Research on the Impact Factors of Dual Aging in the Renovation of Old Residential Areas in Wuhan Based on AHP-DEMATEL

Jinchen Hu[1], Wang Pei[1,*][a], Yuejun Cao[1] and Jingyu Wang[2]
[1]*School of Urban Construction, Wuhan University of Science and Technology, 430065 Wuhan, China*
[2]*HUST Architectural Planning and Design Institute, 430022 Wuhan, China*
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Abstract: In contemporary society, the prevalence of "dual aging" residential areas, characterized by the simultaneous aging of both the physical environment and residents, is increasing. The renovation of these "dual aging" areas has gradually emerged as a significant category of urban renewal. This study, based on research conducted in old residential areas in Wuhan, summarizes the issues of "dual aging" areas into "two levels, six dimensions." It employs the AHP-DEMATEL model to construct an evaluation system for the dual aging dilemma and conducts an analysis. The analysis of the data reveals that the six factors can be categorized into four groups, with strong causal relationships between internal factors. Different types of key factors determine the extent of dual aging in the community and the focal points of age-appropriate renovation.

1 INTRODUCTION

Due to the long-term dependence of the elderly on their living environment and their sense of belonging to residential places, the proportion of elderly people in old residential areas has become increasingly serious. The renovation of old residential areas has a crucial impact on the living environment and quality of life of local elderly people. However, the phenomenon of "dual aging," where the aging of the physical environment accompanies the aging of residents, has gradually become an important type of renovation for old residential areas (Chen et al., 2022). (Yu 2022) analyzed the influencing factors of the renovation of old residential areas using the Decision Making Trial and Evaluation Laboratory (DEMATEL) method. (Zheng et al., 2023) used CiteSpace to visually analyze the hotspots of research on age-friendly transformation of old residential areas, and found that the research attention on age-friendly transformation of old residential areas in China has been increasing, and in the future, research on age-friendly transformation of old residential areas will develop into diversification and diversification in various industries.

In 2020, the population aged 60 and above in the 15 districts of Wuhan reached 2.124 million, accounting for 17.23% of the total population, with the population aged 65 and above reaching 1.456 million, accounting for 11.81%. (Wuhan Bureau of Statistics. 2021) In this context, the state has issued a series of policies aimed at building a community-based, community-reliant, and institution-supported community elderly care service system. According to the development trend of elderly care in China, home-based elderly care will dominate in the future. (Huang et al., 2019) conducted a survey and analysis of a typical old residential area in Wuhan, using the Analytic Hierarchy Process (AHP) to construct a community age-friendliness evaluation system and proposing the renovation of old communities from the perspective of community home-based elderly care models. (Chen et al., 2022), based in the old city area of Wuhan, selected four representative communities and explored the differences in the elderly-friendly transformation of residential communities through surveys and interviews.

As of now, the academic community in China focuses on the renovation of old residential areas primarily from the perspectives of technological renovation and policy and management models.

[a] https://orcid.org/0009-0009-2193-4666

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However, there is insufficient attention to the issues and dilemmas of "dual aging" This study, based on research on old residential areas in Wuhan, summarizes the problems of old residential areas into "two levels, six dimensions," which are the negative impacts of three types of aging in old residential areas on the elderly population and the three types of needs of the elderly population in old residential areas. The Analytic Hierarchy Process (AHP) is used to conduct consistency tests on the "two levels, six aspects" indicators and obtain the weights of various level indicators. Then, the Decision Making Trial and Evaluation Laboratory (DEMATEL) method is used to analyze the influencing factors of the six dimensions. Finally, the AHP method is combined with the DEMATEL method to construct an evaluation system for the dilemma of old residential areas from the perspective of dual aging, and conclusions are drawn through a causal four-quadrant diagram.

2 ANALYSIS OF THE DUAL AGING DILEMMA AND EXTRACTION OF FACTORS

2.1 The Current Status of Dual Aging in Old Residential Areas in Wuhan

According to the seventh census and the proportion of renovations in Wuhan, the situation of "dual aging" in Wuhan is increasing day by day. The old communities lack elderly-friendly facilities, making it difficult to meet the needs of the elderly, and urgent age-friendly renovations are needed.

Due to the most severe aging population in QingShan District, Wuhan City (Figure 1) where the proportion of people aged 60 and above is 25.22% and those aged 65 and above is 17.93%, ranking first, this study conducted on-site surveys and data research on old residential areas in Ganghua Village Street, QingShan District, Wuhan City.

Ganghua Village Street has a total of 12 communities and is a typical example of old residential areas in Wuhan that have undergone housing reform. This survey found that the proportion of people aged 60 and above and 80 and above in communities 117, 118, 119, and 120 (Table 1) exceeds 36% on average, indicating a serious aging population. The age of the residential areas exceeds 35 years, and the phenomenon of "dual aging" is very serious, leading to increasingly severe issues related to the elderly population in these old residential areas.

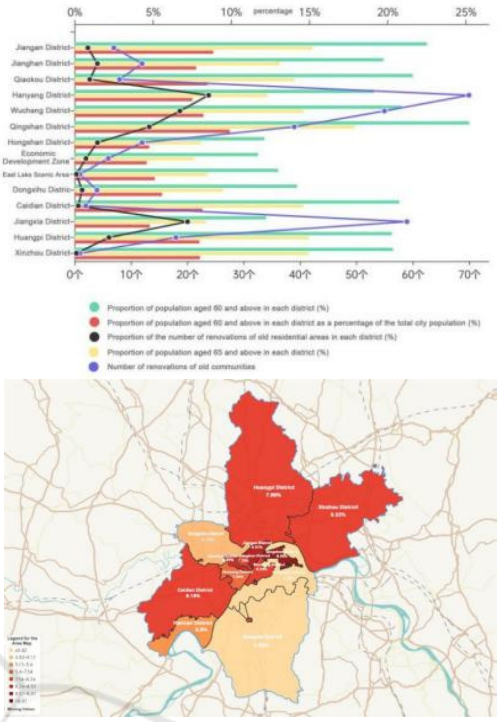

Figure 1: Degree of Aging in Various Districts of Wuhan in 2020.

Table 1: Proportion of Elderly Population in Four Communities in Ganghua Village.

Community	Resident Population	Aged 60 and Above	Percentage(%)	Aged 80 and Above	Percentage (%)
117	5206	1942	37.30%	620	11.90%
118	4396	1573	35.80%	400	9.10%
119	3400	1432	42.10%	246	7.20%
120	3200	965	30.10%	180	5.60%
sum	16202	5912	36.50%	1446	8.90%

The study focuses on four old residential areas in Ganghua Village Street, QingShan District: communities 117, 118, 119, and 120. Through a series of interviews and surveys, the study identifies the negative impact of old residential areas on the elderly population and the needs of the elderly population within these areas. Specifically, it analyzes the challenges in terms of building aging, management aging, safety aging, and the needs of the elderly for travel, environment, and health. The "two

levels, six dimensions" identified in the analysis will serve as the indicators and factors for constructing the AHP-DEMATEL model.

2.2 Negative Impact of Old Residential Areas on the Elderly Population

Through on-site investigation and research of the old residential area, this study systematically analyzed the impact of building aging on the life of the elderly (Kailun et al., 2024), manage the conflicts of the elderly population brought about by aging (Tang, 2023), and the potential fire hazards of the elderly population caused by safe aging (Liang et al., 2023). It also examines issues that communities and relevant departments find difficult to address. The systematic summary of the negative impact of old residential areas on the elderly population is shown in Table 2 below.

2.3 Needs of the Elderly Population in Old Residential Areas

Through the questionnaire survey of the elderly population in the community, the difficulties and needs of the elderly population in the elderly residential area are analyzed. This paper summarizes the mental illness caused by the travel demand of the elderly population (Ibáñezdel et al., 2022), the impact of environmental demand on the elderly (Wang et al., 2023), and the health demand caused by the backward community medical care (Ogrin et al., 2022). At the same time, the needs of the elderly population in the elderly residential areas are systematically analyzed and summarized, which provides a basis for the elderly friendly transformation of the elderly residential areas, as shown in Table 3 below.

Table 2 Negative Impact of Old Residential Areas on the Elderly Population

Architecture Aging	Phenomenon	Lack of elevator facilities, making it difficult for the elderly to go downstairs.	The pipeline facilities are in disrepair, and the discharge system is rudimentary.
	Reasons	The residential buildings are old, and the elderly have poor physical health. The phenomenon of "hanging elderly" is serious, and the lack of elevators severely affects the quality of life of the elderly in their later years.	The pipelines are damaged and blocked, leading to accumulation downstairs, backflow upstairs, and pooling of rainwater in low-lying areas. The drainage system is old and it is difficult to resolve road flooding.
	Dilemma	1.The old buildings have low floors and tight structures. Forcibly installing elevators will accelerate the aging of the buildings and damage the structure; 2.Considering their own interests, it is difficult for homeowners to agree on the installation of elevators. It is difficult for each household to coordinate, making renovation difficult; 3.Although the government provides a lot of support and policies, most low-level residents do not have the willingness to raise funds.	1.The underground pipelines are complex, and there is a lack of data, making it difficult to find many temporary maintenance records, which hinders the preliminary survey work; 2.The underground pipelines are complex, and there is a lack of data, making it difficult to find many temporary maintenance records, which hinders the preliminary survey work; 3.The roads are narrow, making it difficult for large equipment and machinery to enter. The underground system is old, and during excavation, cable and gas damage and leakage are prone to occur, severely affecting residents' normal lives.
Management Aging	Phenomenon	Increase in external personnel, increase in group conflicts	There are serious illegal constructions, and internal roads are congested.
	Reasons	Old residential areas meet the requirements of tenants for convenient transportation and low rent. There are many external populations, and there is a tendency for external personnel to have an increasing impact.	The roads in the old residential areas are congested, the houses are old and small, and illegal constructions and house expansions have become historical problems.

	Dilemma	1.The elderly account for 36% of the community, and tenants account for 35%, leading to a dual division between the elderly and tenants, making it difficult to control the tenant population and easily leading to group conflicts; 2.The elderly are sensitive to management fees, and the young population is mostly tenants with a high turnover rate, resulting in difficulty in property management fees and inability to improve standards; 3.Large property companies avoid old residential areas, with low management and service levels, and problems such as property disputes create a vicious circle of management conflicts.	1.Some elderly residents on the ground floor plant and build sheds or renovate houses in the open space in front of their doors, occupying fire and medical access routes; 2.The elderly rationalize illegal construction psychologically, making it difficult for communities and departments to persuade them, seriously hindering renovation work; 3.Many shops and workshops have been set up inside the community without legal procedures, and the management staff have no way to start, adding to the social burden.
Safety Aging	Phenomenon	Private removal of internal and external vertical walls, barbaric renovation of houses	Fire facilities are aging, and fire awareness is low.
	Reasons	With the improvement of living standards, residents want to change the layout of bedrooms and living rooms, and the approval process of decoration companies is simple, with rough and casual construction processes.	The old residential areas are products of the last century, with little consideration for fire safety in house design, crowded evacuation routes, and incomplete fire facilities.
	Dilemma	1.Lower-level residents arbitrarily open external vertical walls, add houses, and even remove the walls on both sides, leading to fragile building structures. 2.Upper-level residents remove internal vertical walls to expand the use area, forcibly changing the housing structure, and burying deep safety hazards for the houses in the old residential areas; 3.Home decoration companies use the industrial and commercial registration system, without qualification approval and construction permits, to meet the requirements of homeowners. During construction, the safety of the building is not considered。	1.With the diversification of electrical appliances, fire hazards have become deeply rooted, and crowded evacuation routes pose a serious threat to the safety of elderly residents; 2.The internal roads of the community are narrow, and there are serious illegal constructions, occupying fire access routes, affecting the speed of firefighting personnel rescue; 3.The building materials are outdated, the fire equipment is old, and combined with the inherent ideas of the elderly, it is difficult to popularize fire knowledge.

Table 3: Needs of the Elderly Population in Old Residential Areas

Travel Needs	Phenomenon	Urgent Need for Elevator Installation and Addition of Barrier-Free Facilities	The addition of greenery within the community and the expansion of external streets
	Reasons	The elderly population experiences physical deterioration, making it difficult for them to travel downstairs. Disabled elderly individuals need wheelchairs for mobility, but the lack of barrier-free facilities hinders their travel.	The elderly have higher demands for the travel environment, but the lack of greenery in the community and narrow sidewalks outside the streets hinder their mobility.

		1.Travel difficulties cause psychological pressure on empty-nest elderly individuals, leading to unmet psychological needs, which can affect their physical and mental health in the long run; 2.Travel difficulties cause psychological pressure on empty-nest elderly individuals, leading to unmet psychological needs, which can affect their physical and mental health in the long run; 3.Many elderly people lack the company of their children, making it difficult for them to go downstairs for medical treatment or medication during illness.	1.The level of greenery and the internal spatial system determine the willingness of the elderly to travel. The public spaces in the community cannot meet the requirements of the elderly for travel. 2.The narrow streets outside the old community have heavy traffic, and some construction projects occupy sidewalks, posing safety hazards to the elderly due to narrow roads and crowded people. 3.There is a lack of public spaces and recreational facilities within the community, which affects the social interaction and travel willingness of the elderly, harming their physical and mental health.
Environmental Needs	Dilemma	Rectification of the community environment and regulation of group activities	Improving air quality and building a low-carbon environment
	Phenomenon	The elderly have higher demands for the safety and tranquility of their surroundings, hoping that the community can eliminate safety hazards and stay away from noise and bustle.	The elderly are sensitive to air pollution and hope that their living environment will have clean and fresh air, away from sources of pollution.
	Reasons	1.Due to the conflicting lifestyles of the elderly and the young, there are differences in the daily routines of the two groups, and the activities and rest times of the young conflict with those of the elderly. 2.Inconvenient transportation and lack of living facilities make it difficult for the elderly to seek medical treatment or shop, both within and outside the old community. 3.Due to the popularity of the old community among tenants, there is uncontrolled access by outsiders, making it difficult to manage, and leading to a complex internal composition of the community.	1.The stalls of vendors at the entrance of the community produce a large amount of smoke and pollutants. 2.Due to heavy air pollution, the elderly cannot open windows for ventilation, and the long-term low environmental quality is very detrimental to the physical health of the elderly. 3.The elderly are sensitive to changes in the air quality within the community and need a monitoring and warning mechanism to obtain information on air quality, as well as the installation of air quality monitoring equipment.
Health Needs		Establishment of a health service system and improvement of health management concepts	Diverse community medical services and diversified physical examination services
	Dilemma	The elderly have a high demand for medical and health services, but their concepts of health management lag behind.	Physical deterioration and aging of the community environment have led to an urgent need for diversified community medical and health services for the elderly
	Phenomenon	1.Low health literacy, lack of understanding of health status, and inadequate health management skills increase the incidence and mortality of diseases among the elderly. 2.The current level of prevention and treatment of elderly diseases in medicine is not high, coupled with the complexity of old communities, many diseases among the elderly cannot be cured; 3.The elderly choose community and nearby hospitals only for urgently needed medicines, while few undergo systematic treatment, routine check-ups, or rehabilitation therapy.	1.For the elderly, it is essential to have two physical examinations per year, but most community health services are standardized. 2.There are no personalized health service projects for the elderly, and the types of diseases and risks of diseases for the elderly vary with age, gender, and family medical history. 3.Without targeted and selective health services, it is impossible to thoroughly investigate the health status of the elderly, thereby increasing their risk of illness.

2.4 Dual Aging Conflict Relationship and Analysis

By summarizing the negative impact of old residential areas on the elderly population and the demands of the elderly on these areas, this study has identified a dual aging conflict relationship termed as "two levels, six dimensions" (Figure 2). Utilizing Marx's subject-object theory, the study reveals two levels of relationships within this dual aging conflict (Ma 2009). The first level primarily concerns the three major issues stemming from building aging, namely "building-safety," which refers to residential safety issues caused by building structure aging, "building-management," which involves difficulties in managing aged building systems, and "building-management-safety," which encompasses fire safety problems resulting from aging building structures and environments. The second level revolves around the three main conflicts arising from the demands of the elderly. These include "environment-building" and "environment-management," which highlight conflicts between the elderly's lifestyle and environmental needs and the conflicts between tenants and vendors, manifesting as noise issues from the building itself and air quality problems due to lack of management. Additionally, "travel-building" and "travel-safety" depict conflicts between the elderly's needs for downstairs access and walking and the financial challenges of adapting for the elderly, such as elevator problems and narrow sidewalks outside the community. Lastly, "health-management" reflects conflicts between the elderly's medical needs and community health management.

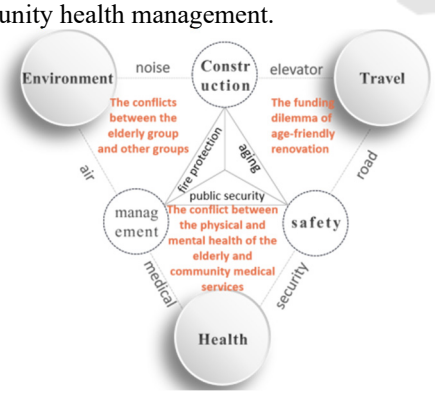

Figure 2: Dual Aging Conflict Diagra.

Figure 3: Hierarchical Diagram of Dual Aging.

3 ASSESSMENT SYSTEM FOR THE DILEMMA OF OLD RESIDENTIAL AREAS FROM THE PERSPECTIVE OF DUAL AGING

3.1 Construction of an Evaluation System for Dual Aging Dilemmas

Based on the aforementioned two levels and six dimensions of issues, this study conducts research from two levels: the negative impact of old residential areas on the elderly population and the demands of the elderly population on the community. These two levels are taken as primary indicators, while the dimensions of building aging, management aging, safety aging, environmental demands, travel demands, and health demands are taken as secondary indicators (Figure 3).The construction of the dual aging dilemma evaluation system involves the use of the AHP-DEMATEL model to analyze the hierarchical structure of the two primary indicators and six secondary indicators (Jia 2023).

Firstly, the AHP method is used to analyze the relationships between the six elements of the evaluation system, establishing a hierarchical structure of the system. This involves qualitatively judging and quantitatively representing the relative importance of each influencing factor at each level. Through mathematical methods, the weights of each level are calculated, and judgment matrices are constructed. Secondly, the DEMATEL method is used to calculate the "four degrees" of the influencing factors. Combined with the comprehensive influence matrix, the impact factors, including the influence degree (D value), the affected degree (C value), the centrality (D+C value), and the causality (D-C value), are calculated. The centrality or causality is then graphically displayed to facilitate viewing and analysis.Finally, the weights of the influencing factors obtained from the AHP and DEMATEL

methods are multiplied and normalized to obtain the comprehensive impact degree of each factor. This analysis helps to identify the key and difficult points in the renovation for aging adaptation.

3.2 Analytic Hierarchy Process (AHP)

3.2.1 Construction of Judgment Matrix

Using the 1-9 scale method in AHP to pairwise compare the primary and secondary indicators. The primary indicators form matrix A, and the secondary indicators form matrix B. Initially, the weights of the six dimensions' factors are determined through literature review, surveys, and expert scoring. By mathematically listing out each factor and judging their importance based on the scoring results, the pairwise comparison matrix is constructed. Here, $a_{ij}=1/a_{ji}$ represents the nature of the comparison between two factors in the judgment matrix.

3.2.2 Survey Data

Through surveys of people aged 60 and above in the 117th, 118th, 119th, and 120th communities, we distributed 400 questionnaires and received 325 valid responses, with an effective rate of 81.25%. Based on the 325 survey responses, the average scores for the six dimensions of aging adaptation renovation are as follows: building aging 8.5, management aging 3.2, safety aging 3.5, travel demand 4.7, environmental demand 3.4, and health demand 3.5. A higher score indicates a stronger willingness among the elderly for renovation.

3.2.3 AHP Weight Analysis

The factor weights are optimized based on the scores of the six dimensions, and then the pairwise comparison matrix is constructed by normalizing the factor weights column-wise, as shown in Table 4 and Table 5. B1 represents building aging, B2 represents management aging, B3 represents safety aging, B4 represents travel demand, B5 represents environmental demand, and B6 represents health demand.Conduct a consistency check based on the following formula:

$$\lambda_{max}=\sum_{i=1}^{n}\frac{[A\omega]_i}{n\omega_i}\rightarrow\lambda_{max}=5.994,CI=\frac{\lambda-n}{n-1}\rightarrow CI=0.098 \quad (1)$$

After consulting the table, it is found that the RI value for a six-order matrix is 1.26. Therefore, CR = CI/CR = 0.078, which indicates that CR < 0.1. Thus, the judgment matrix demonstrates consistency and is suitable for analysis and calculation.

Table 4: Dual Factor Judgment Matrix.

B	B1	B2	B3	B4	B5	B6
B1	1	8/3	2	8/5	2	2
B2	3/8	1	3/4	3/5	1	3/4
B3	1/2	4/3	1	4/5	4/3	1
B4	5/8	5/3	5/4	1	5/3	5/4
B5	1/2	1	3/4	3/5	1	3/4
B6	1/2	4/3	1	4/5	4/3	1

Table5: Normalized Dual Factor Judgment Matrix.

B	B1	B2	B3	B4	B5	B6	ω	$A\omega$
B1	0.29	0.29	0.29	0.3	0.24	0.29	0.288	1.727
B2	0.11	0.11	0.11	0.11	0.12	0.11	0.112	0.676
B3	0.14	0.15	0.15	0.15	0.16	0.15	0.150	0.901
B4	0.18	0.19	0.19	0.18	0.2	0.19	0.190	1.126
B5	0.14	0.11	0.11	0.11	0.12	0.11	0.117	0.712
B6	0.14	0.15	0.15	0.15	0.16	0.15	0.150	0.901

Based on the comparison between the negative impact of old residential areas on the elderly population and the elderly population's needs in old residential areas, matrix A is constructed and compared with matrix B to create six second-order matrices. The consistency ratio (CR) for each matrix is calculated and tested for consistency, as shown in Table 6.Where the negative impact is denoted as A1, the elderly demand as A2, and the weight indicator as FAHP.

Table 6: Two-tier Matrices of the Six Aspects.

B1	A1	A2	$A\omega$	**B4**	A1	A2	$A\omega$
A1	0.57	0.57	1.14	A1	0.43	0.43	0.86
A2	0.43	0.43	0.86	A2	0.57	0.57	1.14
B2	A1	A2	$A\omega$	**B5**	A1	A2	$A\omega$
A1	0.67	0.67	1.33	A1	0.47	0.47	0.93
A2	0.33	0.33	0.67	A2	0.53	0.53	1.07
B3	A1	A2	$A\omega$	**B6**	A1	A2	$A\omega$
A1	0.67	0.67	1.33	A1	0.62	0.62	1.25
A2	0.33	0.33	0.67	A2	0.38	0.38	0.75

Table 7: Composite Weight.

	FAHP	A1	A2
B1	1.727	1.14	0.86
B2	0.676	1.33	0.67
B3	0.901	1.33	0.67
B4	1.126	0.86	1.14
B5	0.712	0.93	1.07
B6	0.901	1.25	0.75
Composite Weight		0.57	0.43

All six matrices have CR values less than 0.1, indicating that they pass the consistency test. The weights of each indicator are then combined to obtain the comprehensive weights of each aspect, which are presented in Table 7.

3.3 DEMATEL Method for Analyzing Factors

3.3.1 Constructing a Comprehensive Impact Relationship Diagram

DEMATEL (Decision-making Trial and Evaluation Laboratory) is a systematic analysis method that uses graph theory and matrix tools to explain problems. By analyzing the logical relationships and direct impact matrices among various elements in the system, it is possible to calculate the degree of influence of each element on other elements, as well as the degree to which each element is influenced. This allows for the calculation of the causality and centrality of each element, serving as the basis for constructing the model and determining the causal relationships among elements and the status of each element in the system. Based on survey data and expert ratings, a comprehensive impact relationship diagram is generated to illustrate the impact relationships of the elements (see Figure 4), with the numbers on the arrows representing the magnitude of the impact, where larger numbers indicate greater impact.

3.3.2 Constructing the Impact Matrix

Following the basic principles of the DEMATEL method, this study organized the expert ratings and survey data on the direct impact scores between the six influencing factors. A direct relationship matrix was constructed and normalized to obtain the normalized direct relationship matrix N. By applying the formula $T = N(I - N)^{-1}$, the comprehensive impact matrix T was derived, and the impact degree D_i, affected degree C_i, centrality R_i, and causality H_i of each influencing factor were calculated (see Tables 8-10 below).

3.3.3 Construction of Cause-and-Effect Quadrant Diagrams

Cause-and-effect quadrant diagrams can intuitively demonstrate the degree of influence of various factors on the dual aging renovation of old residential areas and the relationships between these factors based on the pattern of the diagrams. Two quadrant diagrams are drawn based on the calculated indicators of influence, being influenced, centrality, and causality. The centrality-causality diagram takes the average

value of centrality (2.68, 0) as the origin, with centrality on the X-axis and causality on the Y-axis, as shown in Figure 5; the influence-being influenced diagram takes the average value of being influenced (1.34, 1.34) as the origin, with influence on the X-axis and being influenced on the Y-axis, as shown in Figure 6.

Table 8: Normalized Direct Relationship Matrix N.

	B1	B2	B3	B4	B5	B6
B1	0	0.167	0.2	0.3	0.133	0.2
B2	0.033	0	0.1	0.067	0.167	0.067
B3	0.033	0.133	0	0.1	0.067	0.133
B4	0.033	0.067	0.1	0	0.067	0.2
B5	0.033	0.167	0.1	0.2	0	0.2
B6	0	0.133	0.167	0.233	0.067	0

Table 9: Comprehensive Influence Matrix T.

	B1	B2	B3	B4	B5	B6
B1	0.055	0.378	0.41	0.55	0.298	0.46
B2	0.059	0.116	0.201	0.206	0.234	0.201
B3	0.058	0.233	0.116	0.234	0.154	0.254
B4	0.057	0.181	0.212	0.153	0.149	0.312
B5	0.069	0.308	0.257	0.379	0.128	0.37
B6	0.035	0.251	0.279	0.361	0.167	0.167

Table 10: DEMATEL Calculation Indicators.

	D	C	D+C(R_i)	D-C (H_i)	F(DEMATEL)
B1	2.152	0.332	2.483	1.82	0.154
B2	1.017	1.468	2.484	-0.451	0.154
B3	1.049	1.475	2.524	-0.426	0.157
B4	1.064	1.882	2.946	-0.819	0.183
B5	1.511	1.13	2.641	0.38	0.164
B6	1.259	1.763	3.023	-0.504	0.188

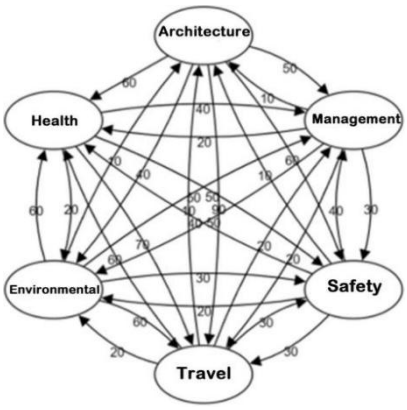

Figure 4: Comprehensive Impact Relationship Diagram.

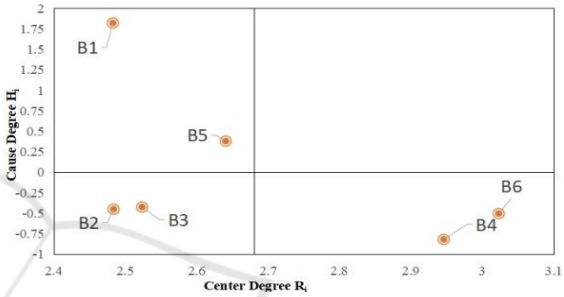

Figure 5: Center Degree-Cause Degree

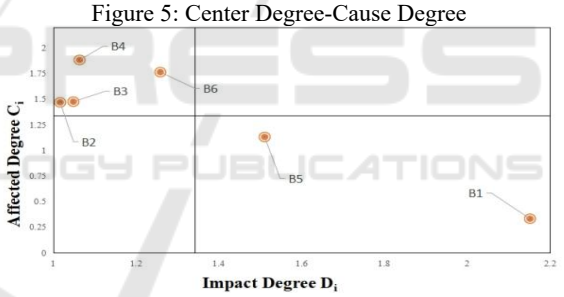

Figure 6: Graph and Influence Degree-Being Influenced Degree Graph.

3.4 Dual Aging Dilemma Evaluation System AHP-DEMATEL Model Analysis

3.4.1 Comprehensive Impact Degree of Influencing Factors

Multiply the weights of the influencing factors obtained from the AHP and DEMATEL methods, normalize them, and obtain the comprehensive factor Zi for each influence, as shown in Table 11 .

3.4.2 Constructing the AHP-DEMATEL Cause-Effect Quadrant Diagram

Based on the calculated degrees of causality and comprehensive impact degree from the table above, plot the comprehensive impact degree on the X-axis and the degree of causality on the Y-axis, with the average value of the comprehensive impact degree (0.1667, 0) as the origin. This will show the comprehensive impact degree-cause diagram, as shown in Figure 7.

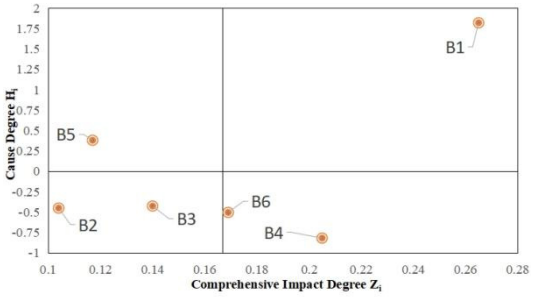

Figure 7: Comprehensive Impact Degree-Causality Diagram.

Table 11: Comprehensive Data.

Factors	FAHP	Rank	FD	Rank	Di	Ci	Ri	Rank	Hi	Rank	Zi	Rank
B1	0.286	1	0.154	5	2.152	0.332	2.483	6	1.82	1	0.265	1
B2	0.112	6	0.154	6	1.017	1.468	2.484	5	-0.451	4	0.104	6
B3	0.149	3	0.157	4	1.049	1.475	2.524	4	-0.426	3	0.14	4
B4	0.186	2	0.183	2	1.064	1.882	2.946	2	-0.819	6	0.205	2
B5	0.118	5	0.164	3	1.511	1.13	2.641	3	0.38	2	0.117	5
B6	0.149	4	0.188	1	1.259	1.763	3.023	1	-0.504	5	0.169	3

Table 12: Causal Relationship Table of Influencing Factors.

Quadrant	Category	Factors	Characteristic
I	Key causal factors	B1	$Z_i>0.1667, H_i>0$
II	Common causal factors	B5	$Z_i<0.1667, H_i>0$
III	Common result factors	B2;B3	$Z_i<0.1667, H_i<0$
IV	Key result factors	B4;B6	$Z_i>0.1667, H_i<0$

3.4.3 Analysis of AHP-DEMATEL Model Results

As shown in Figure 7, among the six factors influencing the dual aging of old communities, there are 2 causal factors and 4 effect factors, of which 3 have a comprehensive influence degree above the average value of 0.1667. Based on the magnitude of the comprehensive influence degree and the positive or negative nature of the causality degree, the 6 influencing factors are classified into four categories: key causal factors, general causal factors, general effect factors, and key effect factors (Meng et al., 2023), as shown in Table 12.

Summary of Table 11, Table 12, and Figure 7 reveals that there are certain causal relationships among the influencing factors:

Firstly, the key causal factor in the first quadrant is building aging, which has a much greater impact on other factors than it is impacted by them. Its comprehensive impact ranks first. In the process of aging-friendly renovation, attention should be paid not only to the impact of building aging on the elderly population in old communities but also to the chain reaction caused by building aging leading to dual aging.

Secondly, environmental needs in the second quadrant have a strong driving force despite being below the average of the comprehensive impact of the 6 factors and ranking lower in the comprehensive impact. Although it falls into the category of common causal factors, its impact should be taken seriously during the aging-friendly renovation of old communities.

Thirdly, the result-type common factors of management aging and safety aging in the fourth quadrant have a relatively low comprehensive impact, with the impact on them greater than their impact on other factors. Their impact on the dual aging dilemma system and aging-friendly renovation is relatively small. Safety aging and management aging rank third and fourth in the six factors, respectively, with rankings in the middle, showing a certain degree of

being driven. However, their effects are not significant. During aging-friendly renovation, the profound impact of mishandling other factors should be considered.

Finally, the key result factors in the fourth quadrant include travel needs and health needs. They have a relatively large comprehensive impact on the dual aging dilemma in old communities, but their causality is less than 0. During aging-friendly renovation, attention should be paid to the unfavorable conditions these factors bring to the elderly population in old communities, and how to ensure the satisfaction of travel and health needs of the elderly population in old communities under unfavorable conditions should be considered.

4 CONCLUSION

Summarizing the negative impact of old residential areas on the elderly population, the needs of the elderly in these areas, as well as the dual aging contradictions, indicator weights, and comprehensive impact degrees of influencing factors in the "two levels, six dimensions," along with the analysis of the constructed quadrant diagram, the following conclusions can be drawn:

Framework Analysis: The study framework includes three dimensions of building aging, management aging, and safety aging, which bring about difficulties in life, unauthorized construction, and fire and housing hazards, respectively. The second level includes three dimensions of travel needs, environmental needs reflecting air quality and noise issues, and health needs reflecting the singularity of health management and services.

Marxist Subject-Object Theory: Using this theory, the study identifies three major problems caused by building aging and three major contradictions formed by the elderly population, analyzing the contradictory relationship of dual aging.

Influencing Factors: The six influencing factors have different degrees of impact on the dual aging contradictions and the adaptation of old residential areas, and there is a certain causal relationship within the evaluation system. These factors can be classified into four categories based on their comprehensive impact degrees and the positivity or negativity of their causality: key causal factors, common causal factors, common result factors, and key result factors.

Key Factors and Countermeasures: Among the six factors, building aging and environmental needs are identified as key causal factors. They play a pivotal role in the dual aging process and should be the focus of adaptation efforts. Addressing these factors not only reduces the risk of dual aging in old residential areas but also safeguards the impact on the other four result factors.

Significance of Key Factors: The study finds that three factors, building aging, travel needs, and health needs, have significantly greater comprehensive impact degrees than the other three factors, making them key influencing factors. Building aging is the top-ranking key causal factor, while travel needs and health needs are key result factors, with their comprehensive impact degrees only slightly lower than that of building aging.

In conclusion, this study provides a new perspective and method for researching dual aging in old residential areas, offering theoretical support for future studies on dual aging contradictions and challenges. The findings can serve as a reference for research on dual aging in old residential areas and provide a theoretical basis for addressing future dual aging contradictions and challenges.

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