stress reduction, improved cognitive performance, and faster recovery in healthcare settings. Environmental benefits include energy savings, improved air quality, and increased biodiversity in urban areas.	Incorporation of natural light, greenery, water features, and natural materials in building design. Creating spaces that promote psychological restoration, stress reduction, and comfort. Specific design elements like green roofs, water walls, and natural ventilation systems.

34	Lan, Y., & Liu, Q. (2023)	Evaluation and Development of Healing Garden Based on Biophilic Design Approach in Harapan Kita Cardiovascular Hospital	The existing 5th-floor rooftop garden meets healing garden standards but requires improvements in private spaces and sensory stimulation (aroma). Sites 2 and 3 (undeveloped areas) have the potential to be developed into functional healing gardens with biophilic elements focusing on patient recovery and relaxation.	Incorporation of curved, organic patterns inspired by the cardiovascular system for circulation and layout. Zoning areas for different activities, including motoric stimulation, sensory areas, communal seating, and private spaces. Use of plants that provide visual, aromatic, and tactile stimulation, alongside hardscape elements such as benches and reflexology paths.
35	Huntsman, D.D., & Bulaj, G. (2022)	The Restorative and Contingent Value of Biophilic Indoor Environments in Healthcare Settings	High indoor green rooms had the highest ratings for preference, perceived restorativeness, and satisfaction. However, medium indoor green rooms were found to be the most cost-effective and preferable for psychological restoration.	potted plants and living walls can improve quarantine environments without over-designing.
36	Makram, A., Abdelrazek, S., & Abou Ouf, T. (2020)	Design Indicators Based on Nature and Social Interactions to Enhance Wellness for Patients in Healthcare Facilities	Access to nature, daylight, and well-designed social spaces leads to faster recovery times, reduced stress, and improved satisfaction among patients. Incorporating natural elements such as gardens, views of greenery, and daylight is essential for a healing environment.	Create hospital layouts with access to outdoor views and daylight. Incorporate therapeutic gardens, open social spaces, and family zones to promote social interaction and relaxation. Use biophilic design principles like natural materials, green walls, and sensory gardens to engage patients' senses.
37	Abo Sabaa, S.G., Abdel Azem, M., Al-Shanwany, H., & El-Ibrashy, M. (2022)	Healthy Dwelling: Design of Biophilic Interior Environments Fostering Self-Care Practices for People Living with Migraines,	Biophilic design and self-care can improve mental health, reduce stress, alleviate pain, and promote sleep quality. Incorporating elements like natural light, plants, and soundscapes into homes can enhance therapeutic effects for people with chronic conditions.	Use natural elements like wood, water, plants, and dynamic lighting to mimic outdoor environments. Integrate features that support relaxation, mindfulness, and physical activity.

		Chronic Pain, and Depression		
38	Howard, A. (2022)	ENHANCING USER EXPERIENCE IN INTERIOR ARCHITECTURE THROUGH BIOPHILIC DESIGN: A CASE STUDY OF URBAN RESIDENTIAL SPACES	Biophilic design improved well-being, reduced stress, and increased emotional satisfaction among residents. Natural elements like light and plants were highly valued across various income levels. Users with higher income showed more appreciation for biophilic elements, while lower-income participants experienced enhanced emotional benefits from these design features.	Incorporation of natural light, plants, and water features in residential architecture. Use of natural materials and open spaces to foster a stronger connection with nature.
39	Sal Moslehian, A., Roös, P.B., Gaekwad, J.S., & Van Galen, L. (2023)	The death of modern hospitals: Towards a comprehensive approach for restorative healthcare environmental design	Biophilic and salutogenic design strategies, such as incorporating natural light, views of nature, and healing gardens, lead to improved patient recovery, reduced stress, and better overall well-being.	Implement restorative environmental design elements like healing gardens, natural light, and social interaction spaces. Use biophilic patterns and materials to create environments that promote psychological restoration and reduce stress for hospital users.
40	Tekin, B.H., & Urbano Gutiérrez, R. (2023)	Developing a new approach to healthcare facility design through biophilic design practices for palliative patients	Key biophilic elements include visual and non-visual connections to nature, natural light, water features, and natural materials.	Incorporate non-rhythmic sensory stimuli like water features or rustling leaves to promote calmness. Ensure thermal and airflow variability for comfort, and introduce dynamic lighting to mimic natural daylight patterns.
41	Bilgic, N. (2019)	Evaluating Intention and Effect: The Impact of Healthcare	Design elements that aligned with wellness and social interaction improved patient and staff	Incorporation of natural light, access to nature, communal spaces, and views of the city and community were key strategies to

		Facility Design on Patient and Staff Well-Being	experiences, but certain areas, such as neighborhood connection, saw mixed results.	enhance well-being. Outdoor terraces and public spaces were critical for promoting social interaction and community connection.
42	Blackhurst, B. (2022)	ARCHITECTURAL BIOPHILIC PRINCIPLE THAT STIMULATES PSYCHOTHERAPY OF NEUROLOGY PATIENTS IN KANO	The most significant biophilic elements for promoting the restoration of neurology patients were landscape and vegetation (RII 0.819), natural ventilation (RII 0.812), and natural lighting (RII 0.745).	Prioritize the inclusion of landscape and vegetation around hospital premises to provide serene and calming environments. Ensure proper natural ventilation and the use of natural lighting to enhance patient comfort and reduce stress. Integrate outdoor spaces such as healing gardens and green areas for patients to relax and recover.
43	Davidson, D. (2013)	Small Garden, Big Impact: Emotional and Behavioral Responses of Visitors to a Rooftop Atrium in a Major Hospital	Even a small healing garden (1,500 sq. ft.) had a strong impact on visitors' perceptions of the hospital.	Incorporate healing gardens, even small ones, into hospital designs. Gardens do not need to be large to have a positive effect on visitors. Ensure easy access and good visibility from waiting areas to enhance the healing garden's impact.