FARU Journal 2026, Volume 13, Issue 1. DOI: https://doi.org/10.4038/faruj.v13i1.397

THE ROLE OF BIOPHILIC ARCHITECTURE IN ENHANCING SALUTOGENIC WELL-BEING: A FOCUS ON ELDERLY CARE CENTRE DESIGN

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Abstract: Biophilic architecture has emerged as an important design approach that enhances the restorative potential of built spaces by strengthening human–nature connections. Complementarily, the concept of salutogenesis focuses on the origins of health by emphasising factors that support and sustain well-being. However, built environment responses for elderly care have traditionally prioritised physical health while often overlooking cognitive and psychological needs. Addressing this gap, this study investigates the role of biophilic architectural strategies in enhancing salutogenic well-being in elderly care centres. The research approach employed data collected through questionnaire surveys, interviews, and activity mapping to evaluate the existing salutogenic conditions, utilising a selected facility in suburban Sri Lanka as a case study. Thereafter, three-dimensional virtual models were developed to simulate spatial design interventions and then reassess residents' perceived well-being. A comparative analysis between existing and developed spaces explores the systematic integration of biophilic architectural attributes to improve both the overall level of salutogenic well-being and the balance between salutogenic domains within Elderly Care Centre environments. The findings demonstrate that integrating biophilic design attributes positively influences multiple dimensions of elders' salutogenic health. Based on these insights, the study proposes a stakeholder-informed framework outlining key architectural considerations to guide the design of future elderly care environments.

Keywords: *Biophilic Architecture; Elderly Care; Salutogenic Well-being; Sense of Coherence; Sri Lanka.*

1. Introduction

Designing built environments for sensitive user groups can be particularly challenging due to their unique needs, vulnerabilities, and conditions. Therefore, designers must exercise careful consideration in creating inclusive and resilient spaces that adequately respond to these users. Older adults represent one such user group. Ageing is a complex life transition that involves a wide range of physical, psychological, and social changes, often accompanied by emotional challenges and increasing levels of dependency.

With the global growth of the ageing population and the influence of changing social structures, the reliance on Elderly Care Centres (ECCs) has increased significantly. Consequently, it has become increasingly important that these facilities are designed to effectively respond to the diverse needs and challenges faced by senior citizens.

One potential approach to addressing this need is the enhancement of salutogenic well-being within elderly care environments. Salutogenesis focuses on the factors that promote health and well-being rather than those that cause illness.

Research Hypothesis;
Biophilic architecture serves as a significant design mediator by integrating natural elements and human–nature connections within the built environment, thereby fostering restorative and health-supportive spaces for the elderly.

This research aims to explore the impact of biophilic architectural attributes on improving the salutogenic well-being of the elderly and to develop a stakeholder-driven framework that better reflects the actual needs and experiences of elderly users within such environments.

The primary objectives of this study are as follows:

- To identify gaps in existing ECC design guidelines that could be addressed through the integration of biophilic architectural attributes to enhance the salutogenic well-being of elders.
- To examine the impact of biophilic architectural attributes on the salutogenic well-being experiences of elders residing in ECCs.
- To develop a stakeholder-driven design framework that incorporates the needs and perspectives of elders in shaping the built environment of ECC.

2. Background

This section presents the theoretical foundations that underpin the research, focusing on biophilic architecture, salutogenesis, and existing design frameworks for ECCs. These theories collectively establish the conceptual basis for investigating how biophilic architectural attributes can enhance the salutogenic well-being of elderly residents.

2.1. BIOPHILIC ARCHITECTURE

The biophilia hypothesis suggests that humans possess an inherent tendency to seek connections with nature for emotional, cognitive, intellectual, and even spiritual fulfilment. The term *biophilia* originates from the Greek words *bio*, meaning "life," and *philia*, meaning "love of," collectively referring to a love for life and living systems (Cambridge Dictionary, n.d.).

As humans are an integral part of the natural ecosystem, the affinity toward nature is believed to be biologically embedded within the human genome (Mitchell, 2018). Within the field of architecture, this concept has evolved into biophilic architecture, which seeks to strengthen the relationship between people and nature within built environments. Through the integration of natural elements, materials, and spatial qualities, biophilic design transforms built structures into environments that support human well-being and reconnect occupants with natural systems (Kellert, 2008).

The roots of biophilic architectural thinking can be traced back to ancient civilisations. For instance, the Hanging Gardens of Babylon demonstrated early attempts to integrate natural landscapes within architectural structures. Although the concept of biophilia was not formally defined at that time, such historical examples illustrate humanity's long-standing desire to incorporate nature into built environments.

Designing spaces that incorporate biophilic principles has been widely recognised as beneficial in improving the salutogenic qualities of environments, thereby supporting occupants' overall well-being. Numerous theoretical frameworks and design approaches have been developed to guide the integration of biophilic principles within architectural practice.

Several influential frameworks include:

- Six Principles of Biophilic Design (Kellert, 2008)
- Fourteen Patterns of Biophilic Design developed by Terrapin Bright Green (Ryan et al., 2014)
- The twenty-five point Biophilic Design Framework (Kellert & Calabrese, 2015)

Although these frameworks differ in structure, they share a common objective: strengthening the human–nature relationship within built environments. They also provide designers with structured guidelines for integrating natural elements into architectural design.

Among these frameworks, the Fourteen Patterns of Biophilic Design proposed by Terrapin Bright Green (Ryan et al., 2014) (Table 1) is widely recognised in contemporary architectural research and practice. These patterns outline specific environmental conditions that support psychological and physiological well-being.

Table 1: 14 Biophilic Attributes
(Source: Ryan et al., 2014)

Nature in the Space
1) Visual Connection with Nature
2) Non-Visual Connections with Nature
3) Non-Rhythmic Sensory stimuli
4) Thermal & Airflow Variability
5) Presence of Water
6) Dynamic & Diffused Light
7) Connections with Natural Systems
Natural Analogues
8) Biomorphic Forms & Patterns
9) Material Connection with Nature
10) Complexity & Order
Natural of the Space
11) Prospect
12) Refuge
13) Mystery
14) Risk / Peril

The study adopts these fourteen biophilic design patterns as the primary analytical framework and integrates them with the Salutogenesis theory and the Sense of Coherence (SOC) model to investigate their role in enhancing well-being within ECC environments.

Biophilic architecture is further supported by several theories in environmental psychology, including:

- Prospect–Refuge Theory (Appleton, 1975), which suggests that people experience psychological comfort in environments where they can observe their surroundings while remaining protected.
- Stress Recovery Theory (Ulrich, 2023), which proposes that exposure to natural environments can reduce stress and promote positive emotional responses.
- Attention Restoration Theory (Kaplan, 1995), which states that interactions with natural environments help restore cognitive resources and reduce mental fatigue.

Together, these theoretical perspectives highlight the significant role that natural environments play in supporting human health, cognition, and emotional well-being.

2.2. SALUTOGENESIS

The word Salutogenesis originates from the Latin word 'Salus', meaning 'health', and the Greek word 'genesis', meaning 'origin'. Salutogenesis is the study of the origins of health and focuses on factors that support human health and well-being, rather than on factors that cause disease. Salutogenesis is explicit in the model as an analytical approach and is specified through health promotion, being oriented towards resources and positive health. In contrast to Salutogenesis, there is Pathogenesis, which is the study of the process by which a disease or disorder develops

(Antonovsky, 1987). The salutogenic model of health posits that life experiences and how an individual views their life (either positively or negatively) influence their health (Hewis, 2023). Out of these two approaches, currently, there is a research impetus on the Salutogenic approach for well-being and development in health (Drageset et al., 2023).

The central concept within the salutogenic model is the SOC, which consists of three interrelated components: Comprehensibility, Manageability, and Meaningfulness. These domains collectively influence how individuals interpret and respond to life experiences and environmental conditions (Antonovsky, 1987).

2.2.1. Comprehensibility

Comprehensibility represents the cognitive dimension of the SOC. It refers to the extent to which individuals perceive the stimuli they encounter, both internal and external, as structured, predictable, and understandable.

When individuals possess a strong sense of comprehensibility, they are more capable of interpreting environmental conditions and anticipating future events. Such predictability enhances cognitive stability and reduces uncertainty, enabling individuals to navigate their surroundings more confidently.

2.2.2. Manageability

Manageability represents the behavioural dimension of the SOC. It refers to the extent to which individuals perceive that sufficient resources are available to help them cope with life's demands and challenges.

In the context of the built environment, manageability relates to how effectively spaces support individuals in performing everyday activities. Environments that are accessible, intuitive, and supportive of daily routines enable users to maintain independence and functional capability.

2.2.3. Meaningfulness

Meaningfulness represents the motivational and emotional dimension of the SOC. It refers to the degree to which individuals feel that their life experiences are worthwhile and deserving of commitment and engagement.

When individuals perceive their daily experiences as meaningful, they are more likely to remain emotionally invested in life activities and social interactions. In contrast, environments that fail to stimulate emotional engagement may contribute to feelings of loneliness, disengagement, or psychological distress.

2.2.4. Healthy ageing and the contribution of Salutogenic Sense of Coherence

It has frequently been supposed that old age is an accretion of losses compelling the elderly to familiarise and adapt to constantly changing physical and social challenges. In most situations, the elderly demonstrate remarkable resilience to adapt with a range of diverse approaches to overcome these challenges. However, over time, the accessible opportunities become fewer as a result of declining resources and capabilities. This can influence the elders' mental and psychological health and increase the risk of social isolation and loneliness (Golembiewski, 2010).

Elders who could be leading monotonous lifestyles, especially those who will be ageing in place within facilities like ECC, can benefit from having these components of SOC for the creation of a salutogenic environment (d'Hombres et al., 2021).

The World Health Organisation's concept of "Active Ageing" defines healthy ageing as the process of optimising opportunities for health, participation, and security to enhance quality of life as people age (WHO, 2002).

Hanson-Kyle summarised different definitions and, based on commonalities, defines healthy ageing as "the process of slowing down, physically and cognitively, while resiliently adapting and compensating to optimally function and participate in all areas of one's life" (Hansen-Kyle, 2005).

2.3. FRAMEWORKS RELATED TO THE DESIGN OF ECCS.

Among the various environments in which elderly individuals reside, this study focuses specifically on ECCs. The research, therefore, examines how biophilic architectural attributes can be integrated into ECC design frameworks to enhance salutogenic well-being.

2.3.1. Fleming – Bennett design principles

The Fleming–Bennett environmental design principles, originally developed in 1987 and further refined over the following decades, provide guidelines for designing environments that support individuals with dementia.

- Unobtrusively reduce risks

Obstructions in circulation pathways can lead to agitation in mentally challenged elders, and thus, safe and easy internal and external circulation is encouraged when designing, which will also facilitate wayfinding.

- Provide a human scale

Three key factors would predominantly determine the scale:

- Number of people that the person encounters,
- Overall size of the building
- Size of the individual components

The scale of the built space should be comfortable and enhance the experience of the user.

- Allow people to see and be seen

There should be opportunities for better visual interaction among the staff and the elders. This will ensure a good and

safe relationship between us. Also, elders suffering from dementia have better comfort when they have visual access to the main spaces of the building.

- Reduce unhelpful stimulation

Unnecessary or competing noise, visual clutter can cause unwanted stimulation, leading to agitation in elders with dementia.

- Optimise helpful stimulation

Enabling the person living with dementia to see, hear, and smell allows them cues about where they are, and what they can do to help lessen their confusion and doubt.

- Support movement and engagement

Moving with purpose can improve participation and preserve one's health and wellness. It is promoted by offering a well-defined route that leads past interesting locations and chances for social engagement or activity, devoid of roadblocks and difficult decision-making moments.

- Create a familiar place

The surroundings must represent the residents' individual histories. It is best to invite the dementia patient to participate in personalising the space with items from their everyday life.

- Provide opportunities to be alone or with others

The freedom to choose between spending time with others or being alone is essential for people suffering from dementia. This calls for a range of areas, including places where people may spend time alone, in bigger groups, and for quieter conversations.

- Link to the community

This will remind an individual about their identity, who that person was, which is a struggle for most dementia patients. Inclusion of places that are shared by the wider community and the number of people living with dementia could help them restore the memories related to their identity.

- Design in response to vision for way of life

Supports everyone in the facility for the chosen lifestyle for both the elders with dementia and the staff. The spaces should assist the users of the spaces to maintain their lifestyles (Fleming & Bennett, 2015)

2.3.2. Zeisel approaches

Several writers and scientists have discovered strategies that will guarantee that the constructed surroundings assist those suffering from dementia. Among them is Zeisel, who suggests that the following components are essential to providing an atmosphere that upholds dignity and well-being (Zeisel et al., 1994).

- Exit controls
- Walking paths
- Common spaces
- Unit privacy
- Outdoor access
- Home likeness
- Sensory comprehension
- Independence support

2.4 RESEARCH GAP IN EXISTING ECC DESIGN GUIDELINES

Despite the existence of various design frameworks for ECCs, previous studies have identified a tendency for design guidelines to prioritise physical health and safety considerations, while giving comparatively less attention to psychological and emotional well-being (Lee et al., 2013).

Issues such as falls, injuries, and physical accessibility are often prioritised because they are easily observable and measurable. However, psychological conditions such as loneliness, anxiety, and loss of meaning may be less visible but equally impactful on overall health.

Furthermore, current design guidelines rarely provide detailed strategies for integrating natural elements within ECC environments, despite growing evidence supporting the health benefits of nature-based design approaches.

3. Method

The case study for the research is Cinnamon Care, an ECC facility located in Bandaragama, Sri Lanka. It is a fee levying facility for the elderly that currently provides a range of care activities. Cinnamon Care ECC offers a purpose-built, well-functioning facility with attributes that encompass biophilic elements. Further, the ECC sets itself apart from many others in Sri Lanka, where they are rarely purpose-built, but rather repurposed buildings.

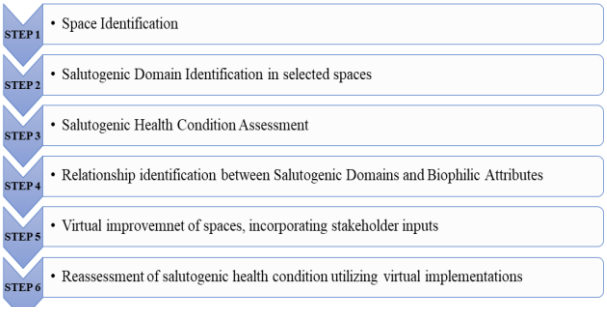

Figure 1: Case study Framework
(Source: Author)

Research data inputs of 35 elders with the assistance of their caregivers were utilised for this study.

The case study consists of 6 steps that will utilise different data collection and analysis methods, as presented in Figure 1 and detailed in sections 3.1 to 3.6 below.

The key stakeholders are the elders who reside in the ECC and their Caretakers.

3.1. SPACE IDENTIFICATION

Figure 2: Spaces of ECC mainly used by elders
(Source: Author)

In order to identify the most utilised spaces by elders, a data collection method of activity mapping is developed with the incorporation of caregivers' observations (Figure 2)

It is important to identify the spaces, because these spaces;

- Would have a higher impact on the well-being of the elderly, because those are the spaces that they use for a longer duration of time.
- Could be maximally benefited through the integration of biophilic attributes and the improvement of salutogenic experience in those spaces.

3.2. SALUTOGENIC DOMAIN IDENTIFICATION IN SELECTED SPACES

This stage of the study aimed to identify the dominant salutogenic domain associated with the spaces previously identified through activity mapping. A structured questionnaire was utilised to gather perceptions from participants regarding the type of well-being experience they associated with each space within the facility.

Participants were asked to indicate which of the following experiences they most strongly associated with each space:

- A dynamic feeling of security, confidence, and control over both predictable external and internal environmental conditions, interpreted as the Comprehensibility domain of salutogenic well-being.
- Enhancement of residents' personal resources for recovery, maintenance of independence, and support for the retention of essential life skills, interpreted as the Manageability domain.
- A sense of belonging that encourages the exploration of personal identity and respect for socio-cultural values, interpreted as the Meaningfulness domain.

3.3. EXISTING SALUTOGENIC HEALTH CONDITION ASSESSMENT

The Salutogenic Health Indicator Scale (SHIS)
Survey form on salutogenic health indicators

How have you felt in <u>the last 4 weeks</u> with regard to the following? *(The further to the left you enter your tick, the more you agree with the statement to the left, and vice versa)*

In the last 4 weeks, I have …

	(6)	(5)	(4)	(3)	(2)	(1)	
A: felt alert	❒	❒	❒	❒	❒	❒	felt tired, exhausted
B: felt happy, optimistic	❒	❒	❒	❒	❒	❒	felt depressed, sad
C: felt calm, relaxed	❒	❒	❒	❒	❒	❒	felt worried, tense
D: slept well	❒	❒	❒	❒	❒	❒	slept badly
E: found it easy to concentrate	❒	❒	❒	❒	❒	❒	found it hard to concentrat
F: had lots of ideas, been creative	❒	❒	❒	❒	❒	❒	have been lacking ideas, not been creative
G: have made decisions easily	❒	❒	❒	❒	❒	❒	have been at a loss what to do, hesitant
H: have been emotionally balanced	❒	❒	❒	❒	❒	❒	have been emotionally imbalanced
I: felt well	❒	❒	❒	❒	❒	❒	felt sick
J: have had lots of energy	❒	❒	❒	❒	❒	❒	have had very little energy
K: functioned well with other people	❒	❒	❒	❒	❒	❒	not functioned well with other people
L: felt that my body has functioned well in relation to what my life situation needs	❒	❒	❒	❒	❒	❒	felt that my body has not functioned well in relation to what my life situation needs

Figure 3: SHIS Survey
(Source: Bringsén, et.al, 2009))

This step was conducted using a tool designed to measure the perception of salutogenic health according to a scale known as The Salutogenic Health Indicator Scale (SHIS) (Figure 3). The questionnaire consists of twelve simple questions. It was considered higher the values, the more the presence of salutogenic well-being indicators.

3.3.1. SHIS Tool utilisation

The SHIS tool questionnaire utilised in this research has been developed by Kristianstad University of Sweden, based on psychological research related to salutogenesis (SHIS, n.d., Bringsén, et.al, 2009). This tool was utilised to explore the level of salutogenesis and to identify how the main domains of salutogenesis, comprehensibility, manageability and meaningfulness were prevalent among the elderly.

For each respondent, an index value will be calculated. Each question could yield a maximum score of 6 (for a positive response) and a minimum score of 1 (for a negative response). A total index value will be calculated by totalling the value for all twelve questions. This means a score range between the maximum positive index value of 72 and a corresponding minimum index value of 12 is possible to be scored by each adult.

Through this, a score for each domain can be calculated to identify the distribution of the salutogenic indicators by categorising the 12 indicators which were questioned through the (SHIS) Survey, under the 3 main domains of SOC (Table 2).

Table 2: Relationship between 12 indicators of SHIS and 3 Domains of Sense of Coherence (Source: Author)	
A. Degree of Alertness	Manageability
B. Perception of Happiness	Meaningfulness
C. Relaxation	Meaningfulness
D. Quality of sleep	Manageability
E. Level of Concentration	Comprehensibility
F. Amount of Creativity	Comprehensibility
G. Decision-making ability	Manageability
H. Emotional balance	Meaningfulness
I. Feeling of Wellness	Meaningfulness
J. Energy Level	Manageability
K. Interaction with others	Comprehensibility
L. Body functioning	Comprehensibility

3.4. RELATIONSHIP IDENTIFICATION BETWEEN SALUTOGENIC DOMAINS AND BIOPHILIC ATTRIBUTES

This step screens out the biophilic attributes that will enhance the 3 salutogenic domain indicators in each of the selected spaces, being one of the most crucial steps of the research. The Questionnaire utilised in this step comprises the 14 Biophilic attributes identified through the systematic literature review related to biophilic architecture (Table 1).

The questionnaire was administered in three parts. Each part questioned and focused on the biophilic attributes that enhance the salutogenic domain indicators.

Part 1 - In this activity space, which of the aspects of nature out of the given would give you a dynamic feeling of security, confidence and control over a predictable external and internal environment that would result in improving your Level of Concentration, Amount of Creativity, Interaction with others and Body functioning?

Part 2 - In this bedroom space, which of the aspects of nature out of the given would enhance your resources for recovery, the sense of independence and the subsequent atrophy of essential life skills to improve your Degree of Alertness, Quality of sleep, Decision Making ability and Energy Level?

Part 3 - In this living space, which of the aspects of nature out of the given would promote your sense of belonging and inspire the search for human's identity and respect for socio-cultural values to improve your Perception of Happiness, Relaxation, Emotional balance and Feeling of Wellness?

The questionnaire is useful to evaluate how the 3 main domains of SOC, which are Comprehensibility, Manageability and Meaningfulness, could be fulfilled by the role played by 14 Biophilic Attributes. The elderly, as the main users of the ECC, would be able to give their direct contribution to identifying this relationship between the Biophilic attributes and the way they feel a SOC in each of the spaces that are being widely used by them.

3.5. VIRTUAL IMPROVEMENT OF SPACES INCORPORATING STAKEHOLDER INPUTS

One-on-one interviews were conducted among selected elders in order to obtain their insightful feedback on the experience of spaces and the attributes of Biophilic Architecture, which include open-ended semi-structured questions. This depicts their perception and their ideas on how spaces should be designed with integration of Biophilic attributes, which is helpful to attain the research objective of incorporating stakeholders and real users of the spaces, in order to develop a stakeholder-driven design framework. Based on the stakeholder inputs, the responses will be analysed using thematic analysis, and the spaces are then virtually improved, using three-dimensional modelling software SketchUp and rendering software Lumion.

3.6. REASSESSMENT OF SALUTOGENIC HEALTH CONDITIONS BASED ON VIRTUAL IMPLEMENTATIONS.

The virtually improved spatial models developed in Step 5 formed the basis for the reassessment conducted in this stage of the research. To evaluate the potential impact of the proposed design interventions, the same questionnaire utilised in Step 3 was administered again to the stakeholders. Participants were presented with the virtually improved spatial environments and asked to respond to the questionnaire based on their perceptions and anticipated experiences within these redesigned settings. However, this step introduces a methodological limitation. Since the design interventions were presented through virtual simulations rather than physically implemented environments, the responses reflect anticipated or perceived well-being improvements rather than actual lived experiences.

3.7. SCOPE AND LIMITATIONS

The SHIS questionnaire data were collected with the assistance of the caregivers; therefore, no cultural/linguistic adaptation, pilot testing in Sri Lankan elders, or psychometric checks were conducted. The "virtual improvement" is a visualisation; therefore, responses can be impacted by novelty effects, social desirability, lack of control/comparison facility, repeated testing effects, and a same instrument, same respondent bias.

Due to ethical reasons of the ECC, neither photographs nor personal details of the individual elders were revealed in the research. Further, the careful input of the caregivers and the facility administration was adopted throughout the process. A proxy consent of the administration of the ECC was obtained and was continually monitored.

4. Results and Discussion

4.1. SPACE IDENTIFICATION

The identification of key spaces was conducted through activity mapping carried out over one week by the researchers and caretakers within the premises of the ECC. This process enabled the researchers to determine the spaces most frequently used by the elderly residents. The analysis revealed that the following spaces were predominantly utilised: the Activity Area, Bedroom Area, Living Area, Garden Space, and Dining Area.

4.2 SALUTOGENIC DOMAINS WITHIN THE SELECTED SPACES OF THE ECC

The results of the first questionnaire, which was completed by the elderly residents, illustrated the relationship between the salutogenic domains and the most frequently used spaces within the ECC (Figure 4).

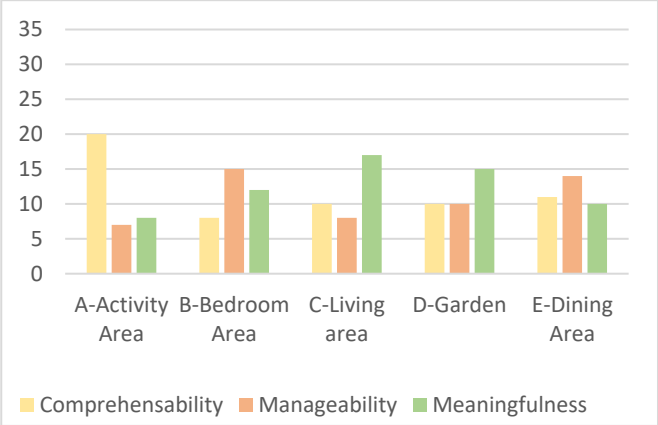

Figure 4: Questionnaire Survey 1 Results (*Source: Author*)

Based on the number of responses indicating the dominant salutogenic domain within each space and considering the representation of all three domains within the scope of this study, three spaces were selected for further investigation. This selection also reflects the methodological limitation of representing each salutogenic domain within the analysis.

- Space A -activity area-comprehensibility domain.
- Space B –personal bedroom-manageability domain.
- Space C -living area-meaningfulness domain

4.3 EXISTING SALUTOGENIC HEALTH CONDITION ASSESSMENT

Each respondent's score was calculated individually, with a maximum possible score of 72. These scores provided an overall understanding of the current salutogenic health conditions of the residents within the ECC. The analysis indicated that the manageability domain constituted the most significant component of the residents' overall salutogenic health (Figure 5).

Furthermore, most respondents obtained scores above 36, which represents the midpoint of the scale. This suggests that most residents experience a moderate to relatively positive level of salutogenic well-being within the care centre environment.

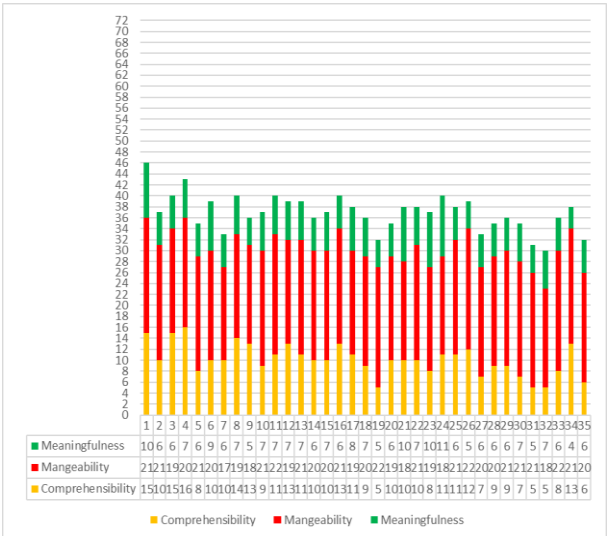

Figure 5: Scores (y-axis) obtained on SHIS Survey by the 35 elders (x-axis) based on current conditions of ECC (Source: Author)

4.4. RELATIONSHIP IDENTIFICATION BETWEEN SALUTOGENIC DOMAINS AND BIOPHILIC ATTRIBUTES

The second questionnaire was conducted to explore the relationship between 14 biophilic design attributes and their role in supporting the three salutogenic domains within the selected spaces of the ECC. Based on the responses received, the two most frequently mentioned biophilic attributes for each space were selected for detailed analysis. In total, six biophilic attributes were examined in depth to understand their contribution to enhancing salutogenic well-being and to identify potential architectural interventions that could strengthen these attributes.

4.4.1 Space A – Activity Area

Within the Activity Area, the Comprehensibility Domain of salutogenic well-being emerged as the most significant. (Figure 6) The two most frequently identified biophilic attributes were:

- Visual Connection with Nature (BA 1)
- Non-Visual Connection with Nature (BA 2)

Visual Connection with Nature

Nature views would be one of the most obvious and simple ways of implementing biophilia into a built environment. This attribute is the most often discussed attribute related to biophilia because of the natural affiliation of humans towards nature. As a result, biophilic design often gets confused with designs that have views of nature only.

Visual connections with nature can be achieved through two primary approaches:

- The preferred way is to have direct visual access to views of nature. Visual preference and responses

to views of nature show reduced stress, more positive emotional functioning, and improved concentration and recovery rates

- Simulated representations of nature, such as images, murals, or sculptures, particularly in spaces where direct views are unavailable.

(Ryan et al., 2014)

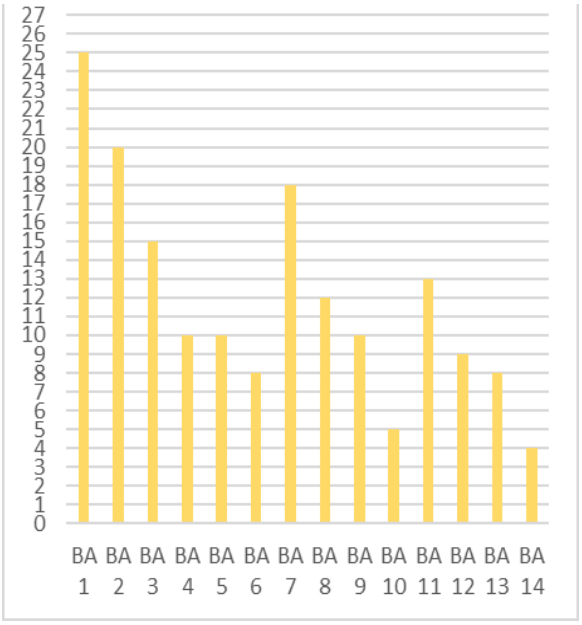

Figure 6: Biophilic Attributes (x-axis) impact on Comprehensibility (y-axis)
(Source: Author)

Within the comprehensibility domain of salutogenic well-being, the concentration levels of elderly residents play a significant role. Maintaining higher levels of concentration is particularly beneficial for the elderly while engaging in small recreational and cognitive activities conducted in the activity areas of ECCs.

Direct visual access to nature has been widely demonstrated to enhance human concentration abilities (Berman et al., 2008). In the selected case study, many elders expressed a clear preference for seating areas that provide a direct view of the garden, as these spaces are commonly chosen for carrying out their daily activities. Furthermore, elders who experience mobility limitations and require assistance to access the outdoor garden spaces expressed a strong appreciation for indoor areas that offer high-quality visual connections with nature, as such views positively influence their ageing-in-place experience.

Non-Visual Connection with Nature

In the case study, the use of nature-based imagery on windowless façades further demonstrated the importance of visual references to nature. Participants indicated that, when windows were unavailable, their next preferred option would be visual elements depicting natural landscapes or scenery. These visual simulations were reported to create a sense of calmness and mental clarity, which contributes to improved concentration levels during cognitive improvement activities such as card making, painting, and hand–eye coordination tasks.

Although nature is most commonly incorporated into built environments through visual connections, it can also be experienced through non-visual sensory perceptions. These may include auditory, olfactory, gustatory, and tactile stimuli, each of which can strengthen an individual's sense of connection with nature (Alvarsson et. al., 2010).

Such non-visual sensory interactions may be particularly beneficial in enhancing the concentration levels of elders within activity areas of care centres. These spaces often serve as locations where residents engage in creative activities, social interaction, and even shared meals, making them key environments for cognitive engagement.

Concentration and creativity are closely linked to the cognitive abilities of elderly individuals, which play a crucial role in the various crafting and hand-based activities carried out in these spaces. Previous studies suggest that exposure to natural sounds and environmental vibrations can positively influence cognitive performance (Ljungberg et al., 2004).

During interviews, many elders reported perceived improvements in mental clarity and tranquillity as a result of non-visual sensory interactions with the surrounding natural environment. These experiences were often contrasted with the urban noise and pollution they had encountered throughout much of their earlier lives. Such observations highlight the importance of auditory connections with nature in enhancing the comprehensibility domain of salutogenic well-being among elderly residents.

Similarly, pleasant aromas have been identified as having a soothing effect on the salutogenic well-being of elders by supporting improved mental coordination. Participants noted that even the fragrance of incense sticks used during daily religious practices provided them with a momentary sense of relief and calmness. They expressed appreciation for environments that could provide consistent and pleasant olfactory stimulation, suggesting the inclusion of flowering trees within courtyard spaces as a natural source of fragrance throughout the day. Additionally, they expressed enthusiasm for easily accessible fruit-bearing plants, which could provide a gustatory connection to nature whenever desired.

Although these considerations may appear minor within the broader context of architectural design, studies have shown that small-scale or momentary sensory interventions can produce meaningful positive impacts on human health (Biederman & Vessel, 2006). Such findings support the potential role of these sensory strategies in enhancing salutogenic well-being within ECC environments.

Finally, aspects of bodily functions associated with the comprehensibility domain may also benefit from the incorporation of tactile stimuli within architectural surfaces. Interviews with elderly residents, followed by thematic analysis, revealed that subtle textural variations inspired by natural patterns, when incorporated into façade or surface details, could contribute positively to their sensory engagement and overall bodily awareness within the space.

4.4.2. Space B – Bedroom Area

Within the Bedroom Area, the Manageability Domain was identified as the dominant salutogenic factor. (Figure 7)

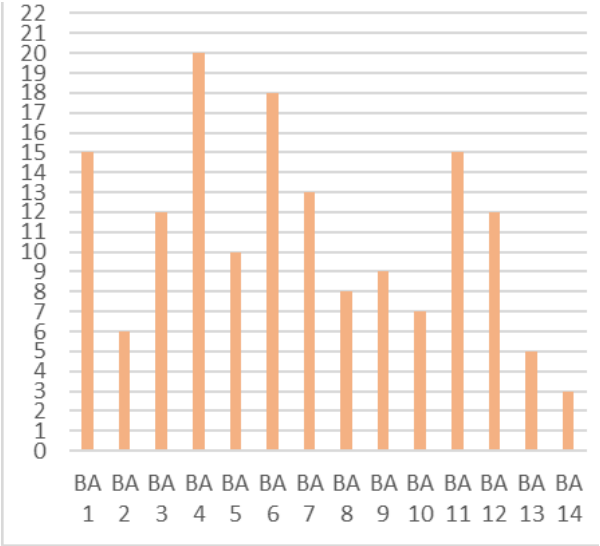

Figure 7: Biophilic Attributes (x-axis) impact on Manageability (y-axis)
(Source: Author)

The two most significant biophilic attributes were:

- Thermal and Airflow variability (BA 4)
- Dynamic and Diffuse light (BA 6)

Thermal and Airflow Variability

Thermal and airflow variability refers to environmental conditions that mimic natural atmospheric fluctuations. Factors such as air temperature, humidity, airflow across the skin, and radiant surface temperatures contribute collectively to a sense of comfort similar to that experienced in outdoor environments.

Suggestions provided by the elders regarding this attribute included the provision of variable seating options with differing levels of solar heat gain, both indoors and outdoors, as well as seating areas located near operable windows. Such spatial arrangements were perceived as beneficial for improving the overall thermal comfort of the environment during daytime activities.

The elders' overall perception indicated a clear preference for comfortable natural airflow and moderate temperature conditions within their bedroom spaces rather than relying on artificial climate-control appliances such as air conditioners. This preference was particularly emphasised during nighttime, when respiratory sensitivity may increase. Under such circumstances, the ability to experience natural ventilation and appropriate thermal variability was considered essential for maintaining comfort and self-manageability.

Previous research suggests that individuals generally prefer moderate levels of sensory variability in environmental conditions, including temperature fluctuations. Environments that lack sensory stimulation and environmental variability may result in boredom and passivity. Such conditions may contribute to decreased energy levels among elders, thereby negatively affecting the manageability aspect of salutogenic well-being.

The objective of the Thermal and Airflow Variability biophilic pattern is therefore to create environments where occupants can experience natural sensory variations in airflow and temperature. Such environments should ideally provide opportunities for personal control over thermal conditions, either through individual controls or by allowing access to areas with varying ambient environmental conditions.

In contrast to this approach, conventional thermal design attempts to maintain a uniform indoor environment, which predictive laboratory models suggest would satisfy approximately 80% of occupants at any given time. While this outcome has traditionally been considered acceptable within the building industry, an alternative strategy involves creating environmental conditions that more closely resemble natural outdoor environments, combining variations in ambient temperature, surface temperature, humidity, and airflow, while simultaneously allowing users some level of personal control over these conditions. Given the physical capabilities of elderly residents, such operable environmental controls must remain easily accessible and within comfortable reach.

Dynamic and Diffused Light

Within the principles of biophilic design, emphasis is placed on the optimal use of natural daylight, while artificial lighting patterns should complement and replicate the qualities of natural light when daylight is insufficient (Kellert and Calabrese, 2015).

The objective of the Dynamic and Diffuse Light biophilic pattern is twofold: first, to provide lighting conditions that stimulate the visual system and capture attention in ways that produce positive psychological and physiological responses, and second, to support the proper functioning of the human circadian rhythm.

Effective lighting design should avoid overly uniform illumination that results in visually monotonous spaces, while also preventing extreme contrasts in brightness that may cause glare and visual discomfort.

Numerous studies have demonstrated that light exposure plays a critical role in regulating human circadian rhythms. Within the context of salutogenic well-being, alertness levels and sleep quality are important indicators of the manageability domain. Consequently, access to appropriate natural lighting conditions can significantly benefit elderly residents. Participants also highlighted the importance of variations in illuminated surfaces, which assist them in interpreting spatial conditions, performing different tasks, and navigating spaces safely. Such lighting variations can support elders in making independent decisions regarding mobility within the care centre.

In addition, the elders expressed strong appreciation for the personal outdoor patios connected to their bedroom spaces, which provide generous access to natural daylight. These spaces were perceived as beneficial in enhancing energy levels during daytime hours, even on days when residents may not feel physically well. Previous studies similarly support the positive influence of daylight exposure on energy levels and psychological well-being among elderly populations.

Lighting conditions were also identified as closely related to emotional states and mood regulation. Many elders reported feeling more relaxed under the warm-toned artificial lighting conditions used within their bedrooms during the evening and nighttime hours. Since bedroom spaces are not typically used for attention-demanding tasks, unlike activity areas, warmer lighting environments were perceived as more comfortable and calming, contributing positively to their overall sense of relaxation and well-being.

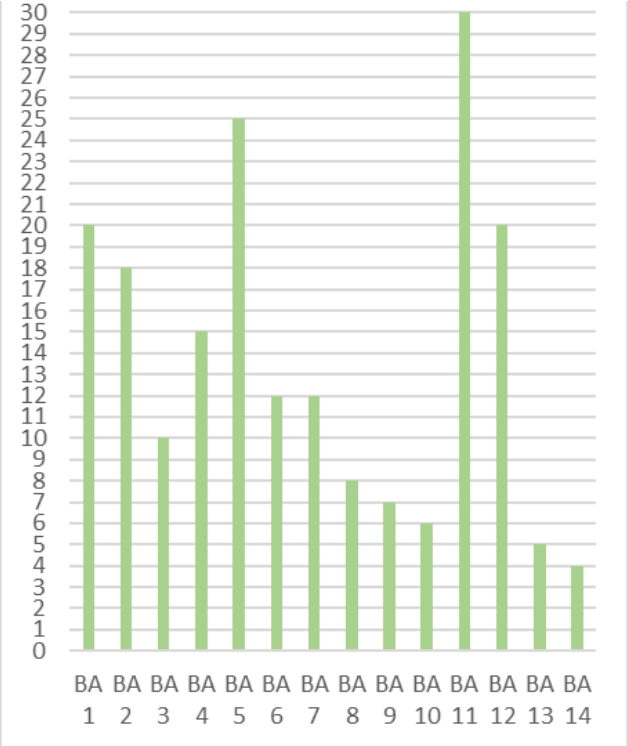

Figure 8: Biophilic Attributes (x-axis) impact on Meaningfulness (y-axis)
(Source: Author)

4.4.3. Space C – Living Area

Within the Living Area, the Meaningfulness Domain emerged as the most significant contributor to salutogenic well-being. (Figure 8) The two most frequently mentioned biophilic attributes were:

- Presence of Water (BA 5)
- Prospect (BA 11)

Presence of Water

The objective of the presence of water attribute is to dominate the multi-sensory characteristics of water to improve the experience of a place in a way that is calming, improves emotions, and enhance recovering from cognitive exhaustion.

The presence of water is well perceived as well as most beneficial when not only providing visual perception, but also auditory and tactile perceptions for the users. This is further supported by auditory sensation research by Alvarsson et al. (2010) that auditory stimuli and apparent or probable tactile admittance to water decreased stress in participants.

Elders highlighted that the existing water features within the care centre primarily contribute to auditory sensory experiences rather than visual ones, as the dimensions of the water installations are relatively small when compared with the extensive greenery present within the facility. Despite their modest visual presence, the elders noted that the sound of flowing water provides a sense of tranquillity, relaxation, and overall well-being, which contributes positively to the meaningfulness domain of their salutogenic well-being. In this case study, therefore, the presence of water functions predominantly as an auditory sensory stimulus.

However, participants also expressed that, although the current water features are not visually prominent, they would prefer water elements to be designed as stronger visual features within the landscape, while still maintaining their multi-sensory qualities. Architectural interventions such as fountains or waterfall features may enhance this experience, while indirect design strategies such as water reflections cast onto surrounding surfaces or façades can further strengthen the sensory impact of water within the environment.

Additionally, if designers are involved in the project from the initial stages of development, including the site selection phase, the potential to incorporate water-related environmental qualities can be further enhanced. For example, selecting a site located in proximity to a natural water body could provide an additional design advantage in the development of salutogenic well-being–oriented ECCs, similar to the case study explored in this research.

Prospect

Another important biophilic attribute contributing to the meaningfulness domain of salutogenic well-being is the concept of prospect. Prospect refers to a spatial condition characterised by unobstructed views across a distance, enabling individuals to visually survey and anticipate their surrounding environment. Spaces that provide strong prospect conditions often feel open and liberating while simultaneously offering a sense of safety and environmental control.

The prospect pattern originates from visual preference research and studies on spatial habitat responses. Its objective is to provide users with environments that allow them to observe and anticipate the surrounding atmosphere, identifying both potential opportunities and hazards. In landscape settings, prospect is often associated with views from elevated positions or across wide expanses of open space. Although elevated viewpoints may enhance the prospect experience, they are not essential for achieving effective prospect conditions (Dosen & Ostwald, 2016).

Within the living area of the care centre, the spatial layout provides ample opportunity for elders to experience prospect through unobstructed views of the garden space within the facility. Many participants identified this area as their most preferred space within the centre, noting that it provides a strong sense of happiness and emotional upliftment, even on days when they experience physical discomfort or illness.

Particularly on sunny days, elders enjoy observing the small wildlife frequently present within the garden, including squirrels, butterflies, and birds. These encounters with nature contribute to their sense of connection with the surrounding environment. Participants also noted that the sheltered space extending into the garden allows them to continue enjoying uninterrupted views of the landscape even during rainy weather conditions. This design feature enhances the prospect experience, allowing elders to maintain a visual connection with nature regardless of weather conditions.

4.5. VIRTUAL IMPROVEMENT OF SPACES INCORPORATING STAKEHOLDER INPUTS

Based on the insights gathered from one-to-one interviews with the elderly residents, their perceptions of biophilic attributes were analysed in detail. The residents also identified aspects of the existing ECC environment that they perceived as lacking.

Using these insights, virtual three-dimensional models were developed to simulate potential design improvements that incorporate biophilic attributes. As the daily users of these spaces, the residents provided valuable practical suggestions that could enhance their salutogenic well-being through relatively simple architectural interventions (Figure 9).

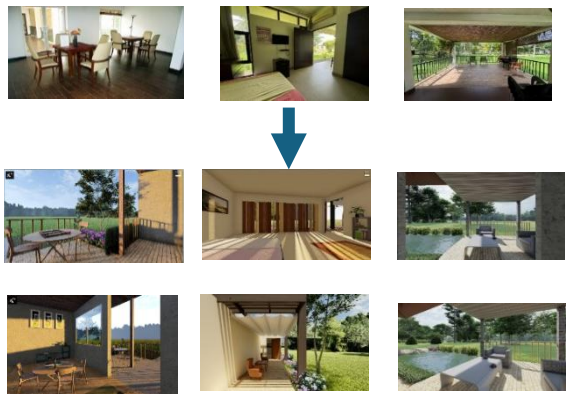

Figure 9: Virtual Improvements for the spaces (Source: Author)

4.6. REASSESSMENT OF SALUTOGENIC HEALTH CONDITION BASED ON VIRTUAL IMPLEMENTATIONS

Re-assessment of each score showed that there is an increase in the overall scores of all the elders, considering the virtual condition. Also, it showed an increase in all the elders' scores, related to the indicators of the Meaningfulness Domain of Salutogenic well-being. Figure 10 shows a comparison of the salutogenic well-being scores of the elders in the virtual condition, showing an overall increase. This is a result of the application of biophilic attributes according to the framework.

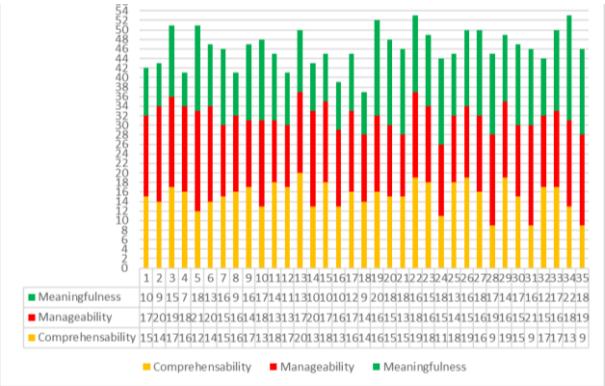

Figure 10: Comparison of SHIS survey scores of 35 elders (Source: Author)

The comparative analysis demonstrated that the systematic integration of biophilic architectural attributes can significantly improve both the overall level of salutogenic well-being and the balance between salutogenic domains within ECC environments.

These findings highlight the potential of biophilic design strategies as an effective architectural approach for promoting health-supportive environments for elderly populations.

Table 3 provides a synthesis of design implications for future applications, derived from research findings, insights, and recommendations collected from stakeholders of the ECC facility.

Table 3: Design Framework for future Implications
(Source: Author)

DESIGN FRAMEWORK FOR THE FUTURE IMPLICATIONS

Salutogenic Domain	Salutogenic Indicators	Selected space	Similar spaces in an ECC of similar salutogenic domain	Biophilic Attributes	Sample Biophilic Architectural Implications
Comprehensibility	Level of Concentration Amount of Creativity Interaction with others Body functioning	Activity Area	**Common spaces with specific functions** *Ex- Dinning Area* Cognitive oriented	**Visual connection with Nature**	
				Views to nature	Provision of ample windows and viewpoints in spaces.
				Adaptation to windowless spaces	Spaces to accommodate and experience images sculptors related to nature
				Non visual connections with Nature	
				Auditory perception	Design of spaces that better transfer sounds from exterior to interior.
				Olfactory perception	Design of landscape with conscious decision on vegetation that provides a pleasant smell.
				Gustatory perception	Design of landscape with conscious decision on vegetation such as fruit bearing plants that are accessible
				Tactile perception	Design of façade surfaces that mimic textures of nature
Manageability	Degree of Alertness Quality of sleep Decision Making ability Energy Level	Bed Rooms	**Personal spaces** *Ex- Treatment area* Physiological oriented	**Thermal & Airflow Variability**	
				Air temperature	Design of façade fenestration with attention to windows such as glazing and shading as well as easily operable windows for elders
				Relative humidity	Conscious utilization of water features in design that would not create uncomfortable humidity conditions for health sensitive elders
				Airflow across the skin	Placement of openings for stack and cross ventilation in optimum ways
				Radiant temperature of surrounding surfaces	Opportunities to experience varied temperature ranges such as design seating spaces with differing levels of solar heat gain
				Dynamic & Diffused Light	
				Natural light	Natural light that 1.stimulates the eye that engenders a positive psychological /physiological response such as way finding and, completion of tasks 2.maintain circadian system functioning
				Artificial light	Artificial light that 1.stimulates the eye that engenders a positive psychological /physiological response such as way finding and, completion of tasks 2.maintain circadian system functioning
Meaningfulness	Perception of Happiness Relaxation Emotional balance Feeling of Wellness	Living Room	**Common spaces with no specific function** *Ex- Verandah* Psychological oriented	**Presence of Water**	
				Visual perception	Incorporation of water into green spaces
				Auditory perception	Perception of sounds of water that would provide a healing sensation for elders
				Tactile perception	Practical opportunities for elders to interact with water actively
				Prospect	
				Undisturbed view	Design of spaces that have unobstructed views of nature that elders could enjoy.
				Sense of safety	Presence of sheltered spaces with seating for elders to overlook the distant views

5. Conclusion

The key findings of this study were derived through a six-step research process that employed a mixed-method approach, incorporating the perspectives of both elderly residents and caretakers as primary stakeholders of the Cinnamon Care ECC facility.

The results indicate several significant relationships between biophilic architectural attributes and the enhancement of salutogenic well-being domains among elderly residents.

- Visual Connection with Nature and Non-Visual Connection with Nature were identified as biophilic elements that have the potential to strengthen the Comprehensibility domain of salutogenic well-being.

These attributes were particularly influential in activity-oriented common spaces, where cognitive engagement and mental clarity are essential for the well-being of elderly residents.

- Thermal and Airflow Variability and Dynamic and Diffuse Light demonstrated the potential to enhance the Manageability domain of salutogenic well-being. These attributes were found to be particularly relevant in personal spaces such as bedrooms, where physiological comfort and environmental control contribute to residents' ability to manage their daily routines and physical conditions.
- Prospect and Presence of Water were identified as key biophilic attributes supporting the Meaningfulness domain of salutogenic well-being. These attributes were most effective in shared, relaxation-oriented spaces, where they contributed to psychological comfort, emotional satisfaction, and overall happiness among elderly residents.

Overall, the findings suggest that the systematic integration of biophilic design attributes within ECC environments can improve not only residents' salutogenic health but also the balance among the three salutogenic domains—comprehensibility, manageability, and meaningfulness.

Furthermore, the study highlights the importance of incorporating stakeholder input in the design and improvement of ECC facilities. Engaging both elderly residents and caretakers in the design process can significantly contribute to the development of more inclusive, resilient, and user-responsive environments.

Salutogenic well-being, together with associated concepts such as SOC and its three domains—comprehensibility, manageability, and meaningfulness—, provides valuable conceptual benchmarks for the design of ECC environments. As the global ageing population continues to grow, ECC facilities are expected to become an increasingly important building typology in the coming decades.

Within this research, biophilic architecture was explored as a mediating design approach capable of supporting salutogenic well-being. Extensive literature has already demonstrated the role of biophilic design in enhancing the healing qualities of built environments. The present study further contributes to this body of knowledge by demonstrating how biophilic attributes can be strategically applied within elderly care settings to improve the well-being of residents.

Future work could include a pilot physical intervention with before–and–after measures, and expand the current scope to encompass a multi-site study.

The built environment plays a critical role in shaping human experiences, as it forms the spatial context within which individuals live their daily lives. This role becomes particularly significant in the case of elderly individuals, many of whom may spend a substantial portion of their later years within a single care facility environment. Consequently, the design of such spaces must carefully respond to the physical, psychological, and emotional challenges associated with ageing.

Designers and planners involved in the development of ECC facilities must therefore adopt an empathetic and human-centred design approach, ensuring that these environments are not only functional but also supportive, restorative, and dignified places for ageing populations.

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