Design and transformation of the interior space for home-based care for the aged based on network security

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Abstract: With the prominent issue of population aging, home-based elderly care has become an important way of elderly care. The current home-based elderly care environment is unable to meet the practical needs of the elderly in terms of functionality and safety. This paper is based on the characteristics of the elderly, the needs and development status of indoor space design, and combined with network security, to study the design and renovation of indoor spaces for home-based elderly care. And from the perspectives of functionality, safety, and aesthetics, the results showed that the average score for the design and renovation of indoor spaces for home-based elderly care based on network security in terms of safety evaluation was 8.27 points, higher than the traditional method's 7.11 points. This indicates that the method proposed in this paper can effectively ensure the daily safety of elderly people and meet their housing safety needs.

Keywords: interior space design; network security; home-based care for the aged; elderly group; functional improvement; aging population; needs of the elderly; aesthetic design.

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1   Introduction

With the maturity of the market economy and the improvement of medical technology, the ageing of the population has gradually become one of the main problems and challenges faced by social development. Although the current pension service system is increasingly perfect, most elderly people still take home-based pension as the main mode. Influenced by objective conditions, most of the elderly people's home space is relatively

simple, and it is difficult to fully adapt to old age, and cannot meet the physical, physiological, emotional, and spiritual needs of the elderly. Therefore, how to better protect the elderly care needs of home-based elderly patients, improve their living environment, and achieve the unity of indoor space functionality and safety would become urgent problems for social elderly care services. With the development of information technology, network security technology has made considerable progress and has been widely used in many fields. For example, it can play a great role in mobile internet, business applications, website data, etc. In the design of indoor spaces for home-based elderly care, network security technology can sense the security risks of the elderly living environment according to the actual needs of elderly care services, and improve the level and quality of home-based elderly care services from the perspective of spatial layout, functional zoning, etc.

With the continuous growth of the demand for elderly care services, the design and transformation of the interior space for home-based elderly care has become the focus of many scholars. Wu (2022) used intelligent technology to understand the safety requirements in the interior space design of the nursing home for the elderly. It included indoor air quality, thermal environment, accessibility, and low possibility of accidental injury to ensure the healthy and comfortable daily life of the elderly. To study the nursing facilities and general design of the elderly care room, Min and Lee (2020) systematically analysed the peer-reviewed journal database and 125 papers, including field research, case study, comparative analysis, etc. This can provide a scientific basis for the design and transformation of elderly care space. Lee et al. (2020) put forward a method based on building information modelling and studied the interior circulation and space allocation in the old interior space design. He finally proved through project practice that the building information modelling method can provide quantitative analysis results quickly and reliably to solve the problems of circulation and space distribution in the reconstructed elderly care room. Based on the general design supporting space concept, Kim and Kim (2020) investigated the accessibility standards of indoor space design for the home-based elderly. Through chi-square analysis, he found that the elements such as the sink, bathtub, and dressing room still need to be improved in the interior space design. At present, many studies have put forward suggestions and methods for the design and transformation of the interior space for the aged from different angles, which was of great significance to the improvement of the living environment for the aged. With the in-depth development of the concept of providing for the aged, the design of the interior space for home-based people also needs to be properly improved and optimised. The current research did not take into account the actual needs of the elderly.

With the continuous improvement of the elderly care service level, the actual elderly care needs of the elderly have gradually received attention and attention. Through reviewing relevant literature, Engineer et al. (2018) revealed the knowledge gap of interior design in the health and longevity of the elderly from a multidisciplinary perspective. He adopted an adaptive design strategy to identify and address the unique situational needs of each user and provide the best treatment and living environment for the elderly population. Bonenberg (2019) believed that the needs of the elderly should be effectively incorporated into the family interior design process, and the inclusive design related to the kitchen should be applied in practice. He finally showed through the results that the design scheme could meet the kitchen use needs of the elderly. At present,

most of the research only discussed the design and transformation of the elderly care interior space from the shallow theoretical level and the intelligence of the space design needed to be improved.

To improve the quality of life of the elderly and improve the level of home-based elderly care services, this paper has carried out in-depth research on the design and transformation of the indoor space for home-based elderly care based on network security. To verify the effectiveness of the method in this paper, in the design practice, this paper took the two-bedroom residential unit in a residential project as a sample and carried out the interior space design and transformation. This paper evaluated the residential function, safety, and aesthetics. Under the method of this paper, the functionality and safety of interior design have relatively ideal performance. Compared with the traditional design method, the beauty of the interior design transformation results in this paper also has certain advantages. In the application practice, the design and transformation of the indoor space for the aged home based on network security can effectively combine the needs of the elderly. This can provide them with a comfortable, safe, and reliable living environment, which is of great significance for alleviating the pressure of social pensions.

2 Design and transformation of the interior space for home-based care for the aged

2.1 Overview of home-based care for the aged and interior space design

2.1.1 Definition

Home-based elderly care is an elderly care model centered on family life, which mainly relies on community activities to enable the home-based elderly living to enjoy the professional services provided by the social elderly care service system (Zhu, 2022). Its mode is shown in Figure 1. Professional services mainly include life care services and health management services. Under the development trend of population ageing, the social pension service system has assumed great pressure. Problems such as insufficient endowment resources have had a certain impact on the traditional institutional endowment model and community endowment model (Alidoust et al., 2019). Home-based pension not only effectively integrates the advantages of the other two traditional pension models, but also effectively alleviates the serious shortage of pension resources.

The transformation of interior space design needs to reflect the humanised design concept through space structure layout, furniture configuration, and other aspects (Hicks, 2022). Therefore, the design and transformation of the home-based care interior needs to combine the living habits of the elderly and meet the living needs of the elderly as the premise. This design concept is also sustainable. In the process of transformation, according to the material and spiritual needs of the elderly, people should improve the quality and level of home-based elderly care services from the perspective of design. This can play an important role in promoting the improvement and development of the social pension system.

Figure 1   Home-based pension model (see online version for colours)
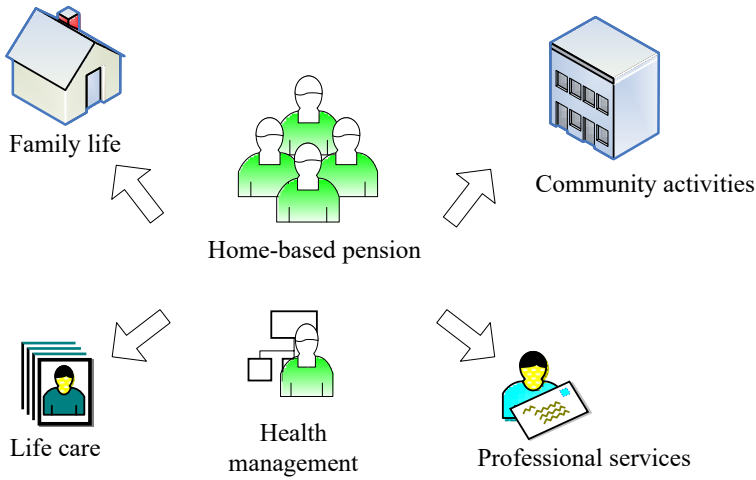
2.1.2 *Characteristics of the elderly*

As a space carrier for the home-based elderly, indoor space is not only the place for the daily activities of the elderly but also an important space for social interaction. The specific planning of interior space design and transformation is closely related to the group characteristics of the elderly. Only by fully understanding their group characteristics can people design a more ideal and comfortable living space for the elderly. The characteristics of the elderly group are mainly divided into three parts: psychological characteristics, behavioural characteristics, and physiological characteristics, as shown in Table 1.

Table 1   Characteristics of the elderly

Sequence	Characteristics	Definition
1	Psychological	The psychological activities of the elderly often show stable characteristics
2	Behavioural	The basic characteristics of the elderly in their lives under the influence of social and cultural systems and personal values
3	Physiological	Physical external representation of the elderly

From the perspective of psychological characteristics, people's psychological characteristics are mainly affected by their living environment and conditions. Economic income, cultural level, and family conditions would have a certain impact on people's psychological characteristics. With the continuous decline of the memory, judgement, and other information-processing abilities of the elderly, and the impact of age growth on their lives, the elderly tend to have psychological characteristics such as loss and depression. In addition, while the social role and economic income of the elderly have changed, their social life and family life structure have also changed dramatically. The design and transformation of the elderly care space have an important impact on the mental health of the elderly residents (Rakhshani and Nastiezaie, 2019).

From the perspective of behavioural characteristics, the daily living habits of the elderly often have certain rules, and their main activities are shown in Table 2.

Table 2   Daily activities of the elderly

Range	Sequence	Activity
Behaviour characteristics	1	Leisure and entertainment
	2	Home life social activities
	3	Rehabilitation
	4	Healthcare

In addition to rehabilitation treatment, most activities of the elderly are carried out indoors, with a small range of activities. With the decline of the elderly's health level, their range of activities would also decrease. The growth of age and the restriction of physical conditions make their activities concentrated in the home and the community. Most elderly people usually only exercise through some simple family activities, and their behavioural characteristics are relatively simple.

From the perspective of physiological characteristics, human beings are from birth to maturity, then to ageing and death (Burnley and Jones, 2018). With the growth of age, people's physiological characteristics change significantly, which is mainly reflected in the great changes and decline of human physiological and metabolic functions. The first is the decline of audio-visual ability. The decline of visual ability is mainly manifested by blurred visual objects and significantly reduced photosensitivity. Taking lighting demand as an example, the minimum requirement for teenagers is 150 lux, while that for the elderly is at least 600 lux, four times that of teenagers. In terms of hearing, the elderly showed more significant degradation in high-frequency sound, while there was no significant decline in middle and low frequencies. Secondly, the nervous function of the elderly population would also gradually decline, which is mainly reflected in the decline of activity ability, slow daily activities, and slow response (Licher, 2019). With the growth of age, their physical functions would become worse and worse, mainly manifested by the atrophy of muscle strength and the fragility of bones, which would lead to the decline of their self-care ability. Finally, the decline of immune function would lead to the aggravation of the condition of the elderly and the slow recovery of the body.

2.1.3   *Interior space design demand*

1   *Function*

In the design of the interior space for the elderly, the needs and living habits of the elderly should be considered, and the space should be divided from the perspective of function. Each part of the space has specific functional requirements. In the elderly care apartment, the elderly should have one or two separate living and nursing spaces, and in this space, it should be ensured that the elderly can easily and safely wash, go to the toilet and other activities, and be accompanied by caregivers. Therefore, design from a functional perspective can better reflect the ageing of the elderly care space. This can better meet the actual needs of the elderly and improve their quality of life.

2   Layout

In the process of design and transformation, it needs to plan and analyse the layout of its space reasonably from the aspects of the elderly's self-perception and self-cognition. Compared with the general interior space design, the space design for the elderly should present a new layout. The elderly room, bathroom, kitchen, and action space are expanded, and the living room space is moderately compressed. At present, the housing units are general housing that lacks pertinence and adaptability to the old. The old apartment units that the old people lived in from their youth to the present can no longer meet the various needs of their current life. The different layout of the indoor space for the aged home-based has an important impact on their quality of life. A good layout can provide more safety and convenience for indoor activities of the elderly.

3   Dimensions

Through the analysis of the psychological, behavioural, and physiological characteristics of the elderly group, it can be recognised that each node scale in the indoor space should be planned and designed according to the physical scale and behavioural habits of the elderly to meet the needs of the elderly at different life stages. The size of the home-based elderly care space has a great relationship with the home-based behaviour habits of the elderly. The human body is in an ageing process, and the human body scale would also changes constantly. Therefore, the indoor space must have good scale adaptability. According to relevant data, at present, the expected housing area of middle-aged and elderly people is 60–90 square meters, and the most ideal house type is two or three bedrooms. As the elderly get older, their requirements for houses are also getting lower and lower. Because in the process of ageing, their physical quality would become worse and worse, and daily activities would become more and more difficult. If they live in a large space, their quality of life would be greatly affected. Therefore, if the size is not handled properly, it would bring great security risks to the lives of the elderly.

4   Walking streamline

In daily life, the elderly have problems such as poor eyesight, poor hearing, cervical spine, and lumbar spine, and they spend more time indoors. Therefore, in the design and transformation of interior space, the interior streamline should be reasonably planned and innovated according to the physique and behaviour habits of the elderly.

5   Barrier-free design

The barrier-free design in this paper mainly refers to the barrier-free residential environment design. The basic requirement of barrier-free design is that the planning and design of indoor space should be aimed at facilitating the travel and use of the elderly (Sharma and Kumar, 2022). For example, in the interior design, the floor, handrail, toilet, room, etc. should be considered to facilitate the activities and access of the elderly. The indoor space for the aged home-based is a space with the elderly as the main user. Compared with young people, the spatial needs of the elderly should be dominated by accessibility (Lee et al., 2018).

6 Lighting and daylighting design

The physical function and vision of the elderly are weak, so they need much more light than the young. In terms of psychological characteristics, the lighting and lighting design of indoor space would greatly affect the mood of the elderly. Therefore, sufficient natural light and sufficient artificial light are the necessary conditions for the indoor space of the home-based elderly.

2.1.4 Development status of interior space design

At present, most of the interior space design of elderly care is based on the previous community elderly care and institutional elderly care models. In terms of space design and planning methods, there are still many special features of traditional elderly care mode indoor space, and most of the space planning has not reached the relevant design standards. With the continuous improvement of residents' living standards, to meet the living needs of the elderly, it is necessary to carry out corresponding transformations. In general, there are several problems in the current interior space design:

1 Lack of barrier-free design

The barrier-free design is mainly reflected in the requirements of indoor space scale and the treatment of indoor and outdoor height differences. At present, the living space pattern of most elderly people is single, and the indoor aisle area is small, which is likely to lead to the inconvenience of the elderly in wheelchairs. Even though there are barrier-free walkways in some spaces, most of them do not have handrails. For example, there are no handrails installed on the toilets and no handrails in the shower. There are no anti-skid floor tiles or rest chairs. In addition, most of the design did not take into account the difference between the corridor, bathroom, and other spaces and the indoor floor height, which had a great impact on the daily life of the elderly. If the height difference of indoor spaces such as corridors and public toilets is large, it would increase the probability of elderly people tripping when walking.

2 Poor functional space layout

In terms of indoor space layout, most of the designs have problems such as poor privacy, insufficient storage space, natural lighting, and poor ventilation in indoor rooms. This is mainly caused by the unreasonable and imperfect design of auxiliary equipment in the interior space. In addition, the spatial layout of the living room is poor and the area is too small, which would lead to the inconvenience of the elderly in the living room and bathroom.

3 Low Intelligence

With the rapid ageing of the population, the demand for family pensions is also growing. At present, the application of 'Internet plus' technology in interior design transformation can improve the efficiency of design work to a certain extent. At present, the intelligent level of interior decoration design is still very low and needs further improvement. At present, relevant service platform equipment is still in the initial stage of development

and application. There are still some difficulties in collecting and analysing the basic information and space design needs of the elderly with intelligent devices, integrating them, and realising data sharing.

4   *Hidden danger of network information security*

With the continuous development of smart cities and smart elderly care, the application of network technology is becoming more and more extensive, and network security problems also appear. The design and transformation of the interior space for the aged home must be put into use without the support of network technology. Most of the network platforms require the elderly to register and upload their personal information through their real name, so that they can analyse it in the background, to provide targeted interior design for the elderly. However, the current network security situation cannot fully guarantee the information security of the elderly. When the elderly provide their relevant information to the platform, there are certain information security risks, and it is easy to breed fraud, theft, and other criminal activities. These potential safety hazards have become an important obstacle to the interior design and renovation of the home-based elderly.

2.2   *Network security technology*

Network security refers to the network service that protects the software, hardware, and data of the network to prevent accidental and malicious interference, thus ensuring the stability and continuous operation of the entire system (Fu, 2018). Network security is to protect the security of information. In a broad sense, the theory and technology covering the authenticity and controllability of network information belong to the research scope of network security theory. Network security is a complex subject, involving cryptography, computer science, information security technology, applied mathematics, and other aspects. It mainly uses technical and management means to ensure the security of network information (Fang et al., 2023).

   The goal of network security would also change with different perspectives (Lawson-body et al., 2023). For the renovation design of the interior space of the home-based elderly care service, the main goal is to ensure the integrity, confidentiality, and availability of the privacy or basic information of the elderly. For integrity, it is to ensure that the information of the elderly is transferred from the real sender to the real receiver. It prevents information loss, modification, forgery, and other problems caused by various reasons. Confidentiality means to ensure that the information of the elderly group is shared by the authorised person and not disclosed to others. Confidentiality is based on the credibility and availability of information, which is an important means to ensure the security of users' personal information. Integrity is to prevent information from being damaged, while confidentiality is to prevent information from being disclosed. In terms of availability, it is necessary to ensure that the information and computer information network of the elderly can provide services for the authorised person at any time. That is to say, legal users can obtain and use the right information resources without unauthorised persons abusing their rights and refusing to provide services to authorised persons. The most fundamental role of an information network is to provide services for users, and the demand for elderly care services has a certain randomness and diversity.

According to the actual development of interior design renovation, this paper proposes a risk assessment system for elderly care space based on network security, as shown in Figure 2.

Figure 2　Risk assessment system (see online version for colours)
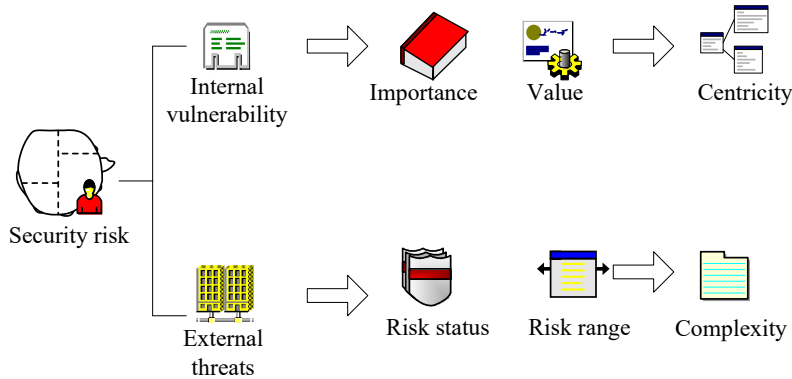
The security risks faced by the elderly can be divided into two parts, namely, the vulnerability inside the indoor space and the external threats. The internal vulnerability mainly includes the importance and value of each indoor node, and the external threat mainly includes the risk status and risk distance.

The importance of each indoor node reflects the importance of the current risk evolution of the node. The higher the importance of the node, the greater the security risk. This paper uses centrality to calculate the importance of nodes in the elderly care spatial information network:

$$c_d(x) = \frac{s(x)}{n-1} \tag{1}$$

The parameter definition is shown in Table 3.

Table 3　Definition of formula parameters

Sequence	Parameter	Meaning
1	$s(ex)$	Indicates the degree of node x
2	n	Indicates the total number of indoor nodes
3	$n-1$	Indicates the maximum possible number of adjacent points

Indoor node value is a relatively complex decision-making problem. To better understand the value of nodes, this paper considers the value of each node's information in the interior design from three aspects, namely, the loss of integrity, confidentiality, and availability of the information in its space after the node suffers security risk, according to the qualitative index fuzzy quantification method of analytic hierarchy process (AHP). The quantitative criteria are shown in Table 4.

Table 4   Value quantification standard

Index	Optional value	Scoring criteria
Integrity	High	0.5
	Medium	0.3
	Low	0.1
Confidentiality	High	0.5
	Medium	0.3
	Low	0.1
Availability	High	0.5
	Medium	0.3
	Low	0.1

According to the characteristics of AHP and node information value, the value is divided into high, medium, and low levels according to integrity (I), confidentiality (C), and availability (A), and the corresponding quantitative values are 0.5, 0.3, and 0.1 respectively. The resulting value:

$$R = w_I I + w_C C + w_A A \tag{2}$$

Among them, w_I, w_C, *and* w_A are the weight of integrity (I), confidentiality (C), and availability (A) respectively.

The risk distance f_d of node information is the number of changes required for security risk evolution. When $0 \le f_d \le n$, the value is an integer (Wang et al., 2023):

$$f_d = 0 \tag{3}$$

At this time, the information of this node has been subjected to certain security risks.

According to the AHP quantification method of the indicators, the risk of indoor node information in the process of space security risk evolution can be calculated. To set the risk value of the node at [0,1], the calculation formula is expressed as:

$$d_{Node} = e^{-\left(\frac{w_C C}{w_I I + w_A A}\right)} \tag{4}$$

In the design process, the weight can be selected according to the actual needs of the elderly and the focus of the assessment.

The hidden node information risk can also be directly calculated by formula (4). The risk d_p of the dominant node consists of two parts: the risk of the indoor node information and all hidden risks contained in the space:

$$d_p = d_{Node} + \sum d_{Node} \tag{5}$$

Under the risk assessment system based on network security, the potential risks in the space network of the elderly care room can be effectively quantified. In the process of design and transformation, based on this objective basis, it can effectively combine the needs of different elderly groups, carry out intelligent design and transformation, and improve the functionality and safety of the design to a certain extent.

3   Design and transformation practice of indoor space for the aged at home

To verify the effectiveness of the analysis of the design and transformation of the indoor space for home-based care for the aged based on network security, this paper takes a residential project for home-based care for the aged as an example to carry out the design and transformation of the indoor space for the two-bedroom residential unit in the residential project. This paper evaluates the residential function, safety, and aesthetics respectively, and the evaluation method is an expert scoring method. This paper invited six interior space designers to score the final design results (Take the average value of the results), with a score of 1–10 points. To ensure the objectivity of the experimental results, this paper compares it with the traditional design and transformation methods. The basic information of the residential project is shown in Table 5.

Table 5   Basic information on residential projects

| Sequence	Item	Information
1	Total building area	2313 square meters
2	Land area	8577 square meters
3	Floor	6th to 12th floors
4	Number of buildings	6

It can be seen from Table 5 that the residential project has a large construction scale and its development potential is also large. This paper takes this as a sample of interior design transformation, which has certain representativeness.

1   *Functionality*

The functional evaluation of this paper mainly focuses on the six aspects of the interior design transformation results, namely, ageing, ventilation, privacy, integrity of supporting facilities, interior streamline, and barrier-free design (numbered 1–6 in this paper in order). The functionality of the elderly care space plays an important role in meeting the needs of the elderly group's family life development. In the design of interior space, it is necessary to combine the actual life development needs of the elderly group. This paper compares the residential functional evaluation results under the two types of methods, as shown in Figure 3.

From Figure 3, the functional evaluation results of the two design methods show different levels. In Figure 3(A), the scores of the interior design transformation results under this method in terms of ageing, ventilation, privacy, integrity of supporting facilities, interior streamline, and accessibility design are 7.92 points, 7.45 points, 8.01 points, 7.26 points, 7.41 points, and 7.96 points respectively. The average functional score is about 7.67. In Figure 3(B), the scores of interior design transformation achievements under the traditional method are 6.54, 7.12, 7.39, 6.77, 7.19, and 7.53 respectively. The average functional score is about 7.09. From the specific scoring results, people can see that the interior design using this method is more functional. Under the risk assessment system, the functional layout of the elderly care space is more intuitive and compact, and the needs of the elderly care group can also be effectively perceived.

Figure 3   Functional evaluation results: (A) shows the functionality of this method and (B) shows the functionality of traditional methods (see online version for colours)
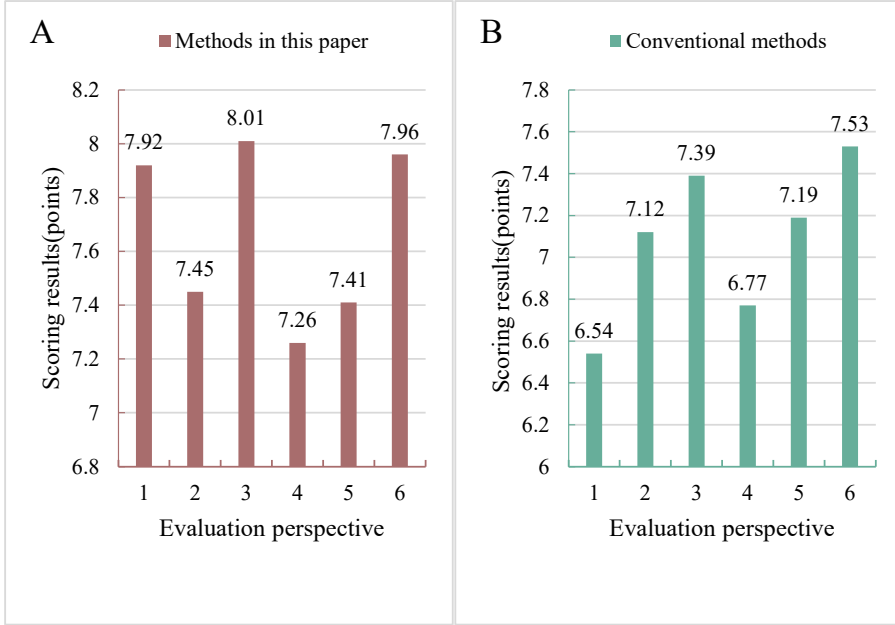

2   Security

The safety evaluation is mainly to evaluate whether the six node design information (numbered 1–6 in this paper in order) of the indoor living room, dining room, kitchen, bathroom, corridor, and balcony meet the safety needs of the elderly. According to the behavioural and physiological characteristics of the elderly, it can be seen that the safety of indoor space is one of the important principles of renovation design. This paper compares the residential safety evaluation results under the design and reconstruction of the two methods, as shown in Figure 4.

From Figure 4, the score of the design method in this paper in the safety evaluation of each node is generally higher than that of the traditional design method. In Figure 4(A), the scores of this method in the safety evaluation of each node are 8.14 points, 8.66 points, 8.32 points, 8.15 points, 8.09 points, and 8.23 points. The average safety score is about 8.27. In Figure 4(B), the traditional method scores 7.21 points, 6.94 points, 6.76 points, 7.29 points, 7.15 points, and 7.32 points in the safety evaluation of each node. The average safety score is about 7.11. It can be seen from the comparison of the results that the traditional methods do not fully consider the security requirements in the design process. Under the quantification of AHP, the risk assessment system can effectively assess the risk of indoor information at each node and minimise the residential information risk of the elderly. This plays an important role in ensuring the daily life and basic elderly care services of the elderly.

Figure 4 Safety evaluation results: (A) shows the security of this method and (B) shows the security of traditional methods (see online version for colours)
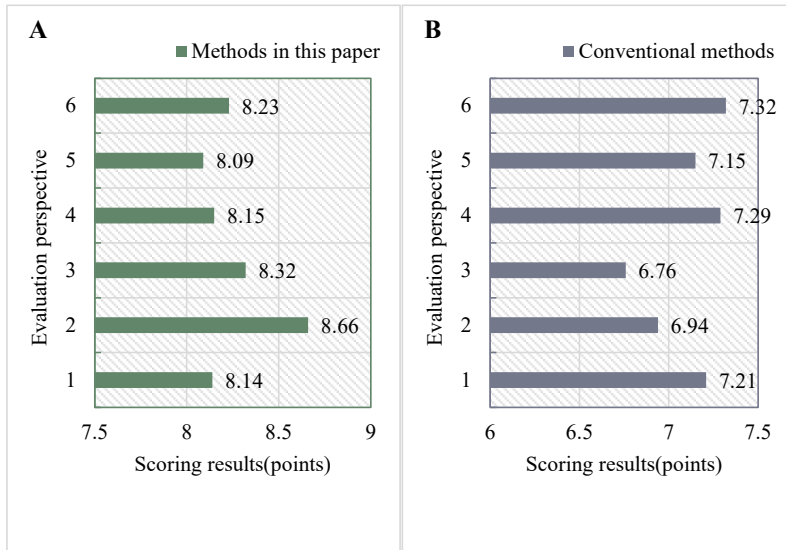
3 Aesthetics

To meet the spiritual life and self-value needs of home-based care for the aged, the aesthetic design of the elderly care space is also essential. The aesthetic evaluation focuses on the layout, size, design elements, and lighting of the design results. This paper compares the aesthetic evaluation results of residential buildings under the two types of methods, as shown in Figure 5.

Figure 5 Aesthetic evaluation results: (A) shows the aesthetics of this method and (B) shows the aesthetics of traditional methods (see online version for colours)
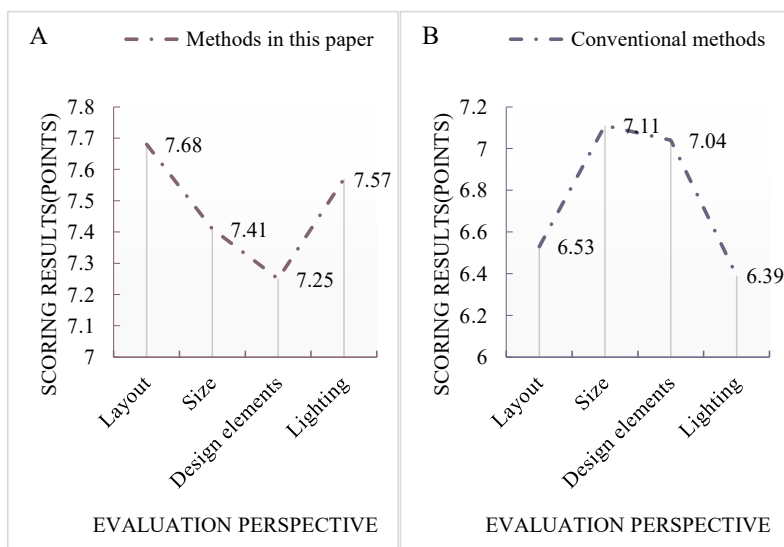
In Figure 5(A), the design method in this paper scored 7.68 points, 7.41 points, 7.25 points, and 7.57 points in terms of layout, size, design elements, and lighting. The average score of aesthetics is about 7.48. In Figure 5(B), the scores of traditional methods in layout, size, design elements, and lighting are 6.53 points, 7.11 points, 7.04 points, and 6.39 points respectively. The average score of aesthetics is about 6.77. It can be seen that the design and transformation of the indoor space for home-based care for the aged based on network security is more beautiful. In terms of ensuring the basic functions and security requirements, network security technology can combine the user information of the elderly group to meet their spiritual life needs in terms of layout, size, design elements, lighting, etc., thus greatly improving the viewing value of interior design.

4   Conclusions

With the prominent problem of population ageing, the problem of old-age housing for the elderly has been widely discussed by all sectors of society. At present, the design of indoor elderly care spaces does not fully integrate the characteristics and needs of the elderly, affecting the quality of home-based elderly care services. This can provide a comfortable living space for the elderly and improve the scientificity and rationality of interior design transformation. Based on network security, this paper made an in-depth study on the design and transformation of the interior space for home-based care for the aged. It not only significantly improved the functionality and safety of the elderly care space based on the actual elderly care needs of the elderly, but also improved the aesthetics of the interior design to a certain extent, so that the daily life and spiritual life of the elderly are effectively guaranteed. Although the analysis of the design and transformation of home-based elderly care interior space based on network security can provide some guidance for improving home-based elderly care services, there are still some areas that need to be improved in the research process. In the design and transformation practice, this paper only selected a two-bedroom apartment in a certain elderly care housing project for practice, and the universal applicability of the conclusion needed to be deepened. In future studies, it would improve the level of home-based elderly care services and improve the quality of life of the elderly.

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