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Original Paper

Research on Age-Friendly Design of Living Spaces in Institutional Elderly Care Models

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Abstract

With the increasing trend of population aging, elderly care institutions have become important places for the daily lives of older adults. However, there are still many issues in the current design of living spaces in institutional elderly care models, such as unreasonable spatial layout, inadequate functionality, and inconvenient facilities. To address these issues, this paper conducts a comprehensive analysis through literature review and field research, integrating the physiological and psychological characteristics of older adults and the advantages and disadvantages of living spaces in actual elderly care institutions. Based on spatial design principles and technical approaches, this paper summarizes the key points and strategies for designing age-friendly living environments for older adults in institutional elderly care models. This provides a reference basis for the design of living spaces for older adults in elderly care institutions in China, promoting the improvement of quality of life for older adults and the development of healthy aging care.

Keywords

institutional elderly care model, living space, age-friendly design, older adults

1. Introduction

1.1 Research Background

The design of living space in institutional elderly care models has a significant impact on the quality of life for older adults (Yin, 2022). Currently, there are widespread issues with unreasonable spatial design, inconvenient facilities, and incomplete functionalities in institutional elderly care models in China, which result in decreased quality of life for older adults and even affect their physical and mental health (Xie, 2019). Therefore, the purpose of this study is to explore how to conduct aging-friendly design for

living spaces in institutional elderly care models, in order to improve the quality of life and well-being of older adults.

1.2 Research Objectives and Significance

This study will start from the needs of older adults, explore aging-friendly residential space models, determine basic structures and necessary configurations, and promote the healthy development of elderly care services in institutions. By optimizing the living environment and quality of life for older adults, this study aims to facilitate invisible care for older adults and ensure their physical health. Based on the physiological and psychological characteristics of older adults, and through literature review and field research, this study will explore and summarize the key design points and strategies for living spaces in institutional elderly care models, providing reference for aging-friendly design of living spaces in elderly care institutions in China.

1.3 Research Methods

This study will employ research methods such as literature review and on-site investigation to explore the design of age-friendly living spaces in institutional elderly care models. Specifically, by comprehensively analyzing the physiological and psychological characteristics of older adults and conducting on-site investigations, the advantages and disadvantages of living spaces for older adults in elderly care institutions will be identified. Based on principles of spatial design and technological approaches, key points and strategies for designing age-friendly living spaces for older adults in institutional elderly care models will be summarized.

2. Classification and Study of Physical Changes in the Elderly Population

2.1 Human Factors Engineering based on Physical Changes in the Elderly

By analyzing the daily life of the elderly, we can understand the spatial dimensions needed for the elderly, including the physical dimensions of common elderly individuals (Table 1), dimensions of assistive devices (Table 2), and differences in spatial requirements for elderly individuals with varying levels of care-giving needs (Zhai, 2020).

Table 1. Our Elderly Wheelchair Users Side Activity Size

Position Height	Knuckles	Seat	Knee	Elbow	Shoulder	Sight	Top of head
elderly male users(mm)	380-400	490	645	700	1040	1225	1335
elderly female users(mm)	420-450	490	605	690	990	1155	1255

Table 2. Pushchair Size Analysis

Wheelchair Type	Applicable people	Rotate 90 °	Rotate 180 °	Full swing
Pushchair	Lower extremity movement disorders	≥1350mm	≥1400mm	≥1500mm

As the elderly age, there are noticeable differences in their physical condition and lifestyle compared to younger individuals. For example, self-care capable elderly individuals have a larger range of activities in their living spaces, higher space utilization, and greater independence in performing basic daily activities. In contrast, care-dependent elderly individuals rely heavily on caregivers for assistance, and therefore, caregiver activity spaces should be considered in age-friendly design.

2.2 Physiological Changes in the Elderly and Corresponding Environmental Measures

With advancing age, various physiological functions of the elderly decline significantly (Table 3), resulting in their reduced ability to perform self-care in daily life and increased vulnerability to external injuries and illnesses (Jing, Zhang, & Ge, 2018).

Table 3. Characteristics of Physiological Changes in the Elderly

Physiological function	Performance symptoms	Decline characteristics
Tactile function	Fingers are not flexible and easily injured	Sluggish stimulus response and degraded grasping ability
Taste function	Unable to swallow,susceptible to wind and cold	Decreased chewing ability, decreased ability to handle heat and cold
Visual function	Blurred eyes, stinging eyes	Reduced visual acuity, reduced photo-reception and color discrimination
Central Nervous System	Slow reflexes, memory loss	Reduced motor nerve conduction
Cardiovascular system	Arteriosclerosis, heart attack, high blood pressure	Sclerosis of blood vessels, decreased elasticity
Skeletal Muscular System	Stumbling and falling, easily fractured	Osteoporosis, muscle weakness

To improve the quality of care services for the elderly in geriatric facilities, the living environment for the elderly should be optimized, including indoor lighting and illumination, color guidance systems, and text signage, through age-friendly design. In space design, considerations should be given to the grip strength of elderly, height, and hand muscle exercise needs. Emergency call systems should also be installed to prevent sudden illnesses in the elderly and ensure timely assistance. In addition, the emergency call system should be installed to ensure timely assistance in case of sudden illnesses in the elderly.

2.3 Changes in Psychological Characteristics of the Elderly and Corresponding Environmental Measures

As elderly individuals age, their psychological characteristics also undergo various changes, such as anxiety, depression, loneliness, and low self-esteem. These psychological issues can result in emotional distress and psychological imbalance in older adults, leading to symptoms such as depression,

pessimism, and agitation (Table 4). These problems not only worsen the elderly individuals' existing health conditions but also trigger other diseases (Feng & Cao, 2018).

Table 4. Characteristics of Psychological Changes in the Elderly

Psychological Characteristics	Formation factors	Performance symptoms
Depression	Psychological gap caused by retirement	Depressed mood, psychological disorders, depression
Anxiety	Physiological aging, fewer choices	Distraction, impulsiveness, lack of confidence and enthusiasm
Low self-esteem	Excessive low self-esteem, reduced social perception	Self-doubt, self-denial
Loneliness	Severe sense of abandonment, doubting self-worth	Desire less, helplessness, hopelessness

Although elderly individuals have diverse psychological needs, they also share common desires. For example, in terms of medical and health care, older adults seek professional medical care and integrated elderly care approaches to maintain their health. In terms of mental needs, older adults wish to participate in daily cultural and recreational activities to alleviate mental loneliness and restore vitality. Regarding personal privacy, older adults also desire personal spaces that can protect their privacy. Therefore, elderly care facilities should provide corresponding services, facilities, and environments to meet the needs of older adults (Ma, 2017).

3. Analysis of Aging-Friendly Design Cases for Residential Spaces in Institutional Elderly Care Models

3.1 Overview

Shuangfeng Liyuan Elderly Care Center is a newly established public-private elderly care service institution led by the Civil Affairs Bureau of Shun Yin District. It is located in Building 25 of YunHe Creek Residence, Lu'ne7, Ma Po Town, Shun Yin District, Beijing, with a total area of 4942.55m^2 and a building area of 3893.46m^2. It has a total of 116 beds, including 91 beds for social elderly services and 25 beds for government-funded welfare recipients. The institution primarily provides 24-hour care and nursing services for older adults who are self-care, semi-self-care, functionally disabled, cognitively impaired, or recovering from illnesses. Its services mainly include life care, dietary services, and cleaning and sanitation services, providing single rooms, double rooms, and multi-person rooms for elderly residents.

3.2 Design Limitations

Through research, the following design flaws were identified in the residential spaces for elderly residents (Figure 1):

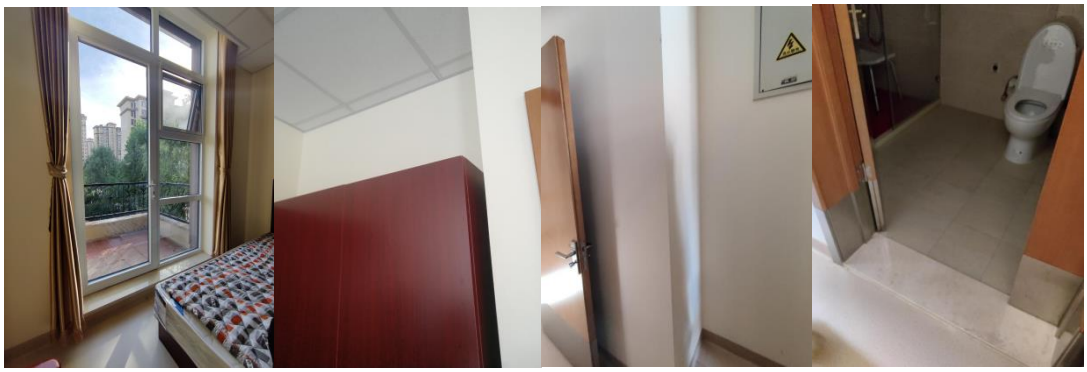

Figure 1. Current Situation of the Elderly Living Room

1) The thresholds of the balcony doors are too high, causing inconvenience for older adults to pass through; the bottom of the balcony railings has high steps, posing risks for older adults with psychological barriers.

2) There is excessive unused space above the wardrobe in the rooms, resulting in wasted space and low utilization of the interior space.

3) The window area for natural lighting in the rooms is too small, resulting in insufficient indoor lighting, which can cause dimness indoors and affect the health of older adults.

4) The personalized space settings for elderly residents were not considered in the room design, resulting in a lack of sense of belonging and security in the short term for older adults.

5) The bathrooms have thresholds, causing inconvenience for older adults to pass through and posing risks of falls.

6) The corners of the walls in the rooms are too sharp without corner protection or rounded corner treatment, making it easy for older adults to get injured.

3.3 Optimization of Living Spaces for the Elderly in Elderly Facilities

To address the aforementioned issues, the following optimization ideas are proposed:

1) The threshold of the balcony door should be removed in elderly living spaces, and a sloped ramp should be provided for the height difference between the balcony floor and indoor floor to facilitate mobility for semi-self-care elderly individuals.

2) The steps at the bottom of the balcony railing should be removed to prevent accidents for the elderly.

3) The wardrobe in the living space should be designed as a full-height wardrobe to reduce wasted indoor space and increase storage space for the elderly.

4) Artificial lighting should be increased in areas with insufficient natural light in the living spaces.

5) Regarding personalized space for the elderly, some furniture and decorations in the living space can be provided by the elderly or their family members to reduce costs and achieve personalized living spaces for the elderly.

6) The corners of walls and furniture in the living spaces should be rounded or covered with corner guards to prevent injuries from collisions for the elderly.

7) The sides of the toilet splash guard should be sloped to facilitate wheelchair access for elderly individuals.

4. Principles and Strategies for Spatial Design of Elderly Living Spaces in Elderly Facilities

4.1 Principles of Elderly Living Space Design in Elderly Facilities

Designing living spaces that are suitable for aging is a concept that focuses on improving the quality of life and happiness of the elderly. In the context of elderly care facilities, the design of elderly living spaces should adhere to the following principles (Table 5):

Table 5. Analysis of Demand for Elderly Institutions

Crowd Analysis	Space requirements	Extracted elements	Summary principles
Elderly residents	Health and safety, functional flexibility, quiet and comfortable, interaction needs	Material safety, reasonable function, appropriate scale, sense of belonging	Safety, functional rationality, practicality, convenience, health, flexibility
Caregivers	Efficient work, convenient flow	Convenient movement, flexible function	Efficient and convenient
Operation perspective	Occupancy rate and service environment	Efficient, economical	Targeted, economical, sustainable

1) Safety principle: Ensuring the safety of living spaces for the elderly, preventing accidents such as falls and collisions.

2) Convenience principle: Ensuring that the elderly can easily enter, move around, and use facilities and equipment, reducing the difficulty of their activities.

3) Familiarity principle: Creating a familiar and comfortable living environment for the elderly to make them feel at home and comfortable.

4) Ease of maintenance principle: Considering the selection of facilities and equipment that are cost-effective, reducing maintenance and upkeep costs, and reducing the burden on the elderly.

4.2 Key Design Points for Functional Areas in Living Spaces

The following are the key design points for various functional areas in elderly living spaces in elderly facilities:

1) Front space: In elderly care facilities, enhancing the sense of personal space and belonging for the elderly by setting up nameplates with their names; installing high and low viewing holes on the door panels, leaving space for wheelchair maneuverability in front of the viewing holes; using push-type handles as the main door handles, making it convenient for the elderly to use, and installing sturdy and easy-to-clean collision guards at the bottom of the door panels to prevent collisions with wheelchairs and other assistive devices and facilitate daily cleaning and maintenance by caregivers.

2) Entrance foyer: This area should meet the living habits of the elderly while also improving their sense of safety and convenience through design of the storage platform; installing hooks for hanging clothes at different heights in the foyer to facilitate standing and sitting use; installing motion sensor lights to help the elderly discern spatial boundaries and objects, and improve their safety during movement; reserving space for wheelchair storage to avoid limiting the mobility of the elderly due to lack of storage space.

3) Storage area: When planning the location of storage in living spaces, the principles of proximity and centralized storage should be followed, and open storage should be visually intuitive for easy searching and access of items needed by the elderly; cabinet-style storage can be used for items that require high cleanliness, such as clothes, bedding, etc.

4) Reading Area for the Elderly: Compared to recreational activities, elderly individuals prefer activities that focus on self-cultivation and refinement, such as painting, calligraphy, reading, and singing. Therefore, the living space should be designed with sufficient space and tabletops for the placement of relevant items. Additionally, a washing area should be conveniently located near the tabletop to facilitate ink cleaning.

5) Leisure Activity Area: The activity area should be planned according to the types of activities that the elderly engage in, such as sunbathing and chatting, and should have an area of approximately 1.5-3m². Sufficient natural light should be maintained in the activity area, and the spatial planning should be compact and reasonable, while also fully meeting the entertainment needs of the elderly.

6) Sleeping Area for the Elderly: The design of the sleeping area should consider placing the beds away from doors and windows to avoid cold drafts. Sufficient storage space should be provided between beds for passage and for storing walking aids, canes, assistive devices, and portable toilets. Call buttons should be installed near the head of the bed to ensure that the elderly can call for caregivers.

7) Bathroom: The design of the bathroom should consider the functional needs of the elderly while taking into account their living habits. It should ensure safety, usability, and practicality, while also meeting the pursuit of elderly of quality of life.

4.3 Design of Physical Environment in Living Spaces

Human perception of the world relies on sensory systems, and the most important factors affecting the perception of elderly individuals include color environment, lighting environment, temperature, and other physical factors. Therefore, optimizing the physical environment of living spaces plays an important role in the physical and mental health of elderly individuals.

1) Color environment: Considering the physical characteristics of color and its psychological effects on individuals is crucial in optimizing the visual environment of elderly care institutions. Reasonable use of color can help elderly individuals better discern spatial contours, reduce the perception of spatial distance and weak stereoscopic vision caused by visual degradation. This helps reduce the risk of accidental falls due to errors in judging the distance and height of objects, thereby protecting the health of elderly individuals and assisting in the treatment of chronic diseases. Therefore, fully utilizing the characteristics of color, adjusting the psychological emotions of elderly individuals, and optimizing the visual environment in elderly care institutions have a positive impact on the quality of life and health status of elderly individuals (Table 6).

Table 6. Physiological and Psychological Sensations Caused by Color

Color	Physiological sensations	Mental association
Red	Stimulates nerves, increases blood pressure and blood circulation	Warm, festive, anxious, restless
Orange	Helps to absorb calcium, induces appetite, and is good for health	Light-hearted, energetic, warm, enthusiastic
Yellow	Stimulates the nervous and digestive systems, improves logical thinking	Happiness, hope, warmth, nobility
Green	Relieves visual fatigue, reduces appetite, and eliminates negative emotions	Tranquility, health, security, calmness
Blue	Effectively relieves pain and other diseases, and has a hypnotic effect	Refreshing, professional, sensible, calm
Purple	Calms motor nerves and heart, relieves pain	Mysterious, decompression, depression, sadness
White	Helps balance blood pressure, calms nerves and emotions	Simple, pure, happy, decompressed
Black	Calms the elderly and has a calming effect on them	Deep, silent, depressing, mysterious

2) Day lighting: Since natural light best meets the adaptive requirements of human eyes to light, the amount of natural day lighting in living spaces should be reasonably arranged and adjusted according to different seasons and regions. In spaces with single-sided day lighting, the depth of the space should not be too long to avoid glare for elderly individuals. When the light is too intense, partial sunlight can be blocked by shading curtains to prevent discomfort for elderly individuals.

3) Artificial lighting: Artificial light can increase the illumination of the space while assisting natural light, and multi-level lighting can be used to optimize the spatial environment in living spaces, with dedicated lighting for specific areas. The placement of lighting fixtures should be arranged reasonably

to ensure the safety of elderly individuals and meet the diversity of their spatial needs, playing a good regulatory role in the indoor lighting environment (Table 7). Since different color temperatures can affect the psychological perception of individuals, the use of appropriate light source color temperatures in living spaces has a positive impact on the physical and mental well-being of elderly individuals (Xia & Li, 2011).

Table 7. Lighting Environment Data Analysis

Color phase	Color temperature K	Light source type	Area of use
Cool white light	5500K-6500K	Daylight color fluorescent lamp	Other areas
Natural white light	3500K-4500K	Cool white fluorescent lamp	Reading area
Warm white light	3000K-3300K	Warm white fluorescent lamp	Recreation area
Warm yellow light	2500K-3000K	White woven lamp	Sleeping area

4) Heating and Ventilation: Heating and ventilation design are critical factors that have a significant impact on the living quality of elderly facilities in age-friendly design. On one hand, Due to the reduced Temperature regulation of older people, there are a number of potential risks to their health. Therefore, maintaining room temperature within a comfortable range for elderly residents is highly important. Air conditioning for cooling and heating, as well as heating systems, are commonly used in indoor environments, but both methods may result in uneven temperature distribution. Therefore, zone heating should be implemented to avoid potential burns from uneven heat sources for elderly residents. In terms of ventilation design, it is necessary to enhance air flow within the living spaces and avoid creating dead zones where air circulation is insufficient. These design measures contribute to protecting the health and comfort of elderly residents.

5) Noise Reduction and Soundproofing: Effective noise control and soundproofing design are crucial for the physical and psychological health of elderly individuals. In the living environment of elderly care institutions, careful site selection should avoid areas with high noise levels. Window and door design can incorporate features such as double-glazed windows and soundproof doors to achieve noise reduction. Furniture, heavy curtains, soft cushions, and decorative items with soft surfaces can be used to absorb some of the sound energy. Sharp noises produced by furniture movement on the floor should be minimized. To reduce flushing noise, toilets can be equipped with back-discharge toilet bowls that discharge wastewater to outdoor pipes or larger diameter pipes. Furthermore, staff management and training should be strengthened to create a quiet and comfortable living environment that meets the needs of elderly residents in care institutions. Overall, effective noise reduction and soundproofing measures should be implemented to promote the well-being of elderly residents.

6) Furniture: According to the principles of accessibility for the elderly, furniture for elderly facilities should be selected with considerations of size and age-friendly details to meet the needs of older adults

and enhance their quality of life. When designing sofas and chairs, the height and tilt angle of the seat should be adjusted moderately to best fit the contour of the back of elderly, and the seat cushion should be made of high-resilience or medium-hardness materials to reduce physical exertion when getting up. The upholstery material should have good air permeability, anti-static properties, fade resistance, and antimicrobial properties. For tables and chairs, the sharp corners of the table should be rounded, and the table surface should be covered with fire-resistant board veneer to improve safety factor (Figure 2).

Figure 2. Aging-friendly Furniture Design Details

7) Soft furnishings: Handicrafts and artworks created by the elderly are the best decorations in elderly facilities as they not only recognize their intrinsic value but also showcase their life and spirit. Selecting vintage objects that reflect the times can help strengthen the sense of elderly of affinity and belonging to the community. When choosing decorations, consideration should be given to the living environment of the elderly, and suitable decorations that are conducive to the physical and psychological well-being of older adults should be selected to have a positive impact.

8) Indoor plants: In addition to their emotional benefits, indoor plants can effectively purify indoor air, enrich indoor colors, soften and weaken confined spaces, and create a friendly and natural living environment. When selecting plants, priority should be given to non-toxic, non-prickly, and allergy-friendly species to avoid adverse effects such as odor, pollen, or parasites triggering allergies or asthma in older adults. At the same time, the placement of indoor plants should consider the health and safety of older adults, ensuring that they do not cause any inconvenience or danger. Sufficient storage space should also be provided for planting tools, such as spray bottles and weeding tools, to facilitate older adults in plant care and management.

4.4 Material Selection and Detailed Design of Living Space

4.4.1 Factors and Considerations for Material Selection

Different materials used in architectural spaces have different textures, patterns, and odors. In space design, the common characteristics and features of materials should be fully understood, and materials suitable for elderly living should be selected. These materials should possess characteristics such as

safety, cushioning, mold resistance, slip resistance, environmental friendliness, and ease of maintenance in order to protect the physical health of the elderly and prevent accidents (Liu, 2015).

4.4.2 Selection of Wall, Floor, and Ceiling Materials

1) Wall Materials: In elderly care facilities, wall materials for senior residents' rooms should preferably include wallpapers, paints, fabric in some areas, tiles, wood, and other materials. Wallpapers should have characteristics such as resistance to pollution, friction, good texture, waterproofing, easy cleaning, and durability for ease of maintenance in the long term. Paints should be durable, low maintenance, rich in color, and glossy, but special attention should be paid to the issue of glare. Fabric installation may be more challenging and costly to maintain, but it has good sound absorption effects and can be used appropriately. When using tiles on walls, they can be used as partial decorations, but fragile materials such as large glass should be avoided to prevent potential hazards to the safety of elderly residents (Table 8).

Table 8. Analysis of Living Room Wall Materials

Material	Vinyl wallpaper	Ceramic wall tile
Features	Easy to clean, maintain and repair, fire resistant, scratch resistant, no seams, meets aging sanitation requirements, textures and finishes can also be used as special prints, can be used in health care buildings hospitals and nursing homes living spaces	Easy to clean, can be used in the sink, toilet, wall, behind the tile
Applicable area	Can be used in health care buildings, hospitals and nursing units, public spaces and corridor walls	Indoor bathroom, bathroom for the elderly with dementia can use different color tiles to emphasize the functional position

2) Floor Materials: The selection of floor materials for elderly residents' rooms should consider factors such as slip resistance, cushioning, waterproofing, durability, and maintenance difficulty. The colors of floor materials should not be overly diverse to avoid visual confusion for elderly individuals. Due to factors such as osteoporosis, decreased mobility, reduced balance, and increased risk of falling among elderly individuals, floor materials with higher slip resistance should be chosen to effectively reduce the probability of accidents. At the same time, considering that care-dependent elderly individuals may use assistive devices such as canes, walkers, wheelchairs, etc., durable floor materials should be chosen to minimize wear and tear from assistive devices (Table 9).

Table 9. Analysis of Living Room Floor Materials

Material	Features	Applicable areas
High-grade hardwood	Natural hardwood featuring depth and grain, less denting, water resistant	Nursing unit and living room floors
Vinyl slats	No scratches and stains, high resistance to wear and tear, low maintenance	Public space and corridor floors
Flooring tiles	Non-slip and easy to clean, easy to use for elderly wheelchair users, low maintenance cost	Bathroom floors in self-care and semi-self-care units
Synthetic poured flooring systems	Wear-resistant, non-slip, strong grip, hollow base, seamless skirting, age-appropriate hygiene standards, anti-bacteria and dirt, not easy to produce urine stains and odor	Nursing unit bathroom floors

3) Ceiling Materials: Ceiling materials should be lightweight, sound-absorbing, and resistant to staining. The color of the ceiling material should be predominantly light to increase brightness in the room and avoid a sense of oppression for elderly individuals caused by dark colors. Additionally, fragile and detachable materials should be avoided to prevent safety hazards for elderly residents (Table 10).

Table 10. Analysis of Ceiling Materials in Living Rooms

Material	Asbestos sound-absorbing panels	Acoustic spraying	Gypsum Vinyl Acoustic Panel
Features	Efficient noise absorption to reduce rebound fire and moisture	Excellent noise and sound reduction	Easy to clean and fire resistant with no joints
Applicable area	Public area	Living room unit living room part	Living room bathroom and public space

4.4.3 Design Considerations for Doors and Windows in Elderly Facilities

To facilitate wheelchair use by elderly individuals, door thresholds should be avoided in room entrances. Door handles should be selected with consideration for longer rotation arms, and the optimal height should be between 900mm and 1000mm. For indoor windows, the design should take into account day lighting and viewing needs, and double-glazed windows should be used to improve sound insulation and thermal insulation. Considering the average height of elderly individuals, the height of interior window sills can be set at a standard height of approximately 750mm so that older individuals can view the outside scenery while sitting or lying on the bed. These measures aim to create a more comfortable and convenient living environment for elderly individuals (Ma, 2014).

5. Conclusions

Based on the literature review and field investigations, this paper analyzed the physiological and psychological characteristics of the elderly, as well as the problems and pros and cons of elderly living spaces in actual elderly care institutions. Based on this analysis, this paper proposed key design principles and strategies for age-friendly design of elderly living spaces in institutional care settings, including principles for spatial design of elderly care institution rooms, design considerations for various functional areas within living spaces, material selection and detailed design, and physical environmental design of living spaces. In the future, further research should be conducted on the care needs of elderly, and through refined design and practice, more livable environments that are suitable for elderly living should be created to meet the diverse care needs of the elderly, and to improve their quality of life and well-being.

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