

Review

The healing power of nature. Biophilic design applied to healthcare facilities

L. Miola¹, A. Boldrini¹ and F. Pazzaglia^{1,2}

Healthcare facilities and hospitals are environments where stress and anxiety are commonly experienced. Empirical evidence highlights the positive impact of incorporating natural elements in these settings on health and well-being for individuals and communities. This article reviews recent literature on the application of biophilic design in healthcare environments, examining its beneficial effects on both individual and social well-being. The main principles of biophilic design are outlined and summarized. Recent systematic and scoping reviews confirm that biophilic principles enhance patient well-being, support recovery, and improve the overall quality of healthcare environments. Experimental studies further demonstrate that higher levels of biophilic integration, including virtual nature experiences, are particularly effective in reducing stress and enhancing perceived care quality. Moreover, the literature has also highlighted the benefits of biophilic and healthcare environments on the social dimensions of well-being. Future studies should further explore how biophilic design influences social interactions and well-being, for both patients and healthcare professionals.

Addresses¹ Department of General Psychology, University of Padova, Via Venezia, 8, 35131, Padova, Italy² Interuniversity Research Center in Environmental Psychology (CIRPA), University of Rome "La Sapienza", via dei Marsi 78, 00185, Rome, ItalyCorresponding author: Miola, L. (laura.miola@unipd.it)**Introduction**

An increasingly large body of literature have demonstrated that the interactions between individuals and environments can produce positive or negative effects depending on the type of spaces (e.g., green vs urban environments) influencing emotional states, thoughts,

behaviours up to physical health [1–6]. In everyday environments, individuals can encounter psychological and physiological stress. Notable examples are healthcare settings, which encompass ambulatory clinics, long-term care centers, rehabilitation facilities, nursing homes, and hospices and have been recognized as major sources of stress for both patients and healthcare professionals [7–12]. Stress in these settings is intertwined with experiences of suffering, illness or pain, lack of privacy, exposure to unfamiliar or anxiety-inducing sounds, inadequate lighting, and unpleasant odors [7,13]. Such stressors can exacerbate anxiety and concern for health, leading to broader physiological effects, including impacts on the immune, inflammatory, and cardiovascular systems [14–17]. Exposure to nature can reduce stress, and its mechanisms are explained by Ulrich (1983) [18] and the Stress Reduction Theory (SRT). SRT is an environmental psychology theory suggesting that exposure to natural environments facilitates both psychological and physiological recovery from stress. According to this theory and subsequent experimental evidence, nature has been shown to reduce physiological markers of stress, such as blood pressure, heart rate, and cortisol levels [19–22]. Additionally, nature tends to elicit positive emotions like calmness and contentment, effectively replacing negative states such as anxiety and tension, enhance resilience, and improve individuals' ability to cope with everyday challenges [23–28], factors that can be especially crucial for patients. As a result, healthcare patients and professionals, are particularly well-suited to benefit from the restorative effects of nature. Therefore, integrating nature into healthcare environments is essential for fostering psychological and psychophysiological well-being.

The positive effects of nature can be explained by psychological need to connect with natural elements and living beings explained through the Biophilia Hypothesis such as the innate connection between humans and nature biologically present in human genes [29,30]. Biophilic design, therefore, incorporates natural aspects into constructed and built spaces, creating environments that enhance human well-being by fostering a deeper connection with nature [31,32]. It is noteworthy, however, that beyond individual well-being and perception, biophilic design and nature-based solutions are also examined from a community perspective (see Figure 1). Research in this area often explores collective

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Figure 1



Healthcare biophilic design components

Note. Well-being benefits in the context of biophilic design in healthcare. Photo downloaded from Freepik (www.freepik.com).

preferences by assessing which benefits are most valued at different social scales, such as communities [33,34], or specific demographic groups, like older adults [35,36]. In this review, we will explore the key principles of biophilic design and delve into the latest research on its impact in healthcare settings. Specifically, we will examine how biophilic design fosters psychological well-being, enhances general health, and supports the social dimensions of well-being. Our goal is to provide an overview of the current state of the art, focusing on studies from the past four years, their findings on the effects of biophilic design, and the strengths and limitations of the existing literature.

Biophilic design and its principles

Biophilic design is a form of design that incorporates natural elements on built environments, integrating biophilia into the field of architecture [30]. It tries to embed the principles of connection with nature into the design of built environments, spaces that traditionally disconnect us from the natural world in which we

evolved. The adoption of biophilic design can not only enhance the environmental conditions of a building and improve people's well-being in the short term, but it also has the potential to foster a resilient and sustainable natural community in the long term [37]. The principles of biophilic design were operationalized in 15 patterns proposed by Terrapin Bright Green, a corporation focused on environmental issues and strategic planning [38]. The patterns aim to inform, guide and assist in the design process and can be applied in various ways to both indoor and outdoor settings allowing architects, designers, environmental psychologists and experts to clearly define the patterns of biophilia and to incorporate its advantages into design practices. Such patterns can be categorized in: *Nature in the Space*, that is direct interaction with natural elements (e.g., plants, water, light) through seven patterns like visual connection with nature and presence of water; *Natural Analogues*, defined as indirect nature via imitative designs (e.g., natural shapes, materials) with patterns like biomorphic forms; *Nature of the Space*, such as spatial configurations evoking

exploration and safety, with four patterns like prospect, refuge, and risk/peril. These patterns guide designers in creating nature-inspired spaces that improve environmental conditions and user satisfaction.

Applications of biophilic design in healthcare facilities

Overall, from 2017 to 2023, biophilic design research has experienced substantial growth and significant expansion in literature databases [39]. In this section, we reviewed the existing literature of the application of biophilic design in healthcare facilities (including hospitals, rehabilitation centers, and residential care homes, etc.) to improve well-being. The goal was to explore how biophilic principles have been recently integrated into these settings to enhance patient and healthcare professionals' well-being, support recovery, and improve the overall environmental quality of healthcare spaces. To achieve this, we conducted a literature search on the Scopus database, focusing on publications from the last four years (2020–2024). For the search we used the keywords “biophilic” OR “biophilia” AND “design” AND “healthcare”, to ensure the inclusion of relevant studies addressing both theoretical frameworks and empirical applications of biophilic design in healthcare facilities. First, we examine comprehensive systematic and scoping reviews on the topic. A recent systematic review of literature confirms previous findings [19,40] indicating that biophilic and nature-based design interventions in a variety of facilities are associated with reduced hospitalization times, lower patient mortality rates, decreased pain levels, faster recovery, reduced anxiety, and improved experiences for patients, their families, and healthcare staff. However, it should be noted that this review did not include a meta-analysis to quantify these impacts [7]. Another systematic review provided a more targeted analysis identifying specific biophilic criteria critical for different groups within cancer care settings. The findings revealed that for outpatients, key factors included air quality, daylight, thermal comfort, and a welcoming and relaxing atmosphere. For inpatients, the essential elements were a sense of relaxation, comfort, prospect-refuge, security and protection, daylight, and views of nature. Finally, healthcare staff prioritized privacy, refuge, and quietness [41]. A scoping review was conducted to summarize the positive effects of nature-based design specifically for stroke patients. The review highlighted that most studies on this population employed nature-based practices for rehabilitation. Therefore, therapists frequently utilized gardens and outdoor spaces as extensions of therapeutic environments, integrating them into activities such as physical training, sensory stimulation, individualized therapies, and meaningful, engaging tasks. These settings also promoted socialization, enhanced motivation, improved mood, and supported overall mental well-being. While these

findings are noteworthy, the review did not address specific design features or elements and the impact of engagement in other aspects of nature-based interventions [42]. Another scoping review on hospitals reinforced the results on benefits of nature-based design, emphasizing modest but significant improvements primarily in psychological outcomes such as anxiety, depression, pain, and patients' satisfaction. This study also provided deeper insights regarding the duration of exposure and type of nature. Greater benefits were observed with prolonged exposure and higher levels of immersion in nature, such as multisensory experiences facilitated by technologies like virtual reality (VR) [43]. The last scoping review on hospitals highlighted the challenges in incorporating indoor plants. The available literature discusses the potential risks associated with direct exposure to potting soil or flower vase water and the inhalation of fungal or bacterial pathogens released from soil when is dry or disturbed. However, no definitive evidence supports these claims due to methodological limitations. In other words, current evidence does not establish a clear link between microorganisms in plant soils or vase water and the occurrence of hospital-acquired infections [44].

Finally, some studies investigated the effect of biophilic features through experimental studies in the healthcare context by comparing biophilic and control conditions in real or virtual healthcare environments. One study experimentally compared healthcare rooms with low, medium or high biophilic levels during COVID scenarios. The findings indicate that rooms with biophilic interventions showed greater impacts on preference, perceived restorativeness, satisfaction, and willingness to pay (WTP; maximum amount of money people are willing to pay for the hypothetical scenario change) compared to the non-biophilic room. Among the three levels of biophilic intervention (low, medium and high), the high indoor green environment had the strongest effects, while the low indoor green room had the weakest [45]. Another study applied machine learning and EEG data to determine changes in mood in response to three different biophilic designs of hospital rooms. The results showed that applications of biophilic interior designs, such as a plant wall or digitally presented nature, had a positive effect on emotions and reduced anxiety states [46]. Moreover, a study suggested that compared to other healthcare areas, the waiting room has the greatest potential to apply biophilic strategies [47]. The effects of waiting rooms have been studied using virtual realistic biophilic environments, testing whether natural materials, or the presence of nature or a combination between the two has a role on anxiety, perceived waiting time and service quality, comparing them to a non-biophilic version of the same waiting room. The results showed that natural elements have a positive influence on patients in terms of reduced anxiety levels, lower perception of waiting times and

perception of a better service quality. Specifically, the combination between the natural material and plants seem to show the higher positive impact on participants [48]. Regarding the social dimension of well-being, it is essential to highlight that characteristics of the hospital environment, such as the presence of gardens within the facility, play a crucial role in enhancing social support by facilitating communication and encouraging social interaction [40]. Urban green spaces, whether outdoor or indoor, provide settings where people establish connections, participate in activities, and interact with their surroundings [49]. The importance of green environments for social well-being has been confirmed by previous literature in different settings. The inclusion of greenery in indoor settings like offices, schools, healthcare centers can enhance the quality of social spaces, promote communication and collaboration, and help reduce aggression, inequalities and increase feelings of social safety [49–51].

The social dimension is not the primary focus of existing studies in healthcare settings; nevertheless, it emerges as a secondary yet significant benefit of biophilic design. This approach has been associated with increased workplace satisfaction, improved productivity, and enhanced employee engagement [7]. Nevertheless, it remains unclear whether such an environment can actively foster and strengthen relationships between caregivers and staff and further research is needed to explore the potential impact of biophilic design on social interactions within professional settings, particularly in healthcare environments.

Limitations and future directions

Overall, recent studies on biophilic healthcare confirm the benefits of biophilic environments for patients, families and staff's well-being, however, some methodological limitations should be considered. A key gap in the literature is the lack of rigorous meta-analyses alongside systematic reviews that quantify the effects of biophilic interventions on patients' well-being. Such analyses would provide a more precise assessment of the overall impact and variability of these interventions. Moreover, the differential effects of biophilic environments on distinct groups, including inpatients, outpatients, and staff, remain insufficiently quantified. Further research is needed to identify the most beneficial biophilic elements or pattern for patients with diverse characteristics and medical conditions. For instance, understanding whether access to natural light, views of greenery, or sensory stimulation is more impactful for patients with chronic conditions versus those receiving acute care could refine biophilic design strategies. Differentiating these effects is essential not only for studying various patterns but also for understanding their interactions, for example the relationship between greenery and light, to better tailor interventions to

specific patient needs. Regarding experimental studies, most research is conducted in single environments, limiting the ability to generalize findings. Future studies should examine multiple healthcare settings and systematically vary their characteristics.

Finally, in healthcare environments, biophilic elements may contribute to strengthening patient–provider relationships by improving staff well-being and job satisfaction, which could, in turn, enhance the quality of interactions with patients and their families. Additionally, biophilic design may encourage more frequent and prolonged visits from family and friends by creating a more welcoming and comfortable atmosphere, thereby reinforcing patients' social support systems. Beyond direct social interactions, exposure to nature in built environments has been linked to greater feelings of social connectedness. Future research should further explore these dynamics by assessing whether the impact of biophilic design on social interactions and perceived social support in healthcare settings is a direct effect or an indirect consequence of stress reduction. Understanding these mechanisms could provide valuable insights into how biophilic design contributes to a more holistic approach to health and well-being.

Author statements

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Declaration of competing interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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- * of special interest
- ** of outstanding interest

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Further reading

7. A systematic review on studies from 2010 to 2023 on the impact of biophilic design in patients and caregivers. This review confirms previous findings on the positive effects on patients, families, and staff in healthcare settings.
8. This study explored the stressors associated with cognitive and behavioral stress reactions, burnout symptoms, health status, quality of sleep, job satisfaction, and intention to leave the organization and the profession among health professionals. The main findings revealed that the incompatibility of health professionals' work and private life was significantly associated with their stress reactions, job satisfaction and intention to leave.
32. This meta-analysis focuses on experimental studies that explored the emotional impacts of human exposure to natural and urban environments. The findings indicated that exposure to natural environments had a medium to large effect on both increasing positive affect and decreasing negative affect, supporting the emotional dimension of the biophilia hypothesis.
41. This systematic review aimed at identifying biophilic design parameters specifically relevant to three different user groups: outpatients (fresh air, light-daylight, thermal comfort, welcoming and relaxing), inpatients (feeling relaxed and comfortable, prospect refuge, security and protection, light-daylight, view), and staff (privacy-refuge, quietness).
42. This scoping review aimed at exploring the application of nature-based design in stroke rehabilitation facilities. The findings highlight methodological variations and identify gaps in the existing literature.
43. This scoping review examined existing literature on the impact of nature exposure on the progression and outcomes of acute hospitalizations. Exposure to nature during acute hospital stays seems to provide a modest therapeutic benefit, primarily influencing psychological factors such as anxiety, depression, pain, and overall patient satisfaction.
44. This scoping review explored the potential risks and benefits of incorporating natural indoor plants into the design of healthcare facilities. Current findings lack sufficient scientific evidence to determine how, and to what extent, indoor plants might contribute to hospital-acquired infections.