Biophilic Design Elements for Enhancing Social Participation and Active Ageing in Senior Living Environments Via Systematic Literature Review

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Abstract

Ageing population is growing rapidly, necessitating innovative strategies to enhance the quality of life for older adults. One such approach is biophilic design, which integrates natural elements into built environments to promote physical, psychological, and social well-being. This study conducts a systematic literature review to explore the role of biophilic design elements in fostering social participation and active ageing in living environments. The review synthesizes findings from previous research to identify key design attributes that encourage community interaction, enhance cognitive function, and improve overall well-being among the elderly. Key biophilic elements identified include access to natural light, indoor and outdoor greenery, water features, and multi-sensory environments that stimulate engagement. Additionally, the presence of communal green spaces, nature-inspired aesthetics, and walkable landscapes has been shown to support mobility, reduce stress, and encourage social interactions among older residents. The findings emphasize that integrating biophilic principles into senior housing and care facilities can lead to healthier, more socially connected ageing experiences. This paper highlights the importance of designing senior living spaces that go beyond basic functionality to actively promote social engagement and well-being. The study provides recommendations for architects, urban planners, and policymakers to incorporate biophilic strategies that enhance the quality of life for ageing population. Future research should further explore culturally specific biophilic adaptations and empirical evaluations of their impact on elderly well-being. By fostering nature-based interactions, biophilic design can play a vital role in creating inclusive, age-friendly environments that support active ageing fundamental knowledge.

Keywords: Biophilic design, Active ageing, Social participation, Senior living environments, Systematic literature review

Introduction

Biophilic design, which incorporates natural elements such as light, vegetation, and water into the built environment, can play a crucial role in improving the well-being of seniors by fostering a connection to nature, which has been shown to reduce stress, improve mood, and promote healing (Kellert & Calabrese, 2015; Hamid et al., 2018). In senior living environments, the application of biophilic design faces obstacles such as limited green spaces, urban density, and a lack of awareness about its benefits among designers and policymakers (The Number of Tourist Arrivals, Governance and Their Impact on Threatened Bird Species: Worldwide Evidence, 2018) (Hamid et al., 2018). Integrating biophilic design principles can create spaces that support the emotional and social well-being of residents, thereby addressing issues of social isolation and inactivity (Ryan et al., 2014; Hamid et al., 2018; Browning & Ryan, 2020).

Designing senior living spaces that promote social participation and active ageing is a critical challenge facing the ageing population. Neuroarchitecture, which explores the relationship between architectural design and brain function, can offer valuable insights to enhance these environments (Lee & Park, 2021; Zhao et al., 2022), by addressing both psychological and physiological needs (Eberhard, 2009). By understanding how design elements impact cognitive and emotional processes, we can create spaces that cater to the psychological and physiological needs of elderly residents (Sternberg, 2009; Zhao et al., 2022; Sabaa et al., 2022). Therefore, integrating biophilic design with neuroarchitecture principles presents a comprehensive approach to transforming senior living environments into engaging, supportive spaces that enhance the quality of life for seniors.

The elderly housings are not well designed to cater to the needs of the elderly community when it comes to including architectural spaces for communal integration, fulfilling social and psychological needs, and well-equipped design for personal spaces. Therefore, most of the elderly housing structures only bypass the standard typical housing, without a practical feasible architectural solution that would cater to the elderly community's needs (H. Ismail, Halil, Abidin & Hasim, 2020). Furthermore, many senior living facilities do not incorporate greenery and natural elements into their living spaces and communal areas (Aung et al., 2018; A. S. Ismail et al., 2021). Consequently, elderly residents may become passive and disengaged from their surroundings and the built environment (A. S. Ismail et al., 2021). The lack of biophilic design, an approach that seeks to connect building occupants more closely to nature, in these spaces can adversely affect mental well-being and contribute to various health issues (Evans, 2003; Spencer & Baum, 1997; Stigsdotter, 2005; Martin et al., 2015; Asim et al., 2020). Therefore, the absence of greenery and natural elements in senior living design represents a missed opportunity, given the growing body of research highlighting the importance of natural elements for human health, particularly for active ageing (Boffi et al., 2021).

The ageing population is a growing global phenomenon, with Malaysia projected to become an aged nation by 2040, when 15% of its population will be 65 years and older (Department of Statistics Malaysia, 2020). As life expectancy increases, ensuring the well-being of older adults becomes a critical societal challenge. Traditional senior living environments often prioritize medical care and basic functionality but may overlook the importance of social

engagement, mobility, and psychological well-being (WHO, 2015). Active ageing, a concept promoted by the World Health Organization (WHO), emphasizes maintaining autonomy, health, and social participation throughout the later stages of life (WHO, 2002). One emerging approach to enhancing active ageing is biophilic design, which integrates natural elements into the built environment to promote well-being and social interaction (Kellert et al., 2011).

Biophilic design has been widely recognized for its ability to improve cognitive function, reduce stress, and enhance overall mental and physical health (Browning, Ryan, & Clancy, 2014). Studies suggest that access to natural light, green spaces, water features, and nature-inspired interiors can positively impact elderly residents by fostering a sense of connection to their surroundings (Ulrich, 1984; Kaplan & Kaplan, 1995). Furthermore, well-designed outdoor environments encourage mobility and social engagement, which are essential for preventing isolation and loneliness among older adults (Sugiyama et al., 2009).

Despite growing evidence supporting biophilic design in healthcare and workplace settings, limited research explores its role in senior living environments, particularly in Malaysia (Tan et al., 2021). Given the country's cultural and climatic context, there is a need to identify and adapt biophilic principles that enhance active ageing and social participation. This paper conducts a systematic literature review to examine key biophilic design elements that contribute to social well-being and active ageing in Malaysian senior living environments. By synthesizing existing research, this study provides valuable insights for architects, urban planners, and policymakers in creating age-friendly spaces that foster inclusivity, well-being, and social connectedness.

Literature Review

By compiling previous research studies, it has become evident that there are various design frameworks derived from the theories of biophilic design. Over the past two decades, there are nine different Biophilic Design literature reviewed design frameworks incorporating nature experiences into built environment and can be categorized into 15 different patterns of biophilic design (Patel et al., 2022). These patterns are classified into three main categories (refer to Table 1), which provide a framework for a pattern language for biophilic design (Browning & Ryan, 2020).

Pattern Language for Biophilic Design		
Nature in Space Patterns	**Natural Analogues**	**Nature of the Space Patterns**
Direct experiences of nature within the built environment.	Experiences of nature in a more indirect or representational manner within the built environment.	Replicating common spatial experiences found in nature.

Table 1: A framework for a pattern language for biophilic design (Browning & Ryan, 2020)

The first category of biophilic patterns is “Nature in The Space Patterns,” which involves direct experiences of nature within the built environment. This can include things like looking out a window to see a natural view, being able to smell potted herbs, feeling a breeze blowing through a space, or experiencing the shifting of natural light patterns created by leaves moving in the wind. The second category of biophilic design patterns is “Natural Analogues”, which refers to experiences of nature in a more indirect or representational manner within the built environment. This could involve incorporating elements such as floral patterns on pillows, a column designed to resemble a natural form, a carpet pattern that resembles abstracted moss or a flooring pattern that incorporates fractal geometry. The third category of biophilic design patterns is called “Nature of the Space Patterns” and involved replicating common spatial experiences found in nature. This includes features like a window at the end of a hallway, a secluded booth in a restaurant, a partition with peekaboo cut-outs, or a transition from a low-ceilinged entry to a high-ceilinged lobby (Browning & Ryan, 2020). Table 2 shows the 15 patterns of biophilic design which have been used as a reference in many architectural studies, which will be explored in the following chapter.

15 Patterns of Biophilic Design		
Nature in Space Patterns	**Natural Analogues**	**Nature of the Space Patterns**
1. **Visual Connection with Nature –** A view of an element of nature, living systems, and natural processes. 2. **Non-visual**	8. **Biomorphic Forms and Patterns -** Symbolic references to contoured, patterned, textured, or numerical arrangements that	11. **Prospect –** An unimpeded view over a distance for surveillance and decision-making. 12. **Refuge -** A place for withdrawal from

Connection with Nature – Auditory, haptic, olfactory, or other stimuli that engender a deliberate and positive reference to nature, living systems, and/or natural processes.

3. **Non-Rhythmic Sensory Stimuli –** Stochastic and ephemeral connection with nature that may be analyzed statistically but not precisely predicted.
4. **Thermal and Airflow Variability** – Changes in air temperature, relative humidity, airflow, and/or surface temperatures that mimic natural environments.
5. **Presence of Water –** A condition that enhances the experience of a place through seeing, hearing, or touching the water.
6. **Dynamic and Diffuse Light** – Varying intensities and colors of light and shadow that change over time to create conditions similar to those that occur in nature.
7. **Connection with Natural Systems –** persist in nature.
9. **Material Connection with Nature –** Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place.
10. **Complexity and Order –** Rich sensory information that adheres to spatial hierarchies similar to those encountered in nature.

environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

13. **Mystery –** The promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to venture deeper into the physical environment.
14. **Risk/Peril –** An identifiable threat coupled with a reliable safeguard.
15. **Awe –** Stimuli including other biophilic patterns that defy an existing frame of reference and lead to a change in perception.

	Awareness of natural processes, especially seasonal and temporal change characteristic of healthy ecosystems.

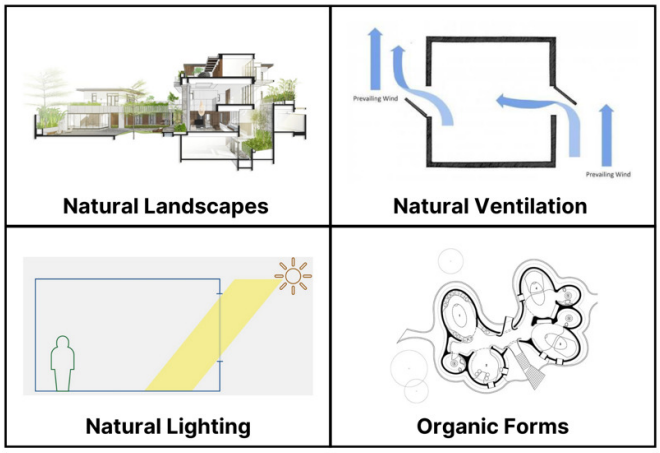

Figure1: Four basic elements of Biophilic Design (Asim et al., 2020)

The biophilic design depends on four basic elements as illustrated in Figure1, natural ventilation, natural lighting, organic forms, and natural landscapes (Asim et al., 2020), which reinforce the connection between human and their immediate environment (Duzenli et al., 2017).
Several senior living environments have successfully implemented biophilic design principles to enhance social participation and promote active ageing.

Visual Connection

The presence of meaningful views of nature in senior living can have significant benefits for the occupants (Peters & Verderber, 2021). Browning et al. (2014) define this pattern as having a view that includes elements of nature, living systems, and natural processes. Studies on biophilic design strategies have consistently supported the positive psychological well-being effects of visual connectivity with nature, as tabulated in Figure1 by Asim et al., (2020).

Kellert (2008) emphasizes the importance of views and vistas, stating that people prefer views of the outdoors rather than looking into other interior spaces. These views should incorporate natural features and vegetation, and the scale should be compatible with human experience. Views that are not overly restricted, unfamiliar, out of scale, or positioned too high above the occupants' typical viewing plane tend to be more satisfying (Peters & Verderber, 2021).

Various studies across different disciplines have shown that incorporating views, plants, and engagement with nature can enhance the experience of residents in senior living (Peters & Verderber, 2021). The presence of plants and opportunities for nature engagement can reduce sensory deprivation and positively contribute to the well-being of not only the elderlies, but also their caregivers (Peters & Verderber, 2021).

Figure 2: Kipling Acres Long Term Care Home, Toronto, Canada, 2015 by Montgomery Sisam Architects (Peters & Verderber, 2021).

An example of senior living that incorporates meaningful visual connections to nature is Kipling Acres, a nursing home in Toronto, Canada (Peters & Verderber, 2021). The facility includes a living wall inside the main entrance, offering access to indoor greenery, and a landscaped exterior courtyard. The courtyard serves as a space where residents interact with children from an on-site childcare center, promoting socialization between different age groups and the broader community (Peters & Verderber, 2021).

Overall, incorporating views of nature, providing exterior amenities, and designing landscape spaces in senior living can enhance residents' well-being, foster socialization, and promote engagement with the natural environment (Peters & Verderber, 2021; Zhao et al., 2022).

Non-Visual Connection

Non-visual connection to nature is an essential aspect of biophilic design, as highlighted by Browning et al. (2014). This biophilic pattern encompasses auditory, haptic, olfactory, or gustatory stimuli that evoke a deliberate and positive association with nature, living systems, or natural processes. Examples of biophilic interventions include incorporating potted plants, bird feeders, courtyard gardens, green walls, and vegetable roofs (Peters & Verderber, 2021).

Other studies also emphasize the significance of non-visual connections with nature in biophilia. The sensory benefits of engaging with plants and including greenery in the built environment are sources of enhanced comfort, satisfaction, well-being, and performance (Kellert, 2008; Peters & Verderber, 2021). Research in nursing home environments demonstrates the advantages of exposure to and caring for plants. Studies conducted in nursing homes found that residents who were given control over their surroundings and plants to care for showed improved health status compared to those without such autonomy (Mallers et al., 2013; Peters & Verderber, 2021). In addition, the Non-Visual Connection with Nature pattern, which incorporates natural sounds, textures, and scents, can create a more engaging and stimulating environment that attracts people to common spaces, enhancing opportunities for social interaction (Ma et al., 2022).

Figure 3: Erika Horn Residential Care Home, Austria, 2015 by Dietger WissounigArchitekten (Peters & Verderber, 2021).

The Erika Horn Residential Care Home in Graz, Austria, exemplifies the maximization of non-visual connections to nature. The design, created by Dietger Wissounig, features seamless and transparent indoor-to-outdoor spaces that provide graduated spatial sequences accessible to elderly residents. The care home incorporates nature throughout its indoor spaces, utilizing wood and raised garden beds in atriums as light wells and social activity areas. It includes a large garden, loggias, and adjacent protected activity spaces, with a vineyard acting as a transitional link to a nearby civic park (Peters & Verderber, 2021).

Natural Ventilation

Keller (2008) emphasizes the importance of fresh air in biophilic design, advocating for natural ventilation whenever possible as it provides enhanced air movement, sensory stimulation (such as feeling and smell), and aesthetic appeal (Peters & Verderber, 2021). Browning et al. (2014), focus on creating indoor environments that mimic natural conditions such as subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures.

Indoor environmental quality, including appropriate levels of thermal, acoustic, visual, and air quality, is crucial for the health, well-being, and comfort of occupants in Long-Term Care (LTC) settings, which is a type of senior living (Peters & Verderber, 2021). Poor-quality indoor environments have been linked to serious illnesses, and the occurrence of sick building syndrome (SBS) has been associated with various healthcare facilities, including LTC facilities (Peters & Verderber, 2021). Inadequate ventilation has been identified as a primary contributor to building-related problems and the occurrence of SBS symptoms. Adequate ventilation and access to outdoor spaces, such as operable windows and balconies, are necessary to maintain good indoor air quality and mitigate the spread of illness (Peters & Verderber, 2021).

Figure 4: The benefits of thermal and airflow variability: Fælledgården Nursing Home in Copenhagen, Denmark 2010 by JJW Arkitekter. The assisted living facility is the largest facility of its kind in Denmark and was renovated to low energy standards, with balconies and operable windows for all rooms (Peters & Verderber, 2021).

The Fælledgården Nursing Home in Copenhagen, Denmark, is an example of a facility that prioritizes natural ventilation and accessible exterior spaces. Each unit in the nursing home is equipped with a balcony and operable windows adjacent to communal courtyard spaces as shown in Figure XX. This emphasis on natural ventilation aligns with the biophilic pattern of Thermal and Airflow Variability, including various lighting, ambient sounds, and temperature levels. Having control over these aspects of the residential setting contributes to residents' well-being, preventing feelings of boredom and introvertedness(Peters & Verderber, 2021).

Dynamic and Diffuse Light

The biophilic pattern of Light and Shadow Variability, as defined by Browning et al. (2020), emphasizes the use of varying intensities of light and shadow that change over time, replicating natural conditions. Kellert (2008) also recognizes the importance of sunlight as a crucial attribute in biophilic design, noting that natural daylight is consistently preferred over artificial light in buildings, due to humans' daytime and their reliance on sigh to secure essential resources and avoid environmental hazards (Peters & Verderber, 2021).

Numerous research studies highlight the significance of natural light in LTS environments, as occupants often endure poorly illuminated conditions for extended periods (Peters & Verderber, 2021). Studies on light therapy for seniors underscore the importance of circadian rhythms in regulating essential bodily functions. Disruptions to these rhythms, caused by unsynchronized indoor lighting conditions, can negatively impact sleep cycles, appetite, body temperature, cardiovascular functions, mood, activity levels, and cognitive functioning (Peters & Verderber, 2021).

An architectural example for this biophilic pattern would be The Wellcare Garden Fukasawa project in Tokyo, Japan, completed in 2017, exemplifies the innovative use of lighting strategies to enhance residents' well-being and minimize stress (World Architecture Festival, 2018; Peters & Verderber, 2021). The facility utilizes controlled daylighting, shading, nature forms, and self-controllable lighting system to create a therapeutic ambiance. The interior lighting is thoughtfully managed with timer-controlled systems to avoid unnecessary over-lighting when natural daylight is available. A circadian lighting system with variable illuminance levels and color temperature helps promote healthy sleep patterns and alertness during waking hours (World Architecture Festival, 2018; Peters & Verderber, 2021). Studies on light levels and therapy with seniors have highlighted the significant role of circadian rhythms in regulating essential bodily functions.

Methodology

Research Design

This study adopts a systematic literature review (SLR) approach to identify and analyze biophilic design elements that enhance social participation and active ageing in senior living environments. A systematic review is a structured method for synthesizing existing research, ensuring a comprehensive and unbiased analysis of relevant literature *(Tranfield, Denyer, & Smart, 2003).*

Data Collection Strategy

The literature search was conducted across multiple academic databases, including Scopus, Web of Science, Google Scholar, and ScienceDirect, to ensure coverage of high-impact peer-reviewed articles. Keywords used in the search included:

- "Biophilic design" AND "active ageing"
- "Senior living environments" AND "social participation"
- "Nature-based design" AND "elderly well-being"

Inclusion criteria for selecting studies were:

1. Relevance: Articles focusing on biophilic design and its impact on ageing populations.
2. Publication Type: Peer-reviewed journal articles, conference papers, and reports.
3. Geographical Scope: Studies related to global perspectives, with a focus on Malaysian and Southeast Asian contexts where available.
4. Publication Date: Studies published between 2010 and 2024 to ensure up-to-date findings.

Data Analysis

Selected articles were systematically analyzed using qualitative thematic analysis, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (*Moher et al., 2009*). Key themes were categorized based on recurring biophilic design principles, their impact on social participation, and their role in enhancing active ageing.

Limitations

This study is limited by the availability of literature specific to Malaysia, as much of the existing research originates from Western contexts. Additionally, while a systematic review provides a broad understanding, empirical field studies would be necessary to validate findings in real-world senior living environments.

Discussion

The findings from this systematic literature review emphasize the critical role of biophilic design in enhancing social participation and active ageing in senior living environments. By integrating elements such as natural light, indoor and outdoor greenery, water features, and multi-sensory environments, biophilic design fosters an enriched living experience that positively influences the physical, psychological, and social well-being of elderly residents.

Impact of Biophilic Design on Social Participation and Well-being

Several studies support the notion that exposure to nature improves cognitive function, stress reduction, and emotional well-being among older adults (Peters & Verderber, 2021). Biophilic design principles, such as visual and non-visual connections with nature, natural ventilation, and dynamic lighting, create an environment conducive to social interaction. For instance, Kipling Acres in Toronto, Canada, provides visual connections to nature through its landscaped courtyards and green walls, encouraging residents to spend time in communal spaces and engage with younger generations from an on-site childcare center. This demonstrates that biophilic design not only improves health outcomes but also fosters intergenerational interactions.

Similarly, the Erika Horn Residential Care Home in Austria incorporates raised garden beds, wood interiors, and natural light wells, ensuring that residents have sensory-rich experiences even indoors. The availability of communal gardens and shared outdoor spaces enhances social cohesion, giving older adults opportunities to interact, form social bonds, and participate in group activities.

Enhancing Cognitive and Psychological Health

The presence of greenery, water features, and natural sounds has been associated with reduced stress, improved concentration, and enhanced mood (Browning et al., 2014). Non-visual connections with nature, such as exposure to natural scents, tactile materials, and auditory stimuli (e.g., water flow, bird sounds), further enhance emotional and sensory engagement.

Moreover, biophilic patterns such as thermal and airflow variability promote physical comfort, which is particularly important for the elderly, who may be more sensitive to environmental changes. The Fælledgården Nursing Home in Denmark incorporates operable windows and balconies, allowing for natural ventilation and air circulation. This improves indoor air quality, reducing the risk of respiratory illnesses and improving overall well-being.

Designing for a Future of Age-Friendly Communities

The systematic literature review also reveals that designing for active ageing requires beyond just functionality, it demands an inclusive approach that integrates sensory, cognitive, and social well-being. The Wellcare Garden Fukasawa in Tokyo illustrates how dynamic and diffuse lighting strategies can be tailored to residents' circadian rhythms, minimizing disruptions to sleep cycles and mental health deterioration.

By prioritizing biophilic elements, architects and urban planners can develop age-friendly living spaces that support not only mobility and safety but also emotional fulfilment and community engagement. Future design adaptations should focus on culturally specific biophilic solutions, ensuring that elderly residents from diverse backgrounds feel a sense of place and belonging in their living environments.

Conclusion

The integration of biophilic design in senior living environments presents a transformative approach to enhancing the overall well-being of elderly residents. As demonstrated through various studies, exposure to nature, whether through direct visual connections, non-visual sensory experiences, or spatial configurations that mimic natural environments, plays a crucial role in improving cognitive function, emotional stability, and social engagement. The findings highlight that incorporating biophilic elements such as natural light, greenery, water features, and dynamic airflow can create spaces that foster active ageing, reduce stress, and enhance the quality of life for seniors.

One of the key takeaways from this research is the impact of nature-integrated spaces in fostering social participation. Facilities such as Kipling Acres in Canada and Erika Horn Residential Care Home in Austria demonstrate how carefully designed environments that incorporate gardens, green walls, and outdoor courtyards encourage interaction among residents and caregivers. These biophilic features not only provide therapeutic benefits but also help combat social isolation, which is a common concern among elderly individuals. Similarly, non-visual connections to naturesuch as tactile materials, natural scents, and auditory stimuli, have been shown to enhance sensory engagement and overall satisfaction in senior living spaces.

Furthermore, the importance of adaptive lighting and natural ventilation in creating comfortable and health-supportive environments cannot be overstated. Research indicates that dynamic and diffuse lighting, as seen in the Wellcare Garden Fukasawa project in Tokyo, plays a significant role in regulating circadian rhythms, reducing sleep disturbances, and improving mood. Likewise, facilities like the Fælledgården Nursing Home in Denmark, which prioritize natural ventilation through operable windows and balconies, demonstrate how airflow variability can contribute to better indoor air quality, reducing respiratory issues and promoting a sense of freshness and connection to the outdoors.

Moving forward, the principles of biophilic design should be integrated into the planning and development of future senior living environments, ensuring that they are not only functional but also deeply connected to the natural world. By prioritizing nature-based interactions, architects and urban planners can create age-friendly spaces that cater to the diverse physical and psychological needs of the elderly. Additionally, biophilic strategies should be culturally adaptable, allowing for personalized and meaningful connections to nature that reflect the backgrounds and preferences of different communities.

In conclusion, biophilic design offers a holistic and sustainable approach to redefining ageing experiences. By bridging the gap between built environments and nature, it has the potential to create spaces that promote health, happiness, and social connectedness among older adults. Future research should focus on measuring the long-term impacts of biophilic interventions, ensuring that they continue to evolve and adapt to the changing needs of ageing populations. With a growing emphasis on sustainability and human-centered design, biophilic principles should become a fundamental aspect of senior living environments, ultimately shaping a future where ageing is not just about longevity but also about quality of life.

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