

Article

The Moderating Effect of Social Participation on the Relationship between Urban Green Space and the Mental Health of Older Adults: A Case Study in China

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Abstract: China is experiencing unprecedented urbanization and aging. Previous studies mostly ignored the internal mechanism of the effect of urban green space on the mental health of older adults. Consequently, the relationship between social participation in urban green spaces and mental health remains uncertain. Therefore, this study explored the impact of urban green spaces, social participation, and other factors on the mental health of older adults and investigated the mechanisms of these effects. This study used linear regression models and conducted a moderating effect analysis using data from the 2018 China Labor Dynamics Survey, comprising 3501 older adults in 146 cities in China. Furthermore, we analyzed differences between solitary and non-solitary older adults. The results indicated that urban green space, road density, physical health, history of hospitalization, subjective well-being, and economic satisfaction significantly affected mental health. Social participation played a significant positive moderating role in the connection between green spaces and mental health among older adults. For solitary older adults, social participation weakened the positive impact of green spaces on mental health; for non-solitary older adults, social participation enhanced the positive impact of green spaces on mental health. These findings could contribute to the future construction of aging-friendly cities in China and help optimize urban construction and strategies for building healthy environments.

Keywords: urban green space; mental health; social participation; solitary older adults; China



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1. Introduction

In recent years, the proportion of China's elderly population has been increasing substantially and is predicted to become a major issue for Chinese society in the future. At the end of 2019, China's population aged 60 years and above reached 253.88 million, accounting for 18.1% of the total population [1]. Environmental and social problems, such as overcrowded housing, deteriorating living conditions, and ecological damage, are prominent due to the aging population and rapid social changes [2]. This can adversely affect the mental health of older adults [3]. Older adults are prone to depression, loneliness, and other psychological problems [4]. Urban green space is a scarce resource that can improve mental health and reduce the negative impact of the 'urban disease' [5,6]. In 2016, the World Health Organization (WHO) introduced the concept of healthy aging, stressing the need to support the urban environment to improve the health status of the aging population, and advocated for the development and maintenance of the functioning required for healthy aging [7]. The 13th Five-Year Plan for Healthy Aging and Healthy

China 2030 proposed the construction of a healthy and liveable environment for older people [8]. Therefore, analyzing the influences of urban green space on the mental health of older adults is important for optimizing urban construction and implementing strategies for creating a healthy environment.

In recent years, the influence and mechanisms of the urban environment on the mental health of older adults have received increasing attention in the fields of geography, sociology, and urban planning. Macro-level factors, such as environmental pollution and healthcare, have significantly impacted the mental health of older adults [9]. At the meso- and micro-levels, built and social environmental factors, such as urban blue and green spaces, community green spaces, building design, neighborhoods, social networks, and social participation, affect mental health [10–13]. Green spaces are daily life locations that can relieve environmental pressure and create a positive urban environment for older adults [14]. Moreover, green spaces can improve the mental health of older adults by relieving stress and promoting social interaction [5,6]. Studies have demonstrated the mediating role of stress relief in green spaces and mental health; however, consensus regarding the effects of physical activity and social interaction is lacking [15]. Home et al. suggested that green space use could improve the mental health of older adults by promoting social interactions [16]. Maas et al. found that a lack of social support mediated this association, whereas social cohesion and interaction with friends and neighbors did not [17]. Sugiyama et al. found that recreational walking and social cohesion only partially explained the relationship between neighborhood greenness and mental health [18]. In addition to the built environment, social participation factors related to the social environment not only had a direct positive impact on the mental health of older adults [19,20] but also mediated the relationship between green spaces and mental health [21]. In this sense, urban green spaces can be regarded as ‘spaces of encounter’ [22], which are important for older adults’ social participation and social connections and thus improve their mental health [23]. China is experiencing unprecedented urbanization and aging. Most studies in China have analyzed green spaces as an indicator of built environment factors; however, few studies have examined the influence of urban green space on the mental health of older adults and the moderating effects of social environmental factors, such as social participation, on this relationship.

There has been a gradual increase in research on urban green spaces and the mental health of older adults. Nevertheless, research in China has three deficiencies compared to that in other countries. First, previous studies mostly ignored the internal mechanism of the effect of urban green space on the mental health of older adults. Second, research on the impact of green space on the mental health of older adults focuses mainly on the materiality of public space, neglecting the key roles of sociality, such as social participation. Moreover, studies lack comprehensive investigations of the relationships between these three factors and their internal mechanisms. Third, most studies on mental health have focused on the general population, whereas research on older adults, particularly on the heterogeneity among vulnerable groups (e.g., solitary vs. non-solitary older adults), is scarce.

Therefore, to help fill the gaps in the introduction mentioned above, we proposed a framework (Figure 1). This study investigated the moderating effect of social participation on the relationship between urban green space and mental health and the differences between solitary and non-solitary older adults. This study aimed to provide a reference and scientific basis for community development and management and public policy construction. This study sought to help create communities for healthy aging and aging-friendly cities in China by optimizing urban construction and implementing healthy environmental construction strategies. This research proposed the following hypotheses:

Hypothesis 1: *Green spaces directly enhance the mental health of older adults.*

Hypothesis 2: *Social participation has a moderating effect on the relationship between green spaces and the mental health of older adults.*

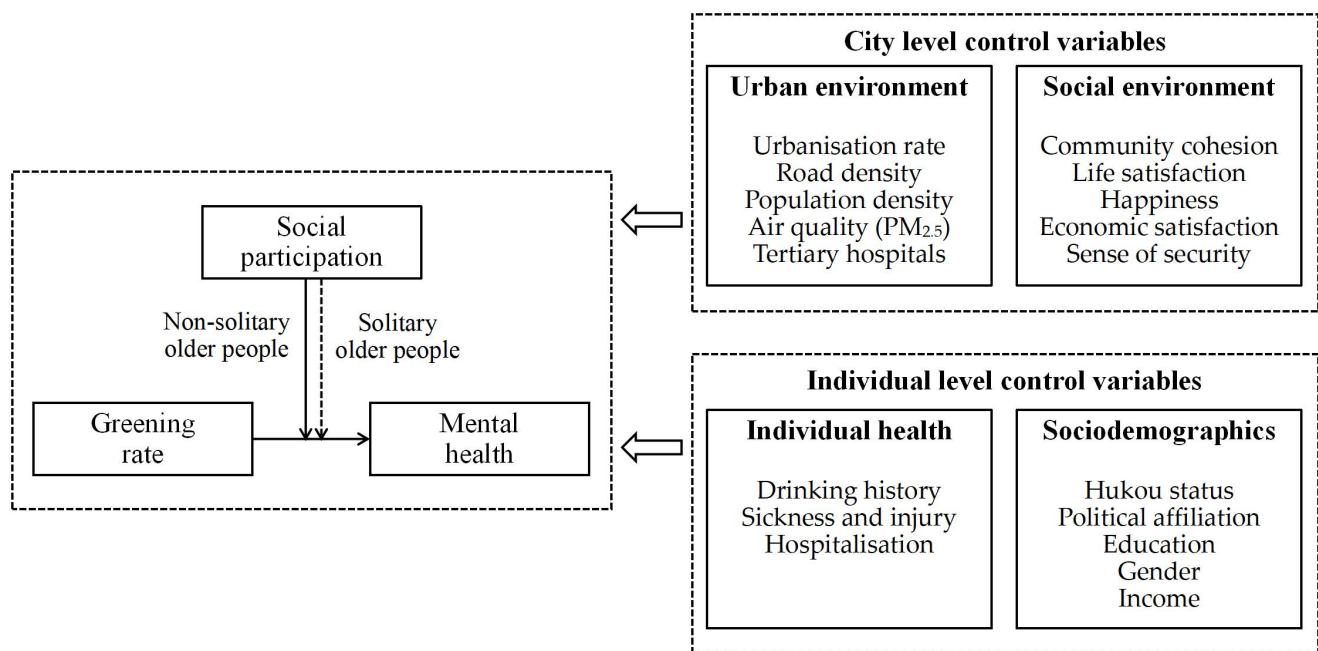


Figure 1. Conceptual framework.

2. Literature Review

2.1. Mental Health and Its Measurements

The concept of mental health originated with William Sweetser, who pioneered the term ‘mental hygiene’. Subsequently, mental health has been described and studied in various disciplines, such as psychology, sociology, and geography. Maslow and Mittleman proposed 10 criteria for mental health: a full sense of security, a full understanding of oneself, realistic life goals, contact with the external environment, maintaining the integrity and harmony of personality, the ability to learn from experience, good interpersonal relationships, moderate emotional expression and control, limited personality development, and moderately meeting the basic needs of individuals [24]. The definition provided at the Third International Conference on Mental Health in 1946 stated that mental health refers not only to the absence of mental diseases and good social adaptation but also to the perfection of the personality and full development of mental potential, as well as the best state of mind under certain objective conditions. Based on positive psychology, Gu et al. have considered the dual-factor model of mental health, which argues that mental health is a two-dimensional state of being and that the two necessary elements of individual health are assessed and diagnosed through positive (e.g., life satisfaction and subjective sense of well-being) and negative psychological indicators (e.g., depression, negative emotions, and sensitivity to relationships) [25]. This has given rise to new concepts and the theoretical foundation for the development of interventions and preventions for mental health disorders [26].

2.2. Influencing Factors

2.2.1. Urban Environmental Factors

Most studies on factors influencing the mental health of older adults have focused on the built and social environment dimensions and used the constructed environment to define and characterize the urban environment. Cervero et al. proposed that the built environment consists of three dimensions (3Ds): density, diversity, and design [23,24]. This was later expanded to five dimensions (5Ds): density, diversity, design, accessibility to public transportation, and accessibility to destinations [27,28]. Barnett et al. measured diversity using a land-use mix or diversity of activity sites [29]. Chen et al. measured destination accessibility using the density of recreational facilities and the number of parks,

and they measured design using the number of junctions [30]. Thus, the 5D framework is a widely used indicator system in measuring urban environments.

Studies have explored the influence of the built environment on mental health from the microscale of architectural design to the urban scale; however, they have mainly focused on a small scale. For instance, PM_{2.5} is significantly positively correlated with depression and anxiety symptoms in older adults and has a stronger correlation with individuals with lower socioeconomic status [31]. Good-quality housing and neighborhoods can help improve the mental health of older adults [32]. Moreover, older adults living in neighborhoods with better access to amenities, such as healthcare, have higher levels of perceived health [33,34]. Additionally, previous studies have found that urban greenways and parks improve older adults' mental health [35,36]. Furthermore, blue–green spaces in cities have a significant positive effect on the mental health of older adults [11].

Urban green spaces are an important component of the urban environment and significant for improving the mental health of older adults. They can create a good urban living environment and improve the mental health of older adults through three paths: (1) relieving environmental stress, such as noise and air pollution; (2) relieving stress and restoring energy; and (3) promoting physical activity and social interaction [37–39]. For instance, the mental health of older adults can be improved by being in green environments, which helps them feel less stressed and mentally exhausted [35]. Green spaces are crucial for social connection, which enhances quality of life by encouraging physical exercise and social activities, thereby improving mental health [18]. Urban green space not only provides a place for older adults to participate in daily social activities but also helps older adults walk, exercise [40], and actively participate in gardening activities [41], improving their mental health. Moreover, many studies have focused on the positive effects of factors such as the visitation frequency [42], quality [43], type [44], and accessibility [6] of green spaces on mental health.

2.2.2. Social Environment Influencing Factors

The activity theory suggests that successful aging requires the continuation of interests and activities from mid-adulthood and the prevention of reductions in the number and type of social interactions [45], emphasizing the importance of social participation. Extensive evidence indicates that social participation can produce positive health outcomes in the mental health of older adults [20,46]. Previous studies have shown that social participation improves the mental health of older adults by encouraging physical exercise [47], encouraging positive health and medical choices [48], maintaining a positive psychological state [49], and reducing stress [50]. For instance, social participation can improve the mental health and subjective well-being of older adults by fostering larger social networks, boosting social support, and reducing life pressure and stress [49,51]. Social interaction can enhance the social integration of older adults, suppress social isolation, and reduce their inner social exclusion, thus impacting their mental health [52].

The continuity theory proposes that people only need to maintain their required frequency of social participation to obtain an optimal effect on their physical and mental health, suggesting that the influence of social participation should be viewed dialectically [53]. This theory emphasizes the autonomy and moderate frequency of an individual's social interactions, rather than a sustained increase in the number of interactions [19]. Moreover, prior studies have suggested that frequent social participation does not always have a positive health effect on older adults. Takeuchi et al. showed that frequent participation in sports groups and hobby clubs was associated with better dental health; however, infrequent participation in neighborhood community associations was significantly correlated with improved dental health [54]. Min et al. argued that participation in religious services increased the risk of depressive symptoms, and the positive effects of attending social gatherings were limited to older adults with good mental health, with no effect on older adults with pre-existing depressive symptoms [55].

2.3. Research on Older Adults

Studies have examined the factors affecting the mental health of older adults. Roberts et al. analyzed these factors from three aspects: physical, psychological, and social resources [56]. Chou et al. used the socioemotional selectivity theory as a framework to analyze these factors considering social support and relationships [57]. Many studies have examined the impact of differences in personal characteristics on the mental health of older adults, mainly in the areas of family and social support, educational level, and marital status. Baune et al. reported that older adults with high levels of education were generally engaged in mental work and better at finding social support when they encountered physical and mental problems than those with low levels of education; thus, they are able to maintain a good emotional state [58]. Bennetto et al. suggested that intergenerational support provided by children, particularly emotional support, reduces psychological symptoms, such as loneliness and depression, among older adults [59]. Studies have revealed a strong association between intact family relationships and the emotional and mental health of older adults [60]. Significant differences were found in the mental health of solitary older adults (unmarried, widowed, divorced) [61,62]. However, older adults in a Chinese community exhibited no differences in well-being, including happiness and health, between those who lived with their families and those who lived alone [63].

China's rapid urbanization, longstanding family planning policies, declining fertility levels, and a significant rise in divorce rates have driven changes in family structures and housing patterns [64,65]. Children increasingly leave their parents' homes and live independently after starting a family. The divorce of parents or death of a spouse after a child has left the family creates an older, one-person family. Moreover, China's large-scale urban–rural population mobility has led to a continuous increase in the proportion of older families left behind in rural areas [66]. The scale of poverty-nesting and solitary older adults is constantly expanding [66]. As their health and financial capacity decline, solitary older individuals may become more vulnerable to depression, anxiety, and other problems [61]. Therefore, the heterogeneity of mental health among solitary and non-solitary older adults in China should be examined to optimize urban construction and implement healthy aging strategies.

3. Materials and Methods

3.1. Data Sources

The data were obtained from the 2018 China Labor Dynamics Survey (CLDS), a nationally representative large-scale labor force dynamics-tracking survey designed and implemented by the Centre for Social Science Research at Sun Yat-sen University. The CLDS includes questionnaires at three levels: individual, household, and community. In terms of sampling method, the CLDS adopted a multi-stage, multi-level, proportional probability sampling method to ensure the randomness and scientificity of sample selection. The 2018 CLDS database includes data collected from 28 provinces in China, excluding Hong Kong, Macao, Taiwan, Tibet, Hainan, and Xinjiang. It encompasses a comprehensive dataset featuring information from 368 communities, 13,501 households, and 16,537 individual members of the labor force.

The common definition of older people is 60 or 65 years old and above [67,68]. However, the differences in retirement age between men and women in China are not taken into account. The delayed retirement policy has also been raised and discussed, so the current definition of the elderly cannot reflect the actual situation. Therefore, this study defines older people as males aged 65 and above and females aged 60 and above. To ensure data quality and relevance, we applied a filter to exclude cities with fewer than ten samples from the CLDS 2018 database. This filtering process resulted in a final dataset comprising 3501 valid samples from 146 Chinese cities (Figure 2).



Figure 2. Locations of selected cities.

We utilized city-scale geographic data to obtain urban environmental characteristic variables, including greening rate, urbanization rate, air quality ($\text{PM}_{2.5}$), road density, tertiary hospitals, and population density. The greening rate, population density, urbanization rate, road density, and tertiary hospitals were derived from the 2018 China Urban Statistical Yearbook [69]. The greening rate was measured by the proportion of the green coverage area of urban built-up areas to the total area of built-up areas, in which green space includes public green, residential, affiliated, protected, production, and roadside green spaces as well as scenic forest areas. The calculation method of population density in this study is population per unit of land area, and each city is given its corresponding value. For example, 1312.61 persons/ km^2 in Beijing, 3823.3 persons/ km^2 in Shanghai, and 2004.78 persons/ km^2 in Guangzhou. Urbanization rate was defined as the proportion of resident urban population to total resident population. Air quality data were obtained from the atmospheric composition analysis group of Washington University in St. Louis [70], with the annual mean $\text{PM}_{2.5}$ extracted for each city. The measurement methods for variables are described in Supplementary File S1.

Table 1 shows the sociodemographic characteristics of the total sample and two sub-samples (solitary and non-solitary older adults). The 2017 China Demographic Statistical Yearbook estimated that the man to woman ratio among senior citizens was approximately 4:6; therefore, the total sample data used in this study was representative. In view of the

classification of ‘Solitary’ [71], this study defined the elderly who are unmarried, separated, divorced, or widowed as solitary older people, and the elderly who are married, remarried, or cohabited as non-solitary older people. Hukou referred to whether the resident’s household registration place was the same as their living place. Second, the differences in the characteristics of solitary and non-solitary older adults were compared. The proportions of Communist Party of China (CPC) members and education level of solitary older adults were lower than those of non-solitary older adults.

Table 1. Participants’ sociodemographic characteristics.

Characteristic	Total	Non-Solitary	Solitary
Total number	3501	3199	302
Mean age (years)	67.72	67.55	69.5
Sex (%)			
Male	40.7	40.7	40.7
Female	59.3	59.3	59.3
CPC membership (%)			
Member	6.8	6.8	6.6
Non-member	93.2	93.2	93.4
Hukou (%)			
Local	94.9	94.8	95.7
Non-local	5.1	5.2	4.3
Education (%)			
Primary school or below	61.2	60.9	64.6
Junior high school	23.5	23.9	18.5
High school	13.2	13	14.9
College or above	2.1	2.1	2
Income (%)			
0–50,000	56	55	56.8
50,000–100,000	4.4	3	4.5
100,000–200,000	0.2	0.7	0.2
200,000 or above	38.7	41.3	38.5

3.2. Variables and Measurement

3.2.1. Dependent Variables

This study used the Depression Self-Assessment Scale (CES-D20) presented by Qiu et al. [72] to measure mental health. The Kaiser–Meyer–Olkin (KMO) value of the scale in this study was 0.934, with a significant Bartlett’s test of sphericity. Five of the twenty items on the mental health scale were daily behaviors that indicated poor mental states, and fifteen of the items were frequent negative emotions that could have happened in the previous week. The scale uses a 4-point reverse scoring system (1 = almost always, 5–7 days per week; 2 = often, 3–4 days per week; 3 = rarely, 1–2 days per week; and 4 = almost never, less than one day per week). Higher scores on the overall scale, which range from 20 to 80, indicate that older adults’ mental health has improved over the previous week. Cronbach’s α of the mental health subscale was 0.939, indicating the reliability of the research questionnaire (Supplementary File S2).

3.2.2. Independent Variable

Drawing on existing studies that have used the green space proportion to measure urban green space [73], this study employed the built-up regions’ green space coverage rate as an indicator to quantify urban green space. This is a highly accessible and commonly used greening exposure indicator. The greenspace coverage rate of built-up areas was obtained from the 2018 China Urban Statistical Yearbook. Due to the random processing of the community in the questionnaire, this questionnaire could not locate the community of each respondent, only the city information related to each respondent, so we could not study the accessibility of green space. This study gave respondents corresponding values according to the green space coverage rate of each city.

3.2.3. Moderating Variable

According to the activity theory, the participation of older adults in social activities can reduce the negative effects of role loss and ensure their vitality and enthusiasm at psychological and social levels [74]. Participating in favorable social activities can promote mental health [75]. However, heterogeneity in the effect of green space on mental health needs to be explored at different levels of social participation (high and low frequency). Drawing on existing studies that have used social participation as a moderating variable [25], the data on social participation in this study were obtained using the following question from the 2018 CLDS: ‘How often did you participate in the activities of this organization in the past year?’. The question included categories of recreation and art groups, physical exercise groups, senior citizen associations, skill correspondence groups (e.g., cooking), knowledge learning groups (e.g., book clubs), volunteer groups (e.g., social workers, volunteers), and religious groups. Scores for the frequency of social participation were rated on a 5-point Likert scale (1 = never; 5 = daily). Higher scores indicated that older adults had been socially engaged more frequently in the past year. The Cronbach’s α of frequency of social participation was 0.827, indicating that the questionnaire had good reliability (Supplementary File S2).

3.2.4. Control Variables

The control variables in this study were built environment, social environment, sociodemographic characteristics, and individual health characteristics.

In the health city model (HCM), Sarkar et al. revealed that built environments can directly or indirectly affect mental health in multiple ways [76]. Growth of the built environment in the city was measured using three main indicators: urbanization rate, road network density, and population density. These indicators are connected to the quality of living standards of the older population. Due to the vulnerability of older adults to negative consequences of urban challenges, such as environmental pollution, their physical and emotional well-being is compromised. The number of urban tertiary hospitals in 2018 and air quality (PM_{2.5}) were selected as indicators.

Regarding social environment characteristics, this study analyzed the impact of social environment factors on the mental health of older adults, focusing on three dimensions: subjective well-being, community cohesion, and residential security. Zhang et al. noted that mental health is affected by the subjective and objective social environment [77], emphasizing the importance of analyzing features of the social environment in mental health research. Subjective well-being is an individual’s comprehensive judgment of their overall life situation, which reflects their self-perceived health to a certain extent [78]. While the community is a place of daily life for older adults, good community cohesion [79] and a sense of residential security [80] are important factors affecting their mental health. We used three dimensions to measure the psychological well-being of older adults in terms of social environment characteristics: ‘Do you think you are living a happy life?’, ‘Are you satisfied with your living situation?’, and ‘Are you satisfied with your family’s economic situation?’. Responses were rated on a 5-point Likert scale (1 = very dissatisfied; 5 = very satisfied). Higher scores indicated higher subjective well-being in older adults. Drawing on Maas et al. [17], this study used neighborhood familiarity, trust, and mutual assistance to construct community cohesion indicators. We inquired, ‘What is the degree of familiarity between you and the neighbors, neighborhoods and other residents of this community (village) with each other?’, ‘Do you trust the neighbors, neighborhoods and other residents of this community (village)?’, ‘Do you have mutual assistance with the neighbors, neighborhoods and other residents of this community (village)?’, ‘Do you trust your neighbors, neighborhoods and other residents in your community (village)?’, and ‘Do you and your neighbors, neighborhoods and other residents in your community (village) help each other?’. The answers were rated on a five-point Likert scale, with higher scores indicating a higher level of community cohesion among older adults. The Cronbach’s α of the community cohesion scale was 0.763, indicating that the questionnaire had good

reliability (Supplementary File S2). Furthermore, this study considered existing measures of residential safety [81,82] and critically revised the scale according to the protocol used. The Cronbach's α of the scale in this study was 0.825. The scale included five items on the risk of encountering relevant events in the community: 'hanging out and staying in', 'going out alone at night', 'not locking doors and windows and being burglarised', 'leaving money out and being targeted', and 'children being abducted and sold when they are out alone'. This scale was designed to measure older adults' sense of security. The scale was based on a reversed 5-point scale (1 = often; 5 = never). The overall scores ranged from 5 to 25, with higher values correlating with a greater perception of safety among older adults. Cronbach's α for the perceived residential safety scale was 0.825, indicating that the questionnaire had good reliability (Supplementary File S2).

Individual health characteristics, history of alcohol consumption, illness, injury, and hospitalization history were selected to measure the individual health characteristics. A history of alcohol consumption value of 1 indicated that older adults had no history of alcohol consumption. Due to the limitations of questionnaire questions, illness and injury among older adults were measured based on whether they had had an illness or injury in the past two weeks. A value of 1 indicated that the participant had had no illness or injury in the past two weeks. Additionally, a value of 1 for hospitalization history indicated that, since July 2017, the respondents did not have a physician diagnosis requiring hospitalization.

3.3. Research Methods

The study was analyzed in two steps. Firstly, linear regression equations and moderating effects were used to investigate the moderating effect of social participation in urban green spaces on the mental health of older adults. A variance inflation test was carried out and revealed no multicollinearity among explanatory variables. Second, we divided the sample into two groups (solitary and non-solitary older adults) and analyzed the heterogeneity of the moderating role played by social participation. All statistical analyses were performed using STATA 13.1.

3.3.1. Linear Regression Model

According to existing research [83], the urban environment, social environment, and individual characteristics determine the mental health of older adults. The indicator of mental health was a continuous variable. A linear regression model was used to measure the impact of the urban built environment and individual characteristics on the mental health of older adults and calculate the explanatory power of each variable regarding differences in the mental health of older adults. A random intercept model was used, as follows:

$$Y_{ij} = \alpha_1 + \eta X_j + \beta_1 Z_{ij} + \gamma_1 W_{ij} + \delta_1 S_{ij} + \varepsilon_1 N_{ij} + \mu_{1ij} + \theta_{1ij} + \lambda_{1ij} + v_{1ij} \quad (1)$$

where Y_{ij} is the mental health index of older adults in individual i in city j ; X_j is the green space rate in city j ; Z_{ij} is the sociodemographic characteristics variable of resident i in city j ; W_{ij} is the individual health characteristics variable of resident i in city j ; S_{ij} is the built environment variable of resident i in city j ; N_{ij} is the social environment variable of resident i in city j ; α_1 is the intercept; η is the effect of independent variable greening rate; β_1 , γ_1 , δ_1 , and ε_1 are the coefficients of sociodemographic characteristics, individual health, built environment, and social environment, respectively; μ_{1ij} is the residuals of sociodemographic characteristics; θ_{1ij} is the residuals of individual health characteristics; λ_{1ij} is the residuals of social environment characteristics; and v_{1ij} is the residuals of built environment characteristics.

3.3.2. Moderating Effect Analysis

This study explored the relationship between the proportion of urban green space, social participation, and mental health. According to the basic logic of the moderating effects analysis, M was a moderating variable if the relationship between variables Y and X

was a function of variable M , that is, the relationship between Y and X was affected by a third variable, M [84]. The moderating effect model is shown below:

$$Y_{ij} = \alpha_2 + \eta'X_j + \beta_2Z_{ij} + \gamma_2W_{ij} + \delta_2S_{ij} + \varepsilon_2N_{ij} + \tau O_{ij} + \eta''X_jO_{ij} + \mu_{2ij} + \theta_{2ij} + \lambda_{2ij} + v_{2ij} \quad (2)$$

where O_{ij} is the social participation of city j resident i , X_jO_{ij} is the interaction term between the moderating and independent variables (greening rate $\times$ social participation), and η'' is the effect of the interaction term.

4. Results

We conducted independent samples t -tests for all categories. As shown in Table 2, the results indicated that the score on the mental health scale exhibited statistically significant differences in the categories of sex ($T = 4.805$, $p = 0.000$), CPC membership ($T = 67.18$, $p = 0.000$), Hukou ($T = 6.431$, $p = 0.000$), marital status ($T = 2.187$, $p = 0.029$), sickness and injury status ($T = 9.812$, $p = 0.000$), hospitalization history ($T = 7.911$, $p = 0.000$), and history of alcohol consumption ($T = -2.481$, $p = 0.013$). Men had significantly higher scores than women ($M = 72.88$ vs. $M = 71.39$), indicating that men's mental health was significantly better. Regarding sickness and injury, hospitalization history, and history of alcohol consumption, the result revealed that good physical health had a significant positive effect on mental health. Specifically, the mean value of the mental health of solitary older adults was 70.71, which was lower than that of non-solitary older adults ($M = 72.12$), suggesting that solitary older adults had worse mental health than non-solitary adults [57].

Table 2. Results of the independent sample test.

Category		Mean Value	T-Value	p-Value
Sex	Male	72.88	4.805	0.000
	Female	71.39		
CPC membership	Member	75.04	6.718	0.000
	Non-member	71.77		
Hukou	Local	74.59	6.431	0.000
	Non-local	71.74		
Marital status	Non-solitary	72.12	2.187	0.029
	Solitary	70.71		
Sickness and injury status	No sickness or injury in the last two weeks	72.69	9.812	0.000
	Sickness and injury within the last two weeks	68.03		
Hospitalization history	No hospitalizations since July 2017	72.54	7.911	0.000
	Hospitalization since July 2017	68.7		
History of alcohol consumption	No history of alcohol consumption	71.81	−2.481	0.013
	History of alcohol consumption	72.79		

Table 3 depicts the factors influencing the mental health of older adults in the total sample. Model 1 used the random intercept model. The results indicated that the ratio of green land area had a significant positive effect on mental health (coefficient = 0.192, $p < 0.01$), supporting Hypothesis 1. Previous studies have shown that green land can improve mental health by purifying the air, relieving psychological stress, and promoting social integration. Green plants absorb air pollutants and eliminate noise. Moreover, green plants provide a feeling of comfort, relieve pressure, and reduce fatigue. Furthermore, green spaces provide open activity venues to promote sports and social activities among older adults [85].

Table 3. Moderating effects on the participants' mental health.

Variable	Model 1		Model 2	
	Coefficient (95% CI)	Standard Error	Coefficient (95% CI)	Standard Error
Urban environment				
Greening rate	0.192 *** (0.10, 0.27)	0.044	0.19 *** (0.10, 0.27)	0.044
Urbanization rate	−0.079 *** (−0.11, −0.04)	0.017	−0.08 *** (−0.11, −0.04)	0.017
Road density	2.714 *** (1.90, 3.52)	0.411	2.716 *** (1.91, 3.52)	0.411
Air quality (PM _{2.5})	0.023 (−0.00, 0.05)	0.015	0.023 (−0.00, 0.05)	0.015
Tertiary hospitals	0.057 *** (0.02, 0.08)	0.015	0.06 *** (0.03, 0.09)	0.016
Population density	−0.002 *** (−0.00, −0.00)	0.000	−0.002 *** (−0.00, −0.00)	0.000
Social environment				
Community cohesion	0.128 * (−0.00, 0.26)	0.07	0.126 * (−0.07, 1.00)	0.07
Life satisfaction	0.48 * (−0.06, 1.02)	0.276	0.463 * (0.59, 1.62)	0.276
Happiness	1.101 *** (0.58, 1.62)	0.265	1.109 *** (0.59, 1.62)	0.265
Economic satisfaction	1.268 *** (0.90, 1.62)	0.184	1.296 *** (0.93, 1.65)	0.185
Sense of security	0.324 *** (0.24, 0.40)	0.042	0.321 *** (0.23, 0.40)	0.042
Individual health				
History of alcohol consumption	−0.184 (−0.99, 0.62)	0.412	2.797 (−0.97, 0.64)	0.412
Sickness and injury	2.789 *** (1.95, 3.62)	0.424	2.797 *** (1.96, 3.62)	0.423
Hospitalization history	2.239 *** (1.39, 3.08)	0.429	2.261 *** (1.41, 3.10)	0.429
Sociodemographic characteristics				
Hukou	0.264 (−1.03, 1.56)	0.661	0.234 (−1.06, 1.53)	0.661
CPC membership	0.611 (−0.57, 1.81)	0.607	0.654 (−0.53, 1.84)	0.607
Sex	0.915 *** (0.24, 1.58)	0.343	0.905 *** (0.23, 1.57)	0.343
Marital status	0.817 (−0.19, 1.83)	0.517	0.815 (−0.19, 1.82)	0.517
Education	0.795 *** (0.39, 1.2)	0.207	0.814 *** (0.40, 1.22)	0.209
Income	0.324 *** (0.15, 0.48)	0.084	0.336 *** (0.17, 0.50)	0.085
Moderating variable				
Social participation			0.022 (−0.07, 0.12)	0.051
Interaction term				
Greening rate × social participation			0.034 ** (0.00, 0.06)	0.015
Constant	39.986 *** (35.24, 44.72)	2.419	39.354 *** (33.40, 45.30)	3.033
R ²	0.176		0.178	

Note: *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

Among the built environment characteristics, road density, air quality, and the number of tertiary hospitals were positively associated with mental health, with regression coefficients of 2.714, 0.023, and 0.057, respectively. This indicated that a comfortable and convenient urban built environment improved the level of mental health. Moreover, a high road network density reduces vehicle speed, decreasing older adults' concerns regarding traffic accidents. A high road network density improved accessibility to the community, providing more walking options to make it easier to reach service facilities. A larger number of tertiary hospitals indicated that the medical resources in the area were highly accessible, making it easier for older adults to access medical and mental health services. Urbanization rate and population density showed a negative correlation with mental health level, with regression coefficients of −0.079 and −0.002, respectively. A high urbanization rate and crowded population may lead to an increase in noise, pollution, and stress in life, which may adversely affect older adults' mental health, as shown in previous studies [86]. Regarding social environment characteristics, community cohesion, life satisfaction, life happiness, economic satisfaction, and community safety exhibited significant positive correlations with the mental health of older adults, with coefficients of 0.128, 0.480, 1.101, 1.268, and 0.324, respectively. This indicated that the subjective self-satisfaction evaluation of older adults reflected their mental health status and that positive social support, living

conditions, and social environment provided a sense of emotional security and stability, which positively affected their mental health.

Among the physical health characteristics, sickness and injury and hospitalization history were significantly correlated with mental health, with correlation coefficients of 2.789 and 2.239, respectively. Few instances of sickness, injury, and hospitalization showed higher regression coefficients for mental health. Older adults experience psychological stress and environmental challenges when facing health problems and frequent hospitalizations. Moreover, they are removed from familiar social circles when hospitalized, reducing opportunities to socialize and receive emotional support. Thus, good physical health in older adults helps promote mental health, which was consistent with the findings of Ohrnberger et al. [87]. Among the sociodemographic characteristics, sex, education level, and income were significantly positively associated with the mental health of older adults, with regression coefficients of 0.915, 0.795, and 0.324, respectively. A previous study revealed a positive relationship between education level and physical and mental health, with more educated older adults paying more attention to their physical and mental health, being more health conscious, and more actively coping with mental health problems than less educated people [88].

Incorporating the interaction term in Model 2, the regression coefficient of the interaction term was significant and positive (coefficient = 0.034, standard error = 0.015, $p < 0.05$). Social interaction enhanced the mental health benefits of green areas for older persons, supporting Hypothesis 2.

Tables 4 and 5 present results for the two subsamples of solitary and non-solitary older individuals. Model 3 was used for the subsample of solitary older adults. The results indicated that the rate of green space had a significant favorable effect on the mental health of solitary older adults (coefficient = 0.279, $p < 0.1$). The regression coefficient of the negative impact of urbanization in the built environment was -0.220 , which was larger than that of the sample of non-solitary older adults (coefficient = -0.212 , $p < 0.01$). The negative impact of the high-density city on solitary older adults was larger. High-density cities increase inconvenience in the lives of solitary older adults, hindering psychological stress relief. Road network density had a significant favorable effect on the mental health of solitary older adults (coefficient = 4.447, $p < 0.01$), indicating that solitary older adults required a well-developed road network to improve the accessibility of facilities in the community and their standard of living, thus affecting their mental health. Among the social environment characteristics, economic satisfaction had a significant effect on the mental health of older adults (regression coefficient = 3.136, $p < 0.01$). Financial pressure was an important factor in mental health problems, and a positive financial situation reduced psychological pressure and burden on solitary older adults of their financial situation [89]. In terms of sociodemographic characteristics, none of the variables regarding solitary older adults demonstrated significance. A possible explanation is that solitary older individuals are in a solitary environment for a long period of time and may not be significantly affected by these sociodemographic characteristics. Among the physical health factors, solitary older adults without a history of alcohol consumption had a significant positive correlation with the level of psychological well-being (coefficient = 4.952, $p < 0.01$), and excessive alcohol consumption over a long period of time led to drunkenness and aggravated psychological stress. Our results showed that excessive alcohol consumption leads to depressive symptoms and mental health problems.

With the addition of the interaction term in Model 4, the interaction term's regression coefficient was significant and negative (coefficient = -0.137 , standard error = 0.069, $p < 0.05$). Social participation weakened the influence of urban green spaces on the mental health of solitary older adults.

Model 5 used a subsample of non-solitary older adults, and the rate of green space had a considerable positive effect on non-solitary older adults (coefficient = 0.178, $p < 0.01$). Compared to solitary older adults in Model 3 and non-solitary older adults in Model 5, the greening rate had a significant positive correlation (coefficients = 0.192 and 0.178) in both

subsamples. Among the characteristics of the built environment, the urbanization rate and population density showed significant negative correlations, whereas the number of tertiary hospitals and the road network density showed significant positive correlations. Regarding the features of the social environment, happiness satisfaction, economic satisfaction, and community security showed significant positive correlations for non-solitary older adults, and only economic satisfaction showed a significant positive correlation for the sample of solitary older adults. This suggested that non-solitary older adults focused more on life and relationships with family and community, which positively affected their mental health, whereas solitary older adults paid more attention to personal economic satisfaction to support their mental health. Among the sociodemographic characteristics, education, sex, and income showed significant positive correlations for non-solitary older adults, and there was no significant term for the sample of solitary older adults. Among the physiological health characteristics, hospitalization had no significant effect on solitary older adults. A possible explanation is that hospitalization involves a level of social and care contact with others that may be welcome for someone otherwise managing health problems on their own. Sickness and injury status had a significant effect on both samples (coefficients = 3.639 and 2.760), suggesting that physical health status is an important factor influencing mental health among older adults.

Table 4. Moderating effects for solitary older adults.

Variable	Model 3		Model 4	
	Coefficient (95% CI)	Standard Error	Coefficient (95% CI)	Standard Error
Urban environment				
Greening rate	0.279 * (−0.05, 0.61)	0.168	0.343 ** (0.01, 0.67)	0.169
Urbanization rate	−0.22 *** (−0.34, −0.09)	0.063	−0.212 *** (−0.33, −0.08)	0.063
Road density	4.447 *** (1.33, 7.55)	1.579	4.504 *** (1.41, 7.59)	1.568
Air quality (PM _{2.5})	0.037 (−0.07, 0.15)	0.057	0.038 (−0.07, 0.15)	0.057
Tertiary hospitals	0.189 *** (0.08, 0.29)	0.055	0.168 *** (0.05, 0.27)	0.055
Population density	−0.003 * (−0.00, 0.00)	0.002	−0.003 * (−0.00, 0.00)	0.002
Social environment				
Community cohesion	0.332 (−0.19, 0.86)	0.268	0.356 (−0.16, 0.88)	0.267
Life satisfaction	1.437 (−0.38, 3.26)	0.928	1.368 (−0.44, 3.18)	0.922
Happiness	−0.752 (−2.64, 1.14)	0.961	−0.667 (−2.54, 1.21)	0.954
Economic satisfaction	3.136 *** (1.82, 4.44)	0.667	3.167 *** (1.85, 4.47)	0.665
Sense of security	0.039 (−0.28, 0.36)	0.163	0.027 (−0.29, 0.34)	0.163
Individual health				
History of alcohol consumption	4.952 *** (2.20, 7.70)	1.396	5.139 *** (2.39, 7.88)	1.393
Sickness and injury	3.639 ** (0.80, 6.47)	1.441	3.861 *** (1.03, 6.68)	1.434
Hospitalization history	2.048 (−1.28, 5.38)	1.693	2.096 (−1.21, 5.40)	1.68
Sociodemographic characteristics				
Hukou	−0.47 (−5.70, 4.76)	2.657	−0.393 (−5.59, 4.80)	2.64
CPC membership	3.068 (−1.38, 7.51)	2.26	3.311 (−1.12, 7.74)	2.251
Sex	1.962 (−0.52, 4.44)	1.262	1.992 (−0.47, 4.46)	1.254
Education	0.068 (−1.45, 1.59)	0.773	0.206 (−1.34, 1.75)	0.786
Income	0.135 (−0.47, 0.74)	0.31	0.161 (−0.44, 0.76)	0.309
Moderating variable				
Social participation			0.425 ** (0.00, 0.84)	0.214
Interaction term				
Greening rate × social participation			−0.137 ** (−0.27, −0.00)	0.069
Constant	41.431 *** (24.73, 58.13)	8.481	22.829 * (−0.78, 46.44)	11.994
R ²	0.352		0.367	

Note: *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

Table 5. Moderating effects for non-solitary older adults.

Variable	Model 5		Model 6	
	Coefficient (95% CI)	Standard Error	Coefficient (95% CI)	Standard Error
Urban environment				
Greening rate	0.178 *** (0.08, 0.26)	0.045	0.176 *** (0.08, 0.26)	0.045
Urbanization rate	−0.063 *** (−0.09, −0.02)	0.018	−0.064 *** (−0.09, −0.02)	0.018
Road density	2.468 *** (1.63, 3.30)	0.425	2.472 *** (1.64, 3.30)	0.424
Air quality (PM _{2.5})	0.02 (−0.01, 0.05)	0.015	0.019 (−0.01, 0.04)	0.015
Tertiary hospitals	0.041 ** (0.00, 0.07)	0.016	0.045 *** (0.01, 0.07)	0.016
Population density	−0.001 *** (−0.00, 0.00)	0.000	−0.001 *** (−0.00, −0.00)	0.000
Social environment				
Community cohesion	0.102 (−0.03, 0.24)	0.072	0.099 (−0.04, 0.24)	0.072
Life satisfaction	0.333 (−0.23, 0.89)	0.288	0.309 (−0.25, 0.87)	0.288
Happiness	1.279 *** (0.74, 1.81)	0.274	1.292 *** (0.75, 1.82)	0.274
Economic satisfaction	1.076 *** (0.70, 1.45)	0.191	1.102 *** (0.72, 1.47)	0.191
Sense of security	0.345 *** (0.25, 0.43)	0.044	0.344 *** (0.25, 0.42)	0.044
Individual health				
History of alcohol consumption	−0.716 * (−1.56, 0.12)	0.43	−0.675 (−1.51, 0.16)	0.43
Sickness and injury	2.76 *** (1.89, 3.62)	0.443	2.769 *** (1.90, 3.63)	0.442
Hospitalization history	2.224 *** (1.35, 3.08)	0.441	2.246 *** (1.38, 3.11)	0.441
Sociodemographic characteristics				
Hukou	0.285 (−1.04, 1.61)	0.679	0.258 (−1.07, 1.59)	0.679
CPC membership	0.263 (−0.96, 1.49)	0.627	0.32 (−0.90, 1.55)	0.627
Sex	0.847 *** (0.15, 1.54)	0.355	0.852 ** (0.15, 1.54)	0.355
Education	0.887 *** (0.46, 1.30)	0.214	0.886 *** (0.46, 1.30)	0.216
Income	0.318 *** (0.14, 0.48)	0.087	0.33 *** (0.15, 0.50)	0.088
Moderating variable				
Social participation			−0.005 (−0.10, 0.09)	0.052
Interaction term				
Greening rate × social participation			0.041 *** (0.01, 0.07)	0.015
Constant	41.461 *** (36.58, 46.34)	2.488	41.745 *** (35.66, 47.82)	3.099
R ²	0.166		0.169	

Note: *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

In Model 6, the interaction term's regression coefficient was significant and positive after the inclusion of the interaction term (coefficient = 0.041, standard error = 0.015, $p < 0.01$). Overall, social participation strengthened the mental health benefits of green areas.

5. Discussion

Considering the aging population in China, this study explored the benefits of urban green space on the mental health of older adults and the moderating effect of social participation in this relationship. The results indicated that social participation enhanced the influence of urban green space on the mental health of non-solitary older adults but weakened this effect among solitary older adults. These findings could help manage community aging, improve mental health among older adults, and construct aging-friendly cities.

5.1. Urban Green Space

Among the built environment characteristics, green rate, road density, air quality, and the number of tertiary hospitals were positively associated with older adults' mental health, which was consistent with existing research findings [90–92]. The urbanization rate and population density had significant negative effects on the mental health of older adults. A high urbanization rate and crowded population may lead to an increase in noise, pollution, and stress in life, which may adversely affect older adults' mental health [86]. Among social environment characteristics, life satisfaction, happiness, economic satisfaction, and

community safety exhibited significant positive correlations with mental health. This suggests that building a good and safe neighborhood is conducive to the mental health of older adults [13]. Furthermore, low illness, injury, and hospitalization rates promoted mental health. As shown in previous studies, good physical health affects the mental health of older adults [87]. Additionally, sex, education level, and income were associated with mental health. According to previous studies, men, individuals with high educational levels, and those with high income tend to be concerned about their mental health [58,93].

In the total sample, urban green space had a significantly positive influence on older adults' mental health, which was in line with previous studies [94,95]. However, access to urban parks in China may be hindered by extremely high population densities and insufficient urban park cover. Considering their materiality, urban green spaces can alleviate 'urban disease' and improve the environment by reducing air pollution [96]. Furthermore, the sociality of urban green space requires attention. Urban green space provides older adults with places for social interaction and physical exercise and promotes neighborhood exchanges, thereby improving mental health [5]. However, one study found no association between open green space and self-reported health [97]. This may be due to differences in green space quality and the extent to which green spaces align with individual needs, capacities, and preferences [98].

Moreover, social participation had a positive moderating effect on the relationship between urban green space and mental health among older adults. The social activities of older adults are often closely associated with public spaces, such as green spaces [99]. A close neighborhood environment with green spaces can be considered a place to foster social ties between older people and enable an experience of neighborliness [100], which are important to enable social contacts, to meet other people, and to engage with strangers [101]. Promoting older adults' active and frequent participation in social activities can relieve mental stress and reduce depression and loneliness, thereby improving mental health. This study supported the activity theory and was consistent with existing research [102,103].

5.2. Solitary and Non-Solitary Older Adults

Social participation had a negative moderating effect on the relationship between green spaces and mental health in solitary older adults. Due to the long-term lack of social care, solitary older adults tend to experience loneliness and depression. When the level of social participation is low, high-quality green spaces can improve the mental health of solitary older adults by relieving mental stress [38]. Studies have shown that individuals' social roles and relationships are reconfigured during the aging process, and successful individuals adapt to the challenges posed by new social roles and relationships [53]. This suggests that the lack of social relationships among solitary older adults can be reconstructed and replenished through social participation. Green spaces can help seniors living alone build new relationships and social networks by providing regular access to current recovery needs [104]. As the level of social participation increases, the materiality of green spaces gradually diminishes, and their social nature increases. Solitary older adults are more likely to want to expand their social networks and gain emotional comfort through social participation. Some research has indicated that solitary older adults can also generate positive emotions through informal interactions and shared normative behaviors (witnessing similar activities or encounters) [105,106]. In addition, it may be perceived that the attractiveness of green space enjoyment will be further enhanced through the social interaction associated with it [107]. Therefore, solitary older adults may visit them alone, and possibly in a way that they wish to engage with nature and its psychological benefits.

Conversely, social participation had a positive moderating effect on the relationship between green spaces and mental health among non-solitary older adults. Non-solitary older adults have close and affectionate family relationships and reliable social support [108]. Family relationships are directly correlated with older adults' well-being and health and become increasingly important with age and the decline of social support networks [109]. One study found that non-solitary older adults visit green spaces more frequently than

solitary older adults [110]. This is because social integration is a precondition for older people to visit parks. Lack of integration in social networks can become the decisive barrier that prevents park visitation from the start [111]. In addition, non-solitary older adults prefer to visit parks and green spaces in pairs and enjoy visiting green spaces more in a socially interactive environment [112]. Therefore, they want their experiences to be enjoyed with others and like it that way.

5.3. Limitations and Future Directions

This study had some limitations. First, this study only directly measured green space ratios from a macro perspective. Future studies should examine exposure to the green environment from the human perspective, that is, green visibility and sensory perception of urban vegetation. Second, this study explored the influence of green space from a static perspective; however, older adults often have mobility problems and complex emotions and are unable to perceive the psychological benefits of green space. Therefore, future studies should adopt dynamic methods, such as the ecological momentary assessment and day reconstruction method, from a humanistic perspective to measure the effect of the mental health benefits of green space in older adults. Third, due to the cross-sectional data used in this paper and the lack of longitudinal comparison, the discussion of mental health in this study is still insufficient. It can only explore the correlation between variables and residents' mental health but cannot identify the causal relationship. It needs to be improved through follow-up investigations.

6. Conclusions

This study explored the mechanism of the effect of urban green space on the mental health of older adults in China. We used a research framework with social participation as a moderating variable in the relationship between urban green space and mental health, and built environment, social environment, sociodemographic characteristics, and individual health characteristics as control variables. The results revealed that urban green space had a significant and positive influence on mental health, which was moderated by social participation. Social participation positively moderated the relationship between urban green space and mental health among non-solitary older adults and negatively moderated this relationship among solitary older adults.

Urban planning and governance should focus on the physical and social aspects of green spaces. Healthy aging is the core of a healthy city, and community planning should improve the quality of urban green spaces and consider their parity and accessibility. Communities should improve the materiality and social attributes of urban green spaces and consider the psychological demands of older adults and other disadvantaged groups. Community governance can improve the quality of green environments and ensure the safety of outdoor activities by adapting green spaces to aging. Spatial design should pay attention to barrier-free design and the elimination of unnecessary height differences. In addition, community governance should also carry out age-appropriate renovations of community public facilities and promote the equalization of community public service facilities in order to meet the needs of older adults for physical exercise, social participation, and other activities. Additionally, urban planning should consider the heterogeneity of older adults, particularly the needs of different socioeconomic groups. Community governance should meet the needs of non-solitary older adults for social integration and for broadening and deepening their social networks through the construction of high-quality public green spaces and the development of age-appropriate green spaces and environmental facilities. However, as solitary older adults experience worse physical and mental health, low levels of social participation, a lack of carers, and a withdrawn nature, optimizing the environment to promote active integration into society is challenging. Therefore, community governance should pay more attention to social contact and social activities and not just rely on the green space environment to improve mental health. Community governance should pay more attention to the construction of community

service facilities and guarantee regular visits, family health care, and accompanying services for solitary older adults.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land13030317/s1>. File S1: Urban environmental characteristics of the data; File S2: Dimensions and measurements of social participation, mental health, sense of safety, and community cohesion.

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