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Ageing Suitability Evaluation of Residential Districts Based on Active Ageing Theory

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Abstract: Residential districts, the primary locations for older adults, struggle to satisfy the needs of the rising older population due to ageing infrastructure, etc. China has begun to focus on this issue through the popularization of approaches such as active ageing theory (AAT), and has implemented ageing suitability renovations. Meanwhile, recent evaluation models failed to validate their logic and standardization. The current evaluation models prioritize the indoor environment above the external environment. Therefore, this study attempts to provide a comprehensive evaluation model of the ageing suitability of residential districts. First, 23 indicators of ageing suitability were identified by a systematic literature review and expert interviews; next, the indicators were categorized using the active ageing theory. Second, the grey correlation analysis approach was used to calculate the weights of evaluation indicators, and the existing evaluation criteria were incorporated to formulate the evaluation criteria for the project. Eventually, the evaluation model was constructed. Finally, the feasibility of the model was validated by a case study. The findings of this study can help provide directions for the future renovation of old residential districts (for example, the activity area should be over 200 m^2) and the construction of suitable houses for older adults, such as the installation of a continuous handrail, to alleviate the increasingly grave problem of ageing and promote the development of the pension industry.

Keywords: active ageing theory; ageing suitability evaluation; residential districts; systematic literature review; grey correlation analysis

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1. Introduction

With the decline in the fertility of the global population and the mortality rate, and the continuous rise of longevity, the degree of aging of the population is becoming increasingly serious [1]. With the popularization of sophisticated medical facilities and the advancement of medical technology, the quality of ageing is improving, from "healthy ageing" to "successful ageing" to "productive ageing" and eventually to "active ageing" [2]. Active ageing is defined by the WHO as the process of optimizing opportunities for health, participation, and security in order to enhance the quality of life as people age [3]. According to the World Health Organization, one in six people worldwide will be 60 or older by 2030 and the number of adults 60 and older will rise from 1 billion to 1.4 billion between 2020 and 2030 [4]. According to the National Bureau of Statistics, by 2019, approximately 254 million Chinese citizens were aged 60 and over. China is one of the fastest ageing countries in the world. It took France 115 years, Sweden 85 years and the USA 69 years to increase the proportion of the population aged 60 years or over from 7% to 14%. However, it took China only 20 to 26 years to experience the same change in population ageing [5]. In China, older adults spend more than 80 percent of their time in residential districts, which are neighborhoods with a certain scale and infrastructure [6]. Additionally, home care services

are largely in accordance with the national conditions in China, compared to the communal and institutional ones [7]. However, the majority of the current districts are outdated structures with limited spaces and low environmental quality, which can result in fatigue and other serious health issues [8]. Meanwhile, numerous families select a residential district exclusively for work or education without considering the needs of older adults [9]. Since it is extremely difficult to find companions in such a place, older adults are usually left alone during the day [10]. Groups experiencing loneliness or isolation are more likely to report worse physical and mental health [11]. According to Roy et al. (2018), the demand of older adults who age in place for the suitability of residential districts is expected to grow drastically in the future, owing to the proportion of ageing places being "90 percent home care, 7 percent community care, 3 percent institutional care" [12]. However, is the current residential district considerably suitable for older adults? What should be implemented to transform residential districts to assist ageing in a suitable manner? These problems still need to be resolved. To provide a better basis for renovations which promote suitable ageing, it is essential to strengthen the ageing suitability evaluation of residential districts [13].

Due to their earlier development into ageing societies compared to China, developed countries such as Europe, America, and Japan possess more research experience in the ageing suitability of residential districts and have advanced such research more quickly. *Global Age-Friendly Cities: A guide* was also published by the WHO. Unfortunately, there are insufficient mature and perfect suitability evaluation models to verify the reasonableness and standardization of the construction and renewal of the suitability of residential districts, and the theoretical guidance for this process is limited. Scholars place more emphasis on the suitability of the indoor environment of residential districts while placing less emphasis on that of the public environment. According to the active ageing theory (AAT), ageing is a healthy and active process. As the significance of active ageing policies has grown, scholars have begun to link AAT and ageing housing. They, nevertheless, have paid more attention to how the life of older adults is affected by the infrastructure and ecology of residential districts. The three main components of active ageing include health, participation, and security; however, based on the current evaluation of the ageing suitability of residential districts, participation is rarely considered an important indicator and is even less likely to be combined with two other components for a thorough evaluation.

The aim of the paper is to develop an overall evaluation model of the suitability of residential districts for older adults. Specifically, it includes: (1) What are the indicators for evaluating the ageing suitability of residential districts from the perspective of AAT? (2) What are the criteria for evaluating the suitability of residential districts for older adults? (3) How to establish the evaluation model of residential district suitability for older adults? This study first identified the evaluation indicators through a systematic literature review and an expert interview. It then created a preliminary classification of the indicators by using AAT. Principal component analysis was used to confirm the consistency of classification, and then the final evaluation indicator system was built. Secondly, grey correlation analysis was used to illustrate how the three levels of indicators are weighted. Thirdly, the evaluation criteria were formulated by classifying the existing evaluation criteria connected to ageing housing and residential districts. Based on indicators, weights, and scoring criteria, the evaluation model was finally constructed. Finally, taking the current residential district as an example, the feasibility of the model was confirmed. The findings will facilitate the advancement of future residential districts or make renovated districts more suitable for older adults, as well as realize the high-quality and high-level development of the home care business and industry. Besides, in order to construct suitable residential districts, it is essential for the government and businesses to concentrate on the real needs of older adults. This will help them save money and human resources while resolving the various unique and practical living issues that older groups confront.

The rest of the paper is structured as follows. The next section (Section 2) shows the literature review. Section 3 addresses the methodology. Section 4 describes a case

study on a current residential district to test our evaluation model. Section 5 presents the research results and discusses the findings of our study, and the conclusions are provided in Section 6.

2. Literature Review

Active ageing theory is a proactive approach to dealing with ageing, which focuses on healthy, productive, and successful ageing [2]. It involves three key components, namely, health, participation, and security, which have been extensively studied by academics. Health refers to lowering disease induced by ageing, hence, a well-designed physical activity location is a crucial strategy to protect the health of older adults [14]. Participation signifies that older adults may engage in activities according to their abilities, needs, and preferences, and may even contribute to society [15]. Security means that when older adults are unable to care for themselves, their family and the community will provide them with appropriate care services, such as a BEV-AAS framework for active ageing services in the context of role theory [16]. Active ageing and well-being are strongly associated with maintaining the physical health of older adults [17]. Obviously, researchers have concentrated their research primarily on one of the three aspects of active ageing, with fewer studies integrating all three aspects.

Meanwhile, extensive studies have been conducted on the factors that influence active ageing. On the one hand, community capacity at the individual and community levels affects active ageing [18]. On the other hand, spatial location [19] and tourism value [20] also place a strong influence on active ageing. Some researchers identified the extent of active ageing in older adults and investigated how community capacity influences active ageing at the individual and community group levels [18]. The significance of ageing suitability for improving social support for older adults to age actively is related with where they reside [21]. This highlights the value of residential districts as a crucial form of active ageing. Since active ageing policies have gained popularity, scholars have started to study residential districts for older adults based on AAT. Residential districts in our research referred to relatively closed residential groups or residential areas that have been built and put into use with a certain scale of construction and complete supporting facilities [6]. However, they have paid more attention on the influence of the environment and infrastructure of residential districts. Ko and Yeung (2018) examined the relationship between the community environment and social security for older adults in China by including active ageing in the context of the emerging research interest in long-term care policy [22]. Contrarily, the planning of activities in residential districts to promote the involvement of older adults has received little investigative research and has a tenuous relationship with AAT. For instance, by integrating social interaction and the security of public places in residential districts, Schulz et al. (2020) investigated the relative age appropriateness of the external environment for older adults to participate in activities for wellbeing in respect to their goals, abilities, and opportunities. Previato et al. (2019) proposed residential fun groups as a way to further promote active ageing.

With the rise in popularity of active ageing, scholars have combined residential district suitability with active ageing, but most of them only emphasize health and security, and few scholars analyze the factor of participation, although active participation in activities is important for the well-being of older adults [23]. Even fewer scholars have conducted systematic research on residential district suitability by integrating health, security, and participation. The majority of research on the suitability of residential districts concentrates on the interior residential environment, but rarely addresses the outside area. Therefore, a more thorough evaluation model of the ageing suitability of residential districts based on AAT is needed.

3. Methodology

3.1. Research Framework and Process

The contributing elements and their corresponding indicators of the ageing suitability of residential districts were originally obtained using a systematic literature review in the Web of Science. The approach of expert interviews was utilized to supplement the comprehensiveness of these indicators and to eliminate unreliable and ambiguous possibilities. On the basis of the systematic literature review and expert interviews, a questionnaire containing seven sections was constructed to determine the weights of key indicators using grey correlation analysis. The existing criteria were merged with the evaluation criteria for the ageing suitability of residential districts. On the basis of these factors, an evaluation model of the ageing suitability of residential districts was constructed. Lastly, a case study was used to prove the feasibility of the model. The specific research framework is illustrated in Figure 1.

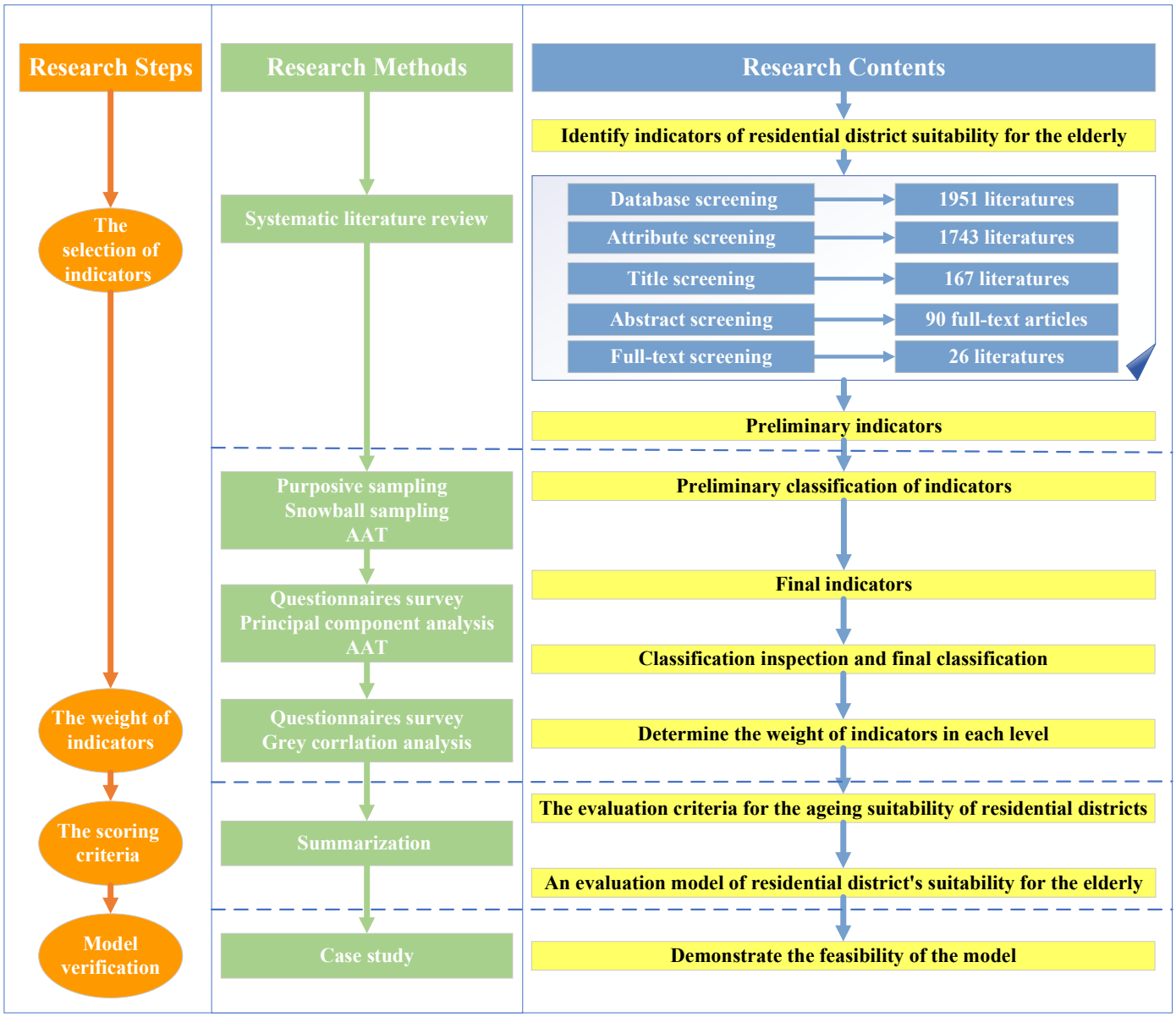


Figure 1. Research framework.

3.2. Systematic Literature Review

Using a systematic literature review (SLR), the main ageing suitability factors were identified. We established a precise literature screening strategy in accordance with the research objectives in order to achieve scientific literature screening findings and eliminate subjective selection-related research mistakes. Web of Science, the primary electronic database, was chosen as the literature source, since it contains all high-quality publications indexed in SSCI, SCI, and A&HCI [24].

"TS = ("the aged" OR "elderly" OR "senior citizen" OR "old people") AND TS = ("adapt*" OR "suit*" OR "comfort*") AND TS = ("community" OR "housing estate" OR "residential quarter" OR "neighborhood unit" OR "residential lot" OR "cluster" OR "residential district" OR "residence community")" is the search formula. To gather literature from the previous decade, publication dates between 2012 and 2022 are chosen. The specified language is "English", and 1951 documents were first searched using the aforementioned search method. Twenty-six articles were selected by attribute screening, title screening, abstract screening, and full-text screening. Figure 2 depicts the connection between literatures and factors. As illustrated in Figure 3, a preliminary classification was developed based on AAT.

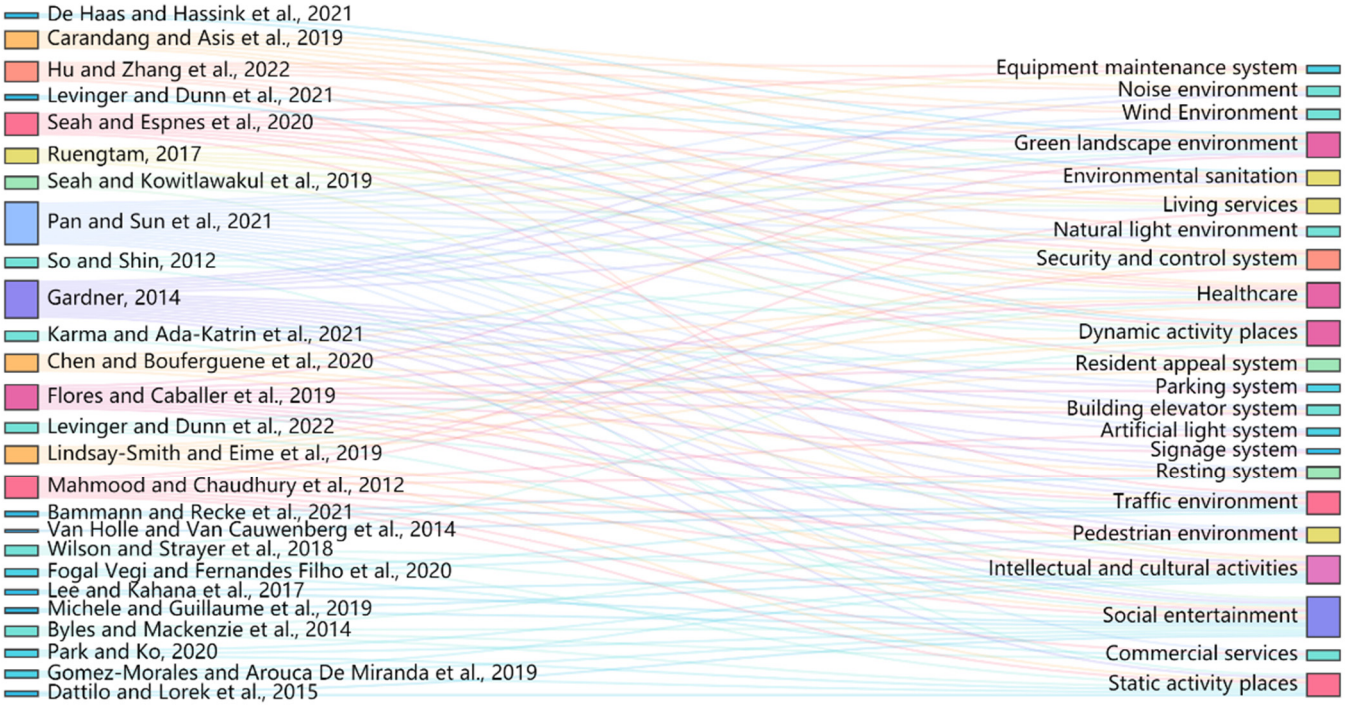


Figure 2. Correspondence between literature and indicators. Note: The left side of the Figure 2 shows the 26 articles [25–50] retrieved through the systematic literature review, and the right side shows the factors related to the evaluation of the suitability for older adults contained in these 26 articles.

3.3. Purposive Sampling and Snowball Sampling

To improve the reasonableness of the identified indicators, expert interviews were conducted using purposive sampling [51] and a snowball method. Previous studies revealed that a minimum of 12 experts was required to ensure that the interviews were reasonable [52]. In this study, a snowball method was used to determine the sample size of experts. When the snowball sample size was saturated, 13 experts were finally identified. Among them, there were three experts from government, three experts from property management, three experts from universities, and four experts from enterprises associated with urban renewal projects. A total of 85% of experts had more than five years of experience in urban renewal and renovation. Detailed information regarding the experts is shown in Figure 4.

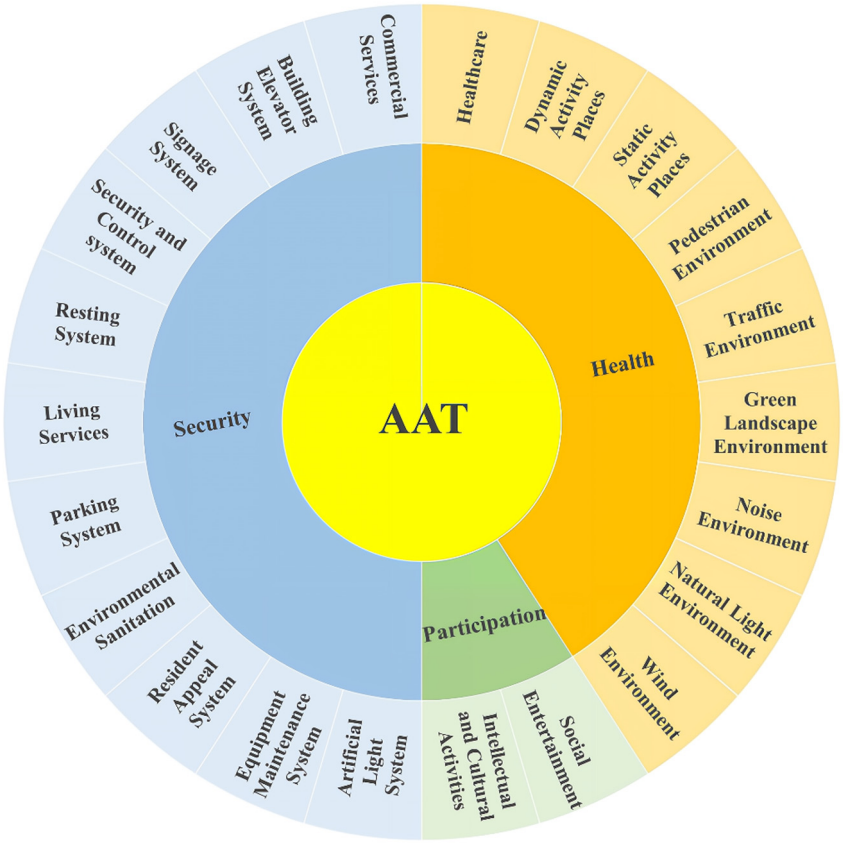
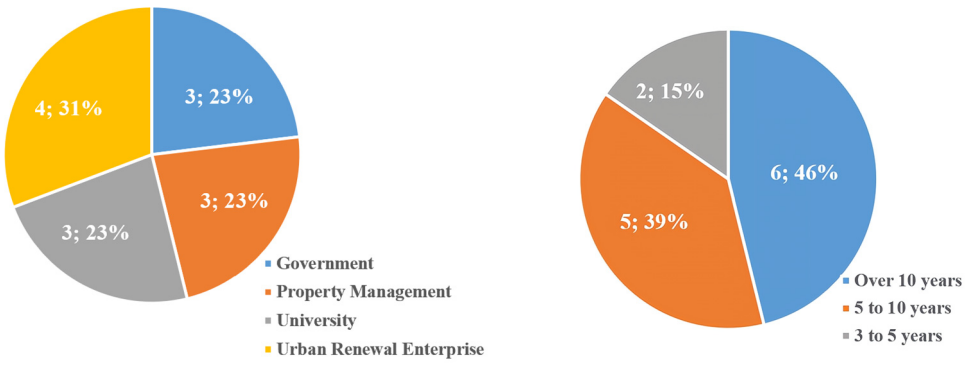


Figure 3. The preliminary classification of indicators.



(**a**) Source (**b**) Working years

Figure 4. Information regarding the experts.

To provide older adults with a clean and pleasant living area, experts believe green landscape environment and environmental sanitation should be included under the category of green landscape environment. Additionally, experts agree that activities might be generally classified into volunteer, sports, artistic, and cultural activities, depending on the type of activity. The community plans sports activities, such as badminton and hiking, to improve the physical health of older adults; square dancing and artistic performances are artistic activities that we hope more older adults will engage in to enrich their lives as they age; cultural pursuits allow older adults to engage in in-depth discussions about current events, newly acquired knowledge, and their interests; and volunteer pursuits allow older adults to give back to society. In all, twenty-three indicators were discovered. The modified indicators were then returned to the experts for a second round of interviews, based on expert interview feedback. Once all 13 experts agreed, the final indicators were

acquired. Finally, the twenty-three indicators were classified according to the connotation and definition of AAT (Figure 5).

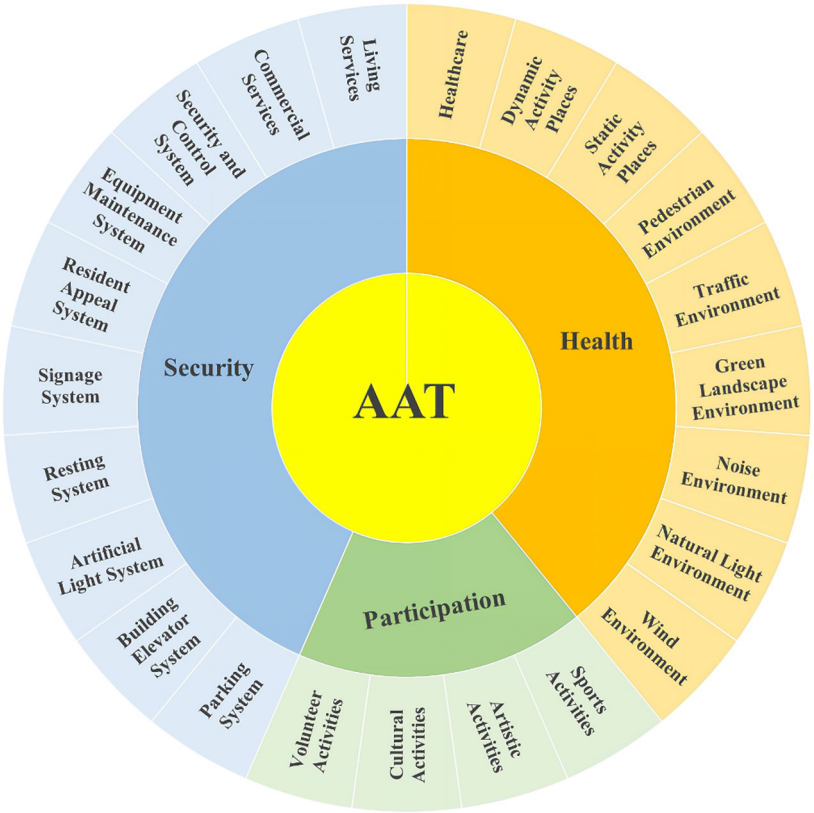


Figure 5. Modified classification of indicators.

3.4. Questionnaire Survey

A questionnaire survey was adopted to determine the indicator score. Considering the uniqueness of older adults, questions were completed face-to-face. The questionnaire includes: (1) social demographic information including gender, age, family population, and address. (2) The significance of measures of ageing suitability for residential districts. On a five-point Likert scale ranging from 1 to 5, 5 indicated the greatest relevance of ageing suitability, while 1 indicated the least.

The survey questionnaire was conducted during June and July 2022. Suojin District, Nanjing, China, was chosen as the survey location due to its large population of older adults, and the fact that the government has implemented several programs, such as the building of additional elevators, etc. The use of simple random sampling ensures that each older adult in the district shares an equal chance of the same probability of getting selected. In addition, it requires the least general knowledge and facilitates data analysis [53]. Before conducting the survey, with the assistance of the director of street office, we compiled a list of all district residents to serve as a sampling framework, and then randomly picked participants using a random number table or a lottery system. Based on the indicators identified before, 23 main questions were contained in the questionnaire. Therefore, a sample size of at least 115 was reasonable according to the principle that the sample size should be at least five times that of the scale questions [54]. The final selection of 200 participants yielded 179 valid responses, or an 89.5 percent response rate.

3.5. Principal Component Analysis

The categorization of the indicators was validated using principal component analysis and AAT was further subdivided. Matrix of rotational component is illustrated in Table 1. The equipment maintenance system, the security and control system, the resident appeal

system, the building elevator system, the artificial light system, the resting system, the signage system, and the parking system may create a generally secure living environment for older adults. Noise environment, wind environment, natural light environment, pedestrian environment, green landscape environment, and traffic environment are all relevant to environmental health. Static activity places, healthcare, and dynamic activity places are locations that give sufficient possibilities for older adults to receive health benefits. Living services and commercial services are consistent with the essence substance of life security. Volunteer and cultural activities are examples of self-improvement participation, which refers to older adults actively sharing information and committing themselves to utilize their abilities for the benefit of society. Sports and artistic activities are categorized as social activity participation, which refers to engaging in social activities that are organized by residential districts for older adults. These activities can even strengthen social connections. In addition to reducing the original twenty-three indicators to six common elements, the principal component analysis method also validated categorization of the indicators based on AAT in Figure 6.

Table 1. Rotational component matrix.

Indicator	Components					
	1	**2**	**3**	**4**	**5**	**6**
Equipment Maintenance System	0.919					
Security and Control System	0.904					
Resident Appeal System	0.886					
Building Elevator System	0.871					
Artificial light System	0.856					
Resting System	0.829					
Signage System	0.823					
Parking System	0.737					
Noise Environment		0.923				
Wind Environment		0.915				
Natural Light Environment		0.908				
Pedestrian Environment		0.876				
Green Landscape Environment		0.867				
Traffic Environment		0.837				
Static Activity Places			0.876			
Healthcare			0.846			
Dynamic Activity Places			0.835			
Commercial Services				0.923		
Living Services				0.854		
Volunteer Activities					0.879	
Cultural Activities					0.838	
Sports Activities						0.887
Artistic Activities						0.852

3.6. Grey Correlation Analysis

A grey correlation analysis was performed to identify the weight of each indicator. To quantify and compare the evolution, the fundamental concept is to assess the degree of link between the dynamic process of the system and its development trend in order. Figure 7 depicts the grey correlation analysis calculation processes.

For a multilevel assessment system with n levels, the correlation degree of the upper level is determined as follows: the correlation coefficients of the indicators in the kth level are averaged prior to calculating the correlation degree of the indicators in the k-1st layer. The correlations of the indicators in the k-2nd layer are synthesized using the correlations in this layer as the source data. Gradually, the correlations of the indicators in the highest layer are produced in this manner. The final weights of evaluation indicators of a residential district's suitability for older adults are displayed in Table 2.

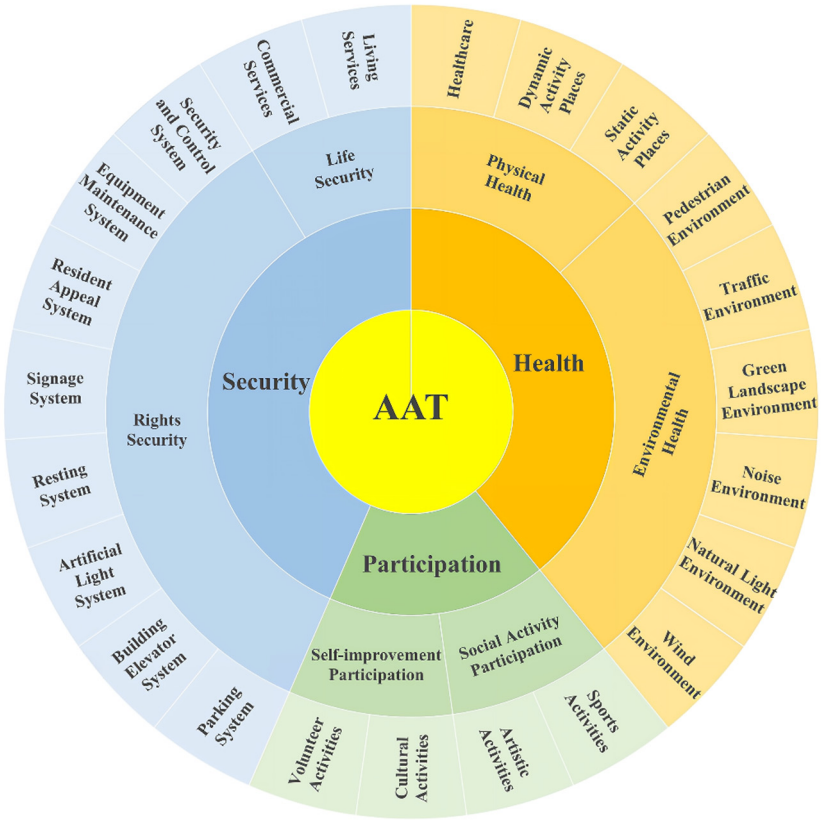


Figure 6. Final classification of the indicators.

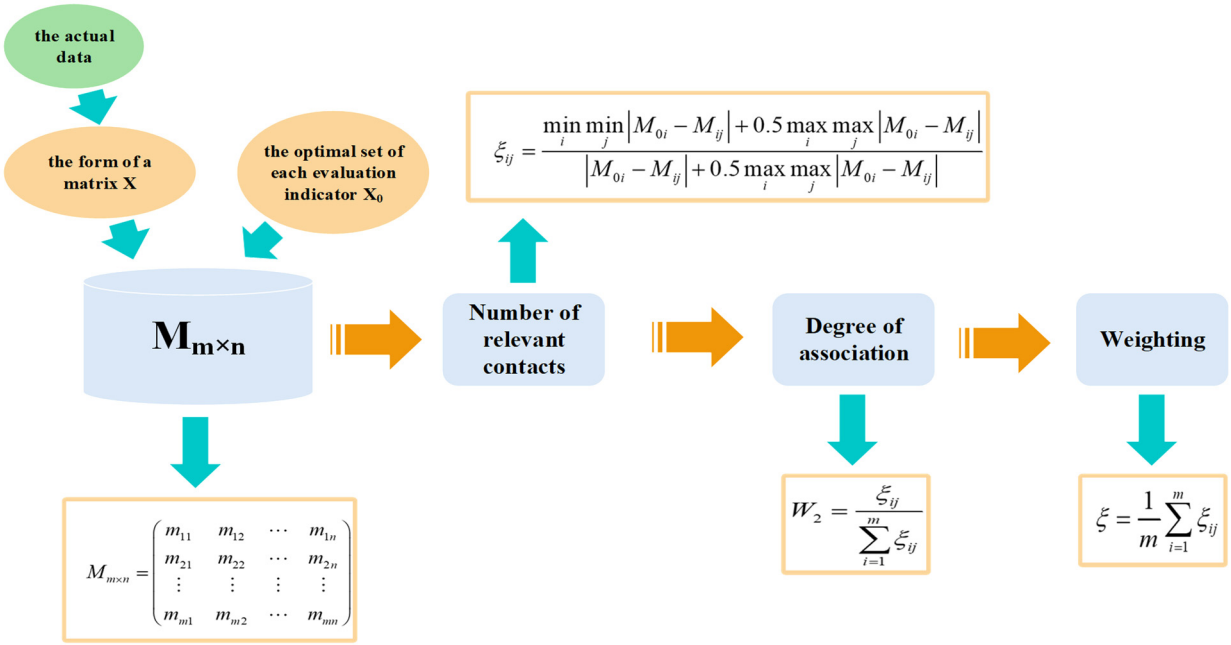


Figure 7. Calculating steps of GCA.

Table 2. Weight of indicators.

First-Level	Weight	Secondary	Weight	Indicator	Weight
Health (H)	0.394	Physical Health, (H_1)	0.500	Healthcare (H_{11})	0.386
				Dynamic Activity Places (H_{12})	0.258
				Static Activity Places (H_{13})	0.356
		Environmental Health, (H_2)	0.500	Pedestrian Environment (H_{21})	0.190
				Traffic Environment (H_{22})	0.133
				Green Landscape Environment (H_{23})	0.194
				Noise Environment (H_{24})	0.124
				Natural Light Environment (H_{25})	0.186
				Wind Environment (H_{26})	0.174
Participtionn (P)	0.313	Social Activity Participation, (P_1)	0.464	Sports Activities (P_{11})	0.447
				Artistic Activities (P_{12})	0.553
		Self-improvement Participation, (P_2)	0.536	Cultural Activities (P_{21})	0.488
				Volunteer Activities (P_{22})	0.512
Security (S)	0.293	Rights Security, (S_1)	0.579	Parking System (S_{11})	0.094
				Building Elevator System (S_{12})	0.133
				Artificial Light System (S_{13})	0.132
				Resting System (S_{14})	0.136
				Signage System (S_{15})	0.136
				Resident Appeal System (S_{16})	0.123
				Equipment Maintenance System (S_{17})	0.123
				Security and Control System (S_{18})	0.123
		Life Security, (S_2)	0.421	Commercial Services (S_{21})	0.328
				Living Services (S_{22})	0.672

3.7. Collation of Evaluation Criteria

There was no applicable evaluation criteria for older adults' housing. Based on Residential building for the aged (15J 923) [55], Assessment standard for healthy building (T/ASC02-2016) [56], Design code for buildings of elderly facilities (GB 50867-2013) [57], Assessment standard for green building (GCT 50378-2019) [58], Code for accessibility design of residential district (DB 11/1222-2015) [59], Codes for accessibility design (GB 50763-2012) [60], and Code for design of residential building for the aged (GB/T 50340-2003) [61], ageing suitability evaluation criteria were provided, and detailed information can be found in Supplementary Material S1. The evaluation criteria for the ageing suitability of residential districts with a certain degree of representativeness are proposed by incorporating the opinions of expert interviews and the analysis of the actual situation learned from field research. The collated criteria were presented to the 13 experts (the same experts as before), who rated the criteria based on actual site conditions. First, we organized the standard details according to the relevant standards, and then invited experts to make adjustments and give suggestions on the standards. Then, we integrated the experts' opinions to modify our standards, and gave the results back to the experts, and after the second round of feedback, the experts' opinions were agreed upon. Ageing suitability districts should satisfy the requirements of all control items of the criteria. The ultimate decision to employ the five-level scoring method was reached after in-depth consultation with specialists. The definition of excellent is 90–100, better is 80–89, the average level ranges between 70 and 79, 60–69 needs development, and poor is defined as a score below 60.

4. Case Study

Any evaluation conducted only on a theoretical level is always flawed [62]. To verify the feasibility of the evaluation model, the Mufu residential district was selected for a case study. It is situated at 143 North Central Road, Gulou District, Nanjing, which is an old district built in 1992. With the introduction of the renovation policy, this district underwent the earliest renovations to accommodate its age.

4.1. Overview of the Selected District

4.1.1. Outdoor Environment

The Mufu residential district includes a unique pedestrian road that combines the traffic environment and pedestrian environment. The road surface is built of cement with high frictional properties and outdoor stairs are equipped with additional anti-slip safety elements. The permanent road has a width of 4.4 m at its widest point, and 2.6 m at its narrowest. The tread with of the 10.6-meter-tall outdoor staircase is two meters. The major permanent road in the fixed environment is circular and does not have dead corners. The situation of the road surface is depicted in Figure 8.

Figure 8. Road conditions (photographed by Yuxin Xu in 2022).

Trees are planted every two meters and the district pays particular attention to green construction. There is a smart waste classification box at the entrance and exit, as well as signs. Although the residential district is relatively clean, there is still obvious rubbish accumulating on the ground. The narrow corridor space becomes increasingly crowded and disorderly as various boxes are piled into certain passages. The outdoor environment conditions are illustrated in Figure 9.

Figure 9. District environment (photographed by Yuxin Xu in 2022).

Each building is composed of five levels with no elevator installed. The staircase has a continuous handrail on one side close to the stairwell. Street lights are erected every three meters in the district, and they emit a gentle, non-blinding light that provides general brightness. Each entrance and exit provides a rest bench. There are suitable evacuation notices on the stairwells and in other locations. As there are exposed electrical lines, the area is relatively hazardous. Public environment of the unit is shown in Figure 10.

Figure 10. Public environment of the unit (photographed by Yuxin Xu in 2022).

4.1.2. Activities

Through our interactions with older adults and property managers, older adults would socialize, play card games, and play chess. They would also actively engage in square dancing in the evening. Furthermore, the interior of the district has a gallery pavilion with a certain degree of privacy, allowing older adults to enjoy peace and quiet. The pavilion is surrounded by a pond lush vegetation, resulting in no space is available for studying or reading.

4.1.3. Infrastructure

A pharmacy is built at the northeast entrance of the residential district, which offers free blood glucose and blood pressure testing, and a physician there will provide basic medical advice and create a health file according to your health situation. There are a number of generally well-equipped medical stations near the pharmacy, such as Mufu Community Health Center. Every Wednesday afternoon, the public equipment is inspected, and the findings are posted in a timely manner on the bulletin board. There are several significant fractures in the road, as well as insufficient maintenance and repair of various pieces of infrastructure.

Additionally, a face recognition system has been placed at the entrance and exit of each unit, and only those whose identities have been accurately verified are permitted entry. The entrance and exit conditions are illustrated in Figure 11. It features a limited number of physical exercise places for dynamic exercises, with rudimentary sports equipment in certain areas. There is no fitness center and there is no distinct outdoor sports area. People usually stroll about or play Tai Chi in groups, and square dancing is the primary activity for older ladies. There are few places for static activities, in addition to the small open space in front of the foyer of the unit, there are no more locations for static additional places. The activity space in front of the foyer is relatively noisy.

4.2. The Process of Evaluation

To prevent subjective mistakes, the number of experts is determined using a fuzzy delphi consensus methodology [63]. A group of thirteen experts (eight older residents of the Mufu residential district, three scholars of the development of the ageing suitability of residential districts from universities, and two property managers from the Mufu residential district with five years of experience) were considered (n = 13). Using evaluation criteria, the existing situation of older adults in the Mufu residential district was assessed. The specific score after weighting is shown in Table 3.

Figure 11. District entrance and exit (photographed by Yuxin Xu in 2022).

Table 3. Score after weight.

General Objective	Total Score	First-Level, Score	Secondary, Score	Indicator, Score
Ageing suitability evaluation of residential districts	74.53	H, 75.11	H_1, 74.96	H_{11}, 66.67 H_{12}, 71.21 H_{13}, 86.67
			H_2, 75.25	H_{21}, 85.19 H_{22}, 50.00 H_{23}, 92.31 H_{24}, 72.22 H_{25}, 75.00 H_{26}, 66.67
		P, 76.55	P_1, 77.65	P_{11}, 50.00 P_{12}, 100.00
			P_2, 75.60	P_{21}, 50.00 P_{22}, 100.00
		S, 71.59	S_1, 80.01	S_{11}, 55.56 S_{12}, 67.36 S_{13}, 73.33 S_{14}, 66.67 S_{15}, 100.00 S_{16}, 100.00 S_{17}, 72.22 S_{18}, 100.00
			S_2, 60.02	S_{21}, 80.56 S_{22}, 50.00

Notes: Total score represents the combined score after criteria scoring and weighting. Indicator score is actual scores/standard scores∗100. The secondary score is derived by multiplying the indicator score by the weight. The first-level score is derived by multiplying secondary score by the weights.

The Mufu residential district had a total score of 74.53, which is average. The following indicators received scores of 90 or above: green landscape environment, artistic activities, volunteer activities, signage system, resident appeal system, security, and control system. Certain indicators were below 60, such as traffic environment, sports activities, cultural activities, parking system, and living services.

5. Results and Discussion

5.1. Health

According to the evaluation model, physical and environmental health carry equal weight (0.500). Healthcare has the highest weight for physical health (0.386), followed

by static activity places (0.356), while dynamic activity places have the lowest weight (0.258). This suggests that healthcare is the most significant aspect for physical health in AAT. Due to the unique bodily functions of older adults, access to medical facilities, affordability of health care costs, range of services, and capacity of medical facilities are particularly important [64]. Therefore, additional efforts should be undertaken in the future to encourage active ageing. Static activity places are more significant than dynamic ones. On the one hand, although older adults are aware of the advantages of sports, they may find it difficult to engage in sport due to a variety of factors, such as physical condition, inclement weather, and previous injuries. On the other hand, static activity places might offer a calmer atmosphere [65], allowing people to reflect. However, according to some research, many areas have not established such a special place owing to limited land resources [66]. We thus consider introducing static activity locations in the future. Green landscape environment has the greatest weight (0.194) among environmental health indicators, followed by pedestrian environment (0.190). Older adults may relax in peaceful natural surroundings. Furthermore, an outdoor area with a great number of green plants is more beneficial to their health [67]. Therefore, to better support active ageing, we must pay attention to the development of green space. Given the prevalent inclination for post-meal walking [68], the positive correlation between walking environment features as well as the frequency of walking [69] and the decrease in physical fitness and endurance of older adults, the design of walking should take the demands and characteristics of older adults into consideration. The hearing of older adults will be more sensitive as they age. And a noisy environment will increase their irritability, as well a dark and gloomy environment, leading to health concerns [70]. It is, therefore, necessary to pay attention to the noise environment (0.124), natural light environment (0.186). and wind environment (0.174). Thus, a peaceful, warm, and comfortable interior and outdoor environment atmosphere should be provided for older adults as much as possible.

The application of the model yields a physical health score of 74.96 for the Mufu residential district, while the environmental health score is slightly higher (75.25). For physical health, healthcare, which is regarded the most vital, scored the lowest, with 66.67. The survey revealed that the district cannot provide convenient medical care for older adults due to its obsolete infrastructure. Additional initiatives to improve healthcare should be examined, such as cooperating with local pharmacies and building health records specifically for older adults, taking into consideration the significance of medical care and the real needs of older adults. The scores of dynamic activity places and static activity places are 71.21 and 86.67, respectively. Due to the limited land resources, developers will focus more on the building itself, which results in a lack of suitable physical equipment and reasonable indoor and outdoor exercise places, which is why the disparity in score between dynamic and static is as high as 15.46 points. After the preliminary ageing renovation, the residential district has built a comparatively autonomous outdoor space as a static activity place for older adults to watch and interact. Thus, in the future, we should consider the development of dynamic areas, the wise use of available unoccupied space, and the supply of sports facilities for older adults, such as providing at least six sports facilities suitable for older adults, with more than 50% of sports facilities being free of charge

The ratings of various indicators of environmental health vary considerably. The score of green landscape environment is 92.31, while the score of traffic environment is 50. Green landscape environment is given a reasonably high weight in the evaluation model, and the scores assigned to this indicator in real situations suggest that it has been given consideration. Since the initial alteration, the variety of plant species and the overall health of plants have increased, which may serve as an example for others. The layout of the outdoor space of this residential district is unreasonable, the pedestrian environment and traffic environment are intertwined, and the width of the trail is inadequate for safety and smoothness. This is a typical issue in most older residential districts [71]. Therefore, we should focus on enhancing the traffic environment, such as by widening the trails appropriately, using ground wire flexibly, and differentiating the pedestrian environment

from the traffic environment. Besides, the net width of the walk is greater than 1.2 m, and the local width is not less than 1.8 m as much as possible. The wind environment is relatively poor in the natural light environment (75), noise environment (72.22), and wind environment (66.67). In the future, we should improve the ventilation of buildings, use green plants flexibly, reduce the noise of domestic life scientifically, and simultaneously reduce light obstructions, such as sundries and nonbearing walls [72].

5.2. Participation

Participation includes social activity participation and self-improvement participation, and valuable activities which contribute to the well-being of older adults [73]. The self-improvement participation (0.536) has a higher weight than social activities (0.464). Gil-Lacruz et al. (2020) point out that older adults are more willing to engage in volunteer or cultural work than other forms of participation [74]. In terms of self-improvement participation, volunteer activities have a slightly higher weight (0.512) than cultural activities (0.488). It has been demonstrated that volunteer service produces a good influence on older adults, their local communities, and the entire society [75]. AAT also emphasizes the significance and value of volunteer activities [76]. Hence, residential districts should expand volunteer activities, maximize the worth of older adults, and foster their pride, self-confidence, and feelings of belonging. Cultural pursuits are an important component of active ageing. On the one hand, such pursuits can improve the happiness of older adults, and on the other hand, they can motivate older adults to actively change their environment and establish goals for their lives [77]. Therefore, residential districts should plan more learning-motivating activities for older adults. Social activity involvement consists mostly of artistic activities and sports, with weights of 0.533 and 0.447, respectively. Rich artistic activities (such as square dancing and cultural shows) reduce the loneliness of older adults and increase their happiness [78]. Hence, residential districts can regularly organize artistic activities, broaden the forms of activities, and strengthen connection ties amongst older adults. Frequent participation in sports may enhance the physical fitness and reduce discomfort and anxiety in older adults [79]. The research shows that the majority of older adults prefer group activities [65]. Hence, the forms of group activities should be diversified in the future [80], and brisk walking and Tai Chi can be considered.

The application of the model yields ratings of 77.65 and 75.6, respectively, for social activity participation and self-improvement participation, which are at the average level. Judging from these indicators, the ratings of artistic and volunteer activities are full marks, while the scores for sports and cultural activities are just 50. The study revealed that the Mufu residential district provides opportunities for older adults to volunteer and contribute to the district's maintenance. Older adults are highly motivated to join three square dancing teams, which are currently operating. As a consequence of their poor physical state and lack of safety, older adults do not participate in a large number of cultural events in this region. Nevertheless, the weight of sports activities and cultural activities is lower than that of artistic activities and volunteer activities, which both exceed 0.4, demonstrating that they cannot be ignored in the ageing transformation of residential districts. To increase the enthusiasm of older adults, future residential districts should implement suitable sports and cultural activities, such as aerobics and reading, sharing and exchange activities, and the frequency of activities should be at least two times a month.

5.3. Security

Rights security and life security are the two primary manifestations of security in active ageing, with the former accounting for 0.579. Resting system and signage system tied for first place in the security category, with a weight value of 0.136. Followed by building elevator system (0.133) and artificial light system (0.132), resident appeal system, equipment maintenance system and security and control system are all 0.123, while the parking system has the lowest weight (0.094). Older adults are prone to weariness while walking over long distances as they age [81], and their identification and judgment skills are generally

reduced [82]. Therefore, the three elements, namely, resting system, signage system, and artificial light system, should be fully considered in the construction of ageing in residential districts, and rest benches should be placed reasonably (one seat is set every 100 m by the roadside), safety signs should be as visible as possible, and night lighting should be as gentle as possible (outdoor lighting color rendering index higher than 60). Elevators facilitate the movement of older individuals who reside on upper levels. Therefore, districts without elevators should consider installing them [83]. Resident appeal system, equipment maintenance system, and security and control system all contribute to the physical and psychological safety of older adults. Therefore, in the future, measures should be refined, the division of responsibilities must be clear, and the needs of older adults should be satisfied in a timely and effective manner. Older adults are less sensitive to parking systems due to their increased reliance on public transportation and decreased usage of private automobiles and electric vehicles [84]. This is the least essential description for a parking system. In life security, the weight of living service (0.672) is double that of commercial service (0.328). Older adults show little interest in commercial services, with the exception of the vegetable market [85]; consequently, living services are therefore more crucial for older adults. Due to the restricted mobility of older adults, there should be a greater emphasis on providing basic domestic services, such as housekeeping [86].

The application of the model yields a score of 80.01 for rights security, which is satisfactory and consistent with the higher weight. Full scores are awarded for the security and control system, the signage system, and the resident appeal system. Actual study shows that the property management personnel in this residential district can satisfy their needs in a timely manner and fully adopt their suggestions. In addition, the district has been fully equipped with a facial recognition system, which closely registers foreigners entering and exiting, a practice that other residential districts might benefit from. The parking system received the lowest grade, just 55.56. Due to the absence of an underground parking garage and the unorganized administration of above-ground parking management, private automobiles occupy a congested area with significant security threats. Hence, in the future, old residential districts can begin to build private parking lots utilizing all available open space and constructing parking places. The elevator system in the building receives a low score (67.36). The district features steep stairs and a narrow stairway, yet there is no elevator, since the building has just five levels. Hence, being out is more challenging for older adults. If renovating the current staircases is difficult, installing outside elevators may be a viable alternative. The ratings of artificial light and equipment maintenance system are also average at 73.33 and 72.22, respectively. Future enhancements to these systems should include the installation of induction bulbs and the provision of a residential service app. The weight of resting system is higher, but the score in practical application (66.67) is lower. It demonstrates that the importance has not been completely acknowledged. Future action should be focused on significant challenges and the characteristics of older adults, such as the addition of circular stools and benches. The weight of living services is the largest among all indicators, at 0.672, but its actual score is the lowest, at only 50 points. According to our analysis, economic conditions make it particularly difficult to implement a day-support program. To offer attentive care services, the newly created residential districts may collaborate with the housekeeping center and incorporate a day center [87]. Due to the availability of the vegetable market and the sheer quantity of retailers, the commercial service (80.56) is excellent.

6. Conclusions

Faced with the present severe ageing condition and the prevalence of accidents resulting from the unsuitability of residential districts, it is imperative to conduct research on ageing difficulties. As the primary locations for older adults in their latter years, residential districts must understand the needs of the older population in order to improve their quality. As a result of a systematic literature review and expert interview, twenty-three latent indicators from the categories of health, participation, and security were identified as

the basis for a theoretical model. The weights of the indicators were determined using grey correlation analysis. The findings revealed that older adults emphasize the health factor and have a strong desire for healthcare and static activity places. Participation prefers to the organization of cultural activities and volunteer activities. The maintenance of the signage system and resting system is more important in terms of security. By organizing the current evaluation standards for "housing for older adults" and "residential district", we establish evaluation standards for the suitability of a residential district for older adults. The evaluation model is eventually constructed based on the evaluation indicators, weights, and evaluation criteria. A case study is used to verify the feasibility of the model. Through empirical studies, it was found that the narrow width of the trail and the lack of safety and accessibility are common problems in many old districts. Besides, residential districts should actively organize a variety of enjoyable sports and cultural activities to motivate older adults to participate. It is also important to provide the necessary security services for older adults to enhance their sense of security. The results of this study enrich the active ageing theory and improve our knowledge of the factors influencing the ageing suitability of residential districts. The results can also be used as a practical guide for the government to more effectively promote the renovation of old districts to increase ageing suitability. For example, older districts should consider installing the necessary outdoor elevators, and the construction of new districts should place a greater emphasis on ageing suitability. For example, great emphasis should be placed on the abundance of activities and the establishment of day care centers. The evaluation of residential districts can identify problems from the perspective of active ageing.

While the majority of research goals of this paper were accomplished, there are still some limitations. Due to the constraints of circumstances, this study only uses one residential district in Nanjing as an example to conduct the case study. Therefore, it remains to be proven whether the constructed model can be generalized to the construction or renovation of residential districts in other areas. Additionally, considering the time, space, and communication constraints of the survey, this study mainly focuses on older adults who can care for themselves, and further research is needed for older adults who cannot care for themselves at all.

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