University of Florence
Department of Architecture

Tongji University
College of Architecture and Urban Planning

Research on Evaluation and Design Strategies of Cross-generational Co-living Space in Residential Neighborhood

Author
ZHANG DONGQING

Supervisor
NICOLETTA SETOLA (University of Florence)
CHEN YI (Tongji University)

July, 2025

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INTRODUCTION

Abstract

In the context of the digital age, younger and middle-aged to elderly groups exhibit dual characteristics: increased time spent on virtual social interactions and reduced frequency of real-world exchanges. Meanwhile, with the intensification of population aging and the miniaturization of family structures, traditional cross-generational mutual-assistance living models based on blood relations are gradually shifting towards cross-generational interaction and shared living (referred to as cross-generational co-living). However, existing research both domestically and internationally predominantly focuses on theoretical discussions of cross-generational interaction or spatial demand analyses for single demographic groups, lacking in-depth exploration into changes in intergenerational interaction forms under the digital era and the interactive mechanisms between older adults and other age groups in public spaces. Therefore, how to promote physical interactions and cooperation among multi-generational groups within public spaces primarily used by older adults in residential communities through design methods, effectively realizing the concept of cross-generational co-living, has become an important scientific issue that urgently needs addressing.

This study takes this context as its background and centers on the object of "cross-generational co-living space in residential neighborhood," conducting empirical research focused on "space evaluation" and "optimization strategies." The aim is to explore how to quantitatively analyze and evaluate cross-generational co-living spaces and propose targeted design optimization strategies to address the weakening of intergenerational interactions in the era of virtual social networking.

The study adopts a multidisciplinary approach:

(1) Conceptual Definition and Theoretical Review: Using Web of Science and China National Knowledge Infrastructure (CNKI) as primary data sources, Citespace tools were utilized to comprehensively review foundational theories and research hotspots related to cross-generational co-living spaces, such as multi-generational housing, cooperative housing, and age-friendly communities. This clarifies the meaning and scope of cross-generational co-living spaces.

(2) Qualitative and Quantitative Analysis: In the qualitative phase, systematic observation, semi-structured interviews, and questionnaire surveys were employed, combined with data collection tools, to conduct case studies of cross-generational co-living spaces. Specifically, the behavioral characteristics and usage habits/needs of older adults, children, adolescents, and middle-aged individuals from China and Italy were surveyed. In the quantitative phase, Space Syntax was introduced as a theoretical tool to quantitatively analyze the spatial configuration relationships in cross-generational co-living modes, revealing how integration and visual integration influence the likelihood of spontaneous interactions.

(3) Evaluation System Construction and Optimization Strategy Development: By

integrating hierarchical fuzzy analysis and multi-objective optimization methods, an evaluation system for cross-generational co-living spaces was established, and optimization design strategies were proposed based on actual cases. The main conclusions are as follows:

First, cross-generational co-living refers to the exchange and interaction of groups across different age ranges in shared spaces, involving public social behaviors of two or more generations without blood ties. Social factors influencing the effectiveness of cross-generational co-living include societal and eldercare backgrounds (intergenerational culture, eldercare methods, welfare), characteristics and habits of older adults (personal cognition, behavior patterns, satisfaction, spatial needs), and operational management (activity organization, participation rates, promotional methods, attracting younger people). Environmental factors include street accessibility, convenience of reaching nearby facilities, barrier-free access, comfort, safety, aesthetics, fun, ergonomics, equipment, flexibility, social participation, open interfaces, community culture/emotional resonance, appropriateness of information, and moderate privacy. Spatial factors include basic spatial features related to types, forms, sizes, and configurations of spaces.

Second, cluster-style spatial forms are most conducive to generating direct and indirect cross-generational exchanges. Spaces most favorable for direct cross-generational interaction include corridors, lobbies, multifunctional halls, bars, entrance plazas, entrance gray spaces, colonnades/connecting corridors, and courtyards. Locations most conducive to indirect (visual) interaction include the center of halls/squares, edges of courtyards, intersections of lobbies/halls/entrances/corridors, connections between multiple open spaces (window openings, connecting corridors), intersections of corridors with large spaces/rooms, and intersections of long corridors. Except for auxiliary rooms, the lower the dispersion of area sizes and the closer the sizes of various spaces in buildings, the better their effect in generating cross-generational interaction.

Third, following five criteria levels, 19 basic items, and 16 advanced items, the paper proposes an evaluation system for cross-generational co-living space environments and establishes corresponding evaluation grades A1~A5. It summarizes optimization design strategies for cross-generational co-living spaces, including site accessibility, spatial integration, environmental comfort, safety and health, and participation and inclusiveness.

On one hand, this study broadens the research boundaries of multi-generational interaction spaces and residential community integration from an architectural design perspective, aiming to alleviate loneliness in later life, providing empirical support for the mechanism research of age-friendly spaces and intergenerational interaction. On the other hand, it investigates spatial factors influencing the frequency of intergenerational interactions in a quantifiable manner, offering systematic and scientific

bases for the evaluation and design of cross-generational co-living spaces. The research findings provide innovative solutions to promote intergenerational integration in communities and enhance the quality of community spaces, holding significant academic value and practical implications for advancing healthy aging in communities.

Keywords

Cross-generational co-living, Space syntax, Spatial configuration, Evaluation system, Optimization design

Research area

In choosing the geographical area of the study, the thesis takes Shanghai and Florence, Italy as the object of study and inspiration, and the specific reasons for the scoping and case selection are explained below.

Assessment of research status in East Asia: Japan and South Korea, as representatives of the east asian cultural circle, have accumulated a wealth of literature on their elderly care model and cross-generational mutual aid research. A bibliometric analysis of the CNKI database reveals that Chinese scholars in the field of building science and engineering have formed a considerable scale of research on Japan and South Korea's aging model (about 1,800 articles), of which about 170 studies involve the topic of cross-generational mutual aid. The research trend shows that relevant studies grow significantly after 2015 as China's aging intensifies, reaching a peak in 2021 and then starting to fall back. Community aging model, cross-generational mutual aid and family support related research topics account for 30%. Given the high similarity between Japan and South Korea and China in terms of the cultural and practical background of aging, in order to explore more differentiated and forward-looking solutions to cross-generational intermingling, it is necessary to expand the horizon to countries and regions with more different cultural backgrounds. It is hoped that through cross-cultural research, in-depth analysis of the characteristics and advantages of elderly care concepts, social support systems and spatial design strategies in different cultural contexts can provide new inspiration and reference for the innovative development of China's elderly care model.

Analysis of the limitations of the high welfare state model: countries in regions with high welfare or more comprehensive social security systems - Scandinavia (e.g., Sweden, Norway) and the United States and Canada - tend to focus on socialized old-age services and mature pension insurance systems. Their pension systems are highly dependent on government financial support, with extensive coverage and high levels of benefits . This model is based on a high level of economic development, a small population size and strong financial capacity. Although the nordic and north american pension models are of theoretical significance, their high dependence on government finance is significantly different from China's pluralistic

Fig 1 Screenshot of an interview on the shared housing project "Move out! Live alone, but not lonely"

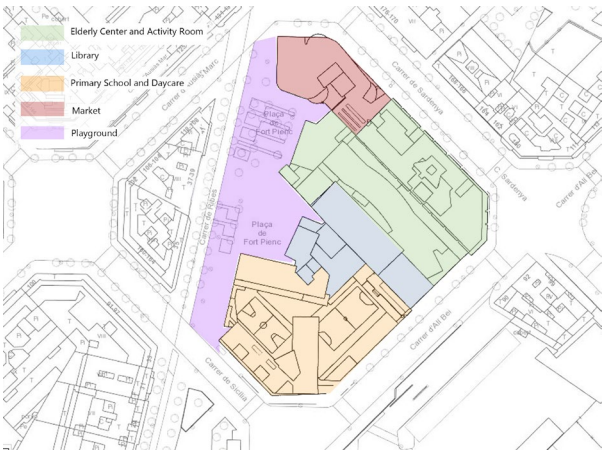


Fig 2 Community Center Complex Functional Plan, Barcelona,Spain

pension framework of "government-led, social participation and family support", and the applicability of the research results is relatively low.

Argument for the applicability of the Southern European model: Southern European countries (e.g., Italy, Spain) are more comparable to China in terms of their level of economic development, cultural traditions and challenges of ageing. The aging model in these countries focuses more on the synergistic role of the family and the community rather than relying entirely on government finances. Southern European countries have adopted diverse community-based aging and cross-generational mutual assistance models in dealing with the aging problem, which can bring greater inspiration to China. For example, AIAS (Associazione italiana assistenza spastici), an independent organization in Bologna, Italy, has adopted the "Move out! Moving out! Vivere da soli, ma non essere soli", a multidisciplinary housing project by AIAS (Italian: Associazione italiana assistenza spastici)in Bologna, Italy. Focusing on independent living, the project adopts a new and original form of shared residential living, incorporating the integration of technology, home automation, education, and socialization, and complemented with services to increase the number of people of other ages who can live together with others. services to increase interaction with other age groups and external inclusiveness, see Figure 1; Milan has a large number of community centers and cohousing projects, and since the summer of 2009, 30 families have started to live in the first "official" cohousing area on the outskirts of Milan, and in Italy as a whole, to create spaces and communities for seniors and other age groups to live and interact together. Spaces and communities for older persons and other age groups to live and interact together; Barcelona, Spain, has implemented a "Super Neighborhoods" program that promotes the social integration of older persons and other age groups through the transformation of community spaces, such as the Centro Civico Fort Pienc, located in the Fort Pienc neighborhood, which is surrounded by a primary school, day care, and a market. Surrounded by an elementary school, daycare, market, and apartments for the elderly, the neighborhood is highly used by residents and seniors, see Figure 2 Through the design of multifunctional integration and the creation of public interaction areas, the community is able to provide a wealth of activities for residents of different age groups. This form of space, which maintains independence and promotes communication, effectively reduces the sense of isolation that older people may feel during the process of aging at home.

Feasibility analysis of Florence: As a city with a long and deep history in southern Europe, Florence has successfully realized the innovative practice of combining the protection of historical buildings with ageing-friendly functions in the process of urban renewal, which provides a strong support for the optimization of the environment of old age and cross-generational interactions, and provides a typical case study

for this thesis . The feasibility of choosing Florence as a research sample is reflected in the following three aspects:

(1) Urban Renewal Experiences: Florence's practice of urban renewal for the ageing has been strongly supported by government policies, while also emphasizing the incorporation of public opinions to ensure that the renewal plan truly reflects the actual needs of the residents. They pay attention to the organic combination of historical building preservation and ageing-friendly functional renovation, and through the adoption of the "Minimal Intervention" strategy, they not only preserve the cultural value of historical buildings, but also satisfy the needs of the elderly for a safe and convenient living environment, and are full of innovative explorations of promoting multigenerational interaction space. It is full of innovative explorations to promote multigenerational interaction space. Currently, Shanghai has shown a remarkable potential for exploring innovative practices in elderly services and spatial design, and is facing ways to transform existing buildings into elderly facilities in urban renewal. Therefore, the experience of Florence in the preservation of historic buildings and ageing-friendly retrofitting is of particular importance.

(2) Economic development and elderly care culture: Italy's GDP per capita at the time of its entry into a super-aging society (2007) was US$22,000, and Shanghai's GDP per capita in 2023 will be close to US$26,000, so there is a possibility that Shanghai will be able to learn from Italy's similar measures in terms of economy. In terms of social and elderly care contexts, China and Italy are predominantly family-centered societies and dominated by family-based care for the elderly (MEDA & Stefania,2014), and relative to other Western countries, Italy and China have similar family concepts and Cross-generational relationships, with both Shanghai and Florence currently in a stage of deep aging that emphasizes the central role of the family. Similar aging cultures greatly influence attitudes towards family, community, and aging, and thus the conceptualization and utilization of cross-generational co-living spaces, and the differing approaches of the two cities provide diverse learning experiences, for example, Chinese senior living facilities tend to emphasize community integration and family ties, while Italian designs are more focused on maintaining the independence and social participation of older adults (Zhang et al.,2023).

(3) Guarantee of research feasibility: The author receives funding from the China Scholarship Council (CSC) program to gain an in-depth understanding of the successful experiences and specific practices of local ageing-friendly renovation during the joint training period at the University of Florence. By combining the successful cases of Florence with the actual needs of Shanghai, the author will provide scientific basis and practical guidance for the optimal design of the aging environment, so as to promote the joint development of the two places in the field of aging.

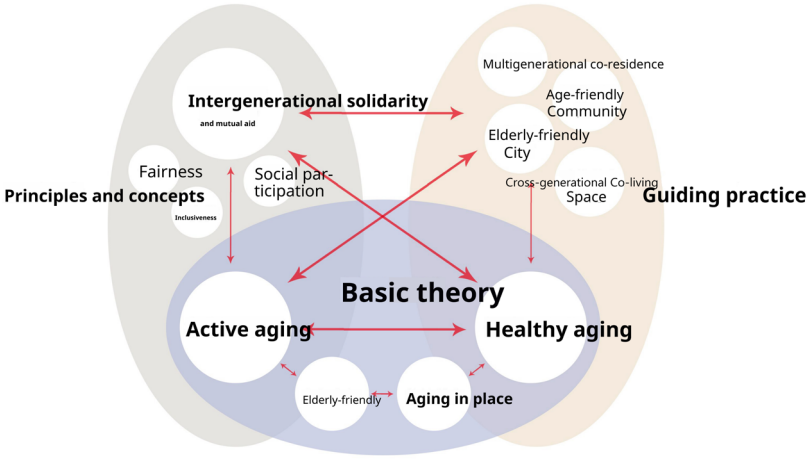


Fig 3 Related research fields about cross-generational co-living model

Research problem

All public spaces open to the public in the city are capable of generating offline cross-generational exchanges, however, combined with the behavioral characteristics and activity distance of the elderly and children, the living community is a place where cross-generational exchanges can occur more frequently. Therefore, the public space mainly used by the elderly in the community is an important carrier for realizing the concept of cross-generational co-living, which is also the main research scope of this paper (related research fields about cross-generational co-living model see figure 3). Existing studies mostly focus on the theoretical exploration of cross-generational interaction or the analysis of the spatial needs of a single group, and lack the exploration of the changes in the form of cross-generational interaction in the digital age, and the interaction mechanism between the elderly and other generational groups in public space. Therefore, the goal of this study is: how to make the public space in the community dominated by older people's use by means of design can effectively promote the interaction and cooperation of multi-generational groups in the physical space in order to effectively realize the concept of cross-generational co-living. The scientific question to be addressed is: how to quantitatively analyze and evaluate cross-generational co-living spaces. This paper focuses on public spaces in communities where older people are the main users, specifically including the indoor and outdoor spatial environments of public buildings such as community activity centers and comprehensive senior activity centers. By analyzing the functions and mechanisms of such architectural spaces in promoting cross-generational interactions and supporting multigenerational coexistence, the following five aspects are specifically explored:

(1) How to define the meaning and scope of cross-generational commons space. There are more relevant concepts in the cross-generational field, and the concepts of inter generation, multigeneration, and cross-generational mutual aid are intersecting with each other, while the space for multigenerational people has a high degree of overlap with the public space, so it is necessary to study how to define cross-generational co-living space, and what kind of public space can effectively realize the concept of Cross-generational co-living?

(2) What are the behavioral needs of cross-generational populations and the influencing factors of cross-generational coexistence spaces. Behavioral characteristics, activity contents and their needs and preferences of different groups of people make diverse demands on spatial environments, and do multidimensional factors such as space, environment, management, operation, society and culture contain representative key influencing elements that play a role in the effectiveness of cross-generational interactions?

(3) What are the spatial organization features that facilitate cross-generational communication, and what spatial location, shape, size and other organizational features contribute to a

stronger communication effect? Starting from the architectural space ontology, the cross-generational co-living space itself is explored in depth to explain what spatial grouping features are conducive to cross-generational communication.

(4) Under the synergistic effect of multiple factors, whether there are weighting differences and interaction effects among factors, and how the effect of cross-generational co-living on the spatial environment should be evaluated. Among the multiple spatial environmental influences, which factors are base terms and which are enhancement terms? Are there dominant weighting differences between factors and are any variables independent? How can cross-generational co-living spatial environment effects be evaluated in a relatively objective way in the process of behavioral decision-making?

(5) How to optimize the design of existing or new cross-generational co-living spaces to improve the quality of community public spaces. How can we learn good design experiences from different countries and apply them in new construction and renovation in the future, taking into account actual sample cases?

Research methodology

Literature review

Community care for the elderly encompasses many research results, and related research is not only related to architectural design, but also distributed in the fields of public health and social policy, management organization and service operation, urban planning and activity planning. In order to clarify the research object and identify the gaps in the current research issues, it is necessary to first conduct a systematic review and visual analysis of the published academic results in related fields to summarize the research limitations and establish the basis of analysis and the research object.

This study mainly uses Citespace software to systematically screen the research results in the field of community care for the elderly through the steps of literature identification and acquisition, literature screening, and literature selection, to systematically screen the research related to the spatial environment of community care for the elderly within the Chinese, English, and Italian languages, and to present and analyze the results with keywords and the distribution of the timeline visualization, the content of this methodology will be described in detail in section 3.1, which will not be repeated here. It will not be repeated here.

Qualitative study

(1) Field Observations

On the basis of the literature research, we conducted observation research and interview questionnaires on cross-generational coexistence spaces and user groups in China and Italy. During the field research, the observation method was used to record the influencing factors of the spatial environment and the behavioral characteristics of the age groups, so as to understand the real phenomenon of cross-generational interactions in a natural state. The

detailed observation and recording will help to understand what aspects should be emphasized in the cross-generational co-living space.
(2) Interview questionnaire
Semi-structured interviews were conducted with users, managers and related practitioners, and an indefinite outline was used for the interviews, which was conducive to giving full play to the initiative and creativity of the researcher and the interviewees, to have more in-depth discussions on cross-generational interactions, and to uncover the deeper demands in the answers of the interviewees. Combined with the results of field observations and interviews, questionnaires were used to collect the basic understanding and expectations of the wider population about the spatial environment for cross-generational coexistence. All of the above methods are used to dig into the development status of the cross-generational co-living model in a qualitative way, and the specific research outline and process are explained in detail in Chapter 4.

Quantitative study
The research object of the quantitative analysis focuses on the cross-generational co-living spatial grouping relationships and their effects on interaction behaviors, including spatial connectivity, accessibility, and layout characteristics. Taking the 24 research samples established by the field research as objects, the topological relationship convex graph extraction, integration degree value and visual integration degree value calculations were carried out on the measured data through the theoretical tools of spatial syntax. By quantifying these attribute parameters and analyzing the relationship between spatial connectivity and the probabilistic nature of the occurrence of interactive exchanges, the grouping characteristics of cross-generational co-living spaces composed of spatial form, spatial type and location, and area discretization are derived. The significance of the study is to transform abstract design goals into specific parameter indicators, respond more precisely to user needs, enhance the social function and user experience of the space, and thus provide a scientific basis for design. The selection and application of specific methods are described in section 4.1, and will not be repeated here.

Synthesized assessment
When evaluating the environmental effects of cross-generational co-living space, it is necessary to construct an evaluation system, which involves steps such as screening of indicators, expert evaluation, weight calculation, model building, and empirical testing. In this study, the influencing factors are divided into basic items and improvement items, and the relevant influencing points are extracted from the existing standards and norms as the basic scores, and the basic scores for entering the improvement items are derived from the combination of qualitative research and quantitative analysis. Based on the data scored by experts, the quantifiable AHP hierarchical analysis method is adopted to calculate the weights of each index. Using the fuzzy comprehensive analysis method to

establish an evaluation model to derive the evaluation system of the cross-generational co-living spatial environment. This content is described in detail in Chapter 5 section.

Technological routes

In this paper, we use the logic of inductive and retrospective reasoning to qualitatively and quantitatively analyze the current situation of the Chinese-Italian cross-generational co-living space represented by Shanghai and Florence in terms of the conceptual connotation of cross-generational co-living space, users' perception and needs, and the characteristics of the physical space environment in the current residential community. Through the results of the field survey, it is concluded that people's current cognition and concern about the cross-generational co-living space environment focuses on spatial characteristics, and thus the conceptual basis of spatial configuration is used to explore the intrinsic connection between material space and logical space as an important part of evaluating the cross-generational co-living space. Based on the quantitative analysis of the spatial configuration characteristics, and combining the literature review and field research on the design of cross-generational co-living space, we summarize the environmental evaluation factors of cross-generational co-living space in the residential community in terms of accessibility, spatial configuration, comfort, safety and operation and management, and then we establish an evaluation model and an empirical analysis with the comprehensive built environment evaluation method, so as to make an in-depth explanation of the evaluation system of the cross-generational co-living space in the residential community (see figure 4).

Structure of the research

This thesis consists of seven chapters corresponding to: introduction, theoretical review, qualitative research, quantitative analysis, evaluation model, design strategy, and conclusion of the study, as shown in Figure 5.

Chapter 1 is organized around the overall layout of the study, detailing the background of the study, the scientific questions to be addressed, the definition of the scope of the study, the establishment of the research objectives, the research methodology and technical path, and the overall logical framework of the study.

Chapter 2 focuses on the basic theories related to cross-generational co-living and clarifies the current status and development trend of the related fields through a comprehensive literature review. Using the systematic literature review analysis method, the published research results at this stage are visualized and analyzed in order to excavate the lacks and limitations of the current research, establish the objects and directions of the research, and provide theoretical support for the qualitative and quantitative analyses in the following sections.

Chapter 3 is a qualitative analysis, using field research, semi-structured interviews and questionnaires as the research method, summarizing and generalizing the behavioral

characteristics and interaction needs of each age group, and the current spatial design features, to draw out the main points of people's concern for the cross-generational co-living spatial environment, and to provide data support for later quantitative spatial analyses and extraction of influencing factors.

The fourth chapter is a quantitative analysis, which explores the efficiency of communication and interaction within the space with the support of spatial syntax theory. The spatial data of each sample are analyzed to derive the cross-generational co-living spatial grouping characteristics, and the spatial structural elements affecting the effectiveness of cross-generational communication are summarized from the perspective of architectural design.

Chapter 5 deals with the establishment of indicators and the creation of an evaluation system. An expert evaluation method was used to objectively score the influencing factors of the Cross-generational co-living space and derive the basic and improving indicators. The weights of the indicators are calculated by the AHP hierarchical analysis method, and the evaluation model is established by the fuzzy comprehensive analysis method, resulting in the evaluation system of the cross-generational co-living space environment.

Chapter 6 summarizes the cross-generational co-living space design strategies. Based on the evaluation system, the spatial design strategies are summarized in relation to the real design practices of the practice projects as a reference and guidance for design planning and management.

Chapter 7 is the conclusion, which summarizes the findings and innovations of the study and looks forward to the future direction of the study.

Significance of the research

First, starting from the relevant basic theories and practices of positive aging and cross-generational mutual aid, we explore the current research hotspots and trends in community eldercare, combine the behavioral characteristics and needs of people from all generations, recognize the current situation and development direction of cross-generational symbiotic interaction modes, and define the meaning of cross-generational co-living space.

Second, we grasp the overall situation of cross-generational co-living space in the urban residential communities of Shanghai and Florence, explore the social and spatial environment factors that affect the effect of cross-generational co-living communication from the perspective of qualitative research, and then apply spatial syntactic theories and the integration of spatial topological relations to the study of spatial communication grouping, so as to quantitatively elucidate the grouping characteristics of the space of cross-generational interactions.

Third, combining the existing norms and standards, screening and integrating the spatial influencing factors of cross-generational co-living, and exploring the weighting relationship

among the indicators, evaluating the spatial environment and interaction effects with basic and enhanced items, so as to realize the scientific evaluation of the influence of cross-generational co-living spatial environment characteristics on interaction effects in residential communities.

Fourth, based on the research findings and perceptions, the optimal design strategy for cross-generational co-living spaces in residential communities is proposed, aiming to enhance the construction of community public spaces and promote active aging and the construction of age-friendly cities.

Under the theoretical framework of Active Aging, the promotion of cross-generational mutual assistance is considered to be an important way to improve the physical and mental health of the elderly and enhance their sense of social participation. In recent years, research on cross-generational mutual aid and age-friendly communities has mostly focused on improving the physical environment or proposing management and service policies to address the social problems of the elderly, but there have been few thematic studies that systematically investigate and analyze the spatial environment from the perspective of promoting interaction and communication. In the digital era, community space design centered on cross-generational mutual aid responds to the reality of weakened cross-generational interactions in the virtual socialization era, and in-depth research on the application of digital technological means in cross-generational interaction space also provides innovative solutions for promoting cross-generational integration in the community and improving the quality of community space, which has important academic value and practical significance for promoting the development of healthy aging in the community.

Theoretical level: Starting from the current basic theories related to active aging, this thesis integrates the theoretical knowledge in the fields of cross-generational mutual aid, age-friendly community, sustainable development, environmental behavior, etc., and comprehensively and deeply researches the meaning of cross-generational co-living space, the characteristics of spatial configuration and evaluation system in a multi-angle and multi-disciplinary way, and at the same time, it provides valuable theoretical foundations for the research on multi-generational behaviors, which can supplement and enrich the research in the fields of aging, cross-generational mutual aid, community aging and other related fields. and enrich the research on aging, cross-generational mutual aid, community aging and other related fields.

Realistic level: this study aims to extract and summarize design strategies, analyze and generalize the spatial composition characteristics and environmental influencing factors supported by the cross-generational co-living model by summarizing the design techniques of actual cases, establish an evaluation model to evaluate the indoor space and outdoor environment used by the elderly and other age groups more systematically, and carry out a more scientific and specialized study of the indoor

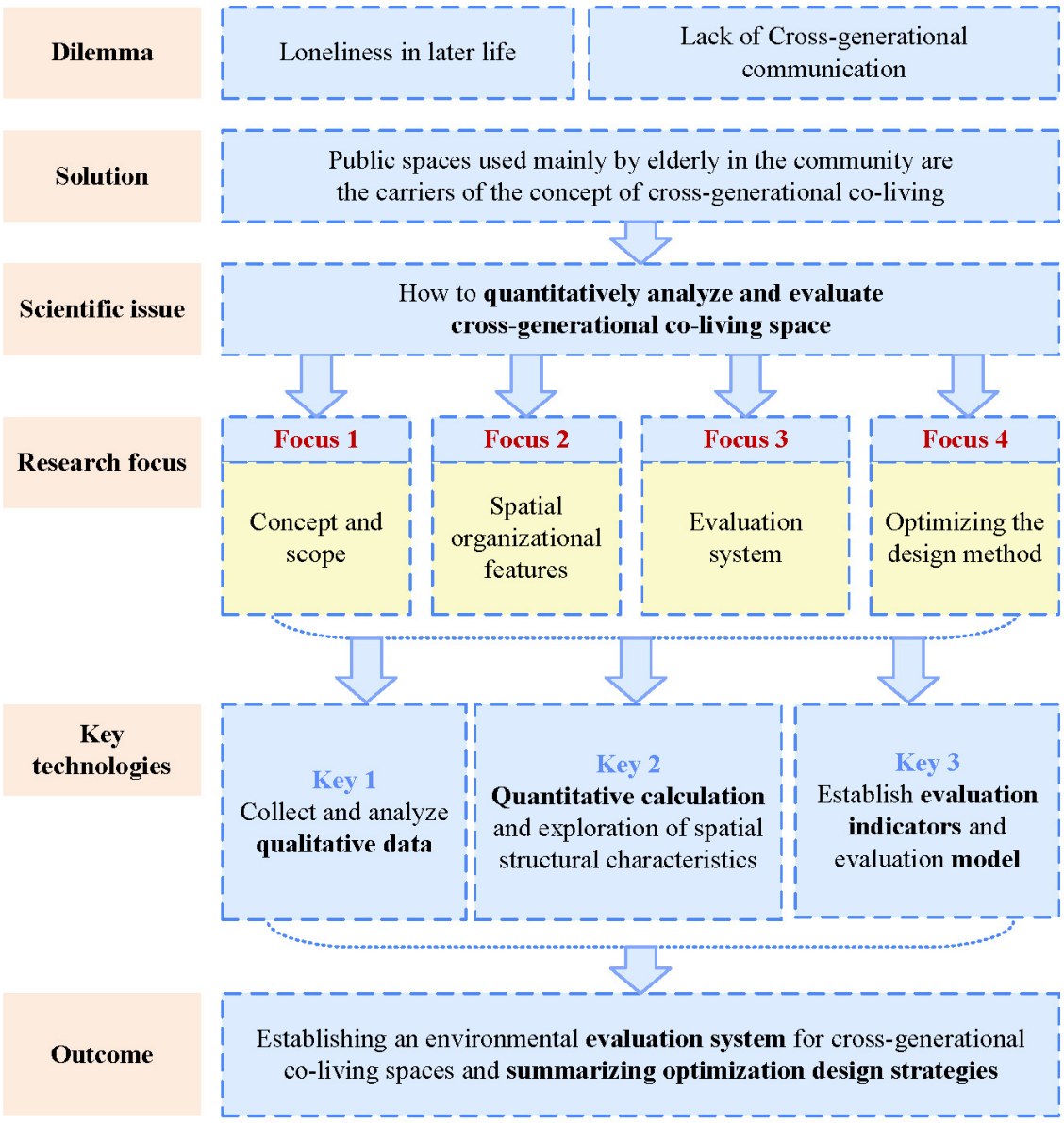


Fig 4 Thesis technical route

and outdoor environments for the elderly on the basis of this evaluation system. The design strategy encompasses the current situation and development prospects of environment, design, management and operation, and provides valuable reference and guidance for managers and designers.

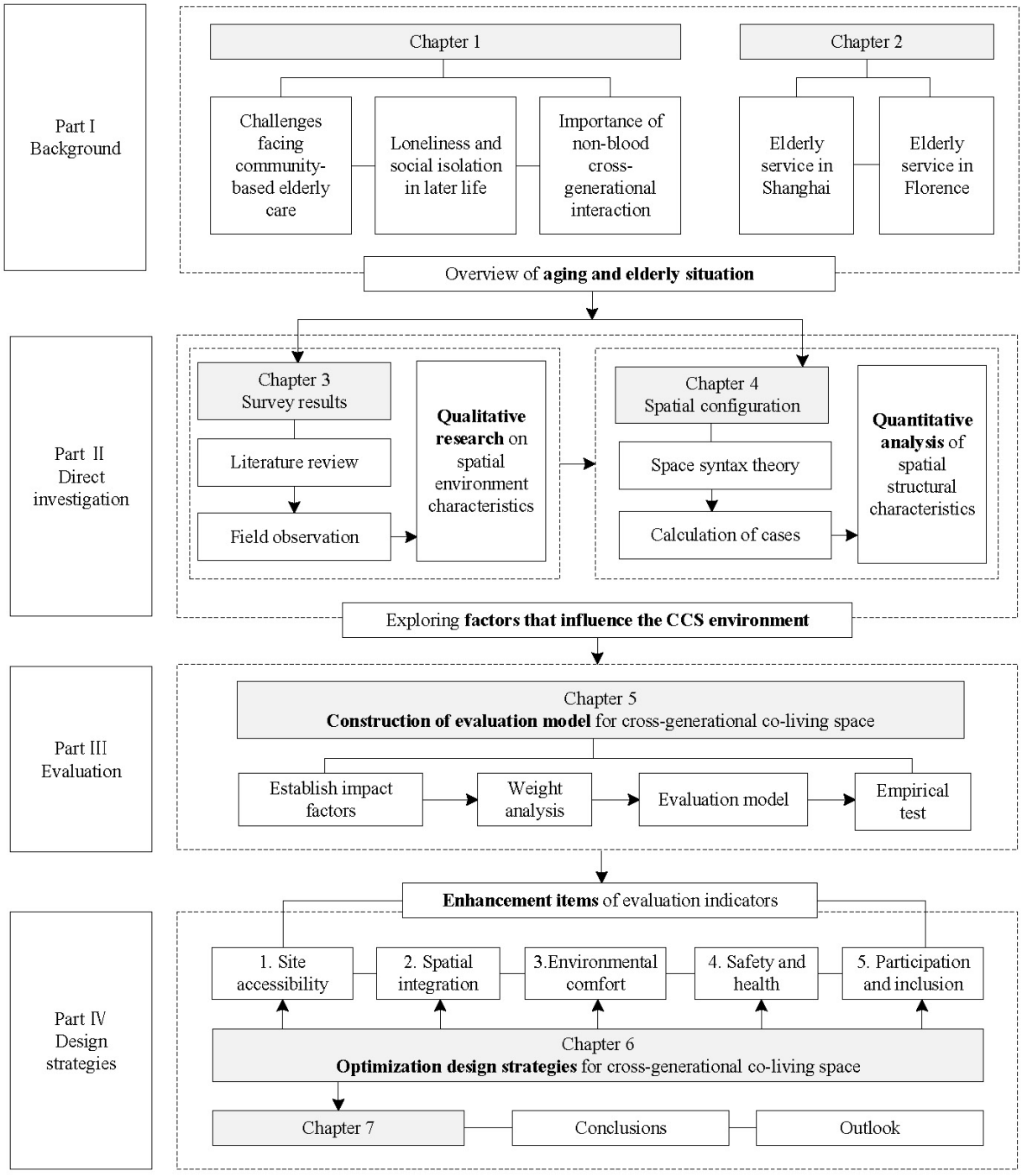


Fig 5 Thesis framework

PART I
BACKGROUND

Chapter 1 Overview of ageing situation
Chapter 2 Overview of elderly service

The global process of population ageing continues to deepen, and the health of older persons has become a focus of widespread concern for the international community. Both the maintenance of physiological health and the adjustment of psychological status are directly related to the quality of life and sense of well-being of the elderly. One of the important tasks in the development of the elderly care business is to prioritize the satisfaction of the basic needs of the elderly for livelihood security, while the health problems caused by loneliness, depression and other psychological factors in old age should not be ignored. Due to the shrinking of family structure and the weakening of the initiative of the elderly to participate in social activities, cross-generational interaction in daily life has shown an obvious shortage. Against this backdrop, exploring practical measures to promote the establishment of more links between the elderly and people of different age groups to meet their psychological and spiritual needs has become a research direction that needs urgent attention.

Chapter 1
Overview of ageing situation

1.1 Challenges facing community-based elderly care

"In the post-World War II period, owing to demographic changes and the increase in life expectancy, the issue of old age care for the elderly in developed countries gradually became a major problem. Developed countries in Europe and the United States have widely adopted a centralized model of old-age care, using large-scale construction of old-age facilities to meet the needs of the elderly. However, the growing elderly population has brought a huge economic burden to the health care system and social services, triggering social discussions on sustainable care models.In the late 1960s, European and American countries launched social welfare reforms one after another, and actively explored the family- and community-based old-age care service system (James, 2022), explicitly proposing to prioritize home and community-based old-age care, and gradually reducing the dependence on the traditional institutionalized old-age care. The dependence on traditional institutions for the elderly has been gradually reduced. Subsequently, cross-generational mutual assistance, co-housing and other diversified models of care for the elderly have begun to emerge (Dong, 2011; Deng & Wang, 2015).

In terms of the evolution of the global development of old age care, advances in medical technology and public health in the mid-twentieth century led to a significant increase in life expectancy, while the baby-boom generation led to the formation of a large older population beginning in the 1980s and 1990s. The initial approach to geriatric care in many developed countries was to establish nursing homes and long-term care facilities, often supported by hospitals and focusing on medical and custodial care. Practice has shown that institutionalized elderly care has revealed many problems in actual operation, such as high operating costs, lack of diversity in living environments, many inconveniences in family visits and the possibility of social isolation of older persons. In particular, against the backdrop of a deepening aging population and a rapidly rising demand for elderly beds, the increasing pressure on related financial expenditures makes the sustainability of this model a serious challenge (Li, 2013). Meanwhile, while medical teams can provide professional, healthy and safe convalescence services, many older people in institutions develop severe social isolation, leading to frequent depression (Coyle & Dugan, 2012).

The term Aging in place (AIP) was mentioned in articles in the early 1980s (Barati, 2022), and many developed countries have begun to promote community-based services, such as home health care and day programs, to enable older people to age in place. As a cost-effective model of aging, community-based aging in place has become one of the key means of coping with global population aging, and it is also an important way of integrating multiple forms of aging services. In many developed countries in Europe and the United States, with

the aggravation of the trend of population aging and the emphasis on the emotional care needs of the elderly, community-based home care has gradually shown more significant advantages than traditional institutional care. Whether from the perspective of meeting the personalized needs of the elderly, or from the level of reducing the overall cost of society, this model has an irreplaceable significance. At present, the vast majority of elderly people around the world prefer to choose community home care (Li, 2021), in Japan, for example, home community care accounted for 97.08%, while institutional care accounted for only 2.92%. Foreign urban community senior care service attaches importance to the concept of maximizing the self-care ability and health of the elderly through preventive measures, and at the same time is committed to reducing the occurrence of social isolation. Provide more diversified, humanized and professionalized services, and emphasize individual and social co-payment in financing, etc. (Huang, 2013).

As China's population continues to age and the size of families becomes smaller, community-based home care has become a new model that meets the real needs of China's elderly. This model takes the family as the basic unit, relies on community resources, and uses professional service organizations as the main implementation body, and operates through a government-led approach, with broad participation by social forces and specific contracting by non-governmental organizations. In terms of service forms, community-based home care covers a variety of types such as door-to-door service, day care and neighborhood mutual aid, and its core content includes socialized support in life care, health management, psychological guidance, etc. (Zhang & Liu, 2011). However, in the process of actual promotion, home-based community care is still facing many challenges, such as insufficient aging environment and facilities, social isolation leading to mental health problems, the contradiction between the supply and demand of elderly care services, shortcomings in community medical and health care services, imperfections in emergency assistance, and insufficient community spiritual and cultural care, etc.(Bambeni, 2022).

1.2 Loneliness and social isolation in later life

Social isolation is becoming an important topic of concern in the mental health of older adults. Research on this phenomenon has covered a variety of theoretical perspectives, such as cognitive theory, social support theory, existentialism theory, and Maslow's hierarchy of needs theory. According to several surveys and studies, although only a minority of older adults exhibit severe social isolation, more than one-third of older adults still experience varying degrees of psychological loneliness in their daily lives (Hauge & Kirkevold, 2012). There are three main factors affecting loneliness in old age in later life:

(1) Factors at the individual level: the psychological loneliness of the elderly is

closely related to their own physiological and psychological state. First, with age, the physical function of the elderly gradually declines, the risk of disease increases, and the mobility is limited, which leads to a significant reduction in the opportunities for social interaction (Liu & Ni, 2003); second, cultural literacy has an important impact on the emotional management ability of the elderly. Elderly people with higher education usually have stronger rational thinking ability, and can actively adjust negative emotions in the face of difficult situations, thus enhancing subjective well-being. In addition, gender differences also have an impact, as studies have shown that male older adults are more likely to feel the stress of social isolation than women.

(2) Impact of family environment: Family relationships are an important supportive force in alleviating loneliness among older people. On the one hand, marital status has a direct effect on the mental health of the elderly - married elderly people usually have a higher sense of security and belonging due to the support of their partners, and therefore have a relatively lower sense of loneliness. On the other hand, the number of children and their living arrangements also have a profound impact on older people's psychological well-being. When there are more children and they live with their parents, the elderly can get more emotional care and support, and their sense of loneliness is naturally reduced. Thus, it is clear that spiritual companionship among family members is crucial for improving the mental health of the elderly (Wang et al., 2004).

(3) Factors at the socio-economic level: The degree of improvement of the social support system directly affects the quality of life of the elderly. At the social level, care and support from relatives, friends, communities and the government are indispensable external conditions for the physical and mental health of the elderly. However, with age, the physical functions of the elderly gradually deteriorate, and their mobility makes them more inclined to live at home rather than go out to socialize, which inevitably reduces their social participation and further exacerbates the lack of cross-generational communication, which in turn becomes an important trigger of loneliness. From an economic perspective, older people with lower income levels not only face greater pressure on healthcare spending, but also may need to rely more on their children for financial support, a passive situation that often has a negative impact on their mental health (Wu, 2008).

The social network of the elderly usually centers on their peers (Singh & Misra, 2009), but as they grow older, the gradual decrease of friends of the same age makes their social circle shrinking. At the same time, due to the deterioration of physical functions and the decline of learning ability, it is difficult for the elderly to adapt to the pace of life of young people, and it becomes more and more difficult for them to integrate into the new generation's social circle. Research has shown that maintaining moderate social activities is important to alleviate the psychological burden of the elderly. By interacting with others, not only can they enhance their psychological resilience, but also their sense of well-being (George, 1996). This interaction is the embodiment of the concept of "cross-generational mutual support". This concept is centered on the policy of positive aging, advocates a people-centered view of development, and is committed to building harmonious ccross-generational relationships. By focusing on the physical and mental health of the elderly and providing them with all-round support in every aspect of their daily lives, it helps the elderly to overcome the fear of aging and realize a more dignified and higher-quality life in their twilight years (Mu, 1999). Cross-generational relationships refer to the interactions and connections between people of different ages, including both interactions among members within the family and interactions among unrelated groups at the social level (Riley & Matilda, 1983). Cross-generational solidarity emphasizes the emotional and behavioral support between multiple generations, and minimizes cross-generational conflicts and disagreements through daily communication and interaction, thus promoting family harmony and the stability of social order.

In China's traditional culture, filial piety as a core value has been deeply rooted in people's daily

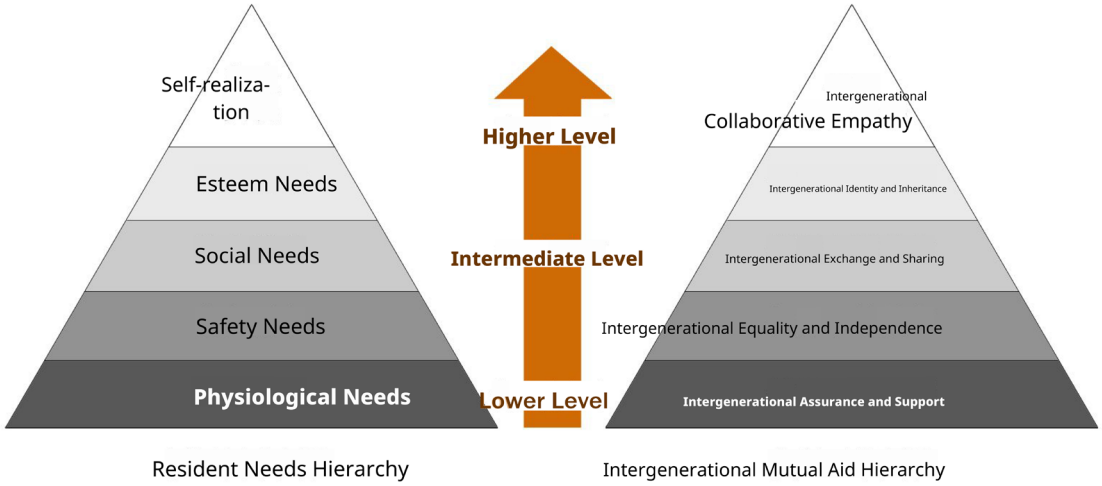


Fig 6 Maslow's hierarchy of needs corresponds to the level of mutual assistance

life, which is inseparable from the influence of confucianism. In contrast, family relationships in China and the West show significant differences. Mr. Fei Xiaotong once pointed out that Western societies generally adopt a "relay model", in which each generation focuses only on raising the next generation, while the elderly are left to the society or government to solve their problems. However, in China and most East Asian countries, cross-generational interactions within the family follow the "two-way responsibility model", which remains relatively stable even as the modern family structure is gradually miniaturized. Specifically, cross-generational solidarity in China is characterized by the sharing of resources within the family, with older people helping to care for their grandchildren and children taking responsibility for their parents' old age. This family-based form of mutual aid constitutes a core feature of cross-generational relations in China (Yang & Li, 2009). With the aging of the population, the widening of cross-generational conceptual differences, and the shrinking of family size, the quality and frequency of cross-generational interactions have been affected to varying degrees. Against this background, the participation of the elderly group in society has declined, and even faces the risk of being marginalized. Therefore, how to build a more inclusive and supportive social environment by strengthening the mechanism of cross-generational mutual aid has become an important topic to be solved. Based on the above analysis, cross-generational mutual aid can be divided into three dimensions, corresponding to basic needs, development needs and self-actualization needs in Maslow's hierarchy of needs theory, see Figure 6.

Evidence-based research shows that in the digital age, community relationships based on wealth rather than blood are very different from the ethnic structures of the past (Lin, 2002). Compared with the traditional social relations based on blood ties, this new type of community relations emphasizes more on resource exchange and benefit sharing among individuals. As Western countries have entered the aging society earlier, their academic research on cross-generational relationships has gradually expanded to the field of bloodless relationships. Relevant studies have shown that in the process of interaction between older adults and unrelated children, both parties will spontaneously establish a pseudo-kinship relationship. Specifically, older adults tend to perceive children as their grandchildren, while children perceive older adults as their grandparents. This psychological projection mechanism facilitates the establishment of emotional trust and increases the level of intimacy between the two parties. At the same time, the formation of proposed kinship can stimulate older people's sense of responsibility, so that they can obtain psychological satisfaction and a sense of value identity in the interaction process. Cross-generational interactions can improve the quality of life in later life and reduce stress (George, 2011). When older people and young people

Fig 7 Mutual support activities in the Old's Cool intergenerational project

are together in the same space, they can realize the transfer of knowledge, skills and experience through communication and cooperation, thus forming a mutually beneficial and win-win mutual assistance system. This kind of cross-generational interaction is not only conducive to promoting the socialization process of children and enhancing their social adaptability, but also enhances the self-efficacy of the elderly and alleviates their sense of social isolation (Newman & Sally, 2002). The development of virtual socialization has led to an increasing number of cross-generational exchanges in non-blood relations, and digital media have broken through the limitations of traditional social interactions based on geography and kinship, allowing different age groups to establish connections through common interests, values or goals. Examples include online education platforms, communities of interest and collaborative projects.

Therefore, non-blood-related cross-generational communication is not only effective in alleviating loneliness for older persons, but also enhances their sense of belonging, self-worth and social participation. Its unique advantage lies in its ability to compensate for the limitations and gaps brought about by changes in family structure and the geographical isolation of , to provide diversified identities and emotional experiences that are no longer limited to the fixed roles of blood relations, and to build a wider social network that promotes social inclusiveness and cross-generational solidarity.

1.3 Importance of non-blood cross-generational interaction

Ageing practices related to cross-generational mutual aid take many forms. Research in the field of architecture focuses more on the construction of diversified systems of mutual assistance in the neighborhood. For example, cohousing is popular in Europe and the United States, Multi-generational co-residence is promoted in Germany, and cross-generational shared sites are implemented in Japan. These innovative designs not only provide emotional support for the elderly, but also alleviate the pressure of aging in Western societies to a certain extent, and thus have attracted much attention. In contrast to the cross-generational model of aging abroad, family relationships in China are heavily influenced by traditional culture, and the "4+2+1" family structure has resulted in the core of cross-generational relationships in China being grandparents taking care of their grandchildren. At the same time, the "4+2+1" family structure has led to cross-generational relationships in which grandparents take care of their grandchildren. The model of "cross-generational mutual assistance for the young and the old" is the most common type of cross-generational mutual assistance under China's current concept of active aging. From an architectural point of view, cross-generational mutual support in China focuses more on the home care model with the family as the core unit, while the exploration of the practice at the community level is relatively limited (Zhang, 2017).

The World Health Organization (WHO) notes in its Global Guide to Age-Friendly Cities that cross-generational activities are considered preferable to activities aimed at older people alone (WHO, 2007). However, leisure activities and service models that are suitable for the majority of the population may not necessarily be suitable for older people (Van et al., 2018), activities that are suitable for multigenerational participation are mainly chess playing, multigenerational family trips, creative projects, cultural activities, and participation in community services, but are not the things that young people in the contemporary era are keen to do, such as video games, dance clubs, amusement parks, and so on. There is a large body of research that attempts to incorporate cross-generational elements into existing services for older people, e.g. model health service initiatives to promote cross-generationality (NG et al., 2020; Kirkpatrick & Brown, 2006), but are often more healthcare oriented and place less emphasis on cross-generational social connections through adapting existing or creating new services in existing social spaces and places, e.g. community cafes, community gardens, youth and older people's centers. The challenge lies in engaging young people in community activities and facilitating communication between them and older adults. Planning and promoting cross-generational programs in residential communities is generally effective in terms of interaction, e.g., "Old's Cool"at the Scottish Castle Youth Center, a

grassroots cross-generational program (Fang et al., 2023). Young people prefer to stay at home and play with their cell phones and surf the internet in their free time, making it difficult for older people to socialize with them, and there is a general lack of recreational spaces and facilities in the community to promote cross-generational interactions (Li & Cao, 2023). Therefore, there is a need to strengthen the thinking on how to promote cross-generational communication in the construction of residential community environment.

From the perspective of social behavioral change, the evolution of the digital era has profoundly changed the mode of human interaction, especially the way of cross-generational interaction. With the popularization of Internet technology and the rise of social media platforms, young groups and the increasing number of middle-aged and elderly groups have gradually shown the dual characteristics of increased investment in virtual social time and decreased frequency of real interactions. For example, according to the 50th Statistical Report on the Internet Development in China released by China Internet Network Information Center (CNNIC), as of June 2022, the scale of China's Internet users has reached 1.051 billion, of which the proportion of elderly Internet users aged 60 and above has reached 11.3%, which is a significant increase compared with the past. These data show that both young people and middle-aged and elderly people are increasingly relying on digital tools for daily communication and social activities. The popularity of digital interactions has changed people's socialization patterns to a certain extent, but its potential shortcomings are also gradually emerging. Studies have shown that over-reliance on digital interactions may lead to a decline in the quality of interpersonal interactions and a superficial emotional connection (Arnd & Margaret, 2015). The fragmented nature of digital interactions may lead to distraction and lack of in-depth conversations, thus affecting individuals' sense of social support and mental health (Primack et al, 2017). A study of young adults found a significant correlation between frequent use of social media and increased loneliness, suggesting that digital interactions may not be able to fully replace the psychological satisfaction of physical interactions (Twenge & Campbell, 2018).

This trend has also had a profound impact on the maintenance of traditional cross-generational solidarity. In the past, communal relationships centered on blood ties within the family were the main form of cross-generational mutual aid, such as grandparents helping to take care of grandchildren and children providing financial support to their parents. However, entering the digital era of the 21st century, this traditional model of blood-based mutual aid is gradually shifting to a community-based relationship that focuses on wealth and interests (Lin, 2002). For example, many urban families can no longer fully rely on cross-generational mutual aid within the family to solve practical problems due to work pressure and accelerated pace of life,

and they are more inclined to satisfy their needs through marketized services or community resources. For example, when contemporary adults face occupational pressure and lack of time and energy, they often choose to hire domestic helpers or childcare organizations to complete tasks such as youth education and childcare, rather than relying entirely on the help of parents or grandparents.

There is a growing need for older persons in the new era to build diverse and mutually supportive multigenerational relationships in a non-blood relationship. For example, in some shared communities, older persons can form mutual supportive relationships with other age groups through participation in volunteer services or interest group activities. Meanwhile, the demand for offline services among contemporary adults is also increasing. For example, many dual-income families, lacking sufficient time and energy to take care of their children, choose to send their children to daycare or interest classes in the community. The demand for cross-generational interactions between non-blood relatives is gradually becoming a new social phenomenon, which in turn puts forward new functional demands for cross-generational interaction spaces.

Although the arrival of the digital era has changed the way people interact, it has also provided an opportunity to explore new modes of cross-generational interaction. Therefore, the concept of "cross-generational co-living", which is based on sharing lifestyles to promote cross-generational interactions, is of greater practical significance. Not only does it make up for the shortcomings of digitalized interactions by means of face-to-face interactions and re-establish real social ties, it also provides a feasible solution to the social challenges posed by demographic changes and people with high mobility. Through the redesign of community space and activities, a sharing and mutual-help platform is built for different age groups, thus promoting the reconstruction of social relations and the optimal allocation of social resources.

Chapter 2
Overview of elderly service

2.1 Elderly service in Shanghai

Current elderly service in Shanghai

Chinese seniors have long history and traditions to live together with their family members, with at least one adult child, which is a living arrangement with mutual assistance. At a relatively young age, healthy seniors usually look after grandchildren and help with household chores. Older people begin to need younger people's care, a transition that is often gradual and usually not needed until age 80. Elderly people who are slightly incapacitated and do not need to receive medical services at any time tend to be cared for by adult children who live together or live nearby, and gradually turn to more formal elderly care institutions or assisted living facilities as the need for elderly care gradually increases. living environment.

Changes in family structure and economic development have resulted in less and less care for family members living together. Two important shifts are of particular note. First, older parents are more likely to live with their adult children when they are younger (45-60 years old), reflecting an implicit transfer of support from parents to adult children, who are more likely to endure than young adults in the past house price cost. Second, for older parents (65+), the share of elderly living with adult children declined, from nearly two-thirds in the early 1980s to about five in 2011. two-thirds. This decline may be influenced by increased migration over the past 30 years, as well as by urban children's increased focus on privacy and parents' ability to live apart. These patterns suggest that informal home-based elderly care services for the disabled are under pressure because of changes in living patterns. Increasing migration and shrinking family sizes reduce the likelihood that adult children will live with or near their elderly parents.

Because they do not live together or live nearby, adult children are less likely to be familiar with their parents' health status and elder care needs. Data from other surveys suggests that many older adults now fear they will be left unattended. The 2010 China Urban and Rural Elderly Population Sample Survey showed that 39.8% of the elderly were worried that no one would take care of themselves when needed, of which 23.6% were "somewhat worried" and 16.2% were "very worried". For those planning to relocate, the need to provide long-term care services to aging parents can come with high and increasing opportunity costs. Previous research has shown that serious illness in older parents can influence children's decisions to work outside the home. For example, Giles and Mu (2007) used the parental mortality rate over the next two years to measure the severity of the current illness, because death in the near future is indicative of current frailty.

They found a sizable inverse association between recent mortality and migration. Many older adults may be incapacitated for a considerable period of time before dying, so moving back to care for a parent may only

occur long after the older parent has been seriously ill. As older adults are more likely to live into their 80s, incapacitation for more than a year or two will become more common. There are also opportunity costs for those who have to juggle work and care responsibilities. A study of the relationship between labor supply and care provision among adults aged 45-65 years showed that elderly care had significant negative effects on labor supply for both rural men and women and reductions in working hours for urban and rural women (Giles et al., 2016). These findings are consistent with previous studies showing that providing care has a negative impact on female labor supply (Ettner, 1995; Van & Skira, 2013) . On the other hand, Maurer-Fazio (2011) also found evidence consistent with the "additional worker effect": the relationship between the likelihood of having a parent or parent-in-law over the age of 75 and a prime-age female working in the household relationship exists.

Pension policy

The Chinese government has recognized the need to establish an efficient and sustainable elderly care system. The development of the elderly care industry is an integral element of complex public policies that affect the daily lives of millions of Chinese people. Aged care policies interact with other social policies, including policies on social assistance, welfare, child care, health care, education (including university curriculum development, professional courses, and vocational training), housing, and labor market policies. All of these will affect the market opportunities for senior service practitioners, as well as the development of related industries such as senior products and services. In recent years, the main policies about elderly care are listed in figure 8.

The elderly care service implemented in China is mainly the "9073" model, which was first proposed by Shanghai in the "Eleventh Five-Year Plan". That is, 90% of the elderly are cared for by their families, 7% have community home-based care services, 3% have institutional pension services (figure 9).

In addition to the late start of the pension business, one of the important factors causing this situation is that the social pension model is not in a dominant position in China. The traditional concept of "raising children to prevent old age" makes the elderly tend to live with their children and descendants without leaving their familiar communities and life circles. Under the influence of traditional concepts, the elderly can not only get the careful care of their children in their later years, but also because of the company of family and friends, they will not have the negative emotions of loneliness and aging.

Day care centers, elderly care homes, and comprehensive service centers for the elderly are the three main service for community elderly care in Shanghai. The survey data shows that the average daily number of elderly people there

are: 19.34, 21, and 28.22, respectively. Table 1 shows amounts and information about elderly care services in Shanghai.

In response to the problem of "difficulty finding a bed" for the elderly who want to live in an elderly care institution, the Shanghai government has listed "increasing elderly beds" as a practical project for 20 consecutive years, and encouraged social capital to participate in the construction of elderly care beds. At present, there are 147,500 old-age beds in Shanghai, achieving the goal that 3% of the elderly can stay in old-age institutions.

For more than 90% of the groups who are aged at home, efforts are made to build a support system in the community that the elderly can live in peace of mind. More than ten years ago, the government and society relying on the community to provide services for the elderly at home came into being in Shanghai and developed rapidly. Subsequently, various forms of services for the elderly, such as community meal assistance, day care in day care centers for the elderly, and the “Older Partner Program” for pairing and caring for the young and the elderly, have been launched one after another, and have been widely carried out in Shanghai communities.In recent years, in the face of the "rigid needs" of the disabled elderly, the elderly living alone, and the elderly who have been discharged from the hospital due to serious illness, Shanghai has established an "elderly care home" embedded in the community by leasing idle old factories. This kind of "micro-institution" for the elderly with less than 50 beds allows the elderly in need to temporarily live for about two or three months, and provides them with short-term residential services such as rehabilitation care. Today, every street and town in Shanghai has at least one "care home for the elderly". This "breathing" service method is close to the needs of the people and is very popular. The utilization rate of one bed is about 4 times a year, which is in short supply.

In 2017, Shanghai began to pilot a "long-term care insurance" that provides funds or service guarantees for basic living care and medical care for the disabled. This new insurance system is generally welcomed by the elderly. The pilot project was successful and was quickly rolled out across the city. By the end of 2018, Shanghai had accepted 272,000 long-term care insurance applications, completed 266,000 assessments, and had received services for 234,000 elderly people.

Now, there are more and more disabled, demented, and elderly people living alone in the community. In response to this part of the rigid needs, Shanghai extends professional elderly care services to the community, and encourages professional teams to enter the community to carry out rehabilitation and rehabilitation for home-based elderly care service personnel. Nursing skills training and supervision.
After continuous attempts, Shanghai integrated resources for the elderly and established a

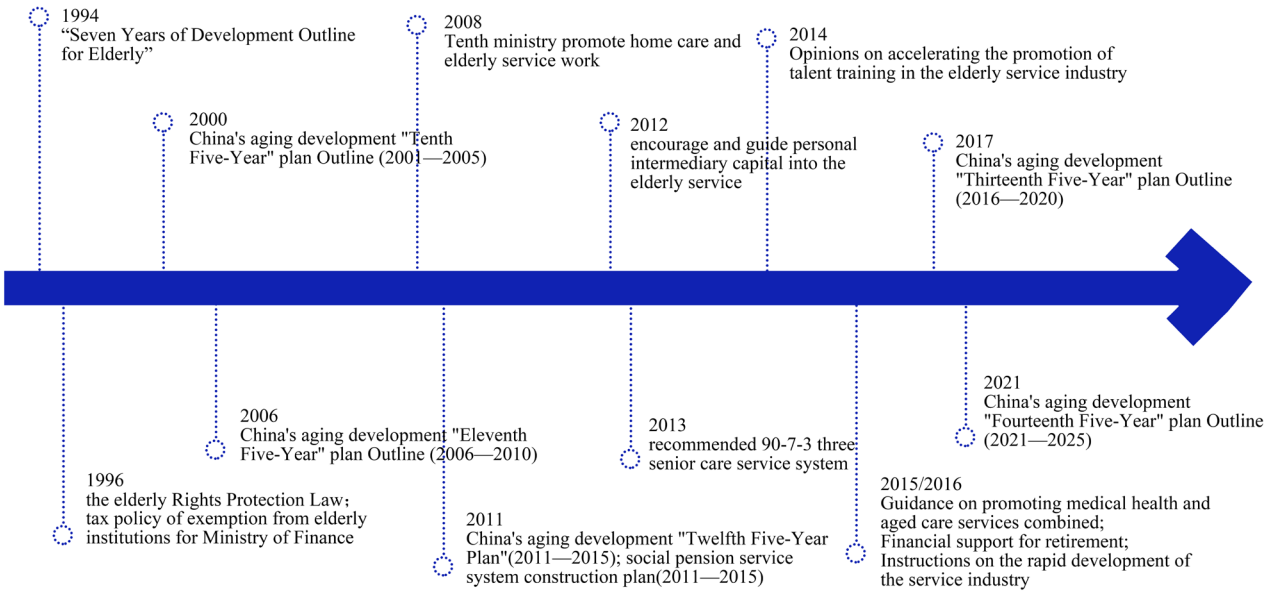


Fig 8 The main policies about elderly care in China

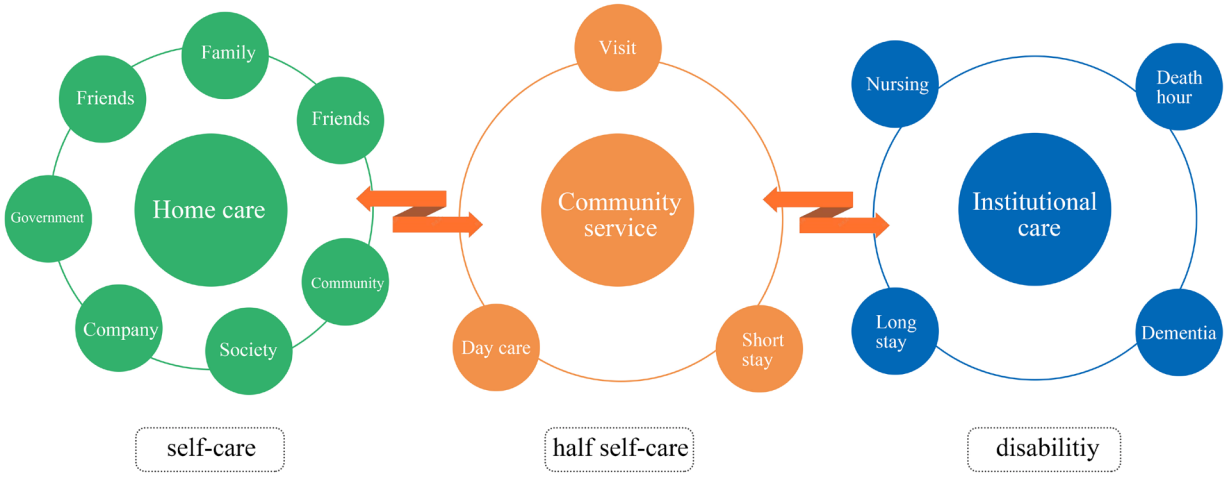


Fig 9 Mainstream elderly care methods in China

Types		Amount	Other information
nursing home		729	the total number of beds is 157,000, with an increase of 7,646 in 2020, an increase of 3.6% over 2019
community care	elderly home	204	17 new ones will be added in 2020, with a total of 5,838 beds
	daily center for elderly care	758	83 new stores will be added in 2020, with an average monthly service population of 15,000
senior meal service places		1232	There will be 212 new services in 2020, with an average monthly service number of 120,000 people, an increase of 18.8% over 2019
community volunteer organization		259	Among the service objects, 74,800 elderly people received government subsidies for elderly care services
community services for the elderly		320	52 new establishments in 2020
standardized elderly activity room		6233	239,800 people on average per day
community center		2544	800 new in 2020

Source: Author made based on the "Statistical Information on the Monitoring of the Elderly Population and Aging Career in Shanghai 2020"

Tab 1 Elderly related service in Shanghai at the end of 2020

"comprehensive service center for the elderly" in the streets and towns. The "hub-style" complex for the elderly provides one-stop elderly care services such as day care, meal assistance, bath assistance, rehabilitation, and nursing for the elderly in the community, and radiates all elderly people in the community, forming a "15-minute service circle".

2.2 Elderly service in Florence

Current elderly service in Florence

Italy is the country with the highest aging rate in Europe. According to the latest Istat data, as of the beginning of 2022, the elderly population aged 65 and above will be 14 million, accounting for 23.8% of the total population. Elderly care services in Italy include: medical services and nursing homes for the elderly who are not self-sufficient, such as residential medical care institutions (Residenze Sanitarie Assistenziali); monitoring services for the health status of the elderly at home, such as PASSI of the Italian healthcare company d'Argento monitoring system; community services for self-sufficient elderly, various public events, etc. In addition to the services provided by the government, the organization of many activities and the creation of the space environment are spontaneously organized by local residents, which are inseparable from the history and culture of the neighborhood and street. Therefore, when considering the regeneration and development of historical urban areas and old buildings, it is necessary to include the renewal of the living environment of the local elderly population.

Faced with the strong and growing presence of the elderly population and the incidence of age-related disabilities, the prevention and treatment policies in favor of elderly citizens have been established(see table 2), in recent years, at the pursuit of some fundamental welfare objectives:

- Promote as long as possible a suitable stay of the frail or non self-sufficient elderly person at their home, providing the means to supplement functional losses and intervening in support of families;
- Improve the quality of life of older people;
- Strengthen the home system as a whole;
- Promote actions aimed at optimizing all territorial resources, with particular attention to inclusion in the network of Third Sector services;
- Get out of the generic nature of interventions on need, ensuring more appropriate and flexible responses to the needs of the elderly and the family.
- Qualify residential services and integrate them with the territory.

The social and socio-health interventions in favor of the elderly population can be summarized in the following categories:

1) Home and territorial interventions, specifically aimed at the home stay of frail or non self-sufficient elderly:

- Direct Home Assistance Service;
- Contribution for Family Assistants;
- Family Support and Indirect Home Assistance;

- Day Centers (see "Airone" and "Le Rondini" details);
- Meal delivery at home;
- Pedicure at home;
- Telecare;

2) Residential services.
For the activation of most of the interventions, in case the person is not known by the social services, it is necessary to have prior acceptance by the local services by contacting the social secretariat:
- Residential facilities and affiliated day centers;

In addition to the material guarantees provided by the government such as elderly care services and nursing homes, Florence also has many measures to enrich the spare time of the elderly. The manual(GUIDA AI SERVIZI PER ANZIANI A cura della Dr.ssa Alice D'Alfonso) published by Societa della Salute in 2009, has shown the goal of providing the elderly - and their families - with the coordinates to learn about and access the services dedicated to them to allow an improvement in their quality of life. Fun, entertainment, friendships are in fact fundamental elements to keep the mind active and slow down the aging process, as well as adequate assistance is necessary for those who need it. Those measures are summarised as follows.
Senior Centers (italian:Centri anziani)
The Elderly Centers are active all year round and are present in all the districts(see figure 10). They offer social, recreational, cultural and support activities to maintain autonomy, an active life and a good physical and mental state of health.
The activities are different from center to center and include: card games, bingo, dance, painting courses, computer science, singing, theater, film screening, language courses, bridge, psychological counseling, barber shop, pedicure, legal advice, tourist trips. etc.
To attend, the registration card is required.

Adapted Physical Activity A.F.A.(italian:Attività Fisica Adattata - A.F.A.)
It is a physical activity program adapted for specific needs. It is particularly useful for preventing and improving painful conditions that can lead to the reduction of functional capacities. Citizens can apply to participate in the A.F.A. on the recommendation of their doctor; however, a medical prescription is not required. A low social rate is applied.

Elderly holidays (italian:Vacanze anziani)
It is a service organized by the Districts that is aimed at retirees (or people of retirement age). It offers a wide range of 15-day summer stays in renowned seaside, mountain and spa resorts, with the "all inclusive" formula (round trip, full board, assistance of one companion per group). Reservations must be made around the month of April at the headquarters of the Districts with a valid identity document. The costs of the stays will be determined by the choice of the location and by any contribution received. The Municipality guarantees to the economically

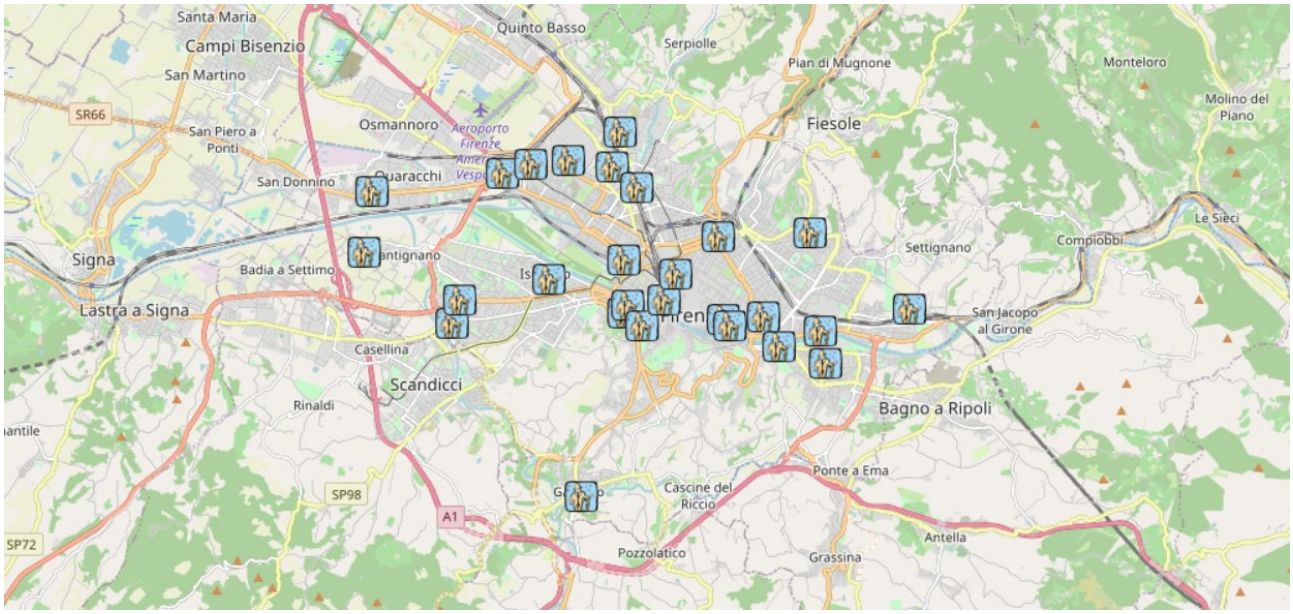


Fig 10 Senior activity center distribution in Florence

weaker subjects an economic support to allow their participation. To take advantage of the grant, interested parties must present themselves with an ISEE certificate.

Friends lunches and dinners (italian:Pranzi e cene in amicizia)
In Montedomini - in via dei Malcontenti 1 - lunches and dinners are organized for lonely elderly people who have no problems leaving the house, to promote socialization and leisure. This possibility also meets all those who are in difficulty for the preparation of meals independently, offering the added value of being in company.

Assistance interventions(italian:Gli interventi assistenziali)
PUNTI INSIEME: a resource for the non self-sufficient elderly For the non self-sufficient elderly, family members can inquire about the various possibilities offered by contacting the Points Together, active since January 2008 and present at the Social Centers of the Municipality and the nursing offices of the Health Authority of Florence .
Interested parties and their families can here describe their needs to operators, starting an evaluation process aimed at seeking the most valid solution for assisting the various problems of non self-sufficiency.

Following the assessment of the non self-sufficient situation, different proposals will be made, tailored to the personal situation of the non self-sufficient person and his family, which be of a home type, therefore aimed at staying at home (home care, day center, contribution for assistants family, ...) or residential type, when the conditions for adequate assistance at home do not exist.
Home-based responses can, if necessary, be integrated with temporary insertions (one or two months) in a residential facility in order to offer a period of relief to the family.The elderly who are not in a condition of non self-sufficiency, but who need assistance interventions, can contact the Social Centers directly.

Assistance interventions including:
A) Stay at home
- House assistance: The Home Care Service (SAD) ensures a range of planned care services for the elderly and their family.
- Indirect home care: It consists in the disbursement of contributions for the expenses incurred by the elderly for daily help interventions similar to those provided by the home care service.
- Contributions for family assistants (carers)
It consists in the provision of financial contributions aimed at establishing an employment relationship with a family assistant.

- Support for family care
The service consists in the provision of financial contributions aimed at supporting family members who are directly responsible for the care of their elderly afflicted with severe forms of senile dementia, in consideration of the significant welfare function they perform and the social and economic costs incurred.
- Meals at home
The service ensures the delivery of meals for both lunch and dinner, as needed.
Thanks to daily contact with delivery operators, the service also allows for constant monitoring of the conditions of users.
- Day centers
They are an opportunity offered to those who can stay at home independently - or with the presence of family support - but who need a strong, qualified and ongoing point of reference for assistance and relationships during the day.
- Relief admissions
The service consists in the hospitalization of the family member for a fixed period in nursing homes. It is used by the family to relieve themselves of the stress and commitment of caring for an elderly person, for a specific period of time, allowing physical and psychological recovery and the possibility of being able to devote themselves to something else.
A sharing of the expenditure is foreseen based on the economic situation.
- Pedicure at home
It allows you to support the user in foot care, with non-sanitary characteristics, through specialized personnel, with the aim of preventing the onset of problems that can hinder proper walking.
The service is currently aimed at people with low incomes and is therefore free.
- Teleservice: a service to stay at home in peace
It is a remote assistance service, active 24 hours a day, every day of the year, which allows seniors who live alone to stay in their own home in autonomy, tranquility and safety.

B) Residential services
If the home-based intervention is not sufficient to guarantee the necessary assistance, the assistance projects may provide for the insertion of the assisted person in residential facilities. The reference structures for this purpose can be differentiated into two main types:
- Healthcare Residences (RSA), aimed at non self-sufficient elderly people;
- Assisted residences (RA), aimed at self-sufficient or partially self-sufficient elderly people.
The hospitalization can be for an indefinite or fixed term. In the latter case, two types can be distinguished:
- temporary hospitalization, for specific needs or in the presence of particular temporary aggravations of the elderly normally assisted by the family;
- Relief admissions, to periodically relieve the family from stress and the commitment to care, at specific times such as a vacation, surgery, needs related to the presence of minors in the nucleus, etc.

Target/object	Types	Content
elderly	services assistance (Italian:Servizi di assistenza)	The city government provides the following services: social secretariat; direct family assistance; Indirect Family Assistance; dine at home or in the cafeteria; pedicure service; remote care; other Alzheimer's Services; solidarity network
	Structures (Italian:Strutture)	Residential structures and day centers for the elderly, L'Airone Day Center for frail elderly people, Le Rondini Day Center for frail elderly people
	not self-sufficient(Italian: Non Autosufficienza)	Documentation, Medical Services, Evaluation of Personalized Assistance Program (PAP)
liberal time	elderly center (Italian:Centri Anziani)	Q1(San lacopino Address:Via delle Carra,4/ Zona Centro Address:Via Malcontenti,12/ Centro per le Attivita dell'Eta Libera Address:Complesso Albergo popolare/ Il Grillo Parlante Address:Via Palazzuolo,10/ Il Fuligno Address:Via Faenza,52/ I Puri Address:Piazza Tasso,6); Q2(Bellariva Oberdan S.Salvi Address:Via Luna,16-sede distaccata P.zza S.Salvi,4/ Parterre Address:Via del Ponte Rosso,2 sede distaccata via Faentina,145/ Villa Bracci Address:Via Stradone di Rovezzano,33/ Campo Marte Salviatino San Gervasio Address:Viale Ugo Bassi,29/ Circolo pensionati Bellariva Address:Lungarno Aldo moro,12); Q3(C.A.M.P.A. Galluzzo Address:Via Biagini,6/ Il Lido Address:Via G.Orsini,44/ Libereta'Reims Address:Via Erbosa,59-Via Reims,22/A); Q4(Baracche Verdi Address:Via delle Mimose,8/ Social Club Address:Via della Casella,92/14 / Ugnano Mantignano Address:Via della Tancia,9/ Vivere in Liberta Address:Viuzzo delle case nuove,18/20 / Arca Address:Via Zanella,8r/ Eta libera Address:Via Anconella,3); Q5(La Mimosa Address:P.zza Cavalieri di Vittorio Veneto,11/ Rifredi-Romito-Vittoria Address:Via Carlo Bini,5/a / Caboto Address:Via dei Caboto,47/ Novoli-Peretola-Quaracchi-Brozzi-Le Piagge Address:Viuzzo delle Calvane,13/ Insieme per Brozzi Address:Piazza 1 Maggio,33/ Il Tabernacolo Address:Via Accademia del Cimento,32)
	seniors holiday (Italian:Vacanze Anziani)	The Municipality of Florence organizes, as every year, in the summer period, holiday stays in seaside, mountain and spa resorts, reserved for self-sufficient elderly people who have reached the age of 60 and resident in the Municipality of Florence. The stays, which allow hundreds of Florentine seniors to enjoy a pleasant holiday, experiencing an experience of socialization and conviviality, last 15 days and include travel, full board, drinks at meals, beach service, guide-entertainer. for the duration of the stay. We renew our wish to spend, with serenity and joy, the holidays that the Municipality organizes for you.
	social garden (Italian:Orti Sociali)	Q1(Address:Viale Edmondo De Amicis 21) Q2(Address:Villa Arrivabene - Piazza Alberti 1/a) Q4(Address:Via delle Torri 23) Q5(Address:Viale Edmondo De Amicis 21)
	training (Italian:Formazione)	computer courses, senior university

Source: The author draws based on the July 2022 statistics on the official website of the Florence city government and the city community handbook

Tab 2 Basic situation of elderly care services in Florence in 2022

PART II
DIRECT INVESTIGATION

Chapter 3 Analysis of survey results
Chapter 4 Analysis of spatial configuration

Based on the literature review of community elderly care and cross-generational mutual assistance, as well as the analysis of concepts related to cross-generational co-living spaces, this chapter summarizes the behavioral characteristics of the elderly, the functional organization and division of cross-generational co-living spaces, spatial composition, social environment, and management methods through field research; By using research methods such as field survey data organization, semi-structured interviews, and questionnaire surveys, the current key points of cross-generational co-living space design are summarized and analyzed. The similarities and differences between the elderly care and cross-generational co-living environments in the two places are analyzed, providing research samples and theoretical basis for the subsequent analysis of spatial layout characteristics, extraction of evaluation factors for cross-generational co-living spaces, and establishment of evaluation systems. Chapter 3 collected and organized the design characteristics of cross-generational co-living spaces in China and Italy, as well as the views and opinions of various groups, through theoretical review and field research visits. From the analysis of the results, it can be concluded that the current focus of people's attention on the environment of cross-generational co-living spaces lies in the spatial characteristics that affect interaction and communication, which is consistent with the concept of spatial organization. Therefore, this chapter starts from the perspective of spatial fabric and uses the Space Syntax theory tool to study the impact of cross-generational co-living spatial fabric on accessibility, interactivity, and visual communication. The goal is to study the spatial composition characteristics of cross-generational co-living spaces, explore the spatial forms, types, and area sizes that are prone to cross-generational communication, and thus explore objective factors for quantitatively evaluating the environmental characteristics of cross-generational co-living spaces.

Research purpose

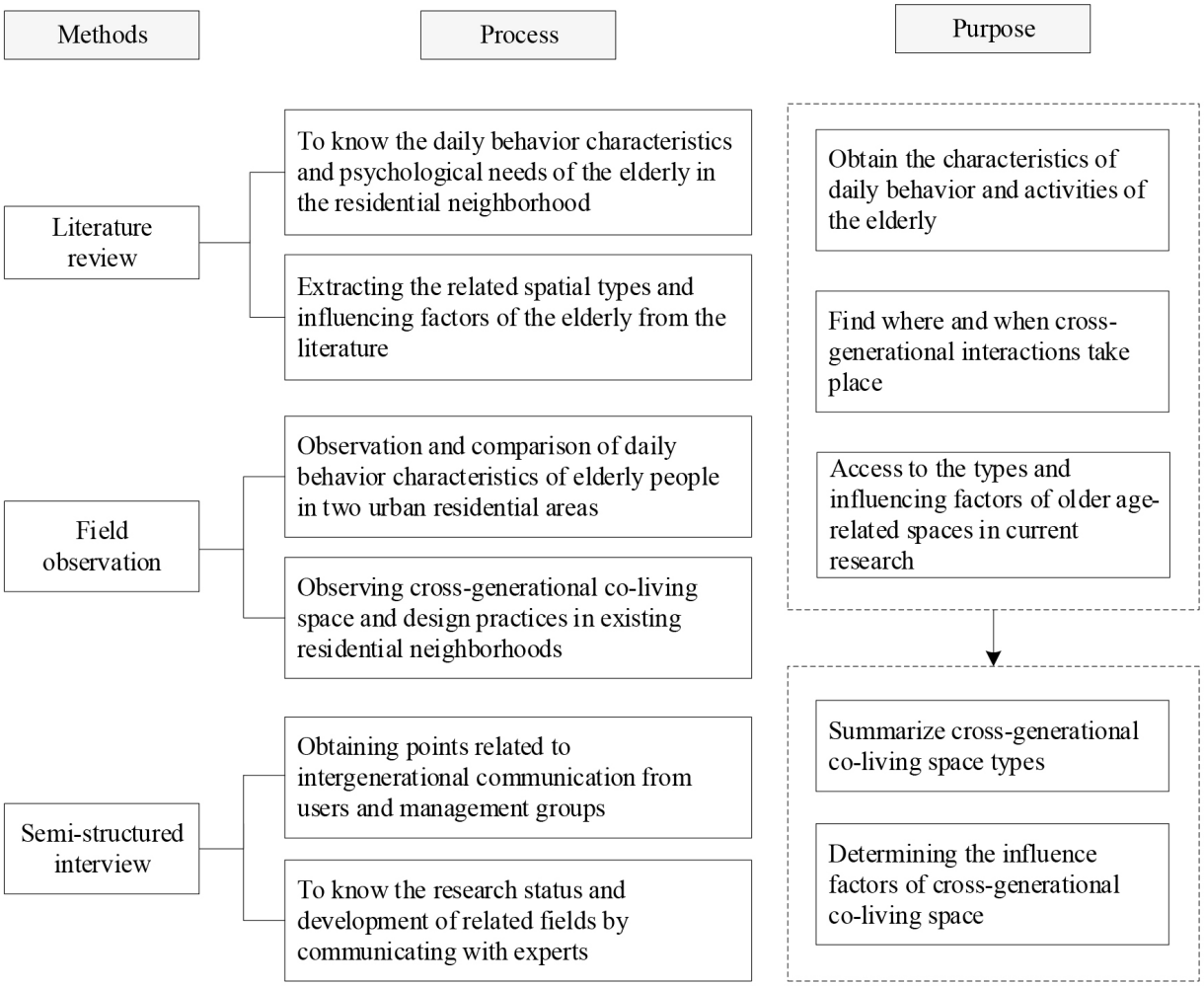


Fig 11 Research methods and process

In order to understand the current situation of cross-generational co-living spaces in the two cities, firstly, literature research, extensive field visits, and follow-up observations are adopted to obtain general phenomena in residential communities and summarize common current problems. Secondly, using semi-structured interviews, the elderly, managers, users, and research experts in related fields were used as the research objects to obtain their subjective spatial perception and preference characteristics. The research in this chapter includes three links, which are literature survey, field observation and semi-structured interview in sequence. The process of each link is shown in figure 11 below. Based on theoretical research, the current space types and related design points related to aging and cross-generational communication are obtained. On the basis of this, field research and interviews are conducted to further summarize and analyze the similarities and differences of the cross-generational co-living spaces of the two cities, and derive the set of influencing factors.

Research methods

(1) Literature review

A literature review is an overview of previously published work on a specific topic (Cooper, 1998). The purpose of literature survey is to familiarize and understand the research status and trends of the subject research field through information retrieval and utilization of existing theoretical data, and to determine the research content, limit the research scope, find suitable research methods, implement research plans and data analysis. etc. play a key role.

Although different age groups have specific space needs, it is difficult for the same type of space to meet all residents at the same time, but the integration of the community requires cross-generational cooperation with space as the carrier. The elderly and children belong to vulnerable groups in terms of physical and mental functions, and their requirements for space location and scale are often consistent, such as the requirements for barrier-free facilities and the requirements for space safety (Li, 2019). According to the relevant design requirements for elderly-friendly communities and child-friendly communities, it is found that the technical or detailed design requirements (such as illumination, furniture size, visual sensitivity, etc.) of the two age groups are different at the physiological level, but the principled requirements are basically the same . Therefore, the design of cross-generational co-living space can be based on the needs of the elderly for public space in the community, and spaces with special requirements can be considered separately.

The literature survey in this chapter has two purposes: 1) by summarizing and extracting the behavioral characteristics and types of space used by the elderly in previous studies; 2) the factors and indicators of spatial environmental impact related to the elderly in residential communities in previous studies and so on, and to understand the similarities and differences of the main spatial environment in residential communities at home and abroad, to lay the foundation for the follow-up field research. A systematic review method was used to sort out the empirical studies in the Chinese and English databases, and Citespace software was used to conduct cluster analysis and statistics on keywords, and preliminarily extracted the influencing factors that may be related to the Cross-generational co-living space. Specific steps are as follows:

A) Collection

The search keywords include four main aspects: 1) Elderly related - Chinese: elderly/ old-age/active aging/mental health/barrier free, English: elderly/old-age/active ageing/mental health/barrier free; 2) Cross-generational communication related - Chinese: cross-generational mutual help/cross-generational/ multi-generational co-living/full-age housing/ age-friendly, English: mutual help/cross-generational/multi-generational co-housing/ lifetime housing/age-friendly; 3) Space type related—Chinese: neighborhood/community/ built environment/public space/retirement space/shared space, English: neighborhood/

community/built environment/public space/ elderly space/shared space; 4) Design index related— Chinese: ageing design/healthy design/ built environment evaluation/spatial influencing factors/design specification/design guideline, English: ageing design/healthy design/built environment evaluation/spatial effects/index/ guide. The retrieval time is: October 2021 to May 2022.

B) Selection
The selecting principles are as follows: 1) Chinese documents are from Chinese core journals, CSSCI, and the annual conference proceedings of national first-level societies, and English documents include Google Scholar, SAGE journal full-text database, Web of Science database, ProQuest ®Dissertation full-text database, Pubmed full-text database, University of Florence library SBA database, Taylor & Francis Online, Elsevier Science Direct full-text database, etc.; 2) The main users of the research are the elderly; 3) The research focus is space In terms of the physical environment, literatures that only discuss social culture, medical care, family relations and living habits (diet), environmental pollution, vegetation, etc. are excluded; 4) The research objects involve the public space of residential communities, and specific types of facilities (such as housing, gymnasiums, nursing homes, medical facilities) space research results.

(2) Field observation
Field observation, field research is the collection of raw data outside the laboratory, library or workplace. The methods and methods used in field observations vary by discipline. Although the method is often characterized by qualitative research, it can (and often does) include a quantitative dimension (Mccall, 1984).

According to the differences in gender, physical condition, age and activity time of the elderly, the range of activities of the Chinese elderly in the community is mainly concentrated in the range of about 1000m (Xu et al., 2019); while a European study on the relationship between walking indicators and health of the elderly in residential areas It is also pointed out that healthy elderly people walk 7,000-10,000 steps a day, which takes about 30 minutes, and a one-way distance of about 1,000 meters is appropriate (Alves et al., 2020). Therefore, the service scope of the cross-generational co-living space should be adapted to the activities of the elderly, and this chapter also selects field observation cases based on this service scope.
Shanghai has a large number of residential communities, built in different eras and with different aging conditions. The selection criteria of the research object of this paper in Shanghai will be explained in detail in Section 3.2 Field Observation Case Overview. The coverage includes old communities, sub-new communities, various new and added spaces in urban sites shared by multiple communities, multi-generational houses, community service centers, community cultural activity centers, good neighborliness centers, citizen stations, urban corner parks, etc. construction space. In November 2021, the selected research objects will be inspected on the spot. The summary of the interview log is shown in Table 3.
Florence is a city with a well-protected history in Europe, and its urban scale, population, and ageing degree are very different from Shanghai. One of its great features is that you can walk around the entire central city scale, which is a veritable "walkable city" (the walkable city). Florence does not have a clear concept of residential community, people's homes are scattered throughout the city. At the same time, because of their special streets and alleys, the elderly can participate in urban life to a great extent. They can go to any space within their ability to continue their long-term life without worrying about the rapid expansion of traffic and cities. Come and travel obstacles. There are basically no centralized residential communities in the urban core, so buildings such as community centers do not exist. The selection of Florence's research objects covers the five neighborhoods Q1, Q2, Q3, Q4, and Q5 (Q is the abbreviation of Quartiere, an Italian neighborhood), and the cross-generational co-living space is also scattered in various public spaces. The analysis can be found in the Survey Results section.

Research area		Semi-structured interview	Investigating cases	Total
Shanghai	Yangpu District	Time: January 2020/October 2021 Interviewees: 12 (6 males/6 females)	Time: January 2020/October 2021 Number of buildings surveyed: 5	14
	Hongkou District	Time: September 2020/November 2021 Interviewees: 4 (3 males/1 female)	Time: November 2021 Number of buildings surveyed: 3	
	Jingan District	Time: November 2021 Interviewees: 1 (1 female)	Time: November 2021 Number of buildings surveyed: 1	
	Huangpu District	Time: November 2021 Interviewees: 3 (2 males/1 female)	Time: November 2021 Number of buildings surveyed: 1	
	Pudong New Area	Time: October 2020/November 2021 Interviewees: 4 (2 males/2 females)	Time: October 2020/November 2021 Number of buildings surveyed: 1	
	Baoshan District	Time: November 2020/December 2021 Interviewees: 6 (3 males/3 females)	Time: November 2020/December 2021 Number of buildings surveyed: 2	
	Putuo District	Time: October 2021 Interviewees: 3 (2 males/1 female)	Time: October 2021 Number of buildings surveyed: 1	
Florence	Quartiere 1	Time: May 2022 Interviewees: 1 (1 female)	Time: April/May 2022 Number of buildings surveyed: 3	12
	Quartiere 2	Time: April 2022 Interviewees: 2 (1 female, 1 male)	Tme: April/May 2022 Number of buildings surveyed: 2	
	Quartiere 3	Time: April 2022	Time: April 2022 Number of buildings surveyed: 1	
	Quartiere 4	Time: April 2022 Interviewees: 2 (1 male, 1 female)	Time: April 2022 Number of buildings surveyed: 1	
	Quartiere 5	Time: May/June/July/September/ Octorber 2022 Interviewees: 8 (4 males, 4 females)	Time: May/June/July/September 2022 Number of buildings surveyed: 5	

Tab 3 Summary of field interview logs

(3) Semi-structured interview

Semi-structured interviews are one of the most commonly used research methods in the social sciences. Semi-structured interviews usually have a leading thematic framework, but the whole is open, allowing the interviewee to come up with new ideas. Semi-structured interviews are widely used in qualitative research (Edwards & Holland, 2013).

Through interviews with users and managers of cross-generational co-living space, we hope to understand the daily life trajectory and behavioral characteristics of the elderly and other groups in the community, extract different needs for cross-generational communication from multiple perspectives, and focus on the elderly Focus on factors affecting the spatial environment, discover existing problems in the built environment, etc.

All interviews were conducted in the form of face-to-face interviews. For a detailed outline, see Appendix 1, Appendix 2. According to the questions in the outline, the interviewees were guided to communicate freely. The interview content adopted the method of keyword shorthand and audio recording. After the end, the text and voice were sorted and summarized. During the interview, considering that the meaning of the term "cross-generational symbiosis" has not been popularized, it was replaced by "communication between the elderly and children and young people". "Residential community" has a broader meaning, including diverse types of residential areas. So use "community", "near home", "street", etc. instead. The interviews in the Shanghai area will focus on October-December 2021, and the interviews in the Florence area will focus on April-May 2022. The basic information of the respondents is shown in the table 3.

Chapter 3
Analysis of survey results

3.1 Literature review

Due to the large number of literatures related to pension and co-living, it is difficult to comprehensively summarize the key points and development process of this research field by using systematic review methods. The Citespace software measures literature (collections) in a specific field and performs citation analysis through the drawing of a visual map. After that, according to the quantitative results, key literatures were selected to provide scientific basis for summarizing space types and extracting influencing factors.

Software analysis results

Citespace provides two indicators, module value (Q value) and average contour value (S value), based on the network structure and the clarity of clustering, which can be used as a basis for us to judge the effect of map drawing. Generally speaking, the Q value is mainly in the [0,1) interval, and Q>0.3 means that the divided community structure is significant. When the S value is 0.7, the clustering is highly efficient and convincing. If Above 0.5, clustering is generally considered reasonable. According to the collection and calculation of English literature, the Q value and S value are both above 0.6, so the clustering is reasonable, and the data results are credible. The detailed analysis is as follows.

(1) English literature keywords

Using the Clarivate database Web of Science as the search engine, since European and American countries entered the aging society earlier, and related research started earlier, the search time range was broadened to nearly 30 years. After an advanced search based on community pension-related topics and abstract keywords, the literature time is limited to May 31, 2022. Excluding some conferences, newspapers, and irrelevant themes, a total of 99 foreign English documents related to community-based pensions are obtained. Figure 12 shows the clustering results of keywords. Currently, the most popular research issues in the field of community elderly care abroad are community, health, built environment, active ageing, and urban green space. (urban green space), physical activity, etc. According to the statistical results, the top 30 keywords in the field of foreign community aged care (English literature) research are arranged in the following table 4.

Western countries have paid more attention to co-living issues and published more papers than domestic ones. After an advanced search based on co-living-related topics and abstract keywords, the literature period is limited to May 31, 2022, excluding some conferences, newspapers and documents that are seriously irrelevant, obtained a total of 294 English literatures related to co-living in the past ten years. Figure 13 shows the clustering results of keywords. Figure 14 shows the results of timeline analysis of keywords of architectural engineering discipline in the field of community elderly care in English literature. According to the statistical results, the most popular research issues in the field of co-living abroad are life, collaborative housing, city, adaptive capacity, etc. High-frequency words(table 5) are collaborative housing community, quantitative survey, public space, social interaction, etc.

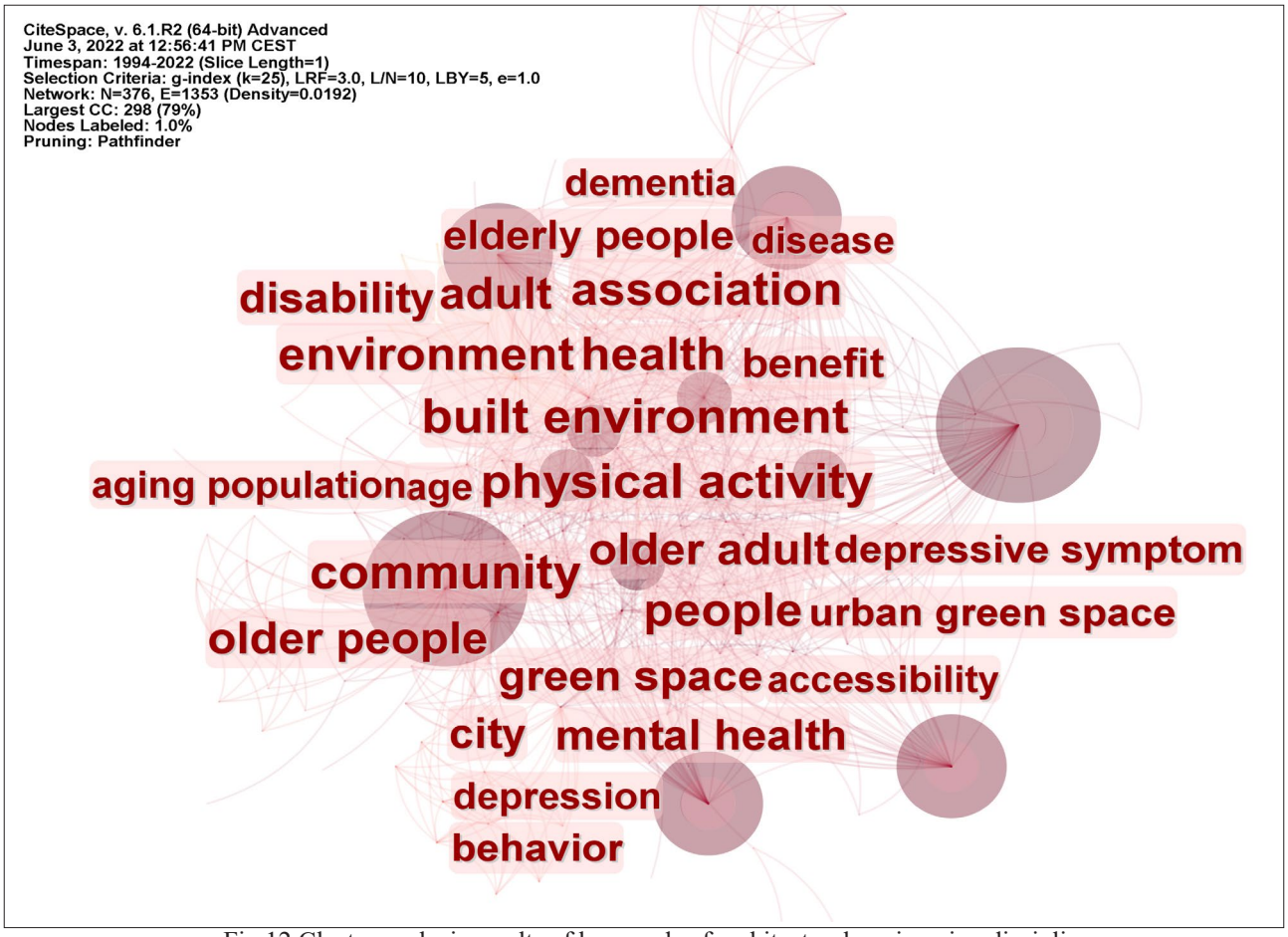


Fig 12 Cluster analysis results of keywords of architectural engineering disciplines in the field of community elderly care in English literature from 1994 to 2022

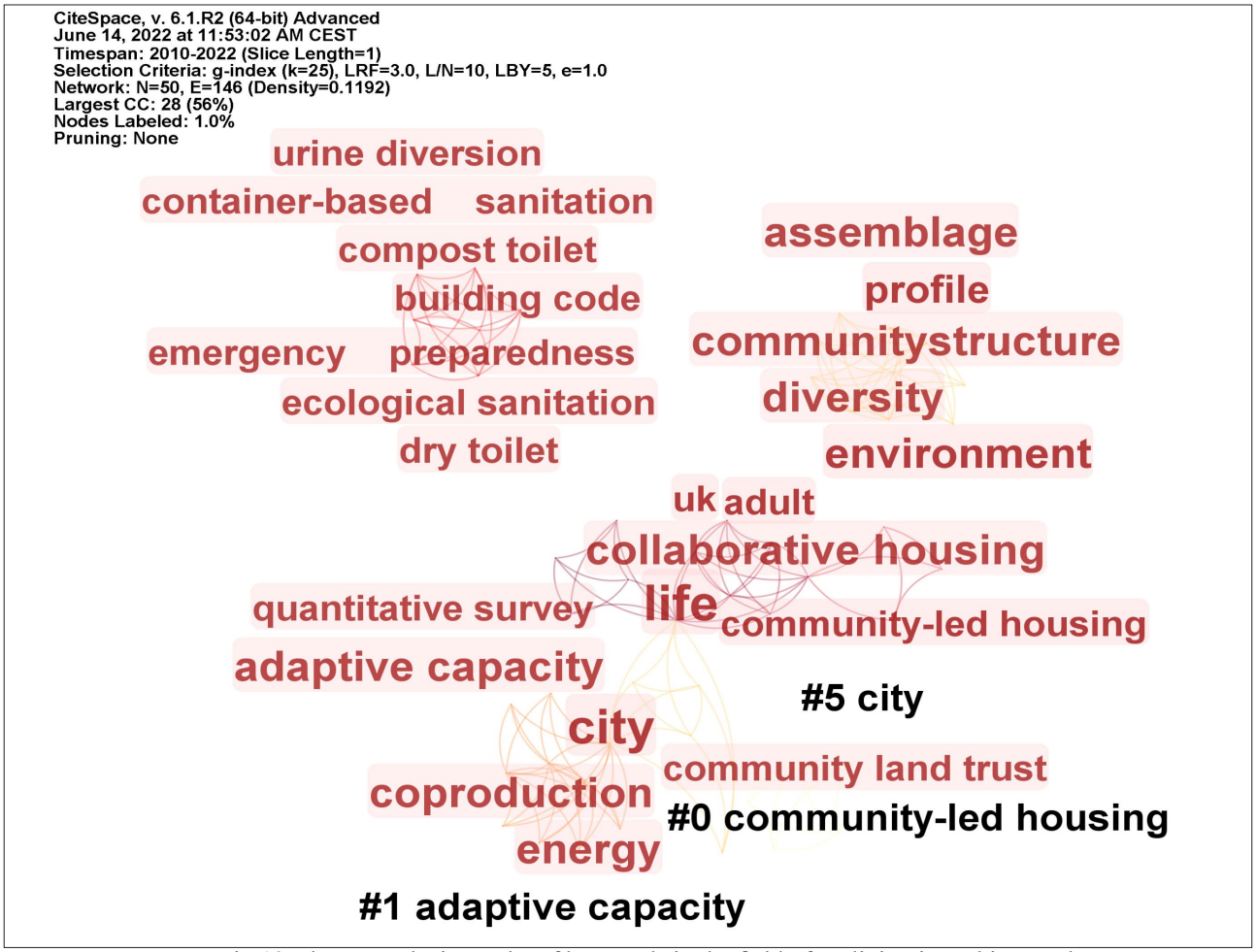


Fig 13 Cluster analysis results of keywords in the field of co-living in architectural engineering in English literature from 2010 to 2022

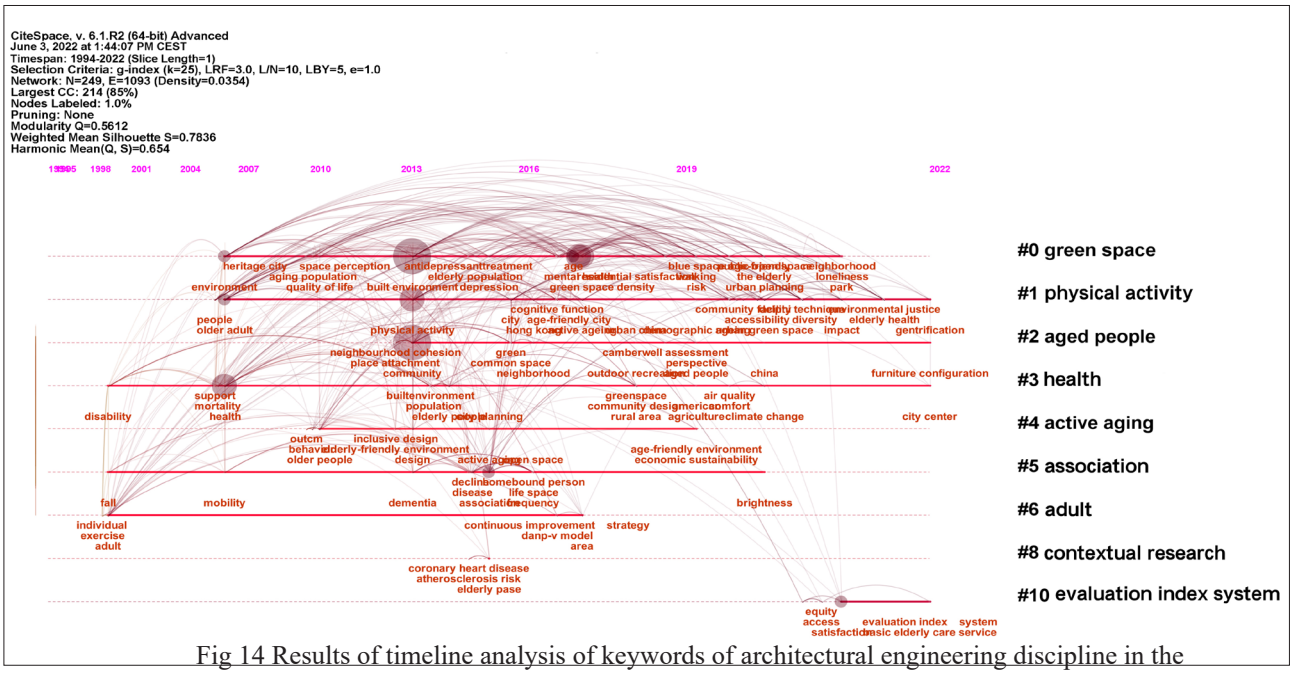


Fig 14 Results of timeline analysis of keywords of architectural engineering discipline in the field of community elderly care in English literature from 1994 to 2022

No.	Frequency	Year of first appearance	Keyword	No.	Frequency	Year of first appearance	Keyword
1	20	2013	community	16	6	2014	elderly people
2	19	2013	physical activity	17	5	2016	city
3	16	2013	built environment	18	5	2010	quality of life
4	13	2006	health	19	5	2020	accessibility
5	12	2006	people	20	5	2006	mortality
6	12	2006	older adult	21	4	2013	design
7	10	2017	green space	22	4	2010	behavior
8	10	2006	environment	23	4	1999	disability
9	10	2015	association	24	4	2021	impact
10	9	2017	mental health	25	4	2017	benefit
11	8	2016	Hong Kong	26	3	2017	active ageing
12	7	2017	age	27	3	2010	aging population
13	7	2010	older people	28	3	2013	dementia
14	6	2020	urban green space	29	3	2020	community facility
15	6	1999	adult	30	3	2017	aging in place

Tab 4 Top 30 keywords of architectural engineering disciplines in the field of community elderly care in English literature from 1994 to 2022

No.	Keyword cluster	High-frequency words (frequency)
1	green space	built environment(17), green space(10), environment(10), mental health(9), age(7), benefit(6), quality of life(5), depression(4), aging population(3), context(2), blue space(2), public open space(2), walking(2), risk(2), loneliness(2), the elderly(2), urban planning(2), park(2), attribute(2), elderly population(2)
2	physical activity	physical activity(19), older adult(13), people(12), hong kong(8), city(7), urban green space(6), accessibility(5), impact(4), community facility(3), space(2), diversity(2), urban china(2), urban(2), age-friendly city(2), gentrification(2)
3	aged people	community(20), perspective(2), aged people(2), neighborhood(2), dense living(2), environmental design(2), furniture configuration(2)
4	health	health(14), elderly people(7), mortality(5), disability(4), population(2), social network(2), support(2), climate change(2)
5	active aging	older people(8), design(4), behavior(4), active aging(3)
6	association	association(12), dementia(3), mobility(3), disease(3), fall(2), activity scale(2), decline(2)
7	adult	adult(6), area(2), exercise(2)
8	contextual research	elderly pase(2), contextual research(2)
9	evaluation index system	satisfaction(3), equity(2), access(2), evaluation index system(2), compound function(2)

Tab 5 High-frequency words in the keyword clustering of architectural engineering disciplines in the field of community elderly care in English literature from 1994 to 2022

No.	Frequency	Year of first appearance	Keyword	No.	Frequency	Year of first appearance	Keyword
1	14	2016	older people	11	2	2021	internet of thing
2	8	2017	environmental study	12	2	2020	urban planning
3	6	2017	comprehensive work	13	2	2018	elder care
4	4	2018	quality of life	14	2	2018	young adult
5	3	2018	nursing home	15	2	2020	qualitative analysis
6	3	2020	public space	16	2	2016	health promotion
7	3	2018	social isolation	17	2	2018/cross-generational relationship	
8	3	2016	medical science	18	2	2016	public health
9	2	2018	social interaction	19	2	2021	mutual help
10	2	2016	health education	20	2	2016	long term health care

Tab 6 Top 20 keywords in the field of community elderly care/co-living (Italian literature) of Italian architectural engineering disciplines from 2016 to 2022

(2) Italian literature keywords

The Clarivate database Proquest and Pubmed are used as search engines, and the language of published literature is limited to Italian. After advanced search based on related topics and abstract keywords such as community pension and co-living, the literature time is limited to May 2022 Before the 31st, excluding some conferences, newspapers, and irrelevant documents, a total of 41 Italian documents related to community pension/co-living were obtained. Figure 15 is the keyword clustering result (the text of the document is in Italian, and the subject/keyword/abstract is in English, so the analysis result is in English). Currently, the most popular research problem in the field of community pension/co-living in Italy is community (community, health, built environment, active ageing, urban green space, physical activity, social isolation, etc. According to the statistical results, the top 20 keywords in the Italian community pension field (Italian literature) research are arranged in the following table 6. Combined with the keyword timeline map (see figure 16), currently the most popular research issues in the field of community pension/co-living in Italy are older people, environmental study, comprehensive work, nursing home, public space, social isolation, etc. High-frequency words are long term health care, healthy aging, health education, health promotion, public health, social interaction, Alzheimers disease, activities of daily living, collective representation, qualitative analysis, age-friendly housing, etc.

(3) Chinese literature keywords

Using CNKI, the Chinese academic journal online publication library, as the search engine, the number of documents in the field of community elderly care in China's architectural engineering disciplines has surged after 2010. After an advanced search based on community pension-related topics and abstract keywords, the literature time is limited to May 31, 2022, excluding some conferences, newspapers, and seriously irrelevant literature, to obtain Chinese literature related to community pensions in the past two decades A total of 506 articles. Figure 17 shows the results of keyword clustering. Each cluster consists of multiple closely related words. The smaller the label number, the more keywords are included in the cluster, which is the most popular research cluster. From this, it can be seen that at present, the more popular research issues in the field of community elderly care in my country are community elderly care, elderly care facilities, aging, home care, and the combination of medical care and elderly care. The hotspots displayed by the keyword clustering map are limited and cannot be presented one by one. According to the statistical results, the top 30 keywords in the domestic community pension field are listed in Table 7.

In addition to community pensions, after an advanced search based on co-living-related topics and abstract keywords, the literature time is limited to May 31, 2022. Excluding some conferences, newspapers, and seriously

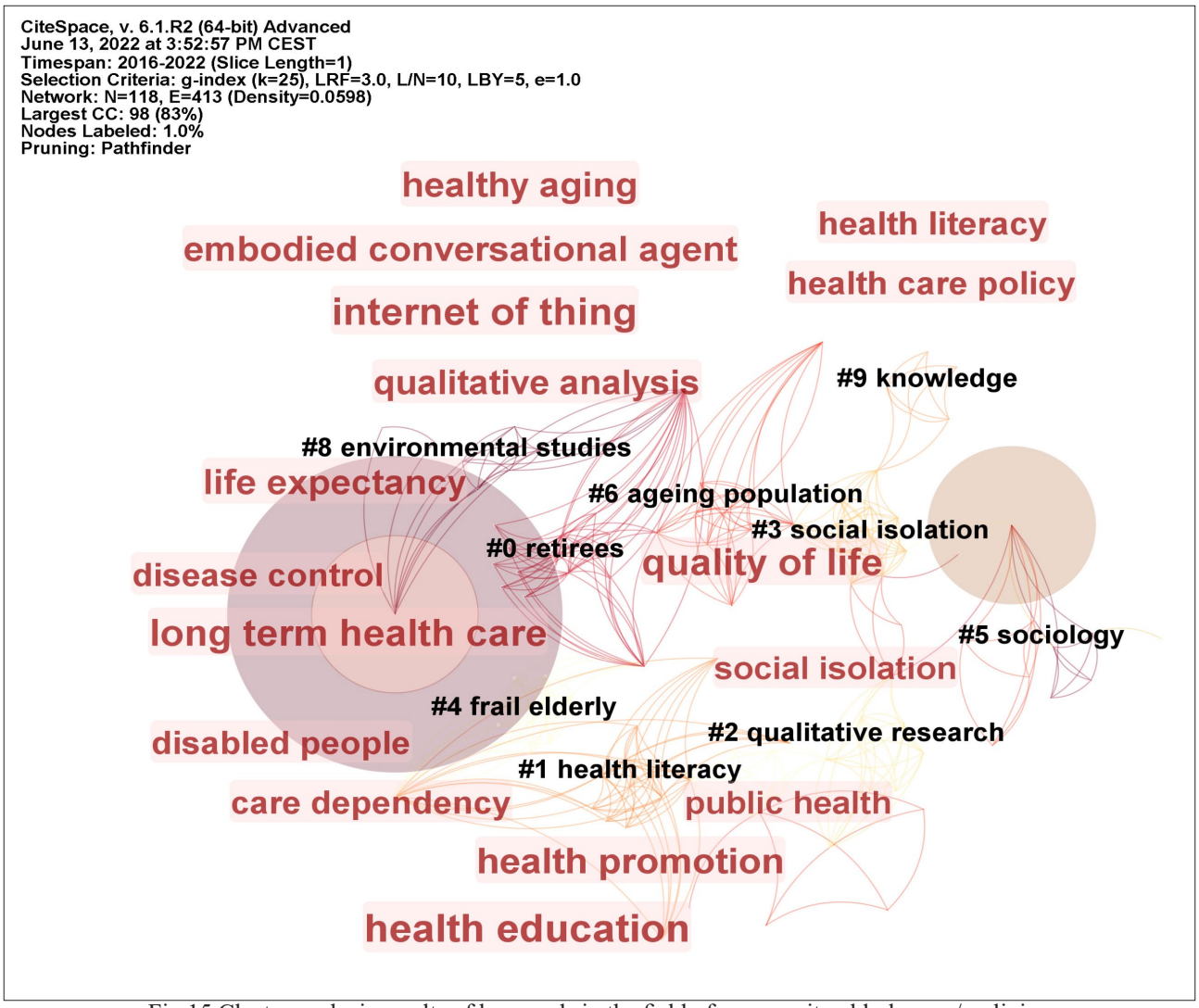


Fig 15 Cluster analysis results of keywords in the field of community elderly care/co-living (Italian literature) of Italian architectural engineering disciplines from 2016 to 2022

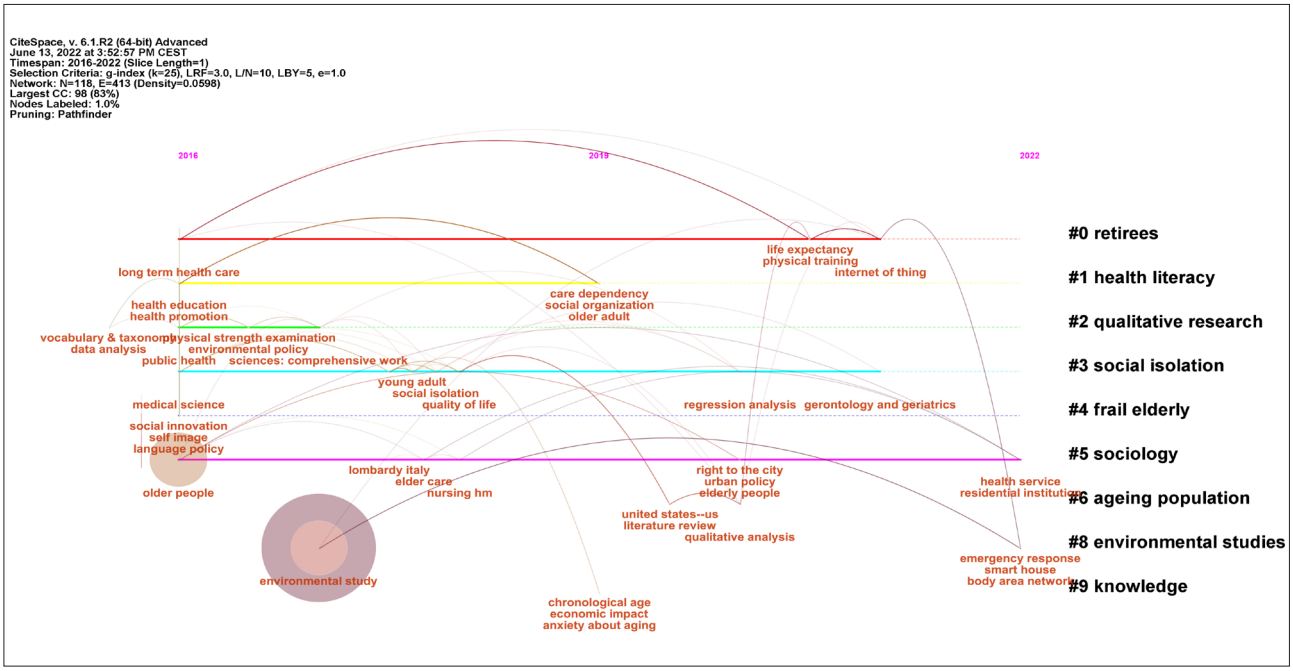


Fig 16 Timeline analysis results of keywords in the field of community elderly care/co-living (Italian literature) of Italian architectural engineering disciplines from 2016 to 2022

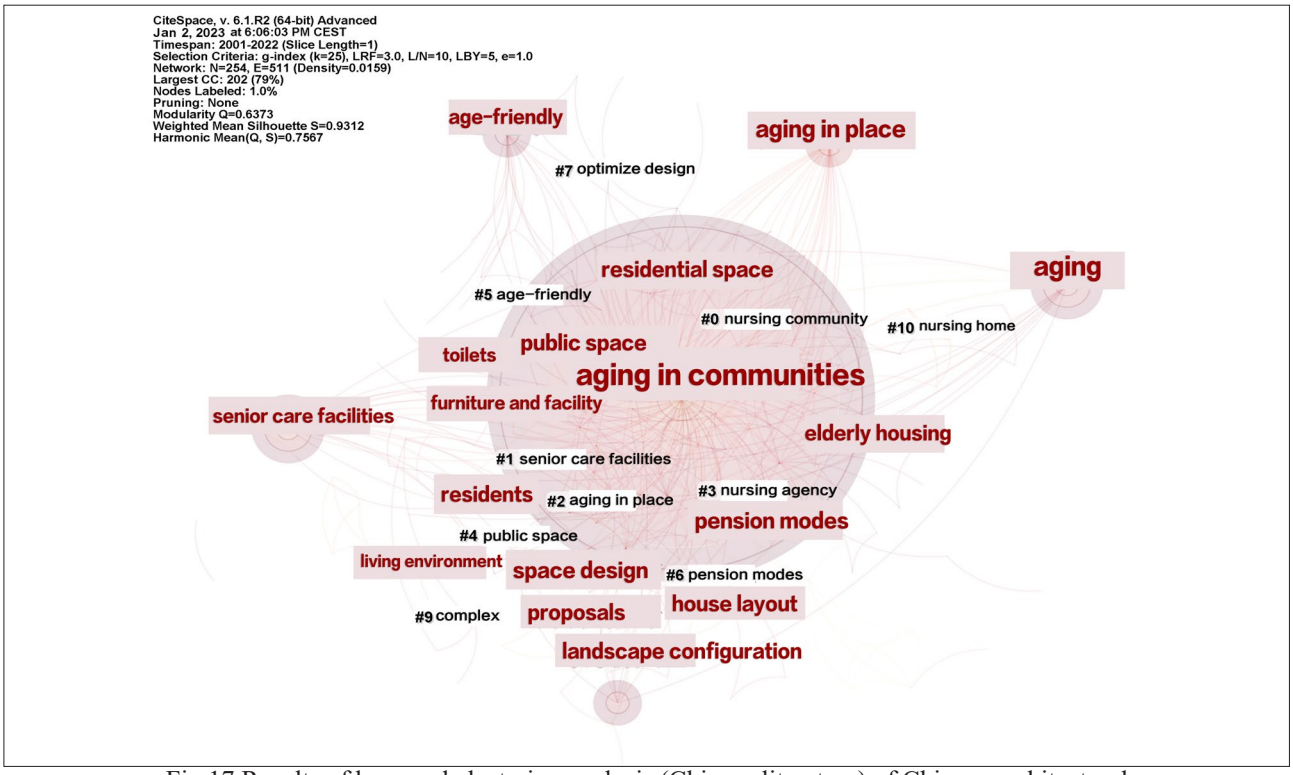


Fig 17 Results of keyword clustering analysis (Chinese literature) of Chinese architectural engineering disciplines in the field of community elderly care from 2001 to 2022

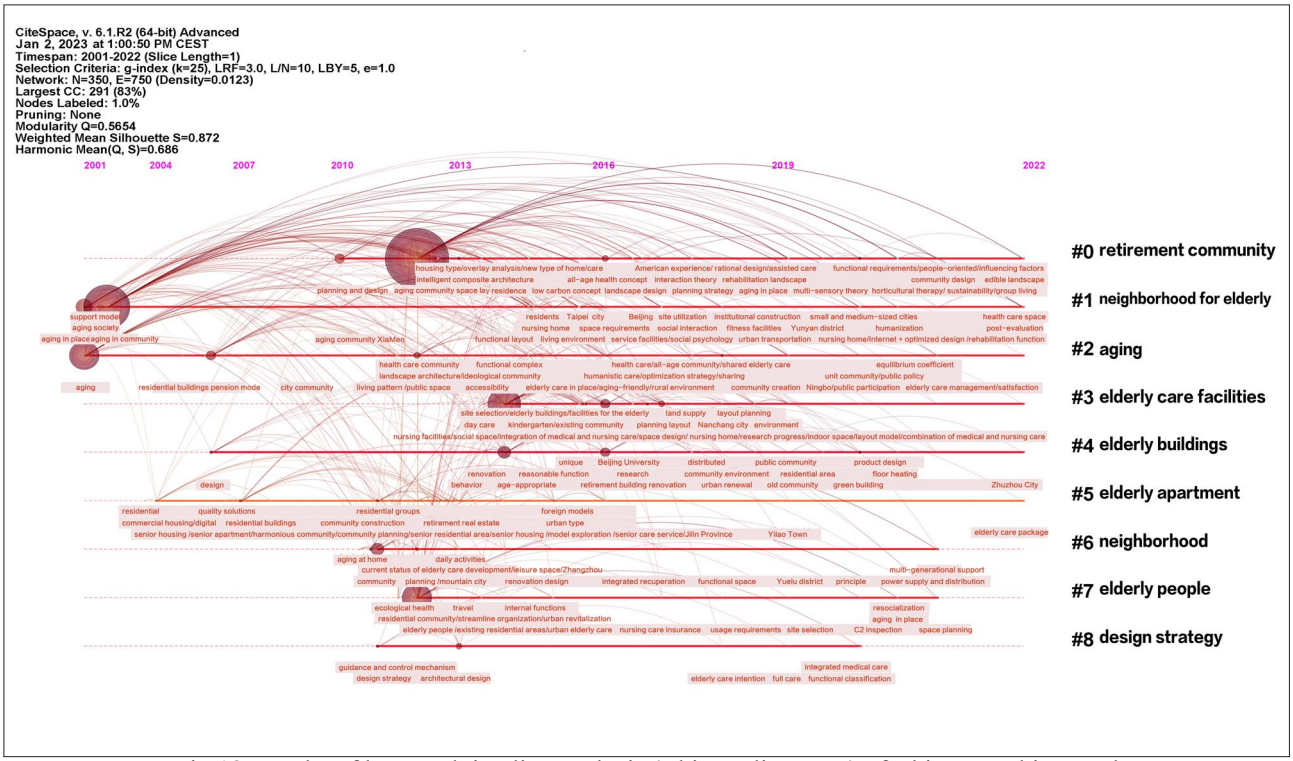


Fig 18 Results of keyword timeline analysis (Chinese literature) of Chinese architectural engineering disciplines in the field of community elderly care from 2001 to 2022

irrelevant documents, it is possible to obtain information related to co-living in the past two decades. There are 24 Chinese literatures. Figure 18 shows the results of timeline analysis of keywords of architectural engineering discipline in the field of community elderly care in Chinese literature. According to the statistical results, currently the most popular research issues(table 8) in the field of co-living in my country are cross-generational mutual assistance, multi-generational living, living styles, the elderly, family structure, quality of life, pensions, and co-living communities. The high-frequency words are living style, the elderly, pension, cross-generational mutual assistance, close living, co-living, space design, suitability for the elderly, etc.

No.	Frequency	Year of first appearance	Keyword	No.	Frequency	Year of first appearance	Keyword
1	131	2012	retirement neighborhood	16	11	2016	landscape design
2	82	2002	community-based elderly care	17	11	2006	design
3	56	2001	ageing care	18	9	2015	elderly services
4	50	2014	ageing facilities	19	9	2012	planning
5	40	2012	elder people	20	9	2007	elderly apartment
6	29	2001	ageing at home	21	9	2017	interior design
7	24	2014	adaptive ageing	22	9	2011	neighborhood planning
8	22	2006	pension mode	23	7	2004	housing for elderly
9	19	2011	neighborhood	24	7	2011	design strategy
10	18	2010	planning and design	25	7	2015	ageing at place
11	17	2016	combination of medical	26	6	2016	optimization strategy
12	13	2016	nursing home	27	6	2016	ageing
13	13	2011	older people	28	6	2015	living environment
14	12	2012	public space	29	6	2020	old-aged neighborhood
15	12	2013	architectural design	30	5	2019	urban renovation

Tab 7 Top 30 keywords of China's architectural engineering discipline in the field of community elderly care from 2001 to 2022

No.	Keyword cluster	High-frequency words (frequency)
1	retirement community	retirement community (131), planning and design (18), landscape design (11), planning strategy (4), space layout (4), horticultural therapy (4), health preservation concept (3), all ages (3), American experience (2), community design (2), building mass (2), rehabilitation landscape (2), residence (2), aging in place (2), sustainability (2), functional requirements (2), low carbon (2), professional nursing (2)
2	neighborhood for pension	neighborhood for pension(82), home-based old-age care (29), living environment (6), elderly communities (4), service facilities (4), old-age care institutions (3), optimal design (3), cross-generational integration (2), toilets (2), space requirements (2), functional layout (2), occupants (2)
3	ageing	ageing (56), old-age care model (22), public space (12), home care for the elderly (7), optimization strategy (6), suitability for the elderly (6), humanistic care (5), community building (3) , residential mode (3), barrier-free (3), functional compound (3), landscape garden (3), urban community (3), health care community (2), residential area (2)
4	elderly care facilities	elderly care facilities (50), combination of medical care and elderly care (17), space design (9), existing communities (5), planning and layout (5), elderly buildings (4), day care (4), old communities (3), functional configuration (2), medical rehabilitation (2), environment (2), communication space (2), interior space (2), pension station (2)
5	elderly buildings	aging (24), elderly buildings (13), design (11), old residential areas (6), urban renewal (5), renovation (4), residential areas (4), community environment (2), green buildings (2)
6	elderly apartment	elderly care service (9), elderly apartment (9), community planning (9), elderly residence (7), elderly residence (5), elderly real estate (3), mixed community (2), elderly residential area (2), residential group (2)
7	neighborhood	neighborhood (19), Pension (13), Planning (9), Residential Pension (2), Functional Space (2)
8	elderly people	elderly people (40), existing residential areas (3), use needs (2), space planning (2), residential communities (2)
9	design strategy	architectural design (12), design strategy (7)

Tab 8 High-frequency words in the keyword clustering of China's architectural engineering discipline in the field of community elderly care from 2001 to 2022

Following the systematic review method and literature selection principles, using the keyword frequency statistics and analysis in Citespace software, a total of 36 relevant research literature and design guidelines were obtained, including 14 Chinese literature, 10 English literature, and 12 Italian literature. After intensive reading of the key literature, the spatial types and relevant influencing factors were classified and organized to provide a theoretical basis for subsequent research and evaluation of factors.

Review

After sorting out the intensive literature research on communities/buildings/indoor and outdoor environments related to the elderly, the overview of space types and influencing factors at home and abroad is as follows: WHO pointed out in the 2007 Global Age-Friendly Cities Guide that an age-friendly city needs to have the elderly Social participation and the respect and tolerance of the whole society. The classification of urban outdoor spaces includes: environment, green belts and walkways, outdoor rest areas, sidewalks, roads, bicycle lanes, security, services, buildings, and public toilets; architectural design includes: accessibility, interior design, and original residence Pension, community integration, housing choice, living environment (WHO, 2007).

In 2000, the American Association of Retired Persons (AARP) defined an age-friendly community as: including affordable and suitable housing, complete community functions and services, and diverse transportation options, etc. This is the earlier connotation definition of the elderly-friendly community in related institutions. Since then, other agencies have mostly adopted the World Health Organization's definition of an age-friendly community: "a community that enhances the quality of life of older adults by providing health care, social participation, and safety services and that encourages active ageing" (AARP, 2005). The list of spatial design for elderly homes/ community centers in the Architect's Guide to Aging Design compiled by the American Council of Architects in 1985 includes: site analysis, building entrances (lobby, reception area, offices, house maintenance, vertical traffic, activities) District, etc.), renovation of existing buildings (aging, barrier-free, medical space, etc.) (AIA, 1985);

In the report released by the British community and local government agencies, the content of the elderly-friendly community is divided into the following aspects: 1) Resident empowerment 2) Public facilities and services 3) Architecture and natural environment 4) Social network and well-being 5) Housing policy (Harding, 2007). Western scholar Solange Núñez-González et al. concluded in a systematic review of the impact of the built environment on mental health that research papers on aging between 2010 and 2019 focused on the built environment, including: interaction with the natural environment, housing types, indoor Design, community green spaces and water bodies, outdoor activities, neighborhood relations, transportation (NÚÑEZ-GONZÁLEZ et al., 2020). ARUP (ARUP. 2015) pointed out in the study of ten aging cities in Europe that the focus of shaping aging cities is:

social level (demographics, living conditions), built environment (elderly communities, elderly housing), traffic (traffic types, accessible sex), the digital environment (smart devices, social networks).

There are a lot of research on elderly-friendly cities, health and well-being, and cross-generational mutual assistance in Italy. Professor Carmela Gargiulo mentioned in the community and neighborhood services for the elderly that accessibility, barrier-free access, nearby services, walking environment, community belonging, new forms of using public spaces, etc. are factors that affect the physical and mental health of the elderly (Carmela et al., 2021). Three current research directions that are more relevant to building age-friendly cities are: the first aims to promote the accessibility of adjacent services and open spaces (built and unbuilt); the second aims to focus on the behavior of the elderly , such as walking habits, use of amenities, perception of safety, etc.; the third is aimed at increasing the accessibility of major services, especially medical services, public transportation, etc. (Carpentieri & Masoumi, 2020).

In the book Detailed Explanation of Architectural Design of Elderly Care Facilities, Chinese scholar Zhou Yanmin and others start from three aspects of site planning and design: architectural layout, road traffic, and activity venues. The public space in the building includes medical space, rehabilitation space, and public activities. space, public toilets, public bathrooms, dining spaces, elevators, and lobby spaces (Zhou et al., 2011); Jiang Lihua and Huang Jiacheng proposed that the construction of a livable community for the elderly should focus on the spiritual environment (communication environment, perception environment), physical environment (fitness environment, Ornamental environment) start (Jiang & Huang, 2011). The first-level evaluation elements proposed by Hou Keming for the space evaluation system of elderly care institutions include living room space, architectural space, site space, and urban space (Hou, 2020).

According to the existing research, the discussion of the residential community and public space for the elderly and multi-generational communication includes two levels: the design of the physical environment and the shaping of the spiritual environment, and the focus of the design of the physical environment is on transportation, building indoor and outdoor spaces, and equipment. facilities etc. The cross-generational co-living space can be used by people of all generations, and its scope should include all public spaces in the residential community. However, combining the behavioral characteristics of the elderly and children and the discussion of the activity distance of the elderly in the previous section, the concentration points of cross-generational co-living behavior in residential communities are public buildings such as community centers and outdoor public spaces. Due to the difference in the concept of residential communities between China and the West, many cross-generational co-living behaviors in Europe are not concentrated in a certain building, but scattered in the city.

Types		Points	Subjects
physical activity	accessibility	street and travel environment	sidewalks, floor coverings, street greening, lighting, street furniture, corner spaces
		access to nearby facilities	whether shops/medical facilities are within walking distance of residents, the convenience of using nearby facilities such as transportation methods to stations, the intensive complex layout of facilities, and the distance to relatives and children's homes
		barrier free	entrance and exit, outdoor steps, outdoor ramps, handrails, stairs, elevators, public corridors, parking lots
	space environment	site	sunshine, orientation, layout, residential density, functional integration, ground material, facility type, natural greening
		comfort	noise, lighting, ventilation, temperature, cleanliness
		safety	number of escape exits, escape signs, anti-skid measures, alarm bells, monitoring
		aesthetics	Logo, color, furniture form, interface decoration, material
		interest	mobility design, lamps/furniture modeling
	ageing design	ergonomics	furniture, seating configuration, armrests, range of wheelchair movement
		equipment and facilities	special services for the elderly, intelligent teaching, toilets for the disabled, medical and health equipment, self-rescue facilities, and emergency calls
psychological perception	social needs	flexibility and diversity	various functions can be set, the walls or partitions can be moved, and the spatial form can be changed
		social participation	organize group activities (activities are easy to complete and do not require special skills), voluntary service, decision-making mechanism with multi-subject participation, cross-generational communication
		open communication	views from windows, indoor and outdoor connectivity, visual communication
	neighborhood atmosphere	community culture	a community/local historical and cultural environment, a home atmosphere
		release of information	installation status of broadcasting/bulletin boards/counters, construction of social networks, ways for seniors to obtain information
		moderate privacy	privacy of special space

Note: The literature sources of each design point can be found in the paper published by Zhang :Enhancing Wellbeing in Aging Communities Through Environmental Design Elements: An Integrative Review of Literature in English, Chinese and Italian. International Journal of Sustainable Development Research 2023, 9(4), 79-88. https://doi.org/10.11648/j.ijsdr.20230904.13

Tab 9 Statistics of relevant design points

Therefore, cross-generational co-living spaces cannot be classified according to specific building types, but should be combined classify the physical boundaries of space. On the basis of the above literature analysis, in order to facilitate the development of research activities such as field observation and data collection, the cross-generational co-living space is divided into three categories: indoor space (functional space, traffic space), transitional space, and outdoor space, which is the theoretical basis of next research.

Extraction of design points

After intensive reading and analysis of the factors affecting the space environment used by the elderly in the key literature, it is found that the current relevant research is mainly based on the physical and mental characteristics of aging-friendly space design, so it can be sorted out from the aspects of physiological activities and psychological perception. The statistics of the design points are shown in table 9.

3.2 Field observation

From the statistical data, it can be seen that the proportion of the elderly population over 65 years old in Shanghai exceeds the city average: Hongkou District, Huangpu District, Putuo District, Chongming District, Jing'an District, Changning District, Yangpu District, Xuhui District, Baoshan District. The spaces where cross-generational communication can take place are mostly concentrated in community-based comprehensive service centers for the elderly and community demonstration good-neighborhood centers. In 2022, the proportion of the population over the age of 65 in Florence has reached 26.88%, and the district with the largest number of residents and elderly population is the fifth district. After taking into account factors such as the scope of action of the elderly, supporting facilities, the degree of openness after the epidemic, and the convenience of research, 14 cases in Shanghai and 12 cases in Florence were selected for field research. The location map of each research object is shown in table 10 . In order to avoid large climate changes in winter and summer, European summer holidays, the enthusiasm of the elderly and children to participate in activities and the frequency of travel, etc. , mostly in November), see table 11 for a summary of the survey respondents.

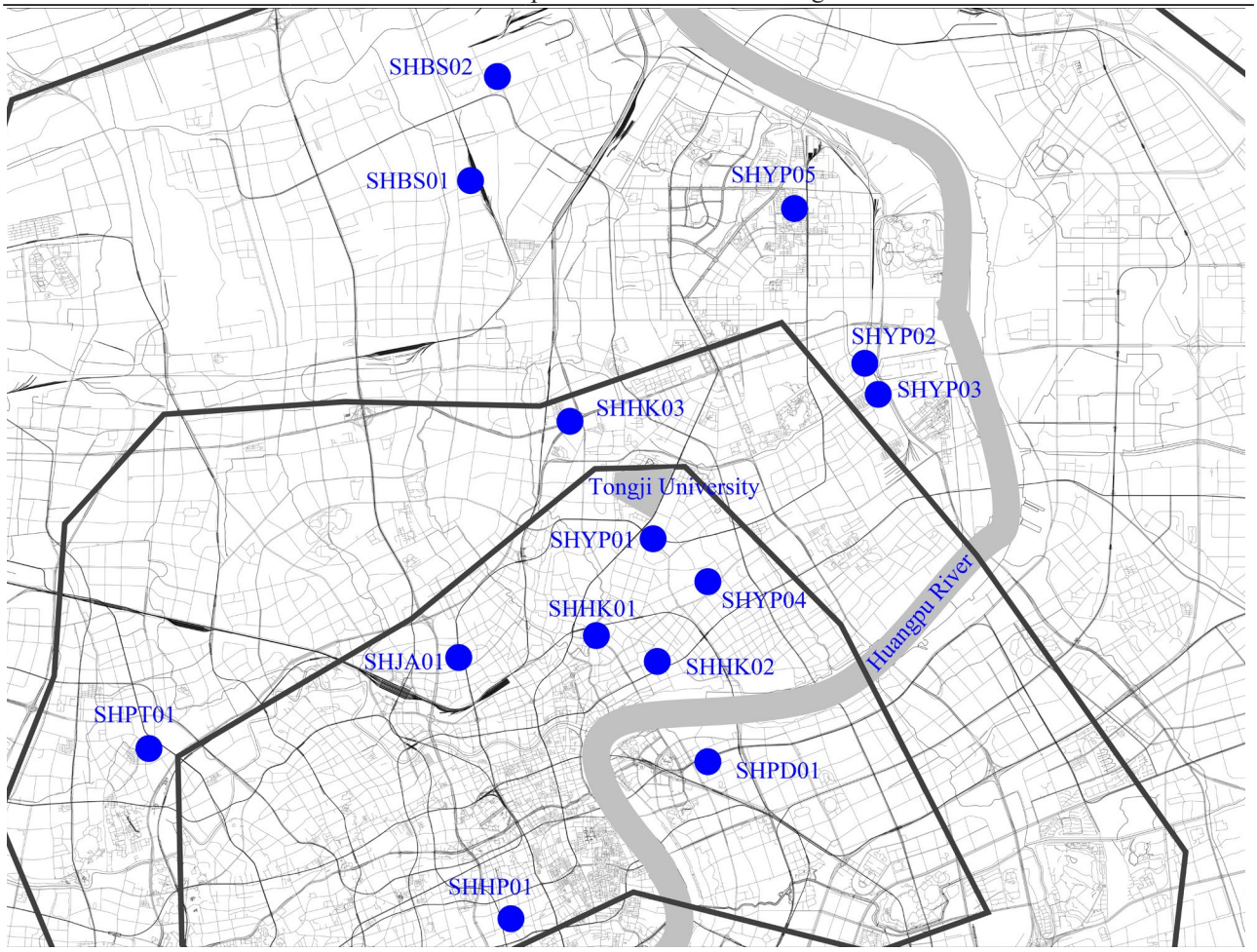
Due to the different social cultures between China and the West, there are many differences in architectural forms and space types. There are typical cloister spaces, churches, etc. in Western architecture. There are buildings such as Good Neighbor Centers and Citizen Service Stations in residential areas in China, but in Florence there is no concept of residential communities, and there are no functional spaces such as community canteens. Elderly people will go directly to restaurants or bars to eat. There are many outdoor dining areas in Europe, which facilitates cross-generational communication with other age groups in the neighborhood.

From the above survey results, we can know that, first of all, cross-generational co-living activities can occur in any space. As long as the space is suitable for people of all ages, cross-generational co-living activities can occur and become an cross-generational co-living space. Based on the analysis results of the literature review and spatial survey, table 12 classifies cross-generational co-living spaces based on specific rooms and locations.

List of Shanghai research cases

Region	Amount	Date	Serial number
Shanghai	14	2020/01/18	SHYP01 Fushun Road Neighborhood Center
		2021/10/25	SHYP02 Yanji Community No. 1 Neighborhood Center
		2021/10/26	SHYP03 Yanji Community No. 3 Neighborhood Center
		2021/11/02	SHYP04 Jiangpu Road Chenjiatou Neighborhood Center
		2021/11/08	SHYP05 Jiangwan International Community Center
		2021/11/13	SHHK01 Jiaxing Road Street Community Cultural Activity Center
		2021/11/17	SHHK02 Jiaxing Road Street Citizen Post Station No. 5
		2021/11/19	SHHK03 Quyang Community Cultural Center
		2021/11/20	SHJA01 Tianmu West Road Street Neighborhood Center
		2021/11/23	SHHP01 Wuliqiao Community Cultural Activity Center
		2021/11/24	SHPD01 Bamboo Garden Neighborhood Center
		2021/12/01	SHBS01 Gaojing Town Community Cultural Activity Center
		2021/12/02	SHBS02 Songnan Ten Villages Community Center
		2021/10/30	SHPT01 Millennium Park (outdoor space)

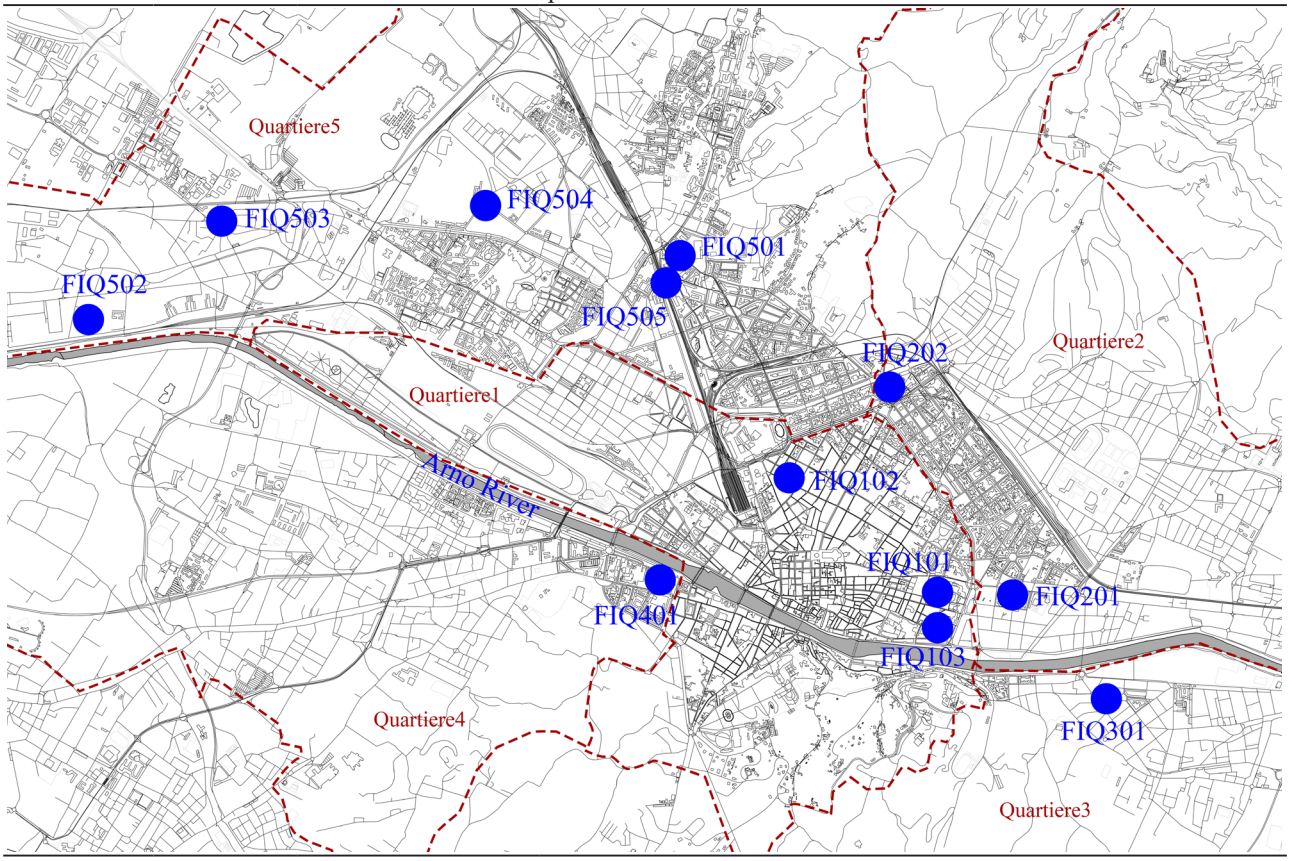
Location map of research cases in Shanghai



Note: Table continues on next page

List of Florence research cases			
Region	Amount	Date	Serial number
Florence	12	2022/04/13	FIQ101 Le Murate
		2022/04/14	FIQ102 Cenacolo del Fuligno
		2022/05/16	FIQ103 Montedomini
		2022/04/13	FIQ201 Centro Eta'Libera"La luna-San Salvi"
		2022/04/18	FIQ202 Centro Eta'Libera Parterre Aps
		2022/04/20	FIQ301 Circolo Arci viale Giannotti
		2022/04/14	FIQ401 Centro Anziani Eta'Libera Santa Rosa
		2022/04/19	FIQ501 Statuto SMS Rifredi
		2022/05/13	FIQ502 Le Piagge
		2022/05/24	FIQ503 Societa'Mutuo Soccorso Ricreativo
		2022/06/28	FIQ504 Orti sociali via Cimento
		2022/07/19	FIQ505 Centro Età Libera Rifredi Romito Vittoria

Location map of research cases in Florence



Tab 10 Summary of research cases and schematic diagram of location distribution

Research objects	Year of use	Organizer	Main users	Floors	Service area
SHYP01	2019	Neighborhood committee	seniors/children/youth	2	Anshan neighborhood
SHYP02	2010	Social organization	seniors	1	Yanji street
SHYP03	2012	Social organization	seniors/children/youth	2	Yanji street
SHYP04	2020	Social organization	seniors/children/youth	1	Jiangpu street
SHYP05	2009	Neighborhood committee	seniors	2	Jiangwan international neighborhood
SHHK01	2020	Neighborhood committee	seniors/children/youth	4	Jiaxing street
SHHK02	2021	Neighborhood committee	middle-aged adults/children	3	Xiangyanqiao street
SHHK03	2010	Neighborhood committee	seniors	4	Quyang neighborhood
SHJA01	2017	District cultural center	seniors/children	3	Tianmu west street
SHHP01	2015	District cultural center	seniors/youth	4	Wuliqiao neighborhood
SHPD01	2020	Social organization	seniors/children	1	Weifang street
SHBS01	2016	Neighborhood committee	seniors	7	Gaojing street
SHBS02	2018	Neighborhood committee	seniors/youth	1	Songnan street
SHPT01	2021	Social organization	seniors	/	Caoyang street
FIQ101	2013	Commune di Firenze	seniors/children/youth	/	Quartiere1 Centro storico
FIQ102	2001	Montedomini ASP	seniors/children/youth	3	Quartiere1 Centro storico
FIQ103	1476 (original built)	Montedomini ASP	young and middle-aged people/children/disabled people	3	Quartiere1 Centro storico
FIQ201	1975	Commune di Firenze	seniors/youth	3	Quartiere2 Campo di Marte
FIQ202	1937	Commune di Firenze	seniors/youth	2	Quartiere2 Campo di Marte
FIQ301	1944	Arci	seniors	3	Quartiere3 Gavinana-Galluzzo
FIQ401	1987	Commune di Firenze	seniors/youth	1	Quartiere4 Isolotto-Legnaia
FIQ501	1914	SMS di Rifredi	seniors	2	Quartiere5 Rifredi
FIQ502	2014	Azienda Usl Toscana Centro	seniors/youth	2	Quartiere5 Rifredi
FIQ503	1959	Arci	seniors/children/youth	3	Quartiere5 Rifredi
FIQ504	2011 (Vegetable garden allocation tender)	Commune di Firenze	seniors/children	1	Quartiere5 Rifredi
FIQ505	1978	Commune di Firenze	seniors/youth	1	Quartiere5 Rifredi

Tab 11 Overview of the basic architectural situation of the research case

Range	Sorts		Specific function/location
Indoor space	functional space	study	library, reading room, electronic reading room, exhibition hall, classroom
		entertainment	theater, gallery, art salon, piano room, music room, chess and card room, multi-purpose room, handicraft workshop
		fitness	gym, dance studio
		commercial	supermarkets, bazaars, second-hand markets, shopping malls
		service office	banks, telecommunications, post offices, driving schools
		church	worship area, exhibition area, rest area
	circulation space	corridor	
		loggia	
		hallway	
Transition space	entrance		information bar, rest area, consultation desk, shop window(vetrine), large steps
	cloister		exhibition area, rest area
	city inner street		passage, exhibition area
	courtyard		exhibition area, rest area
	outdoor dining area		cafe, bar, restaurant
Outdoor space	streets		city intersections, children's amusement facilities, cultural galleries, rest areas
	square		children's playground, dining bar, rest area, market
	waterfront space		green space, rest area
	parks		children's playground, dining bar, rest area

Tab 12 List of types of cross-generational co-living space

Cross-generational co-living space in contemporary residential communities in Shanghai

(1) Research area of elderly behaviour

The investigation into the daily behavioral habits of the elderly involves long-term and detailed observation. In the case samples selected for this study, the area around Case SHYP01 in Yangpu District of Shanghai—specifically the Anshan neighborhood—is used as a representative research site. The behavioral habits and spatial usage patterns of the elderly in this area are introduced in detail (see figure 19).

This neighborhood has a long history and is characterized by a large number of old residential communities, with a relatively high degree of aging. For example, Anshan No. 5 Residential Quarter is a former workers' housing estate built in the early 1950s. The community has a permanent population of 2,027 people, of which 721 are aged 60 or above, accounting for 35.6% of the total population. Among them, 117 are aged 80 or above, making up 16.2% of the elderly population, indicating a high level of aging within the community.

In addition, we observed surrounding public spaces such as Songhe Park and the Zijing Plaza commercial center, documenting the behavioral characteristics and social interactions of the elderly with people of other age groups.

(2) Main behavioral activities of the elderly in public spaces

Multiple observations were conducted in the above observation areas in the morning, afternoon and evening, and the observation times were distributed on different dates. Table 13 shows the behaviors of the elderly in interacting with others in different spaces.

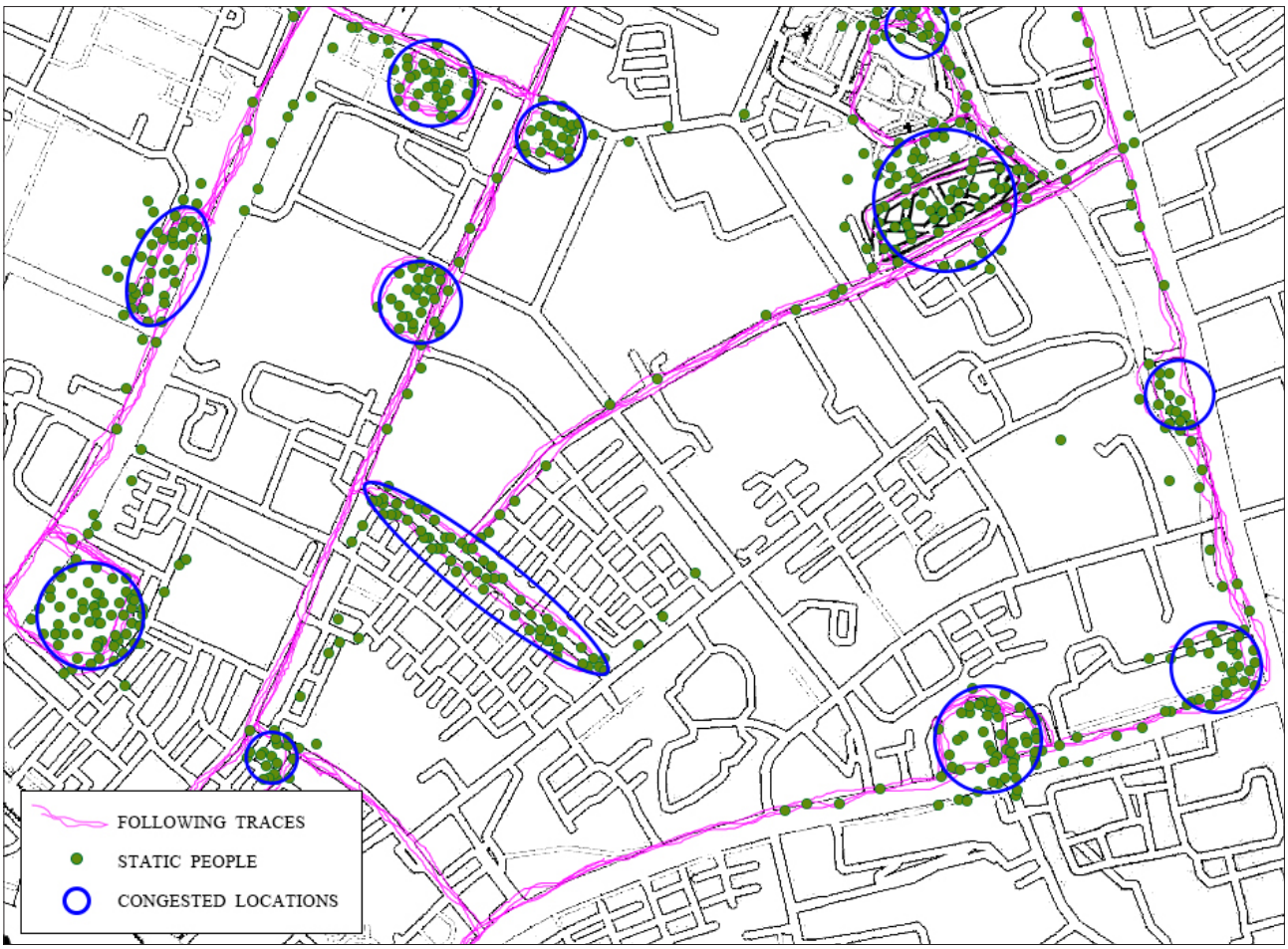
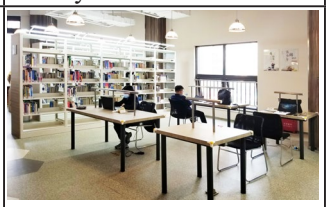
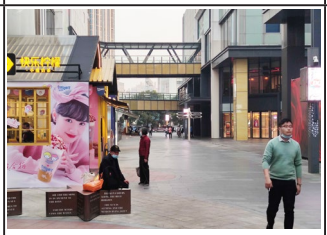


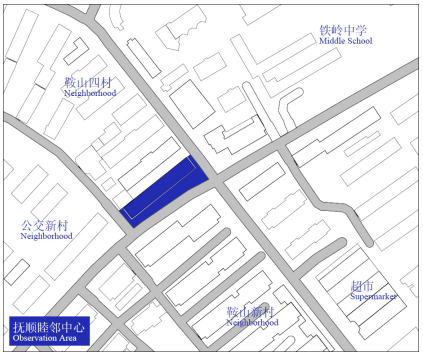
Fig 19 Observation area of the behaviour of the elderly from August to November 2021

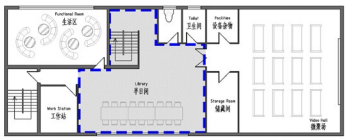
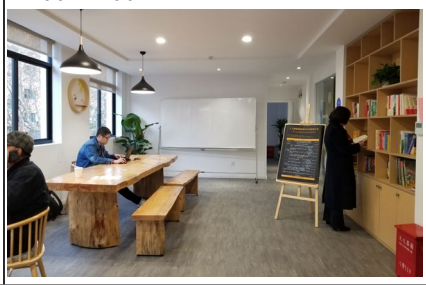
(3) Time period when cross-generational communication takes place

With the increase of age, the physiological function of the elderly declines, and the number of diseases increases, so their work and rest, and the duration of activities have changed. For example, sleep becomes earlier and shorter, and the main behavioral activities are carried out in the morning, etc. The time period during which cross-generational communication can occur in the same place is also related to the work and rest, physical functions, and living habits of each generation. Taking Fushun Road Neighborhood Center in Yangpu District, Shanghai as the observation object(figure 19), the Neighborhood Center serves Anshan New Village in Yangpu District. Anshan New Village is a representative aging community in Shanghai. Equipped with corresponding public service facilities and abundant community resources, there are shops, cooperatives, kindergartens, primary schools, banks, postal services, etc. nearby to meet the living needs of the residents. Observing the main users of this Neighborhood Center at different times, it can be seen that the main users during the day are the elderly who live nearby and those who bring preschool children to play. During the lunch break, young people come to rest, and at 3:30 in the afternoon, teenagers come after school, there will be a large number of students coming to this neighborly center. Due to the requirements of epidemic prevention and control, the Community Center is now closed for sterilization at 12:00 noon for one hour, and is open until 6:00 pm in the afternoon. It used to be open 24 hours a day. The time periods for cross-generational communication in this place are mostly concentrated in the morning, afternoon and evening (table 14).

Indoor space(functional/traffic space)			
Administrative institutions (banks, telecommunications, post offices, etc.)	Supermarkets/food markets	Stores, shopping malls	Restaurants
Behaviors involved: personal business	Behaviors involved:shopping	Behaviors involved:shopping	Behaviors involved:eating and drinking, chatting
Community Center	Pavilion/Salon	Library	Cinema/KTV/Dance Hall
			
Behaviors involved: chatting, reading newspapers, raising children, playing table tennis, community activities	Behaviors involved: visiting, listening to lectures, chatting	Behaviors involved: reading, borrowing	Behaviors involved: Watching movies, chatting, socializing
Transition space			
courtyard	markets	entrance	under the viaduct
			
Behaviors involved: rest, chatting	Behaviors involved: shopping, walking	Behaviors involved: rest, waiting	Behaviors involved: walking, chatting, rest
Outdoor space			
green space	physical exercise area	streets	newsstand
Behaviors involved: rest, chatting, walking the dog	Behaviors involved: doing exercise, chatting	Behaviors involved: reading newspaper, chatting, walking the dog	Behaviors involved: purchasing newspapers, sundries
plazza	city intersection	park	river bank
Behaviors involved: chatting, dancing, playing with the kids	Behaviors involved: rest, chatting	Behaviors involved: rest, chatting, walking the dog, play chess, playing with the kids	Behaviors involved: fishing, walking, exercising

Tab 13 Main activities and behaviors of the elderly in Shanghai

<table>
<tr><td>Research site</td><td colspan="2">Time period(24h)</td></tr>
<tr><td rowspan="4">SHYP01 Fushun Road Neighborhood Center
 


</td><td>09:00-10:00
 </td><td>11:00-12:00
  </td></tr>
<tr><td>Main users: the elderly, preschool children</td><td>Main users: young people</td></tr>
<tr><td>15:00-16:00
 </td><td>17:00-18:00
 </td></tr>
<tr><td>Main users: students, preschoolers, elderly</td><td>Main users: students, young people</td></tr>
</table>

Tab 14 Cross-generational exchanges in the same place

(4) Location/Space where cross-generational communication takes place

Through actual case research and semi-structured interviews, we learned that the design of existing buildings and spaces is basically based on functional requirements, without considering the interaction between the elderly and other age groups. Public spaces and public function rooms can have direct cross-generational communication, while specific function rooms are aimed at a single age group and lack opportunities for interaction, such as electronic equipment classes specially designed for the elderly, yoga studios designed for white-collar workers, and Amusement facilities designed by children, etc. Although there are age restrictions on the functional organization of such spaces, a single functional space penetrates the space through various methods such as not setting closed boundaries, increasing visual communication, and connecting with open spaces. By increasing indirect communication, cross-generational co-living can still be achieved. Taking SHPD01 as an example, the spatial location of direct and indirect cross-generational communication is shown in figure 20. Therefore, it can be considered that, depending on the design strategy, both public and age-specific spaces can have cross-generational co-living patterns.

(5) Design points of cross-generational co-living space

In the existing examples of cross-generational co-living space, different spatial characteristics will bring different communication effects, and cultural differences between China and the West will also bring different spatial types and uses. Based on the space types and design points extracted from the literature review, some characteristic spaces in the research cases are selected for analysis, such as the open reading room, the children's play area with blurred boundaries, and the combined exhibition hall. traffic corridors, etc., see table 15 for specific analysis content.

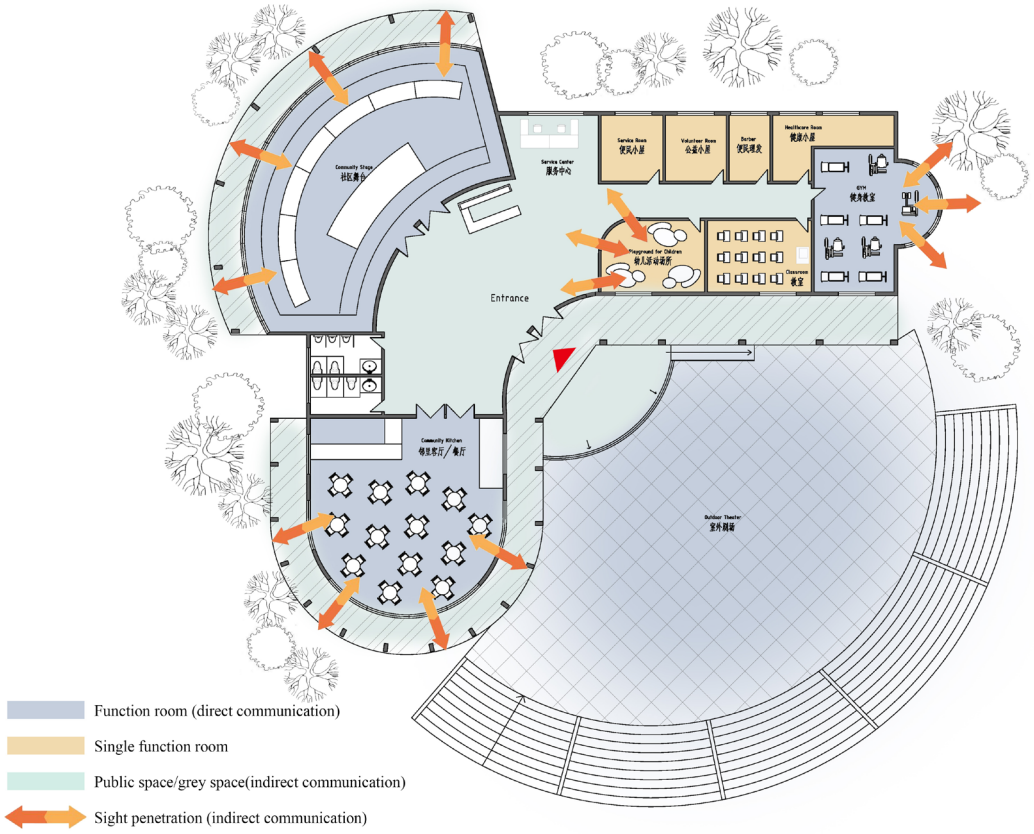
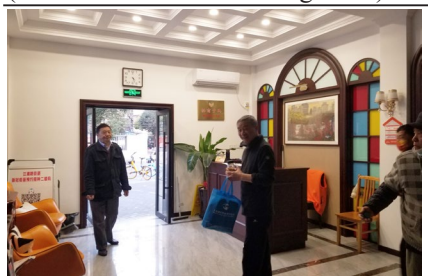
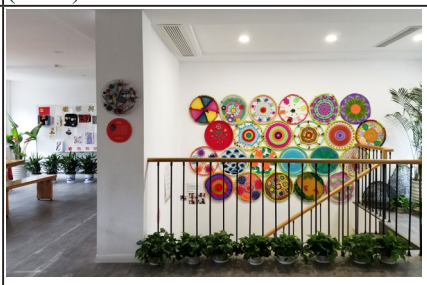


Fig 20 SHPD01 Space where cross-generational communication takes place

Indoor space		
example:SHYP04 Functional space (entrance consultation/living room)	example:SHJA01 Functional space (community restaurant)	example:SHHK01 Functional space (exhibition hall)
		
[Accessibility] • Easy to reach nearby facilities in the community; • Barrier-free design: There is no height difference at the entrance, and there is a disabled toilet; **[Space Environment]** • Sign: Combination of blackboard, notice and electronic screen, large font, clear and easy to read; • Aesthetics: The historical elements of Shanghai Shikumen are used to decorate the walls and windows, which is in line with the aesthetics of the elderly; **[Aging design]** • The ground material is marble tiles, not particularly smooth; • the rest seat is a leather sofa.	**[Accessibility]** • Located at the corner of the road, it is convenient for nearby residents and white-collar workers to access; • Barrier-free design: There is an elevator at the entrance to the restaurant, and there is a disabled toilet; **[Space Environment]** • Aesthetics: Bright furniture and lighting decorate the white space, the overall look is refreshing and lively, suitable for people of all ages; **[Aging design]** • The height of the table and seats in the restaurant is suitable for the elderly. • The price list is posted on the window of the meal, and the font is large and easy to read.	**[Accessibility]** • Close to the foyer, easy to reach, and close to surrounding businesses; • Barrier-free design: there is no height difference at the entrance, there is an elevator and a disabled toilet; **[Space environment]** • Interesting: the combination of multimedia, paper, models, etc., various exhibition arrangements, both popular science publicity and special science and technology attraction; • Aesthetics: The space is simple and flexible, and the lighting arrangement reflects the sense of technology; **[Aging Design]** • A sound-absorbing carpet is laid on the ground, and there are seats in the exhibition hall, which is convenient for the elderly to rest on the way to the exhibition.

Note: Table continues on next page

Indoor space		
example:SHBS01 Functional space (reading room)	example:SHHK02 Functional space (multi-functional room)	example:SHPD01 Functional space (theater stage)
[Accessibility] • Located in a quiet corner on the first floor, connected to the corridor; **[Space environment]** • Lighting: rely on artificial lighting, point light sources on the top interface and local light sources on desk lamps; • Aesthetics: positive white gypsum board, light strips made of folded grooves, white marble on the two side interfaces and the ground, slanted light strips continuing the top surface, and the decoration of brown glass combined with wood-colored lattice; **[Aging Design]** • The furniture is suitable in scale, conforms to the ergonomics of the elderly, and has soft light; **[Neighborhood social atmosphere]** • The interface is open, with green plants and wood as partitions, connecting with the corridor.	**[Accessibility]** • Near the entrance hall, it is convenient for all kinds of users to reach and various activities; • Barrier-free design: located on the first floor, there is no indoor height difference; **[Space environment]** • Lighting and ventilation: natural lighting and artificial lighting are combined; close to the entrance courtyard, the ventilation is better; • Aesthetics: mainly log furniture and warm colors, the warm and natural design style is suitable for people of all ages to use together; **[Aging design]** • The ground material is non-slip, and the furniture selection takes into account the differences in the physical functions of the elderly, including hard seats and sofas.	**[Accessibility]** • It is close to the main entrance hall, but now the online app reservation system is adopted, which reduces the convenience for the elderly; • Barrier-free design: located on the first floor, there is no indoor height difference; **[Space Environment]** • Lighting and ventilation: It is located in the center of the community park, surrounded by green plants, and large glass windows on the outer wall bring natural lighting and achieve natural ventilation; • Aesthetics: The warm and natural design style is suitable for people of all ages, and the indoor green plants are sufficient; **[Neighborhood social atmosphere]** • Multiple functional uses with reservation .
example:SHPD01 Functional space (children playing area)	example:SHYP01 Circulation space (stairs)	example: SHJA01 Circulation space (elevator)
		
[Accessibility] • Barrier-free design: no height difference, only one floor; **[Space Environment]** • Aesthetics: The combination of white and wood colors is clean and bright, the bright colors of the floor and furniture embellish the space, and the overall atmosphere is warm and relaxing; **[Neighborhood social atmosphere]** • The interface that opens towards the corridor and the foyer is enclosed by a gray semi-circular arc counter, which is in line with the scale used by children, and can also meet the nursing needs of adults or the elderly who are sitting and resting on the opposite side.	**[Accessibility]** • Barrier-free design: the stairwell is spacious and has anti-slip treatment, but there is no elevator **[Space Environment]** • Marks: clear traffic location, concise and clear floor guidance, easy to read; **[Aging design]** • The ends of the wooden armrests are rounded to avoid bumps; **[Neighborhood social atmosphere]** • The stairwells are decorated with the handicrafts of the elderly in the surrounding residential communities, and the community culture is displayed with photos and texts.	**[Accessibility]** • Convenience: located in the gray space on the first floor; • Barrier-free design: There are handrails in the elevator, and there is a staff consultation desk at the elevator exit on each floor; **[Space Environment]** • Marks: There are colored floor signs in the elevator, and functional slogans are clearly written; **[Neighborhood social atmosphere]** • There are colored stickers and community activity schedules at the elevator doors and waiting areas. The overall style is relatively lively and close to children's preferences.

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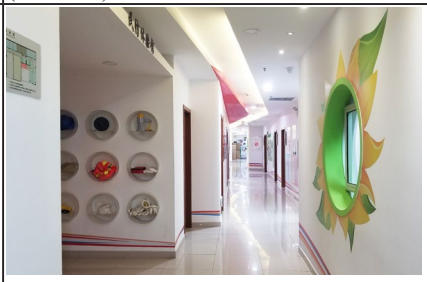
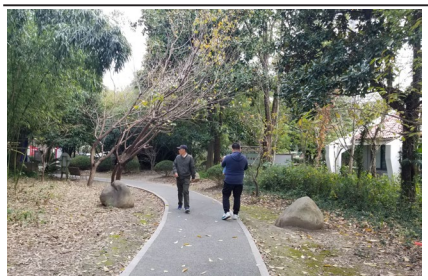
Indoor space		
example:SHYP02 Circulation space (hallway)	example:SHYP05 Circulation space (corridor)	example:SHHK03 Circulation space (corridor)
		
[Space Environment] • Aesthetics: The color and decoration fit the overall interior space style, mainly white, black, and wood colors, and bright colors are used to highlight the bright spaces; **[Aging design]** • The text of the display node is large, the picture display position is not high, and the scale of the furniture is in line with the average height of the elderly; **[Neighborhood social atmosphere]** • Use corridors, corners and other spaces to set up display cabinets, community style photo galleries, rest seats and desks.	**[Space Environment]** • Identification: The text and guide signs are clear and clear; • Aesthetics: Continue the colored polyline above the skirting line of the corridor to introduce the entire traffic flow into the node space. The colors of the interface decoration and furniture are brighter, making the node space more prominent; **[Neighborhood social atmosphere]** • Use corridors, front rooms, corners and other spaces to display residents' works, set up fire experience halls, rest and reading areas, etc.	**[Space Environment]** • Marks: The three-dimensional location map and the display of surrounding information make the logo more clear and prominent; • Aesthetics: All interfaces are white, and the additional nodes are decorated with woody paintings, handmade walls, and brightly colored seats; **[Neighborhood social atmosphere]** • Use the end of the corridor, the enclosed aisle in the atrium, the corner space, etc. to display children's paintings, handicrafts, community cultural promotion, and set up rest seats.
Transition space		
example:SHHP01 (entrance)	example:SHHP01 (courtyard)	example:SHJA01 (grey space)
[Accessibility] • Convenience: The sidewalks are set along the street, and the square is wide and easy to reach; • Barrier-free design: there are long ramps leading to the square and the entrance; **[Space Environment]** • Marks: There are activity arrangements and self-service libraries in the gray space, with large fonts and clear and easy to read; • Aesthetics: The complete stone surface and a layer of transparent glass form a strong contrast; **[Aging design]** • The entrance floor is made of non-slip material, and there are staff outside the hall to help the elderly with registration and online operations, etc.	**[Accessibility]** • The entrance gray space has large steps leading straight down to meet the openness and convenience to the outside world; • Barrier-free design: it can be directly reached from indoors, without the change of height difference; **[Space Environment]** • Aesthetics: The corridors use a large area of orange to contrast with the outdoor green courtyard. There are colorful graffiti on the fence in the courtyard; **[Neighborhood social atmosphere]** • The atrium is equipped with a semi-outdoor basketball court, which is small in size and suitable for young people and the elderly.	**[Accessibility]** • Convenience: Located on the corner of the street, the interface is fully open, easy to reach; • Barrier-free design: there is no height difference in the venue, and there is an elevator; **[Space Environment]** • Marks: There are many notice boards and wall stickers, mainly showing community cultures and activity arrangements; • Aesthetics: The main materials in the space are gray stone brick floors and wooden grilles; **[Neighborhood social atmosphere]** • The grey space can meet the needs of nearby residents and office workers to rest, work, chat, etc. The building and the city streets are connected and open.

Note: Table continues on next page

Outdoor space		
example:SHPD01 (square)	example:SHYP01 (playground for children)	example:SHYP06 (entrance plaza)
[Accessibility] • It is located at the core of the central park of the community, and the border is completely open for easy access; • Barrier-free design: The square is connected to the park road without height difference, and is connected to the Neighborhood Center with a long and gentle ramp; **[Space Environment]** • Marks: The rest seats on the square are marked with color blocks with serial numbers, and movie screening boards and event schedules stand at the entrance; **[Aging design]** • The whole square is covered with non-slip floor tiles, and the outdoor seats are made of wood to keep warm.	**[Accessibility]** • Convenience: close to the outdoor activity area, located at the intersection of the city, easy to reach; **[Space Environment]** • Marks: A welcome slogan is posted on a large piece of glass; • Aesthetics: The colorful arc is not only the decorative function of the façade, but also has the function of a rest seat; **[Neighborhood social atmosphere]** • Transparent glass windows blur the sense of boundaries. While ensuring the development of indoor activities, the scenes of children's play and urban activities are introduced into the room. The connection of sight is an indirect way of communication.	**[Accessibility]** • Located at the main entrance of the community, easy to reach; • Barrier-free design: There is no height difference in the site, and there are no steps at the entrance; **[Space Environment]** • In combination with fountain pools, stone bridges are set up to connect community roads and good-neighborly centers. Plants and water bodies create a pleasant natural ecology with sufficient sunlight; **[Neighborhood social atmosphere]** • It has strong centripetal properties, and is suitable for outdoor activities. Health care activities such as traditional Chinese medicine and moxibustion are carried out here.
example:SHPD01 (green space)	example:SHPT01 (parks)	example: SHYP01 nearby streets
		
[Accessibility] • Located in center of the community, it is convenient for residents in nearby communities to use it together; **[Space Environment]** • The plant species is rich and the natural environment is suitable; there are three high residential buildings around, and the others are multi-storey, and the sunlight is not affected; the lighting conditions at night are better; **[Aging design]** • The ground pavement material is non-slip, which is convenient for walking and running; wooden rest seats are arranged not far away; **[Neighborhood social atmosphere]** • The open environment has become a place where residents often gather and hold outdoor activities, where multiple age groups exercise, chat, etc.	**[Accessibility]** • Barrier-free design: the height difference of the continuous overpass is connected by the ramp; **[Space Environment]** • Marks: There are many paths, not many text signs, there is a park map at the entrance; • Aesthetics: Various accessories, urban furniture, exhibition areas, etc. are decorated with bright colors; **[Neighborhood social atmosphere]** • There is no boundary between indoor and outdoor in the park. Continuous flyovers and rich split-level spaces connect various activity spaces. Walking paths, playing spaces, courts, rest areas, etc. are all at different heights. Platform paths have line-of-sight communication.	**[Accessibility]** • along the main street, it is the only way for the elderly in the nearby community to travel; • Barrier-free design: there is no change in height difference, and the passage path is complete and continuous; **[Aging design]** • The ground materials are made of non-slip materials, and there are many rest seats; **[Neighborhood social atmosphere]** • Combined with the city interface and node space, sports track, fitness equipment, rest seats, newspaper walls, cultural exhibitions, children's amusement facilities, etc. are set up to meet the needs of different groups of people; • Combining sculptures, children's playground equipment, equipment and facilities to display community culture.

Tab 15 Analysis of design points of cross-generational co-living space in research cases

The city of Florence began to gradually lift pandemic restrictions in April 2022. During this period, many indoor spaces remained closed due to public health measures, and some buildings required advance reservations for access. The author conducted a field survey on the activity patterns of elderly residents in urban public spaces in Florence on January 19, 2022.

(1) Research area of elderly behaviour

The survey was conducted in the historic Q1 and Q2 districts of central Florence (see figure 21). Q1 is the historic city center, characterized by a high concentration of heritage buildings. It is currently a major tourist hub, with many residential buildings converted into short-term rental accommodations.

Q2 is connected to Q1 by the Viali di Circonvalazione, a ring road that marks the boundary between the two zones. Q2 represents the extended historical core, planned in 1865 on the left bank of the Arno River. It is known for its high-quality housing and continues to host a significant elderly population, making it another district with a relatively high aging rate.

In addition, we observed major tourist attractions in the historic center, such as the Florence Cathedral (Duomo di Firenze) and the Basilica of Santa Croce, as well as riverside green spaces, documenting the behavioral characteristics and social interactions of the elderly with people of other age groups.

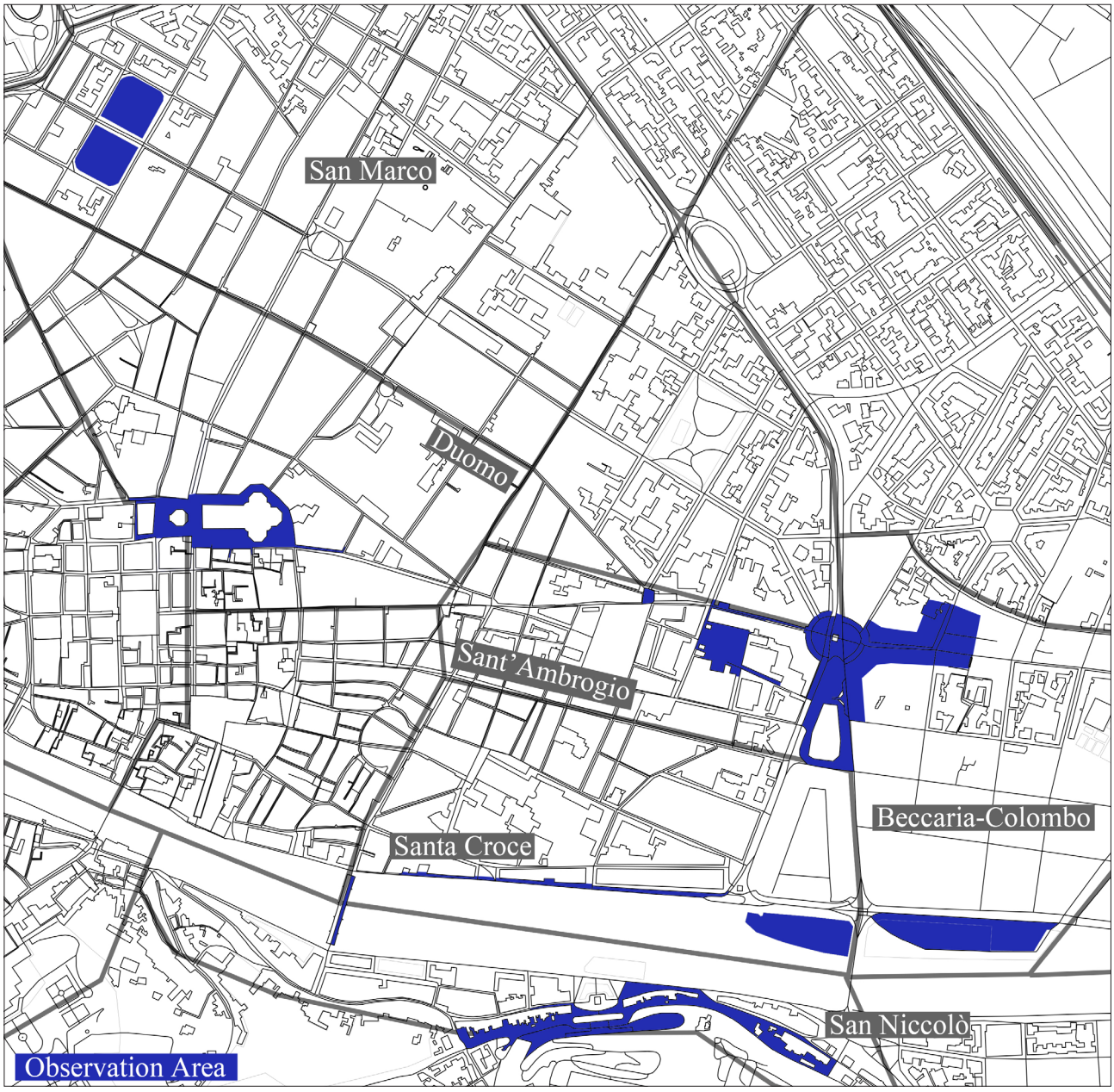
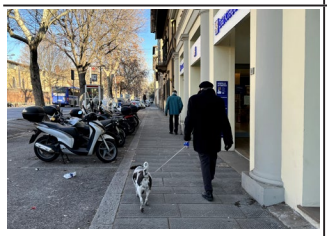


Fig 21 Observation area of the behaviour of the elderly in January 2022

Indoor space(functional, circulation)			
administrative institutions (banks, telecommunications, post offices, etc.)	supermarkets	stores, shopping malls	cafe, bars
Behaviors involved: doing business	Behaviors involved:shopping	Behaviors involved:shopping	Behaviors involved:eating and drinking, chatting
church	exhibition hall	library	gallery
Behaviors involved: Worship, visit	Behaviors involved:visit, chatting	Behaviors involved: reading, borrowing	Behaviors involved: visiting, chatting, socializing
Transition space			
outdoor dining area	markets	entrance	shop window(vetrine)
Behaviors involved: rest, chatting	Behaviors involved: shopping, walking	Behaviors involved: rest, waiting	Behaviors involved: walking, chatting, rest
Outdoor space			
streets	newsstand	plazza	city intersection
			
Behaviors involved: cycling, chatting, walking the dog	Behaviors involved: purchasing newspapers, sundries	Behaviors involved: rest, chatting, exercising, playing with the kids	Behaviors involved: rest, chatting
outdoor stages	park	river bank	green space
Behaviors involved: reading, chatting	Behaviors involved: rest, chatting, walking the dog, playing with the kids	Behaviors involved: fishing, boating, walking, exercising	Behaviors involved: rest, chatting, walking the dog

Tab 16 Main activities and behaviors of the elderly in Florence

(2) Main behavioral activities of the elderly in public spaces

In each of the observed areas, multiple observations were conducted in the morning, afternoon, and evening, with observation times distributed across different dates. Table 16 presents the behaviors of the elderly in different spaces where they interact with others.

(3) Time period when cross-generational communication takes place

Take the city intersection in the Beccaria colombo residential area of Florence as an example. The space is located at the intersection of the commercial street in the residential area. There are cafes, shops, fast-moving stores, large supermarkets, pharmacies, etc. Due to the large flow of people, there are stalls, markets, newsstands, and rest seats and other facilities. Observing the main users of the city at different time periods, it can be seen that the elderly use the space more frequently in the morning and after the lunch break, and the main users of the space at noon and evening are young people. Close to evening (table 17).

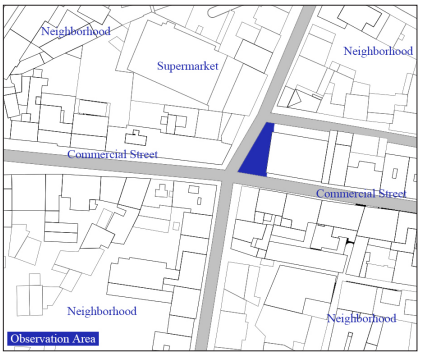
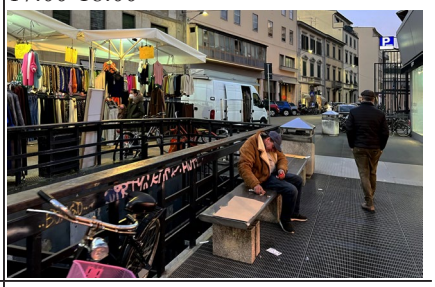
(4) Location/Space where cross-generational communication takes place

According to the observation of the behaviors of the elderly in Florence, combined with the research on local pension policies, community planning, etc., after discussions with experts, it was determined that there are 9 existing Cross-generational co-living models in the five existing neighborhood communities (Quartiere 1-5) in Florence. A typical case is the subject of the survey, and a field trip will be conducted during the Easter unblocking period in April 2022.

From the previous literature reading and visits, we can see that the core of Italian family is the relationship between husband and wife, and the relationship with children is not particularly close compared with China, but it is relatively close compared with most Western countries, and it is in the middle. Therefore, the elderly in Italy still maintain their previous living conditions and living habits, and there is not much contact and interaction with people of other age groups.In the field research, it was found that the main users of buildings such as homes for the elderly and community centers are the elderly, and there is a certain distance from the functional spaces and facilities used by young people or children, which to a certain extent maintains different groups. Relatively private and independent, people of all ages have very clear goals. For example, the elderly use the chess and card room, stage, small theater, reading room, coffee bar, etc.; young people will participate in language classes, yoga classes, billiards, Garden restaurant, etc.; children take ballet lessons, play in outdoor children's playground, etc. At the same time, due to the small scale of streets and alleys in Florence, the public facilities in the community are widely distributed and accessible, so cross-generational interactions will occur in indoor and outdoor public spaces, such as corridors, foyers, coffee bars, and outdoor gardens. , community streets, etc. Taking FIQ202 as an example, the spatial location of direct and indirect cross-generational communication is shown in figure 22.

(5) Design points of cross-generational co-living space

The analysis of the common points in the two city research cases will not be repeated, such as barrier-free design, aging-friendly details, natural environment, etc. Select representative spaces with different design practices in the Florence research case, such as the loggia space combined with the dining area, outdoor open-air theater, urban inner street, social garden, etc., see table 18.

Research site	Time period(24h)	
city intersection in the Beccaria colombo 	09:00-10:00 	12:00-13:00
	Main users: the elderly	Main users: elderly, young and middle-aged people
	15:00-16:00 	17:00-18:00 
	Main users: students, preschoolers, students, young people, elderly	Main users: young and middle-aged people

Tab 17 Cross-generational exchanges in the same place

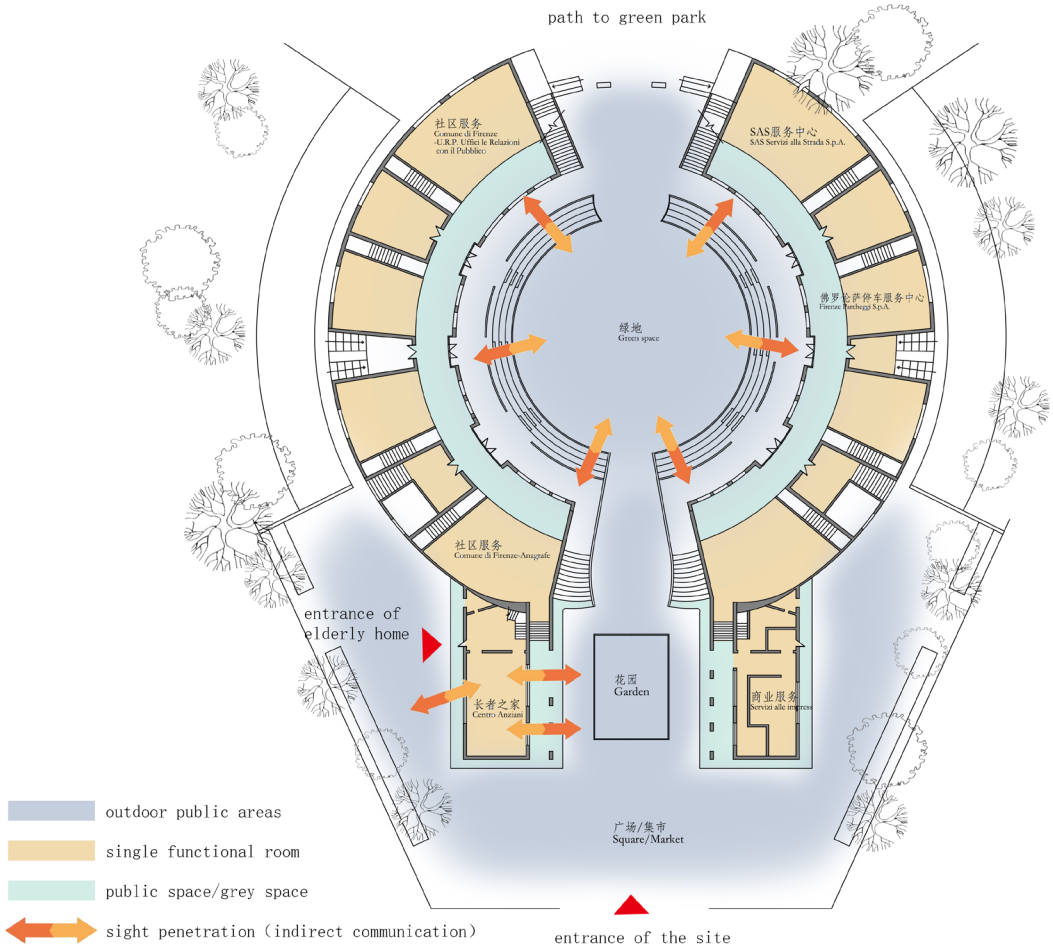
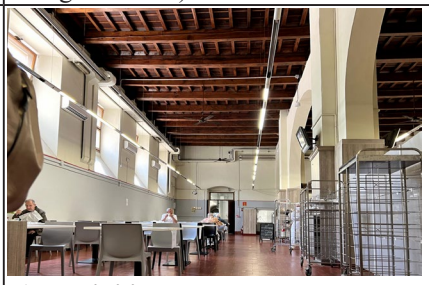
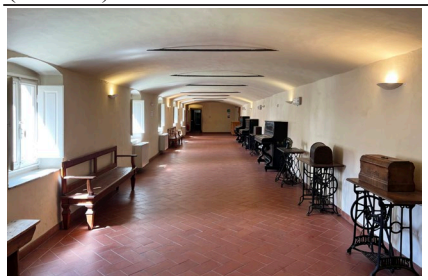
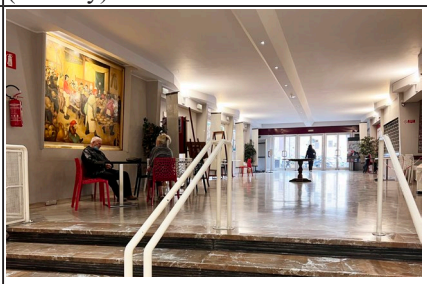


Fig 22 FIQ202 Space where cross-generational communication takes place

Indoor space		
example:FIQ503 Functional space (reading area at entrance)	example:FIQ103 Functional space (restaurant: open to elderly people and college students)	example:FIQ301 Functional space (bar)
		
[Accessibility] • Convenience: The book corner is combined with the entrance hall, which is convenient for exchange and circulation; **[Space Environment]** • Aesthetics: The top and bottom surfaces are dominated by white, and the pillars, furniture and walls are rich in color. There are many paintings and wall paintings by local residents and young people, and the overall atmosphere is lively and lively; **[Neighborhood social atmosphere]** At the end of the reading corner, there is a display of this cultural center, introducing the local historical background through text, pictures, the original organization badge, etc.	**[Accessibility]** • Convenience: There is an entrance and exit hall along the street, which is convenient for nearby college students to come and have meals, and a courtyard is set inside to connect the residence of the elderly; • Barrier-free design: located on the first floor, no height difference; **[Space Environment]** • Aesthetics: The top interface retains the original wooden structure, echoing the color of the red floor tiles, and the walls are made of milky white and light gray, making the space brighter and more refreshing; **[Neighborhood social atmosphere]** The large open space and scattered dining chairs can increase the indirect communication between the elderly and the young.	**[Accessibility]** • Convenience: It is located at the end of the entrance hall and is a pivotal location connecting other rooms; • Barrier-free design: It is a split-level space under the first floor, and the change of height difference is solved by indoor steps and stair lifts; **[Space Environment]** • Aesthetics: Marble floor and long bar, the overall color is red and white, the irregular space shape is more in line with the lively and young style of this leisure center; **[Neighborhood social atmosphere]** The semi-enclosed space has a gathering effect on the crowd, and the open dining space can meet the needs of all generations.
example:FIQ501 Functional space (theatre)	example:FIQ201 Functional space (entertainment room)	example:FIQ202 Functional space (stage)
[Accessibility] In the garden next to the entrance courtyard, it is located on the first floor, with no height difference; **[Space environment]** • Signs: There are posters on the vertical wooden sign at the entrance, there are many brochures on the table and shelves, and the performance information is posted on the wall; • Lighting and ventilation: The large glass windows are dominated by natural lighting. Facing the entrance garden, the landscape levels such as green plants and fountains are rich and interesting; **[Aging design]** There is a gentle slope at the entrance, and there are plenty of seats in the foyer, which is convenient for the elderly to rest.	**[Accessibility]** • Convenience: Located next to the entrance hall on the first floor, easy to reach; • Barrier-free design: The entrance height difference is handled by the ramp, and there are additional elevators and disabled toilets; **[Space Environment]** • Aesthetics: The space is rich in color, the light green walls are combined with the vertical wooden veneer, the top interface and the pillars are large white, and the bottom interface is laid with light colored square bricks. The original doors and windows of the wall are combined with murals for artistic treatment. With ample and flexible furniture, this large space can be used as an event room.	**[Accessibility]** Located next to the entrance hall on the first floor, easy to reach; **[Space Environment]** • Aesthetics: The top interface is a semi-arc dome, which is vivid and interesting with the lighting treatment; the walls are painted light yellow, combined with the half-wall bean paste-colored marble seats, and the bottom interface is covered with large light gray patterns brick. The space effect is simple but full of Tuscan style and texture. **[Neighborhood social atmosphere]** The large space of the multi-functional room has a variety of uses, and it is used as a dance hall and rehearsal room for more time.

Note: Table continues on next page

Indoor space		
example:FIQ102 Circulation space (corridor)	example:FIQ301 Circulation space (hallway)	example: FIQ103 Circulation space (loggia)
		
[Space Environment] • Aesthetics: The structure of the historical building is preserved, and the off-white arc roof and walls contrast with the red square bricks; **[Aging design]** The exhibits are placed at a suitable height, and the scale of the furniture is in line with the average height of the elderly; **[Neighborhood social atmosphere]** Corridors, corners and other spaces are arranged for exhibition, combined historical objects with passages, the arrangement of yellow light sources is also like the previous candles, and sufficient rest seats are arranged at the same time.	**[Space Environment]** • Aesthetics: The overall space is dominated by a large area of white, and the floor is paved with patterned marble. There are concave and prominent volume changes on the wall, posting information, posters, hanging large-scale art paintings, etc. Mainly in various ways of artificial lighting; **[Neighborhood social atmosphere]** The space in the entrance hall is spacious and the furniture arrangement is flexible and free, which can be used for various purposes. Balls, crafts, parties, performances, and more are often held in this space.	**[Space Environment]** • Aesthetics: preserve the integrity of the loggia, highlight the characteristics of historical buildings, red floor tiles, wooden ceilings and white walls contrast with outdoor green plants, increasing the comfort and pleasantness of the traffic space; **[Aging design]** The gentle slope solves the problem of height difference, and the wooden arc handrail on the wall helps the elderly to walk; **[Neighborhood social atmosphere]** The placement of leisure seats, dining tables, etc. makes the traffic loggia can be used as an outdoor dining area and a rest area at the same time.
Transition space		
example:FIQ101 (inner city street)	example:FIQ102 (cloister)	example:FIQ503 (entrance hallway)
[Accessibility] • The through space set along the sidewalk is easy to reach and connects two blocks; • Barrier-free design: you can walk directly from the street without changing the height difference; **[Space Environment]** • Lighting and ventilation: open traffic space, natural light and circulating air; • Aesthetics: In the reconstructed building of the historical prison, the inner street is the location of the original central corridor, retaining the original metal iron art of the prison structure, and adding bright orange-red colors as decoration, the space is rich and interesting.	**[Space Environment]** • Lighting and ventilation: The corridors are arranged around the central courtyard, with natural ventilation and lighting; • Aesthetics: The structure (cross arches) and space effects of historical buildings are well preserved, and some church frescoes are preserved on the white walls; **[Neighborhood social atmosphere]** Each functional space is set up around the courtyard for people of all ages. More wooden and stone rest seats are arranged in the shared courtyard and corridor, providing a place for leisure and social interaction.	**[Accessibility]** Enter from the inner courtyard and lead into the foyer through the corridor, adding interest to the path; **[Space Environment]** • Aesthetics: The entrance courtyard is rebuilt from the original parking lot, and the outdoor corridor and entrance corridor added later form a closed route around the garden. The red balustrade contrasts with the yellow walls. **[Neighborhood social atmosphere]** The space under the corridor here not only meets the function of passage, but also allows different groups of people to rest and chat, stop and drink, etc., and can also interact with members in the courtyard.

Note: Table continues on next page

Outdoor space		
example:FIQ202 (square and market)	example:FIQ504 (vegetable garden/ orti sociali)	example:FIQ101 (inner square)
[Accessibility] It is located near the entrance gate of the community center for easy access; **[Space Environment]** The square is open, and many trees are planted at the same time, with good natural ventilation and lighting. At the same time, more rest areas are set up; **[Aging design]** The ground is non-slip, suitable for the elderly to walk; more rest seats are set; **[Neighborhood social atmosphere]** The circular surrounding entrance plaza has a strong cohesion. There are market stalls every week, including agricultural and sideline products, flowers and green plants, home furnishings, etc., attracting different age groups to come.	**[Accessibility]** A large vegetable field surrounded by residential communities is convenient for nearby residents to come and plant; **[Space Environment]** The path is clear, and a home for the elderly is set up in the center of the vegetable field, where you can rest/ leisure;The cabin tool room is set in a convenient place, and the facilities such as watering and fertilizing are easy to use; **[Neighborhood social atmosphere]** The vegetable field is a place where nearby residents often gather. Children's playgrounds and physical exercise facilities are set up around the elderly's home, allowing multiple age groups to chat and hold activities here.	**[Space Environment]** The materials, facades, and window openings of the historic buildings are completely preserved. Iron art, wooden rest seats and colorful coffee bars are added to the inner courtyard square, which is harmonious and unified with the old building environment; **[Aging design]** The ground is covered with anti-skid tiles, there is no height difference in the site, and there is a ramp leading to the building; **[Neighborhood social atmosphere]** Residents and the elderly who live here will rest or pass by here. There are many art centers and bars used by young groups. Different age groups can share and communicate in the square.

Tab 18 Analysis of design points of cross-generational co-living space in research cases

3.3 Semi-structured interview

Interview in Shanghai

The main objects of the semi-interview of Shanghai cross-generational co-living space are user groups and managers. For the interview outline, please refer to Appendix 1. According to the interview results, words with similar meanings are classified. For example, the interviewee's expressions of "come easily" and "can walk over" are summarized as "walking"; "very comfortable" and "good environment" are summarized as "comfort". By summarizing the relevant subject words, it can be found that the spatial influence factors that both user groups and managers are concerned about include site environment, indoor space, institutional operation and activity organization, and neighborhood social atmosphere. The user groups will also have personal characteristics of residents.(see table 19,table 20).

From the interview results, there are differences in the content of attention of different age groups. Older people pay more attention to accessibility and social environment: it is not convenient for them to pass from home, and whether there are other people to chat with and participate in community activities. For them, if they need to go out for a long distance to find leisure places such as shopping malls, chess and card rooms, table tennis rooms, etc., the elderly who are aged at home are not willing to go often, and the ones closest to home do not need to go very far. The community center is a suitable choice to pass the time and have fun. For preschoolers, interviews with older adults and adults with children show that distance and safety are key considerations. Adequate indoor and outdoor children's play facilities will attract parents to bring their children, and there will be management staff and nearby residents in the community center to take care of them together. For young people, due to their limited time and energy, they will only choose to participate according to their preferences when a variety of activities are organized. Most of the time they can use is the lunch break, and the most attractive feature is the community cafeteria. According to the results of interviews with managers, time and daily routine are the primary factors restricting whether groups of different age groups can interact and communicate frequently. Secondly, in the preliminary design or initial transformation stage, the barrier-free and aging-friendly design at the physiological level is the key point. , without considering creating a space environment suitable for cross-generational communication, many spaces are completely closed and independent. Even though the event organization is not divided into age groups, the Internet and new media are combined in the publicity, but the main group of participants is still the elderly.

Judging from the frequency of mentioning keywords, the top-ranked content that user groups pay attention to are: type of activity, scope of activity, inter-generational communication environment, adequacy of equipment and facilities, frequency of use, physical condition, method of use, and subject of use. The top contents that managers pay attention to are: opening hours, users, operation planning, service scope, activity types, cross-generational communication environment, barrier-free facilities, information release, space openness, comfort, etc.

Topic	Subtopic	Examples of Statements	People Mentioned	Frequency
resident personal characteristics	physical conditions	My body is ok, I go out to exercise every day, walk slowly, and get some sunshine./ I have bad eyesight, can you help me find out what time it is open?	SHYP03 elderly/SHHP01 elderly/SHBS02 elderly	3
	family situation	My wife and I live by themselves, she sings at home and doesn't go out for a walk with me./ I live with my children, they go to work during the day and no one accompanies me.	SHYP01 elderly/SHYP03 elderly	2
	lifestyle	Generally, I come to read the newspaper and chat in the morning, go home for dinner at noon, sleep at home in the afternoon, and rest after dinner and watch TV in the evening.	SHYP01 elderly/SHYP03 elderly	2
	place to do activities	I live in this neighborhood, and I usually come here when I take a walk; I live in a nearby community, not far away, so I will come here for classes./ we all live nearby, and our main activities are usually in this area.	SHYP01 elderly/SHYP03 elderly/SHYP03 youth/ SHHP01 elderly/SHPD01 elderly/SHBS02 elderly	6
site environment	walking environment	We usually come to the Fourth Neighborhood center, and we don't need to go to the First or Second Neighborhood centers. If we go too far, we just come here; it is more convenient for me to walk from home.	SHYP03 elderly/SHBS02 elderly	2
	barrier-free facilities	I usually stay on the first floor, there is no elevator, my legs and feet are inconvenient, and I don't want to climb the stairs to the second floor.	SHYP01 elderly	1
	surrounding facilities	There is a place for exercise in the community, there are shops, supermarkets, snack bars and the like outside, and life is very convenient.	SHYP03 elderly	1
	reservation method	Many activities have to be reserved in advance to participate, and the health code must be checked. I can't use a mobile phone, which is inconvenient; it was not an appointment system before.	SHHP01 elderly/SHPD01 elderly/SHBS01 youth	3
	nature	There is a garden outside, I can take a walk here.	SHYP03 elderly	1
indoor space	comfort	This place is very good, our room is small, there is no such place to do activities./ The second floor is very quiet and comfortable, suitable for us to read and write homework.	SHYP01 elderly/SHYP01 students	2
	aesthetics	There is a photo wall on this side of the corridor, which has been renovated, and the background is the historical photos of Shanghai Lilong.	SHYP03 youth	1
	functional diversity	In the salon on the second floor, in addition to showing movies every week, there will be university students nearby to hold exhibitions and lectures./ This reading room also functions as a restaurant, chatting and playing cards.	SHYP03 youth/SHPD01 elderly	2
	adequacy of equipment	Positive: there is a place to charge, we can play games here; there are water and snacks at the front desk, which is very convenient; the equipment is complete, and rest and exercise can be satisfied; indoor and outdoor children's play facilities are complete. Suggestion: As we are old, it is very difficult to buy a spit burner, and we need an elderly canteen; the outside facilities are for children to play, and there are fewer physical exercise facilities for the elderly.	SHYP01 elderly/SHYP01 youth/SHYP03 elderly/ SHBS02 elderly	4
	safety	There are special children's amusement facilities, some people are watching, and the safety factor is high.	SHYP01 middle-aged people/SHHK01 middle-aged people	2
	open degree	Children on the first floor play a lot and don't feel noisy. Children are very lively here.	SHYP01 elderly	1
	privacy/sense of boundaries	I usually participate in activities downstairs, it is lively, I can watch children play and chat with others; I come upstairs when I want to be quiet; there is a bookstore here that specializes in mental health counseling for teenagers;	SHYP01 elderly/SHYP03 youth	2

Note: Table continues on next page

institutional operation and activity organization	information release	Publish volunteer activities through the platform; generally see the activities to be organized in the near future in WeChat groups or public accounts; there will be a whiteboard at the door to write this week's activity schedule.	SHYP03 youth/SHPD01 elderly	2
	main users	The young people participating in the volunteer service are all college students in the surrounding area; they are generally used by the elderly in the community; there is an activity room specially for the elderly next to it; there are not many people from other age groups.	SHYP03 youth/SHPD01 elderly/SHBS02 elderly	3
	frenquency of use	I come to Chinese painting class every morning; I will come every week when there are activities; I will bring my children to play on weekends; I will come here every day during the lunch break.	SHYP03 youth/SHYP03 elderly/SHHP01 elderly/ SHBS02 elderly	4
	types of activity	I come to sing Shanghai songs every day; we come to line dance every day; I like to come here to take Chinese painting classes and calligraphy classes; there are activities here regardless of age group, and I will come to participate in health activities such as health physiotherapy and moxibustion when I have time. ; I will come to eat at noon; I will come to yoga classes and handicraft classes on weekends; sometimes I bring my children to play in the children's playground; there are regular salons and movies.	SHYP01 elderly/ SHYP01 youth/SHYP03 elderly/ SHYP03 youth/SHHP01 elderly/ SHBS01 youth/ SHBS02 elderly	7
	ways to attract young people	Volunteer activity positions that attract young people will be posted here, and there will be responsible persons recruiting us on campus; there will be incentives to participate in volunteer activities, such as rent-free, rewarding food, etc..	SHYP03 youth	1
	number restrict of people	There are too many people in the community who want to use it, and there is no place to sit here. You can only enter by making an appointment to do activities.	SHPD01 elderly	1
neighborhood social atmosphere	ageing situation	Generally, seniors over 70 years old come to this place; I am 85 years old, and most of the surrounding areas are lived by seniors like us.	SHYP03 youth/SHBS02 elderly	2
	volunteer service	Every week, there will be volunteer young people to teach us about mobile phones and to show us some entertainment activities.	SHYP03 elderly/SHBS02 elderly	2
	cross-generational communication environment	There are very few young people, and basically the elderly come here; there are young people who teach courses on mobile phones, and I will always find a young man who teaches me; the elderly hope to have young people they know to interact and communicate; after bringing their grandchildren, I need to communicate more with people of other ages, so I come here to have a class with everyone; children are very lively here, I hope young people like you often come to chat with us.	SHYP01 elderly/ SHYP01 youth/SHYP03 elderly/ SHYP03 youth/SHPD01 elderly/SHBS02 elderly	6

Tab 19 Related topics mentioned by users

Topic	Subtopic	Examples of Statements	People Mentioned	Frequency
site environment	walking environment	Positive: The Neighborhood Center can also come directly from outside the community; residents from nearby streets can walk there;	SHHK02 officer/ SHJA01 officer	2
	barrier-free facilities	Positive: door ramps and indoor elevators are very convenient for the elderly with poor legs and feet; Negative: There is no elevator, some people complained, this was not taken into account when setting up before; the activity areas are mainly on the second floor, which is not convenient for the elderly;	SHYP05 officer/ SHYP02 officer/ SHHK02 officer/ SHHK03 officer	4
	surrounding facilities	Positive: There are many supporting facilities around, so the needs for eating are not too big;	SHYP05 officer/ SHHK02 officer	2
	service area	Positive: There are four good-neighborliness centers covering 17 neighborhood committees, some are for the elderly, some are for young people, and some are for children; at the beginning, they were established to radiate the entire xx community and surrounding areas;	SHYP02 officer/ SHHK01 officer/ SHHK03 officer/ SHJA01 officer/ SHPD01 officer/ SHBS01 officer	6
indoor space	pre-planning	Positive: the community spontaneously participates in the design; the initial preparation is with everyone, including communities, streets, third-party organizations, etc.; Negative: The combination of accessibility, open space and private space was not considered in the design from the beginning;	SHYP02 officer/ SHYP05 officer	2
	comfort	Positive: The environment here is very comfortable, and it was recently renovated; it was originally a community library, but it was renovated and renovated;	SHHK03 officer/ SHHK02 officer/ SHPD01 officer	3
	aesthetics	Positive: imitating Shikumen culture, very distinctive;	SHYP04 officer	1
	adequacy of equipment	Positive: there are toilets and parent-child activities, which are much better than before; Negative: The remodeled space was not barrier-free before, and elevators need to be added; at present, the aging community is relatively serious, and canteens need to be added;	SHYP04 officer/ SHYP05 officer	2
	safety	Positive: there are escape routes in the basement; Negative: no fire diagrams, just simple signs on the ground;	SHYP04 officer/ SHHK02 officer	2
	open degree	Positive: closed rooms are less conducive to communication, and open spaces are more conducive to integration; Suggestion: It is more convenient to combine shared space and small space, and the room like Vanilla Bar is open;	SHYP05 officer/ SHHK01 officer/ SHHK02 officer	3
	privacy/sense of boundaries	Negative: It is difficult to carry out activities in the lobby; open spaces that are too noisy and too crowded are not conducive to the development of individual activities.	SHYP05 officer	1

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institutional operation and activity organization	operator/ planning subject	Usually, the operation and organization of the Neighborhood Center is handed over to the neighborhood committee; the whole is operated by the community and the street; the activities are contracted to third-party social organizations; different types of activities are organized and planned by different people.	SHYP05 officer/ SHHK02 officer/ SHHK03 officer/ SHHP01 officer/ SHJA01 officer/ SHPD01 officer/ SHBS01 officer	7
	openning time	Positive: Community activities are all held here. Before the epidemic, they were open 24 hours a day. They usually open from morning to night, and there is no rest at noon, because young people will come to use it at noon. The renovated one has been in operation for almost a year. It has been more than ten years; after the epidemic, the door will be closed at noon for an hour every day, and it will be opened until 5 o'clock in the afternoon for another hour, and it will be open until 8 o'clock in the evening;	SHYP01 officer/ SHYP04 officer/ SHYP05 officer/ SHYP02 officer/ SHHK01 officer/ SHHK02 officer/ SHHK03 officer/ SHHP01 officer/ SHJA01 officer/ SHPD01 officer/ SHBS01 officer	11
	information release	Positive: There are public accounts of the Neighborhood Center and community volunteers; courses will be sent to volunteer groups; information is released through the bulletin board at the door; Negative: Some messages are sent through apps and platforms, and elderly people who do not know how to use smartphones know how to sign up;	SHYP05 officer/ SHYP02 officer/ SHJA01 officer	3
	main users	Positive: There are people of all ages, children, white-collar workers, and the elderly; in the middle of the week, the elderly come, and more preschool children come during normal hours; there are more people in this community, and other communities such as table tennis clubs make an appointment Negative: The activities are not divided into age groups, but only the elderly have time to participate in the daytime during the week; the door closes after 5:00 pm, and students cannot come after school; the normal opening hours are not very friendly to young and middle-aged people with children, They all have to go to work, and people only come when there are activities on weekends;	SHYP02 officer/ SHYP04 officer/ SHYP05 officer/ SHHK01 officer/ SHHK02 officer/ SHJA01 officer/ SHPD01 officer/ SHBS01 officer	8
	frenquency of organizing activities	Positive: Basically there are regular activities every week; Negative: If there is no event in the near future, basically no one will come to use it; after the epidemic, group activities need to be reserved in advance, and the frequency of use will be reduced;	SHYP05 officer/ SHHK01 officer	2
	types of activity	Positive: There are many courses for the elderly and preschool children, such as illustration, calligraphy, reading, etc., as well as for young white-collar workers, such as baking, yoga, etc. There are many types of activities, including sports, entertainment, learning, culture Publicity; convenience activities will attract various age groups to come and use, and there are also activities on Respect for the Aged;	SHYP05 officer/ SHHK02 officer	2
	ways to attract young people	Positive: Will go out and engage in activities with other communities, not only for people in this community; prepare some activities that young people like, such as yoga, baking, handicraft, etc.; Negative: Young people are busy and need time, for example, they only come to participate in activities during the lunch break at noon;	SHYP01 officer/ SHYP05 officer/ SHHK01 officer/ SHHK03 officer/ SHBS01 officer	5
	number restrict of people	The number of people participating in the activity is related to the size of the space; there are several activity rooms, and activities will be organized separately;	SHYP05 officer/ SHHK01 officer	2

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neighborhood social atmosphere	ageing situation	Positive: the mobile app receives information, we will teach the elderly who will not use it Negative: The aging of the community is relatively serious, and almost 40% of the people living here are the elderly living by themselves;	SHYP05 officer/ SHJA01 officer	2
	teaching point/ social work service center	Volunteers are developed from community residents. Volunteers, regardless of age group, will help to do some community publicity, organize activities, etc.;	SHYP04 officer/ SHYP05 officer	2
	cross-generational communication environment	Positive: the elderly and children have space for activities; as long as there are activities for all ages, all kinds of people will be attracted, and everyone does not mind socializing together;There will be activities on the second floor, such as movies, singing, dancing, etc. At this time, the elderly and other age groups will participate together; Negative: Generally, activities suitable for the elderly and young people are not deliberately arranged; there are fewer elderly people during the time period when young people come, and there is not much interaction between the elderly and other age groups;	SHYP01 officer/ SHYP05 officer/ SHYP02 officer/ SHHK01 officer	4

Tab 20 Related topics mentioned by principle/officer

Interview in Florence

During the site visit in Florence, the author conducted consulting exchanges with a total of 15 users and managers. Among them, seven representatives were selected for semi-structured interviews, namely Silvia Senatori, a medical staff member of the FIQ103 pension institution Montedomini, Mauro Megli, the chairman of the FIQ503 mutual aid organization Arci, Cristiano Balli, the mayor of the Q5 neighborhood in Florence, and Lara Arbo, the chairman of the FIQ504 Social Garden. Franca Salvini, chairman of the FIQ505 Elderly Retirement Center, Paola Pivetta, a member of the Social Work Association of the Q5 neighborhood district chief, and Giovanna Malgeri, the chairman of the FIQ501 mutual aid organization Arci (see table 21 for interview time and location records). Since the communication in Italian is not very smooth, the author, accompanied by the translation by the foreign tutors Torricelli and Wang Qiong of the University of Florence, learned about the current basic situation of the community centers, nursing homes, and services for the elderly in Florence. The interview outline is detailed in Appendix 2- Appendix 4, and content are recorded. The interviews were mainly carried out around the four aspects of basic information, architectural space environment, social environment, and others (serving the elderly, community collaboration, etc.). Table 22 can be obtained by summarizing the relevant subject terms.

Judging from the frequency of keyword mentions, the top-ranking content that user groups and managers pay attention to is: daily activity arrangement, functional support, service for the elderly, cross-generational communication, operation, shared communication space, etc. According to the interview results, Florence's services for the elderly include not only community organizations managed by the government, but also many private organizations. The predecessors of many of these institutions were the original mutual aid organizations and volunteer assistance in different regions, and developed coordinating organizations such as Arci responsible for cultural activities, Montedomini responsible for elderly care services, etc. This is a bottom-up development process. There are many sources of funding for such institutions, some from the municipal government, some from enterprises, other social organizations, etc. Some of the work or management personnel involved are assigned by volunteer organizations, and some are developed from members of this organization. There is no age limit. Before the epidemic, there will be regular full-time employees and part-time employees. After the epidemic, most of them will be part-time employees.

During the interview, the person in charge of the agency showed us the history of the agency in charge, which also included the reasons for the site selection, such as the nursing home converted from the infectious disease hospital, the community center built on the site donated by local residents, etc. These historical backgrounds will also be presented together

Fig 23 Ceramics workshop for the elderly

Fig 24 Port medals mass-produced for Q5 district

with the community culture through murals, exhibits, texts, photos, etc., such as display in the entrance hall, making brochures, uploading to the introduction website of the institution, etc. The public spaces commonly used by the elderly are generally bars (bars including light meals, coffee, etc., which are not the same concept as domestic bars), canteens, chess and card rooms, courtyards, entrance halls, sports and fitness rooms, etc. Most of the communication is to participate in common activities (such as ball games, cultural games) and use public spaces (such as restaurants, libraries, billiard rooms). The measures to increase cross-generational communication are to organize public welfare activities suitable for all ages, such as writers' meetings, summer garden concerts, ceramics making courses, etc., and to create more ways to attract young people, including more discounts. The price invites them to register as members, offers free language lessons, invites them to paint on building facades, and more.

The organization of these activities and the creation of the architectural space environment are similar to the community centers and neighborly centers in Shanghai. The difference is that the elderly in Florence will be more active in participating in various activities, because many institutions are run by their local residents. Organized spontaneously, it has a long history that has been handed down. At the same time, many part-time jobs are also related to the activities of local communities or government organizations. For example, when we investigated the elderly homes in District 5 in July 2022, we visited their ceramic handicraft workshops and firing rooms. The old man is making the medals of the "Quartiere 5. Assegnati i premi Villa Pallini" (Quartiere 5. Assegnati i premi Villa Pallini) of the five district government every summer, see figure 23, figure 24, and learned from the interview and exchange that from design, firing and molding to the top The colors are all done independently by the elderly, including the Christmas decorations made by them every year and distributed to various streets. There are still many elderly people in the community who can take care of themselves and move easily. They will volunteer and help the older elderly.

The participation of young people is much lower than that of the elderly, which is related to their spare time and living habits. There are many measures to encourage young people to participate together. For example, the Montedomini canteen in District 1 is shared by the elderly and students of the University of Florence; the SMS Mutual Aid Organization in District 5 cooperates with surrounding universities to reserve some study rooms for students in the community center building, One of the three seats on the board must be reserved for young people; many institutions and organizations lend free space to young people to hold events and so on. Even if young people in Florence do not interact with the elderly frequently, they still have more time to participate in these public welfare activities compared to the fast-paced life in Shanghai.

Time	Location	Visiting institution	Contact person	Interviewee
16/05/2022 11.00	via De' Malcontenti 6	ASP Firenze Montedomini	Dott.ssa Silvia Senatori	Dott.ssa Silvia Senatori
25/05/2022 9.30	Via Pratese, 48	S.M.S Peretola - Società Mutuo Soccorso Peretola (ARCI)	Sig. Mauro Megli	Sig. Mauro Megli
09/06/2022 15.00	Villa Pallini in via Baracca 150/P	Presidenza del Quartiere 5	Sig.ra Francesca Minna	Sig.Cristiano Balli
28/06/2022 9.30	Via Carlo Bini 5/A,Via Maestri del Lavoro 3	Centro Età Libera Rifredi Romito Vittoria e laboratorio	Arch. Tucci Fabrizio	Sig.ra Franca Salvini
09/09/2022 10.30	Via Reginaldo Giuliani 115n	Rete di Solidarietà Quartiere 5	Sig.ra Paola Pivetta	Sig.ra Paola Pivetta
01/10/2022 16.00	Via Vittorio Emanuele II 303	S.M.S - Società Mutuo Soccorso di Rifredi (ARCI)	Paola Pivetta	Sig.ra Giovanna Malgeri

Tab 21 Basic Information Records of Interviews in Florence

Topic	Subtopic	Examples of Statements	People Mentioned	Frequency
basic information	openning time	It is closed every Sunday, and the other hours are from 8:00 am to 7:00 pm, and from 9:00 pm to 12:00 pm; except for summer, there are more people using it in the other three seasons, especially in winter, there is heating for socializing; young at night more people;	FIQ503 officer /FIQ504 officer	3
	daily regular activities	There are study courses, regular reading clubs, life-related activities, sports activities, etc.; there are third-party organizations to go to the beach, museums and other activities; there are many activities organized: painting, pottery, dancing, aerobics, vegetable gardens, drama, visiting museums;	FIQ103 officer/FIQ201 elderly/ FIQ202 officer/ FIQ503 officer/FIQ504 elderly/FIQ505 officer	6
	age of main users	Mainly elderly people over 65 years old; more than half of the annual members are retirees; young people will organize activities as volunteers;	FIQ103 officer/FIQ401 youth/FIQ503 officer	3
	management	Volunteers and management personnel are entrusted to third-party associations to recruit; some volunteers or management personnel are developed from members, and some residents of surrounding communities voluntarily participate; there are 892 community activity centers in the 5 districts;	FIQ103 officer/FIQ502 youth/FIQ503 officer/ FIQ505 officer	4

Note: Table continues on next page

architectural space environment	site selection criteria	It used to be a local mutual aid organization, which was composed of nearby sand washers and masons. The current site is the land donated by its members; the site selection is related to its historical background, for example, it used to be a rescue organization; it should be distributed as evenly as possible in the entire area, so as to Smaller-scale streets and jurisdictions are arranged in a wide range;	FIQ103 officer/FIQ503 officer/FIQ504 officer/ FIQ505 officer	4
	comfort	The elderly will be allowed to bring soft furnishings from home, and the hard furnishings are uniform;	FIQ103 officer	1
	aesthetics	There is a display about this cultural center in the reading corner; introduce the local historical background through text, pictures, original organization badges, etc.;	FIQ103 officer/FIQ503 officer	2
	functions	There is a bar at the entrance, a restaurant and a reading corner on the first floor, a billiard room on the first floor, etc.; courtyards, bars, theaters (cinemas), cafeterias, places to play the piano, rehabilitation rooms, etc.; homes for the elderly, art galleries/museums, Gymnasium, vegetable garden, park, etc.;	FIQ103 officer/FIQ301 elderly/FIQ503 officer/ FIQ504 elderly/FIQ505 officer	5
	public and sharing space	Young people like to play billiards and table tennis with the elderly, and the sports venues are shared and communicated more; the public area is for the elderly living here to communicate with their relatives and friends who come to visit them; the canteen (Florence Students from the university's Faculty of Architecture also dine here), the theater (cinema) is under renovation;	FIQ103 officer/FIQ202 officer/FIQ401 elderly/ FIQ503 officer	4
social atmosphere	sufficiency of equipment and facilities	Before the epidemic, the bar and restaurant were open every day (before the epidemic, the restaurant (equivalent to the cafeteria) provided lunch every day, after the epidemic, the restaurant will only be open for use when there are (scheduled) activities, and the bar is in normal use; to ensure the continuity of all services, At the same time, add cultural, social and other public facilities;	FIQ103 officer/FIQ301 officer/FIQ505 officer	3
	cross-generational communication	The elderly like to come here to socialize. For example, some members bring their juniors here to participate in activities, do volunteer services, help out, etc.; we will arrange for the elderly to give children extracurricular tutoring, teach them to draw, rehearse dramas, etc. The elderly or families with minors can apply for a vegetable garden to experience growing vegetables;	FIQ103 officer/FIQ301 elderly/FIQ503 elderly/ FIQ504 elderly/FIQ505 officer	5
neighborhood social atmosphere	service for elderly	Third-party organizations will lead disabled elderly people to visit the city; elderly people in nearby communities can enjoy services such as singing and dancing, playing sports, visiting art galleries, making ceramics, and going to theaters;	FIQ102 elderly/FIQ103 officer/FIQ503 officer/ FIQ504 elderly/FIQ505 officer	5
	community cooperation and coordination	It is a non-profit cultural association. The government does not allocate funds, but it will cooperate with the city government, such as arranging immigrants to learn Italian and helping them integrate into society; different types of activities will form different networks, such as medical care, education and other fields;	FIQ103 officer/FIQ504 officer/FIQ505 officer	3
	ways to attract young people	Provide low-rent housing for young artists, organize commercial and artistic activities; issue membership cards with half-price discounts for young people; publish volunteer activities; set up courses that young people need, and provide party venues;	FIQ101 youth/FIQ501 officer/FIQ505 officer	3

Tab 22 Related topics mentioned by users and principle/officer

3.4 Comparative analysis

According to the survey results, from the four aspects of ageing background, characteristics and habits of the elderly, the built environment of the neighborhood, operation management, the similarities and differences between the current situation on the elderly people and cross-generational co-living space in Shanghai and Florence are compared. The brief points are summarized in the following table 23, table 24.

According to China's "Urban Residential Area Planning and Design Standard GB50180-2018" design standard for supporting facilities: in the 15-minute living circle residential area, service facilities such as cultural activity centers, community service centers (street level), and street offices should be combined to a comprehensive street service center, the land area should not be less than 1hm². Among the five-minute living circle, there are community service stations, cultural activity stations (including youth and elderly activity stations), day care centers for the elderly (nursery centers) , community health service stations, community commercial outlets and other service facilities that should be centralized and jointly built to form a community comprehensive service center, and the land area should not be less than 0.3hm². Looking at the neighborhoods around SHYP01, the observing object in Shanghai, within a walking distance of 500 meters to 1,000 meters, there are necessary equipment and facilities such as the Neighborhood Center, Health Station, and Activity Room for the elderly, and the service radius of the cross-generational co-living space is about 1,000 meters.

There are no gated neighborhoods in Florence. From the perspective of the entire Q1 neighborhood area, the distribution of cross-generational co-living space such as activity centers, homes for the elderly, and game rooms is relatived to churches, residential community and the surrounding historical context. It is different from Shanghai's uniformly setting of service points based on residential groups, and it is more similar to the model of natural growth and development. Comparison of the distribution of cross-generational co-living space at the scale of two urban areas (only counting quantifiable service points such as neighborhood centers, community activity centers, and homes for the elderly, excluding urban open spaces such as squares, streets, and green spaces) see figure 25.

Conclusion

Based on the theoretical basis, it conducts field research on the design practices of the existing cross-generational co-living space in Shanghai and Florence, and conducts semi-structured interviews, comprehensively collected and analyzed the status quo of old-age care in the two cities. The similarities and differences between the two cities' old-age care and cross-generational co-living environment are based on four levels:

(1) From the perspective of the social and elderly care background, both China and Italy are dominated by the family-centered society

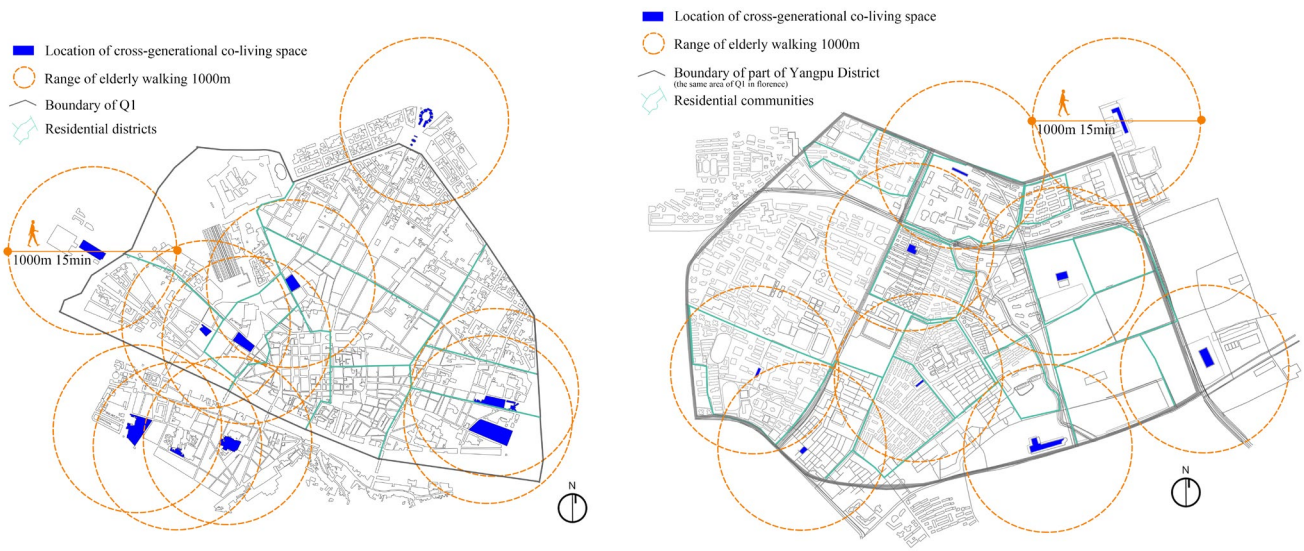


Fig 25 Distribution of cross-generational co-living space in FlorenceQ1 and Shanghai Anshan Village

and home-based elderly care as the main body. At present, the hotspots in the field of elderly care research are different. China still focuses on infrastructure construction and age-appropriate design, while Italy focuses on active aging, age-friendly cities and the construction of a healthy environment. The proportion of the elderly population over 65 years old in Shanghai and Florence is basically the same, but the classification and content of elderly care services are different;

(2) From the perspective of the characteristics and habits of the elderly, the basic daily routines and behaviors are relatively similar. The personal time of the elderly in Shanghai will be more family activities, and they need to take care of their grandchildren. The elderly in Florence basically continue their previous living habits. In contrast, they have more private lives of their own;

(3) From the perspective of the built environment of the neighborhood, since most of Shanghai are gated communities, Florence is mostly open block, so the road planning and walking environment are different. The service radius of the cross-generational co-living space is consistent with the walking distance of 1,000 meters for the elderly, but the elderly people choose the activity center/neighborhood center on different basis. In Shanghai, distance is given priority, while in Florence, function is given priority. The ages of new buildings and renovations in the two places are different. Shanghai has mostly new buildings after 2010, while Florence has mostly historical buildings after the 20th century. The space types are also different due to cultural differences. The design of the interior space focuses on comfort and barrier-free aging. The interior style of Shanghai tends to be modern and intelligent, while Florence mostly retains the local history and culture;

(4) From the perspective of operation and management, Shanghai's good-neighborhood centers/activity centers are funded and managed by the government, and there are few profitable projects. Most of Florence is organized and managed by local elderly voluntarily, and a small number of commercial activities are responsible for their own profits and losses. Both places will cooperate with third-party organizations to organize activities, recruit volunteers, etc., and will also create opportunities to attract young people to participate and increase cross-generational communication.

Compared with the fast-paced development of Shanghai, the pace of life in Florence is very slow. Although young people do not participate in the activities of the elderly to a large extent,

Number	Compared topics	Same and similar parts
(1)	ageing background	1) In China and southern Europe, the family-centered society is dominant[38], and the relationship between parents and children is close. Compared with institutional pensions, home-based pensions dominate. 2) As of December 31, 2020, the proportion of the elderly population over 65 years old in Shanghai was 25.9%, and Tuscany accounted for 25.9% at the end of 2021. The proportions of the two places are basically the same.
(2)	characteristics and habits of the elderly	The physical conditions, work and rest habits, and usual activities that most elderly people like to participate in are all similar. They usually do activities in the morning, take a lunch break in the afternoon, and go to bed earlier in the evening. Therefore, the time for cross-generational communication with other age groups is mostly concentrated at noon or evening.
(3)	built environment in neighborhoods	1) Considering the mobility inconvenience of the elderly, buildings such as activity centers for the elderly and neighborly centers are mainly low-rise buildings (1-3 floors), and a few are multi-storey buildings (4-6 floors). 2) At present, architectural design is mostly guided by functional requirements. The interior space focuses on comfort, and the aging-friendly design focuses on barrier-free.
(4)	operation and management	1) Cooperate with third-party organizations, and coordinate and cooperate among different regions; 2) Paper communication such as bulletin boards and posters is still the main way for the elderly to receive information, and faster media such as the Internet and mobile phone APP cannot cover most of the elderly; 3) Organize activities suitable for all ages to attract participation from other age groups, provide free courses and venues for young people, and create more opportunities for cross-generational communication by setting up volunteer posts to exchange for social benefits, half-price membership cards, etc., but due to reasons such as time, work and rest, and social pressure, the main users are still the elderly.

Tab 23 Similarities between the two cities

cross-generational co-living has not been deliberately emphasized, but the differences between the two places can be seen It is pointed out that Florence has a more relaxed and inclusive environment: for example, creating an age-friendly and healthy city and community; activities and services related to the elderly are collectively referred to as "free age"; self-sufficient elderly who have reached the age of 60 can go to the seaside holidays in , mountains and hot spring resorts; the elderly use their retirement time to work in libraries or museums, and use their spare heat in many jobs in the city, etc. At present, Shanghai is paying more attention to the improvement of infrastructure, and strives to cover a wider range of elderly care services: for example, the facilities of the neighborly centers/activity centers are complete and unified; modern decoration and intelligent system layout, etc. The current pursuit and development of social equality and a healthy environment in developed countries is a problem that China will inevitably face in its future social development. Combating age discrimination and promoting cross-generational mutual assistance are global issues of active aging.

Number	Compared topics	Different parts	
		Italy/Florence	China/ Shanghai
(1)	ageing background	1) The current research hotspots in Italy are age-friendly city construction, health, active aging, built environment, the elderly, nursing homes, public space, social isolation, etc., with emphasis on systems and structures such as healthy environment and urban community renewal. 2) The elderly care services in Florence are divided into: the needs of the elderly (by default, those who need help) - support services, pension institutions, medical assistance; retirement free time (Italian: eta libera, meaning free age) - elderly centers, Seniors holidays, social gardens, training courses.	1) China's current research hotspots in the fields of elderly care and co-living are elderly care facilities, aging, home-based care, combination of medical care and elderly care, cross-generational mutual assistance, family structure, etc., and the focus is on improving the aging-friendly design and infrastructure construction at the material level. 2) Shanghai's elderly care services are divided into: elderly care institutions, community care services, meals for the elderly, community elderly care service organizations, elderly activity rooms, and good-neighborly points.
(2)	characteristics and habits of the elderly	More daily time belongs to oneself, continuation of previous living habits, private life is more private and independent.	Most of the daily time belongs to grandchildren and families, and private life is more public and open.
(3)	built environment in neighborhoods	1) Open blocks, without the concept of a gated community, the streets and alleys are small in size, with little traffic and suitable for walking. 2) Related to the local historical and cultural background, the functions and services of activity centers/homes for the elderly in different locations and blocks are different (for example, some are equipped with theaters and cinemas, and some are equipped with large billiard rooms and game halls, etc.), so the elderly People choose to use according to the activity content and preferences. 3) Part of the land is privately owned, and some buildings are donated by local residents, most of which are new buildings or historical building renovations after the 20th century. 4) There are many buildings with brick-concrete structure, including loggias, corridors, outdoor dining areas, churches and other space types. 5) The interior space pays attention to the inheritance of history and culture.	1) Most of the gated communities have large blocks and roads, and the road conditions are good, but the traffic volume is large and the walking environment is average. 2) According to the "15-minute living circle" planning and layout, the functional facilities such as each neighbor center/community activity center are basically the same, so the elderly choose to use them according to the principle of distance priority. 3) The land is state-owned, and most of the good-neighborlines centers were built after 2010 (including renovation time). 4) There are many buildings with frame structure, including sunken courtyards, gray spaces and other space types. 5) The interior space pays attention to modernity and intelligence.
(4)	operation and management	1) There are mostly local residents and volunteers, most of whom are spontaneously organized, and more inclined to a bottom-up management model. Most of the work and management personnel are elderly people who participate voluntarily without compensation. 2) Most of them have no source of government funds, and rely on social donations and profit income (such as bars, billiard rooms, bingo games) to balance expenditures.	1) Streets and neighborhood committees are the main body, and middle and high-level staff are mainly young and middle-aged people, and they prefer a top-down management model. 2) Government and other social organizations provide funds, each service point is basically all public welfare, and there are few profitable projects.

Tab 24 Differences between the two cities

Chapter 4
Analysis of spatial configuration

Chapter 3 collects and compiles the specific design strategies of the current cross-generational co-living space and the views and opinions of various groups by sorting out relevant literature and on-site research and visits. This chapter starts from the perspective of spatial layout and uses the theoretical tool of space syntax to study the impact of cross-generational co-living spatial layout on accessibility, interactivity, and sight communication(figure 26). The goal is to study the characteristics of the layout of cross-generational co-living space, explore the spatial forms, space types and area scale where cross-generational communication is prone to occur, and summarize and improve the influencing factors of cross-generational co-living space.

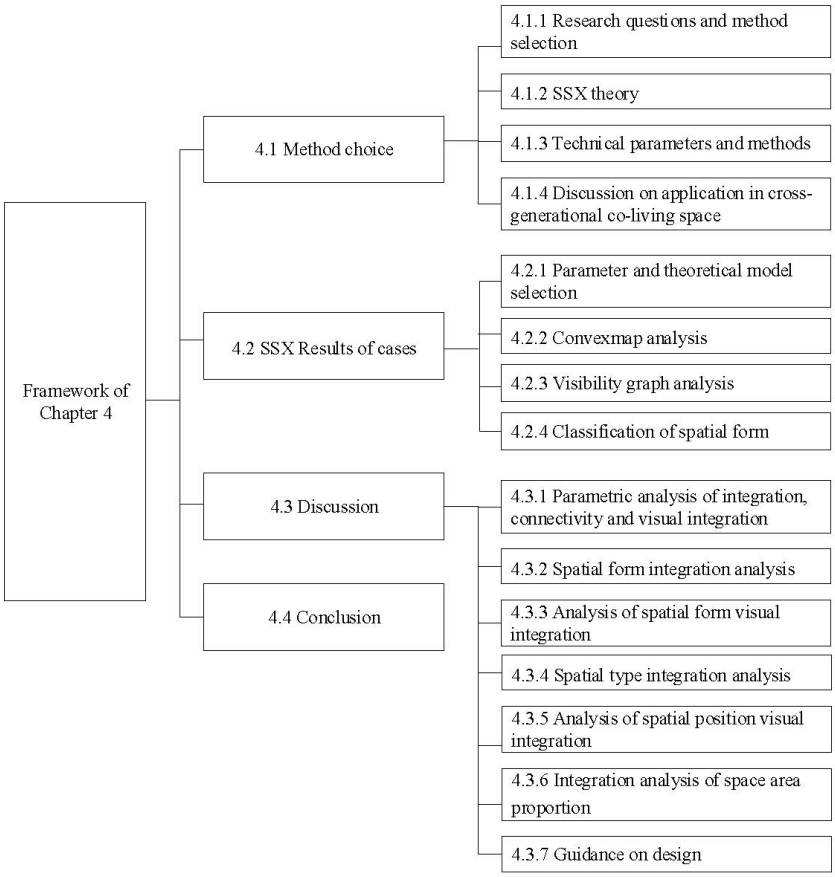


Fig 26 Framework of chapter 4

4.1 Method choice

Research questions and method selection

Cross-generational co-living space design is to increase the interaction between the elderly and people of other age groups, so it is particularly important to explore spaces that are prone to interactivity in indoor and outdoor environments.

Generally speaking, in the same environment, spaces that are more connected to other spaces are easier to choose and use, and it is easier for people to interact. So mathematically speaking, the problem can be transformed into quantifying how connected a certain space is to other spaces in the environment. In the field of architecture, the forms of space are endless. If we simply study the form of space, we will fall into the bottomless abyss of graphics. Therefore, the object of space research must be the spatial organization structure extracted through abstract methods (Yoon, 2004). This involves geometric graph theory methods. "Graph" is the main research object of graph theory. A graph is a graph composed of a number of given vertices and the edges connecting two vertices (Shen,2011; Jin & Jiao, 2019). This kind of graph is usually used to describe a specific relationship between certain things. Vertices are used to represent things, and edges connecting two vertices are used to represent the relationship between two things.

After the graphics are abstracted, the degree of spatial connection can be studied, which involves the topology method of studying spatial connection relationships. Space syntax is the most widely used method in the field of architecture to study spatial connectivity based on graph theory.

In addition to space syntax, commonly used methods include Q analysis method (Earl & Johnson, 1981)and fractal analysis method. Q analysis was originally developed by Atkin based on algebraic topology (Atkin, 1972). It is a mathematical language used to structurally describe and analyze topological relationships between systems. Q analysis methods can be used to examine movement patterns and circulatory systems within buildings. and observing and creating connectivity between building spaces through individual movement paths, as well as identifying unique, central and unique movement areas and spaces within the circulation system (Omer & Goldblatt, 2017). This method mainly focuses on the relationship between the movement route of a certain building plane and the spatial nodes. However, it is difficult to obtain a large amount of route data for the survey examples, so it is not suitable for the multi-space comparative analysis of this study; Fractal theory analysis method is a branch of modern mathematics founded by Mandelbrot to describe irregular and fragmented geometric figures. The similarity between the fractal whole and the local form inspires people to understand the whole by understanding the parts, and to understand the infinite from the finite. When the specific spatial distribution form of the large

space cannot be determined, a smaller range of spatial forms is used for analysis "seeing the big from the small" . However, when the research object already has a clear spatial distribution drawing, there is no need to use this method (Malan, 2020).

To sum up, space syntax theory can use the principles of mathematical logic to quantify space and describe the logic of spatial organization with mathematical relationships. There is a certain correlation between the prediction of human flow and survey statistics. Therefore, in this article, the correlation between space syntax and survey statistical data can be used to analyze and evaluate the spatial distribution of people flow. By quantifying space, it can not only provide effective quantitative analysis of the social attributes of space for the elaboration and in-depth design research, but also enable space design to be optimized by combining perceptual creation with rational analysis. It can also rationally evaluate the built spatial structure based on the social attributes of the space and provide quantitative analysis basis, making the evaluation objective and scientific.

Although the data calculated by space syntax cannot directly reflect the specific conditions of people's activities in the communication space, from a macro perspective, it can predict the size and proportion of the flow of people in different spatial nodes in the community center. Secondly, by quantitatively describing the spatial structure and using specific numbers to illustrate the spatial organizational characteristics of cross-generational co-living spaces in residential communities, as well as the interactive relationship between spatial organization and human activities, we can further derive which types of spaces are suitable for cross-generational interaction. generation interaction and communication. Among the research examples of cross-generational co-living spaces, except for SHPT01 outdoor park and FIQ504 vegetable patch space, the other 24 cases are regular areas with small spatial scale. Therefore, a clear topological model can be established, using topological diagrams, convex space models and visual analysis, through quantitative indicators such as integration, connectivity, and total depth, conduct quantitative analysis to select spaces that are more in line with the behavioral habits and usage of the elderly, such as spaces that are more likely to produce static behaviors (such as staying, resting, talking, etc.).

Space Syntax Theory

Space syntax originated as a planned study in the early 1970s, when Bill Hillier, Adrian Leaman and Alan Beattie came together at UCL's School of Environmental Studies (now part of the Bartlett School of Architecture). Bill Hillier has been appointed director of the Department of Architecture Studies (UAS), succeeding John Musgrove. They established a new MSc course in Advanced Architectural Studies and embarked on a research program aimed at laying a theoretical foundation for

architecture. Previously, Bill Hillier worked as Secretary of the RIBA and co-authored papers, notably 'Knowledge and Design' and 'How Design is Possible'. These provide the theoretical basis for a series of studies aimed at elucidating how the built environment relates to society. An article "Space Syntax" in Environment and Planning in 1976 introduced this analysis method planning. They start from hypotheses and use derived formulas and indicators as well as some basic types of space syntax to provide a structured description of the problem. The concluding chapter of the paper considers the relationship between place and community as a starting point for the development of space syntax methodology (Hillier et al., 1976).

In 1984, the landmark book "The Social Logic of Space" was published, which emphasized that spatial configuration has an impact on social life and vice versa (Hillier and Hanson, 1984). Since then, the methodology has evolved into a design method that determines the nature of a space, helping to understand how buildings, areas, and even entire cities work. Space syntax has evolved into a tool used worldwide in various research fields and design applications such as architecture, urban design, city planning, transportation and interior design. Architecture and urban planning practice Space Syntax Limited was established in 1989 at University College London Bartlett and has completed a number of outstanding design applications. These include working with Foster and Partners to redesign London's Trafalgar Square using urban pedestrian movement models.

In 1997, the first world-class Space Syntax Symposium in London came into being. The first meeting decided to hold a Space Syntax Conference every two years thereafter. Architects, planners, and designers from all over the world gathered together to discuss The development and innovation of space syntax, and share their latest application and thinking of space syntax in their respective disciplines. The space syntax community has published many journal papers on the topic, mainly in Environment and Planning B. At present, most empirical research based on the principle of space syntax focuses on the following four aspects: research on the natural evolution of urban space (Bill & Tao, 2005), proposing effective means to solve the sustainable development problems of historical districts (Dai et al., 2020), and improving pedestrian systems and public spaces (Yang, 2007), and evaluate the spatial structure system of metropolitan sub-centers (Bill & Qiang, 2014).

The basic concepts of space syntax are explained based on two assumptions that attempt to reflect spatial objectivity. The first assumption is that space is closely related to human activity, and that space is not a support for human activity, but an important aspect of any human activity carried out through spatial movement. Space is intended to reflect the direct interaction between the space and its occupants and become humanized through this interaction

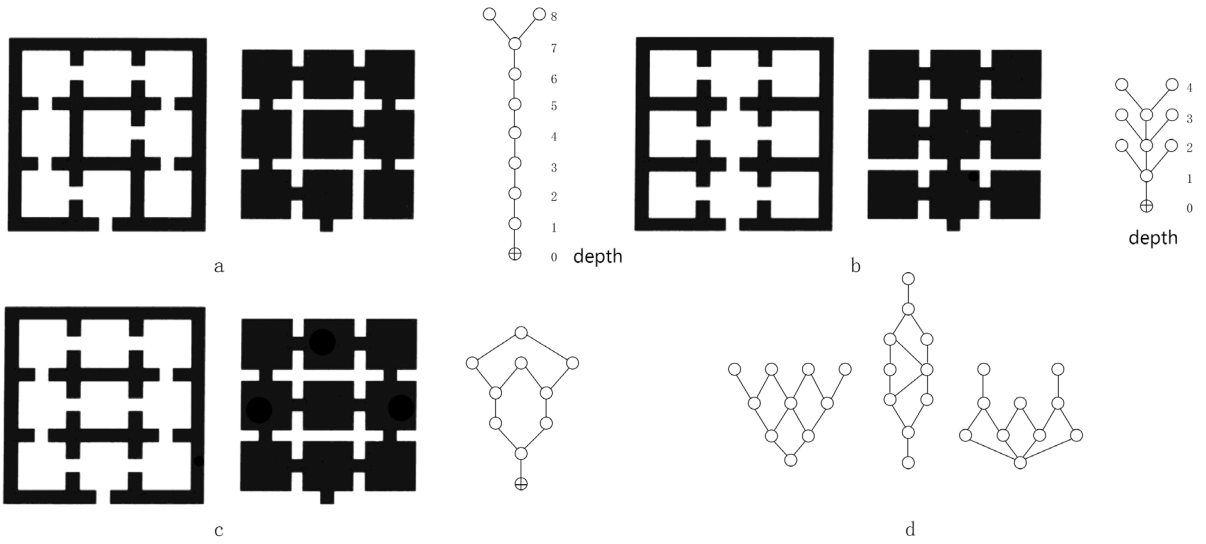


Fig 27 Topological depth illustration

(Hillier and Hanson, 1984, Hanson and Hillier, 1987, Hillier, 2008). Throughout the various civilizations the world has witnessed, space has always been a reflection of the activities and lifestyles of its inhabitants. Spatial analysis inevitably leads to an understanding of society and vice versa. A society is difficult to analyze because it involves factors that are difficult to measure in relation to humans (Bernard, 2000). The second assumption of space syntax is that space is basically a configurational entity (Hillier and Hanson, 1984, Hillier and Penn, 1991, Hillier, 1996, Hillier, 2008). Space is not only the characteristics of space taken individually, but also the relationship between different spaces that make up the entire building or city (Mahmoud and Omar, 2015). This paragraph would be better to be more understandable.

Space syntax has been deeply researched and developed for more than 20 years since it was proposed as the starting point of time, and has been continuously improved and perfected. With the support of theory, the technology and scale have developed even more. The first is the rise of space syntax consulting companies around the world, and the second is the continuous invention of space syntax-related software. For example, the Segmen software designed by Shinichi Iida analyzes based on the angle of the axis, actual distance, topological distance, etc.; Figueiredo (English) Both the mindwork software of the name) and the spatialist software of Pipponis (the English name) can perform space syntax-related analysis. Among them, the software confeego and depthmap have become the mainstream software for space syntax analysis due to their good integration with syntax theory and clear operation interface.

Technical parameters and methods

Space is usually described as a continuous and concrete three-dimensional entity (Franz and Wiener, 2008). To analyze architectural spaces, space syntax approaches typically transform or abstract certain aspects of spatial configuration into syntactic and discrete models (Bafna, 2003). Space syntax uses topological methods to study the relationship between spaces. It discards the GPS coordinate information of the space system and only examines the link relationships in the topological sense. It redraws the topological map into many states, which is called "space". Remapping (relationship remapping)" (see figure 27). To this end, the space syntax approach prioritizes the topological properties of a space over its geography, since people tend to behave (i.e. move) in topologically based ways (Ostwald, 2011). Therefore, space syntax methods use graph theory because it provides a perfect basis for analyzing topological relationships.

Space syntax summarizes the physical space in reality into abstract spatial elements, such as axial space, convex space and visual space; it summarizes behavioral patterns into movement, aggregation, observation and other modes, and concludes that movement corresponds to axial space, and aggregation corresponds to convexity. Space,observation corresponds to the

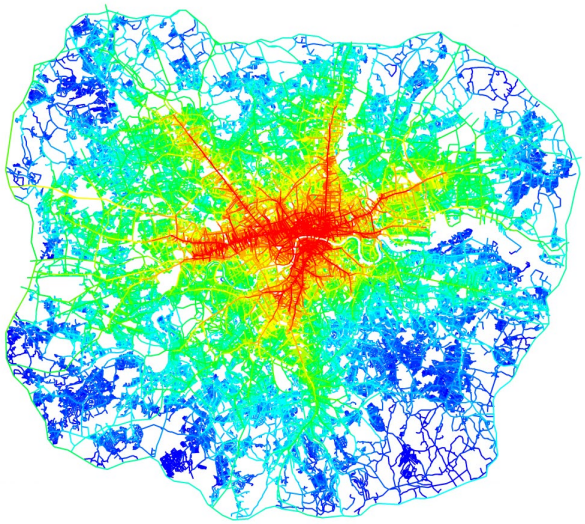


Fig 28 Greater London space syntax integration model

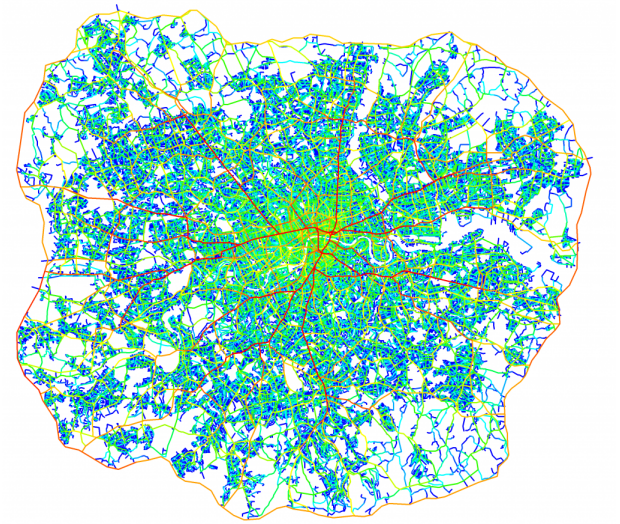


Fig 29 Greater London space syntax selection model

rules of visual field space. Abstracting space into graphics is accomplished by first simplifying the 3D space into a 2D plan or section, and then designing the graphics based on the properties of this simplified space. After the abstraction process, measurements are performed (Klarqvist, 1993). However, the definition and measurement of these values differ in the way the graph is created during the abstraction stage.

Space syntax consists of four basic components that are used in all space syntax applications:

1. Performance of space

Spatial elements are expressed through their geometric forms and how people experience them. They can be geometrically derived (e.g., points, axes, line segments, convex spaces, and isometric lines) or functionally defined (e.g., rooms in a building).

2. Spatial relationship analysis

The relationship between spatial elements arises from their configuration. These relationships can be analyzed objectively using various measures, including integration patterns (see figure 28) and selection patterns (see figure 29). These two measures reflect two basic elements of human movement: first, the choice of destination, and second, the choice of route. One measures ease of access (consolidation), the other measures the amount of traffic that gets through (selection).

3. Explain the model

Spatial models are developed to analyze, describe, explain and predict different types of spatial and socio-economic phenomena. In fact, the model was created to investigate empirical phenomena such as urban movement, urban crime, and centerlines as processes, as well as general processes such as spatial intelligibility.

4. Theory

Theorizing the relationship between space and social patterns aims to explore whether and how space is internalized into socioeconomic processes and through which the built environment is created. This is done in two ways. First, theory can be used to find commonalities in model patterns across functions and cultures. One example is universal urban theory. Second, theory can use space syntax tools to explore what happens to spatial patterns if objects in space are deployed and shaped differently.

The initial basic analysis methods of space syntax mainly focused on the axis method, the convex space method and the view area segmentation method. However, the first two of these three methods each have the problem of various axis drawing and convex space drawing methods. For the same space, Model drawings drawn by different people will lead to differences in analysis results. Later, with the continuous improvement of the theory, methods such as overlapping convex space, all line method, and viewport visible map analysis appeared.

1. Axis method

The most important analysis method in space syntax is the axis method, whose principle is to capture a series of processes by which the observer or observation point perceives space during self-motion. Taking the application of urban planning and design as an example, the

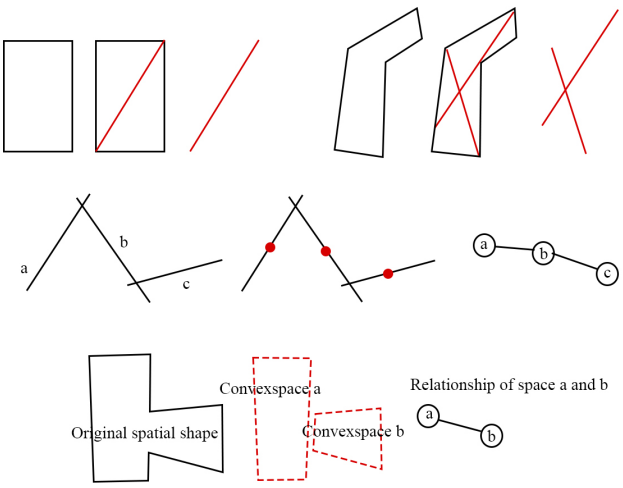


Fig 30 Convex space topology translation

axis method passes through the main path of the spatial movement of the observer's road movement in the city. The farthest place that the observer's sight can reach during the travel process will be determined as the axis. The axis method can accurately reflect the drawing principle of using the longest and least axis to cover the streets in the syntactic axis. The axis method emphasizes using the perspective of movement to perceive space, so it can be widely used in large-scale spatial types such as urban planning and scenic area planning. Through the quantification of the axis method and the graphical expression of the axis model, analysts can do a lot of analysis of large-scale spatial types, such as centrality analysis, integration core area city analysis, global and local relationship analysis, city or landscape analysis Recognizability analysis of areas, etc.

2. View area segmentation method

The basic method of the viewport segmentation method is to select several representative points in the space that needs to be analyzed, find the viewport of each point, and then generate a relationship based on the range and handover relationship of the viewports of these points. Diagram, and perform syntactic variable calculations for each viewport.

3. Convex space method

The definition of convex space in geometry is: if the straight line connection of every pair of points in the unit is in the unit, then the unit is a convex space. This definition can also be understood as that all points in the convex space have Visibility to other points, that is, every point in the space can see the entire space. From the perspective of sight, people can quickly grasp the overall intention of the convex space, because the sight lines of any two points in the convex space are unobstructed. This approach to space syntax begins by dividing a large space by covering the entire system with a minimum and maximum convex space (Hillier & Hanson, 1984) (see figure 30). Next, quantitative calculations are performed on different convex space units, and quantitative indicators such as control value, connection value, and integration degree are assigned to each convex unit, and then used different warm and cold colors are used to express spatial parameters (see figure 31).

4. All line methods

Bill Hillier believes that a simple object placed in a wire bundle can cause many adjacent lines to be infinitely related and tangent (including connected) to it. Then, all lines are tangent to this object (including connected). The sum of connected lines (Hilier, 1996). It can be seen that the all-line method is another analysis method derived from the axis method. As the name suggests, the all-line method performs analysis in a method similar to the exhaustive method and finding the limit value. The all-line method requires finding all the lines in the space in the space, and assigning relevant variables to each line, and conduct a comprehensive analysis. The principle is similar to that of the axis method,

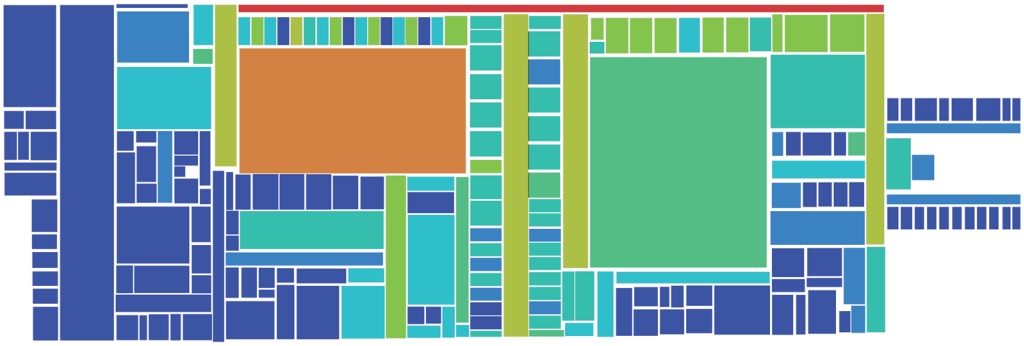


Fig 31 Comparison of convexmap integration and visual integration

but all line analysis methods can describe the microscopic space in a more detailed and detailed manner, and are more consistent with all possible sight lines given by the process of motion perception space. The disadvantage of all line analysis methods is the high degree of computer dependence during analysis because of the large number of lines generated during analysis and the large amount of data analysis.

5. Overlapping convex space method

Based on the convex space method, a more scientific method is derived, the overlapping convex space method. Here, the drawing requirements of the convex space are maximized, that is, the convex space drawn must be the largest convex space within the limited range of the space, which means that each convex shape must hit the peripheral entities or boundaries. In this way, some overlapping convex spaces can be obtained, which we call overlapping convex spaces. These overlapping parts generally have a larger visual range. The method of calculating the intersection relationship of spaces based on these convex spaces and calculating their syntactic variables is the overlapping convex space method.

6. Visible image analysis of the viewport

Visual relationship analysis is the study of the characteristics of visual relationships in a certain spatial environment. This analysis is often used at two levels, namely the eye level where people look and the knee height where people walk. This is key to understanding the spatial layout and can also be called viewshed analysis (Turner & Penn, 2001) is a supplement to the axis method and an extension of the visual zone segmentation method. Generally, the axis method is suitable for urban scale and for research objects where the axis can be clearly extracted in space. It can be seen that the graphical analysis method specifically covers the analysis area through a number of small squares, and quantitatively analyzes and calculates the line of sight reach of each square (see figure 32). This method completes spatial analysis with complex interfaces and achieves more analysis purposes while retaining topological meaning. This method is suitable for irregular areas with small spatial scale.

The above-mentioned methods have different choices when the objects are different. For large-scale urban road networks and space syntax research at streets, urban areas and other scales, the axis method is generally used: the convex space method is often used to analyze some boundaries. In architectural spaces or square spaces with relatively clear boundaries; for architectural spaces with unclear boundaries or complex and changeable shapes with high degrees of freedom, visible graph analysis can be used for analysis. All line rules are applicable to a variety of situations. Buildings can also be represented by a grid of points to form a visibility graph, where each point is connected to every other point it can see. This way, each space in the layout will be classified according to their visibility.

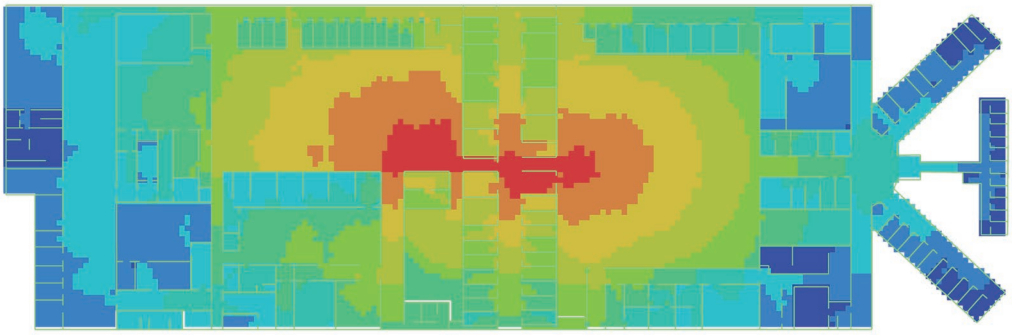


Fig 32 Integration analysis of visibility graph

Space syntax proposes five major technical parameters, namely five major variables: connectivity, control value, depth value, integration and intelligibility.

1. Connection value

Definition: The number of nodes adjacent to a node in the space is the connection value of the node. In an actual space system, if the permeability of a certain space is good, the higher the degree of connection it has with the surrounding space, that is, the higher the connection value.

2. Control value

Definition: Assuming that the weight of each node in the system is 1, then a node a is assigned a weight from an adjacent node b to [1/(b's connection value)], then the reciprocal of the connection value of the node directly connected to a The sum is the weight assigned by a from adjacent nodes, which indicates the degree of mutual control between nodes, so it is called the control value of node a.

3. Depth value

Definition: If the distance between two adjacent nodes is one step, then the minimum number of steps from one node to another node is the depth between the two nodes. The average value of the shortest distance (i.e. the minimum number of steps) from a node to all other nodes in the system is called the average depth value of the node. The formula can be expressed as [MD=(∑depth×number of nodes at this depth)/(total number of nodes-1)]. The total depth value of the system is the sum of the average depth values of each node. Obviously, the depth value expresses the reachability of the node in the topological sense, that is, the convenience of the node in the spatial system.

4. Integration

Definition: The formula is RA=2(MD-1)/(n-2). Where n is the total number of nodes. In order to be positively related to the practical significance, the reciprocal of RA is taken and is called the degree of integration. This method is a calculation method improved by P. Steadman after standardizing it with relative asymmetry in order to eliminate the interference of the number of elements in the system. Corresponding to the overall depth value and the local depth value, there are also overall integration degrees and local integration degrees. The overall integration degree indicates the closeness of the connection between a node and all nodes in the entire system, while the local integration degree indicates the closeness of the connection between a node and the nodes within a few steps nearby.

5. Comprehensibility

Definition: Spatial configuration attributes that describe the ease with which people can perceive complex large-scale spaces. Measuring the local spatial structure seen from a space helps to establish a picture of the entire spatial system and serves as a guide to the entire spatial structure that cannot be seen.

It can be seen from the definition of technical parameters that the connection value, control value and local integration degree in space syntax theory describe the structural characteristics at the local level, while the

integration degree describes the structural characteristics at the overall level. Intelligibility is used To describe the correlation between local variables and global variables. If a certain space in the space has a high degree of connectivity and a high degree of integration, then this is a space with high comprehensibility.

Discussion on application in cross-generational co-living space

There have been many analyzes of space syntax in existing cases in the direction of architecture and spatial environment design, such as the research and analysis of space syntax in medical institution architecture by Saif Haq and others (Saif & Yang, 2012); research on the language of museum space (Bill & Kali, 2006); Research on the application of renovation of historical buildings (Sam, 2012); Research on the use of built environments and public spaces for sports activities (Mohammad et al., 2014); Research on residential buildings Application research (Anna, 2022), etc. The field of Chinese research has focused on traditional villages (Tao et al., 2013; Sun, 2015; Wang, 2008; Hu et al., 2018; Wang, 2010; Chen, 2017; Chen, 2018) and historical district renovation (Wang & Sun, 2012; Bai, 2009; Zhu, 2005; Zhang, 2012; Hu, 2016; Guo, 2014; Chen, 2013; Wang, 2007) and garden space (Sun, 2012; Chen, 2012; Guo, 2014; Lu , 2016; Zhang, 2016) and other cases have been analyzed in combination with space syntax theory.

The research method of space syntax is based on the objective description of spatial form, but it is a software simulation after all. It cannot analyze the psychological changes or feelings of different users in the same spatial structure, nor can it distinguish the furnishings in the space, layout, landscape, etc. are attractive to users; secondly, space syntax can only consider space from a two-dimensional plane, and cannot take into account the height of buildings or structures that interfere with line of sight; third, space syntax is often used In the analysis of urban space, there are still certain deficiencies in spatial analysis and radius classification for residential scales such as elderly communities. Regarding the above-mentioned shortcomings of space syntax, in Section 4.3 of this chapter, we will make a comprehensive analysis of the communication space of the elderly community based on the in-depth research content such as semi-structured interviews and survey questionnaires in Chapter 3. In this way, the qualitative analysis method and the quantitative analysis method of space syntax complement each other , making the summary of the spatial mechanism and influencing factors of cross-generational co-living space more comprehensive and objective.

4.2 Spatial calculation of research cases

Parameter and theoretical model selection

This article hopes to have an in-depth discussion on the following issues through space syntax: (1) Interpret the spatial topological relationships that are prone to cross-generational communication and the way people use space; (2)Compare the layout characteristics of cross-generational symbiosis spaces in two cities relationship with functional settings; (3)Conduct spatial visualization analysis of cross-generational communication and interaction, and introduce the new perspective of organizational system. Cross-generational co-living space is a study of the communication and communication between multi-generational groups in space, which is consistent with the description and analysis of space using two parameters that measure spatial connectivity and integration in the space syntax theory. These two parameters are viewed from an architectural sense. There is strong correspondence.

Connectivity value is defined in space syntax theory as the number of nodes directly connected to a given node in the dual graph. Space syntax considers the accessibility of spaces as a key determinant of their spatial interactions, and its analysis is based on an implicit graph theoretic view of dual graphs. In graph theory, the space syntax connectivity of a node (Equation 1) is called the "node degree".

$$Ci = k(i) \quad (1)$$

k(i): Number of nodes directly connected to node i

Integration value is a calculation method improved by P.Steadman, which is standardized by relative asymmetry. The formula is RA=2 (MD -1)/(n-2) (where n is the total number of nodes). In order to be positively related to the practical significance, the reciprocal of RA is taken and is called the degree of integration. RRA was later used to further standardize the degree of integration in order to compare spatial systems of different sizes. RRA=RA/ Dn. Corresponding to the overall depth value and the local depth value, there are also overall integration degrees and local integration degrees. The overall integration degree indicates the closeness of the connection between all nodes in the entire system, which is more suitable for small-scale buildings and indoor spaces; while the local integration degree indicates the closeness of the connection between a certain node and the nodes within a few steps nearby. It is usually calculated in three steps. The range of steps or ten steps, called "radius-3 integration" or "radius-10 integration", is more suitable for city-wide calculations.

$$MD=TD/(k-1) \quad (2)$$

$$RA=2(MD-1)/(k-2) \quad (3)$$

$$\text{RA of Diamond}=\frac{n\left\{\log_2\left(\frac{n}{3}\right)-1\right\}+1}{\frac{(n-1)(n-2)}{2}} \quad (4)$$

$$\text{Relativized RA}=\frac{RA}{RA\ of\ Diamond} \quad (5)$$

$$\text{Integration(HH)}=\frac{1}{RRA} \quad (6)$$

MD: mean depth
TD: Total depth of the actual node
k: number of nodes

Connectivity reflects the penetration relationship between a certain space and the surrounding space. It measures the number of directly connected spaces. It is a static measurement (Björn, 1993) and can intuitively reflect the connection relationship between spaces. The algorithm result of the degree of integration is the position with the shallowest unit depth in the system, which is also the easiest to reach from a structural perspective. This is similar to the concept of the difficulty of reaching a certain position in architecture. In the paper, it is called "Accessibility" is used to illustrate the characteristics of the object unit in this aspect: the degree of integration and accessibility are directly proportional (Kim & Kwak, 2022). For community centers, the connection degree is used to measure the relationship between each space and the surrounding environment, and the integration degree is used to measure the accessibility of cross-generational communication spaces. This is to better analyze the mechanism and type of cross-generational co-living space, and to position the interactive communication space in The topological depth of community centers.

Based on the previous collation and analysis of space syntax theory, cross-generational co-living space belongs to indoor and outdoor spaces of buildings with relatively clear boundaries. Convex graphics and horizon methods can be used as calculation models to study spatial topological relationships and space types, human flow and interaction occurs. Convexmap extracts the topological relationship of space to study the spatial form and the relationship between spaces (Algeria, 2022). One of the basic tools for analyzing building layout is convex graph analysis. This study uses JASS and DepthmapX software to establish topological relationships to obtain a visual representation and value of each functional space. JASS is designed to perform convex space analysis by converting spaces and their connections into points and lines, drawing networks and converting graphs into reasonable graphs, presented in the form of deep branch trees, shallow ring clusters, etc. (Zhang & Cui, 2022; Hanson, 1998). DepthmapX enables the description of buildings to generate maps of spatial elements, connect them by relationships (visibility, intersection or adjacency) and analyze the resulting network (Mohamed, 2019; Pinelo & Tuner, 2010).

Visibility graph analysis is to refine the spatial plane into a sufficient number of square grids, where each square grid is used as a research element, so that elements within sight can be quantified and quantitative values can be analyzed. It can be seen from the overall spatial system diagram that the line of sight analysis method is more accurate and more numerically calculated. For the refined space grid, the color depth is also used to achieve the purpose of expressing the convenience of each

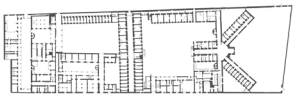
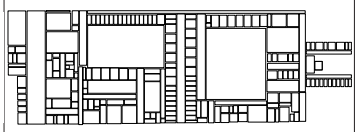
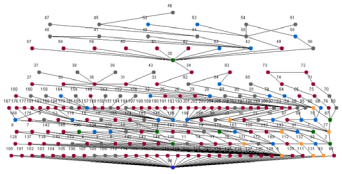
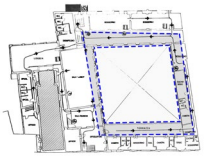
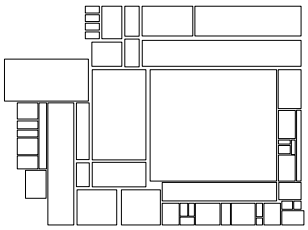
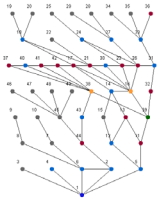
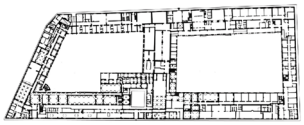
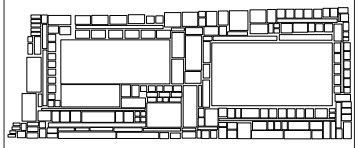
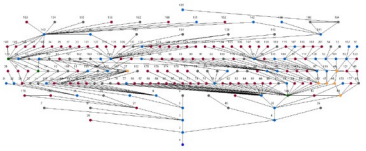
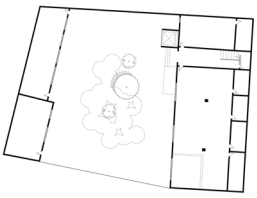
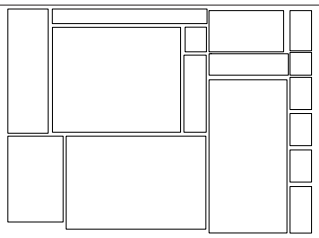
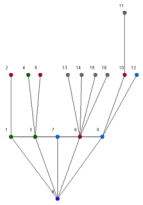
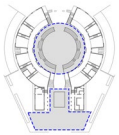
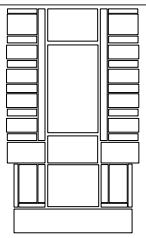
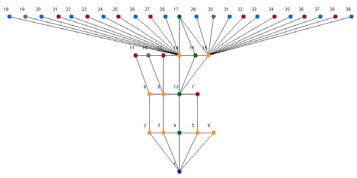
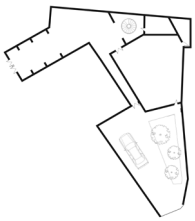
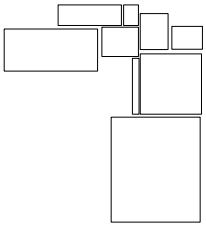
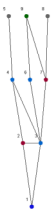
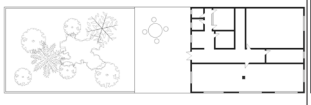
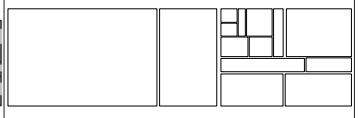
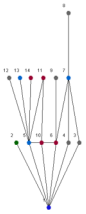
unit of the overall space system. According to Bill Hillier's literature, the higher the degree of integration (the redder), the easier it is for the space to produce static behaviors, such as staying, resting, talking, etc. In this way, we can find the most suitable place in the space system for people to stop and gather together to communicate. The higher the sight integration value, the easier it is for people to see this area and actively use it.The Visual Integration (HH) mentioned in the visual analysis is based on the visual step depth (Visual Step Depth), which is exactly the same as the topological integration algorithm (Malhis, 2016). That is, starting from a specific element and reaching another element, the line of sight needs to turn a few times. This value is fed back and recorded on the head of the starting point. With any other element as the end point, after exhausting all possibilities, the number of turns is summed up. This value is fed back and recorded on the head of the starting point, which is the value of the Total Visual Step Depth of the starting point. After having this value, calculate RA, RRA step by step, and finally find the value of the integration degree, which is the value of the visual integration degree of the element. The entire system is calculated in this way. After each element has the value of the visual integration degree recorded on its head, the software can generate a color feature map. The warmer the element, the higher the value of the visual integration degree.

Line of sight integration is the global line of sight depth after eliminating all topological influencing factors. The higher the value of line of sight integration, the less turning is needed to see from any position in the whole system. The higher the value of sight integration, the easier it is to attract the attention of the eyes and the easier it is to be seen. On the contrary, the lower the value of sight integration, the more difficult it is to attract attention. This model can analyze and explore which spatial locations in the architectural space are suitable for direct or indirect visual communication between people of all ages.

Convexmap analysis

First, use JASS software to illustrate the convex graph and topological relationship of the case, as shown in table 25. Use depthmapx software to visually analyze the two parameters of integration and connectivity of convex graphics, see table 26.

The two parameter values of integration degree and connectivity degree of all sample convex shapes are integrated and arranged in descending order according to the average value, see table 27, 28.

Case	Plan	Convexmap	Spatial topology
FIQ101 Le Murate			
FIQ102 Cenacolo del Fuligno			
FIQ103 Montedomini			
FIQ201 Centro Eta'Libera"La luna-San Salvi"			
FIQ202 Centro Eta'Libera Parterre Aps			
FIQ301 Circolo Arci viale Giannotti			
FIQ401 Centro Anziani Eta'Libera Santa Rosa			

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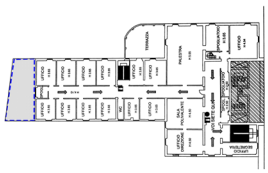
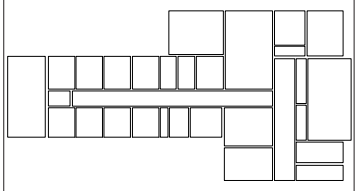
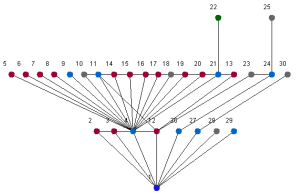
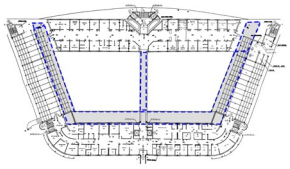
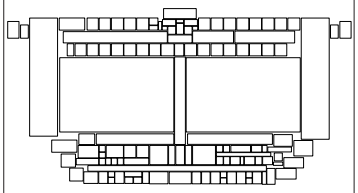
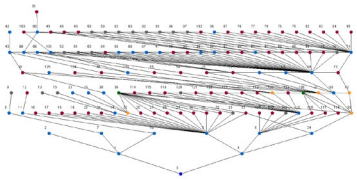
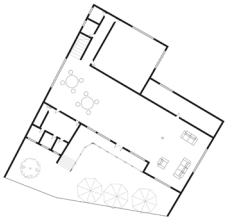
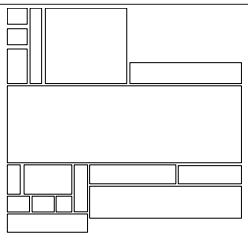
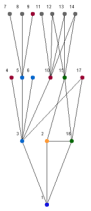
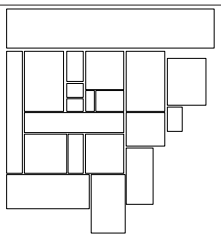
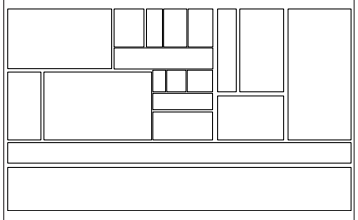
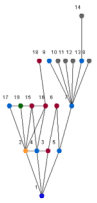
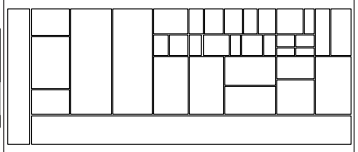
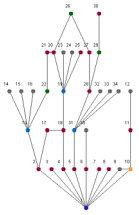
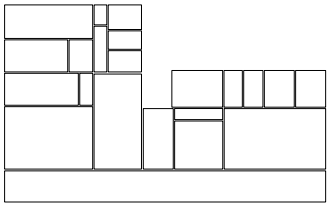
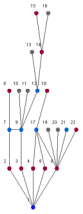
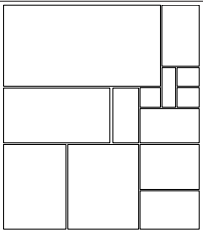
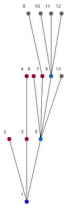
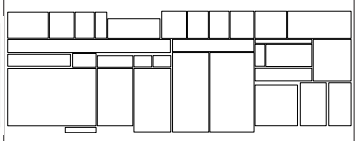
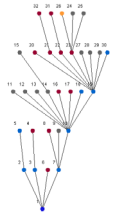
FIQ501 Statuto SMS Rifredi			
FIQ502 Le Piagge			
FIQ503 Societa'Mutuo Soccorso Ricreativo			
FIQ505 Centro Età Libera Rifredi Romito Vittoria			
SHYP01 Fushun Road Neighborhood Center			
SHYP02 Yanji Community No. 1 Neighborhood Center			
SHYP03 Yanji Community No. 3 Neighborhood Center			
SHYP04 Jiangpu Road Chenjiatou Neighborhood Center			
SHYP05 Jiangwan International Community Center			

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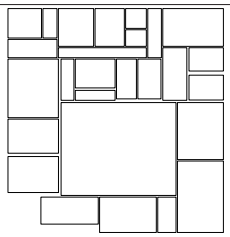
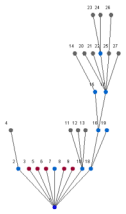
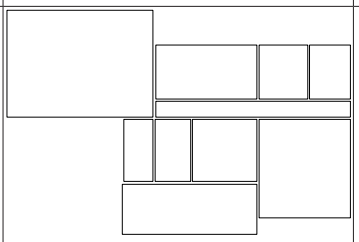
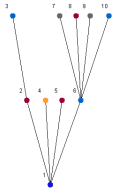
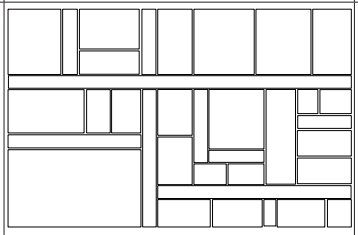
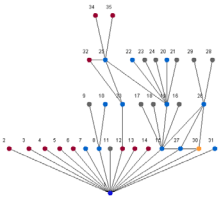
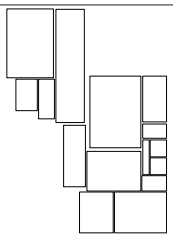
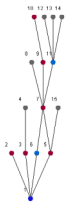
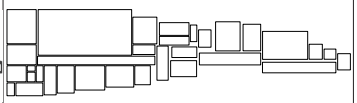
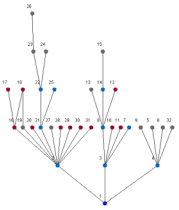
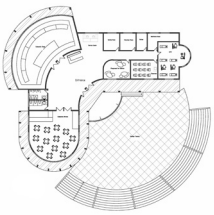
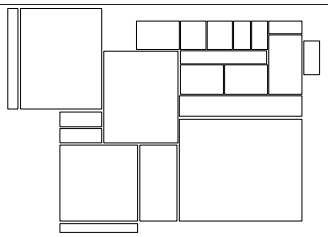
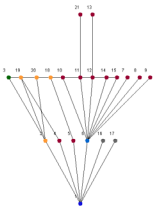
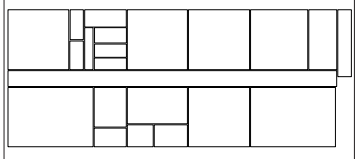
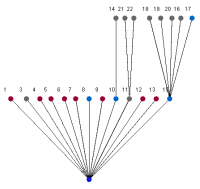
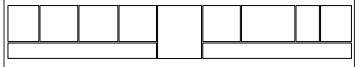
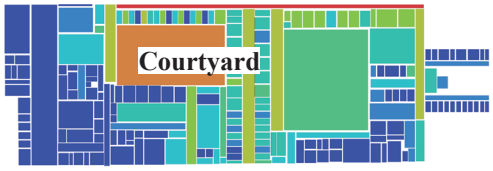
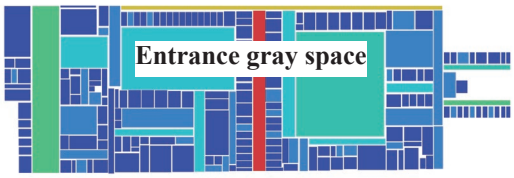
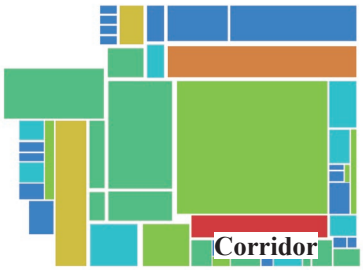
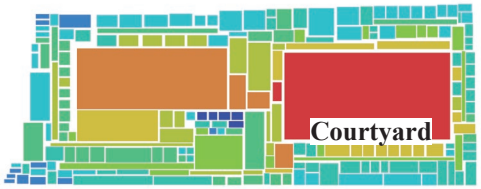
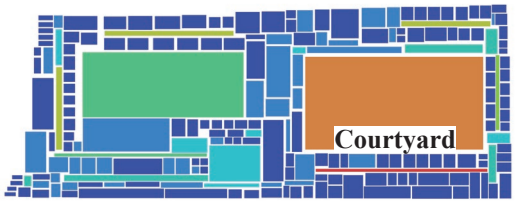
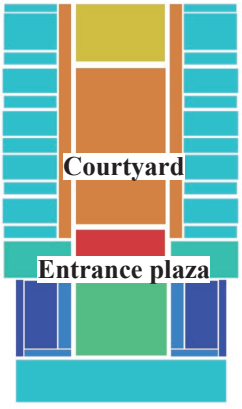
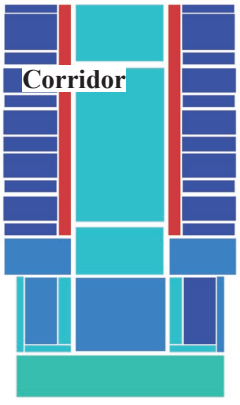
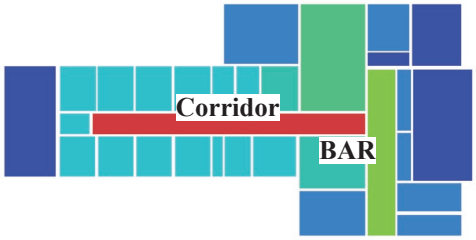
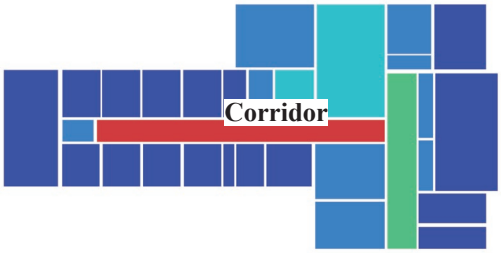
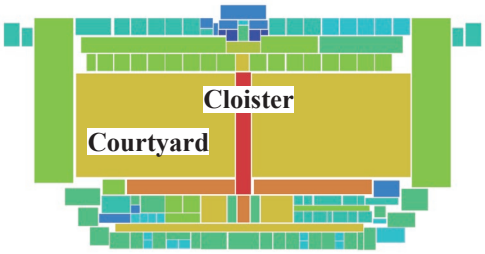
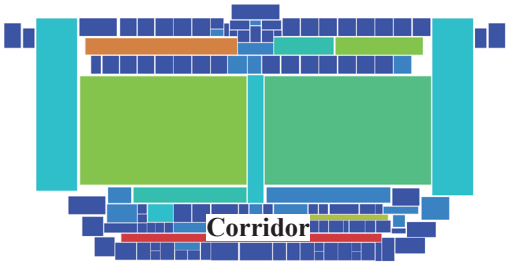
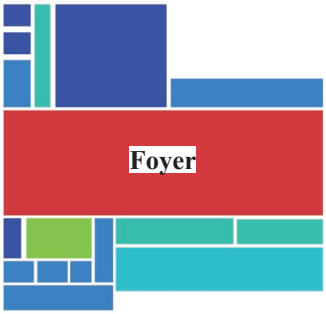
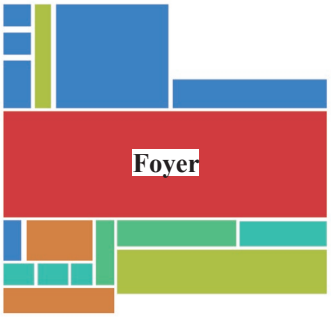
SHHK01 Jiaxing Road Street Community Cultural Activity Center			
SHHK02 Jiaxing Road Street Citizen Post Station No. 5			
SHHK03 Quyang Community Cultural Center			
SHJA01 Tianmu West Road Street Neighborhood Center			
SHHP01 Wuliqiao Community Cultural Activity Center			
SHPD01 Bamboo Garden Neighborhood Center			
SHBS01 Gaojing Town Community Cultural Activity Center			
SHBS02 Songnan Ten Villages Community Center			

Tab 25 Convexmap and spatial topologies of cases

Case	Integration	Connectivity
FIQ101 Le Murate	0.42-1.49	0-27
		
FIQ102 Cenacolo del Fuligno	0.56-1.45	0-7
		
FIQ103 Montedomini	0.53-1.37	0-21
		
FIQ201 Centro Eta'Libera"La luna-San Salvi"	0.66-2.4	0-7
FIQ202 Centro Eta'Libera Parterre Aps	0.83-2.48	0-15
		

Note: Table continues on next page

FIQ301 Circolo Arci viale Giannotti	0.63-2.96	0-5
FIQ401 Centro Anziani Eta'Libera Santa Rosa	0.77-2.6	0-6
FIQ501 Statuto SMS Rifredi	0.77-4.89	0-18
		
FIQ502 Le Piagge	0.58-2.01	0-22
		
FIQ503 Societa' Mutuo Soccorso Ricreativo	0.84-2.66	0-6
		

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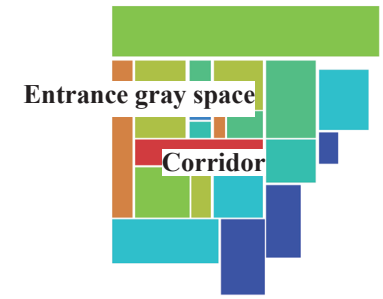
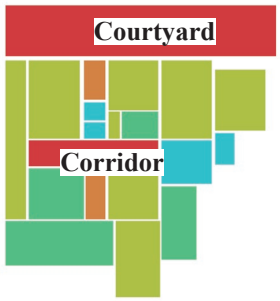
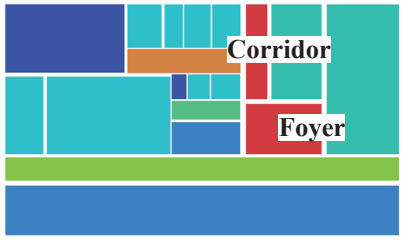
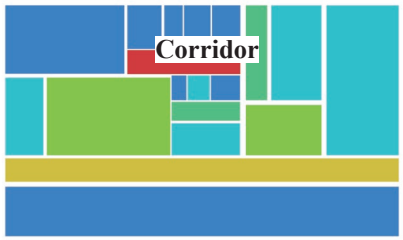
FIQ505 Centro Età Libera Rifredi Romito Vittoria	0.57-1.48	0-5
		
SHYP01 Fushun Road Neighborhood Center	0.6-1.61	0-7
		
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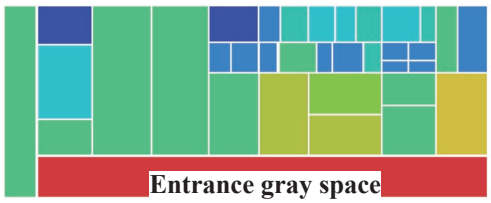
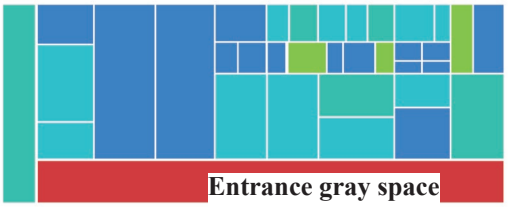
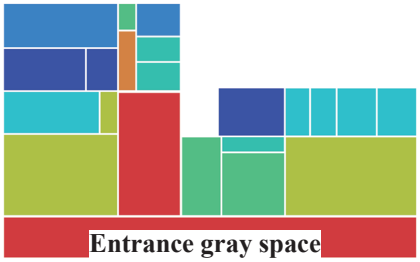
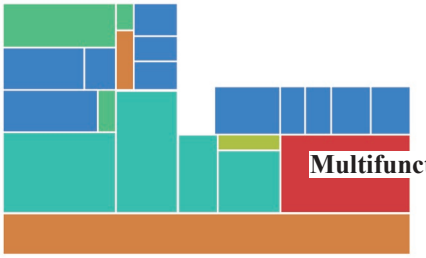
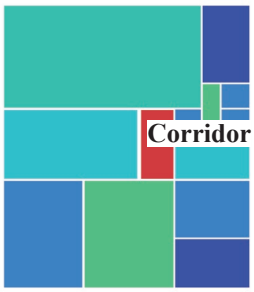
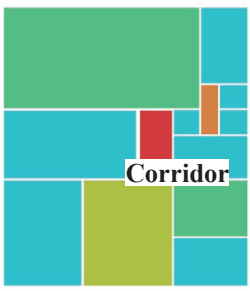
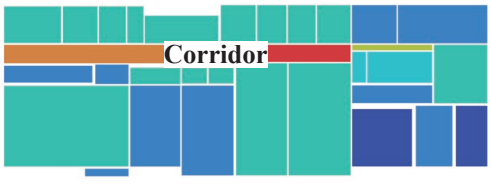
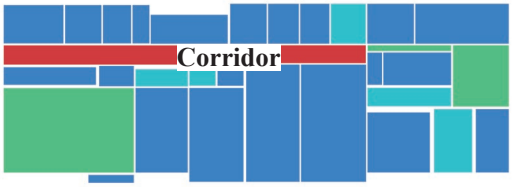
		
SHYP03 Yanji Community No. 3 Neighborhood Center	0.55-1.45	0-6
		
SHYP04 Jiangpu Road Chenjiatou Neighborhood Center	0.55-2.27	0-5
		
SHYP05 Jiangwan International Community Center	0.64-2.38	0-9
		

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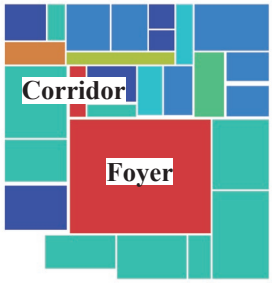
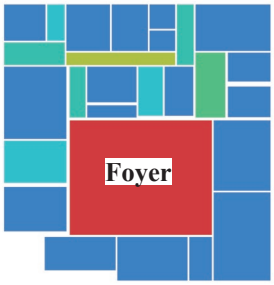
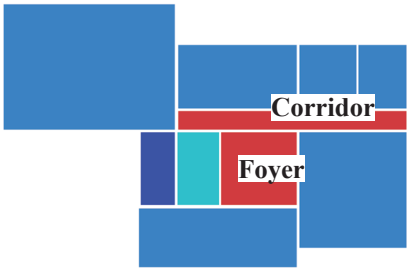
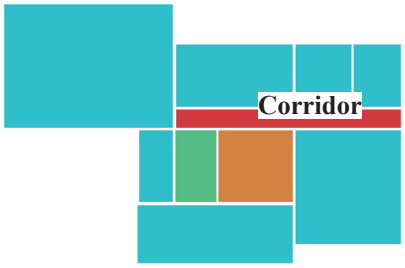
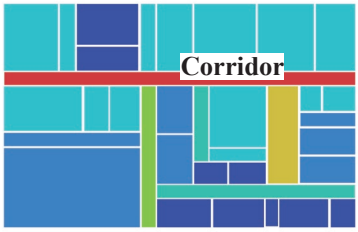
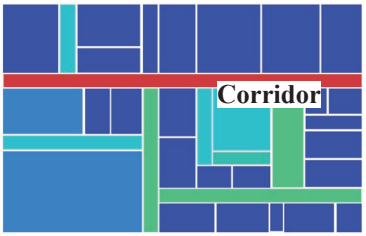
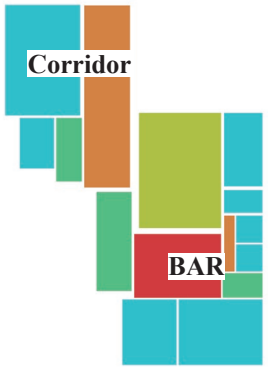
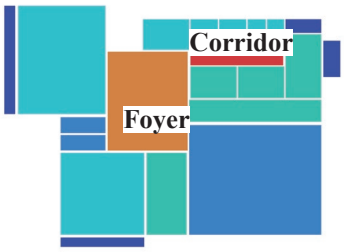
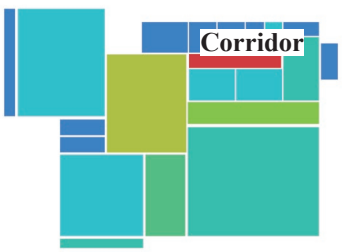
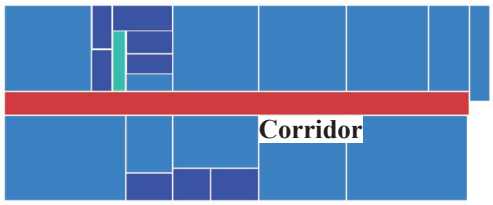
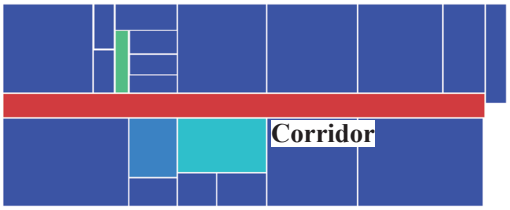
SHHK01 Jiaxing Road Street Community Cultural Activity Center	0.63-1.6	0-9
		
SHHK02 Jiaxing Road Street Citizen Post Station No. 5	0.58-2.2	0-5
		
SHHK03 Quyang Community Cultural Center	1.01-3.57	0-15
		
SHJA01 Tianmu West Road Street Neighborhood Center	0.52-1.81	0-5
		
SHHP01 Wuliqiao Community Cultural Activity Center	0.56-1.93	0-10
SHPD01 Bamboo Garden Neighborhood Center	0.8-2.98	0-9
		

Note: Table continues on next page

SHBS01 Gaojing Town Community Cultural Activity Center	0.98-5.63 	0-13 
SHBS02 Songnan Ten Villages Community Center	0.74-1.66 **Entrance gray space**	0-5 **Entrance gray space**

Tab 26 Integration HH and connectivity of cases

Sample	IntegrationHH		
	MIN	AVERAGE	MAX
FIQ501	0.773	1.781	4.897
SHBS01	0.978	1.67	5.625
SHHK03	0.91	1.509	3.439
FIQ401	0.771	1.41	2.601
SHPD01	0.802	1.409	2.979
FIQ202	0.833	1.359	2.48
FIQ201	0.659	1.263	2.396
FIQ503	0.836	1.263	2.661
FIQ301	0.634	1.243	2.957
FIQ502	0.583	1.224	2.005
SHYP05	0.643	1.16	2.385
SHHK02	0.579	1.106	2.2
Average of integration average		**1.104**	
SHYP04	0.551	1.009	2.273
SHHP01	0.563	1.008	1.93
SHYP01	0.62	0.99	1.606
FIQ505	0.566	0.965	1.48
SHYP02	0.58	0.96	1.689
SHBS02	0.737	0.955	1.659
SHJA01	0.523	0.954	1.811
SHHK01	0.63	0.938	1.599
FIQ103	0.533	0.907	1.37
SHYP03	0.549	0.905	1.452
FIQ102	0.556	0.871	1.45
FIQ101	0.417	0.869	1.489

Note: The average calculation of the average integration degree excludes samples FIQ501 and SHBS01. The reasons are detailed below.

Tab 27 Numerical statistics of integration degree of convexmap

Sample	Connectivity		
	MIN	AVERAGE	MAX
FIQ505	1	2.7	5
FIQ103	1	2.554	21
FIQ502	1	2.516	22
SHPD01	1	2.476	9
FIQ503	1	2.471	6
FIQ501	1	2.467	18
FIQ101	1	2.452	27
FIQ301	1	2.44	5
FIQ401	1	2.423	6
FIQ202	1	2.41	15
FIQ102	1	2.408	7
SHYP01	1	2.316	7
SHHK03	1	2.286	15
Average of connectivity averages		**2.24**	
FIQ201	1	2.25	7
SHYP03	1	2.181	6
SHYP02	1	2.171	9
SHJA01	1	2	5
SHHP01	1	2	10
SHYP05	1	1.938	9
SHHK01	1	1.926	9
SHBS01	1	1.909	13
SHYP04	1	1.846	5
SHBS02	1	1.818	5
SHHK02	1	1.8	5

Tab 28 Numerical statistics of connectivity degree of convexmap

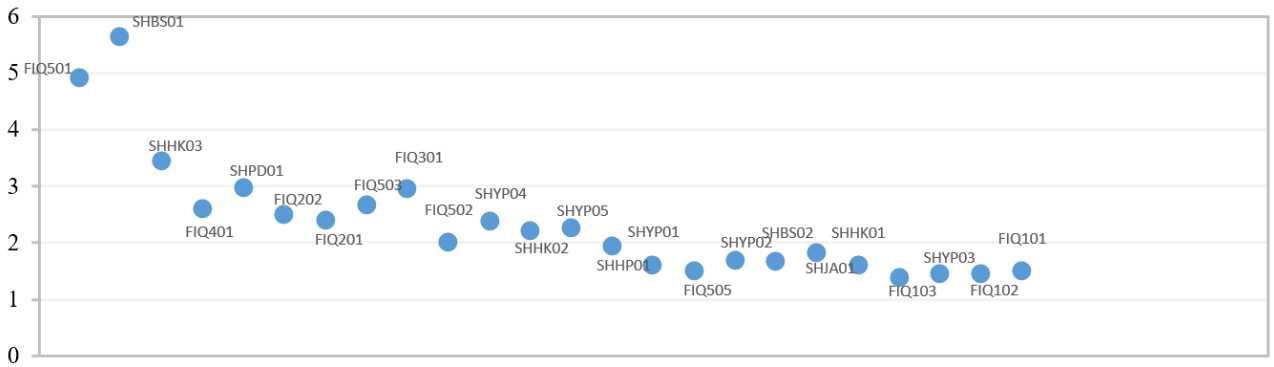


Fig 33 Scatter plot of maximum integration degree of convexmap

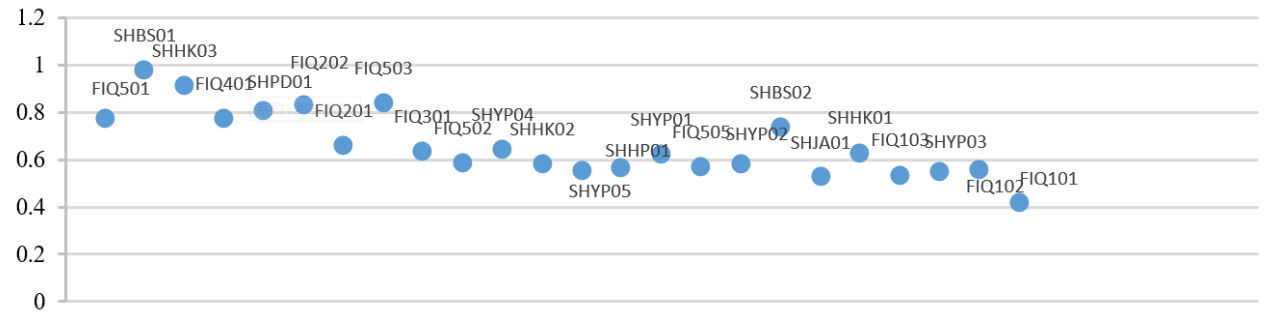


Fig 34 Scatter plot of minimum integration degree of convexmap

	Sum	F	C	S	T	O
FIQ101	207	117	28	46	9	7
FIQ102	49	12	15	19	2	1
FIQ103	201	100	47	45	6	3
FIQ201	16	4	3	5	1	3
FIQ202	39	11	12	3	8	4
FIQ301	9	3	3	2	0	1
FIQ401	14	4	3	5	1	1
FIQ501	30	14	9	6	0	1
FIQ502	125	63	37	18	5	2
FIQ503	17	4	3	6	2	2
FIQ505	20	8	8	1	0	3
SHYP01	19	5	7	5	1	1
SHYP02	35	16	3	11	2	3
SHYP03	22	10	5	6	1	0
SHYP04	13	5	3	5	0	0
SHYP05	32	11	9	11	1	0
SHJA01	15	6	3	6	0	0
SHHP01	32	11	10	11	0	0
SHPD01	21	12	2	2	4	1
SHHK01	27	5	10	12	0	0
SHHK02	10	3	4	2	1	0
SHHK03	35	11	13	10	1	0
SHBS01	22	8	5	9	0	0
SHBS02	11	8	0	0	2	1

Note: F (functional space) refers to functional space, C (circulation space) refers to traffic space, S (service space) refers to service space, T (transitional space) refers to transitional space, and O (outdoor space) refers to outdoor space.

Tab 29 Statistics on the number of functional spaces

In order to facilitate comparison and analysis of the integration degree of different samples, it is planned to use the maximum and minimum values of all samples as a unified standard to recolor the scales of all samples. Due to the discrete nature of the data (see figure 33, figure 34), when the extreme values in individual samples are used as the upper and lower limits of the scale, it will lead to poor differentiation of sample color blocks, which is not conducive to reading and data analysis. After a large number of experiments, it was found that the maximum discreteness of samples FIQ501 and SHBS01 has the greatest impact on the discrimination of data color blocks. Therefore, this study plans to use the maximum values of these two samples and use the extreme values of the remaining samples as the upper and lower limits of the scale. The reason why connectivity is not selected as a unified standard is shown in 4.3.1 Parameter Analysis.

In view of the fact that syntactic results are directly affected by space division, when comparing all sample data, based on the classification of cross-generational co-living spaces in Chapter 3, five types of spaces were abstracted from the cases for differential analysis: functional space (indoor), Traffic space (indoor), service space (indoor), transition space (gray space), outdoor space. Some cases use the standard layer as the main analysis object, so not all samples include the five-category space. The number of various spatial nodes in each sample and the descending order of the average integration degree are shown in table 29 and table 30.

Tab 30 Average statistics of spatial integration degree of each function

Sample	F-space	Sample	C-space	Sample	S-space	Sample	T-space	Sample	O-space
FIQ501	1.779	SHPD01	2.793	FIQ501	1.363	FIQ401	2.601	FIQ202	2.095
SHBS01	1.607	SHBS01	2.529	SHHK03	1.331	FIQ201	2.396	SHBS02	1.659
SHHK03	1.55	FIQ501	2.14	SHBS01	1.249	FIQ502	1.697	FIQ502	1.639
FIQ401	1.416	FIQ301	1.778	SHPD01	1.192	SHBS02	1.474	FIQ102	1.45
FIQ503	1.296	FIQ503	1.75	FIQ202	1.124	SHYP03	1.452	FIQ201	1.314
SHPD01	1.292	SHYP04	1.69	SHYP05	1.124	SHYP02	1.404	FIQ103	1.246
FIQ201	1.28	FIQ401	1.676	FIQ502	1.099	SHHK03	1.386	FIQ101	1.134
FIQ202	1.27	SHHK03	1.621	FIQ401	1.081	FIQ202	1.344	FIQ503	1.132
FIQ301	1.244	SHHK02	1.456	FIQ503	1.022	FIQ102	1.319	SHPD01	1.127
FIQ502	1.203	**Average**	**1.441**	FIQ201	0.975	FIQ503	1.317	**Average**	**1.114**
Average	**1.128**	SHYP05	1.355	**Average**	**0.923**	SHYP01	1.262	FIQ501	1.065
SHYP05	1.063	FIQ201	1.293	SHHK02	0.846	SHPD01	1.244	FIQ401	1.041
SHJA01	1.054	FIQ202	1.269	SHHP01	0.815	FIQ103	1.166	FIQ505	1.002
SHYP02	1.021	FIQ502	1.234	FIQ103	0.811	FIQ101	1.099	SHYP02	0.838
SHHP01	1.007	SHHP01	1.222	SHYP01	0.797	**Average**	**1.054**	FIQ301	0.806
FIQ102	0.988	SHJA01	1.202	SHYP02	0.794	SHYP05	0.881	SHYP01	0.785
SHHK01	0.96	SHYP01	1.171	SHYP04	0.776	SHHK02	0.846	SHYP03	-
FIQ505	0.948	SHHK01	1.167	SHHK01	0.738	FIQ301	-	SHYP04	-
FIQ103	0.914	SHYP02	1.069	SHYP03	0.737	FIQ501	-	SHYP05	-
SHYP01	0.914	FIQ505	1.017	FIQ101	0.732	FIQ505	-	SHJA01	-
SHYP03	0.899	SHYP03	1.008	SHJA01	0.73	SHYP04	-	SHHP01	-
SHHK02	0.897	FIQ103	0.929	FIQ102	0.675	SHJA01	-	SHHK01	-
FIQ101	0.894	FIQ102	0.928	FIQ301	0.658	SHHP01	-	SHHK02	-
SHYP04	0.832	FIQ101	0.849	FIQ505	0.566	SHHK01	-	SHHK03	-
SHBS02	0.737	SHBS02	-	SHBS02	-	SHBS01	-	SHBS01	-

Note: "-" some values are not calculated due to lack of such space.

Visibility graph analysis

The refined plane space grid is 550mm, which is close to the scale of a stream of people. Use the depthmapx software to obtain the integration visualization diagram of all samples as shown in table 31. All samples are The integration parameter values of the line of sight diagram are arranged in descending order according to the average value, see table 32.

Similar to the analysis of the integration value of convex graphics, in order to facilitate the comparison of the line of sight integration of different samples, it is planned to use the maximum and minimum values of all samples (see figure 35, figure 36) as a unified standard. Scales are recolored. After a large number of experiments, it was found that the maximum discreteness of samples FIQ201, FIQ401, and SHYP04 has the greatest impact on the discrimination of data color blocks. Therefore, this study plans to use the maximum values of these three samples and use the extreme values of the remaining samples as the scale.

Sample	Visual IntegrationHH		
	MIN	AVERAGE	MAX
FIQ201	4.436	17.803	35.483
FIQ401	3.317	14.982	26.387
SHYP04	3.438	11.454	20.487
FIQ202	2.885	10.807	17.311
FIQ502	2.65	10.267	15.562
SHPD01	3.256	9.053	17.384
FIQ503	3.212	8.31	14.002
FIQ301	3.035	8.293	17.368
Average value of sight integration average		**7.074**	
SHHK02	3.565	7.062	13.133
SHYP01	2.563	6.193	11.595
FIQ505	3.123	5.924	10.711
SHHK01	2.274	5.853	10.509
SHBS01	3.132	5.723	10.559
SHJA01	1.812	5.645	9.381
FIQ102	1.864	5.47	8.674
SHYP02	2.555	5.332	8.937
SHBS02	3.637	5.308	9.911
SHYP03	2.194	4.764	9.133
SHHP01	1.767	4.339	7.651
FIQ501	2.582	4.323	8
SHYP05	2.088	4.322	8.069
FIQ103	1.715	4.103	5.862
SHHK03	2.472	4.064	7.729
FIQ101	0.695	1.175	1.742

Tab 31 Numerical statistics of VGA integration degree

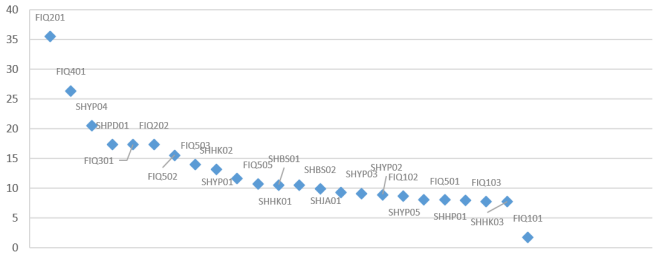


Fig 35 Scatter plot of maximum integration degree of VGA

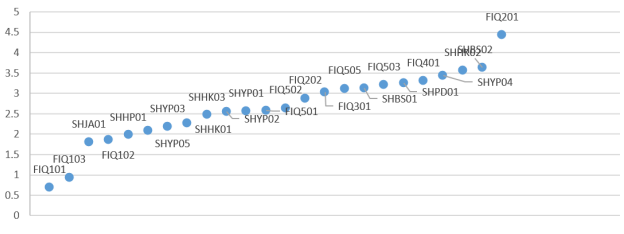
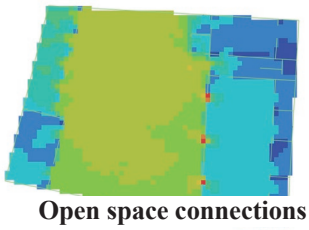
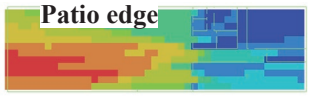
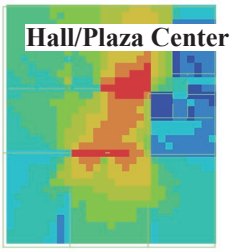
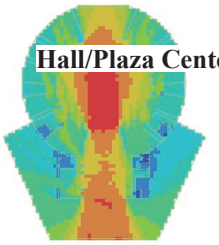
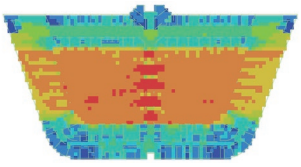
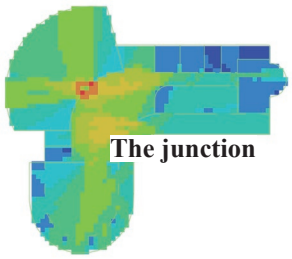
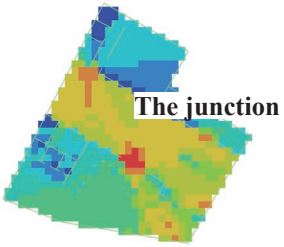
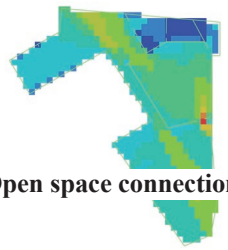
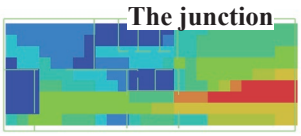
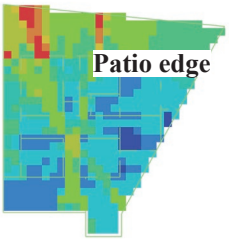
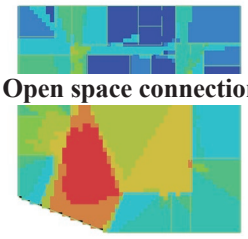
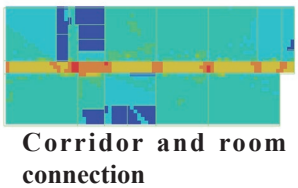
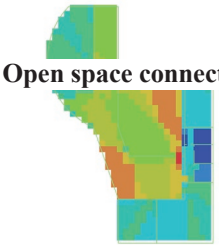
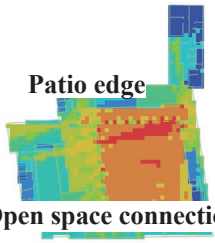
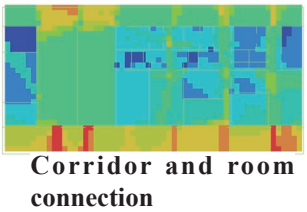
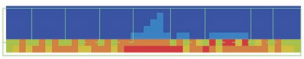
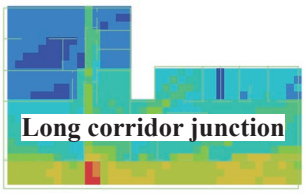
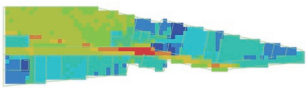
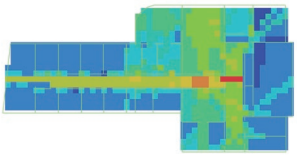
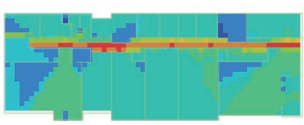
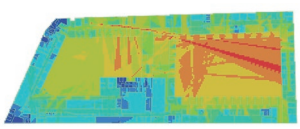
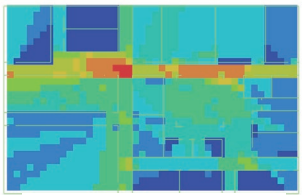
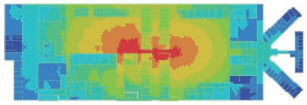


Fig 36 Scatter plot of minimum integration degree of VGA

FIQ201	FIQ401	SHYP04	FIQ202
4.44-35.48	3.32-26.39	3.44-20.49	2.89-17.31
			
FIQ502	SHPD01	FIQ503	FIQ301
2.65-15.56	3.26-17.38	3.21-14	3.04-17.37
			
SHHK02	SHYP01	FIQ505	SHHK01
3.56-13.13	2.56-11.59	3.12-10.71	2.27-10.51
			
SHBS01	SHJA01	FIQ102	SHYP02
3.13-10.56	1.81-9.38	1.86-8.67	2.56-8.94
			
SHBS02	SHYP03	SHHP01	FIQ501
3.64-9.91	2.19-9.13	1.77-7.65	2.58-8
			
SHYP05	FIQ103	SHHK03	FIQ101
2.09-8.07	1.72-5.86	2.47-7.73	0.69-1.74
			

Tab 32 Visual Integration HH of cases(rank by average value)

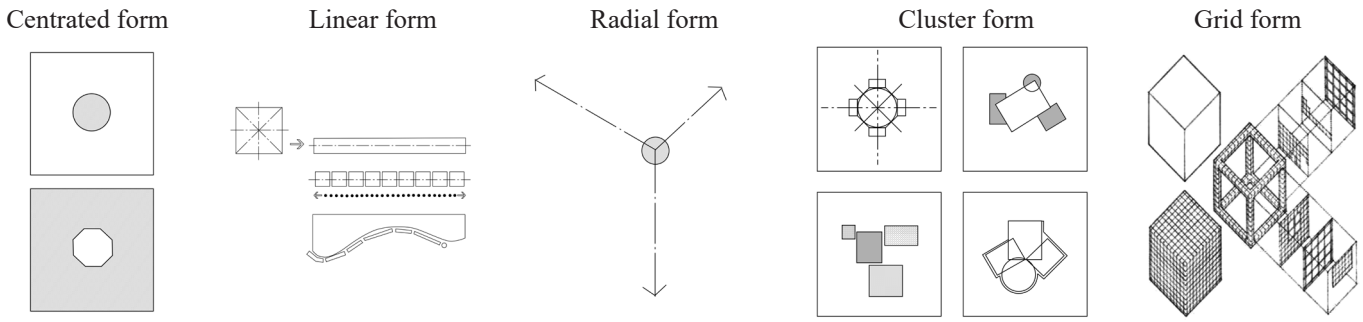


Fig 37 Five spatial configuration schemes

Classification of spatial form

In order to facilitate the overall analysis of each case and find commonalities in the form of cross-generational co-living space, different case planes are classified according to the most basic formal rules. According to Francis D. K. Ching's classification of architectural form spatial order (Ching, 2014), there are five spatial forms and organization methods: centrated form, linear form, radial form, cluster form, and grid form (figure 37).

Centralized forms require the visual dominance of a geometrically regular, centrally located form, such as a sphere, cone, or cylinder. Because of their inherent centrality, these forms share the self-centering properties of the point and circle. They are ideal as freestanding structures isolated within their context, dominating a point in space, or occupying the center of a defined field. They can embody sacred or honorific places, or commemorate significant persons or events.

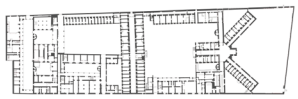
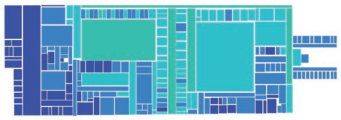
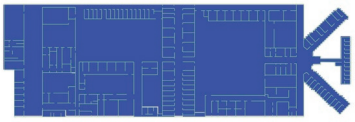
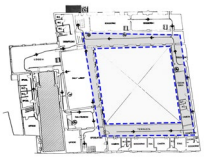
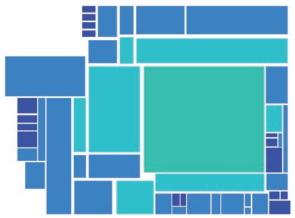
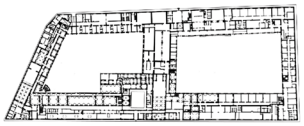
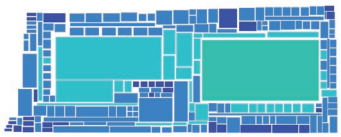
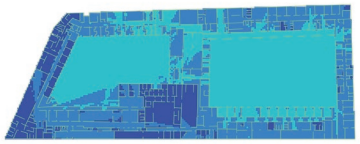
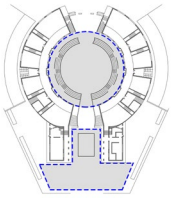
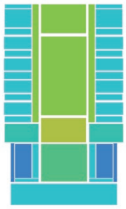
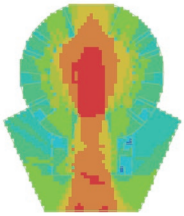
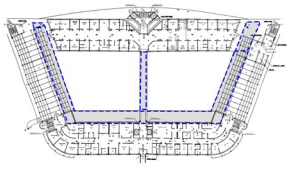
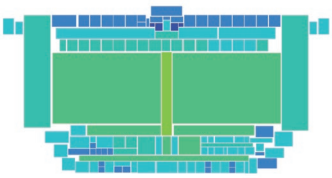
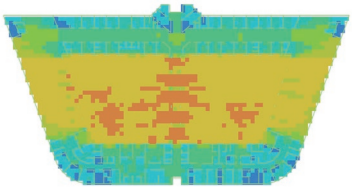
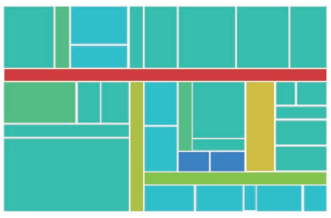
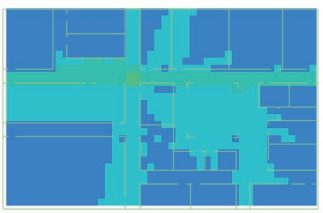
A linear form can result from a proportional change in a form's dimensions or the arrangement of a series of discrete forms along a line. In the latter case, the series of forms may be either repetitive or dissimilar in nature and organized by a separate and distinct element such as a wall or path.

A radial form consists of linear forms that extend outward from a centrally located core element in a radiating manner. It combines the aspects of centrality and linearity into a single composition.

While a centralized organization has a strong geometric basis for the ordering of its forms, a clustered organization groups its forms according to functional requirements of size, shape, or proximity. While it lacks the geometric regularity and introverted nature of centralized forms, a clustered organization is flexible enough to incorporate forms of various shapes, sizes, and orientations into its structure.

A grid is a system of two or more intersecting sets of regularly spaced parallel lines. It generates a geometric pattern of regularly spaced points at the intersections of the grid lines and regularly shaped fields defined by the grid lines themselves.

These five basic spatial forms are the most basic spatial structural forms and can be summarized correspondingly with the spatial forms of cross-generational co-living space cases. Except for the grid form, all other spatial forms appear in the sample. Some samples are a combination of multiple spatial forms. Therefore, when classifying, the spatial form is mainly based on the core space where cross-generational co-living exchanges can occur (based on the highest integration value and on-site survey observations). Among them, the linear form is divided into two categories: bilateral and unilateral according to the location of the corridor. The classification of the five spatial forms of the cross-generational co-living space samples is shown in the table 33.

Spatial Form	Case	Plan	Convexmap Integration under unified standard	Visual Integration under unified standard
Centralized form	FIQ101 Le Murate			
	FIQ102 Cenacolo del Fuligno			
	FIQ103 Montedomini			
	FIQ202 Centro Eta'Libera Parterre Aps			
	FIQ502 Le Piagge			
	SHHK03 Quyang Community Cultural Center			

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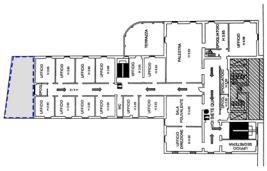
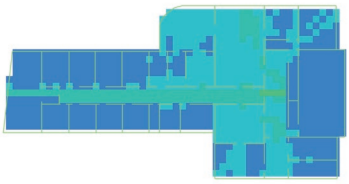
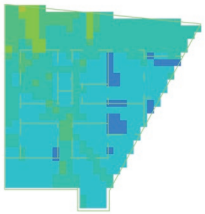
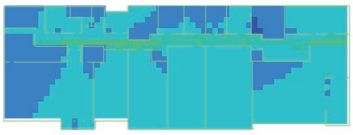
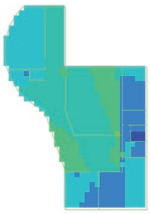
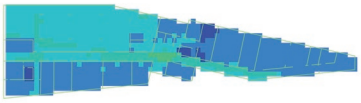
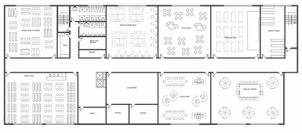
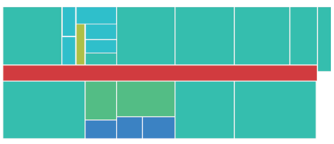
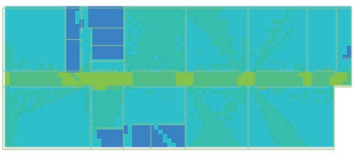
Bilateral linear form	FIQ501 Statuto SMS Rifredi			
	FIQ505 Centro Età Libera Rifredi Romito Vittoria			
	SHYP05 Jiangwan International Community Center			
	SHJA01 Tianmu West Road Street Neighborhood Center			
	SHHK02 Jiaxing Road Street Citizen Post Station No. 5			
	SHHP01 Wuliqiao Community Cultural Activity Center			
	SHBS01 Gaojing Town Community Cultural Activity Center			

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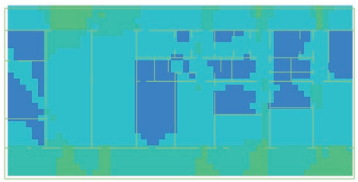
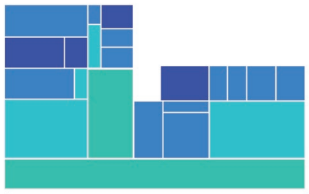
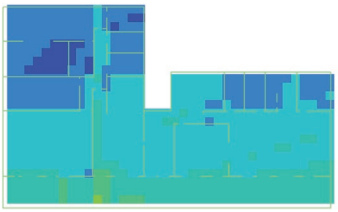
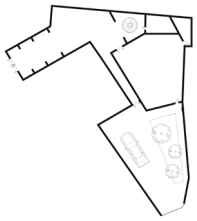
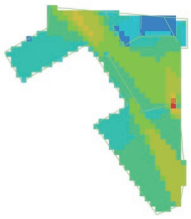
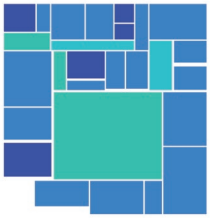
One-lateral linear form	SHYP02 Yanji Community No. 1 Neighborhood Center			
	SHYP03 Yanji Community No. 3 Neighborhood Center			
	SHBS02 Songnan Ten Villages Community Center			
Radial form	FIQ301 Circolo Arci viale Giannotti			
	SHHK01 Jiaxing Road Street Community Cultural Activity Center			

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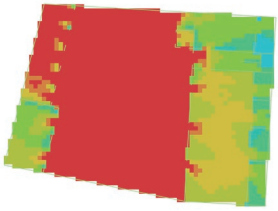
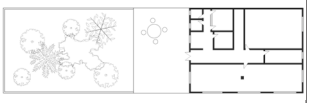
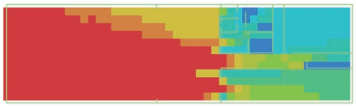
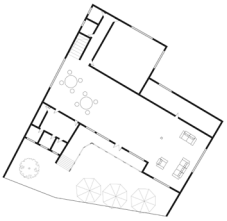
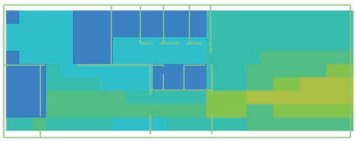
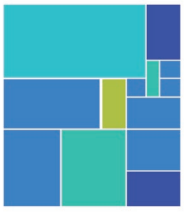
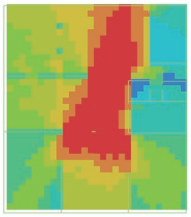
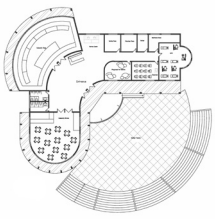
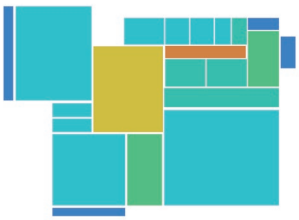
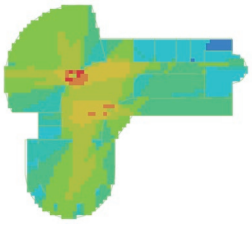
Cluster form	FIQ201 Centro Eta'Libera"La luna-San Salvi"			
	FIQ401 Centro Anziani Eta'Libera Santa Rosa			
	FIQ503 Societa'Mutuo Soccorso Ricreativo			
	SHYP01 Fushun Road Neighborhood Center			
	SHYP04 Jiangpu Road Chenjiatou Neighborhood Center			
	SHPD01 Bamboo Garden Neighborhood Center			

Tab 33 Spatial forms of cases

4.3 Spatial analysis of cross-generational co-living space

Parametric analysis of integration, connectivity and visual integration

According to the visualization of integration degree and connection degree in figure 38, it can be seen that the spatial positions with larger values in all samples are basically consistent, and the two have similar judgments on the connection relationship of the space itself.

Judging from the order of the maximum value, average value and minimum value, the sample order varies greatly. The Florence cases with a larger number of spaces are at the top of the ranking of connectivity, and the Shanghai cases with a smaller number of spaces are at the back. From the calculation formula of connectivity, it can be seen that the calculation of this parameter does not eliminate the influencing factor of the number of spaces, so The more spaces there are, the more node spaces there will be, and the maximum value of connectivity will become larger. The complexity of the space will have a greater impact on the results. And the minimum value of the case connection degree defaults to 1, and it is difficult to compare the minimum connection degree between cases. Comparing the calculation formula of integration degree, the calculation of Integration eliminates the influence of the number of spaces, topological structure symmetry, and topological structure connection relationships. If compared between different cases, the results can reflect the spatial relationship more comprehensively and objectively. Therefore, in In subsequent analyses, a more in-depth analysis of spatial relationships will be conducted based on the degree of integration.

The comparison of the integration and visual integration results of different cases is as followed in figure 39, figure 40.

According to the comparison between the degree of integration and the degree of visual integration, it can be seen that the spatial types with higher integration degrees in all samples are different, and the order of the maximum value, average value and minimum value is different. It is also very large, and the cases with the highest degree of visual integration (such as FIQ201) are not at the top in terms of integration ranking. The high degree of integration of a space illustrates the objective attributes of spatial connection, and whether the doors and windows of different spaces are opened and whether the line of sight in the irregular space is blocked will affect the direct and indirect communication in the cross-generational co-living space, thus manifesting as overall level of sight integration results in the impact of open space on people's sight communication. It shows that the degree of sight integration and the degree of integration are two dimensions for evaluating spatial connectivity. The former is the objective attribute of space, and the latter is the sight communication of people in space. They are both necessary to evaluate whether cross-generational communication is easy to occur.

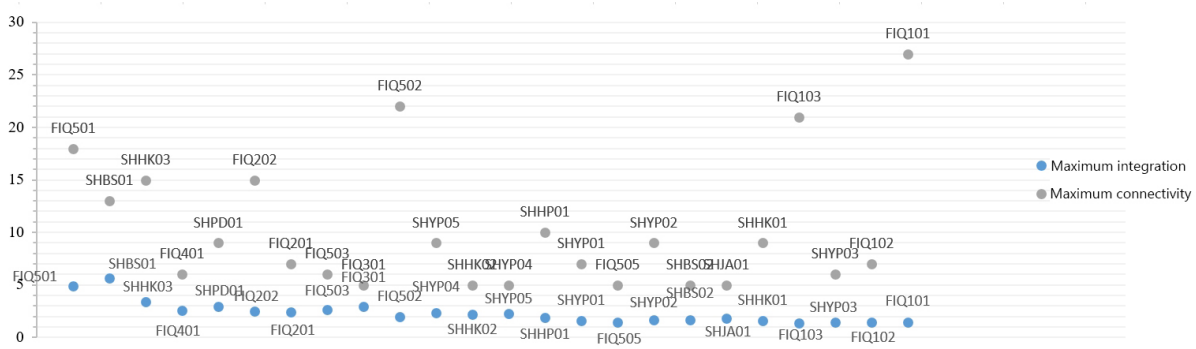


Fig 38 Scatter plot of the maximum value of integration degree and connectivity degree

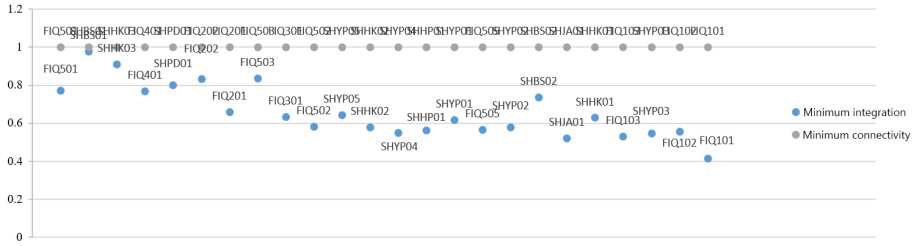


Fig 39 Scatter plot of the minimum value of integration degree and connectivity degree

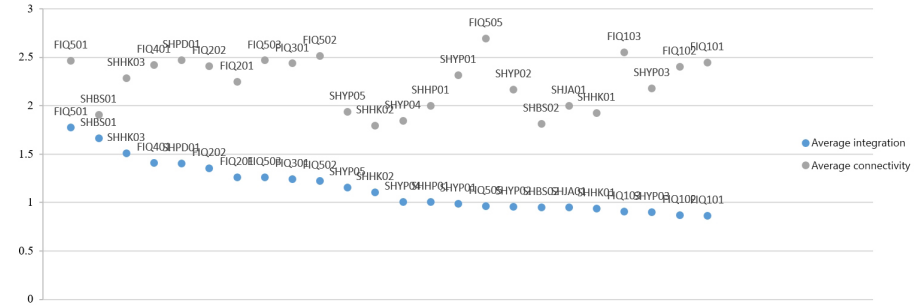


Fig 40 Scatter plot of the average value of integration degree and connectivity degree

Spatial form integration analysis

The five spatial forms corresponding to the cross-generational co-living space are shown in table 34.

The ranking relationship of the average integration degree of various spatial forms is: bilateral linear>cluster>centralized>radial>one-lateral linear. The ranking relationship of the median is: cluster > bilateral linear> radial > centralized> one-lateral linear. Overall, in terms of integration, the cluster form is the spatial form with the highest average integration degree, followed by the bilateral linear form, radial form, and centralized form, while the one-lateral linear form is the spatial form with the lower average integration degree.

By analyzing and comparing the sample cases in Shanghai and Florence, we can see that:

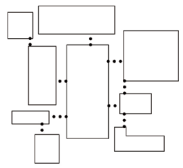
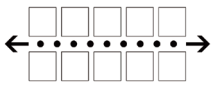
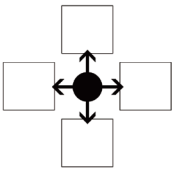
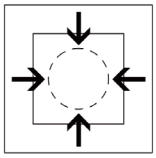
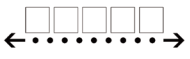
(1) The cluster form samples all have indoor-outdoor transitional gray spaces at the main entrance, which are all spatial combinations around the entry point into the building (courtyard, gray space);

(2) The bilateral linear samples are all closed corridors, and the layout of the rooms on both sides is similar to the layout of an office building with high work efficiency, so it can be used in conjunction with more functional spaces. The Florence case includes classrooms, theaters, office buildings and other functions, while the Shanghai case includes exhibition halls, community shops, cinemas and other functions;

(3) The radial samples all have a dominant space with open space as the center. In the Florence case, the BAR at the corner are the central connections. In the Shanghai case, the lobby are the central connections;

(4) The centralized samples are all enclosed courtyard/atrium cases. Historically converted buildings in Florence are concentrated specimens;

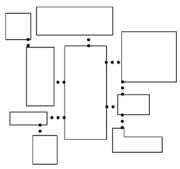
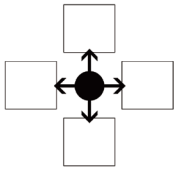
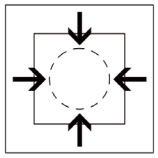
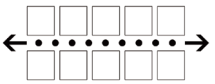
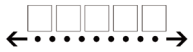
(5) The one-lateral linear space form only appears in the Shanghai case, and they are all connected by outdoor corridors. There are relatively few activity centers with one-side connected groups in the Florentine community.

Cluster form	Bilateral linear form	Radial form	Centralized form	One-lateral linear form
				
Samples	Samples	Samples	Samples	Samples
FIQ201/FIQ401/ FIQ503/SHYP01/ SHYP04/SHPD01	FIQ501/FIQ505 / SHYP05/ SHJA01/ SHHK02/SHHP01/ SHBS01	FIQ301/SHHK01	FIQ101/FIQ102/ FIQ103/ FIQ202/ FIQ502/SHHK03	SHYP02/ SHYP03/SHBS02
average integration average value	average integration average value	average integration average value	average integration average value	average integration average value
1.224	1.235	1.091	1.123	0.94
average integration median	average integration median	average integration median	average integration median	average integration median
1.263	1.106	1.091	1.066	0.955

Tab 34 Integration values of five spatial forms

Analysis of spatial form visual integration

The average ranking relationship of the average visual integration degree of various spatial forms is: cluster > radial > centralized > bilateral linear > one-lateral linear, and the median ranking relationship is the same(table 35). Overall, in terms of visual integration, cluster and radial spatial forms have higher average visual integration, followed by centralized form. Bilateral linear form is close to one-lateral linear form, which means the average integration degree is low. The ranking results of the integration degree of convex figures are different. The cluster form is the highest ranking spatial form of the two. The comparison of the convex figure integration values of the radial form, bilateral linear form and centralized form is similar, while in the visual integration with the comparison of integration degree, the radial form ranks much higher than the bilateral linear form, the centralized form and the bilateral linear form are similar, and the one-lateral linear form ranks lower in both. Corresponding to the practical significance of architectural space, the difficulty of direct communication and visual communication in the five types of space forms is shown in table 36.

Cluster form	Radial form	Centralized form	Bilateral linear form	One-lateral linear form
				
Samples	Samples	Samples	Samples	Samples
FIQ201/FIQ401/ FIQ503/SHYP01/ SHYP04/SHPD01	FIQ301 /SHHK01	FIQ101/FIQ102/ FIQ103/ FIQ202/ FIQ502/SHHK03	FIQ501/FIQ505 / SHYP05/ SHJA01/ SHHK02/SHHP01/ SHBS01	SHYP02/SHYP03/ SHBS02
average VI average value	average VI average value	average VI average value	average VI average value	average VI average value
11.299	7.073	5.981	5.334	5.135
average VI median	average VI median	average VI median	average VI median	average VI median
10.254	7.073	5.645	5.308	4.787

Tab 35 Visual Integration values of five spatial forms

Spatial forms / Degree of difficulty: 1(Easy)-4(Difficulty) / Communication	Cluster form	Radial form	Centralized form	Bilateral linear form	One-lateral linear form
Direct communication	1	2	3	2	4
Visual communication	1	2	2	3	4

Tab 36 The difficulty of direct and indirect communication between the five space forms

Spatial type integration analysis

According to the ranking results of the unified scale integrated degree value average, it can be seen that FIQ501>SHBS01>SHHK03> FIQ401>SHPD01>FIQ202>FIQ201>FIQ5 03>FIQ301>FIQ502>SHYP05>SHHK02 >Average>SHYP04>SHHP01>SHYP01> FIQ505>SHYP02>SHBS02>SHJA01>SH HK01>FIQ103>SHYP03>FIQ102>FIQ101.

The first three samples with the highest integration values are all closed bilateral linear space form. The integration degree value only considers the use efficiency more than the practical meaning. The corridor connects the rooms on both sides without much depth, so it is the location with the best connectivity and highest efficiency. This type of transportation space has the highest integration value. Starting from the fourth and fifth samples, the locations with higher integration are spaces with mixed functions, such as foyers, halls, multi-functional rooms, etc.

Among the lower-than-average samples, FIQ101's two courtyards provide a good interactive space for residents and urban pedestrians living here, but the former introverted and closed historical prison building was renovated, so the connectivity of the entire building is poor, with a large number of rooms and deep depth; FIQ102 has a community canteen close to the east courtyard, which provides a good communication place for the elderly and students from nearby colleges. However, the space itself is located at the end of the building, away from the entrance and the main courtyard. The functional arrangement is only after the college informs the students to go there, so that cross-generational communication will occur during daily lunch; the children's play area of SHYP01 has good indirect communication with the entrance gray space and outdoor play area, but due to the indoor There are no long corridors connecting all the rooms, and the functional areas are spread out over two floors, so there is no high integration value.

From the average comparison of the average integration degrees of various functional partitions in all samples, it can be seen that traffic space > functional space > outdoor space > transition space > service space. There is no significant correlation between the number of nodes and the average degree of integration, indicating that the number of rooms in different functional areas has no direct impact on cross-generational communication.

Spatial types	Samples（Integration Max）	Average of Integration
Corridor(traffic space)	FIQ101(1.62)/FIQ401(2.6)/FIQ501(4.89) /FIQ505(1.48)/ SHYP01(1.61)/SHYP04(2.27)/SHYP05(2.38)/ SHHK01(1.6)/SHHK02(2.2)/SHHK03（3.44）/ SHHP01(1.93)/SHPD01(2.98)/SHBS01(5.63)	2.654
Foyer (traffic space)	FIQ503(2.66)/SHHK02(2.2)	2.43
Multi-functional hall (functional space)	FIQ201(2.4)	2.4
BAR(functional space)	FIQ301(2.96)/SHJA01(1.81)	2.385
Entrance plaza (outdoor space)	FIQ202(2.48)/SHBS02(1.66)	2.07
Entrance gray space (transitional space)	FIQ401(2.6)/SHYP02(1.69)/SHYP03(1.45)	1.913
Cloister (transitional space)	FIQ102(1.42)/FIQ502(2.01)	1.715
Courtyard (transitional space)	FIQ103(1.33)	1.33

Tab 37 The most integrated space type

<table>
<tr><td colspan="5">Traffic space (Corridor)</td></tr>
<tr><td colspan="2">FIQ101</td><td>FIQ401</td><td>FIQ501</td><td>FIQ505</td></tr>
<tr><td colspan="2">•The entrance and exit sequence is arranged to connect the inside and outside;
•Rooms facing the street are transparent;
•Continue historical materials and features;
•The ramp is continuous with no height difference.</td><td>•Accessible handrails;
•The poster board has clear information.</td><td>•Continue the historical style;
•Bright and warm colors;
•Post information on poster board.</td><td>•Appropriate scale;
•The information on the poster board is clear;
•Lounge seating area.</td></tr>
<tr><td>SHYP01</td><td>SHYP04</td><td>SHYP05</td><td>SHHK01</td><td>SHHK03</td></tr>
<tr><td>•The decoration is lively and displays handmade works;
•Bright tones;
•Place green plants.</td><td>•Open interface;
•Multi-functional spaces;
•Traditional cultural decoration;
•Visibility is clear.</td><td>•Linear markings on walls and ceilings are clear and dynamic;
•The wall is combined with community exhibition layout;
•The top is diverse in color and integrates well with lamps.</td><td>•The logo is clear and interesting;
•Set up a community cultural exhibition wall;
•Place green plants;
•Multimedia presentation.</td><td>•Set up a community cultural exhibition wall;
•The interface can be opened and closed, making it a multi-functional space;
•Clear markings;
•Poster display event information.</td></tr>
<tr><td>SHHP01</td><td>SHPD01</td><td>SHBS01</td><td colspan="2">Traffic space (Foyer)</td></tr>
<tr><td></td><td></td><td></td><td>FIQ503</td><td>SHHK02</td></tr>
<tr><td>•Set up theme exhibition walls;
•Multimedia presentation;
•Accessible ramps and handrails;
•Place green plants.</td><td>•The linear markings on the ground are clear and dynamic;
•Set up rest areas;
•Open interface;
•Place green plants;
•Set up a community cultural exhibition wall.</td><td>•Multimedia presentation;
•The logo is set in combination with the theme content;
•Place green plants;
•Set up a community cultural exhibition wall.</td><td>•Set up rest areas;
•Combining movement and stillness, multi-functional space;
•Colorful;
•Set up a community cultural and historical exhibition area;
•Place green plants.</td><td>•Set up a community cultural exhibition wall;
•The interface can be opened and closed, making it a multi-functional space;
•Set up rest areas;
•Through the line of sight with the upper functional space.</td></tr>
<tr><td>functional space
(Multi-functional hall)</td><td colspan="2">functional space (BAR)</td><td colspan="2">outdoor space
(Entrance plaza)</td></tr>
<tr><td>FIQ201</td><td>FIQ301</td><td>SHJA01</td><td>FIQ202</td><td>SHBS02</td></tr>
<tr><td>•Natural and warm colors;
•Wall murals;
•Open interface and multi-purpose.</td><td>•Arc-shaped enclosed open space;
•The dining table can be flexibly set up with columns;
•Rich colors and lighting levels.</td><td>•Open interface;
•Colorful;
•Place green plants.</td><td>•Set up rest areas;
•Axis landscape;
•Accessible ramps;
•Natural greenery.</td><td>•Accessible ramps;
•Linear markings are clear and dynamic;
•Wall murals;
•Natural greenery.</td></tr>
<tr><td colspan="5">transitional space
(Entrance gray space)</td></tr>
<tr><td>FIQ401</td><td colspan="2">SHYP02</td><td colspan="2">SHYP03</td></tr>
<tr><td>•Accessible ramps;
• Set up a rest area with rich furniture styles;
•Natural greening;
•The interface is open and transparent.</td><td colspan="2">•Accessible ramps;
•Ground material changes;
•Window panels and pillars display community activities;
•Natural greening;
•Connected to outdoor activity area.</td><td colspan="2">•Set up rest areas;
•Sufficient sunshine;
•Place green plants;
•Post event notices.</td></tr>
<tr><td colspan="2">transitional space
(Cloister)</td><td colspan="3">transitional space
(Courtyard)</td></tr>
<tr><td>FIQ102</td><td>FIQ502</td><td colspan="3">FIQ103</td></tr>
<tr><td>•Preserve historic structures and decorations;
•Set up rest areas;
•Natural greening;
•Open interface;
•Wall murals;
•Sufficient sunshine.</td><td>•Open interface;
•Natural greening;
•Sufficient sunshine.</td><td colspan="3">•Natural greening;
• Set up a rest area with rich furniture styles;
•Sufficient sunshine;
•The landscape is rich in layers.</td></tr>
</table>

Tab 38 Analysis of the most integrated spatial design features

Judging from the visualization results of convex graphics, the space type with the highest degree of integration in each sample is shown in table 37.

Combined with the above spatial form analysis, it can be seen that:
1) The space types with the highest integration value in the cluster sample are indoor and outdoor transitional gray spaces (FIQ201/FIQ401), corridors (SHYP01/SHPD01), and foyers (FIQ503);
2) The space types with the highest integration value in the bilateral linear sample are corridors (FIQ501/FIQ505/SHYP05/SHHK02/SHHK03/SHHP01/SHBS01) and halls (SHJA01);
3) The space types with the highest degree of integration in the radial sample are entrance square (FIQ202), BAR (FIQ301), and corridor (SHYP04/SHHK01);
4) The space types with the highest integration value in the centralized sample are corridors (FIQ101/SHHK03), cloisters (FIQ102), courtyards (FIQ103), and corridors (FIQ502);
5) The space types with the highest integration value in the one-sided linear sample are the entrance gray space (SHYP02/SHYP03) and the entrance square (SHBS02).
Combined with the field survey and visit analysis in Chapter 3, the spatial design features with the highest integration value in each sample case were analyzed, as shown in table 38.

Corridors, foyers, multi-purpose halls, BARs, entrance plazas, entrance gray spaces, cloisters, and courtyards are the most integrated space types, that is, the locations with the best spatial connections. Among them, multi-functional halls, cloisters/corridors, and courtyards are the most integrated space types that only appear in the cases in Florence. The other space types are found in both Shanghai and Florence. The results of the comparative analysis of the spatial design features with the highest degree of integration shared by the samples from the two places are shown in table 39.

Comparison of space types	Similarities	Difference	
		Shanghai	Florence
Corridor	•Set rest seats; •Bright and warm colors; •Open interface; •Posters (columns) display information; •Accessibility.	•Wall displays handicrafts, traditional culture, and community activities; •Green plants; •Multi-functional spaces; •Linear markings on walls, ceilings, and floors are clear and dynamic, and integrate well with lighting fixtures; •Multimedia presentation.	•Continue historical materials and features.
Foyer	•Set up rest areas; •Set up a community cultural and historical exhibition area (wall); •Versatile mixing.	•Through the line of sight with the upper functional space.	•Colorful; •Place green plants.
BAR	•Open space; •Colorful.	•Place green plants.	•The dining table can be set up flexibly with columns; •Diverse lighting levels.
Entrance plaza	•Natural greening; •Accessible ramp.	•Linear markings are clear and dynamic; •Wall murals; •Natural greenery.	•Set up rest areas; •Axis landscape.
Entrance gray space	•Accessible ramps; •Natural plants; •The interface is open and transparent; • Set up seating areas.	•Ground material changes; •Window panels and pillars display community activities; •Sufficient sunshine.	•Diverse furniture styles.

Tab 39 Comparison of the most integrated spatial design features in the two cities

Analysis of spatial position visual integration

According to the ranking results of the average value of unified scale visual integration, it can be seen that FIQ201>FIQ401>SHYP04>FIQ202>FIQ502>SHPD01>FIQ503>FIQ301>Average>SHHK02>SHYP01>FIQ505>SHHK01>SHBS01>SHJA 01>FIQ102>SHYP02>SHBS02>SHYP03>SHHP01>FIQ501>SHYP05>FIQ103>SHHK03>FIQ101.

Compared with the convex graphic integration degree that corresponds to space usage efficiency, visual integration degree reflects seeing a larger spatial range, so the location with high visual integration degree is generally at the junction of large spaces. The top spatial locations are window openings in open spaces, joints of large spaces, open spaces in the center, entrance halls, etc. Ranked lower are the junctions between closed corridors and large space door and window openings, long corridors, etc. Therefore, having a long corridor is not conducive to visual communication.

Since the visual integration degree is to divide the plane into a pedestrian grid, the highest degree of integration in each case is some specific spatial locations, and the default door and window openings are open (whether the boundaries are closed or not and the length of the wall will block the line of sight) function), some junctions belong to multiple spaces, so they cannot correspond one-to-one with the cross-generational symbiosis space categories (functional space, transportation space, transition space, outdoor space) in Chapter 3. Judging from the visualization results of the sight map, the spatial location with the highest degree of visual integration in each sample is shown in table 40.

Combined with the above spatial form analysis, it can be seen that:

1) The spatial locations with the highest visual integration value in the grouped samples are the joints of multiple open spaces (window openings, corridors) (FIQ201), the edge of the courtyard (FIQ401), and the entrance to the foyer (SHPD01/FIQ503/SHYP01);

2) The spatial locations with the highest degree of visual integration in the radial sample are the center of the hall/square (SHYP04/FIQ202) and multiple open space connections (window openings, corridors) (FIQ301/SHHK01);

3) The spatial locations with the highest visual integration value in the bilateral linear sample are the connection between the corridor and the large space/room (SHHK02/SHBS01/SHYP05/SHHP01), the edge of the courtyard (FIQ505), and the connection between multiple open spaces (window openings, Corridor) (SHJA01), long corridor junction (FIQ501);

4) The spatial locations with the highest visual integration value in the one-sided linear sample are the connection between the corridor and the large space/room (SHYP02/SHBS02) and the junction of the long corridor (SHYP03);

5) The spatial locations with the highest visual integration value in the centralized sample are the junctions of multiple open spaces (window openings, corridors) (FIQ502/FIQ101/FIQ102/FIQ103), the edge of the courtyard (FIQ102), and the junction of long corridors (SHHK03) .

Spatial locations	Samples（VI Max）	Average of VI
Hall/Plaza Center	SHYP04(11.454)/FIQ202(10.807)	11.13
Patio edge	FIQ401(14.982)/FIQ505(5.924)/FIQ102(5.47)	8.792
The junction between the foyer and hall/entrance/corridor	FIQ503(8.31)/SHPD01(9.053)/SHHK02(7.062)/SHYP01(6.193)	7.655
Multiple open space connections (window openings, corridors)	FIQ201(17.803)/FIQ502(10.267)/FIQ301(8.293)/SHHK01(5.853)/SHHJA01(5.645)/FIQ102(5.47)/FIQ103(4.103)/FIQ101(1.175)	7.326
Corridor and large space/room connection	SHBS01(5.723)/SHYP02(5.332)/SHBS02(5.308)/SHYP05(4.322)/SHHP01(4.339)	5.005
Long corridor junction	SHYP03(4.764)/FIQ501(4.323)/SHHK03(4.064)	4.384

Tab 40 The spatial location with the highest degree of visual integration

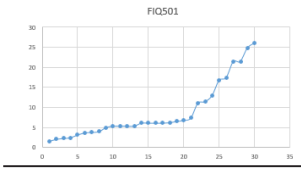
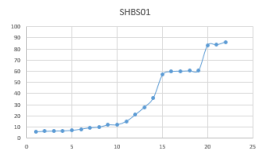
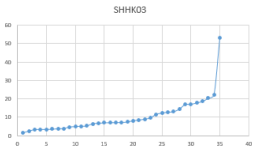
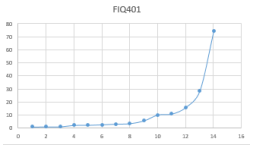
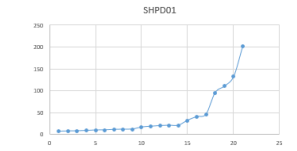
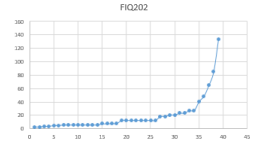
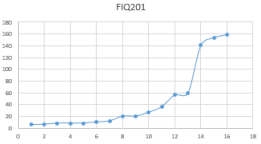
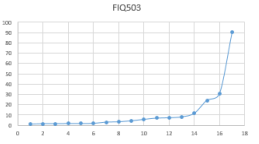
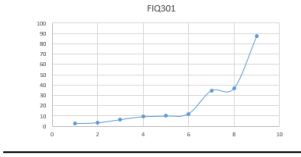
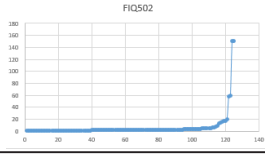
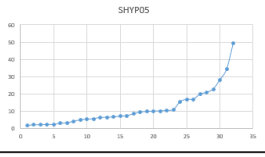
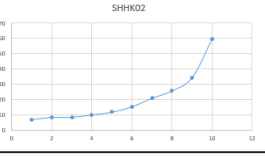
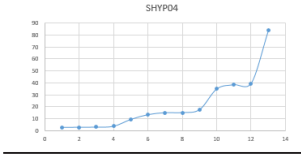
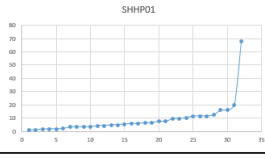
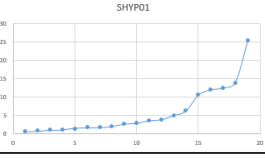
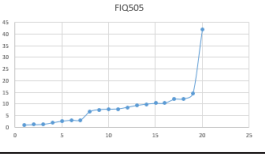
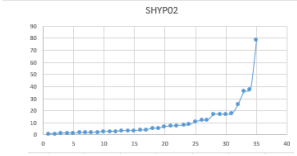
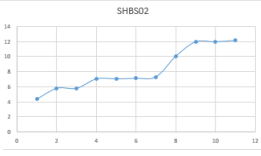
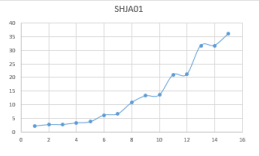
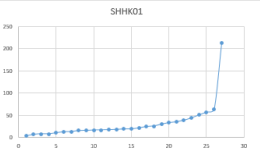
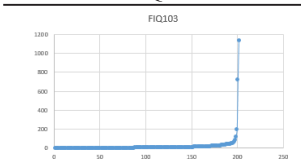
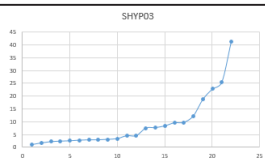
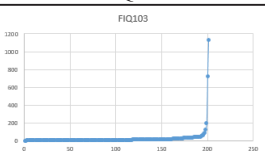
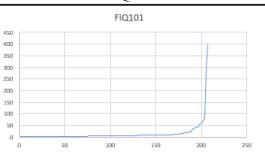
The location with the highest visual integration value is the farthest place within sight. Based on the field survey and visit analysis in Chapter 3, the indirect communication design features related to various spatial locations are summarized as follows:
1) Hall/square center: Set up a rest area, diversified functions, and flexible partitions;
2) Courtyard edge: Open the boundary with open spaces such as main functional rooms or foyers to create transparency;
3) The junction between the foyer and the lobby/entrance/corridor: create an open interface, set up a clear identification system, and have diversified functions;
3) Multiple open space connections (window openings, corridors): increase the area of the connections, diversify the connection methods, and set up rest areas;
4) The connection between the corridor and the large space/room: appropriately enlarge the node area, set up a rich and interesting interface, and create an open interface;
5) At the junction of long corridors: set up a rest area, enlarge the node area, and set up a clear sign system.

Integration analysis of space area proportion

In addition to spatial form and spatial type, the way to evaluate the spatial layout of cross-generational co-living space can also analyze the impact of scale on spatial connectivity through the proportion of spatial area. From the previous comparison of the calculation methods of integration and visual integration values, it can be seen that compared with using a grid to quantify the visual integration of a plane, the integration analysis using convex graphics as a model is easier to quantify the spatial area. The analysis of spatial area ratio in this section is based on the ranking of convexmap integration values.

From the spatial form integration ranking, it can be seen that the average integration value of the sample data corresponding to the cluster form, bilateral linear form and radial form are higher. Ranking by space type, it can be seen that bilateral linear and cluster samples are at the forefront. The area scales of these two spatial forms are relatively small, which can be understood as low discreteness. Therefore, the convexmap areas of all samples are counted in one-to-one correspondence, and the area discreteness of each case is compared. The resulting curve relationship is shown in table 41.

Except for a few cases (FIQ502, SHBS02, SHJA01) due to factors such as a small number of spaces and measurement errors, most of the samples are consistent with the following: the lower the area dispersion (the smaller the difference in size of each spatial scale), the higher the spatial integration value, the better the connectivity. In a practical sense, except for auxiliary and service rooms, the closer the areas of each space in the building are, the better the effect of cross-generational communication will be. It can also be seen from the curve relationship chart that the discreteness

FIQ501	SHBS01	SHHK03	FIQ401
			
SHPD01	FIQ202	FIQ201	FIQ503
			
FIQ301	FIQ502	SHYP05	SHHK02
			
SHYP04	SHHP01	SHYP01	FIQ505
			
SHYP02	SHBS02	SHJA01	SHHK01
			
FIQ103	SHYP03	FIQ102	FIQ101
			

Tab 41 Discreteness of area

of the Shanghai sample is lower than that of the Florence sample. This is because many sample cases in Florence are historical building renovations, which are related to the structure and plane form of the original building itself.

In addition to area dispersion, combined with the best space types for cross-generational communication obtained from the previous data analysis (corridor, foyer, multi-functional hall, BAR, entrance square, entrance gray space, cloister/corridor, courtyard), the cross-generational communication in each sample was Statistics were made on the area proportions of the communication space types.

According to the pie data chart of each sample, it can be seen that the proportion of cross-generational communication areas with good connectivity in different spatial forms is:

1) In cluster form, the courtyard or entrance space accounts for about 50%, and the corridor accounts for less than 5%;

2) The proportion of corridors in the bilateral linear plane should reach 15% to 20%;

3) The proportion of large spaces that serve as connections in the radial plane should reach 40% to 50%;

4) The enclosed central space in the centralized plan should account for 30% to 40%, and the corridor should account for 5% to 10% (except for the corridor as the central space);

5) The proportion of the connector (outdoor gray space) in the one-lateral form should reach 20% to 30%.

Guidance on design

Through data statistics and analysis of sample cases, it can be seen that the influencing factors of the layout of inter-generational symbiosis space include spatial form, space type, spatial location and area proportion, etc. Exploration of the above aspects can guide the design of cross-generational co-living space, as follows:

1) For new cross-generational co-living spaces, cluster space forms are more conducive to direct and visual communication, followed by radial spaces and bilateral linear spaces; for new and old additions, it is necessary to establish the functional positioning of the new building and select appropriate communicating ways, and then choose appropriate spatial forms for connection; for the renovation of historical buildings, it is necessary to calculate the integration and visual integration of the overall space, and select a more suitable part of the space for renovation;

2) The types of spaces that are prone to direct cross-generational communication are corridors, foyers, multi-functional halls, BARs, entrance squares, entrance gray spaces, cloisters/corridors, courtyards, etc. The design points of the cases in Shanghai and Florence are different. The common design points are: setting up a rest area, bright and rich colors, open interface, information display, barrier-free processing, combination of traditional/community culture, multi-functional mixing, and natural greening;

3) The locations where visual communication is prone to occur are the center of the hall/square, the edge of the courtyard, the junction between the foyer and the hall/entrance/corridor, the connection between multiple open spaces (window openings, corridors), the connection between corridors and large spaces/rooms, and long hallway junction. The design points that should be paid attention to are: setting up rest areas, diversifying functions, flexible partitions, creating open interfaces, setting up clear identification systems, increasing the area of connections, and diversifying connection methods;

4) For new buildings and additions, except for auxiliary and service rooms, the closer the area of each space in the building is, the lower the discreteness, the better the effect of cross-generational communication will reach; for the renovation of historical buildings, The choice of area discreteness requires a comprehensive judgment based on the degree of integration and visual integration of the overall space; the proportion of space types with a high degree of integration is related to the specific spatial form.

4.4 Summary

This chapter conducts data statistics and analysis on the cases selected for the survey. Based on the theory of space syntax, the cross-generational co-living space is extracted from the convexmap topological relationship diagram and the line of sight grid analysis, and its spatial layout is deeply explored.

Cross-generational co-living space takes space as the research object, abstracts the structural relationship between spaces, and derives a spatial layout that is easy to produce cross-generational communication, so it involves geometric graphics and topological abstraction. After comparing Q analysis, fractal theory, J diagram and other graphic theories, we chose space syntax, the most widely used method in the field of architecture to study spatial connectivity based on graph theory, as the theoretical basis. After comparative analysis of methods such as the axis method, view area segmentation method, convex space method, all line method, overlapping convex space method, visible map analysis of view areas, etc., we selected the convex figure and line of sight map methods that are suitable for studying cross-generational co-living space. Data analysis was conducted on all sample cases, and the two parameters with the closest spatial connection were obtained: integration degree and visual integration degree. Combining the definition and overview of space in the field of architecture, the data analysis and discussion of integration and visual integration were conducted from three directions: spatial form, spatial type and location, and spatial area proportion of cross-generational co-living space layout, and the results were applied to guide the design.

The basic conclusions drawn in this chapter are as follows:
(1) There are five forms of cross-generational co-living space. Among them, the cluster space form is the most conducive to direct and visual cross-generational communication, followed by the radial form and bilateral linear form, and the centralized and one-lateral linear form are worse;
(2) The types of spaces that are most conducive to direct cross-generational communication are corridors, foyers, multi-functional halls, BARs, entrance squares, entrance gray spaces, cloisters, and courtyards;

(3) The spatial locations that are most conducive to indirect (line of sight) communication are the center of the hall/square, the edge of the courtyard, the intersection between the foyer and the hall/entrance/corridor, the joints of multiple open spaces (window openings, corridors), corridors and large spaces/ room connections and long corridor junctions;

(4) Except for auxiliary and service rooms, the lower the area dispersion and the closer the size of each space in the building, the better the effect of cross-generational communication;

(5)The area proportion of the best space for

cross-generational communication among various spatial forms is: 1)In the cluster plan, the courtyard or entrance space accounts for about 50%, and the corridor accounts for less than 5%; 2)Bilateral linear plan The proportion of the central corridor should reach 15% to 20%; 3)The proportion of large connecting spaces in the radial plan should reach 40% to 50%; 4) The proportion of the enclosed central space in the centralized form should reach 30% to 40%, and the corridor accounts for 5% to 10% (except for the corridor as the central space); 5)The connector (outdoor gray space) in the one-lateral linear form must account for 20% to 30%.

Interpreting the spatial layout of cross-generational co-living space in a quantitative way is a more objective and in-depth study of the relationship between cross-generational co-living behavior and architectural space. It also provides a scientific data research basis for the subsequent establishment of influencing factor scales and establishment of evaluation systems.

PART III
EVALUATION

Chapter 5 Construction of evaluation system for cross-generational co-living space

This chapter, building on the literature review, field research, and qualitative and quantitative studies of spatial configuration presented earlier, explores the factors influencing cross-generational co-living spaces from a more comprehensive perspective. It further develops a framework for evaluating cross-generational co-living spaces in residential communities. The research aims to identify and summarize design elements relevant to cross-generational co-living spaces and to follow the scale development process to propose a design scale for such spaces. This tool can effectively assess the residential community environment, providing scientific guidance for improving the quality of cross-generational co-living spaces and enhancing active aging levels.

Chapter 5
Construction of evaluation system for cross-generational co-living space

5.1 Research methods and progress

Study on Evaluation Methods for Age-Friendly Communities

In the 1950s, Doxiadis first introduced the concept of "Ekistics" or "the science of human settlements" (Doxiadis, 1972). Since then, scholars have shifted their focus to urban livability and the suitability of community environments for the elderly. Current research on the relationship between the elderly and community environments mainly concentrates on influencing factors and evaluation methods (Zhang et al., 2019).

From the perspective of sustainability, Salzano considered the livable environment for the elderly from the angle of sustainable urban development. He argued that interpersonal relationships, community environmental facilities, and site selection significantly impact the living environment for the elderly (Salzano, 1997). Douglas proposed the basic conditions for harmonious development of livable cities from the perspective of the interplay between humans, the environment, and society (Douglass, 2002). The British Economist Intelligence Unit developed an urban livability evaluation index system through comprehensive environmental assessments of elderly communities, including indicators for health and safety, culture and environment, and infrastructure (Peter, 2001). Mercader Moyano Pilar designed a multidimensional assessment system for the built environment by defining and quantifying seven related dimensions and 35 multidisciplinary variables (both quantitative and qualitative) (Mercader-Moyano, 2020). Gu Zongni assessed the equity of elderly communities based on three indicators: density, diversity, and design of the built environment (Gu et al., 2022). Qu Jiayao developed a localized scale to evaluate the living environment for the elderly in Beijing, focusing on four dimensions: housing environment assessment, community environment assessment, service environment assessment, and interpersonal environment assessment (Qu, 2017). Wang Xiaoliang employed the Analytic Hierarchy Process (AHP) to establish a sustainability evaluation system for elderly communities, considering operation models, environmental planning, and architectural space (Wang & Li, 2014).

From the perspective of well-being and satisfaction, Elizabeth J. Burton used the newly designed and tested tool NeDeCC (Neighborhood Design Characteristics Checklist) to objectively measure the happiness of the elderly and the design features of communities, establishing objective measures for the built environment (Burton & Stide,2011). Harvey suggested utilizing geographic information systems, internet surveys, and social media to investigate physical characteristics and resident satisfaction at the neighborhood scale to effectively measure urban community livability (Harver, 2016). Jana Temelová evaluated the residential satisfaction of the

elderly in two central Prague communities through questionnaire surveys examining the accessibility of local services, public spaces, housing, and social support (Temelova, 2012). Jiang Qin and others examined the elderly's community environment satisfaction from two dimensions: satisfaction with the community's interpersonal environment and satisfaction with community facilities (Jiang & Gao,2014).

From the perspective of social interaction and friendliness, H. Khosravi employed regression analysis to investigate 33 built environment indicators affecting the social quality of elderly residents in the urban space of Banafsheh community in Mashhad. Based on perceived and self-reported data collected from questionnaires, these indicators were categorized into seven major urban design factors (Khosravi et al., 2015). Raquel Agost-Felip evaluated the vulnerability of suggested dimensions and calculated a comprehensive global vulnerability index by establishing an inclusive model for age-friendly urban environments (Agost-Felip et al., 2021). Qiuchang Cao used hierarchical logistic regression to study the impact of accessing outdoor spaces and buildings, as well as social or community activities, on the elderly's perceived sense of isolation (Cao et al., 2020). Lu examined the relationship between the subjective well-being of the elderly and built environment factors by selecting 25 factors related to elderly activities, proposing strategies to optimize the built environment of elderly communities (Lu, 2021). Kyeongmo Kim designed four CFA models to validate data from the AARP 2016 Age-Friendly Community Survey, covering 62 indicators across categories such as outdoor spaces, transportation, housing, social participation, community and health services, demonstrating the utility of these indicators in assessing age-friendliness of communities (Kyeongmo, 2022). Yu Yifan proposed an evaluation system for age-friendly communities consisting of eight criteria and 46 technical indicators, covering neighborhood environment, environmental performance, housing, roads and transportation, services and facilities, social participation, social inclusion, and communication and information (Yu, 2020).

In existing studies on the evaluation systems of community environments and their relationship with the elderly, most evaluation factors are derived from existing evaluation scales and literature, combining qualitative and quantitative analysis methods (primarily Comprehensive Evaluation, CE) to develop evaluation models. Research from the sustainability perspective emphasizes evaluations of overall planning, architecture, and hardware facilities. Studies on well-being and satisfaction focus on designing scales to measure livability and interpersonal relationships. Research on social interaction and friendliness centers on establishing age-friendly cities and evaluating built environment elements. Currently, there is a lack of research on the quality of community activity spaces from the perspective of cross-generational interaction. This study aims to fill this gap

by designing, adjusting, and testing the environmental evaluation system for cross-generational co-living space (EESCCS). It promotes the design of built environments that facilitate cross-generational communication by developing new evaluation factors and models, organizing and quantifying various qualitative and quantitative dimensions related to multi-generational needs. This provides policymakers, promoters, and users with comprehensive evaluation tools to promote appropriate design and renovation strategies for cross-generational co-living spaces, thereby enhancing the quality of life for the elderly.

Comparison of Comprehensive Evaluation Methods

This study identifies subjective qualitative factors through case studies and derives objective quantitative factors through a literature review and spatial analysis. To convert qualitative evaluation into quantitative evaluation, the results from both parts of the research are combined, transforming multiple indicators into a single composite indicator that reflects the overall situation. For this purpose, a comprehensive evaluation method is employed.

The primary distinction between evaluation methods lies in how weights are determined. One category is subjective weighting methods, which generally rely on comprehensive consultation and scoring to determine weights, such as the comprehensive index method, fuzzy comprehensive evaluation, analytic hierarchy process (AHP), and efficacy coefficient method. The other category is objective weighting methods, which determine weights based on the correlations among indicators or the degree of variation in indicator values, such as principal component analysis (PCA), factor analysis, and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), also known as the ideal solution method. Currently, there are dozens of comprehensive evaluation methods used both domestically and internationally, with the main methods including PCA, factor analysis, TOPSIS, rank-sum ratio method, grey relational analysis, entropy weighting method, AHP, fuzzy evaluation, matter-element analysis, cluster analysis, value engineering, and neural networks. Chinese scholar Zhu Xiaolei summarized 10 major methods for evaluating the built environment, as explained in table 42 (Zhu, 2005).

Number	Evaluation Method	Mechanism	Application Premise	Advantages	Disadvantages	Application Mode	Scope of Application
1	Scoring Evaluation Method	Establish a comprehensive set of environmental indicators, evaluate, grade, and rank through scoring	① Comprehensive understanding of environmental characteristics and descriptors; ② Determine indicator weights	Quick, intuitive, and results are comparable	Unstable reliability	Checklist	Describe the environment
2	Statistical Survey Evaluation Method	Conduct sampling surveys using questionnaires or scales to obtain quantitative results through statistical analysis	① Establish an appropriate evaluation factor model; ② Sampling; ③ Ensure sample size	Rigorous, efficient, with good reliability and validity	Has subject responsiveness; questionnaire and scale design is somewhat challenging	Sampling survey	Suitable for medium to large-scale evaluations
3	Analytic Hierarchy Process (AHP)	Quantify subjective judgments using matrix ranking principles	① Ensure sample size; ② Moderate number of indicators	Good comparability; can rank indicators; simple calculations	Cannot perform correlation analysis, unable to evaluate the rationality of the indicator structure	Questionnaire survey	Comprehensive Evaluation Comparison
4	Fuzzy Comprehensive Evaluation Method	Comprehensive Evaluation Using Fuzzy Mathematics Principles	① Has indicator weights; ② Must determine membership function	Rigorous, precise; can perform comprehensive evaluation and grading	Same as above, calculation is slightly abstract	Questionnaire survey	Environmental Comparison and Grading
5	Psychophysical Evaluation Method	Measure psychological quantities to study the relationship between stimuli and subjective sensations, i.e., the psychophysical relationship	① Design stimuli; ② Control extraneous variables; ③ Conduct sampling	Accurate, high validity, can establish regression prediction models	Requires multiple measurements, has responsiveness, difficult to design stimuli	Quasi-experimental method	More suitable for visual and other environmental evaluations

Note: Table continues on next page

6	Cognitive evaluation method	Guiding research design from the perspective of psychological cognitive principles, evaluating the environment from the angle of the psychological experience of the environment's subjects	① Sampling; ② Participants have a certain level of knowledge	Real, natural, easy to grasp deep structures, low responsiveness, good reliability	Abstract, difficult to operate, easily influenced by participants' cognitive abilities, unstable validity	① Schematic mode; ② Language mode	Suitable for various environmental scales
7	Behavioral measurement evaluation method	Understanding the actual state of the environment from the perspective of the environment-behavior relationship	Conditions for systematic observation	Realistic and objective, less responsiveness, easy to identify problems, high validity	Time-consuming and labor-intensive; complex evaluation design, high demands on researchers	① Linguistic; ② Non-linguistic	Suitable for assessing behavioral environments and usage patterns
8	Architectural Tour Evaluation Method	Select representative users, conduct on-site evaluations, engage in free-form discussions, and democratically determine evaluation conclusions	① Conditions for selecting different users; ② Cooperation of the owner	Good targeting, better design participation mechanism, real, direct, good validity	Participants may have concerns or private communications that reduce reliability; limited number of people, complex organization	On-site visit method	Very extensive
9	Non-intrusive evaluation method	Using documents, literature, or environmental traces for inferential evaluation	① Reliable literature sources; ② Obvious environmental clues	Non-responsive, high validity, easy to conduct, simple research design	Reliability determined by literature, complex analysis process, cannot be used alone	Literature research method	Suitable for evaluating environments with documented records
1 0	Evaluation method based on researcher participation expe-rience	Comprehensively analyze various aspects of the research object using anthropological case study methods to deeply understand the causes of the problem	① Researchers have extensive professional knowledge; ② In-depth understanding of the background knowledge of the evaluation object	Minimal responsiveness; closely aligned with professional perspectives, good validity, controllable observation methods	Poor reliability, high requirements for researcher skill level, time-consuming, easily affected by research conditions	Field research method (participant observation)	More suitable for pilot studies

Tab 42 Performance comparison of 10 built environment evaluation methods

Compared to evaluation methods more suitable for small-scale, human-centered assessments, highly structured subjective and comprehensive evaluation methods emphasize the validity and completeness of measurement tools, employing more scientific analysis techniques and algorithms, thereby achieving a perfect combination of quantitative and qualitative techniques. The influencing factors of cross-generational co-living spatial environments include some factors with unclear boundaries and those difficult to quantify. Since the data in this study contains a significant amount of qualitative factors and requires the calculation of indicator weights and a comprehensive evaluation, it is more appropriate to apply the fuzzy comprehensive evaluation method and the analytic hierarchy process (AHP). As multi-criteria decision-making approaches that combine qualitative and quantitative techniques, these two methods are capable of conducting a comprehensive evaluation of the membership level (also known as the evaluation set) of the evaluated object based on multiple factors. The basic principles of these two methods are explained below.

The fuzzy comprehensive evaluation method (Fuzzy Synthetic Evaluation Model, FCE), based on fuzzy mathematics (fuzzy sets), was proposed by American mathematician (Lotfi, 1965). It is an evaluation method used to address uncertainty. Grounded in the principles of fuzzy relation synthesis, it simulates human reasoning by replacing numerical variables with linguistic variables during the quantitative analysis of factors with ambiguous evaluation boundaries, thus allowing for a multi-factor comprehensive evaluation of an object's membership level (Song et al., 2021). In the field of architecture, FCE can be used to assess building design and performance, handling aspects that are difficult to quantify with precise data, such as aesthetic appeal, user satisfaction, or environmental adaptability. This method supports multi-standard, multi-dimensional comprehensive evaluations, facilitating a thorough analysis of various aspects of architectural projects, such as functionality, environmental adaptability, and economic benefits. FCE offers flexibility in weight distribution and membership function settings, allowing adjustments to the evaluation model according to specific circumstances. By utilizing fuzzy logic to address uncertainty and subjectivity, FCE converts qualitative evaluations into quantitative assessments, resulting in more comprehensive and flexible evaluation outcomes (Feng & Xu, 1999). Although FCE can handle subjective judgments, excessive reliance on subjective factors may introduce bias into the evaluation results. Therefore, the accuracy of the results depends heavily on the quality of the input data, such as weight distribution and membership function settings. Given the combination of subjective and objective factors in the evaluation of cross-generational co-living spatial environments, which involves various quantitative and qualitative indicators, the fuzzy comprehensive evaluation method is suitable for this research.

The analytic hierarchy process (AHP) is a multi-criteria decision-making support technique developed in the 1970s by Iraqi-born American mathematician Thomas L. Saaty. This method compares multiple alternatives based on several quantitative or qualitative criteria, resulting in an overall assessment of each alternative (Thomas, 1988). In the field of architecture, AHP decomposes decision elements into a hierarchy of objectives, criteria, and alternatives, enabling a ranking of decision options based on judgments. This approach facilitates both qualitative and quantitative analysis and is widely used in the planning, design decision-making, and resource allocation of complex architectural projects. A workflow diagram for AHP is provided in figure 41.

One advantage of AHP is that it introduces quantitative analysis into complex decision-making processes while leveraging the preference information provided by decision-makers in pairwise comparisons, combining the strengths of both qualitative and quantitative analysis. This makes the decision-making process highly structured and scientific, particularly suitable for decision-making analysis in socio-economic systems. However, AHP has a significant subjective component,

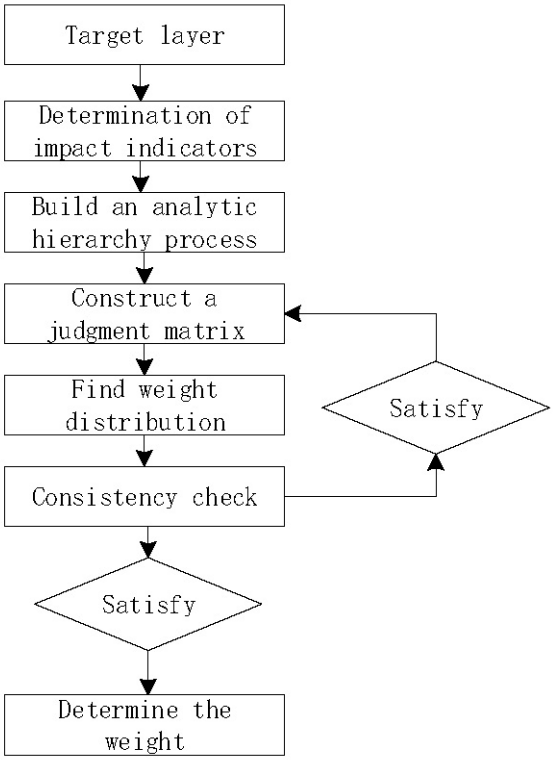


Fig 41 Workflow of analytic hierarchy process

requiring decision-makers to have a deep and comprehensive understanding of the problem at hand.

The AHP method often involves repeated consultation with experts and scoring of weights, commonly utilizing the Delphi method. Rowe and Wright (1999) summarized that the size of Delphi panels in peer-reviewed studies ranged from 3 to 80 members. Most studies involve 8 to 16 panel members, and it is recommended to have at least 8 members. The exact number of panel members should be determined by the specific characteristics of the study, such as the availability of experts, the required geographical representation, and the facilitator's ability. The number of selected panel members should also account for the possibility that some may drop out due to other commitments or lack of interest. Therefore, an adequate number of panel members should be selected at the beginning of the process to ensure sufficient qualified participants by the end of the study (assuming some participants may not complete all rounds). Summaries of Delphi studies indicate that the number of rounds typically ranges from 2 to 6 (Dalkey et al., 1970). More than half of the studies found that convergence after three or fewer iterations was acceptable. In fact, Dalkey et al. (1970) demonstrated that Delphi results are most accurate after the second round, with additional rounds potentially decreasing accuracy (Hallowell et al., 2010).

Since this study involves qualitative research on the built environment, quantitative spatial analysis, and case scoring, the combination of the aforementioned methods, known as the Fuzzy Analytic Hierarchy Process (FAHP), is chosen as the research tool for this chapter. The following sections will provide a detailed explanation of the research methodology and evaluation process.

5.2 Evaluation Method Based on Fuzzy Analytic Hierarchy Process (FAHP) and Multi-Objective Optimization

Indicator Design

Each evaluation indicator measures the magnitude of a specific characteristic of the system from different perspectives. The establishment of an evaluation indicator system depends on the specific evaluation problem at hand. Generally, the principles to follow when establishing an evaluation indicator system are: systematicness, scientific accuracy, comparability, measurability (or observability), and (as much as possible) mutual independence (Yi et al., 2019). Specifically:

(1)Systematicness

The establishment of the evaluation indicator system should be targeted and systematic, with the overall goal being the evaluation system for cross-generational co-living spaces. It should reflect the characteristics of such spaces from multiple angles and levels.

(2)Scientific Accuracy

The determination of the evaluation system should strictly adhere to scientific principles, starting from practical considerations, and should involve scientific and reasonable definitions and classifications.

(3)Comparability

The evaluation factors should have different levels. The spatial evaluation factors should be organized into primary and secondary factors to accurately reflect the differences between primary factors while ensuring that the same level factors are comparable.

(4)Measurability (or Observability)

The evaluation of space should be specific and quantifiable. Especially when dealing with multifaceted and multi-level spatial factors, quantitative evaluation indicators are more helpful for technical personnel to evaluate spatial characteristics, identify key control factors, and guide design solutions.

(5)Mutual Independence

Different factors at the same level and factors across different levels should consider their interrelationships. While they are interconnected, they must be distinct and not represent the same concept to avoid redundancy. Ultimately, all factors should contribute to the overall goal of space evaluation.

Expert Evaluation Method Based on FAHP

The Fuzzy Analytic Hierarchy Process (FAHP) combines the Analytic Hierarchy Process (AHP) with Fuzzy Comprehensive Evaluation. It is based on expert surveys and can effectively analyze the importance relationships among different factors. By integrating spatial factor evaluation, FAHP can effectively assess the controlling factors and the significance of

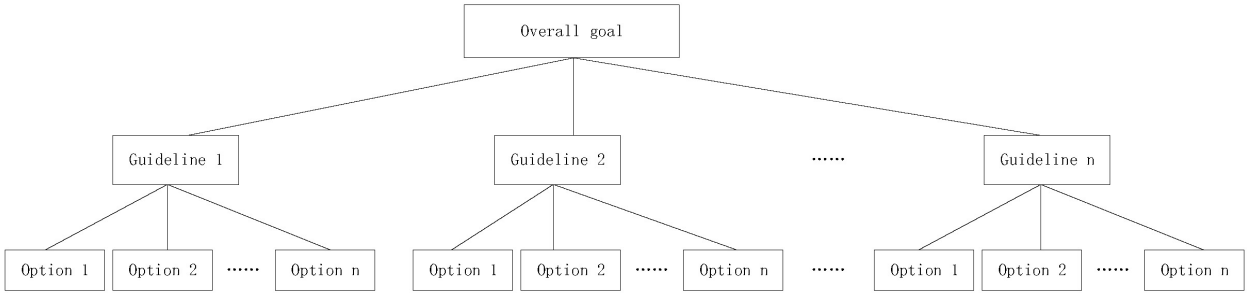


Fig 42 Hierarchical distribution of evaluation factors

different factors in cross-generational co-living spaces, and it is easy to operate.

The main steps for using FAHP to evaluate spatial systems are as follows:
(1) Establish the evaluation hierarchy
(2)Expert evaluation (assessing the importance of evaluation factors and controlling factors, etc.)
(3)Calculate the rating of factors at different levels
(4)Calculate the evaluation of controlling factors

The detailed steps are described as follows.

Establishment of the Evaluation Hierarchy
Establish the evaluation factor hierarchy around the spatial evaluation system, commonly using three levels. The structure is shown in figure 42.

As shown in the evaluation system factor hierarchy diagram, the overall goal of the evaluation system is to establish a spatial evaluation system. The first-level factor layer includes five main aspects (first-level factors), while the second-level factor layer is summarized based on national standards, previous research, and field surveys.

Expert Evaluation and Calculation of Factor Relative Importance Weights
To determine the importance weights of different factors within the same level and group, the calculation is divided into the following three stages:

(1)Generating the Judgment Matrix from Expert Scores
After establishing the analytic hierarchy model, pairwise comparisons are made among elements at each level to construct a comparison judgment matrix. These judgments are expressed numerically by introducing appropriate scales, forming the judgment matrix. The judgment matrix represents the relative importance comparisons of factors at the current level concerning the factors at the previous level. It is the fundamental information for the analytic hierarchy process and a crucial basis for calculating relative importance.

When constructing the pairwise comparison judgment matrix, it is assumed that the elements of the previous level B_k serve as criteria, dominating the elements of the next level, E_1, E_2, ..., E_n. The goal is to assign weights to E_1, E_2, ..., E_n based on their relative importance B_k under criterion E_n. In this step, the following question must be answered: For criterion B_k, which of the two elements, E_i and E_j, is more important, and to what degree? The importance is assigned a numerical value, which can be obtained directly from participants through designed questionnaires or analyzed mathematically from environmental rating data (including qualitative judgments).

Serial Number	Importance Level	E_{ij} Assigned Value n
1	Elements i and j Equally important	1
2	Element i Slightly more important than element j	3
3	Element i Significantly more important than element j	5
4	i Element is significantly more important than j element	7
5	i Element is extremely more important than j element	9
6	i Element is slightly less important than j element	1/ 3
7	i Element is obviously less important than j element	1 /5
8	i Element is significantly less important than j element	1 /7
9	i Element is extremely less important than j element	1/9
10	Intermediate degree based on judgment level	2,4,6,8,1/ 2,1/4,1/6,1/8

Tab 43 Explanation of the importance comparison assignment for two indicators

For n elements, the pairwise comparison judgment matrix $E=(E_{ij})_{n*n}$ is formed, where E_{ij} represents the importance value of factor i relative to factor j concerning the goal.

B_k	E_1	E_2	…	E_n
E_1	E_{11}	E_{12}	…	E_{1n}
E_2	E_{21}	E_{22}	…	E_{2n}
…	…	…	…	…
E_n	E_{n1}	E_{n2}	…	E_{nn}

The matrix E has the following characteristics:

$$E_{ij} > 0$$

$$E_{ij} = 1/E_{ji}(i \neq j)$$

$$E_{ii} = 1(i = 1,2, \dots, n)$$

We refer to this type of matrix E as a reciprocal matrix. For a reciprocal matrix E , if for any i , j , and k , $E_{ij} * E_{jk} = E_{ik}$, it is called a consistent matrix. In practical problem-solving, the constructed judgment matrix may not always exhibit consistency, necessitating a consistency check.

Based on the analytic hierarchy model, each indicator at each level is compared pairwise to judge their relative importance. The indicators at each level are scored using a 9-point scale to construct the judgment matrix. The importance comparison values between each pair of indicators are shown in table 43.

(2)Fuzzy Judgment Matrix

In practice, expert scoring often involves a significant degree of subjective conjecture, which introduces the fuzzy judgment method to enhance the accuracy of the judgment matrix.

Fuzzy numbers employ fuzzy sets$F = \{x \in R | \mu_F(x)\}$, where x can take values from negative infinity to positive infinity. $\mu_F(x)$ is a continuous mapping from R to the closed interval [0,1]. A triangular fuzzy number can be represented as M = (l, m, u). Its membership function is defined as follows:

$$\mu_M(x) = \begin{cases} 0, & x < l \text{ or } x > u \\ (x-l)/(m-l), & l \leq x \leq m \\ (x-u)/(m-u), & m \leq x \leq u \end{cases}$$

l and u represent the lower and upper bounds of the support of M, respectively, while m is the median of M. It is important to note that in the application of triangular fuzzy numbers, the values of l and u are directly related to the level of fuzziness in the judgment—an increase in u-l indicates a higher level of fuzziness, whereas a decrease in u-l points to a lower level of fuzziness. Particularly, when 'l = m = u' holds true, this situation typically corresponds to a non-fuzzy number, indicating that the judgment made is definitive.

This method can be used to determine the corresponding weights. Assume that the decision maker uses the linguistic weight set W, W={ALI,VSLI,SLI,WLI,EI,WMI,SMI,VSMI

Importance linguistic scale	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
EI	(1/2 1 3/2)	(2/3 1 2)
WMI	(5/2 3 7/2)	(2/7 1/3 2/5)
SMI	(9/2 5 11/2)	(2/11 1/5 2/9)
VSMI	(13/2 7 15/2)	(2/15 1/7 2/13)
AMI	(17/2 9 19/2)	(2/19 1/9 2/17)

Tab 44 Importance language scale

,AMI}, where ALI (absolutely less important) signifies absolutely unimportant, VSLI (very strongly less important) signifies very strongly unimportant, SLI (strongly less important) signifies strongly unimportant, WLI (weakly less important) signifies slightly unimportant, EI (equally important) signifies equally important, WMI (weakly more important) signifies slightly important, SMI (strongly more important) signifies strongly important, VSMI (very strongly more important) signifies very strongly important, and AMI (absolutely more important) signifies absolutely important. The following table provides the triangular fuzzy conversion scale table 44.

The middle values can also be chosen as 2, 4, 6, or 8, and the corresponding fuzzy scales and reciprocal scales can be referenced from the table above.

Common hybrid methods include the extended analysis method and fuzzy rating design questionnaire. In this paper, the fuzzy network analysis method is proposed for decision-making. The specific steps are as follows:

(a) The pairwise comparison judgment matrix (AHP) method's importance judgment has uncertainty, which can be integrated using fuzzy triangular numbers. This method aims to construct a relatively objective fuzzy judgment matrix based on the subjective evaluation of decision-makers. The pairwise comparison matrix expressed using triangular fuzzy numbers is shown as follows:

$B = (B_{ij})$, where B_{ij} is a triangular fuzzy number, determined by:

$B_{ij} = (l_{ij}, m_{ij}, u_{ij})$, with $l_{ij} \leq m_{ij} \leq u_{ij}$. B_{ij} is a triangular fuzzy number. The method to determine this is:

$l_{ij} = \text{mink}\,(B_{ijk})$
$m_{ij} = \text{Geomeank}\,(B_{ijk})$
where Geomean represents the geometric mean, which can also consider the weighted geometric mean of various experts,
$u_{ij} = \text{maxk}\,(B_{ijk})$

(b) Based on the fuzzy judgment matrix $B = (B_{ij})$, the eigenvalue method is used to determine the corresponding fuzzy weight vector.

(c) The concept of alpha-cuts in fuzzy analysis is used for defuzzification of the weights. Let $\alpha \in [0,1]$ denote the alpha-cut parameter, and assume that

$$w_i = (w_i^L, w_i^M, w_i^U), \text{ let}$$

$$\left.\begin{aligned} w_i^L(\alpha) &= (w_i^M - w_i^L)\alpha + w_i^L \\ w_i^U(\alpha) &= (w_i^U - w_i^M)\alpha + w_i^M \\ w_i(\alpha,\lambda) &= \lambda w_i^U(\alpha) + (1-\lambda) w_i^L(\alpha) \end{aligned}\right\}$$

where α is the decision maker's optimism

Order n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.24	1.36	1.41	1.46

Tab 45 Random index RI values

Evaluation value n	Comments	Grading
n ≤1.5	Very poor	A 5
1.5 < n≤ 2.5	Poor	A 4
2.5 < n≤ 3.5	Average	A 3
3.5 < n≤ 4.5	Good	A 2
n > 4.5	Excellent	A 1

Tab 46 Evaluation criteria and grading

coefficient regarding the weights. Furthermore, α is normalized to obtain the normalized weight vector:

$$W_i(\alpha,\lambda) = w_i(\alpha,\lambda)/(\sum_i w_i(\alpha,\lambda))$$

The current decision weight system is based on two key parameters: α and λ. The roles of these parameters can be explained as follows: α indicates the extent to which the judgments of decision experts vary. Specifically, when α = 0, it means that a broader range of expert opinions has been integrated, reflecting the maximum range of variation in the decision-making process. Conversely, when α = 1, it means that the information reflects the weights of the smallest number of experts, essentially equivalent to the method of aggregating expert decision weights before applying fuzzy processing. Therefore, α can be regarded as a parameter describing the decision environment.

λ, on the other hand, represents the parameter for summarizing the weight information from different decision-makers. When λ = 0, it indicates that the experts tend to adopt the most optimistic estimates, i.e., selecting the maximum weight values. When λ = 1, it indicates that the experts hold a more conservative stance, tending to choose the minimum weight values. Therefore, λ is also considered a coefficient reflecting the optimism level of the decision-makers.

In determining the actual weights, if the expert team has reached a high consensus on a particular issue, a higher α value can be chosen. The selection of λ reflects the decision-maker's optimistic attitude toward the problem; the more optimistic, the higher the λ value.

(3)Calculation of Eigenvalues and Eigenvectors of the Judgment Matrix

To calculate the relative importance weights between the elements represented by each judgment matrix, the maximum eigenvalue of the matrix and its corresponding eigenvector can be obtained. There are various methods for solving eigenvectors: the power method, the sum-product method, and the square root method. Generally, the precision of the sum-product method is sufficient. The steps are as follows:

(a) Normalize each column of the judgment matrix E

$$E'_{ij} = \frac{E_{ij}}{\sum_{i=1}^{n} E_{ij}} (i = 1,2,\dots,n;\ j = 1,2,\dots,n)$$

(b) Sum up the normalized matrix by row

$$\overline{E}_i = \sum_{i=1}^{n} E'_{ij}\,(i = 1,2,\dots,n;\ j = 1,2,\dots,n)$$

(c)Normalize $\overline{E}_i$ to obtain the feature vector

$$W = (W_1, W_2, \dots, W_n)^T, W_i = \frac{E_i}{\sum_{i=1}^{n} \overline{E}_i}\ (i = 1,2,\dots,n)$$

(d)Calculate the maximum eigenvalue λ_{max}

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(EW)_i}{nW_i}$$

Among them, E is the aforementioned judgment matrix.
(e)Calculate the consistency index (CI)using the following formula.

$$CI = {}^{\lambda_{max} - n}/_{n-1}$$

Based on the order of the matrix n, select the index RI from table 45. The RI is formal because judgment matrices of orders 1 and 2 always have perfect consistency. When the order is greater than 2, the ratio of the consistency index CI of the judgment matrix to the average random consistency index RI of the same order is called the consistency ratio, denoted as CR. This ratio is used to assess the consistency of the calculation results.

The formula for calculating the consistency ratio (CR) is as follows:

$$CR = CI/RI$$

If the calculated CR < 0.1, the consistency of the judgment matrix K is considered to be assured. If the CR value exceeds 0.1, the judgment matrix is discarded, indicating that the expert's judgments about the different factors at that level lack consistency. As previously mentioned, if the consistency index indicates perfect judgment, the judgment matrix is a perfectly consistent matrix, and the calculated eigenvalue (the maximum eigenvalue) should be n, resulting in a consistency ratio CR of 0.

(4)Factor Ranking
The eigenvector W calculated in the previous section, once normalized, represents the relative importance weights of the corresponding factors at the same level with respect to a factor at the higher level. This process is called level-specific ranking, and it requires a consistency check. Subsequently, the composite weights of elements at each level with respect to the overall system goal are calculated to perform the overall ranking, determining the importance of each element at the lowest level in the overall objective of the hierarchy.

Evaluation Factors and Evaluation Levels
"For a specific case, each expert should score different secondary factors using a five-scale scoring system, rating each factor from 1 to 5 (F_{ij}, the score of the ith primary factor and the jth secondary factor). After combining the scores, the primary scoring matrix F_i is obtained. Subsequently, the membership vectors of different levels of factors are calculated.

The formula for calculating the membership vector of the primary factors is as follows:

$$v_j = \omega_j^T \cdot F_j$$

where υ_j is the evaluation membership vector of the j th primary factor, ω_j is the weight vector indicating the relative importance of each secondary factor under the j th primary factor, and F_j is the overall evaluation matrix of the j th primary factor.

Subsequently, an auxiliary column vector β (a 5-row by 1-column vector) is introduced to calculate the evaluation scores of each factor, expressed as follows:

$$\beta = (5 \quad 4 \quad 3 \quad 2 \quad 1)^T$$

The calculation method for the evaluation scores R of each factor is as follows:

$$R_{ij} = v_{ij} \cdot \beta$$
$$R_i = v_i \cdot \beta \cdot \cdot$$
$$R = v \cdot \beta \cdot \cdot \cdot$$

where R, R_i, and R_{ij} are the comprehensive evaluation scores for the overall objective, primary factors, and secondary factors, respectively. υ, υ_i, and υ_j are the membership vectors for the overall objective, primary factors, and secondary factors. The final comprehensive evaluation refers to the evaluation quantification standards proposed by Zhu Xiaolei for subjective evaluation of urban residential environment quality and the Likert evaluation quantitative standards (Zhu, 2005), assigning corresponding evaluation values to each level, as shown in table 46.

Multi-Objective Optimization Method

However, this study found in the actual design evaluation system that: the evaluation of cross-generational co-living spaces involves evaluating the basic spatial conditions of the building itself, and the evaluation of building spaces will affect the final evaluation of cross-generational co-living spaces. For example, the accessibility of the site involves both the rating of the space itself, such as ease of passage, availability of barrier-free facilities, completeness of signage information, and surrounding facilities, as well as the rating of cross-generational co-living spaces, such as customized travel plans. The evaluation of the space itself will influence the judgment of the environmental effect of the cross-generational co-living space. If these two sets of indicators are designed as indicators at the same level, it would violate the mutual exclusivity of indicators in the FAHP (Fuzzy Analytic Hierarchy Process), significantly affecting the scientific validity of the results. To design a more reasonable evaluation method, this paper draws on the multi-objective optimization methods used in engineering projects (Ching-Lai & Abu, 1979), setting the basic evaluation of building spaces (such as fire safety, security, comfort, etc.) as prerequisite indicators and the environmental characteristics affecting cross-generational interaction (such as openness, spatial configuration, etc.) as optimization and enhancement indicators, to achieve a more reasonable and objective multi-objective optimization process.

The multi-objective optimization process involves calculating the optimal solution under different influencing factors. As mentioned earlier, the same objective, such as space evaluation and cross-generational co-living evaluation, will jointly affect the rating of site accessibility. Moreover, the evaluation of space influences the cross-generational co-living evaluation. To illustrate the relationship between the two, the concept of the correlation coefficient

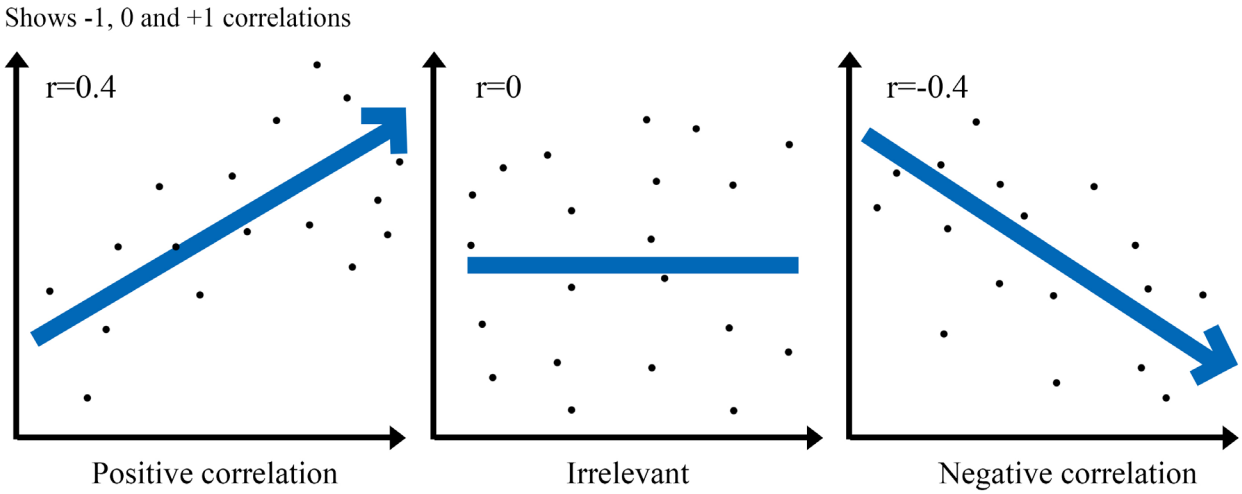


Fig 43 Schematic diagram of correlation coefficient function

is introduced. The correlation coefficient formula is used to determine the strength of the relationship between data, returning a value between -1 and 1, as shown in figure 43, where:
1 indicates a strong positive correlation,
-1 indicates a strong negative correlation,
and a result of zero indicates no relationship at all.

In this evaluation system, the cross-generational co-living space environment is built upon existing residential communities, public spaces, and other physical carriers. The attributes of the buildings and spaces themselves inevitably influence the existence or enhancement of the cross-generational co-living model, which can be considered to have a completely positive correlation. The multiplication formula can be used for the calculation:

$$U_j = \prod_{i=1}^{n} x_{ij}$$

U_j is the total utility of the j-th influencing factor, and x_{ij} is the secondary influencing factor under the j-th influencing factor. According to the calculation method of the multi-objective comprehensive evaluation system, the score R is revised as follows:

$$R_{ij} = v_{ij} \cdot \alpha_{ij} \cdot \beta \cdot$$
$$R_i = v_i \cdot \alpha_i \cdot \beta$$
$$R = v \cdot \alpha \cdot \beta \cdot$$

where α_{ij}, α_i, and α_j are the corrections for the overall objective, primary factors, and other factors under the overall objective, respectively. The actual situation is used to determine the levels of other factors, and normalization is performed accordingly.

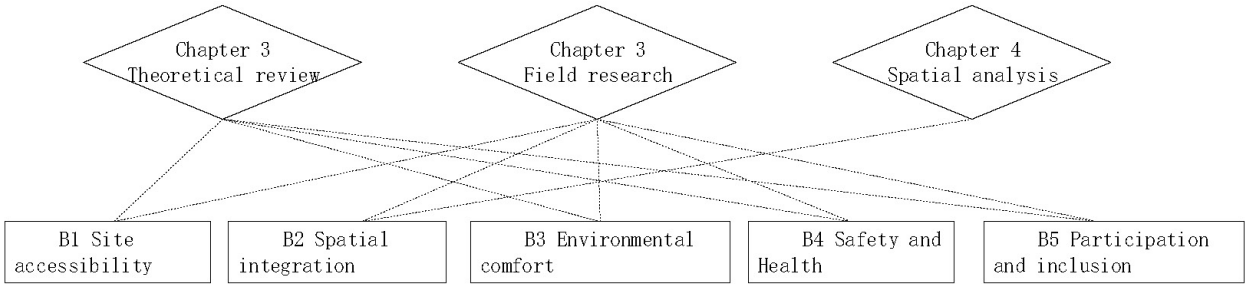


Fig 44 Schematic diagram of the chapter to which the criterion layer belongs

5.3 Environmental evaluation system for cross-generational co-living space (EESCCS)

The subject of this study is the cross-generational co-living space within residential communities. In the development of the evaluation system, the original conditions and needs (higher or lower quality) of existing communities were considered. Combining international and Chinese standards and norms for residential communities, public buildings, and age-friendly spaces, an evaluation model for cross-generational co-living spaces was established using FAHP and multi-objective optimization methods.

Determination of Evaluation Indicators

As described in section 5.2.3, the evaluation of the cross-generational co-living spatial environment in residential communities is divided into two different levels of indicators: basic prerequisites (evaluation of the fundamental conditions of the space itself) and optimization and enhancement (evaluation of the cross-generational co-living space). The corresponding sections and sources of each indicator are shown in figure 44 and table 47. The total number of criteria and sub-criteria is listed in table 48.

Prerequisite Indicators: These indicators are related to the basic living requirements of residents, including aspects such as residential community and public building spaces (health, safety, environmental comfort, etc.). They were identified through a literature review, screening of existing international standards, and interviews with residents and experts. The specific explanations and sources of the prerequisite indicators are summarized in table 49. These indicators provide the most fundamental constraints on the spatial environment and serve as general and basic evaluation standards; therefore, they are assigned equal weights.

Enhancement Indicators: These indicators focus on fostering cross-generational interaction, improving user satisfaction across different age groups, and enhancing aesthetic features. They were identified through literature review, field research, interviews, and surveys, and are summarized in table 50. The weights of the enhancement indicators were determined using the Delphi method and AHP, providing a basis for optimizing and improving cross-generational co-living spaces in the future.

Evaluation Process

(1)Establish a Hierarchical Structure Model of Factors

To establish a hierarchical structure model of evaluation factors, one must start from the basic dimensions involved in the evaluation concept and identify closely related influencing factors. According to the principles of the AHP method, evaluation factors are generally divided into three categories: the goal level, the criteria level, and the alternatives level. The final indicator

Criterion Layer (B)	Sub-criterion Layer (P&E)	Source				Corresponding Chapter		
		Literature Review	Field Observation	Interview Questionnaire	Spatial Calculation	Two	Three	Four
Site Accessibility B1	Accessibility P1	√	√			√	√	
	Accessibility Facilities P2	√	√	√		√	√	
	Complete Signage InformationP3	√	√			√	√	
	Supporting FacilitiesP4	√	√	√		√	√	
	Customized Travel Plans E1	√		√			√	
	Walkability E 2	√	√	√		√	√	
Spatial Integration B2	Spatial FormE3		√		√			√
	Spatial Types and LocationsE4		√	√	√		√	√
	Area DiscretenessE5		√		√			√
Environmental Comfort B3	Air Quality P5	√	√			√	√	
	Humidity and Temperature Control P6	√	√	√		√		
	Ventilation Adjustment P7	√	√			√		
	Natural Lighting P8	√	√	√		√	√	
	Artificial Lighting P9	√	√		√	√		
	Noise Control P10	√		√	√	√	√	
	Basic Water Management P11	√	√			√		
	Cleanliness and Maintenance P12	√	√			√	√	
	Adequacy of Rest Facilities P13	√	√	√		√	√	
	Visual Aesthetics E6	√	√	√			√	
	Cultural Belonging E7	√	√	√		√	√	
	Maximization of Natural LightE8	√	√				√	
	Ergonomic DesignE9	√	√			√	√	
Safety and Health B 4	Emergency Systems P14	√	√			√		
	Pollution-Free Indoor MaterialsP15	√	√	√		√	√	
	Privacy P16	√		√		√		
	GreeningP17	√	√	√		√	√	
	Intelligent Integrated Security Systems E10	√	√			√		
	Health Promotion Programs and Facilities E11	√	√	√			√	
	Mental Health Services E12	√	√			√	√	
	More Natural Contact E13	√		√			√	
	Environmental SustainabilityE14	√	√			√		
Participation and Inclusion B5	Activity Richness P18		√	√			√	
	Volunteer Services P19	√	√	√		√	√	
	Establishing Social Networks E15	√	√	√		√	√	
	Cross-generational Communication Plans and Activities E16	√	√	√			√	

Tab 47 Sources of Evaluation indicators and corresponding chapters

Goal (A)	Indicators (B)	Sub-indicators (Preconditions) (P)	Sub-indicators (Enhancement) (E)
Evaluation of environment of cross-generational co-living space	B1 Site Accessibility	P1 Ease of Passage	E1 Location and Layout
		P2 Accessible Facilities	E2 Customized Mobility Solutions
		P3 Signs	/
		P4 Surrounding Amenities	/
	B2 Spatial Integration	/	E3 Spatial Form
		/	E4 Spatial Types and Locations
		/	E5 Area Discreteness
	B3 Environmental Comfort	P5 Air Quality	E6 Visual Aesthetics
		P6 Humidity and Temperature Control	E7 Cultural Belonging
		P7 Ventilation Adjustment	E8 Maximization of Natural Light
		P8 Natural Daylight	E9 Ergonomic Design
		P9 Artificial Lighting	/
		P10 Noise Control	/
		P11 Basic Water Management	/
		P12 Cleanliness and Maintenance	/
		P13 Adequacy of Rest Facilities	/
	B4 Safety and Health	P14 Emergency Systems	E10 Intelligent Integrated Safety Systems
		P15 Indoor Material Pollution-Free	E11 Promotion of Physical Health Programs and Facilities
		P16 Privacy	E12 Mental Health Services
		P17 Plants and Greening	E13 Increased Natural Contact
		/	E14 Environmental Sustainability
	B5 Participation and Inclusion	P18 Activity Richness	E15 Establishing Social Networks
		P19 Functional Diversity	E16 Cross-generational Programs and Activities

Note: P represents Preconditions, E represents Enhancement.

Tab 48 Evaluation indicators for environment of cross-generational co-living space

Note: Quantitative data annotated in the table is sourced from national standards

[1] GB50763-2012 Barrier-free Design Code,2012, China
[2] ADA Standards for Accessible Design, 2010, USA
[3] DGNB Criteria Districts SOC2_1 Barrier-free design, 2020, Germany
[4] Regulation laying down rules for the elimination of architectural barriers in buildings, spaces, and public services n.503,1996, Italy
[5] Guidelines for the Implementation of the National Standard for the Classification and Evaluation of Elderly Care Institutions (2023 Edition), 2023, China
[6] LEED v4.1 Building Design and Construction, 2019, USA
[7] GB 50034-2013 Standard for Lighting Design of Buildings, 2013, China
[8] BREEAM Communities Manual 2012,2012, UK
[9] WELL Building Standard™ version 2, 2020, USA
[10] Standard for Indoor Environmental Pollution Control of Civil Building Engineering GB50325-2020, 2020, China

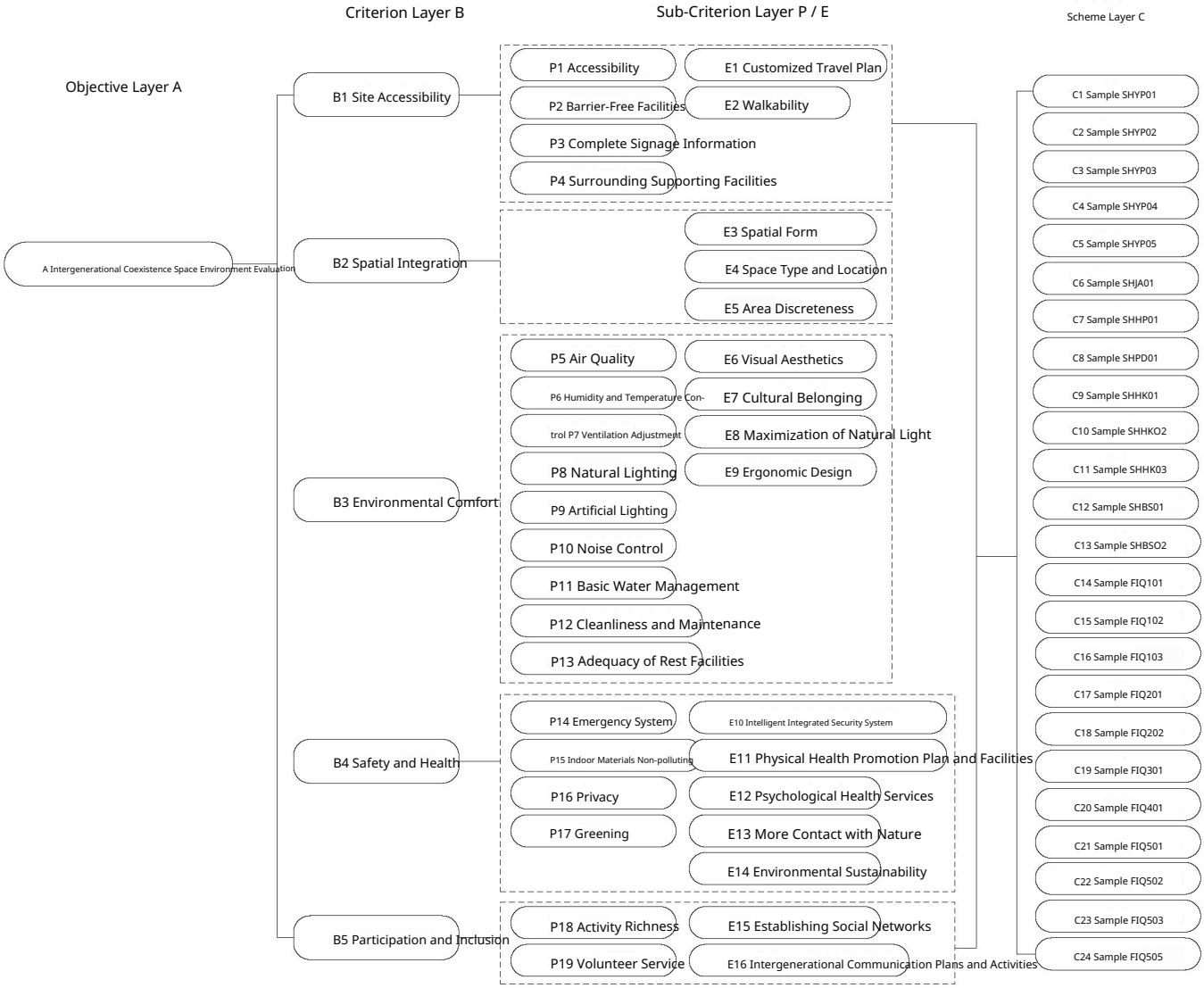


Fig 45 Hierarchical structure of evaluation indicators

Objective Layer (A)	Criterion Layer (B)	Sub-criterion Layer (P)	Qualitative and Quan
Cross-generational Co-living Space Environment Evaluation	Site Accessibility B1	Accessibility P1	Convenient and smooth traffic organization, meeting evacuation and transpo
		Accessibility Facilities P2	Complying with basic requirements for barrier-free design, especially conce thresholds and level differences, or threshold height and ground level differe chair passage (net width >0.8m); Barrier-free treatment in the bathroom, anti-slip and anti-collision measures
		Complete Signage InformationP3	Equipped with traffic guidance signs, service guidance signs, safety warning to view;
		Supporting FacilitiesP4	Within 1 kilometer or a 15-minute walking distance, there are easily accessi cal facilities), transportation stations, service equipment for special groups,
	Environmental Comfort B3	Air Quality P5	Provide indoor air quality levels that ensure users' health, prohibit smoking.
		Humidity and Temperature Control P6	Provide a thermally comfortable environment acceptable to most users, with indoor temperatures between 26-28℃ in summer, with relative humidity ≤6 ators, air conditioners, electric fans, humidifiers, dehumidifiers, etc., with st
		Ventilation Adjustment P7	Public activity spaces are equipped with operable windows, corridors and a lation facilities are provided;
		Natural Lighting P8	Public activity spaces and public corridors have good natural lighting, and s
		Artificial Lighting P9	The illuminance value in the activity area is not less than 300lx, the illumin warm-colored and energy-saving, providing visual comfort to users through
		Noise Control P10	Entertainment areas ≤ 45dB, healthcare areas ≤ 40dB. Public activity spaces ducted simultaneously, sounds do not interfere with each other. There is no
		Basic Water Management P11	Water intended for human contact (such as drinking, cooking, dish-washing of ≤ 1 NTU, F TU or F NU, and no E. coli should be detected in any 100ml
		Cleanliness and Maintenance P12	Public areas are clean and hygienic, and the environment is easy to maintain
		Adequacy of Rest Facilities P13	Set up rest seats within a suitable walking distance of 150m for the elderly, corridor of the activity space, and the rest area in front of public facilities sh
	Safety and Health B4	Emergency Systems P14	Clear and easy-to-use emergency procedures and functions, providing safety measures in case of danger, etc., to avoid accidents and falls;
		Pollution-Free Indoor MaterialsP15	Indoor environmental pollutant concentration limits should meet: Radon (B Benzene (mg/m³) ≤0.09, Toluene （ mg /m³ ≤0.2, Xylene (mg /m³) ≤0.2, T
		Privacy P16	Set up private and personalized spaces;
		GreeningP17	Introduce nature into indoor and outdoor environments, ensuring trees and p volatiles, or odor pollution; The elderly pass through areas without thorny p obstruct passage.
	Participation and Inclusion B5	Activity Richness P18	Various types of activities for all age groups, combined with the organizatio groups;
		Volunteer Services P19	Establish platforms or collaborate with other organizations to provide volun

Note: Table continues on next page

titative Descriptions	Operating Instructions
ortation requirements, avoiding the impact of vehicles on pedestrian traffic;	On-site Inspection
erning: ground level difference treatment (steps, ramps, elevators, no ence inside and outside the door ≤15mm, with a sloped transition), wheel- , setting up universal barrier-free signs, etc. ;	On-site inspection of the main entrance, disabled toilets, elevators, etc., public corridors, using tools such as tape measures or infrared rangefinders for measurement
g signs, etc., that are firmly installed and easy for the elderly and children	On-site Inspection
ble medical and health facilities (including on-site support or nearby medi- emergency equipment, commercial service facilities, etc.;	On-site inspection or use mobile map applications to calculate walking distance
, and create a smoke-free environment;	On-site inspection, use air quality detection tools for measurement, or refer to measurement data from relevant authorities
h indoor public space temperatures not lower than 18℃ in winter, and 60%. Equipped with temperature and humidity control devices such as radi- andard performance and safe usage;	On-site inspection, using thermometers and other tools for measurement
uxiliary rooms are equipped with operable windows, or mechanical venti-	On-site Inspection
some east-west facing rooms are equipped with effective shading measures;	On-site Inspection
ance is sufficient, uniform, and glare-free, the light source should be artificial lighting;	On-site Inspection
s can achieve dynamic and static zoning. When multiple activities are con- noticeable echo or noise during conversations or equipment movement.	On-site inspection and measurement using detection tools
, hand-washing, showering, or bathing) should meet the turbidity standard sample.	On-site inspection, actual measurement, according to the test reports of relevant departments
n;	On-site inspection, check maintenance and cleaning records
set up rest seats and activity facilities (such as chess tables, etc.) along the hould be ≥1.5m × 1.5m;	On-site Inspection
y guarantees, non-slip flooring materials, warning signs, emergency call	On-site inspection, maintenance record check
q/m³) ≤ 150, Formaldehyde (mg /m³) ≤0.08, Ammonia (mg /m³) ≤0.2, T VOC (mg /m³) ≤0.5 ;	On-site inspection, actual measurement, according to the test reports of relevant departments
	On-site Inspection
plants do not have high-allergen pollen, flying hairs, flying fluffs, harmful plants, roots that easily protrude from the ground, or climbing branches that	On-site Inspection
onal frequency of activities based on the time preferences of different age	On-site Inspection
nteer activities and services suitable for different groups of people.	On-site inspection, review of service records

Tab 49 Cross-generational co-living space environment evaluation indicators and specific descriptions (prerequisites)

Objective Layer (A)	Criterion Layer (B)	Sub-criterion Layer (E)	Qualitative and Quantitative Descriptions	Operating Instructions
Cross-generational Co-living Space Environment Evaluation	Site Accessibility B1	Customized Travel Plans E1	Integrate various forms of transportation services to provide tailored options for users, such as special transportation services or collaboration with local service agencies to meet the travel needs of the elderly and children;	On-site inspection, interviews
		Walkability E2	Accessible walking routes to use sites or building spaces, enhancing the overall support for pedestrian travel in the area;	On-site inspection of the surrounding walking environment
	Spatial Integration B2	Spatial Form E3	Focus on the impact of Cross-generational Co-living spatial forms (clustered, centralized, linear, radial) on interaction, and adopt appropriate spatial forms whenever possible;	Spatial Calculation
		Spatial Types and Locations E4	Focus on The impact of spatial types and locations where cross-generational interactions occur on interaction, and try to choose appropriate spatial types and locations ;	Spatial Calculation
		Area Discreteness E5	Focus on The impact of the proportion of cross-generational co-living space area on interaction, and try to choose an appropriate area proportion ;	Spatial Calculation
	Environmental Comfort B 3	Visual Aesthetics E6	The intuitive feeling of the spatial environment (paying attention to the particularities of the elderly and children), including the use of materials close to nature, systematic and scientifically reasonable signage settings, stable and diverse furniture, warm and livable colors mainly in warm tones, etc.;	On-site Inspection
		Cultural Belonging E7	Community, local historical and cultural environment, and neighborhood sense of belonging;	On-site inspection, interviews
		Maximization of Natural Light E8	Maximize the use of natural light to enhance the physical and mental health of users;	On-site Inspection
		Ergonomic Design E9	Furniture, facilities, and fixtures designed in accordance with ergonomic requirements to reduce the risk of discomfort or injury;	On-site Inspection
	Safety and Health B4	Intelligent Integrated Security Systems E10	Use smart technology to enhance safety, such as emergency call systems, intelligent security monitoring systems, etc.;	On-site Inspection
		Health Promotion Programs and Facilities E11	Promote physical health through design, monitoring, and facilities, such as: adding fitness centers, yoga studios, and meditation areas, equipped with wearable devices and health monitoring systems, etc.;	On-site Inspection
		Mental Health Services E12	Increase attention to the mental health of people of all ages, providing mental counseling services tailored to different groups;	On-site inspection, interviews
		More Natural Contact E13	Building on C 15, further integrate more natural elements into indoor and outdoor space designs. If conditions permit, try to increase opportunities to access nearby natural environments, to better leverage the healing effects of nature;	On-site Inspection
		Environmental Sustainability E14	Use eco-friendly materials, reduce energy consumption, and minimize the carbon footprint of the space environment as much as possible;	On-site inspection and record checking
	Participation and Inclusion B 5	Establishing Social Networks E15	The setup of broadcast/public bulletin boards/counters, methods of notifying users, establishing WeChat groups, and online social media like community homes;	On-site inspection, interviews
		Cross-generational exchange programs and activities E16	Organize activities aimed at promoting cross-generational interaction and mutual learning, such as: teaching smart devices, caregiving, etc.	On-site Inspection

Tab 50 Cross-generational Co-living Space Environment Evaluation Indicators and Specific Descriptions (Enhancement Items)

Objective Layer (A)	Criterion Layer (B)	Score	Sub-criterion Layer (Improvement Items) (E)	Score
Cross-generational Co-living Space Environment Evaluation	Site Accessibility B1	4.6	Customized Travel Plans E1	3.6
			Walkability E2	3.8
	Spatial Integration B2	4.1	Spatial Form E3	4
			Spatial Types and Locations E4	4.2
			Area Discreteness E5	3.2
	Environmental Comfort B3	4.4	Visual Aesthetics E6	3.8
			Cultural Belonging E7	3.5
			Maximization of Natural Light E8	4.2
			Ergonomic Design E9	4.3
	Safety and Health B4	4.8	Intelligent Integrated Security Systems E10	3.7
			Health Promotion Programs and Facilities E11	3.9
			Mental Health Services E12	3.8
			More Natural Contact E13	4
			Environmental Sustainability E14	3.1
	Participation and Inclusion B5	3.9	Establishing Social Networks E15	3.2
			Cross-generational Communication Plans and Activities E16	3.8

Tab 51 Expert scores for enhancement items

level should not exceed 25 factors, and the number of lower-level elements under any given element should not exceed 9. The hierarchical structure model used in this study is shown in figure 45. The specific steps are as follows:

(1)Determine the evaluation goal set A = (Comprehensive Evaluation of Cross-generational Co-living Space Environment in Residential Communities in Shanghai or Florence);
(2)Determine the criteria level set B = {B1, B2, B3, B4, B5} = {Site Accessibility, Spatial Integration, Environmental Comfort, Safety and Health, Participation and Inclusion}. Each sub-criteria level set is represented by B_iP_i for prerequisite items and B_iE_i for improvement items (i = 1, 2, ..., n), as follows:

B1P = {P1, P2, P3, P4} = {Ease of Passage, Barrier-free Facilities, Completeness of Signage Information, Surrounding Facilities};

B3P = {P5, P6, P7, P8, P9, P10, P11, P12, P13} = {Air Quality, Humidity and Temperature Control, Ventilation, Natural Lighting, Artificial Lighting, Noise Control, Basic Water Management, Cleanliness and Maintenance, Adequacy of Rest Facilities};

B4P = {P14, P15, P16, P17} = {Emergency Systems, Non-polluting Indoor Materials, Privacy, Greening};

B5P = {P18, P19} = {Richness of Activities, Volunteer Services};

B1E = {E1, E2} = {Customized Travel Plans, Walkability};

B2E = {E3, E4, E5} = {Spatial Form, Spatial Type and Location, Area Discreteness};

B3E = {E6, E7, E8, E9, E10} = {Visual Aesthetics, Cultural Belonging, Maximization of Natural Light, Ergonomic Design};

B4E = {E11, E12, E13, E14, E15} = {Smart Integrated Safety Systems, Health Promotion Programs and Facilities, Mental Health Services, More Natural Contact, Environmental Sustainability};

B5E = {E16, E17} = {Establishment of Social Networks, Cross-generational Exchange Programs and Activities}.

(3)Calculation of Relative Importance Weights of Factors
1)Expert Scoring and Construction of Fuzzy

Criterion Layer Indicators	B 1	B 2	B 3	B 4	B 5
B 1	(1 1 1)	(7/2 4 9/2)	(3/2 2 5/2)	(2/5 1/2 2/3)	(13/2 7 15/2)
B 2	(2/9 1/4 2/7)	(1 1 1)	(2/5 1/2 2/3)	(2/13 1/6 2/11)	(3/2 2 5/2)
B 3	(2/5 1/2 2/3)	(3/2 2 5/2)	(1 1 1)	(2/7 1/3 2/5)	(9/2 5 11/2)
B 4	(3/2 2 5/2	(11/2 6 13/2)	(5/2 3 7/2)	(1 1 1)	(15/2 8 17/2)
B 5	(2/15 1/7 2/13)	(2/5 1/2 2/3)	(2/11 1/5 2/9)	(2/17 1/8 2/15)	(1 1 1)
Weight Vector	0.278	0.076	0.160	0.445	0.041

Tab 52 Judgment matrix for importance

Indicator Layer	λ_{max}	CR	Consistency Test
A	5.050	0.011	Pass
B1	-	-	Pass
B 2	3.018	0.018	Pass
B 3	4.117	0.044	Pass
B 4	5.169	0.038	Pass
B 5	-	-	Pass

Tab 53 Consistency test of indicators

Judgment Matrix

Based on the selection of enhancement indicators for the cross-generational co-living spatial environment, the standard values for each indicator were quantified and categorized to form an operational evaluation system. The assignment of values in this study was independently provided by experts familiar with the issue. As discussed in Section 5.1.2, regarding the validity of the number of panel members and rounds in the Delphi method, research shows that involving 8 to 16 experts typically yields accurate results, with data collection after the second round of evaluations being relatively precise. Considering the available number of experts in the Cross-generational co-living field, the required geographical representation, and the moderator's capabilities, a total of 10 experts were selected for two rounds of questionnaires. This resulted in relatively accurate and reasonable weight values for the indicators (Du & Pang, 2021). The average scores for each indicator, based on the expert weight questionnaires (see Appendix 5), are shown in table 51. In the analytic hierarchy process (AHP), to quantify decision judgments and form a numerical judgment matrix, the judgments were quantified based on the average score scale for each indicator. The commonly used 1-9 scale method was applied in this study.

In this study, based on the average importance values of the criteria level (B1~B5) from the expert questionnaire survey, a fuzzy judgment matrix A was constructed using the questionnaire ranking method. The scale values and weight calculations are shown in table 52. This paper selects $\alpha = 0$ and $\lambda = 1$. $\alpha = 0$ indicates comprehensive weights, including all decision weight information from the experts, while $\lambda = 1$ signifies that the experts have adopted a relatively conservative attitude.

The importance of the sub-criteria level (E1~E16) is the same as above. The judgment matrix and weight calculations are detailed in Appendix 6.

2)Calculation of Eigenvalues and Consistency Test

According to matrix theory, we can conclude that if $\lambda 1, \lambda 2, \ldots\ldots, \lambda n$ are numbers that satisfy the equation, they are the eigenvalues of matrix A. When the matrix has perfect consistency, $\lambda 1 = \lambda max = n$, and the remaining eigenvalues are zero. However, when matrix A does not have perfect consistency, $\lambda 1 = \lambda max > n$, and the remaining eigenvalues $\lambda 2, \lambda 3, \ldots\ldots, \lambda n$ have the following relationship:

$$\sum_{i=2}^{n} \lambda i. = n - \lambda max.$$

The maximum eigenvalues and CR values of each criteria level obtained from the calculations are shown in table 53.

Evaluation Model and Scoring Levels

The weight proportions of the improvement indicators obtained after the consistency test are shown in table 54.

In terms of weight, the top three indicators are [E13 More Natural Contact], [E2 Walkability], and [E11 Health Promotion Programs and Facilities]. The bottom three indicators are [E7 Cultural Belonging], [E15 Establishing Social Networks], and [E5 Area Discreteness], indicating the areas that should be prioritized in design and management.

Additionally, according to the multi-objective optimization method described in Section 5.2.3, the scores of the prerequisite items are also taken into account. Since each prerequisite item is a basic element of spatial facilities without significant weight differences, they are assigned equal weights within the same category. For example, if a space has ease of passage, barrier-free facilities, and complete signage information but lacks surrounding facilities, the accessibility score is multiplied by 0.75 to reflect the impact of the prerequisite items on the improvement items.The overall evaluation model for the cross-generational co-living spatial environment is shown in table 55.

After calculating the total score through weighted calculations, the evaluation standards in table 56 are referenced. Based on the "grading" system, the final result is obtained, determining the evaluation grade (A1~A5) of the cross-generational co-living space environment in the residential community at the goal level.

Criterion Layer (B)	Weight	Sub-criterion Layer (E)	Relative Weight	Absolute Weight
Site Accessibility B 1	0.278	Customized Travel Plans E1	0.333	0.093
		Walkability E2	0.667	0.186
Spatial Integration B2	0.076	Spatial Form E3	0.341	0.026
		Spatial Types and Locations E4	0.593	0.045
		Area Discreteness E5	0.065	0.005
Environmental Comfort B3	0.160	Visual Aesthetics E6	0.114	0.018
		Cultural Belonging E7	0.055	0.009
		Maximization of Natural Light E8	0.307	0.049
		Ergonomic Design E9	0.524	0.084
Safety and Health B4	0.445	Intelligent Integrated Security Systems E10	0.115	0.051
		Health Promotion Programs and Facilities E11	0.263	0.117
		Mental Health Services E12	0.166	0.074
		More Natural Contact E13	0.416	0.185
		EnvironmentalSustainabilityE14	0.039	0.018
Participation and Inclusion B5	0.041	Establishing Social Networks E15	0.167	0.007
		Cross-generational Communication Plans and Activities E16	0.833	0.034

Tab 54 Weight distribution of improvement items for cross-generational co-living space environmental evaluation

Criterion Layer B	Weight Wb	Prerequisite Item P	Weight Wp	Score Np	Improvement Item E	Weight We	Score Ne	Scores of Each Criterion Layer (n represents the number of indicators in each layer)	Total Score (Sum of Subscores)	Rating
B 1	0.278	P1	0.25		E1	0.093		$Wb_1 * \Sigma (N p_n * Wp_n) * \Sigma (Ne_n * We_n)$		
		P2	0.25		E 2	0.186				
		P3	0.25		/	/				
		P4	0.25		/	/				
B 2	0.076	/	/	/	E3	0.026		$Wb_2 * \Sigma (Ne_n * We_n)$		
					E4	0.045				
					E5	0.005				
B 3	0.160	P5	0.11		E6	0.018		$Wb_3 * \Sigma (N p_n * Wp_n) \Sigma (Ne_n * We_n)$		
		P6	0.11		E7	0.009				
		P7	0.11		E8	0.049				
		P8	0.11		E9	0.084				
		P9	0.11		/	/	/			
		P10	0.11		/	/	/			
		P11	0.11		/	/	/			
		P12	0.11		/	/	/			
		P13	0.11		/	/	/			
B 4	0.445	P14	0.25		E10	0.051		$Wb_4 * \Sigma (N p_n * Wp_n) \Sigma (Ne_n * We_n)$		
		P15	0.25		E11	0.117				
		P16	0.25		E12	0.074				
		P17	0.25		E13	0.185				
		/	/	/	E14	0.018				
B 5	0.041	P18	0.5		E15	0.007		$Wb_5 * \Sigma (N p_n * Wp_n) \Sigma (Ne_n * We_n)$		
		P19	0.5		E16	0.034				

Tab 55 Environmental evaluation model for cross-generational co-living space

5.4 Application of the EESCCS

The evaluation model established in Section 5.3 was applied to 24 sample cases from Shanghai and Florence for empirical examination. The basic items were assessed (as shown in Appendix 7), with a value of 1 assigned for present items and 0 for absent items. Experts were then invited to score 16 sub-criteria indicators under 5 criterion level indicators. Based on the Likert scale, the standard pattern was categorized into five sequential strength structures: very good, good, average, poor, and very poor, corresponding to scores of 5, 4, 3, 2, and 1, respectively. The detailed questionnaire can be found in Appendix 8. Given the large number of cases and the substantial workload, each case was evaluated by 5 experts, and the scoring results are presented in Appendix 9.

Sample Evaluation Scores and Ratings

Based on the scoring results of the basic items and improvement items, the scores and ratings of each sample case are shown in table 56.

From the table above, it is evident that each case has room for improvement. The average scores for Shanghai and Florence are shown in the following figure 46. The figure indicates that most cases fall within the A2 and A3 rating intervals. The distribution of evaluations across cases is relatively even, meeting the requirements of the Likert scale, and the evaluation standards are reasonably defined.

In order to display the evaluations of different criterion levels for each sample case, the average radar charts for each sample case are plotted as shown in table 57. Since the sub-criteria within each criterion level are not evenly distributed, a normalization process on a uniform scale was applied to facilitate both horizontal and vertical comparisons. First, the average values for each criterion level of the cases were calculated. Then, the scores of each case were divided by the respective average value to obtain the normalized scores for that criterion level.

The following conclusions can be drawn from the figure:

1. The two samples with the highest scores and ratings, both classified as A2, are the Florence case FIQ501 and the Shanghai case SHHP01. The radar distributions of these two samples are similar; both are single buildings with strong site accessibility. Their scores are relatively balanced across the five dimensions, indicating a comprehensive layout that meets the spatial and environmental needs of all age groups rather than excelling in just one aspect.
2. Based on the rating distribution, the sample cases of cross-generational co-living spaces in Shanghai and Florence have similar scores, suggesting that the level of practical exploration in the field of cross-generational co-living space environments is currently similar across most countries.
3. To achieve a high overall evaluation, a

Scheme	Sample	B 1 Score	B 2 Score	B 3 Score	B 4 Score	B 5 Score	Total Score	Rating
C21	FIQ501	1.376	0.252	0.541	1.960	0.198	4.328	A 2
C10	SHHP01	0.907	0.186	0.479	1.959	0.198	3.729	A 2
C11	SHPD01	0.907	0.329	0.604	1.523	0.102	3.464	A3
C1	SHYP01	0.865	0.244	0.546	1.562	0.176	3.393	A3
C20	FIQ401	0.837	0.374	0.590	1.373	0.095	3.268	A3
C5	SHYP05	0.656	0.159	0.479	1.867	0.082	3.243	A3
C16	FIQ103	0.711	0.163	0.519	1.753	0.075	3.222	A3
C23	FIQ503	0.711	0.294	0.536	1.455	0.204	3.200	A3
C6	SHHK01	0.930	0.170	0.689	1.125	0.198	3.112	A3
C22	FIQ502	0.381	0.284	0.659	1.592	0.077	2.992	A3
C8	SHHK03	0.893	0.175	0.402	1.221	0.183	2.874	A3
C9	SHJA01	0.935	0.184	0.397	1.193	0.081	2.790	A3
C18	FIQ202	0.795	0.287	0.508	0.883	0.096	2.569	A3
C12	SHBS01	0.372	0.217	0.548	1.268	0.082	2.488	A4
C4	SHYP04	0.586	0.356	0.370	1.081	0.077	2.470	A4
C19	FIQ301	0.656	0.273	0.349	1.072	0.075	2.425	A4
C15	FIQ102	0.419	0.163	0.459	1.306	0.076	2.423	A4
C14	FIQ101	0.381	0.111	0.442	1.331	0.131	2.397	A4
C2	SHYP02	0.865	0.171	0.441	0.789	0.088	2.354	A4
C17	FIQ201	0.381	0.374	0.477	0.995	0.048	2.275	A4
C24	FIQ505	0.381	0.166	0.411	1.082	0.092	2.133	A4
C7	SHHK02	0.456	0.204	0.327	0.845	0.082	1.913	A4
C13	SHBS02	0.446	0.176	0.351	0.647	0.051	1.671	A4
C3	SHYP03	0.288	0.142	0.340	0.636	0.071	1.480	A5

Tab 56 Sample case evaluation scores and ratings

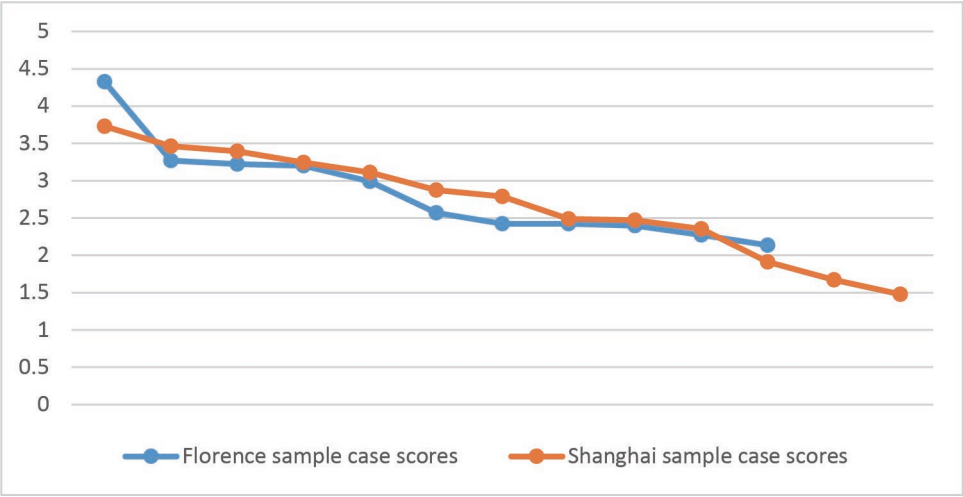
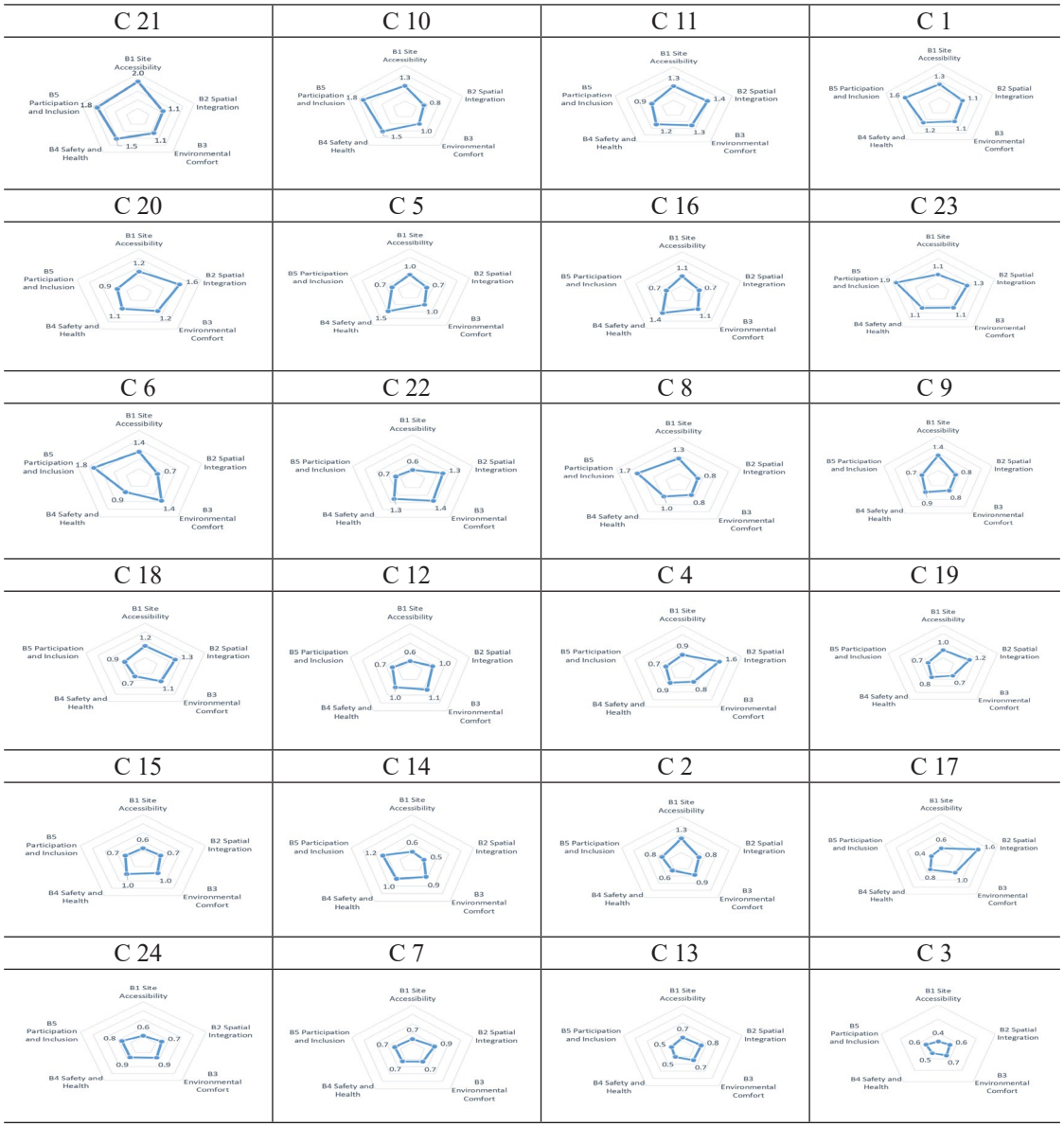


Fig 46 Hierarchical structure of scores for sample cases in Florence and Shanghai



Tab 57 Comparison of sample scores radar chart

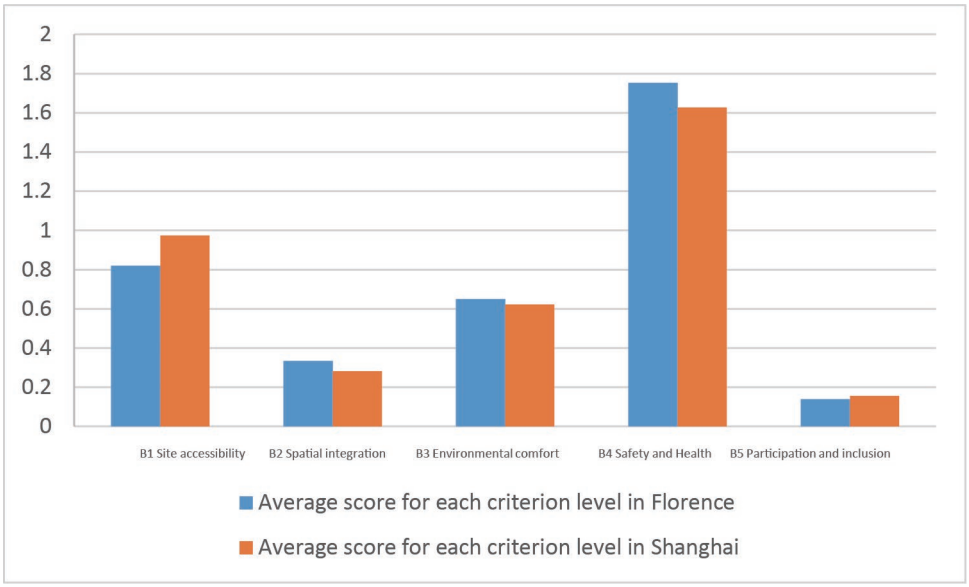


Fig 47 Average scores of each criterion layer for Florence and Shanghai samples

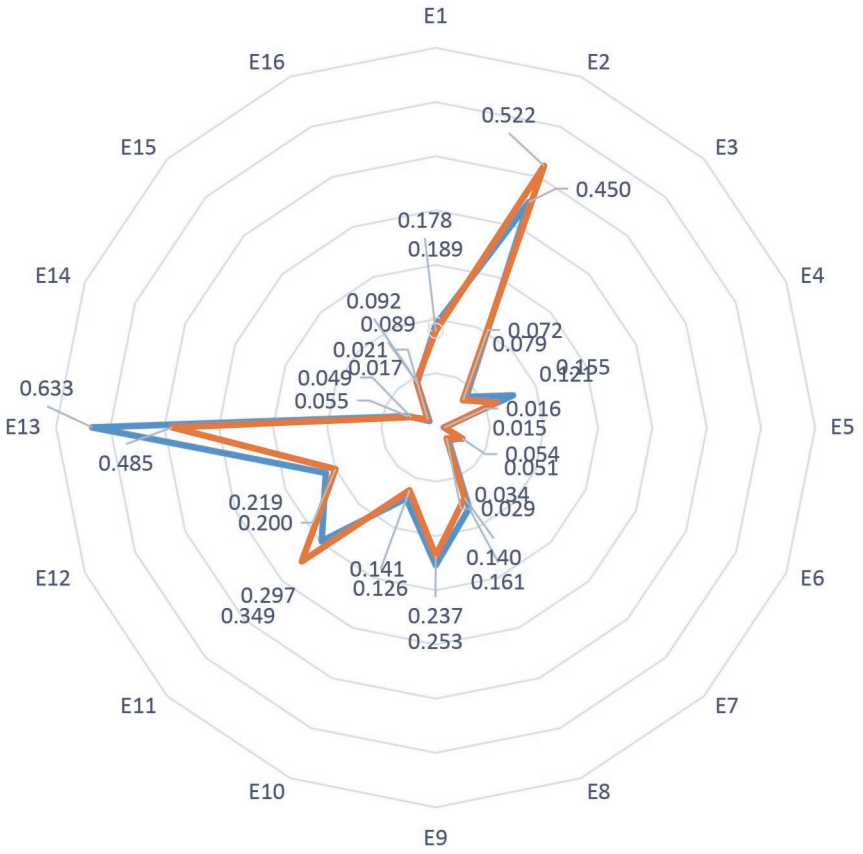


Fig 48 Radar chart of average scores of various case indicators in Florence and Shanghai samples

case must score above the average level in all aspects, without any significant weaknesses. For instance, the top four cases have relatively balanced scores across all criterion levels.

4. Cases with middle-range evaluations typically have noticeable shortcomings. For example, case C6 scores above average in B1 (site accessibility), B3 (environmental comfort), and B5 (participation and inclusion), but falls short in B2 (spatial integration) and B4 (safety and environment), highlighting areas for improvement.

5. Cases with lower evaluations generally have scores below the average level across all aspects, indicating that there is room for improvement in each criterion level.

Indicator Weight Analysis

Based on the preliminary item scores, all samples meet more than half of the basic conditions. This indicates that public spaces in residential communities currently place considerable emphasis on infrastructure development, sufficiently meeting most residents' needs within the community. From the criterion-level weight analysis, B4 (Safety and Health) is the most prioritized aspect, accounting for nearly half of the total weight. This is followed by site accessibility and environmental comfort. Spatial integration and participation and inclusion receive comparatively less attention. Regarding the improvement item weights, the top three indicators are E2 (Walkability), E13 (Increased Contact with Nature), and E11 (Health Promotion Programs and Facilities). The bottom three indicators are E7 (Cultural Belonging), E15 (Establishing Social Networks), and E5 (Spatial Discreteness), with social networks and activities directly related to cross-generational interaction receiving the least weight. This suggests that there is still a greater focus on physical health, with less emphasis on cross-generational communication.

As shown in figure 47, Shanghai sample cases outperform Florence cases in B1 (Site Accessibility), while Florence sample cases excel over Shanghai cases in B2 (Spatial Integration) and B4 (Safety and Health). In terms of B3 (Environmental Comfort) and B5 (Participation and Inclusion), the two cities are quite similar. This indicates that the two cities prioritize different aspects in their spatial design: Shanghai focuses more on the connectivity of different spaces, while Florence emphasizes human interaction and the safety and health protection of cross-generational spaces.

Indicator Score Analysis

Based on the average indicator scores for cases in Florence and Shanghai (figure 48), the top three and bottom three indicators are generally consistent. The difference lies in that the top indicator for Shanghai cases is E2 (Walkability), while for Florence, it is E13 (Increased Contact with Nature). Florence, as a city, has better overall walkability compared to a metropolis like Shanghai. However, in terms of walkability within cross-generational co-living spaces, Shanghai scores higher. This is because many of Shanghai's sample cases are located in easily accessible community and urban neighborhoods, whereas many of Florence's sample cases are built along city roads and streets.

Shanghai's natural contact mainly involves artificial greenery and parks, while Florence integrates natural reserve areas such as original green spaces and waterways. The indicators with relatively large score differences between the two cities are E13 (Increased Contact with Nature) with Florence scoring higher than Shanghai, E2 (Walkability) with Shanghai scoring higher than Florence, E11 (Health Promotion Programs and Facilities) with Shanghai scoring higher than Florence, E4 (Space Type and Location) with Florence scoring higher than Shanghai, and E8 (Maximizing Natural Light) with Florence scoring higher than Shanghai.

5.5 Summary

This chapter integrates previous qualitative and quantitative analyses to systematically study the quantitative evaluation of cross-generational co-living space environments in residential communities. An evaluation system for cross-generational co-living space environments was established and its feasibility was verified through sample case studies. First, following the indicator design process of literature review and comprehensive evaluation methods, criterion indicators were developed with a focus on basic and improvement items. Based on this, the scoring methods and weights for each indicator were determined using the Analytic Hierarchy Process (AHP) and Fuzzy Comprehensive Evaluation Method. This led to the establishment of an evaluation system comprising 5 criterion levels, 19 basic items, and 16 improvement items. The 5 criterion levels, ranked by weight, are: Safety and Health, Site Accessibility, Environmental Comfort, Spatial Integration, and Participation and Inclusion.

During the construction of the evaluation system, multiple rounds of expert questionnaires, expert discussions, and on-site scoring were conducted to apply the evaluation system to 24 sample cases from Shanghai and Florence, confirming its effectiveness and reliability.

The establishment of this evaluation system provides a scientific basis for the quantitative evaluation of community spatial environments from the perspective of cross-generational interaction. The research findings can also serve as a reference for identifying key points for environmental improvement and proposing optimization strategies.

PART IV
DESIGN STRATEGIES

Chapter 6 Optimization design strategies for cross-generational co-living space

This chapter focuses on the research of optimization design strategies for cross-generational co-living spaces in communities. Based on the improvement criteria from the evaluation system for cross-generational co-living spaces presented in Chapter 5, it examines design strategies for 16 sub-criteria in five aspects: site accessibility, spatial integration, environmental comfort, safety and health, and participation and inclusion in the built environment. The chapter explores actual cases that scored highly in the quantitative evaluation, and discusses specific design practices in Shanghai and Florence. Each optimization design point is discussed in detail through practical examples, proposing specific design ideas, methods, and application key points.

Chapter 6
Optimization design strategies for cross-generational co-living space

In the evaluation system of cross-generational co-living spatial environments, the prerequisites refer to the fundamental conditions that each architectural space must meet. This chapter focuses on research regarding optimization design strategies for cross-generational co-living spatial environments within communities, with a particular emphasis on improvement criteria. The discussion is centered on five key aspects: site accessibility, spatial integration, environmental comfort, safety and health, as well as participation and inclusivity within the built environment. The design strategies for 16 sub-criteria are explored, focusing on practical cases that achieved higher scores in quantitative evaluations, as illustrated in figure 49. Additionally, the specific design approaches of Shanghai and Florence are discussed, analyzing the key points of optimized design based on actual case studies, and proposing concrete design ideas, methods, and application principles.

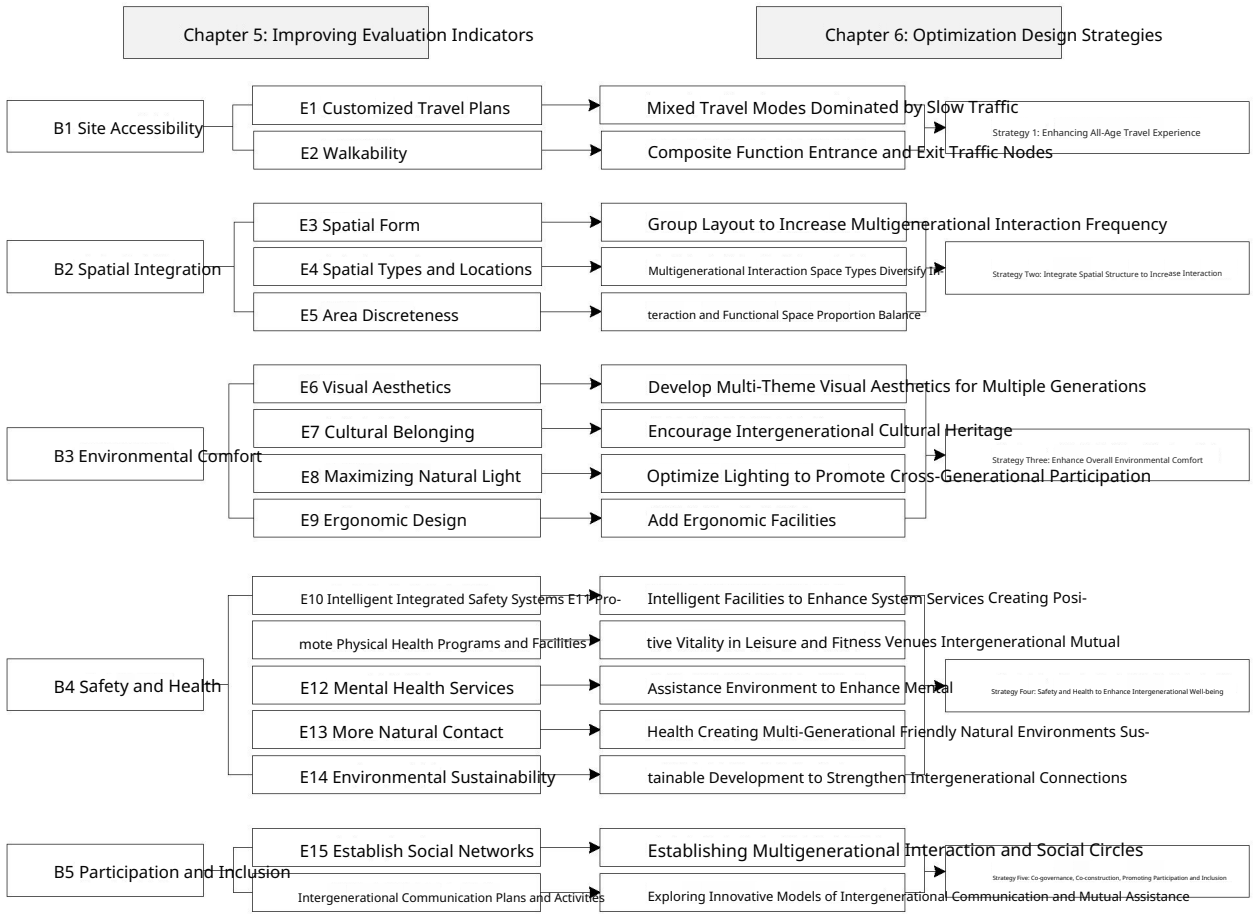


Fig 49 Corresponding relationship between improvement evaluation indicators and optimization design strategies

6.1 Enhancing Site Accessibility and Strengthening All-Age Travel Experience

A Mixed Mode of Travel Predominantly Characterized by Slow Movement

Slow-paced mixed travel refers to the integration of various transportation modes to encourage a slower and more attractive travel experience, prioritizing sidewalks, bike lanes, and public transit options suitable for different age groups, and reducing reliance on fast-paced vehicular travel. This approach addresses the travel behavior and needs of different generations, facilitating free choice among various non-interfering routes such as light rail, walking, buses, cycling, driving, and subways, thus enhancing site accessibility through seamless connectivity of different transportation modes.

In road planning and design, the concept involves layered 'slowing down' within a 5-10 minute living radius in communities, gradually transitioning to fully pedestrianized spaces. For the elderly and children, travel safety is the first step to leaving home and building cross-generational connections, with walking being their primary mode of transportation. Establishing continuous pedestrian networks that connect neighborhoods with various transportation facilities, green spaces, and public areas can improve the spatial quality of communities and surrounding districts, thereby creating an age-friendly and cohesive walking system.

Whether in residential communities in China or living quarters in Italy, slow-paced travel prioritizes residents of all ages, reducing cross-generational travel conflicts and promoting cross-generational cohabitation and communication through site planning. Specific design strategies of the top six cases ranked by E1 score are analyzed in table 58.

From the practical cases of Shanghai and Florence, the key design points can be observed as follows: (1) Establishing a diversified transportation network; (2) Reducing the space allocated for motor vehicles and creating a street order that prioritizes slow movement, ensures pedestrian pathways, and facilitates smooth cycling; (3) Transitioning community streets from being traffic-oriented to focusing on the lives and interactions of multi-generational residents; (4) Reducing vehicle speeds near cross-generational co-living spaces and areas to establish a fully pedestrianized network.

Entrance and exit traffic nodes with multiple functions

Site entrances are crucial areas for buffering and access, serving as traffic nodes and mandatory passage points for multi-generational residents. These entrances should be developed into multifunctional, diverse interaction spaces to enhance the inclusivity, overall vitality, and impression of streets and sites. Considering the behavioral needs of different age groups, entrance designs that present an open interface to the city and community are more attractive. For example, creating active interfaces and setback spaces allows urban life to extend into the site; gradual transitions in paving,

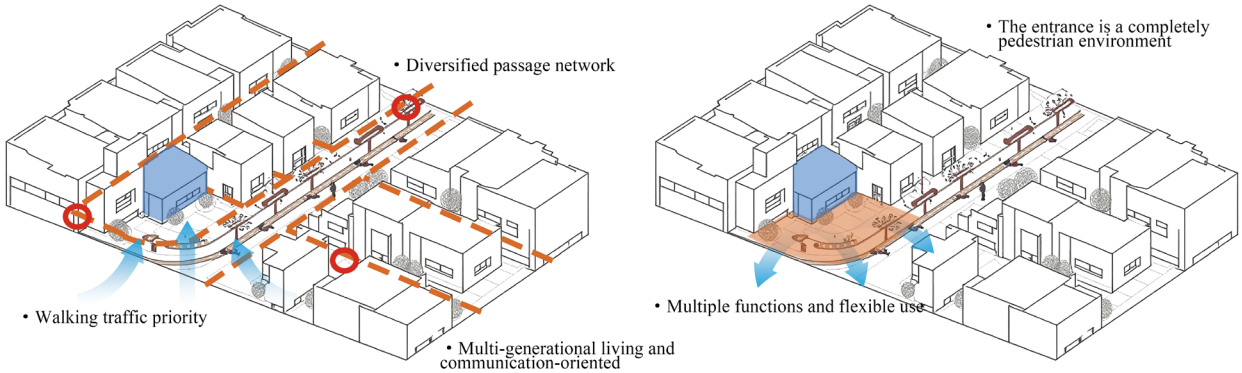
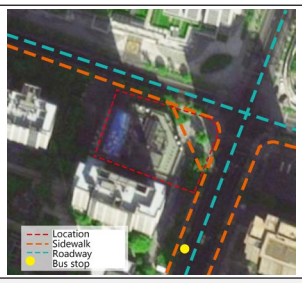
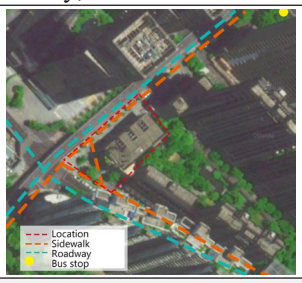
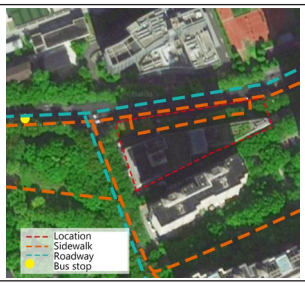
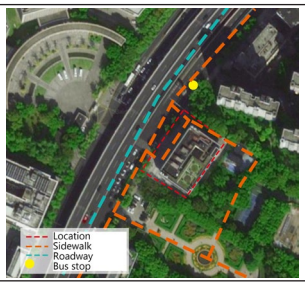


Fig 50 Diagram of strategies for enhancing site accessibility

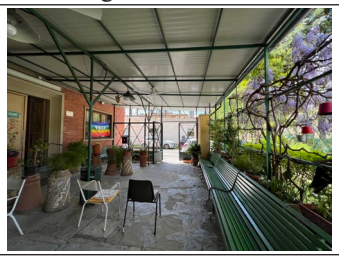
lighting, and scale help guide movement and psychologically prepare users for spatial changes; and integrating outdoor activity spaces, courtyards, plazas, and resting areas attracts and gathers people of all ages, facilitating a smooth transition from urban and community spaces to the site. Specific optimization design strategies of the top six cases ranked by E2 score are analyzed in table 59.

The practical cases of Shanghai and Florence reveal the key design points as follows: (1) The main entrance serves as a fully pedestrian environment traffic node; (2) Besides its transportation function, the main entrance integrates mixed-use functions with residents' daily lives; (3) The use of transitional spaces is flexible and diverse.

Site location and transportation are the primary factors influencing the cross-generational co-living spaces in residential communities. Whether the space is easily accessible and whether it facilitates easy walking for the elderly and children are critical to its usage efficiency. According to the B1 score rankings, samples with diverse transportation modes, pedestrian-friendly environments, open interfaces to the city/community, transitional treatment combining outdoor and semi-outdoor spaces, and multifunctional entrance areas score higher. These are also the optimization design strategies for enhancing the accessibility of cross-generational co-living spaces(see figure 50 for schematic illustration of the strategy).

Sample: FIQ501	Sample: SHHK01	Sample: SHJA01
Design Strategy: Light rail station as site entrance, surrounded by sidewalks and slow lanes, bus stop one block away;	Design Strategy: Located at the corner of an intersection, surrounded by sidewalks and slow lanes, parking at a nearby mall, bus stop nearby;	Design Strategy: Located at the corner of an intersection, surrounded by pedestrian urban plazas, expressways, and sidewalks, bus stop one block away;
		
Sample: SHHP01	Sample: SHHK03	Sample: FIQ202
Design Strategy: Located at the intersection of the city's main road and side road, surrounded by pedestrian and slow lanes, with a bus stop nearby;	Design Strategy: Located by the city's main road and expressway, surrounded by sidewalks and a walking park, with a bus stop nearby.	Design Strategy: Opposite a landmark attraction, the building is situated in a pedestrian plaza, surrounded by driveways and sidewalks, with multiple bus stops and an underground parking lot.
		

Tab 58 Design strategies for diverse slow travel modes

Sample: FIQ501	Sample: SHYP01	Sample: SHPD01
Design Strategy: Pedestrian access to the site, with entrance courtyards and rest areas serving as a transition between the city and the community center, with smooth and barrier-free paving;	Design Strategy: The sidewalk connects to the entrance plaza, with the corner plaza serving as a transportation node equipped with outdoor play and rest facilities;	Design Strategy: The park trail leads to the entrance plaza, with the recreational area also functioning as an outdoor movie screening venue;
Sample: SHYP02	Sample: SHHK01	Sample: FIQ401
Design Strategy: Open to the community park and main pedestrian roads, with gentle slopes connecting the entrances of each room, and rest seats set up at the entrance;	Design Strategy: Facing the street corner, surrounded by a wide sidewalk, with a flat and level surface, used as a market and square dance venue in the evening;	Design Strategy: Located in a historic preservation pedestrian district, walkable to an entrance gray space with seating, connecting the main entrance and outdoor garden.
		

Tab 59 Composite function entrance design strategy

6.2 Integrating Spatial Configuration to Enhance Cross-generational Interaction Opportunities

Cluster Layout to Increase Multigenerational Interaction Frequency

The floor plan layout of a building can influence the frequency of space usage. Based on qualitative and quantitative studies, there are five forms of cross-generational co-living spaces, with the cluster layout being the most conducive to direct and visual cross-generational interaction. Radiating, bilateral linear, and centralized forms follow, while the unilateral linear form is less effective. The cluster layout can provide a homogeneous spatial experience and create diverse multigenerational interactions. Typically, cluster layouts group various units around shared public areas (such as gardens, courtyards, or communal rooms), breaking down rigid separations and using open interfaces to facilitate more encounters and social activities, making it easier for residents of different ages to interact.

Additionally, setting up buffer and transition areas between different functional spaces can naturally encourage cross-generational interaction. For instance, a transition area between a children's play zone and an adult leisure space can be designed to encourage shared use. Placing public facilities in visible and easily accessible locations for all age groups can also increase interaction. The top six samples ranked by E3 score all feature cluster layouts. Their specific optimization design strategies are analyzed in table 60.

The practical cases of Shanghai and Florence reveal the key design points as follows: (1) Grouping spatial units around a central shared area to enhance space utilization and flexibility; (2) Adopting an open layout that breaks down rigid separations, allowing visibility of activities in different areas, thereby attracting spontaneous participation from residents of different generations; (3) Placing public areas such as gardens, playgrounds, and meeting rooms at the center of the space to promote random interactions among residents of all ages.

Diversifying and Expanding Types of Cross-generational Interaction Spaces

Spaces where direct cross-generational interactions are likely to occur include corridors, lobbies, multipurpose halls, bars, entrance plazas, entrance grey spaces, cloisters/corridors, and courtyards. Flexibly expanding these public spaces can enhance cross-generational interaction by, for example, setting up rest areas, using bright and varied color schemes, creating open interfaces, displaying information, ensuring accessibility, incorporating traditional/community culture, mixing functions, and integrating natural greenery.

Spaces conducive to indirect interactions are typically located in the center of lobbies/plazas, at the edges of courtyards, at junctions of lobbies and entrances/corridors, at intersections of multiple open spaces (such as window openings, corridors), at connections between corridors and large spaces/rooms, and at the intersections of long corridors. Enhancements for these spaces can include setting up rest areas, diversifying

functions, using flexible partitions, creating open interfaces, installing clear signage systems, enlarging connection areas, and diversifying connection methods. The specific optimization design strategies of the top six cases ranked by E4 score are analyzed in table 61.

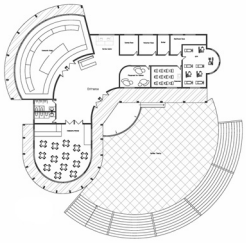
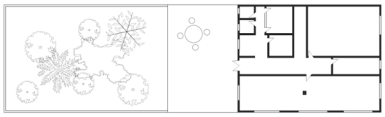
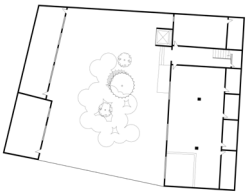
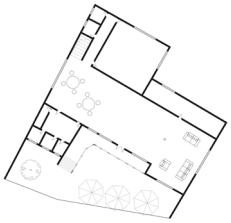
The practical cases of Shanghai and Florence reveal the key design points as follows: (1) Space types are flexible and variable, allowing for reconfiguration to support different activities and group sizes, and adapting space functions according to various needs; (2) Core connection areas are designed with open interfaces to facilitate both direct and indirect interactions; (3) Large connection areas incorporate rest spaces and landscaping to encourage multigenerational use and engagement.

Balanced Proportions of Interaction and Functional Spaces

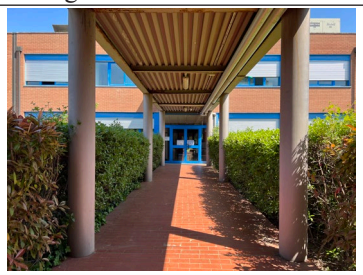
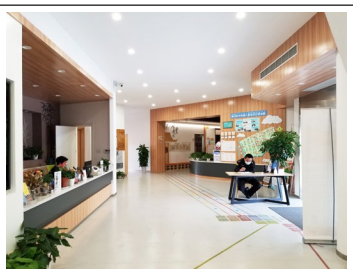
Analysis of the average integration value and area proportion of each functional space reveals that, except for auxiliary and service rooms, the lower the spatial area variability and the more similar the sizes of functional spaces within a building, the better the effect on cross-generational interaction. Research on cross-generational activities indicates that communities with higher resident integration have key shared spaces that gather multiple generations, such as high-frequency interaction and functional spaces. Emphasizing the balanced proportion of these spaces can appropriately increase their usage frequency, thereby enhancing opportunities for cross-generational interaction.

In design, ergonomics and environmental psychology should be considered to finely design the area scale and proportion of interaction and functional spaces, enhancing the site's attractiveness and increasing the frequency of meetings and interactions between generations. The specific optimization design strategies of the top six cases ranked by E5 score are analyzed in table 62.

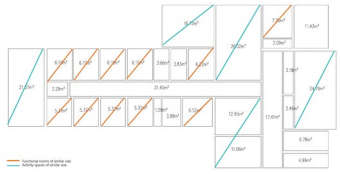
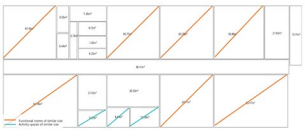
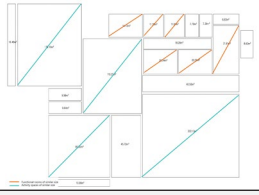
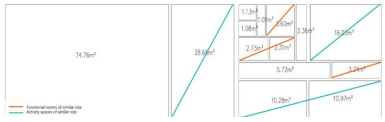
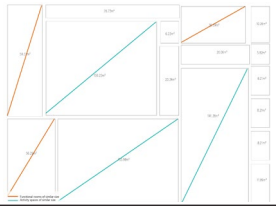
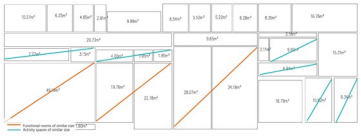
Spatial structure and layout influence the usage and interaction frequency of different generations from the perspective of architectural spatial relationships. According to the B2 score rankings, samples with cluster layouts, diverse space types, multifunctional large connection nodes, and a balanced proportion of interaction and functional spaces score higher. These are also optimization design strategies for the spatial integration of cross-generational co-living spaces(see figure 51 for schematic illustration of the strategy).

Sample: SHPD01	Sample: FIQ401	Sample: FIQ201
Design Strategy: The layout surrounds the outdoor plaza in a semi-enclosed manner, with groupings of large and small spaces;	Design Strategy: The courtyard, entrance gray space, and indoor space are arranged in three evenly sized groupings;	Design Strategy: Overall layout consists of three groups arranged left, center, and right;
		
Sample: SHYP01	Sample: SHYP04	Sample: FIQ503
Design Strategy: Functional rooms are grouped without distinct separations such as corridors;	Design Strategy: Spaces are relatively open, with an overall layout consisting of three groups arranged top, center, and bottom;	Design Strategy: No distinct corridors or rigid interfaces; the courtyard, foyer, and activity room are arranged in three groups from top to bottom.
		

Tab 60 Group layout design strategy

Sample: F IQ201	Sample: FIQ401	Sample: SHYP04
Design Strategy: The multi-functional hall, which can directly facilitate cross-generational communication, is an open large space connected to the large outdoor courtyard. The wall windows are the best places for visual interaction between the two large spaces;	Design Strategy: The entrance gray space, which connects large spaces, is arranged as a nature-friendly and diverse resting environment. The corners of the courtyard and the transition spaces are the best places for interaction.	Design Strategy: The open corridor is the core location of the entire building, connecting multiple large spaces. While the scale is widened, it can also serve as a multifunctional space and is the best place for visual interaction.
Sample: FIQ202	Sample: FIQ502	Sample: SHPD01
Design Strategy: The entrances and centers of squares are locations that connect open spaces. Combined with landscape settings, they are often used as market entrances.	Design Strategy: The connecting corridor is the core location that connects the large courtyard space and two major functional bodies. The interface is completely open, serving both as a traffic connection and a place for walking and interacting with nature.	Design Strategy: The entrance lobby is the core location connecting various open spaces, integrating functions such as consultation, rest, wayfinding, health check-ups, and also providing a view of children's activities.
		

Tab 61 Diverse spatial expansion design strategies

Sample: F IQ501	Sample: SHBS01	Sample: SHPD01
Design Strategy: The scales of relatively enclosed rooms such as activity rooms and chess rooms are similar, around 6 ㎡; classrooms, multi-functional halls, and B AR are similar in scale, around 20 ㎡ ;	Design Strategy: The sizes of rooms with similar scales such as exhibition corridors, balconies, and lounges are around 10 ㎡ ; the sizes of rooms with similar scales such as calligraphy classrooms, photography classrooms, and dance training rooms are around 70 ㎡ ;	Design Strategy: The size of rooms such as barber rooms, handicraft rooms, and children's play areas, which are similar in scale, is around 20 ㎡ ; the size of multi-functional halls, outdoor movie squares, and dance training rooms, which are similar in scale, is around 100 ㎡ ;
		
Sample: FIQ401	Sample: FIQ201	Sample: SHYP05
Design Strategy: The size of rooms such as calligraphy and painting rooms, and classrooms, which are similar in scale, is around 5 ㎡ ; the size of music activity rooms, training rooms, and entrance rest areas, which are similar in scale, is around 20 ㎡ ;	Design Strategy: The size of rooms such as libraries, restaurants, and B AR, which are similar in scale, is around 50 ㎡ ; the size of multi-functional rooms and courtyards, which are similar in scale, is around 150 ㎡ ;	Design Strategy: Exhibition halls, rest areas, and conference rooms have similar scales, approximately 10 ㎡ in size. Calligraphy classrooms, medical care rooms, and training classrooms have similar scales, approximately 50 ㎡ in size.
		

Tab 62 Space proportion balance design strategy

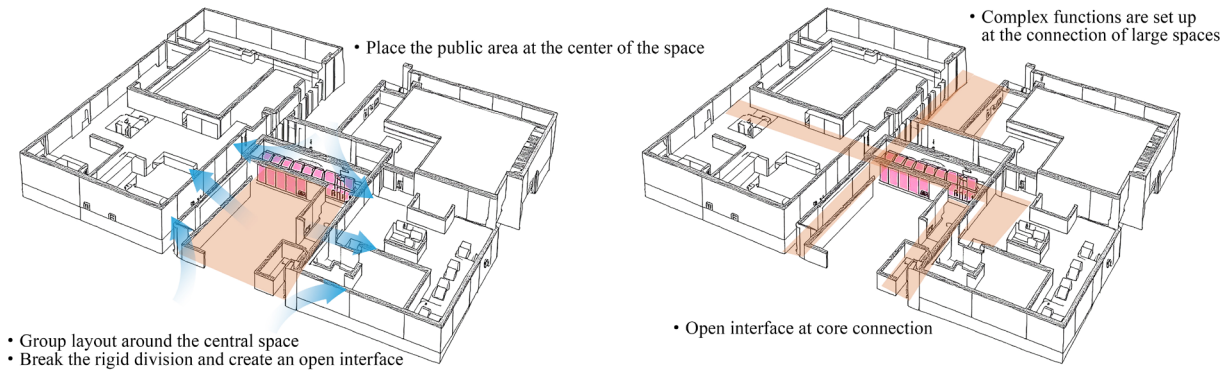


Fig 51 Diagram of strategies for integrating spatial structure

6.3 Enhancing Environmental Comfort to Attract All Generations

Developing Multi-Theme Visual Aesthetics for All Generations

Multigenerational visual aesthetics refers to creating spaces that are visually appealing to different age groups by understanding their psychological and cultural backgrounds and shaping the environment to enhance their perception and interaction abilities. Developing multi-themed visual aesthetics involves designing spaces with specific themes for seniors, children, and multigenerational use to foster better interaction experiences. The following approaches can be used to develop multi-themed, multigenerational visual aesthetics:

(1)Integrate architectural elements and patterns that resonate with different cultures and age groups to foster a sense of belonging and inclusivity.
(2)Utilize color psychology with palettes that evoke various emotional and cognitive responses, attracting people of all ages.
(3)From the perspective of sensory design, incorporating visual comfort and tactile diversity, use lighting that adapts to natural circadian rhythms and the visual acuity of different age groups, and employ various materials to provide different tactile experiences.
(4)Focus on aesthetic flexibility by designing spaces that blend traditional and modern elements, creating thematic consistency throughout the space, telling stories, or conveying a sense of time and place to enhance engagement among users of different ages.
(5)Ensure that visual aesthetics do not alienate any user group, prioritizing inclusivity and universality.
(6)Incorporate digital displays or interchangeable decorations that can be updated or modified to reflect current events, seasons, or cultural celebrations, creating an adaptive visual space.
The specific optimization design strategies of the top six cases ranked by E6 score are analyzed in table 63.

From the practical cases of Shanghai and Florence, it can be observed that Shanghai's current visual aesthetics primarily use wood tones and white as the main color scheme, emphasizing interface design to meet the aesthetic needs of most users. Various themed rooms, such as reading corners, exhibition halls, and smart houses, are designed with community cultural activities in mind. In Florence, practical cases utilize the original architecture and differentiate themed rooms using color, focusing on color and decoration. The materials and furniture used are a mix of old and new, with a strong historical character. Their common design points are:

(1)Visually, they prioritize universal design with colors and natural elements, selecting tones and materials that are acceptable to most people.
(2)Interface design aligns with the space theme and the nature of activities.
(3)The types of furniture and facilities are rich and diverse.

Encouraging the Cross-generational Transmission of Regional Culture

Embedding a sense of regional cultural identity into spatial environments can enhance community recognition, serving as a medium for the cross-generational transmission of cultural values and traditions, which is crucial for the long-term preservation of cultural heritage. The integration of regional culture with cross-generational transmission can be approached from the following aspects: (1) Modernizing historical buildings with contemporary facilities while preserving their unique characteristics, transforming heritage sites into interactive learning environments where the younger generation can actively experience and understand cultural heritage; (2) Continuing the use of region-specific architectural styles, materials, and construction techniques, encouraging the use of traditional building and decorative methods that require manual skills, thus preserving and promoting historical heritage in new constructions; (3) Integrating symbols, themes, and decorative arts, setting up exhibition halls/stalls/bulletin boards to narrate the region's history, folklore, and cultural milestones; (4) Utilizing modern technology to tell historical events or traditional crafts, organizing interactive exhibitions, such as using augmented reality (AR) and virtual reality (VR), to make learning experiences more appealing to the younger generation; (5) Establishing cross-generational co-living spaces/community centers as cultural landmarks to promote cross-generational engagement; (6) Creating open, accessible spaces that encourage spontaneous cultural expressions and celebrations, thereby solidifying these traditions as attractions for all generations. The top six sample cases, ranked according to E7 scores, are analyzed for their specific optimization design strategies, as detailed in table 64.

Practical cases from Shanghai and Florence reveal the key design principles as follows: (1) Preserving the characteristics of historical buildings and districts, integrating multiple generations into the historical environment; (2) Establishing exhibition areas with regional cultural backgrounds, using text, images, audio, and video media to disseminate local culture; (3) Integrating symbols and events as decorative methods to convey cultural narratives across different interfaces and shared spaces.

Optimizing lighting to promote cross-generational engagement

Enhancing emotional and cognitive functions by maximizing the use of natural light creates a more comfortable spatial environment, helping regulate the biological clocks of both the elderly and the young, thereby enhancing overall vitality and emotional stability. Lighting optimization can be achieved through the following aspects: (1) Developing lighting solutions suitable for all ages, such as increasing illumination levels required for elderly users, providing soft, diffuse lighting for children, and reducing harsh shadows and bright spots. Soft, diffuse light can improve safety and visual comfort for this age group; (2) Creating flexible and adaptive

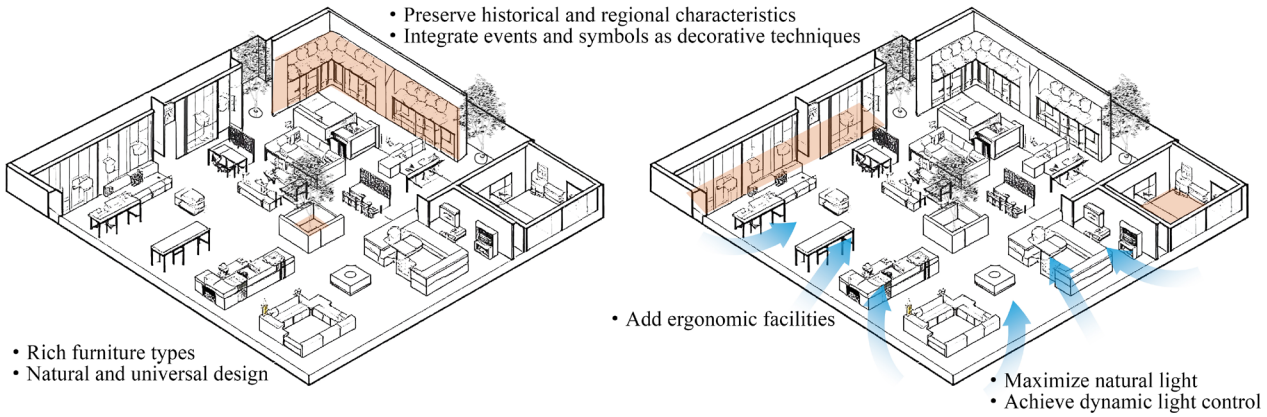


Fig 52 Diagram of strategies for enhancing environmental comfort

lighting systems that allow for dynamic lighting and personal control; (3) Ensuring uniform illumination of walkways, stairs, and other transitional areas to protect the elderly and young children, preventing accidents. The top six sample cases, ranked according to E8 scores, are analyzed for their specific optimization design strategies, as detailed in table 65.

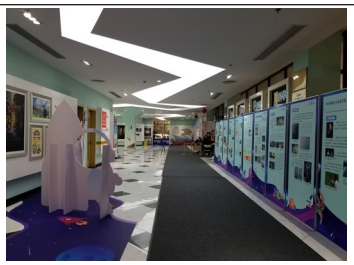
Practical cases from Shanghai and Florence highlight the key design principles as follows: (1) Using floor-to-ceiling windows in areas with high interaction and communication to maximize natural light; (2) Combining natural and artificial lighting in reading and study areas; (3) Implementing dynamic control of natural light by integrating shading systems according to activities and daylight changes; (4) Creating a soft, diffuse lighting environment in children's activity areas and multi-generational interaction spaces.

Adding ergonomic facilities

Adding ergonomic facilities can meet the specific needs of different age groups, aiming to provide an inclusive, comfortable, and convenient environment for all users. The design requirements for such facilities include: (1) Facilities should have adjustable flexibility, achieved by incorporating adjustable components such as sit-stand desks, counters, and seating at various heights; (2) The usage of facilities should be easy to understand, utilizing clear visual cues, simple movement paths, and consistent signage; (3) The design should minimize fatigue, for example, door handles and faucets should be operable with a single, effortless motion, and should include elements that reduce the need for prolonged standing or excessive effort; (4) Regardless of the user's body size, posture, or mobility, facilities should provide ample space for approach, reach, manipulation, and use, such as wide doorways and corridors that can accommodate wheelchairs and strollers. The top six sample cases, ranked according to E9 scores, are analyzed for their specific optimization design strategies, as detailed in table 66.

Practical cases from Shanghai and Florence highlight key design principles as follows: (1) A variety of furniture types with comfortable height and tactile features to meet the diverse needs of different groups; (2) Anti-slip treatments on floors, handrails, and furniture corners; (3) Large fonts and images on indoor and outdoor facility signage to facilitate reading for the elderly and children.

Enhancing the comfort of the spatial environment can positively affect the emotions and physical needs of different age groups, extending their usage and stay time. According to B3 score rankings, samples that score higher include those with visually appealing designs, thematic spaces, emphasis on preserving regional culture, abundant natural light in interaction spaces, and a significant amount of ergonomic furniture and facilities. These are also optimal design strategies for the comfort of cross-generational co-living spaces(see figure 52 for schematic illustration of the strategy).

Sample: SHYP01	Sample: SHHK01	Sample: SHPD01
Design Strategy: Natural wood-colored environments cater to the aesthetic needs of all age groups. The areas used by children are set with lively characteristic elements, balancing both universal and personalized needs;	Design Strategy: The main color tones are white and wood color. The lively roof shapes and floor paving, combined with lighting, make the themes of each space more distinct;	Design Strategy: Natural and warm tones cater to the aesthetics of multiple generations, while vibrant colors in furniture, wayfinding, and decorations enhance the attention of children and the elderly;
Sample: FIQ503	Sample: SHYP05	Sample: SHHP01
Design Strategy: Each room has a different theme color, with a variety of furniture styles and bright colors. Compared to the Shanghai case, the ceiling and lighting designs are relatively ordinary;	Design Strategy: White is the main color, with rest areas and exhibition areas using bright colored walls to enhance visual focus. The furniture is colorful, and the colored lines in the decorations have strong guidance;	Design Strategy: The overall visual atmosphere is a light and brisk technological feel, with the linear lighting on the ceiling being the main visual focus. The interior space primarily uses wood and white tones;
		

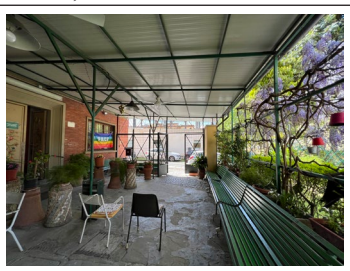
Tab 63 Visual aesthetic design strategy

Sample: FIQ503	Sample: FIQ401	Sample: SHYP01
Design Strategy: Set up a cultural exhibition wall at the entrance, combining books, written records, and audio-visual materials to continuously introduce the historical background and contributing members of the community;	Design Strategy: Located in a historic preservation district, opposite an industrial heritage site, frequently organizes cultural activities indoors to promote local characteristics;	Design Strategy: Use local residents' handicrafts and children's paintings as wall decorations to promote various cultural activities while exhibiting;
Sample: FIQ501	Sample: FIQ101	Sample: SHYP04
Design Strategy: Use historical photos of building and union development as wall decorations, set up exhibition rooms to display historical development context, such as textual materials, awarded medals, records of visits by staff from various countries, etc.;	Design Strategy: Transform historical building complexes into public residential communities, retain original building materials and forms, and update structures and technologies to allow people to continue contemporary life directly within history;	Design Strategy: Incorporate elements such as Shanghai Shikumen and stained glass into interface decorations, using abstract modern expressions to continue historical culture.

Tab 64 Design strategies for cultural belonging

Sample: FIQ401	Sample: SHPD01	Sample: FIQ503
Design Strategy: Spaces frequently used for gatherings and events should face the side with the best natural light. Floor-to-ceiling glass doors and large windows ensure ample indoor lighting;	Design Strategy: The multi-functional room's circular windows provide optimal reading light in the morning when sunlight is best, and sufficient lighting for dining at noon and in the evening;	Design Strategy: Integrate floor-to-ceiling glass windows with the gray space at the entrance to create a soft, diffused light environment for the reading corner in the entrance lobby;
Sample: SHHK01	Sample: FIQ502	Sample: SHYP01
Design Strategy: The area near large floor-to-ceiling windows is designated for studying and reading, creating a bright, diffused light environment;	Design Strategy: Transparent glass corridors and adjustable exterior window systems bring ample natural light into the building;	Design Strategy: Frameless floor-to-ceiling windows along the street break the boundary between the city and indoor space, while providing a diffused light environment for children playing indoors.

Tab 65 Optimized lighting design strategies

Sample: SHHK01	Sample: FIQ502	Sample: SHYP01
Design Strategy: The rest area is equipped with tables and chairs of different heights and textures to accommodate resting, chatting, and dining functions;	Design Strategy: Smooth interior and a variety of seats to meet the safety and comfort needs of the elderly and children;	Design Strategy: Tables and chairs of different heights and textures to meet the reading and discussion needs of different groups;
Sample: FIQ401	Sample: SHPD01	Sample: FIQ503
Design Strategy: Place different types of seats in the entrance rest area, and flexible seats can be set in different scenarios;	Design Strategy: Adjustable height tables and chairs to meet the needs of different handicraft classes;	Design Strategy: A variety of desks, reading chairs, and discussion chairs to meet the needs of different age groups for access and use.
		

Tab 66 Ergonomic facility design strategies

6.4 Safety and Health Design Enhances Cross-generational Well-being

Smart Facilities Improve System Services

Smart facilities integrate intelligent building technology and advanced information systems, utilizing automation, real-time data processing, and user-centered interfaces to create adaptive and responsive environments that meet the diverse needs and preferences of different age groups. The cross-generational design of smart facilities can be achieved through the following aspects: (1) Automated thermal comfort systems that adjust temperature and humidity based on indoor conditions and external weather, ensuring optimal comfort for all ages, particularly the elderly and children who are more sensitive to temperature changes; (2) Smart lighting systems that adjust intensity and color based on time of day and occupancy, meeting the circadian rhythms and vision needs of different generations, thereby improving comfort and productivity; (3) Using real-time data to predict needs and dynamically modify the environment to enhance user experience while enabling predictive maintenance; (4) Enhanced accessibility and usability through smart interfaces in smart facilities, making services more intuitive and easier for both the younger and older generations to use, such as interactive displays and controls, user-friendly touch screen panels, and voice control systems; (5) Smart security systems providing enhanced safety features, such as surveillance and monitoring, emergency response, and automated alerts. The top six sample cases, ranked according to E10 scores, are analyzed for their specific optimization design strategies, as detailed in table 67.

Practical cases show that Shanghai's key design principles for smart facilities include an integrated intelligent security system, centralized management of equipment and facilities, and the use of robots and electronic signs for smart voice navigation. In Florence, smart equipment is reflected in the updated integration of new and old systems, such as logistics management systems and home automation systems.

Recreational and Fitness Facilities Foster Positive Vitality

From the perspective of promoting health for all ages, creating indoor and outdoor recreational and fitness spaces with integrated and balanced activity areas can serve as activity centers supporting cross-generational interaction and improving the quality of life for people of all ages. Design considerations should include: (1) Adopting inclusive design principles to ensure that recreational and fitness facilities are accessible and usable for people of all ages and abilities; (2) Providing equipment and facilities suitable for different age groups, such as softer playground surfaces for children, fitness equipment with enhanced grip and support for the elderly, accessible pathways, ample signage, and facilities that meet standards; (3) Designing flexible spaces that can accommodate various activities and group sizes, such as a yoga room that can host advanced classes in the morning and junior classes in the afternoon, or a basketball court that can be converted into

a volleyball court or event space; (4) Creating integrated indoor and outdoor spaces, such as fitness trails that loop from outside to inside, providing year-round usability regardless of weather conditions; (5) Encouraging facilities for group activities and games, such as interactive digital fitness challenges or traditional board games, to attract people of all ages. The top six sample cases, ranked according to E11 scores, are analyzed for their specific optimization design strategies, as detailed in table 68.

Practical cases from Shanghai and Florence highlight key design principles as follows: (1) A wide variety of sports equipment that meets the fitness needs of different age groups; (2) Sports facilities located in prominent, easily accessible areas; (3) Proximity to healthcare facilities to promptly address emergencies.

Cross-generational Supportive Environments Enhance Mental Health

Cross-generational supportive environments integrate considerations of therapeutic settings and social interactions, enhancing mental health focus across all age groups. Creating an atmosphere conducive to mental health and supportive relationships can be approached through the following aspects: (1) Incorporating biophilic design, such as integrating natural elements like light, plants, water, and natural materials, to reduce stress, improve mood, and enhance overall health; (2) Customizing environments to stimulate or soothe the senses, particularly effective in elderly care and children's therapeutic spaces, including tactile materials, controlled soundscapes, and visually calming color palettes; (3) Facilities should accommodate a range of activities and needs, including quiet areas for rest and private counseling rooms, as well as public areas for group therapy and social activities; (4) Designing spaces that can adapt to various culturally specific therapeutic practices and social services to ensure broader participation and support. The top six sample cases, ranked according to E12 scores, are analyzed for their specific optimization design strategies, as detailed in table 69.

Practical cases from Shanghai and Florence highlight key design principles as follows: (1) Establishing semi-private or professional psychological counseling rooms to provide consultation services for community residents; (2) Creating multifunctional rooms that serve as cross-generational activity spaces, hosting regular interaction and exchange activities for all ages; (3) Actively fostering a positive environment using decorations and natural plants to create a relaxed and pleasant atmosphere.

Creating Multigenerational Biophilic Environments

Creating a biophilic environment suitable for multiple generations provides opportunities for people of all ages to connect with nature, enhancing the health and well-being of all community members. Biophilic design practices include: (1) Integrating site selection and spatial layout with urban gardens and community green spaces; (2) Designing public areas with nature-themed and biophilic elements to serve as gathering spaces for cross-generational interaction; (3) Combining interactive elements such as sensory gardens, nature trails, and

engaging installations to encourage cross-generational cooperation and exploration, thereby fostering connections among different age groups; (4) Incorporating water features to naturally regulate microclimatic conditions, such as designing fountains or ponds in outdoor and semi-outdoor spaces, and using reflective pools to increase indirect natural light in adjacent areas; (5) Creating relaxing and comfortable environments by mimicking organic forms, materials, and textures found in nature. Architectural interventions like large windows, skylights, and open atriums can be used to optimize daylight penetration. The top six sample cases, ranked according to E13 scores, are analyzed for their specific optimization design strategies, as detailed in table 70.

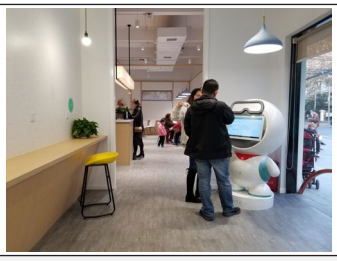
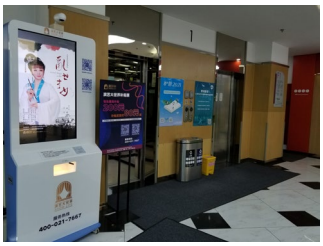
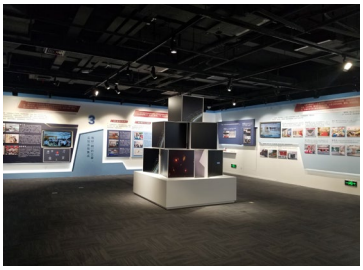
Practical cases from Shanghai and Florence highlight key design principles as follows: (1) Incorporating green courtyards at site entrances and within buildings; (2) Integrating with community parks and urban green spaces, situating cross-generational co-living spaces within them; (3) Preserving the original natural environment and minimizing human intervention.

Sustainable Development Strengthens Cross-generational Connections

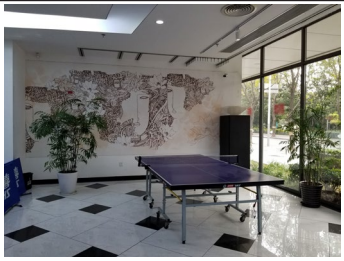
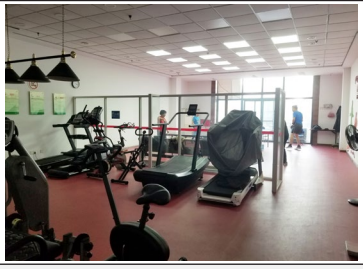
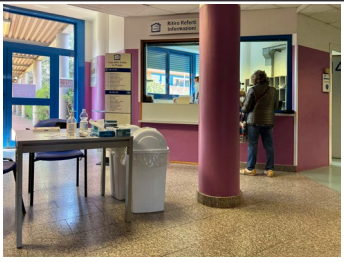
Sustainability is inherently an cross-generational phenomenon, as its focus is on leaving a clean and safe world for future generations (Kruger et al., 2014). The main aspects of sustainable development in the current architectural environment include: (1) Reducing the environmental impact of buildings by integrating eco-friendly materials and technologies, such as using passive solar design, natural ventilation, advanced insulation techniques, and renewable energy to minimize energy consumption; (2) Selecting materials that are sustainably sourced, recyclable, and durable, to reduce the overall environmental footprint of buildings. Planning for future renovations or demolitions to allow for the reuse or recycling of materials at the end of their lifecycle, thereby supporting the circular economy; (3) Modernizing historical buildings to meet contemporary needs while preserving their unique characteristics, providing a physical connection to the past, and enriching the cultural landscape of the community. The top six sample cases, ranked according to E14 scores, are analyzed for their specific optimization design strategies, as detailed in table 71.

Practical cases from Shanghai and Florence highlight key design principles as follows: (1) Reusing existing buildings after renovation and modernization; (2) Preserving original materials and completing space renovations with minimal intervention; (3) Integrating eco-friendly and circular economy concepts into space design.

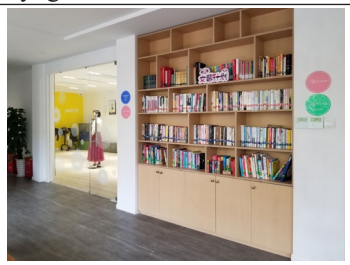
Safety and health, rooted in people-centered principles and social space inclusivity, are the primary concerns for various groups. According to B4 score rankings, samples that provide integrated smart safety systems, encourage diverse recreational and fitness activities, focus on cross-generational mental health care, offer more natural contact, and embody sustainability principles score higher. These are also optimal design strategies for enhancing safety and health in cross-generational co-living spaces(see figure 53 for schematic illustration of the strategy).

Sample: SHYP01	Sample: FIQ103	Sample: SHHP01
Design Strategy: Robots placed in corners provide voice guidance and introductions while integrating with intelligent devices throughout the space for centralized control;	Design Strategy: In historical buildings, pipelines, door and window structures, etc., are renovated with body sensing and intelligent control;	Design Strategy: Electronic display boards are set up at the elevator entrances on each floor to fully showcase community information, activity content, and functional guides;
		
Sample: SHYP05	Sample: SHHK01	Sample: FIQ101
Design Strategy: Firefighting experience and knowledge explanation are combined with corner exhibition spaces to set up V R experiences, making education entertaining;	Design Strategy: A themed exhibition hall is set up at the entrance, showcasing the community's features through multimedia and interactive devices.	Design Strategy: The renovated building is equipped with an advanced home automation system, which intelligently manages the lighting and temperature control systems.
		

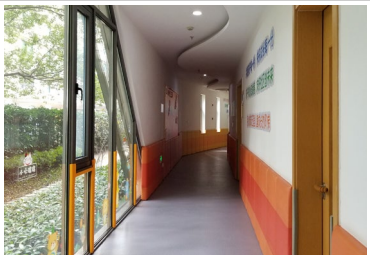
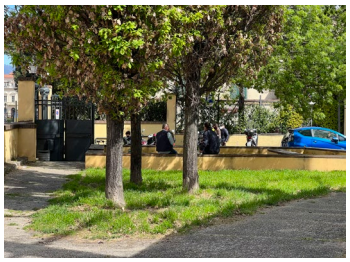
Tab 67 Design strategies for intelligent facilities and systems

Sample: SHHP01	Sample: SHYP05	Sample: SHBS01
Design Strategy: The sports and fitness facilities are diverse, including outdoor basketball courts and indoor yoga for young people, as well as table tennis for the elderly.	Design Strategy: The gym, dance room, and table tennis facilities are diverse, and there is also a moxibustion healthcare center.	Design Strategy: The swimming pool, table tennis, gym, and other sports types are diverse and equipped with medical and health services;
		
Sample: SHHK03	Sample: SHYP01	Sample: FIQ502
Design Strategy: The gym is open to young people in the surrounding area at night, with table tennis suitable for the elderly and dance classrooms suitable for children;	Design Strategy: Combine the entrance outdoor plaza with a variety of children's play facilities and general fitness equipment to create a diverse sports venue;	Design Strategy: Located in the hospital, the elderly can enjoy various physical rehabilitation facilities or sports activities that interact with other age groups.
		

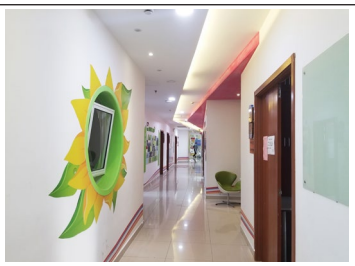
Tab 68 Design strategies for leisure and fitness venues

Sample: SHYP05	Sample: SHYP01	Sample: FIQ501
Design Strategy: Set up semi-private psychological consultation rooms, and place ‘smile walls’ in corridors and exhibition halls;	Design Strategy: Set up a multi-functional room in a quiet corner of the library, to be used as a psychological consultation and mediation room, relaxation yoga room, etc.;	Design Strategy: Regularly hold community residents’ birthday parties, allow families to apply for venues for children’s celebrations, and offer a variety of stress-relief activities;
		
Sample: FIQ103	Sample: FIQ502	Sample: FIQ503
Design Strategy: Set up a psychological mediation room at the entrance, connected to the church;	Design Strategy: Adjacent to the children’s psychological activity room, lively yet attentive to personal privacy;	Design Strategy: Multi-functional room as a language classroom and women’s psychological counseling room.

Tab 69 Design strategies for mental health environments

Sample: F IQ501	Sample: SHHP01	Sample: FIQ103
Design Strategy: The entrance features a large courtyard with ancient trees, fountains, and greenery creating a tranquil and serene environment, with a leisure courtyard on the side;	Design Strategy: Green belts are arranged around the building, with large glass windows on the corridor side facing the courtyard, opening to the outdoors;	Design Strategy: The internal courtyard retains the original forest, regulating temperature, reducing noise, and providing visual screening;
		
Sample: FIQ401	Sample: FIQ502	Sample: SHPD01
Design Strategy: The pedestrian street in the historical district retains much of the original natural environment with minimal human intervention;	Design Strategy: Buildings and transportation corridors are surrounded by large natural landscapes with scattered rest areas;	Design Strategy: The building is located within a community park, surrounded by greenery and plazas.
		

Tab 70 Biophilic design strategies

Sample: SHYP01	Sample: FIQ501	Sample: SHHP01
Design Strategy: Transformed from an old towel factory, utilizing local materials and minimal intervention to create a new urban space;	Design Strategy: Continuing the historical development context, using local materials to maintain the original appearance;	Design Strategy: Set up a book circulation device at the entrance, integrating environmental concepts into equipment and facilities;
Sample: FIQ103	Sample: SHYP05	Sample: FIQ401
Design Strategy: Introduce new materials and structures into old buildings, achieving quality updates while preserving original materials;	Design Strategy: Modernize the original office building with minimal intervention;	Design Strategy: Utilize existing industrial buildings for low-cost renovation in historical districts.
		

Tab 71 Sustainable development design strategies

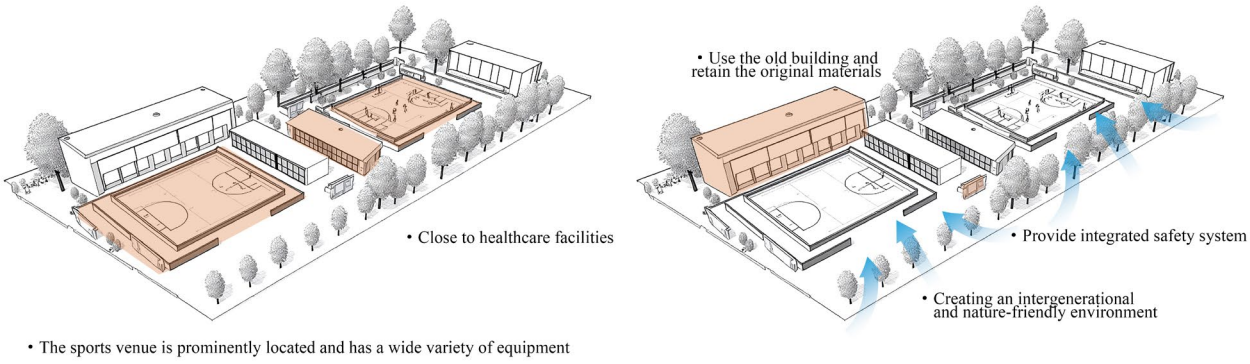


Fig 53 Diagram of strategies for safety and health design

6.5 Collaborative Governance and Construction Promote Social Participation and Inclusion

Establishing Cross-generational Interaction and Collaborative Social Circles

Actively promoting environments for cross-generational social circles and collaborative planning ensures that all generations can gather for social interaction and collaborative planning in a supportive setting. This contributes to a more inclusive and dynamic social structure, making each generation feel valued and involved. Key strategies include:

(1) Creating digital collaborative governance platforms and social groups, integrating communication-enhancing technologies such as public screens for information sharing and Wi-Fi zones that encourage digital interaction across age groups;
(2) Designing dedicated social spaces to promote regular cross-generational interaction, with central gathering spaces like cafes, lounges, or courtyards serving as natural meeting places for casual interaction and scheduled group activities. Outdoor and recreational spaces can encourage informal social gatherings and health-oriented activities;
(3) Establishing participatory design processes and cross-generational governance organizations, involving community members of all ages in the design process to ensure the spaces meet their needs and preferences. This can be facilitated through workshops, surveys, and public forums.

The top six sample cases, ranked according to E15 scores, are analyzed for their specific optimization design strategies, as detailed in table 72.

Practical cases from Shanghai and Florence highlight key design principles as follows: (1) Platforms for collaborative governance should align with the scope of living circles and neighborhood administrative areas, working with multiple organizations to jointly manage operations and organize activities; (2) Conducting various collaborative governance activities in community public spaces, with a particular emphasis on encouraging active participation from the elderly and children; (3) Promoting collaborative governance initiatives through both online and offline methods, such as paper flyers and online platforms.

Develop Innovative Models for Cross-generational Communication and Mutual Assistance

Developing innovative models for cross-generational communication and mutual assistance not only meets the diverse needs of users from different generations but also fosters a strong sense of community, shared goals, and mutual respect among different age groups. Current popular cross-generational activities include:

(1) Developing and implementing programs that cater to various interests and promote structured and cross-generational learning, such as cross-generational workshops, courses, and social events;

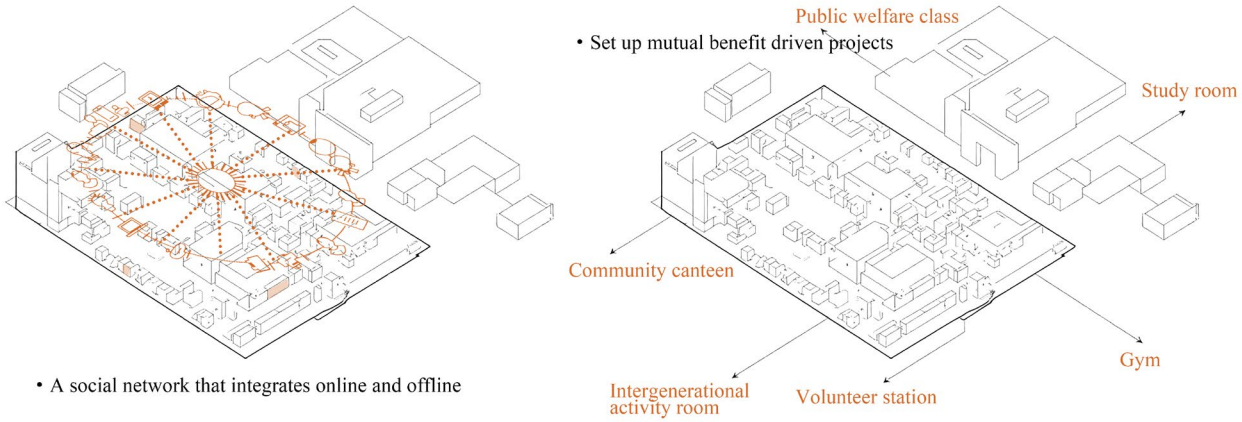


Fig 54 Diagram of strategies for social participation and inclusion

(2) Designing mutual assistance training programs that attract people of different ages, such as libraries hosting children's reading programs and adult lecture series, or community kitchens offering cooking classes;
(3) Using modular design elements that can be easily reconfigured to accommodate various cross-generational activities, such as movable walls or furniture that can be adjusted to fit different group sizes and interaction types;
(4) Organizing educational programs that encourage lifelong learning and skill development, allowing older adults to share their expertise and knowledge with younger community members, thereby creating a natural mentoring atmosphere;
(5) Encouraging volunteer programs for all ages to participate in the maintenance and planning of spaces, fostering a collaborative community spirit.

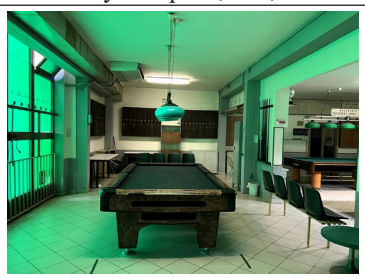
The top six sample cases, ranked according to E16 scores, are analyzed for their specific optimization design strategies, as detailed in table 73.

Practical cases from Shanghai and Florence reveal that current cross-generational projects stem from individual interests and needs, mainly dividing into cross-generational learning centers focused on the elderly and young, and mutual assistance training primarily involving the elderly and youth.

The impact of participation and inclusion goes beyond providing accessible infrastructure; it also involves cultivating environments that foster meaningful dialogue, collaboration, and learning across age groups. Creating spaces that accommodate diverse activities, interests, and interaction modes can promote cross-generational communication and experience sharing. According to B5 score rankings, samples that establish collaborative governance platforms, integrated online and offline social networks, and cross-generational learning and mutual assistance training organizations score higher. These are also optimal design strategies for enhancing participation and inclusion in cross-generational co-living spaces(see figure 54 for schematic illustration of the strategy).

Sample: SHYP01	Sample: SHHP01	Sample: SHHK01
Design Strategy: Dedicated multi-functional rooms, primarily used to promote regular cross-generational interactions, such as study rooms and seminars;	Design Strategy: Encourage residents to participate more in organizing and conducting community activities;	Design Strategy: Increase residents' participation in community activities and showcase their achievements;
Sample: FIQ503	Sample: FIQ501	Sample: SHHK03
Design Strategy: Establish a multi-community interaction platform to attract participation from various organizations;	Design Strategy: Highlight local characteristics as a development focus to significantly promote resident participation;	Design Strategy: Collaborate with nearby schools and communities to conduct various activities.

Tab 72 Social interaction and collaborative social design strategies

Sample: FIQ503	Sample: FIQ501	Sample: SHYP01
Design Strategy: Have middle-aged and elderly people teach billiards knowledge to young people and participate together in community banquets, etc.;	Design Strategy: Elderly and middle-aged people playing board games together;	Design Strategy: People of all ages using libraries and study rooms together;
		
Sample: SHHP01	Sample: SHHK01	Sample: SHHK03
Design Strategy: People of all ages watching movies and using multimedia rooms together;	Design Strategy: V R Experience bringing themed exhibitions to people of all ages;	Design Strategy: Starting from children's projects, creating various educational activities to attract the participation of young people.

Tab 73 Cross-generational communication and activity design strategies

6.6 Summary

This chapter is based on the improvement items in the cross-generational co-living space evaluation system that measure the quality of spatial environments. From a design application perspective, it explores the optimization design strategies for cross-generational co-living spaces in residential communities, providing designers with research findings based on practical value. From an cross-generational perspective, the focus of optimization design strategies is to create environments that are accessible, inclusive, and conducive to the well-being and participation of individuals across different age groups. By adopting principles of universal design, biophilic design, and social space equity, architects can create diverse environments that promote social cohesion and foster a sense of belonging and collective identity within the built environment.

Chapter 7
Conclusions and outlook

7.1 Main conclusions

Addressing the current issues of neglecting elderly loneliness and the challenges of cross-generational integration in residential communities, this study investigates actual case studies in both China and Italy from the perspectives of active aging and Cross-generational co-living. By conducting field surveys, combined with a literature review and qualitative and quantitative research, the study explores the relationship between the Cross-generational co-living model and the spatial environment of urban residential communities. Based on quantitative analysis of spatial configuration relationships and the identification of spatial environmental factors, an evaluation system for the cross-generational co-livingspatial environment in residential communities was established, and specific optimization design strategies were proposed based on evaluation criteria and sample cases.

This study provides an in-depth analysis of the research questions posed, with the following key contributions:

1. Definition and Scope of Cross-generational co-livingSpaces:
Through theoretical and field research, the concept and scope of cross-generational co-livingspaces were explored. The study emphasizes that the Cross-generational co-living model should particularly focus on interactions and mutual assistance between the elderly and younger generations without kinship ties. Broadly speaking, cross-generational co-livingactivities can occur in any space that accommodates people of all ages, making it an cross-generational co-livingspace. More specifically, such spaces include indoor spaces (functional areas, traffic spaces), transitional spaces (entrances, corridors, urban alleys, courtyards, outdoor dining areas with roofs), and outdoor spaces (streets, squares, waterfront areas, parks).

2. Social and Environmental Factors Influencing Cross-generational Interaction:
From multiple perspectives, this study summarizes the social and spatial environmental factors influencing the effectiveness of cross-generational co-livinginteractions. A comparative analysis of community elderly care and cross-generational co-livingspaces in Shanghai and Florence is conducted based on factors such as social and elderly care contexts, elderly characteristics and habits, community built environment, and operational management. Through literature review and field research, the study identifies key research focuses for community elderly care and cross-generational interactions, including street accessibility, proximity to neighborhood facilities, accessibility, comfort, safety, aesthetics, ergonomics, social participation, community culture/emotion, and appropriate levels of privacy.

3. Quantitative Analysis of Spatial Configuration and Interactions:
Using quantitative analysis, the study investigates the relationship between spatial configuration and cross-generational interactions, demonstrating that spatial integration and visual integration in space syntax influence the likelihood of random interactions. Based on the calculation and analysis of sample data, five forms of cross-generational co-livingspaces are identified. Among these, the cluster-type space layout is the most conducive to direct and indirect cross-generational interactions. Spaces most conducive to direct cross-generational interactions include corridors, lobbies, multifunctional halls, bars, entrance plazas, transitional spaces at entrances, and courtyards. Spaces that promote indirect (visual) interactions include the central lobby/square, courtyard edges, junctions of lobbies, entrances, and corridors, as well as intersections of multiple open spaces (e.g., window openings, corridors), and intersections of long corridors. Spaces with lower area discreteness and more consistent sizes (excluding auxiliary and service rooms) are more effective in promoting cross-generational interaction.

4. Construction of an Evaluation System for Cross-generational co-living Spaces:
The study develops an evaluation system for cross-generational co-livingspatial environments in residential communities. Through a comparison of different built environment evaluation methods, the study selects a combination of qualitative and quantitative indicators using the hierarchy-fuzzy analysis method and multi-objective optimization method as evaluation tools. Based on indicator design principles, built environment evaluation features, and expert weight scoring, the system includes 5 criteria layers, 19 fundamental criteria, and 16 improvement criteria. The five criteria layers, ranked by importance, are: safety and health, site accessibility, environmental comfort, spatial integration, and participation and inclusiveness. During the construction of the evaluation system, a total of 24 sample cases in Shanghai and Florence were evaluated through expert questionnaires, expert discussions, and field scoring, confirming the system's effectiveness and reliability.

5. Optimization Design Strategies:
Focusing on the improvement criteria of the cross-generational co-livingspatial environment evaluation system, the study proposes systematic optimization design strategies based on qualitative research outcomes such as surveys and interviews. Results indicate that, in terms of site accessibility, recognized optimization strategies include diverse transportation modes, pedestrian-friendly environments, openness to urban/community interfaces, transitional treatment with outdoor and gray spaces, and multi-functional entrance areas. In terms of spatial integration, optimized strategies include cluster-type layouts, diversified spatial types, multi-functional large-space connection nodes, and balanced proportions of interaction and

functional spaces. For environmental comfort, strategies such as aesthetic visual design, thematic spaces, continuity of local culture, ample natural light in interaction spaces, and ergonomic furniture and facilities are highlighted. For safety and health, integrated intelligent security systems, diverse recreational and fitness activities, cross-generational psychological care, more opportunities for contact with nature, and sustainable development principles are recommended. For participation and inclusiveness, strategies include establishing co-governance platforms, online-offline social networks, and cross-generational learning and mutual assistance organizations.

A comparative study of Shanghai and Florence provides a comprehensive understanding of how historical, cultural, and socio-economic factors in the East and West impact the design and function of cross-generational co-living spaces. Florence's experience in preserving historical buildings offers valuable insights for Shanghai's integration of traditional architectural elements in new developments and renovations, while Shanghai’s innovations in high-density residential design provide lessons for enhancing the resilience and adaptability of Florence’s urban spaces. Through qualitative and quantitative research on cross-generational co-livingspaces, it is concluded that spaces promoting multi-generational interaction should integrate the behavioral characteristics of all generations, foster a strong neighborhood social atmosphere, prioritize physical health, and emphasize the enhancement of spatial environments and service management. The following improvements are suggested to enhance the user experience of cross-generational co-livingspaces: improving site accessibility and reinforcing age-inclusive mobility, adopting cluster-type layouts for equal and homogeneous spatial experiences, enhancing environmental comfort, using safe and healthy designs to promote cross-generational well-being, and fostering social participation and inclusiveness through co-governance.

7.2 Research Innovations

The empirical qualitative and quantitative data analysis in this study represents two interrelated and mutually reinforcing scientific research processes. By linking the issue of psychological loneliness among the elderly with the practical measures of Cross-generational Co-living spaces that promote interaction, this research delves into the deeper relationship between environment and behavior. The main innovations of this study are as follows:

1. Defining the Concept and Scope of Cross-generational Co-living Spaces:
Combining a literature review with qualitative research, this study defines the concept and scope of Cross-generational Co-living spaces and summarizes the social and environmental factors that influence these spaces in both China and Italy. Existing research on active aging and cross-generational mutual assistance often focuses on meeting the material needs of the elderly and improving the quality of the built environment, primarily in the fields of senior housing, age-friendly communities, and multi-generational living. This study approaches the issue from the perspective of alleviating elderly loneliness and, from an architectural design standpoint, defines the concept of Cross-generational Co-living spaces. By broadening the theoretical boundaries of research on multi-generational interaction and community integration, it fills gaps in current studies. Additionally, through a global perspective and qualitative data collection and analysis of cross-generational interaction characteristics among different age groups, the study compares the needs and key concerns of cross-generational groups in China and Italy under different socio-cultural contexts, making this research novel.

2. Applying Spatial Configuration Concepts and Space Syntax Theory to Cross-generational Co-living Spaces:
This study is the first to explore, from a mathematical and logical perspective, the spatial factors affecting the frequency of cross-generational interactions. By applying the concept of spatial configuration and space syntax theory to cross-generational co-living spaces, it quantifies the spatial configuration characteristics. Based on qualitative research findings that highlight the importance of spatial features, the study investigates the essence of interaction and space through the concept of spatial configuration and space syntax theory, applying it to the field of cross-generational co-living spaces. Using real data from representative case studies, the study quantitatively calculates and uncovers spatial forms, types, locations, and the area discreteness of cross-generational co-living spaces. This study represents the first attempt to scientifically quantify the spatial configuration characteristics that influence the frequency of cross-generational interactions through mathematical logic.

3. Using Hierarchical Fuzzy Analysis and Multi-Objective Optimization in Cross-generational Co-living Space Evaluation:

This study develops a set of evaluation criteria and an evaluation system for Cross-generational Co-living spaces in residential communities by applying hierarchical fuzzy analysis and multi-objective optimization methods. It establishes a comprehensive set of evaluation indicators for cross-generational co-living spaces, extracting subjective influence factors through qualitative research and objective influence factors through quantitative literature review and data analysis. Based on the Delphi expert evaluation method, expert interviews, and AHP weight calculations, the study identifies five key parameters for cross-generational co-living spaces: safety and health, site accessibility, environmental comfort, spatial integration, and participation and inclusiveness. Unlike traditional single-method evaluations, this study introduces two types of evaluation criteria—basic and enhanced—considering the impact of the built environment on cross-generational interaction. By integrating hierarchical fuzzy analysis and multi-objective optimization, and following the principles of indicator design, built environment evaluation, and expert weighting, a comprehensive evaluation system with five criteria layers, 19 basic items, and 16 enhancement items is established. This system provides a more scientific and objective basis for evaluating age-inclusive spaces and extends the boundaries of quantitative research in the field of cross-generational mutual assistance.

4. Proposing Optimization Design Strategies for Cross-generational Co-living Spaces in Residential Communities:

Based on the analysis of influence factors and evaluation standards, this study proposes optimization design strategies for cross-generational co-living spaces in residential communities. By analyzing the different needs of cross-generational groups for spatial environments and multiple influencing factors, and focusing on the spatial configuration characteristics of actual case studies and the realization process of the spatial evaluation system, the study combines scientific research findings with practical design strategies. It provides recommendations for the design of cross-generational co-living spaces in residential communities, summarizes design methods, and presents a summary table of design strategies. This, to some extent, addresses the limitations of existing age-friendly spaces that focus solely on improving material needs while neglecting psychological well-being, contributing positively to promoting multi-generational interaction in public spaces within residential communities.

7.3 Research Limitations and Outlook

Cross-generational co-living behavior is typically influenced by a variety of factors, including the physical and mental needs of different age groups and socio-cultural backgrounds. This study, based on community elderly care in China and Italy, focuses on residential areas in the cities of Shanghai and Florence, conducting field surveys of multiple community centers, elderly care service centers, and cross-generational activity centers. By defining the research environment and distinguishing research subjects, efforts were made to minimize the influence of extraneous factors. While this approach improves the precision of the study, it also overlooks other influencing factors, leading to certain research limitations:

1. Scope of the Study: This research primarily focuses on the objective realities of two representative cities, without accounting for the significant differences in community service distribution and environmental development priorities that exist due to varying city sizes in both countries.
2. Theoretical Limitations: The application of space syntax in this study abstracts and simulates all users as objective entities, only calculating the effects of connectivity and integration on interaction frequency within spaces. It neglects subjective differences among cross-generational groups, such as varying goals, needs, environmental perceptions, and emotions.
3. Practical Application: The summary of the spatial evaluation system and design strategies lacks opportunities for practical application and empirical validation.

Based on the above limitations, future research can be further deepened and refined in the following areas:

1. Future studies should expand the scope to broader regions and more in-depth influencing factors, extending the research from urban to regional scales. For example, expanding from Shanghai to the Yangtze River Delta region, and from Florence to the Tuscany region. Emphasis should be placed on identifying both universal and differentiated evaluation criteria, with the aim of better revealing current issues from multiple perspectives and proposing appropriate solutions.
2. Future research should delve deeper into subjective factors related to individual behavior choices, such as investigating how different age groups use cross-generational co-living spaces and their duration of stay. Comparative studies could be conducted between individual differences and objective simulation models.
3. In future practical applications, efforts should be made to verify and improve the accuracy of the cross-generational co-living space evaluation system and the practicality of the design strategies, to further refine and reduce reliance on subjective assumptions.

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Appendix 1 Semi-structured interview outline for Shanghai cases

Purpose	Collect information about the current community center/nursing home/service for the elderly, etc.
Time	
Location	
Target	
Questions	1. Basic information 1.1 establishment time 1.2 the main operator 1.3 number of users/degree of participation 1.4 age composition 1.5 charge 2. Architectural space environment 2.1 city/community location/convenience 2.2 architectural form and area 2.3 building plan (configuration of various types of rooms) 2.4 space for the elderly/barrier-free design/safety/sign 2.5 indoor and outdoor environment of cross-generational co-living space (comfort/frequency of use) 3. The social environment 3.1 social leisure equipment and facilities 3.2 cultural perception/community identity 3.3 information release method (broadcast/announcement board/internet, etc.) 4. Management environment 4.1 opening hours 4.2 arrangement of daily activities 4.3 design concept and features 5. Suggestions

Appendix 2 Montedomini interview outline and interview transcript

Purpose	Collect information about the current community center/nursing home/service for the elderly, etc.
Time	16/05/2022
Location	ASP Firenze Montedomini
Target	Silvia Senatori(doctor in Montedomini)
Questions	1. Basic information 1.1 The main director (Whether the funds come from the government or someone else) 1.2 Aging proportion of users (year 60~69, 70~79, 80~89, over 90) 1.3 How to recruit volunteers/managers (on websites or from other institutions)? 1.4 (The official file from Montedomini shows: promozione e realizzazione d'attività socio-educative e formative per l'inserimento lavorativo per i giovani, in particolare per quelli appartenenti a famiglie disagiate, per portatori di handicap, adulti e anziani, nonché per sostenere i compiti formativi e sociali delle famiglie, quali reti primarie di relazione e sostegno tra i vari componenti e le loro diverse generazioni; /attuazione di progetti che contribuiscano al miglioramento della qualità di vita dell'anziano, attraverso anche iniziative di socializzazione; / VOLONTARIATO: favorire le condizioni per creare un clima confortevole dal punto di vista delle relazioni umane;/ contribuire alla realizzazione delle attività ricreative e di socializzazione anche all'esterno delle strutture;/ collaborare a risolvere problemi pratici degli utenti;/ impegnare il tempo libero degli utenti attraverso specifiche ed opportune iniziative.) What are the specific activities or measures? Can volunteer activities solve the problem of psychological loneliness of the elderly? 2. Architectural space environment 2.1 (The official file from Montedomini shows: L'autorizzazione al funzionamento per le strutture dell'ASP Firenze Montedomini sono le seguenti: Montedomini Sede n° 12539 del 28/11/2006; Principe Abamelek n° 12533 del 28/11/2006; San Silvestro n° 151 del 21/11/2003; Centro Diurno Athena n° 13011 del 13/12/2007.) What are the criteria for choosing the sites? Is it related with the population density of neighborhood or the surrounding seniors? 2.2 What public spaces are often used by the elderly? 2.3 Are there any rooms or space for the elderly to share and communicate with other age groups? 2.4 Will the disabled elderly be organized to visit the city? 2.5 Could you please provide some floor plans/interior photos for research? 3.The social environment 3.1 (The official file from Montedomini shows: L'Azienda ha sempre perseguito la filosofia della massima apertura delle proprie strutture verso il territorio pertanto, l'accesso alle strutture da parte di familiari e/o di conoscenti degli utenti è libero nei seguenti orari: RSA/RA/BIA: dalle ore 10.00 alle ore 20.30 Centro Diurno Athena: dalle ore 10.00 alle ore 17.00) Are there public facilities or space open to the public? 3.2 (The official file from Montedomini shows: Arredo camera All'interno della camera l'utente può fruire dell'arredo presente e utilizzare l'armadio e il comodino per custodire gli effetti personali, può integrare l'arredo con piccoli oggetti personali, previa autorizzazione del Coordinatore di Struttura, compatibilmente con lo spazio a disposizione e sempre che non sia pregiudicata la possibilità di movimento e comunque nel rispetto della condivisione dello spazio comune.) Will it be considered that use the original decoration style of the elderly to reduce their psychological loneliness?

Questions	3.3 (The official file from Montedomini shows: Pertanto l'Azienda procede alla periodica somministrazione dei questionari di gradimento a tutti gli utenti dei servizi residenziali e semiresidenziali, ai loro familiari, agli utenti del Telec@re, alle utenti del Servizio PSIA e ai dipendenti. I focus individuati sono il servizio Ristorazione, i servizi del Telec@re e dello PSIA, il Fabbisogno formativo dei dipendenti, il Decoro gli ambienti interni la pulizia e gli spazi verdi delle strutture e il Servizio di Accoglienza.) Could you please provide us with the content of the satisfaction questionnaire? (or related statistics) 4. Others 4.1 What are the main differences from other institutions such as Casa della Salute/Arci? 4.2 In addition to the protection of culture and art such as Bigallo, is there any corresponding display of the institution's culture and history?

Montedomini interview transcript

1. Basic information

1.1 Question: The main director (Whether the funds come from the government or someone else)

Answer: Institution is the main operator, and there are many sources of funds, including municipal governments, enterprises, banks, etc.. It's open for all social classes across the city (unlike private operators).

1.2 Question: Aging proportion of users (year 60~69, 70~79, 80~89, over 90)

Answer: Most seniors are over 65 (with some exceptions).

1.3 Question: How to recruit volunteers/ managers (on websites or from other institutions)?

Answer: Recruited through a volunteer association organization.

1.4 Question: (The official file from Montedomini shows: promozione e realizzazione d'attività socio-educative e formative per l'inserimento lavorativo per i giovani, in particolare per quelli appartenenti a famiglie disagiate, per portatori di handicap, adulti e anziani, nonché per sostenere i compiti formativi e sociali delle famiglie, quali reti primarie di relazione e sostegno tra i vari componenti e le loro diverse generazioni; / attuazione di progetti che contribuiscano al miglioramento della qualità di vita dell'anziano, attraverso anche iniziative di socializzazione; / VOLONTARIATO: favorire le condizioni per creare un clima confortevole dal punto di vista delle relazioni umane;/ contribuire alla realizzazione delle attività ricreative e di socializzazione anche all'esterno delle strutture;/ collaborare a risolvere problemi pratici degli utenti;/ impegnare il tempo libero degli utenti attraverso specifiche ed opportune iniziative.

What are the specific activities or measures? Can volunteer activities solve the problem of psychological loneliness of the elderly?

Answer: There are many kinds of activities, covering life, culture, entertainment, sports and other aspects. For example, some organizations (third parties) will take the elderly to the beach and visit museums. Montedomini is also organizing an event for children that will involve older people and encourage them to interact with younger people. Volunteering is a supplementary service for the elderly.

2. Architectural space environment

2.1 Question: (The official file from Montedomini shows:

L'autorizzazione al funzionamento per le strutture dell'ASP Firenze Montedomini sono le seguenti:

Montedomini Sede n° 12539 del 28/11/2006;

Principe Abamelek n° 12533 del 28/11/2006;

San Silvestro n° 151 del 21/11/2003;

Centro Diurno Athena n° 13011 del 13/12/2007.)

What are the criteria for choosing the sites? Is it related with the population density of neighborhood or the surrounding seniors?

Answer: The site is chosen in relation to its

historical context, for example, it was once a relief agency (eg Pia Casa di Lavoro).

2.2 Question: What public spaces are often used by the elderly?
Answer: Courtyards, bars, theatres (cinemas), canteens, places to play the piano, recovery rooms, etc..

2.3 Question: Are there any rooms or space for the elderly to share and communicate with other age groups?
Answer: Some, for example, the existing public area is for the elderly living here to communicate with relatives and friends who come to visit them; the canteen (students of the School of Architecture of the University of Florence also come to eat); the theater (cinema) is waiting for Renovation; the new accommodation space design has just been tendered and is being remodeled, and there will also be some new public spaces.

2.4 Question: Will the disabled elderly be organized to visit the city?
Answer: Yes, it will organized by other institutions to lead the tour.

2.5 Question: Could you please provide some floor plans/interior photos for research?
Answer: Yes, we will send it to you by e-mail.

3.The social environment
3.1 Question: (The official file from Montedomini shows:
L'Azienda ha sempre perseguito la filosofia della massima apertura delle proprie strutture verso il territorio pertanto, l'accesso alle strutture da parte di familiari e/o di conoscenti degli utenti è libero nei seguenti orari:
RSA/RA/BIA: dalle ore 10.00 alle ore 20.30
Centro Diurno Athena: dalle ore 10.00 alle ore 17.00)
Are there public facilities or space open to the public?
Answer: At present, except for the canteen, which is shared by elderly and students at the nearby University of Florence, other public facilities are still being designed.

3.2 Question: (The official file from Montedomini shows:
Arredo camera
All'interno della camera l'utente può fruire dell'arredo presente e utilizzare l'armadio e il comodino per custodire gli effetti personali, può integrare l'arredo con piccoli oggetti personali, previa autorizzazione del Coordinatore di Struttura, compatibilmente con lo spazio a disposizione e sempre che non sia pregiudicata la possibilità di movimento e comunque nel rispetto della condivisione dello spazio comune.)
Will it be considered that use the original decoration style of the elderly to reduce their psychological loneliness?
Answer: The elderly will be allowed to bring soft furnishings from home, and the hard furnishings are unified. For example, the electrical safety, management, etc., have to be taken under control.

3.3 Question: Could you please provide us with the content of the satisfaction questionnaire? (or related statistics)
Answer: Yes, we will send it to you by e-mail.

3.4 Question: Have you considered the psychological loneliness of the elderly? Do you think it is necessary to add more cross-generational communication?
Answer: The elderly like to come here to socialize, and there are a lot of cross-generational interactions with young people and children here. For example, some members bring their juniors here to participate in activities, volunteer services and so on.

4. Others
4.1 Question: What are the main differences from other institutions such as Casa della Salute/ Arci?
Answer: Casa Della Salute is a medical institution, Arci is an organization for cultural activities. We are here simply to provide help and services for the elderly, similar to a nursing home.

4.2 Question: In addition to the protection of culture and art such as Bigallo, is there any corresponding display of the institution's culture and history?
Answer: Initiated by Rossi Prodi, there is a preparation for the design of Villaggio Montedomini. In order to build an open structure that communicates with the city, while ensure the independence of the elderly mini-apartments, maintain continuity with all services, add cultural, historical and social content. The facility will be a training center for female students and health professions students such as geriatricians and nurses. This is a project resulting from a synergy between the City of Florence, Florence Montedomini, the region, the local health authority, the CR Firenze Foundation and the University. Welfare MP Sara Funaro said, "Montedomini Village is a necessary response to the needs of the elderly and can provide assistance to those who are physically challenged but still able to take care of themselves. Projects like this offer concrete solutions to combat loneliness, allowing seniors maintain a correct and healthy lifestyle that has a positive impact on their health."

Appendix 3 Arci interview outline and interview transcript

Purpose	Collect information about the current community center/nursing home/service for the elderly, etc.
Time	25/05/2022
Location	Societa'Mutuo Soccorso Ricreativo
Target	Mauro Megli(President of Arci)
Questions	1. Basic information 1.1 Opening hours 1.2 Arrangement of daily activities 1.3 Age composition of users 1.4 Number of volunteers/managers 1.5 How to recruit volunteers/managers? 1.6 Which months of the year will there be more users? 2. Architectural space environment 2.1 What are the criteria for the selection of site of Arci? Does it have anything to do with the density of residents in the neighborhood, or the surrounding seniors? 2.2 What public spaces are often used by the elderly? 2.3 Are there spaces for the elderly to share and communicate with other age groups? 3.The social environment 3.1 Are there any activity center/facilities open to the public? 3.2 What services can the elderly who live in the nearby community enjoy? 3.3 Is there a corresponding display of the culture and history of the community where the organization is located? 3.4 Have you considered the psychological loneliness of the elderly? Do you think it is necessary to add more cross-generational communication? 4. Others What are the main differences from other agencies such as SMS Rifredi/Montedomini?

Arci interview transcript

1. Basic information

1.1 Question: When is Societa'Mutuo Soccorso Ricreativo open?

Answer: Monday to Saturday 8:00-19:00, 21:00-24:00, closed on Sunday.

1.2 Question: What are the daily activities?

Answer: About learning, there are Italian lessons, after-school tutoring for children (children with learning disabilities or immigrants, teachers are all volunteers), and regular reading and sharing sessions; about life, there is a bar and restaurant; about sports activities, there are billiards and outdoor basketball; there are also some summer concerts, painting, crafts and other activities.

1.3 Question: What is the age composition of users?

Answer: There are almost 400 members every year. In 2021, there were 400 members, and more than half of them were retirees. A total of 480 membership cards have been issued, 80 of which are dedicated to young people. The discount price for youth is 6 euros per card, and the original price is 13 euros per card.

1.4 Question: How many volunteers or managers are there?

Answer: There were 7 employees before the epidemic, 3 were full-time and 4 were part-time. 2 of the full-time employees are chefs, and the part-time employees are mainly responsible for the bar. After the epidemic, there are only 2 part-time employees who are responsible for the bar. If there are other activities or work, members will coordinate and handle them as volunteers.

1.5 Question: How are volunteers or managers recruited?

Answer: It develops from members, and some residents of surrounding communities will also join us spontaneously.

1.6 Question: Which months of the year will there be more users?

Answer: In summer, most people will go on vacation, like the beach, etc. Therefore, except for summer, there are more people in the other three seasons. Especially in winter, because it's cold and there's nowhere to go, there's heating here for socializing. Usually there are more people after dinner, and most of the young people come here in the evening.

2. Architectural space environment

2.1 Question: What are the criteria for the selection of site of Arci? Does it have anything to do with the density of residents in the neighborhood, or the surrounding seniors?

Answer: The predecessor here was SMS (Mutual Aid Organization), which was composed of many local sand washers and masonry workers in 1873. It was originally located in the Peretola area. In 1935 the Fascists captured the headquarters. And in 1955 here was captured (occupied) by the gendarmerie (according to a law of September 1, 1943, the property of the Fascist party should be confiscated), the former site is now the gendarmerie. Where we are now is the land donated by one of the members, construction started in 1955 and completed in 1959.

2.2 Question: What public spaces are commonly used by seniors?

Answer: bar, restaurant, reading corner in the entrance hall, billiard room on piano 0, etc..
Then pay by the hour for billiards in membership price.

2.3 Question: Do seniors have space to share and communicate with other age groups?
Answer: Young people like to play billiards, table tennis, etc. with the elderly, and people of different age groups enjoy playing together (Older people are willing to teach young people the technology, and young people are willing to learn from elders). When organizing dinner, the waiters are basically young people.

3.The social environment
3.1 Question: Are there any activity center/ facilities open to the public?
Answer: Before the epidemic, the bar and restaurant were open every day. Membership registration was required for using them. After the epidemic, the restaurant will only be open for use when there are activities, and the bar is operated as usual.

3.2 Question: What services can the elderly who live in the nearby community enjoy?
Answer: They can come here to chat, play billiards, eat and drink, and participate in various public welfare activities, including learning and reading, entertainment, sports and fitness, etc.

3.3 Question: Is there a corresponding display of the culture and history of the community where the organization is located?
Answer: The reading corner in the entrance hall has a display of this cultural center, introducing the local historical background through words, pictures, the original organization badge, etc.

3.4 Question: Have you considered the psychological loneliness of the elderly? Do you think it is necessary to add more cross-generational communication?
Answer: The elderly like to come here to socialize, and there are a lot of cross-generational interactions with young people and children here. For example, some members bring their juniors here to participate in activities, volunteer services and so on.

4. Others
Question: What are the main differences from other agencies like SMS Rifredi/Montedomini?
Answer: SMS Rifredi was organized by the workers of the Galileo munitions factory (production of scientific and astronomical instruments, optical and optoelectronic instruments, and scientific instruments for satellite and space exploration.), unlike the predecessors here, but the are both mutual aid organizations (Società di Mutuo Soccorso). Montedomini is mainly an institution for the elderly, with more services for the elderly. Our Società di Mutuo Soccorso pays more attention to organizing cultural activities in the Quartiere 5.
p.s.
Società di Mutuo Soccorso Peretola (SMS)– Arci Firenze) is a non-profit cultural association (Associazione Promozione Sociale), which does not receive funding from the government, but cooperates with the municipal government, such as arranging immigrants to learn Italian and helping them integrate into society.

Appendix 4 Quartiere 5 President interview outline and interview transcript

Purpose	Collect information about the current community center/nursing home/service for the elderly, etc.
Time	09/06/2022
Location	Villa Pallini in via Baracca 150/P ,50127 Firenze
Target	Sig.Cristaino Balli (President of Quartiere 5) Francesca Minna (Contact Secretary)
Questions	1. Basic information 1.1 What kind of organization is the Consiglio di Quartiere 5? Are the personnel staffed by the municipal government? 1.2 The approximate total population of Quartiere 5 1.3 The proportion of the elderly 1.4 What institutions (municipal government, non-profit cultural associations, religious institutions, etc.) in Quartiere 5 are related to the community life of the elderly? 1.5 The number or distribution of various community activity centers (such as Arci and other cultural associations). 2. Architectural space environment 2.1 What are the criteria when designing building spaces relevant to the elderly or the community? 2.2 What public spaces are often used by the elderly? 2.3 Are there spaces for the elderly to share and communicate with other age groups? 3.The social environment 3.1 Is there an activity center/public facility open to the public? 3.2 What services can the elderly who live in the nearby community and elderly care at home enjoy? 3.3 Have you considered the psychological loneliness of the elderly? Do you think it is necessary to add more cross-generational communication? 4. Others 4.1 What is the management of cooperation with other institutions? 4.2 Any cooperation with other quartieri?

Quartiere 5 President interview transcript

1. Basic information

1.1 Question: What kind of organization is the Consiglio di Quartiere 5? Are the personnel staffed by the municipal government?

Answer: Quartiere 5 is a district-level government, and its personnel belong to the government.

1.2 Question: The approximate total population of Quartiere 5

Answer: 105,693. The amount is updating every month on the commune website.

1.3 Question: The proportion of the elderly

Answer: 27,496 people, accounting for about 26% of the total population of District 5 (as of June 28, 2022, population data is updated monthly)

1.4 Question: What institutions (municipal government, non-profit cultural associations, religious institutions, etc.) in Quartiere 5 are related to the community life of the elderly?

Answer: There are 8 government agencies. In addition to the church, there are other similar institutions related to union organizations, historical relief agencies, etc.

1.5 Question: The number or distribution of various community activity centers (such as Arci and other cultural associations).

Answer: 892 related service establishments in District 5.

2. Architectural space environment

2.1 Question: What are the criteria when designing building spaces relevant to the elderly or the community?

Answer: It should be distributed as evenly as possible in the whole area, and the streets and jurisdictions of smaller scale should be widely arranged.

2.2 Question: What public spaces are commonly used by seniors?

Answer: Elderly homes, art galleries/museums, gyms, vegetable gardens, parks, etc..

2.3 Question: Do seniors have space to share and communicate with other age groups?

Answer: We often arrange for the elderly to give children extracurricular tutoring, teach them to draw, rehearse plays, etc. We have a special plantation program where young and old can experience growing vegetables. There are 210~220 pieces of land in Florence, each piece is 50~70 square meters in size, and you can apply for it every 2 or 3 years. Young people must withdraw from use after they reach the age of 18, and the elderly with mobility difficulty are better to quit.

3.The social environment

3.1 Question: Are there any activity center/ facilities open to the public?

Answer: What is open to the elderly is basically open to the public.

3.2 Question: What services can the elderly who

live in the nearby community enjoy?
Answer: Activities like singing and dancing, playing sports, visiting art galleries, making ceramics, going to the theater, etc.

3.3 Question: Have you considered the psychological loneliness of the elderly? Do you think it is necessary to add more cross-generational communication?
Answer: The elderly and young people will have cross-generational communication when they do activities, and we usually organize activities for all ages to encourage the elderly to communicate more.

4. Others
4.1Question: What is the management of cooperation with other institutions?
Answer: Different types of activities will form different networks, such as medical care, education and other fields, and there will be corresponding organizations to cooperate with the management.
4.2 Question: Any cooperation with other quartieri?
Answer: We will organize activities with other districts and discuss administrative strategies together.

Appendix 5 AHP Expert Interview Questionnaire - Enhancement Items

Greetings! Thank you for taking time out of your busy schedule to participate in this survey. Based on the study of Cross-generational co-living spaces in residential communities to evaluate the importance of spatial environmental impact indicators, your opinion will be very important to help this study. This survey will not be open to the public and will only be used for academic research. Please feel free to answer according to the actual situation, and we faithfully thank you for your great support to our research!

The objective of this study is to create an environmental evaluation system for Cross-generational co-living space (*Cross-generational co-living space can be understood as a house (building) such as a neighborhood center/residents' activity room/clubhouse in a small area). The prerequisite items (equally important) include 1.site accessibility: ease of passage, barrier-free facilities, complete signage and information, and surrounding amenities; 2. environmental comfort: air quality, humidity and temperature control, ventilation, natural lighting, artificial lighting, noise control, basic water management, cleanliness and maintenance, and adequacy of resting facilities; 3. safety and health: emergency response system, non-polluting indoor materials, privacy, and greenery; 4. participation and inclusion: activities and events; and 5. participation and inclusiveness: activities and events, and activities for the residents, and activities for the residents. 6. Participation and inclusion: activity enrichment, volunteerism.

The prerequisite items are the basic judging guidelines, and in order to enhance the quality of the Cross-generational co-living spatial environment, it is hoped that this questionnaire will determine the weights of the evaluation indicators of the Cross-generational co-living spatial environment enhancement items (including 5 guideline layers and 15 sub-criteria layers, with a score from 1 to 5 for each indicator representing very unimportant to very important, respectively). The following is the system of evaluation indicators for the Cross-generational co-living spatial environment of this research study:

1. Guideline level B1 [Site accessibility] (Interpretation: Impact of the location and layout of Cross-generational co-living spaces on accessibility in an urban site) [Single choice] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

2. Guideline level B2 [Spatial integration] (Interpretation: Impact of cross-generational symbiotic spatial characterization on interactivity) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

3. Guideline level B3 [Environmental comfort] (Interpretation: Impact of the physical environment of a transgenerational symbiotic space on comfort) [Single-choice questions]*
○Very unimportant ○Unimportant ○Average ○Important ○Very important

4. Guideline level B4 [Safety and health] (Interpretation: Safety and health-related design in Cross-generational co-living spaces) [Single option] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

5. Normative level B5 [Participation and inclusion] (Interpretation: The impact of the organization of activities and the setting up of services on people's participation and inclusion) [Single-choice question]*
○Very unimportant ○Unimportant ○Average ○Important ○Very important

6. Sub-criteria level E1 [Customized mobility solutions] (Interpretation: Integration of various forms of transportation services to provide users with tailor-made options, e.g., special transportation services or cooperation with local services to meet the mobility needs of older persons and children) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

7. Sub-criterion level E2 [Walkability] (Interpretation: Walkable access to a use site or building space that enhances the overall level of support for walking trips in the area) [Single-choice] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

8. Sub-criterion level E3 [Spatial form] (Interpretation: Pay attention to the impact of Cross-generational co-living spatial forms (clustered, centralized, linear, radiating) on interactivity, and maximize the use of appropriate spatial forms) [Single-choice questions] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

9. Sub-criterion level E4 [Spatial type and location] (Interpretation: Pay attention to the impact on interactivity of the

spatial type and location in which Cross-generational exchanges take place, and maximize the choice of appropriate spatial type and location) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

10. Sub-criteria level E5 [Area discretization] (Interpretation: Pay attention to the impact of the area share of cross-generational symbiotic space on interactive exchanges, and try to choose the appropriate area share) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

11. Sub-criteria level E6 [Visual aesthetics] (Intuitive perception of the spatial environment (with attention to the special characteristics of the elderly and children), including the use of materials that are close to nature, systematic and scientifically sound signage, solid and varied furnishings, and warm and livable colors, with a predominance of warm tones, etc.) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

12. Sub-criterion level E7 [Sense of cultural belonging] (Communities, local historical and cultural environments and sense of belonging to the neighborhood) [Single choice] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

13. Sub-criteria level E8 [Maximization of natural light] (Interpretation: Maximize the use of natural light to enhance the physical and mental health of users) [Single-choice question]*
○Very unimportant ○Unimportant ○Average ○Important ○Very important

14. Sub-criteria level E9 [Ergonomic design] (Interpretation: Furniture, fixtures and fittings are designed to incorporate ergonomic requirements to minimize the risk of discomfort or injury) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

15. Sub-criteria level E10 [Intelligent integrated security systems] (Interpretation: The use of intelligent technology to enhance security, such as emergency call systems, intelligent security monitoring systems, etc.) [Single-choice questions]*
○Very unimportant ○Unimportant ○Average ○Important ○Very important

16. Sub-criteria level E11 [Programs and facilities to promote physical fitness] (Interpretation: Promoting physical fitness through design, monitoring and facilities, e.g., adding fitness centers, yoga studios and meditation areas, equipping with wearable devices and health monitoring systems, etc.) [Single-choice questions] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

17. Sub-criteria level E12 [Mental health services] (Interpretation: Raise awareness of the mental health status of people of all ages and provide mental guidance services for different groups) [Single choice] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

18. Sub-criteria level E13 [More access to nature] (Interpretation: Going a step further in indoor greening by incorporating more natural elements into the design of indoor and outdoor spaces, and maximizing access to nearby natural environments, if possible, to better utilize the healing power of nature) [Single-choice questions]*
○Very unimportant ○Unimportant ○Average ○Important ○Very important

19. Sub-criteria level E14 [Environmental sustainability] (Interpretation: Use of environmentally friendly materials, reduction of energy consumption and minimization of the carbon footprint of the spatial environment) [Single-choice questions]*
○Very unimportant ○Unimportant ○Average ○Important ○Very important

20. Sub-criteria level E15 [Establishment of social networks] (Interpretation: broadcasting/publicizing the status of boards/counters, ways of informing users, building online social media such as WeChat groups, community houses, etc.) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

21. Sub-criteria level E16 [Cross-generational exchange programmes and activities] (Interpretation: Organization of activities aimed at facilitating Cross-generational interaction and mutual learning, e.g., teaching of smart devices, caregiving, etc.) [Single-choice question] *
○Very unimportant ○Unimportant ○Average ○Important ○Very important

Appendix 6 Importance Matrix Judgment Matrix

Attached Table 1 Judgment Matrix for Importance of Site Accessibility Indicators

Site Accessibility Indicators Indicators	E1	E2	weight vector
E1	(1 1 1)	(2/5 1/2 2/3)	0.333
E2	(3/2 2 5/2)	(1 1 1)	0.667

Attached Table 2 Matrix for judging the importance of spatial integration indicators

Indicators of spatial integration	E3	E4	B5	weight vector
E3	(1 1 1)	(2/5 1/2 2/3)	(11/2 6 13/2)	0.341
E4	(3/2 2 5/2)	(1 1 1)	(15/2 8 17/2)	0.593
B5	(2/13 1/6 2/11)	(2/17 1/8 2/15)	(1 1 1)	0.065

Attached Table 3 Matrix for judging the importance of environmental comfort indicators

Environmental comfort indicators	E6	E7	B8	B9	weight vector
E6	(1 1 1)	(5/2 3 7/2)	(2/9 1/4 2/1)	(9/2 5 11/2)	0.114
E7	(2/7 1/3 2/5)	(1 1 1)	(2/13 1/6 2/11)	(2/15 1/7 2/13)	0.055
B8	(7/2 4 9/2)	(11/2 6 13/2)	(1 1 1)	(2/5 1/2 2/3)	0.307
B9	(2/11 1/5 2/9)	(13/2 7 15/2)	(3/2 2 5/2)	(1 1 1)	0.524

Attached Table 4 Matrix for judging the importance of safety and health indicators

Safety and health indicators	E10	E11	B12	B13	B14	weight vector
E10	(1 1 1)	(2/7 1/3 2/5)	(2/5 1/2 2/3)	(2/9 1/4 2/1)	(9/2 5 11/2)	0.115
E11	(5/2 3 7/2)	(1 1 1)	(3/2 2 5/2)	(2/5 1/2 2/3)	(11/2 6 13/2)	0.263
B12	(3/2 2 5/2)	(2/5 1/2 2/3)	(1 1 1)	(2/7 1/3 2/5)	(9/2 5 11/2)	0.166
B13	(7/2 4 9/2)	(3/2 2 5/2)	(5/2 3 7/2)	(1 1 1)	(13/2 7 15/2)	0.416
B14	(2/11 1/5 2/9)	(2/13 1/6 2/11)	(2/11 1/5 2/9)	(2/15 1/7 2/13)	(1 1 1)	0.039

Attached Table 5 Participation and Inclusion Indicator Importance Matrix

Participation and inclusion indicators	E15	E16	weight vector
E15	(1 1 1)	(2/11 1/5 2/9)	0.167
E16	(9/2 5 11/2)	(1 1 1)	0.833

Appendix 7 Case Prerequisite Scoring Scale

Based on the pictures of the site and the results of the research interviews, please make a judgment on the case of SHYP01

Target level (A)	Guideline layer (B)	Sub-criteria layer (P)	Qualitative and quantitative description	Score (satisfied or not) and tick in the appropriate place	
Cross-generational co-living space environment assessment	Site accessibility B1	Ease of access P1	The traffic organization is convenient and smooth, meets the requirements of evacuation and transportation, and avoids the influence of vehicles on the movement of people;	Satisfaction ()	Not satisfied ()
		Accessibility P2	Compliance with the basic requirements for barrier-free design, especially concerning: treatment of floor height differences (steps, ramps, elevators, no thresholds and height differences, or threshold heights and height differences between the floor inside and outside the door of ≤ 15mm, and with a sloped transition), wheelchair access (net width of 0.8m), restroom accessibility treatments, anti-slip and anti-collision measures, installation of universal accessibility signs, etc. ;	Satisfaction ()	Not satisfied ()
		Marking information complete P3	There are access guide signs, service guide signs, safety warning signs, etc. that are securely installed and located so that they can be easily viewed by the elderly and children;	Satisfaction ()	Not satisfied ()
		Neighborhood Facilities P4	Easy access to healthcare support facilities (including on-site support or nearby medical facilities), transportation stops, service equipment for special groups, emergency equipment, commercial services, etc., within 1 km or 15 minutes' walking distance of the surrounding area;	Satisfaction ()	Not satisfied ()
	Environmental comfort B3	Air quality P5	Provide indoor space air quality levels that ensure the health of users, discourage smoking and create a smoke-free environment;	Satisfaction ()	Not satisfied ()
		Wet temperature control P6	Provide a thermally comfortable environment that is acceptable to most users, with indoor temperatures of not less than 18°C in public spaces in winter and 26-28°C in summer, and relative humidity of ≤60% . Temperature and humidity regulating equipment, such as radiators, air conditioners, electric fans, humidifiers, dehumidifiers, etc., are provided, and their performance is up to standard and safe to use;	Satisfaction ()	Not satisfied ()
		Ventilation regulation P7	Public activity spaces are provided with external windows with opening fans, and corridors and ancillary rooms are provided with external windows with opening fans or with mechanical exhaust ventilation;	Satisfaction ()	Not satisfied ()
		Natural Lighting P8	The public activity spaces and public corridors have good natural lighting, and some east-west oriented rooms are equipped with effective shading measures;	Satisfaction ()	Not satisfied ()
		Artificial Lighting P9	The illuminance value of the activity area is not less than 300lx , the illumination is sufficient, uniform and glare-free, and the light source is suitable to be warm and energy-saving, and to provide visual comfort to the users through artificial lighting;	Satisfaction ()	Not satisfied ()

Target level (A)	Guideline layer (B)	Sub-criteria layer (P)	Qualitative and quantitative description	Score (satisfied or not) and tick in the appropriate place	
Cross-generational co-living space environment assessment		Noise Control P10	Recreational activities area ≤ 45dB, health care area ≤ 40dB. The public activity space can realize the motion static partition, and when several activities are carried out at the same time, the sound will not interfere with each other, and there will be no obvious echo and noise when people are talking and equipment is moving;	Satisfaction ()	Not satisfied ()
		Basic Water Management P11	Water intended for human contact (e.g., drinking, cooking and dishwashing, hand washing, showering, or tub bathing) shall meet a turbidity level of ≤1 NTU, FTU, or FNU, with no detectable Escherichia coli in any 100 ml sample;	Satisfaction ()	Not satisfied ()
		Cleanliness and Maintenance P12	The common areas are clean, sanitary and the environment is easy to maintain;	Satisfaction ()	Not satisfied ()
		Adequacy of rest facilities P13	Resting seats are installed within 150m of the walking distance for the elderly according to suitability, and resting seats and activity facilities (such as chess and card tables) are installed along the corridors of the activity space, with the resting area in front of the public facilities measuring ≥1.5m by 1.5m;	Satisfaction ()	Not satisfied ()
	Safety and health B4	Emergency Response System P14	Clear and easy-to-use emergency procedures and features provide safety and security, non-slip paving materials, reminder signs, and emergency call-outs in case of danger to avoid accidents, falls, and more;	Satisfaction ()	Not satisfied ()
		Indoor materials are non-polluting P15	The concentration limits of indoor environmental pollutants shall meet the following: radon (Bq/m^3) ≤ 150, formaldehyde (mg/m^3) ≤ 0.08, ammonia (mg/m^3) ≤ 0.2, benzene (mg/m^3) ≤ 0.09, toluene (mg/m^3) ≤ 0.2, xylene (mg/m^3) ≤ 0.2, TVOC (mg/m^3) ≤ 0.5 ;	Satisfaction ()	Not satisfied ()
		Privacy P16	Set up private and personalized spaces;	Satisfaction ()	Not satisfied ()
		Greening P17	Introduce nature into the indoor and outdoor environments; trees, flowers and plants are free of highly allergenic pollen, flying hairs, flying flotsam, harmful volatiles and odor pollution; there are no plants with thorns, roots and stems that can easily be exposed to the ground in the locations where the elderly pass by, and no sprawling branches to block the passage.	Satisfaction ()	Not satisfied ()
	Participation and inclusion B5	Activity richness P18	Multiple types of activities for all age groups, combined with the frequency of organization of activity times for different age groups;	Satisfaction ()	Not satisfied ()
		Volunteerism P19	Setting up platforms or cooperating with other organizations to provide volunteer activities and services suitable for different groups of people.	Satisfaction ()	Not satisfied ()

Appendix 8 Case Enhancement Item Scoring Sheet

Based on the pictures of the site and the results of the research interviews, please make a judgment on the case of SHYP01

Target level (A)	Guideline layer (B)	Sub-criteria layer (E)	Qualitative and quantitative description	Scoring (very good (5), good (4), fair (3), poor (2) and very poor (1))
Cross-generational co-living space environment assessment	Site accessibility B1	Customized Travel Solutions E1	Integration of various forms of transportation services to provide users with tailored options, e.g., special transportation services or cooperation with local services to meet the mobility needs of seniors and children;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Walkability E2	Walkable access to use sites or building spaces enhances the overall level of support for walking trips in the area;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
	Spatial integration B2	Space form E3	Pay attention to the impact of spatial forms (clustered, centralized, linear, radial) on interactivity in cross-generational symbiosis, and try to adopt appropriate spatial forms;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Space type and location E4	Pay attention to the impact on interactivity of the type and location of the space in which Cross-generational communication occurs, and try to choose the right type and location of space;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Area dispersion E5	Pay attention to the impact of the area share of Cross-generational co-living space on interaction and communication, and try to choose the appropriate area share;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
	Environmental comfort B3	Visual Aesthetics E6	The intuitive feeling of the spatial environment (paying attention to the special characteristics of the elderly and children), including the use of materials close to nature, systematic and scientific signage, stable and diverse furniture, warm and pleasant colors, and predominantly warm tones;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Cultural belonging E7	Community, local historic and cultural environment and neighborhood belonging;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Natural Light Maximization E8	Maximize the use of natural light to enhance the physical and mental health of users;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Ergonomic design E9	Furniture, facilities and fixtures are designed with ergonomic requirements to reduce the risk of discomfort or injury;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
	Safety and health B4	Intelligent Integrated Safety System E10	Use smart technology to enhance safety, such as emergency call systems, intelligent security monitoring systems, etc;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Physical Health Promotion Programs and Facilities E11	Promote physical wellness through design, monitoring and facilities such as: additional fitness centers, yoga studios and meditation areas with wearable devices and health monitoring systems;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )

Target level (A)	Guideline layer (B)	Sub-criteria layer (E)	Qualitative and quantitative description	Scoring (very good (5), good (4), fair (3), poor (2) and very poor (1))
Cross-generational co-living space environment assessment	Safety and health B4	Mental Health Services E12	(c) Raise awareness of the mental health situation of people of all ages, and provide psychiatric counseling services tailored to different groups of the population;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		More natural exposure E13	Taking C15 a step further, the healing power of nature is better utilized by incorporating more natural elements into the design of indoor and outdoor spaces, and maximizing access to nearby natural environments when possible;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Environmental sustainability E14	Use of environmentally friendly materials to reduce energy consumption and minimize the environmental carbon footprint of the space;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
	Participation and inclusion B5	Building social networks E15	Status of broadcast/publicity board/counter set-up, ways to notify users, building social media networks such as WeChat Groups and Community Houses;	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )
		Cross-generational Exchange Programs and Activities E16	Organization of activities aimed at promoting Cross-generational interaction and mutual learning, e.g., teaching smart devices, caretaking, etc.	5 ( ) 4 ( ) 3 ( ) 2 ( ) 1 ( )

Appendix 9 Case Improvement Item Scoring Summary

case (law)	Sub-criteria layer (E)	Very good (5)	Better (4)	General (3)	Worse (2)	Very poor (1)
SHYP01	Customized Travel Solutions E1	0	0	2	3	0
	Walkability E2	5	0	0	0	0
	Space form E3	2	3	0	0	0
	Space type and location E4	0	0	3	2	0
	Area dispersion E5	0	0	3	2	0
	Visual Aesthetics E6	5	0	0	0	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	2	3	0	0	0
	Ergonomic design E9	2	2	1	0	0
	Intelligent Integrated Safety System E10	0	1	4	0	0
	Physical Health Promotion Programs and Facilities E11	0	2	3	0	0
	Mental Health Services E12	0	5	0	0	0
	More natural exposure E13	0	2	3	0	0
	Environmental sustainability E14	1	4	0	0	0
	Building social networks E15	4	1	0	0	0
	Cross-generational Exchange Programs and Activities E16	1	4	0	0	0
SHYP02	Customized Travel Solutions E1	0	0	2	3	0
	Walkability E2	5	0	0	0	0
	Space form E3	0	0	1	3	1
	Space type and location E4	0	0	2	3	0
	Area dispersion E5	0	0	1	4	0
	Visual Aesthetics E6	0	4	1	0	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	0	1	3	1	0
	Ergonomic design E9	4	1	0	0	0
	Intelligent Integrated Safety System E10	0	0	3	2	0
	Physical Health Promotion Programs and Facilities E11	0	0	3	2	0
	Mental Health Services E12	5	0	0	0	0
	More natural exposure E13	0	4	1	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	4	1	0	0	0
	Cross-generational Exchange Programs and Activities E16	1	4	0	0	0
SHYP03	Customized Travel Solutions E1	0	0	1	4	0
	Walkability E2	0	0	0	5	0
	Space form E3	0	0	0	1	4
	Space type and location E4	0	0	2	2	1
	Area dispersion E5	0	1	0	4	0
	Visual Aesthetics E6	0	0	2	3	0
	Cultural belonging E7	0	4	1	0	0
	Natural Light Maximization E8	0	1	3	1	0
	Ergonomic design E9	0	2	3	0	0
	Intelligent Integrated Safety System E10	0	0	4	0	1
	Physical Health Promotion Programs and Facilities E11	0	0	4	1	0
	Mental Health Services E12	0	0	4	1	0
	More natural exposure E13	0	1	3	1	0
	Environmental sustainability E14	0	1	2	2	0
	Building social networks E15	0	1	2	2	0
	Cross-generational Exchange Programs and Activities E16	1	2	1	1	0

SHYP04	Customized Travel Solutions E1	0	0	0	5	0
	Walkability E2	0	1	4	0	0
	Space form E3	4	1	0	0	0
	Space type and location E4	4	1	0	0	0
	Area dispersion E5	0	1	3	1	0
	Visual Aesthetics E6	0	2	3	0	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	0	1	3	1	0
	Ergonomic design E9	0	3	2	0	0
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	0	3	2	0	0
	Mental Health Services E12	0	0	4	1	0
	More natural exposure E13	0	1	4	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	2	3	0	0	0
	Cross-generational Exchange Programs and Activities E16	0	3	2	0	0
SHYP05	Customized Travel Solutions E1	0	1	1	3	0
	Walkability E2	0	3	1	1	0
	Space form E3	0	0	1	3	1
	Space type and location E4	0	0	0	5	0
	Area dispersion E5	0	3	1	1	0
	Visual Aesthetics E6	4	1	0	0	0
	Cultural belonging E7	4	0	1	0	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	3	2	0	0
	Intelligent Integrated Safety System E10	0	4	1	0	0
	Physical Health Promotion Programs and Facilities E11	4	1	0	0	0
	Mental Health Services E12	4	0	1	0	0
	More natural exposure E13	0	4	0	1	1
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	5	0	0	0	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0
SHHK01	Customized Travel Solutions E1	0	0	4	1	0
	Walkability E2	0	3	2	0	0
	Space form E3	0	0	5	0	0
	Space type and location E4	0	0	0	4	1
	Area dispersion E5	0	0	1	4	0
	Visual Aesthetics E6	5	0	0	0	0
	Cultural belonging E7	2	3	0	0	0
	Natural Light Maximization E8	3	2	0	0	0
	Ergonomic design E9	5	0	0	0	0
	Intelligent Integrated Safety System E10	2	3	0	0	0
	Physical Health Promotion Programs and Facilities E11	0	1	4	0	0
	Mental Health Services E12	0	4	1	0	0
	More natural exposure E13	0	1	3	1	0
	Environmental sustainability E14	0	4	0	1	0
	Building social networks E15	5	0	0	0	0
	Cross-generational Exchange Programs and Activities E16	4	1	0	0	0

SHHK02	Customized Travel Solutions E1	0	0	1	4	0
	Walkability E2	0	4	1	0	0
	Space form E3	0	0	1	3	1
	Space type and location E4	0	1	3	1	0
	Area dispersion E5	0	2	3	0	0
	Visual Aesthetics E6	0	3	2	0	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	0	1	3	1	0
	Ergonomic design E9	0	1	3	0	1
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	4	1	0	0	0
	Mental Health Services E12	4	1	0	0	0
	More natural exposure E13	0	1	3	1	0
	Environmental sustainability E14	0	3	2	0	0
	Building social networks E15	5	0	0	0	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0
SHHK03	Customized Travel Solutions E1	0	3	2	0	0
	Walkability E2	4	0	1	0	0
	Space form E3	0	0	2	2	1
	Space type and location E4	0	0	2	2	1
	Area dispersion E5	0	4	1	0	0
	Visual Aesthetics E6	0	1	3	1	0
	Cultural belonging E7	0	0	4	1	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	1	3	1	0
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	5	0	0	0	0
	Mental Health Services E12	1	1	3	0	0
	More natural exposure E13	0	0	5	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	4	1	0	0
	Cross-generational Exchange Programs and Activities E16	4	0	1	0	0
SHJA01	Customized Travel Solutions E1	0	4	1	0	0
	Walkability E2	4	1	0	0	0
	Space form E3	0	0	1	4	0
	Space type and location E4	0	1	0	4	0
	Area dispersion E5	0	4	1	0	0
	Visual Aesthetics E6	0	4	0	1	0
	Cultural belonging E7	4	0	1	0	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	4	0	1	0
	Intelligent Integrated Safety System E10	0	4	0	1	0
	Physical Health Promotion Programs and Facilities E11	4	1	0	0	0
	Mental Health Services E12	0	1	3	1	0
	More natural exposure E13	0	1	3	1	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	4	1	0	0	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0

SHHP01	Customized Travel Solutions E1	0	4	1	0	0
	Walkability E2	4	0	1	0	0
	Space form E3	0	1	1	3	0
	Space type and location E4	0	1	1	2	1
	Area dispersion E5	0	0	1	3	1
	Visual Aesthetics E6	4	0	1	0	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	4	0	1	0
	Intelligent Integrated Safety System E10	0	4	0	1	0
	Physical Health Promotion Programs and Facilities E11	4	0	1	0	0
	Mental Health Services E12	0	4	1	0	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	5	0	0	0	0
	Cross-generational Exchange Programs and Activities E16	4	1	0	0	0
SHPD01	Customized Travel Solutions E1	0	1	3	1	0
	Walkability E2	5	0	0	0	0
	Space form E3	4	1	0	0	0
	Space type and location E4	1	3	1	0	0
	Area dispersion E5	4	1	0	0	0
	Visual Aesthetics E6	4	0	1	0	0
	Cultural belonging E7	0	4	0	1	0
	Natural Light Maximization E8	5	0	0	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	4	1	0	0
	Physical Health Promotion Programs and Facilities E11	4	1	0	0	0
	Mental Health Services E12	0	4	1	0	0
	More natural exposure E13	5	0	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	4	1	0	0	0
	Cross-generational Exchange Programs and Activities E16	5	0	0	0	0
SHBS01	Customized Travel Solutions E1	0	0	2	3	0
	Walkability E2	0	0	4	1	0
	Space form E3	0	0	1	4	0
	Space type and location E4	0	1	3	1	0
	Area dispersion E5	5	0	0	0	0
	Visual Aesthetics E6	0	4	1	0	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	4	1	0	0
	Physical Health Promotion Programs and Facilities E11	5	0	0	0	0
	Mental Health Services E12	0	3	1	1	0
	More natural exposure E13	0	1	4	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	5	0	0	0	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0

SHBS02	Customized Travel Solutions E1	0	0	1	3	1
	Walkability E2	0	4	1	0	0
	Space form E3	0	1	1	2	1
	Space type and location E4	0	1	0	3	1
	Area dispersion E5	0	1	3	1	0
	Visual Aesthetics E6	0	1	3	1	0
	Cultural belonging E7	0	0	1	3	1
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	2	2	1	0
	Intelligent Integrated Safety System E10	0	0	1	4	0
	Physical Health Promotion Programs and Facilities E11	0	0	1	4	0
	Mental Health Services E12	0	0	1	4	0
	More natural exposure E13	0	4	1	0	0
	Environmental sustainability E14	0	1	4	0	0
	Building social networks E15	0	4	1	0	0
	Cross-generational Exchange Programs and Activities E16	0	0	2	2	1
FIQ101	Customized Travel Solutions E1	0	0	2	2	1
	Walkability E2	0	1	3	1	0
	Space form E3	0	0	1	3	1
	Space type and location E4	0	0	0	1	4
	Area dispersion E5	0	0	0	0	5
	Visual Aesthetics E6	0	4	1	0	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	0	1	3	1	0
	Ergonomic design E9	4	1	0	0	0
	Intelligent Integrated Safety System E10	4	1	0	0	0
	Physical Health Promotion Programs and Facilities E11	0	1	3	1	0
	Mental Health Services E12	0	1	3	1	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	2	2	1	0
	Cross-generational Exchange Programs and Activities E16	0	2	2	1	0
FIQ102	Customized Travel Solutions E1	0	1	3	1	0
	Walkability E2	0	1	3	1	0
	Space form E3	0	0	1	4	0
	Space type and location E4	0	0	1	4	0
	Area dispersion E5	0	0	0	2	3
	Visual Aesthetics E6	0	0	1	4	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	0	1	3	1	0
	Mental Health Services E12	0	4	1	0	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	1	4	0	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0

FIQ103	Customized Travel Solutions E1	0	1	1	3	0
	Walkability E2	0	4	1	0	0
	Space form E3	0	0	1	4	0
	Space type and location E4	0	0	2	2	1
	Area dispersion E5	0	0	0	2	3
	Visual Aesthetics E6	0	4	1	0	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	4	1	0	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	4	1	0	0
	Physical Health Promotion Programs and Facilities E11	0	1	3	1	0
	Mental Health Services E12	0	2	3	0	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	1	3	1	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0
FIQ201	Customized Travel Solutions E1	0	0	1	4	0
	Walkability E2	0	0	5	0	0
	Space form E3	4	1	0	0	0
	Space type and location E4	5	0	0	0	0
	Area dispersion E5	4	1	0	0	0
	Visual Aesthetics E6	3	2	0	0	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	4	1	0	0	0
	Ergonomic design E9	0	1	3	1	0
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	0	0	1	4	0
	Mental Health Services E12	0	0	1	3	1
	More natural exposure E13	0	4	1	0	0
	Environmental sustainability E14	0	3	2	0	0
	Building social networks E15	0	1	3	1	0
	Cross-generational Exchange Programs and Activities E16	0	0	1	4	0
FIQ202	Customized Travel Solutions E1	0	4	1	0	0
	Walkability E2	0	4	1	0	0
	Space form E3	0	0	1	3	1
	Space type and location E4	4	1	0	0	0
	Area dispersion E5	0	4	1	0	0
	Visual Aesthetics E6	0	1	3	1	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	4	1	0	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	0	2	2	1	0
	Mental Health Services E12	0	4	1	0	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	1	3	1	0
	Cross-generational Exchange Programs and Activities E16	0	0	1	4	0

FIQ301	Customized Travel Solutions E1	0	1	3	1	0
	Walkability E2	0	2	2	1	0
	Space form E3	0	2	2	1	0
	Space type and location E4	0	4	1	0	0
	Area dispersion E5	0	4	1	0	0
	Visual Aesthetics E6	0	1	3	1	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	0	1	4	0	0
	Ergonomic design E9	0	1	4	0	0
	Intelligent Integrated Safety System E10	0	4	1	0	0
	Physical Health Promotion Programs and Facilities E11	0	0	1	4	0
	Mental Health Services E12	4	1	0	0	0
	More natural exposure E13	0	1	3	1	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	1	3	1	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0
FIQ401	Customized Travel Solutions E1	0	1	1	2	1
	Walkability E2	4	1	0	0	0
	Space form E3	4	1	0	0	0
	Space type and location E4	5	0	0	0	0
	Area dispersion E5	4	1	0	0	0
	Visual Aesthetics E6	0	1	3	1	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	5	0	0	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	1	4	0	0
	Physical Health Promotion Programs and Facilities E11	0	1	4	0	0
	Mental Health Services E12	0	4	1	0	0
	More natural exposure E13	5	0	0	0	0
	Environmental sustainability E14	4	1	0	0	0
	Building social networks E15	1	3	0	1	0
	Cross-generational Exchange Programs and Activities E16	4	1	0	0	0
FIQ501	Customized Travel Solutions E1	4	1	0	0	0
	Walkability E2	5	0	0	0	0
	Space form E3	0	2	2	1	0
	Space type and location E4	0	2	2	1	0
	Area dispersion E5	5	0	0	0	0
	Visual Aesthetics E6	1	4	0	0	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	1	4	0	0	0
	Ergonomic design E9	2	3	0	0	0
	Intelligent Integrated Safety System E10	1	3	1	0	0
	Physical Health Promotion Programs and Facilities E11	1	2	2	0	0
	Mental Health Services E12	4	1	0	0	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	1	2	2	0	0
	Building social networks E15	1	3	1	0	0
	Cross-generational Exchange Programs and Activities E16	5	0	0	0	0

FIQ502	Customized Travel Solutions E1	0	0	1	4	0
	Walkability E2	0	1	3	1	0
	Space form E3	0	0	1	4	0
	Space type and location E4	4	1	0	0	0
	Area dispersion E5	0	0	1	4	0
	Visual Aesthetics E6	0	4	1	0	0
	Cultural belonging E7	0	4	1	0	0
	Natural Light Maximization E8	4	1	0	0	0
	Ergonomic design E9	4	1	0	0	0
	Intelligent Integrated Safety System E10	0	4	1	0	0
	Physical Health Promotion Programs and Facilities E11	4	1	0	0	0
	Mental Health Services E12	4	1	0	0	0
	More natural exposure E13	5	0	0	0	0
	Environmental sustainability E14	4	1	0	0	0
	Building social networks E15	0	2	3	0	0
	Cross-generational Exchange Programs and Activities E16	0	4	1	0	0
FIQ503	Customized Travel Solutions E1	0	4	1	0	0
	Walkability E2	0	1	4	0	0
	Space form E3	4	1	0	0	0
	Space type and location E4	0	2	3	0	0
	Area dispersion E5	0	1	4	0	0
	Visual Aesthetics E6	4	1	0	0	0
	Cultural belonging E7	5	0	0	0	0
	Natural Light Maximization E8	1	2	2	0	0
	Ergonomic design E9	0	2	3	0	0
	Intelligent Integrated Safety System E10	0	3	2	0	0
	Physical Health Promotion Programs and Facilities E11	0	4	1	0	0
	Mental Health Services E12	4	1	0	0	0
	More natural exposure E13	4	1	0	0	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	4	1	0	0	0
	Cross-generational Exchange Programs and Activities E16	5	0	0	0	0
FIQ505	Customized Travel Solutions E1	0	0	1	4	0
	Walkability E2	0	1	3	1	0
	Space form E3	0	0	1	4	0
	Space type and location E4	0	0	1	4	0
	Area dispersion E5	0	0	1	3	1
	Visual Aesthetics E6	0	4	1	0	0
	Cultural belonging E7	4	1	0	0	0
	Natural Light Maximization E8	0	4	1	0	0
	Ergonomic design E9	0	4	1	0	0
	Intelligent Integrated Safety System E10	0	1	3	1	0
	Physical Health Promotion Programs and Facilities E11	0	4	1	0	0
	Mental Health Services E12	0	1	3	1	0
	More natural exposure E13	0	1	3	1	0
	Environmental sustainability E14	0	4	1	0	0
	Building social networks E15	0	2	1	2	0
	Cross-generational Exchange Programs and Activities E16	4	1	0	0	0

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