BUHealth

Volume 2 Article 9

2024

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Human beings increasingly lack interaction with nature in modern civilizations due to urbanization and lifestyle preferences. Research has shown that biophilic elements, like greenery, natural light, etc., create healing environments that alleviate stress, enhance emotional well-being, and promote recovery. This forms the basis of the *Biophilic hypothesis*, which states that being around nature is imperative for the well-being of humans. This article explores the transformative potential of biophilic design in healthcare settings, explaining its profound impact on patient outcomes and well-being. Several bodies of research prove that introducing biophilic elements in hospitals has led to shorter postoperative stays, reduced administration of pain relief drugs, lower stress levels for people with chronic diseases, and improved overall well-being of patients. Using Virtual Reality (VR) to simulate biophilic environments has shown promise in significantly reducing patient stress and anxiety levels. The fusion of architecture and nature holds immense promise in transforming healthcare spaces into vibrant ecosystems that prioritize holistic patient well-being.

Keywords: *biophilic design, healthcare architecture, patient outcomes, healing environments*

"In watching diseases, both in private houses and in public hospitals, the thing which strikes the experienced observer most forcibly is this, that the symptoms or the sufferings generally considered to be inevitable and incident to the disease are very often not symptoms of the disease at all, but of something quite different – of the want of fresh air, or of light, or of warmth, or of quiet, or of cleanliness, or of punctuality and care in the administration of diet, of each or of all of these."[1] These words by Florence Nightingale, the founder of modern nursing and a healthcare visionary, perhaps position her as the pioneer in recognizing a link between holistic care and the patient's surroundings.

The architects of Khoo Teck Puat Hospital in Singapore, winner of the first-ever Stephen R. Kellert Biophilic Design Award, have integrated nature and architecture beyond theory, finding real-world applications in the daily experiences of patients and healthcare staff. It is far more than simply a hospital; it's an ecosystem where lush greenery and water features create a tapestry of a healing environment that transcends clinical care. The hospital's commitment to sustainability is reflected in its flourishing green spaces, with diverse plant species, water habitats, and natural ventilation by channeling prevailing winds using aluminum fins or "Wind Wall."[2] Its hallways are lined with a thriving ecosystem of native tropical plants and aquatic life living in harmony in a design inspired by the natural world. Surveys suggest that the hospital consistently outperforms all other hospitals in Singapore in terms of public satisfaction.[2]

The foundational premise guiding Khoo Teck Puat Hospital's unique approach to healthcare architecture is *The Biophilia hypothesis*, which integrates natural systems and processes into the built environment. According to this hypothesis, humans need to have a relationship with nature since it is fundamental to their well-being.[3] Unfortunately, in modern civilizations defined by urbanization, architectural style, and lifestyle preferences, there is often little human interaction with the environment. Therefore, biophilic design aims to incorporate natural elements and processes into the built environment, providing people with the essential exposure to nature they require.[3]

In his book, Stephen R. Kellert, who helped pioneer this innovative concept, mentions several studies relevant to understanding the influences of biophilic elements on patients, families, and staff, such as nature views and daylight in healthcare settings. These studies demonstrate that evidence-based biophilic design can yield positive outcomes, like stress reduction, enhanced emotional well-being, pain relief, and improved health outcomes.[4] Acknowledging the inherent limitations in these studies, Kellert emphasizes the vital lesson of drawing inspiration from the natural world, a practice that has been a part of human history for millions of years. Humans have a natural appreciation for beautiful design and a desire to copy the wonders of nature, which has led to the development of biomimicry.[4]

Creating these healing environments in healthcare becomes critical since it significantly influences patient outcomes. According to Park and Mattson, patients in hospital rooms with plants and flowers had considerably more positive physiological responses as compared to patients in the control room, as shown by lower systolic blood pressure and reduced pain, anxiety, and exhaustion.[5] In their research, Iyendo and colleagues demonstrated that patients with views of trees had shorter postoperative stays, decreased administration of pain relief drugs, and better outcomes as compared to patients who had views of brick walls.[6] These studies not only

prove the profound influence of nature-inspired settings but also highlight the transformative power that intentional design holds in healthcare.

The need for biophilic design in healthcare facilities is especially important for people grappling with chronic illnesses who often suffer from psychological distress, fatigue, anxiety, or depression. In 2023, Tekin and colleagues conducted a systematic review which examined more than thirty peer-reviewed research studies from across nations to establish various parameters integral to the biophilic design, including light, air, ecosystems, thermal and airflow variability, etc.[7] It looked at several compelling pieces of evidence proving that biophilic design can significantly impact supportive care, especially for patients suffering from chronic diseases. Additionally, being near nature lowers stress levels, induces pleasant mood swings, and promotes emotional, mental, and spiritual health. The study emphasized how crucial it is to consider the wants and needs of different user groups, including staff, outpatients, and inpatients. Further, it demonstrated the importance of factors like daylight and fresh air, thermal comfort, quietness, security, and protection. Therefore, using biophilic design concepts becomes evident as a transformative strategy as well as a humane response to the special difficulties this specific population faces in healthcare environments. The application of biophilic design is not limited to medical settings. It can be applied to people with chronic conditions in residential settings. People with medical problems like cancer and chronic obstructive pulmonary disease (COPD) may benefit clinically from the integration of biophilic components in home care settings. This includes enhancing the quality of sleep and lowering despair, anxiety, and chronic pain; it also involves using music to lessen symptoms of depression.[8]

Although the use of biophilic design in hospitals is growing, it may take several decades to be widely implemented across healthcare facilities. Nonetheless, there are alternative approaches that have been scientifically proven to improve patient wellbeing by making small adjustments. Rather than a full overhaul like Khoo Teck Puat Hospital's biophilic design, meaningful improvements can start smaller, even in patient rooms. For instance, Laursen and colleagues examined how visual environment interventions such as natural artwork, decorative plants, and sunlight exposure affected patients' stress levels. The results showed that patients who underwent these visual therapies saw a significant decrease in stress and anxiety.[9] Notably, patients who were placed in rooms with biophilic design features reported lower stress levels, less pain, and fewer painkillers. These outcomes suggest that the visual components of biophilic design, such as incorporating decorative plants and windows in patient rooms, can offer a simple yet effective starting point for enhancing patient well-being.

Another approach to integrating biophilic elements into healthcare settings involves the use of Virtual Reality (VR). This technology offers a means to introduce biophilic elements to patients artificially. In 2020, Yin and colleagues explored the use of VR alongside wearable biomonitoring sensors to examine the positive effects of biophilic interior environments on patient outcomes. The research, which comprised of one hundred participants, demonstrated that VR exposure to biophilic environments facilitated recovery by considerably lowering stress and anxiety levels on both a psychological and physiological level.[10] This immersive experience, simulating natural views and indoor green spaces, proved instrumental with patient recovery. These findings demonstrate the potential of incorporating biophilic design components via VR to enhance patient outcomes.

The remarkable potential of the biophilic design can be seen in the 150-year long journey from Florence Nightingale to the ground-breaking Khoo Teck Puat Hospital in Singapore. Over the years, the overwhelming body of research proves that addressing the patient's emotional, mental, and environmental aspects is as important as managing the physical aspects. Although it may take a few more decades to implement the idea extensively, research indicates that even small steps might result in substantial advancements. To open possibilities further, researchers should dive deep to explore the maximum potential of VR to simulate natural environments. The common thread is the healing power of nature, whether through VR technology or architectural interventions like green spaces. The fusion of architecture and nature has the power to completely reshape healthcare spaces, turning them from sterile environments into dynamic ecosystems.

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