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Healthy aging with parks: association between park accessibility and the health status of older adults in urban China

Abstract

Accessibility is a crucial element reflecting the potential availability of parks. By conducting a cross-sectional study of 700 older adults sampled from 30 communities in Wuhan, China, we examine the association between the accessibility of parks and the health status of older adults. A varying two-step floating catchment area model was developed to measure the accessibility of parks for older adults that simultaneously considered the physical environment and sociopersonal context. Based on the results of a logistic regression analysis, older adults with the greatest access to parks experience significantly lower odds of cardio-cerebral vascular diseases, joint diseases and endocrine diseases than their counterparts with the least access to parks. The effects of the physical environment and sociopersonal context on the accessibility of parks and health status are also discussed. In general, these two factors jointly influence the potential alternatives to parks and participation in park-based activities among older adults and in turn affect the health benefits for older adults. This study provides empirical support for the role of parks in supporting healthy aging. It also emphasizes the need for more comprehensive economic planning strategies to improve park accessibility and promote healthy aging in transitional cities.

Keywords: Accessibility of parks; Health status; Older adults; Urban China

1. Introduction

In China, it is estimated that the proportion of the population over 65 years of age will increase to 13.7% by 2025 and reach 25% by 2050 (Chen & Liu 2009; Flaherty et al. 2007). Within the context of this rapid demographic increase in the aging population, the health status of this group has become a key issue to address for the future of this developing and transitional country (Gong et al. 2012). Along with increases in life expectancy, older adults face many challenges, such as chronic diseases and disabilities, deteriorating vision and hearing (Lin et al. 2013), and decreased mobility (Ahacic, Parker & Thorslund 2000). Health problems decrease the quality of life of the elderly and limit their ability to participate in social and community activities, posing severe challenges for the Chinese government.

Along with the increasing interest in healthy urban planning, planning interventions have emerged as not only an important issue but also an urgent need on the healthy aging agenda (Buffel, Phillipson & Scharf 2012). As one of the therapeutic landscapes within the urban environment, urban parks provide opportunities for physical activity and socialization, offering individuals both physical and psychological health benefits (Bratman, Hamilton & Daily 2012); thus, urban parks have become the focus of planning interventions to create healthy living environments (Xiao, Wang, Li & Tang 2017).

Accessibility is a crucial element reflecting the potential availability of parks by revealing the ability of different people to overcome spatial, physical, and socioeconomic barriers to park use and participation in outdoor activities (Wang, Brown & Liu 2015). The health benefits of improved park access have been discussed extensively in the literature; these benefits include a higher level of physical activity (Jáuregui et al. 2016), improved mental health (Sturm & Cohen 2014) and self-reported health (Mowen, Orsega-Smith, Payne, Ainsworth & Godbey 2007), and reduced chronic health conditions (Besenyi et al. 2014; Chum & O'Campo 2015).

However, few studies have performed a relatively comprehensive investigation of the impact of park accessibility on the health status of older adults, and thus a theoretical basis for promoting healthy aging via park planning is lacking.

First, only a limited number of studies have focused on the role of park accessibility in shaping the health status of older adults (Finlay, Franke, Mckay & Sims-Gould 2015; Mowen, Orsegasmith, Payne, Ainsworth & Godbey 2007). During aging, older adults are affected by an increasingly serious decline in mobility and cognition, and they become more vulnerable to barriers in their surrounding physical environment (Clarke & Nieuwenhuijsen 2009). Motivation to visit parks among older adults is also highly dependent on the convenience of park locations (Gibson 2017). Therefore, compared to their younger counterparts, the uneven accessibility of parks might have particularly severe effects on the usage of parks among older adults and in turn exacerbate the experienced health inequity.

Second, the accessibility indicators employed in existing research on the associations between the accessibility of parks and health benefits do not correspond with recent advances in this field. Based on location theory, the majority of existing research on accessibility has mainly relied on unilateral physical characteristics—namely, spatial dimensions and the quality of destinations—when measuring accessibility, such as objective proximity (Mowen, Orsegasmith, et al. 2007), perceived proximity (Cauwenberg et al. 2015), density (Schipperijn et al. 2017), and size (Kaczynski, Potwarka, Smale & Havitz 2009). However, physically oriented measurements largely overlook the role of the sociopersonal context in shaping accessibility. For example, population sizes might have a bearing on park accessibility due to the barrier presented by crowds (Ekkel & Vries 2017). According to evidence from recent studies, the accessibility of parks is also stratified by socioeconomic characteristics (Cutts, Darby, Boone & Brewis 2009; Sister, Wolch & Wilson 2010). Moreover, people who live in the same neighborhood display discrepancies in individual mobility, which are closely associated with sociopersonal characteristics (Bisht, Mishra & Fuloria 2010), such as age, education, travel aspirations and health conditions (Aartolahti, Tolppanen, Lönnroos, Hartikainen & Häkkinen 2015; Paterson & Warburton 2010; Roland J. Thorpe Jr. et al. 2011), resulting in the different size of the regular travel area; these discrepancies also contribute to unequal access to parks. Thus, the role of the sociopersonal context deserves to be emphasized when examining the association between park accessibility and individual health status. Several important questions should be addressed to fill these gaps. How should researchers measure the accessibility of parks for older adults while considering physical environments and the sociopersonal context? To what extent does the accessibility of parks affect the health status of older adults? This study pursued the following objectives to answer these questions: (1) to identify an effective method for measuring park accessibility to older adults with the aim of integrating the physical environment and sociopersonal context and (2) to explore the relationship between the accessibility of parks and the health status of older adults.

2. Literature review

2.1. Park accessibility and health benefits

The accessibility of parks is conceptualized as one of the major factors influencing the utilization of parks, as it evaluates the relative opportunity for contact or use of a park (Gregory, Johnston, Pratt, Watts & Whatmore 1981). In existing studies, the proximity, density, and size of parks are generally employed as a proxy for accessibility, and based on these measurements, the health benefits of park accessibility are examined and discussed extensively in the literature. For example, regarding health status, a cross-sectional study of 1515 older adults revealed that the perceived walking proximity of parks is positively correlated with general self-reported health, which is mediated by park visitation and physical activity (Mowen, Orsega-Smith, et al. 2007). Besenyi et al. (2014) investigated 583 participants and found that middle-aged adults (i.e., people aged between 40 and 59) who resided within one-half mile of a park exhibited a reduced risk of developing chronic health conditions. In a study of 2411 adults aged between 25 and 64 in Toronto, Canada, by Chum & O'Campo (2015), the number of parks within a 10-minute walking distance of the home was negatively correlated with risks of cardiovascular diseases. A city-level study also observed that park density (i.e., the acres of parkland as a percentage of land area) was negatively correlated with prevalence of obesity in 67 metropolitan areas in the U.S. (West, Shores & Mudd 2012).

Insights into potential mediators that link park accessibility with health status can be drawn from existing studies into two groups: social interaction and physical activity. Systematic reviews have summarized how social capital acts as a crucial factor to facilitate the self-management of chronic diseases in all age groups (Hu et al. 2014; Vassilev et al. 2011) and promote the health status of older adults (Coll-Planas et al. 2016). Previous qualitative studies have suggested that parks provide settings and opportunities for individuals to enhance their social cohesion and interpersonal socialization with both intimates and consequential strangers (Maller et al. 2010; Moulay, Ujang & Said 2017; Peters, Elands, Buijs & Bell 2010). Recent quantitative research has also shown that longer and more frequent park visits present positive correlations with several key dimensions of park-based social capital (Mowen & Rung

2016). As such, parks are regarded as the “third place” after the home and workplace in people’s social lives (Mowen & Rung 2016), and parks play a key roles in the promotion of social interaction and the accumulation of social capital, thereby improving health status.

In addition, several studies have examined the statistical correlation between various measures of park accessibility and diverse measures of physical activity (see Bancroft et al. (2015) and Kaczynski & Henderson (2007) for reviews), which in turn are associated with several chronic diseases, such as obesity, cardiovascular diseases, diabetes and joint diseases (Meisinger, Löwel, Heier, Kandler & Döring 2008; Messier et al. 2004; Veiga et al. 2009). Statistical correlation has often been used as a tool to understand such associations, although they may not necessarily suggest causality (Bancroft et al. 2015). In general, when modeling the accessibility of parks, proximity, perception measures, and a smaller buffer size are predictors of physical activity.

For example, objective proximity to parks is positively correlated with total levels of moderate to vigorous physical activity (MVPA) in adults (Schipperijn et al. 2017) and with recreational physical activity in older individuals (Cauwenberg et al. 2015). Moreover, based on the current evidence, perceived proximity to parks presents a positive correlation with physical activity among different age groups (see Ries et al. (2009) for data from adolescents, Jáuregui et al. (2016) for data from adults, and Mowen, Orsegasmith, et al. (2007) for data from older adults). Mowen, Orsegasmith, et al. (2007) also suggested that perceptions might be a prerequisite for park use by older adults. Regarding park density, a study conducted in Beijing, China, employing 308 participants (the majority were young or middle-aged individuals) found that number of parks within 0.5 kilometers of the home exhibited a positive correlation with self-reported time engaged in MVPA (Liu, Li, Li & Zhang 2017). Similarly, by studying 8568 participants aged between 18 and 66 from 8 countries, a recent multicountry study indicated that the number of parks within one kilometer of the home was associated with greater leisure-time physical activity and accelerometer-measured MVPA (Schipperijn et al. 2017). As shown in the study by Veitch et al. (2016), Australian women with more parks located near the home tend to meet physical activity recommendations, and American women have lower odds of excessive time spent viewing the TV under the same conditions. In addition, regarding park size, based on a survey of 1803 participants by Giles-Corti et al. (2005), adults with good access to large parks have a higher probability of participating in high levels of total walking than their counterparts. Kaczynski et al. (2009) also observed that each hectare increases in park area within walking distance resulted in a positive correlation with park-based activity, particularly for younger (18 to 34 years) and older (>55 years) adults.

2.2. Modeling park accessibility

Classic quantitative accessibility measures focus on the spatial-physical dimensions of accessibility and are categorized into two groups: the travel cost and container approaches (Xiao et al. 2017). Measured by distance (Euclidean or network) and travel time (Xing, Liu, Liu, Wei & Mao 2018), the travel cost approach provides an evaluation of the costs of overcoming spatial segregation between the population and parks. The container approach emphasizes the density and existence of parks, which are commonly measured as the percentage of parkland, park acreage or the number of parks within specific geographic units, such as the zip code (Stark et al. 2014), grid (Lee & Hong 2013), and buffer (Liu, Li, et al. 2017). Relying on physical variables, these methods provide a relatively simple and intuitive means to measure and interpret accessibility.

Nevertheless, these spatial-physical approaches might not completely capture the various barriers that must be overcome to increase park usage and thus might not accurately reflect the potential availability of parks. Zhang, Lu & Holt (2011) argued that the travel cost approach assumes that individuals will exclusively visit the nearest parks, while the accessibility assessment in the container approach largely depends on the definition of a geographic unit due to the well-known modifiable areal unit problem.

In general, the accessibility of parks encompasses both physical and nonphysical dimensions. In addition to the location and distribution of parks, the quality of parks and the social-personal context likely also play a key role in shaping accessibility. Better park accessibility is suggested to be linked with higher quality in terms of the sufficiency of facilities, management, safety, etc. For example, the availability of facilities is important for attracting visitors who reside far from a park (Liu, Chen & Dong 2017), and cleanliness and maintenance are positively associated with park preferences (Bertram, Meyerhoff, Rehdanz & Wüstemann 2017). According to Wang et al. (2015), perceived safety is the most influential predictor of park accessibility for lower socioeconomic status (SES) groups.

Regarding the sociopersonal context, Ekkel & Vries (2017) found negative effects of the crowding barrier on the recreational use of parks, thus emphasizing the role of population size in park accessibility assessments. Moreover, discrepancies in mobility might also lead to disparities in accessibility at the individual level (Byrne, Wolch & Zhang 2009). In a cohort study sampling 34485 older adults, Kuritzky (2011) observed significant differences in the gait speed, i.e., the mobility, of older adults.

Thus, individual mobility should also be considered to obtain an accurate assessment of park accessibility for older adults.

Studies have also examined the significant impact of sociopersonal characteristics on the accessibility of parks due to self-selection into settlement, the distribution of parks and social segregation (Cutts et al. 2009; Sister et al. 2010; Xiao et al. 2017). For example, McConnachie & Shackleton (2010) observed that low-income and ethnic minority neighborhoods had low levels of access to park resources. Sister et al. (2010) argued that people with lower SES are often likely to live close to parks with high levels of congestion and insufficient facilities, and thus their usage of parks is largely hindered by the imbalance between population demand and the provision of facilities. Conversely, some recent research has also observed a potential for equal or better opportunities of disadvantaged groups to access parks in the context of urban China (Wei 2017; Xiao et al. 2017).

Based on the literature review, a framework is proposed to establish the association between park accessibility and health status, particularly the physical outcomes of older adults. As shown in **Figure 1**, park accessibility was constructed as the integral reflection of two dimensions: the physical environment (i.e., the location of parks, quality of parks, and the road network) and the sociopersonal context (i.e., population size and individual mobility). Individual SES (i.e., age, gender, income, education, occupation, and household structure) was included in the research to control for self-selection effects on accessibility and the health outcomes of older adults. We hypothesized that along with the mediating effect of physical activity and social interaction, park accessibility would have positive effects on the health status of older adults.

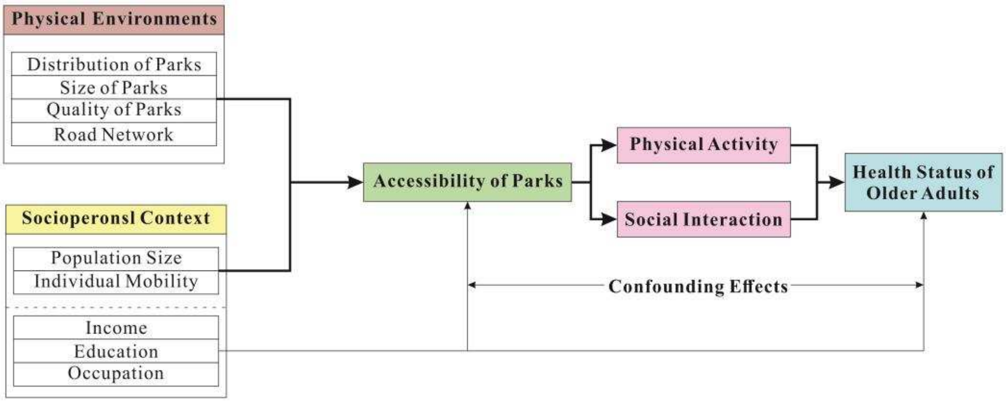

Figure 1 Potential association between the accessibility of parks and the health status of older adults.

3. Research design

3.1. Study area and data

This study was conducted in the city center of Wuhan, China **(Figure 2)**. Wuhan has a population of 10.7 million (as of 2015) and a total area of 8,494.4 km^2. As the capital of Hubei Province, central China, this city is rapidly growing, as it is undergoing high-speed urbanization and experiencing a rapid increase in its aging population. The registered aging population is 1.63 million, accounting for nearly 20% of the total population at the end of 2015, and its spatial variation manifests a central concentration and suburbanization in some areas (Xie, Zhou & Luo 2015). The health status of older adults in Wuhan is far from optimistic, with noncommunicable diseases posing a heavy burden on this group in recent years. According to data from the Health and Family Planning Commission of Wuhan Municipality in 2014, more than 70% of older adults suffer from a chronic disease.

Two main datasets were included in the current study: (1) geospatial data and (2) survey data. Geospatial data were provided by Wuhan Land Resources and Planning Information Center, including population, road networks, and detailed information on parks. Specifically, urban omnibus parks (UOP) and neighborhood parks (NP) are two of the main park types in China. Our focal area contained 47 UOPs and 842 NPs, covering areas of 1413.3 ha and 763.9 ha, respectively (mean area: 30.1 ha for UOP versus 0.9 ha for NP). These parks were primarily concentrated in central areas rather than being dispersed throughout the suburbs **(Figure 3)**. The local government is responsible for funding the design, construction, and management of UOPs, while the development of NPs mainly depends on developers, and their maintenance is largely undertaken by residential committees. Accordingly, these two types of parks have great disparities in their quality, such as scale, landscape, and supply of amenities.

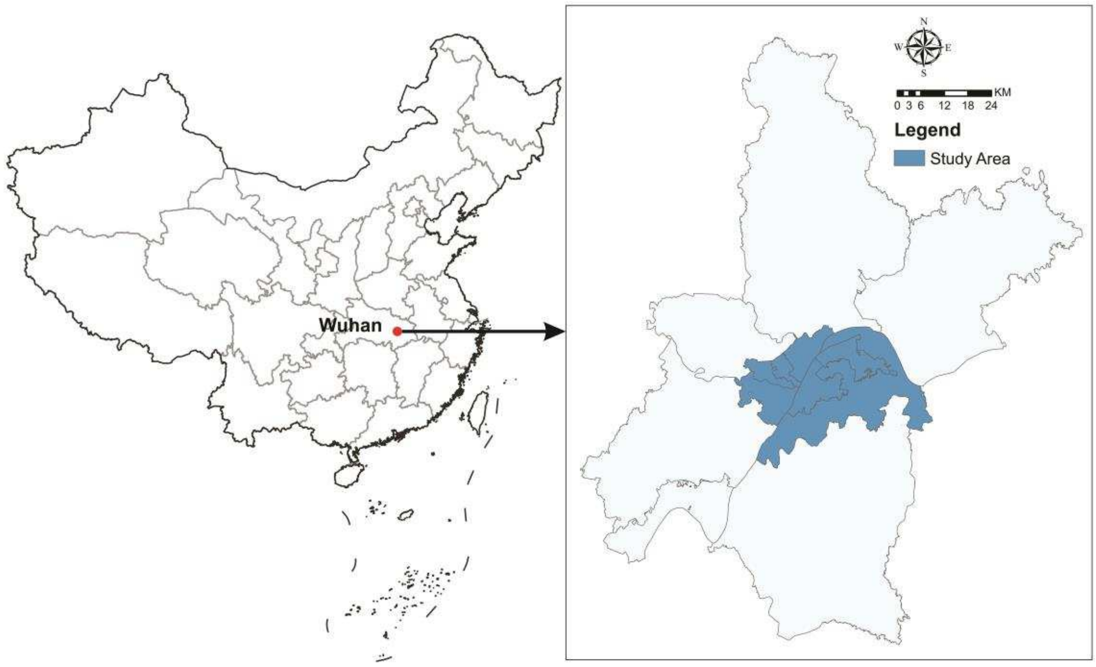

Figure 2 The location of the study area.

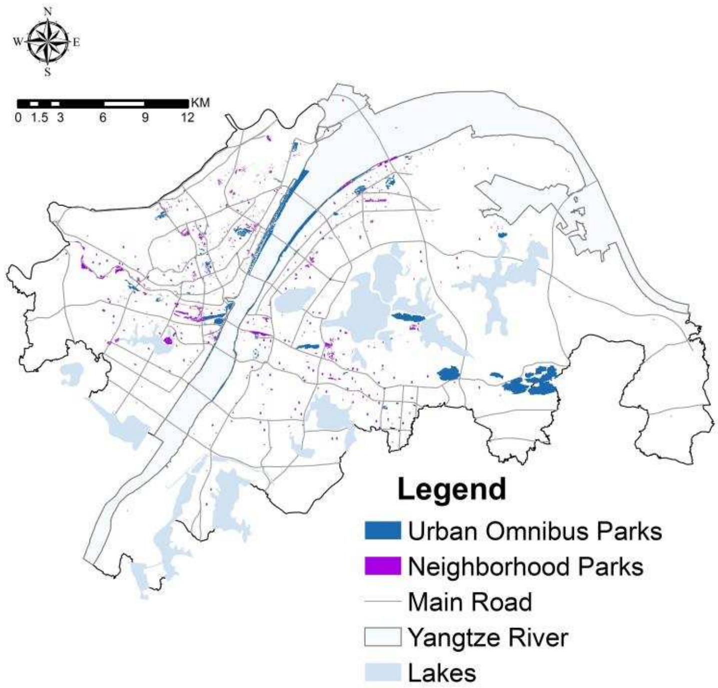

Figure 3 The spatial distribution of parks in Wuhan.

A questionnaire survey was conducted in 30 communities between September 10 and October 16, 2016 **(Figure 4)**. The community, namely, juweihui, is the jurisdiction of each residents' autonomous organization and the smallest administrative unit in urban China. A multistage sampling method was used to select the sampled communities. First, all sampled communities were required to be aging communities with a certain scale to ensure the representation and appropriateness of the interviewees: (1) the ratio of the older adults in these communities was required to exceed 10% according to the classic definition of aging communities (Zhou, Xie & Kwan 2015), and (2) the number of older adults in these communities was required to exceed 350, which is approximately the lower quartile value in our focal area. In setting these conditions, we downsized the sampling frame from 1248 to 396 communities. Second, since proximity to parks is considered a common indicator and proxy for evaluating park accessibility (Rigolon 2017), we developed a list of 396 communities sorted by their locations (i.e., distance from the nearest park), and we used a systematic sampling method to randomly select 30 communities as follows: (1) labeling each community with a unique identification number, according to ascending order of their distance from the nearest park; (2) calculating the sampling interval by dividing the sample size by the total number of communities, yielding a sampling interval of 13 in the current research; (3) selecting the first sampled communities from label 1 to label 13; and (4) taking 13 as the cycle and the label of the first sampled communities as the starting point, completing the whole sampling process.

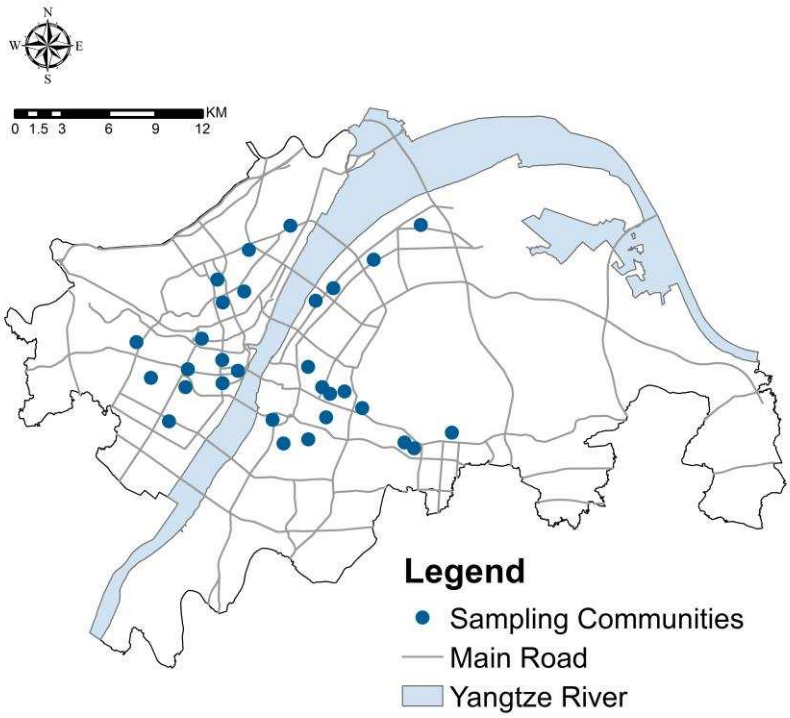

Figure 4 The spatial distribution of sampled communities.

After a pilot survey, three groups with five students in each group were responsible for distributing the questionnaires, and each of the sampled communities was visited by one group primarily during 3 different time periods (i.e., 6:30-8:30, 14:00-16:00, and 18:00-20:00) on the weekends. Surveys were conducted in the public areas of the community, and only people aged 60 years or older were included in the sample. Within each community, three to seven survey locations frequented by older adults were selected based on the size of the aging population. After considering the residents who never or seldom traveled to parks, the survey locations within communities were diversified and separated and included not only parks but also courtyards, roadsides and spaces around residential buildings. Moreover, in each survey location, a student was only able to perform a maximum of one valid investigation to maintain the balance of the sample size and diversity of the samples. Before the questionnaires were distributed, we sought permission from each respondent, and the questionnaires were ultimately completed by the interviewers in approximately 30 minutes.

The questionnaire was composed of the following sections: age, gender, income, health status, parks regularly visited, regular travel routes, and quality of parks. The park that each older adult visited most frequently was recorded. According to the survey, the residences and routes used for regular trips to the park by older adults were recorded to calculate the actual travel distance based on the road network. In the section on the quality of parks, we conducted interviews and employed a psychometric tool with a 5-point Likert scale to record the older adults' level of satisfaction with parks based on six factors: internal traffic convenience (i.e., the convenience of walking in the park), scale, security, facilities, landscape, and management. Each item had a potential value of five points for a possible total of 30 points. In the health status section, the respondents were also asked whether they had been diagnosed with any chronic diseases by professional doctors at the time of the interview. The interviewers recorded the detailed names of the diseases, and with the guidance of a doctor, they classified them into seven of the most common age-related diseases in China, including cardio-cerebral vascular diseases (CCVD), joint diseases (JD), digestive diseases (DD), endocrine diseases (ED), urological diseases (UD), nervous system diseases (NSD) and respiratory diseases (RD). Illnesses that had been cured were not recorded on the questionnaires. Ultimately, we attempted to distribute the questionnaires to 731 older adults; 700 of the questionnaires were valid, and the total response rate was 95.76%.

3.2. Accessibility measures

3.2.1. Varying two-step floating catchment area (V2SFCA)

A modified floating catchment area (FCA) method, namely, V2SFCA, was employed for park accessibility assessments. The advantage of integrating the physical environment and sociopersonal context has popularized the use of FCA methods in accessibility evaluations (Dai 2011; Luo & Wang 2003). Unlike the physically oriented method, FCA methods fully consider various barriers influencing park usage. First, these methods emphasize the supply-demand balance between park services and the population (Dony, Delmelle & Delmelle 2015). Second, using floating service catchments, FCA methods capture the influence of the quality of parks on serviceability (Dony et al. 2015). Third, as identified by floating time-based or distance-based travel catchments, the methods include individual mobility in the accessibility assessment (Delamater 2013).

The FCA method divides the measurements into two sections: (1) the calculation of the supply and demand ratio between the park area and population size and (2) the estimation of accessibility based on this ratio. In addition to the park area and population size, two types of catchment areas that are defined as buffer areas around communities and parks play decisive roles in calculating the supply and demand ratio. Specifically, the service catchment area, which is primarily influenced by the park quality, is used to represent the supply capacity of parks. The travel catchment area indicates the residents' average travel scope within the community and in turn reflects the demand of residents.

Nevertheless, FCA methods hypothesize that all parks and all residents in the study area share unified service and travel catchment areas, respectively, which might lead to biased or inaccurate results. The distinction of park quality would have significant implications for the preference of park to visit among residents from different regions, resulting in discrepancies in service catchment areas (Bertram et al. 2017). Regarding the travel catchment area, significant differences in the mobility of different populations of older adults have been observed, and individuals with poor health status are more susceptible to developing mobility limitations (Kuritzky 2011; Roland J. Thorpe Jr. et al. 2011). Moreover, most residents might not prefer to visit the parks located closest to their residence, and within a certain range, their frequency of park visits would increase as the distance between the home and parks increases (Rossi, Byrne & Pickering 2015). In summary, unitary catchment areas might lead to an over- or underestimation of the accessibility of different regions (Wan, Zou & Sternberg 2012).

Therefore, we identified independent service and travel catchment areas and proposed a V2SFCA model to measure the accessibility of parks for older adults. This model consists of the two steps listed below.

Step 1: As shown in **Eq. (1)**, d_{kj} denotes the distance between community k and park j, and it is measured using the origin-destination cost matrix based on road networks, including main roads, side roads, and pathways. The geographic centroid is used to indicate the location of the community and park, as described by Dai (2011). For each park j, the acreage-to-population ratio R_j is calculated according to the acreage of the parks S_j, the population of the community P_k within the service catchment area (i.e., $d_{kj} \leq D_j$), and the distance decay function $G(d_{kj})$.

$$R_j = S_j / \sum_{k \in \{d_{kj} \leq D_j\}} P_k G(d_{kj}) \quad (1)$$

Step 2: As shown in **Eq. (2),** for each community i, the acreage-to-population R_j ratio of all of the parks within the travel catchment area (i.e., $d_{ij} \leq D_j$) is summed, from which the distance decay function is subtracted. The travel catchment D_i of each community was confirmed independently. A_i is the accessibility index, which reflects the potential area of park availability among older adults within community i:

$$A_i = \sum_{j \in \{d_{ij} \leq D_i\}} R_j G(d_{ij}) \quad (2)$$

Compared to other functions, the Gaussian function decreases accessibility continuously with an increase in distance (Dai 2011). This function is formulated as follows (**Eq. (3)**):

$$G(d_{ij}) = \begin{cases} \dfrac{e^{-1/2 \times (d_{ij}/d_0)^2} - e^{-1/2}}{1 - e^{-1/2}} & \textbf{if } d_{ij} \leq D_i \\ 0 & \textbf{if } d_{ij} > D_i \end{cases} \quad (3)$$

3.2.2. The determination of catchment sizes

Regarding the service catchment of parks, a distinction between a UOP service catchment area (UOPSCA) and an NP service catchment area (NPSCA) might exist. The logic behind this assumption is that older adults might be more attracted to visit UOPs than NPs due to the better quality of UOPs, for example, their larger scale, better facilities, and greater variety of activities. This attractiveness increases the willingness of older adults to travel a relatively longer distance to use UOPs, resulting in an expansion of the scope of UOPs (Zhou & Li 2011). Therefore, service catchment sizes were confirmed using scatter plots showing the travel distance to parks and the distance between the residence and parks.

A multivariate linear regression model was used to integrate multiple factors and determine travel catchment sizes, since actual travel distance to parks varies as a result of differences in the spatial distribution and health status of older adults. The third quartile of travel distance was considered the threshold (i.e., 856 m for NPs and 2317 m for UOPs). The following regression model was used:

$$D_i = \alpha_0 + \sum_{j=1} \beta_j x_{ij} + \varepsilon_i \quad (4)$$

where D_i is the distance that forms the travel catchments and is represented by the actual travel distance of older adults in the model, and x_{ij} is the independent variable. The coefficient β_{ij} is estimated using ordinary least squares under the usual assumptions for the residual term ε_i.

Table 1 lists all variables included in the model and their definitions. By dividing older adults in each community by health status, the size of the travel catchment was fitted according to the distribution of communities (i.e., distance to parks) and parameters estimated by the ordinary least squares (OLS) formula presented in **Eq. (4)**.

Table 1 Definitions of variables incorporated in the model for determining travel catchment sizes

Dependent Variable	**Definitions**
Actual Travel Distance	Distance traveled on a regular trip to the parks based on the road network
Independent Variables	**Definitions**
Dummy Variable	
Chronic Health Condition	1. Fitness (x=1) 2. Chronic disease (Reference; x=0)
Continuous Variables	

Nearest Distance to UOP	Nearest distance from the residence to the nearest UOP based on the road network
Nearest Distance to NP	Nearest distance from the residence to the nearest NP based on the road network

3.3. Statistical analyses

Logistic regression analyses were used to examine the association between the accessibility of parks and the health status of older adults. As the dependent variable, health status variables were indicated by the presence or absence of chronic health conditions and the occurrence of specific chronic diseases and quantified using dummy variables (i.e., chronic health condition: 0=fitness and 1=suffering from a chronic disease; occurrence of a specific chronic disease: 0=not suffering from this disease and 1=suffering from this disease). Because chronic disease is a process that transforms people from a state of fitness to one of illness, the accessibility of parks for healthy older adults served as the independent variable. The estimation model for each of the diseases was performed separately. Sociopersonal characteristics have been reported to be closely associated with health status (Deeg & Kriegsman 2003; Hewitt, Rowland & Yancik 2003; Wilkinson & Pickett 2006; Zhang & Wu 2017) and residential location choices pertaining to accessibility of parks (Cutts et al. 2009; Schindler, Texier & Caruso 2018; Sister et al. 2010; Xiao et al. 2017). Considering these confounding effects of sociopersonal characteristics, four additional control variables that are jointly linked with health status and residential location choices were selected: individual monthly income, education, occupation, and household structure. Age and gender were also included in the estimation models to control for potential sampling bias.

4. Results

4.1. Descriptive statistics

Table 2 provides the key statistics of our sampled communities. The number of individuals in the average aging population ranged from 373 to 1399, and 3 to 7 survey locations were selected accordingly. Ultimately, 15 to 34 older adults in each community were sampled, with high response rates ranging from 88.9% to 100%.

Table 3 summarizes the sociodemographic characteristics, park usage, and health status of our sampled older adults. The monthly income of the subjects in our samples was slightly higher than the city-level average for older adults in Wuhan (2621 yuan versus 2320 yuan, i.e., 383 U.S. dollars versus 339 U.S. dollars) (Wuhan Municipal Bureau Civil Affairs 2014). Our subjects predominantly completed high school education (50.1%) and lived with their spouses (43.1%), while the proportions of their occupations were relatively even. Although our subjects resided in closer proximity to NPs than UOPs (598.6 meters versus 1950.5 meters), the majority (53.4%) preferred UOPs as their regular site to engage in activities. Various dimensions of park quality are indicated by the park satisfaction score. The subjects were relatively satisfied with the overall quality of the park (mean overall score=20.2), and specifically, internal traffic convenience generally received a high score (mean score=4.2), while the completeness of facilities scored lower (mean score=2.9). Regarding the health status of older adults, 70.6% of our subjects suffered from chronic diseases, which is close to the average level in Wuhan (73.18%) (Health and Family Planning Commission of Wuhan Municipality 2015). CCVD and JD were the most prevalent diseases, accounting for more than 30% of the total subjects (35.7% for CCVD and 33.9% for JD).

Table 2 Summary statistics of sampled communities

Characteristics of Sampled Communities	Min	Max	Mean	S.D.
Total Population	822.0	8034.0	4360.3	1954.7
Aging Population	373.0	1399.0	715.8	263.1
Area (ha)	3.7	113.1	35.0	20.4
Number of Survey Locations	3.0	7.0	4.9	1.2
Samples	15.0	34.0	23.3	6.7
Relative Sampling Proportion (%)	2.1	9.9	4.9	2.2
Response Rate (%)	88.9	100.0	95.8	0.0

Table 3 Summary statistics of older adults' characteristics, health status and usage of parks

Variables		
Demographic characteristics		
Age (%)		
60-64 years		25.9
65-74 years		38.6
75-84 years		26.3
>85 years		9.3
Gender (%)		
Male		43.3
Female		56.7
Personal monthly income (yuan)	Mean (S.D.)	2621.4 (1474.9)
Education level (%)		
Primary or below		14.1
Junior		16.3
Senior		50.1
Bachelor's or above		19.4
Household structure (%)		
Three generations		20.4
Couple with grandchildren		19.3
Couple with children		10.0
Couple		43.1
Single		7.2
Occupation before retirement (%)		
Agricultural worker		14.3

Service employee		22.2
Blue collar worker		34.4
Government official		29.1
Location of residents (meters)		
Distance to UOP	Mean (S.D.)	1950.5 (828.0)
Distance to NP	Mean (S.D.)	598.6 (63.9)
Park preference (%)		
Urban omnibus park		53.4
Neighborhood park		46.6
Actual travel distance (meters)	Mean (S.D.)	1356.7 (1586.1)
Satisfaction with parks (1–5-point Likert scale, 1=strongly disagree and 5=strongly agree)		
Internal traffic convenience	Mean (S.D.)	4.2 (0.8)
Scale	Mean (S.D.)	3.1 (1.8)
Security	Mean (S.D.)	3.4 (0.6)
Landscape	Mean (S.D.)	3.2 (1.8)
Management	Mean (S.D.)	3.4 (1.5)
Facilities	Mean (S.D.)	2.9 (1.7)
Health status (%)		
Chronic diseases		70.6
Cardio-cerebral vascular diseases		35.7
Joint diseases		33.9
Digestive diseases		15.1
Endocrine diseases		24.9
Urological diseases		2.3
Nervous system diseases		1.9
Respiratory diseases		15.7

4.2. Park accessibility in Wuhan

4.2.1. Service catchment area

As mentioned above, the substantial difference in the service catchment sizes of UOPs and NPs might be logical under the premise that these two kinds of parks exhibit discrepancies in quality. The scores for satisfaction with parks were used to illustrate the comparison between the quality of UOPs and NPs. The average scores for NPs and UOPs were 18.08 and 22.06, respectively. Significant differences in the scores for several factors were observed between NPs and UOPs: scale (2.63 versus 3.54), management (3.07 versus 3.72), facilities (2.47 versus 3.35) and landscape (2.71 versus 3.65) (**Figure 5**). Accordingly, the attractiveness of NPs might be potentially limited as a result of poor landscapes, mismanagement, and insufficient facilities, all of which contribute to creating a low-quality park environment.

Using scatter plots, the service catchments of different types of parks were determined, which also further illustrate our perspective. **Figure 6** shows a comparison between the actual travel distance to parks and the distance from the residence to the nearest UOP. Within the range of 1800 meters, older adults had a more concentrated selection of UOPs than NPs, and 71.7% of the respondents reported an inclination to use UOPs as their regular location for outdoor activities. When the distance from the residence to the nearest UOP exceeded 1800 meters, older adults became more inclined to choose NPs (85.4%) **(Table 4)**. Based on this finding, UOPs located within a range of 1800 meters were more attractive to older adults than NPs. Therefore, 1800 meters was set as the distance threshold for service catchment of UOPs. Regarding the service catchments of NPs, the proportion of individuals selecting NPs was not obviously different based on an increase in the distance from the residence to the nearest NP **(Table 4 and Figure 7)**, with only 54.4% of the respondents selecting the nearest NP as a regular location. Therefore, proximity is not the only factor that affects the service catchment of NPs. Recent studies have presented a refined method for estimating service catchments according to the scale of the park. Wendel, Zarger & Mihelcic (2012) classified parks by their sizes, and their research group has proposed general criteria to identify service catchment areas of 400 meters (when acreage <1 ha) and 800 meters (when 1 ha<acreage<5 ha). In the present study, we used these distances as the service catchment of NPs to measure accessibility.

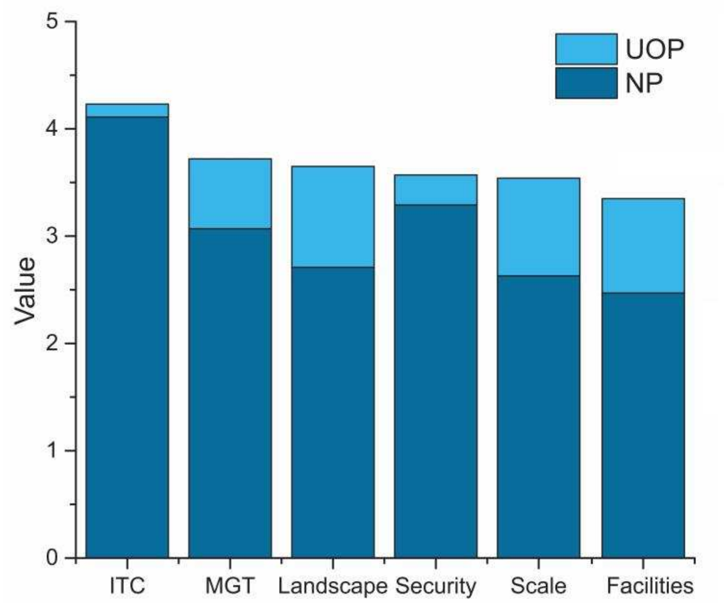

Figure 5 Satisfaction with UOPs and NPs among older adults.

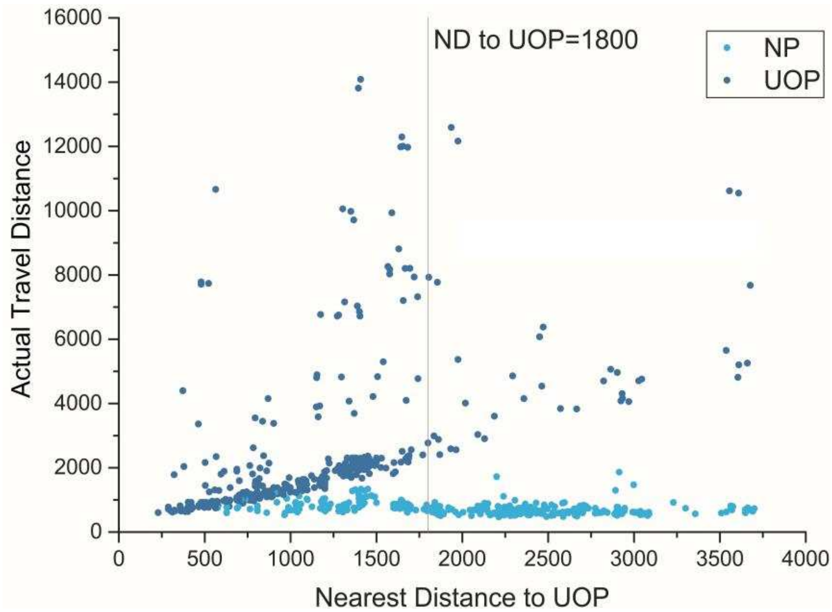

Figure 6 Variations in the actual travel distance of older adults as the distance to the nearest UOPs increased.

Table 4 The tendency of older adults to select NPs with increasing distance to parks

Nearest distance to UOPs (km)	<1.0	1.0-1.2	1.2-1.4	1.4-1.6	1.6-1.8	1.8-2.0	>2.0
Proportion	10.3%	30.6%	35.1%	32.3%	47.5%	73.2%	87.3%
Nearest distance to NPs (km)	0.35-0.40	0.40-0.45	0.45-0.50	0.50-0.55	0.55-0.60	>0.60	
Proportion	47.5%	53.2%	53.7%	36.7%	48.1%	59.7%	

Abbreviations: urban omnibus parks (UOPs), neighborhood parks (NPs).
Note: The proportion refers to the percentage of older adults who selected neighborhood parks as their regular place to engage in activities based on the distance to the park.

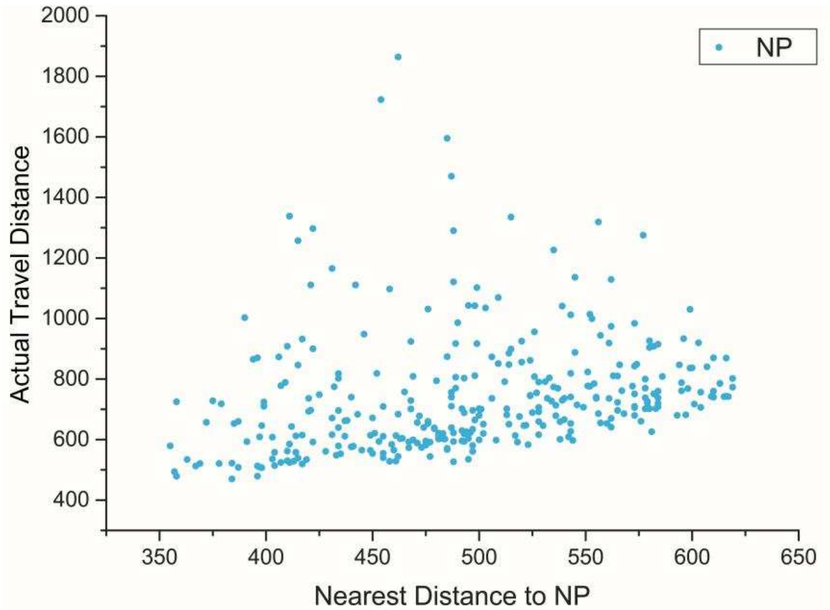

Figure 7 Variations in the actual travel distance of older adults as the distance to the nearest NP increased.

4.2.2. Travel catchment area

The travel catchments of older adults were determined using a regression model. **Table 5** indicates that the health status of older adults was not correlated with the actual travel distance to NPs. This finding might be due to the relatively short travel distance from the residence to the NPs, resulting in a lack of a significant impact of the travel catchment of NPs on the health of older adults. Therefore, the health status variable was removed from the estimation of the travel catchment area for NPs. Older adults residing in the city center, particularly in the region along the Yangtze River in Wuhan, travel a short distance to parks; thus, their travel catchments are smaller than those for individuals residing in other areas (**Figures 8A and B**), and they only choose NPs within a modest travel distance due to the weaker attractiveness of NPs. Accordingly, this choice produced greater variations in the travel catchments for UOPs than for NPs.

Table 5 Results from regression models used to determine the travel catchment of older adults

	UOP			**NP**		
Variable	Beta	T-value	P-value	Beta	T-value	P-value
Constant	137.712	2.626	0.009**	544.313	7.107	0.000**
Nearest Distance to UOP/NP	1.344	9.790	0.000**	0.545	3.375	0.001**
Health Condition						
Fitness	151.580	2.356	0.019*	37.093	0.508	0.612
Chronic Disease					Reference	

Abbreviations: urban omnibus park (UOP), neighborhood park (NP).
*P<0.05, **P<0.01.

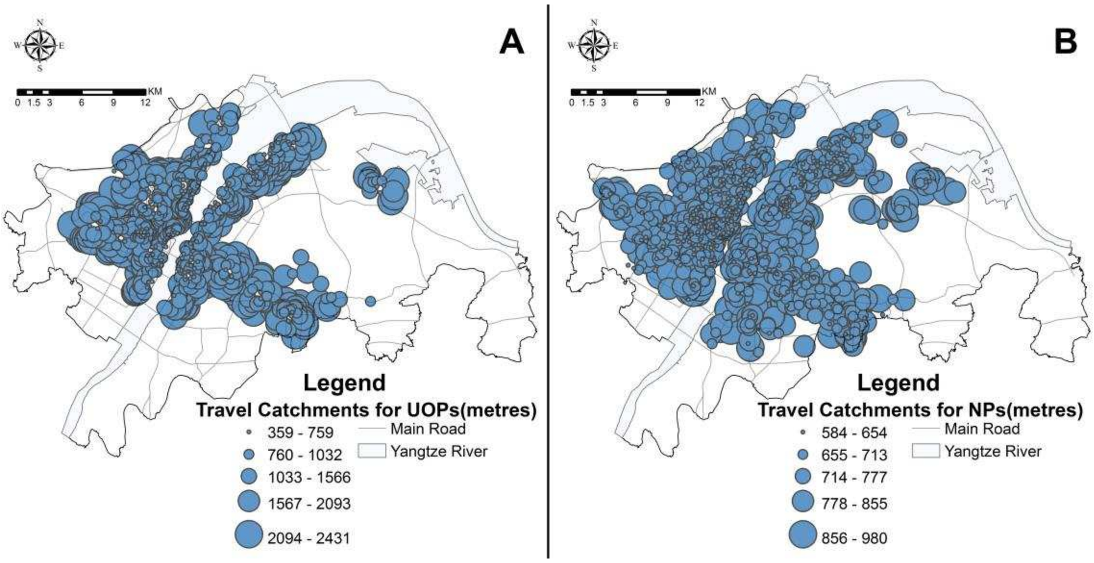

Figure 8 Travel catchment sizes of healthy older adults for UOPs **(A)** and NPs **(B)**.

4.2.3. Park accessibility

Ultimately, the current study estimated the accessibility of parks for healthy older adults in Wuhan. As shown in **Figure 9**, the distribution of the accessibility index exhibits strong geographic variations. The accessibility index was higher in the urban core than in the urban fringes, particularly in areas along the Yangtze River. Despite the high density of the aging population and the small number of parks in these areas, most of the parks are linear UOPs with a sufficient area that extends for several kilometers, which might potentially provide greater accessibility for older adults.

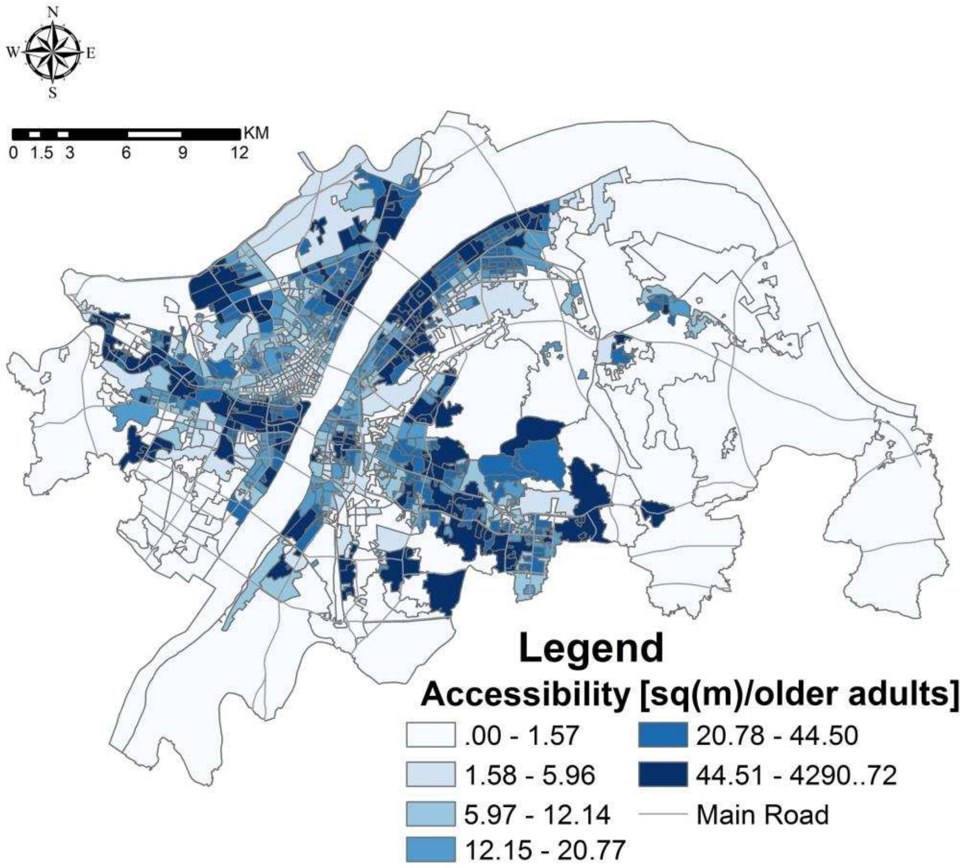

Figure 9 The accessibility of parks from the perspective of healthy older adults.

4.3. Association between the accessibility of parks and the health status of older adults

Logistic regression analyses were used to examine the correlation between the accessibility of parks and occurrence of chronic diseases among older adults. Based on the quartile statistics, the accessibility score (ACS) was divided into four levels, and four corresponding geographical zones were created based on this calculation: the low ACS zone (ACS ranging from 0 to 3.67), medium-low ACS zone (ACS ranging from 3.68 to 12.41), medium-high ACS zone (ACS ranging from 12.42 to 29.15) and high ACS zone (ACS score ranging from 29.16 to 4290.72). We then used the low ACS zone as a reference and analyzed the odds of the development of typical diseases for healthy older adults in the higher ACS zones by calculating odds ratios (ORs).

After controlling for individual sociodemographic characteristics, the accessibility of parks exhibited negative correlations with the occurrence of CCVD, JD, and ED in older adults, exhibiting a decreasing trend from the low ACS zone to the high ACS zone **(Figure 10)**. Starting with the low ACS zone, the ORs for typical diseases in older adults residing in the higher ACS zone decreased gradually with an increase in accessibility. In addition, as shown in **Table 6**, the highest quartile of park accessibility displayed significant negative correlations with the odds of developing CCVD (OR: 0.577; CI: 0.366-0.910), JD (OR: 0.599; CI: 0.376-0.952), and ED (OR: 0.580; CI: 0.350-0.962) among older adults. The highest ORs for the three typical diseases were observed in the low ACS zone. In contrast, the lowest ORs were observed in the high ACS zone, namely, the values were 40% to 42% of those in the low ACS zone. Moreover, regarding JD and ED, the odds of developing these two diseases in the medium-high ACS zone were also approximately 38% (OR: 0.618; CI: 0.396-0.966) and 39% (OR: 0.606; CI: 0.357-0.980) of those in low ACS zone, respectively, indicating that the accessibility of parks exerted greater preventative effects on these diseases than other diseases. However, the correlations between the accessibility of parks and RD, DD, NSD and UD remained unclear in the current study.

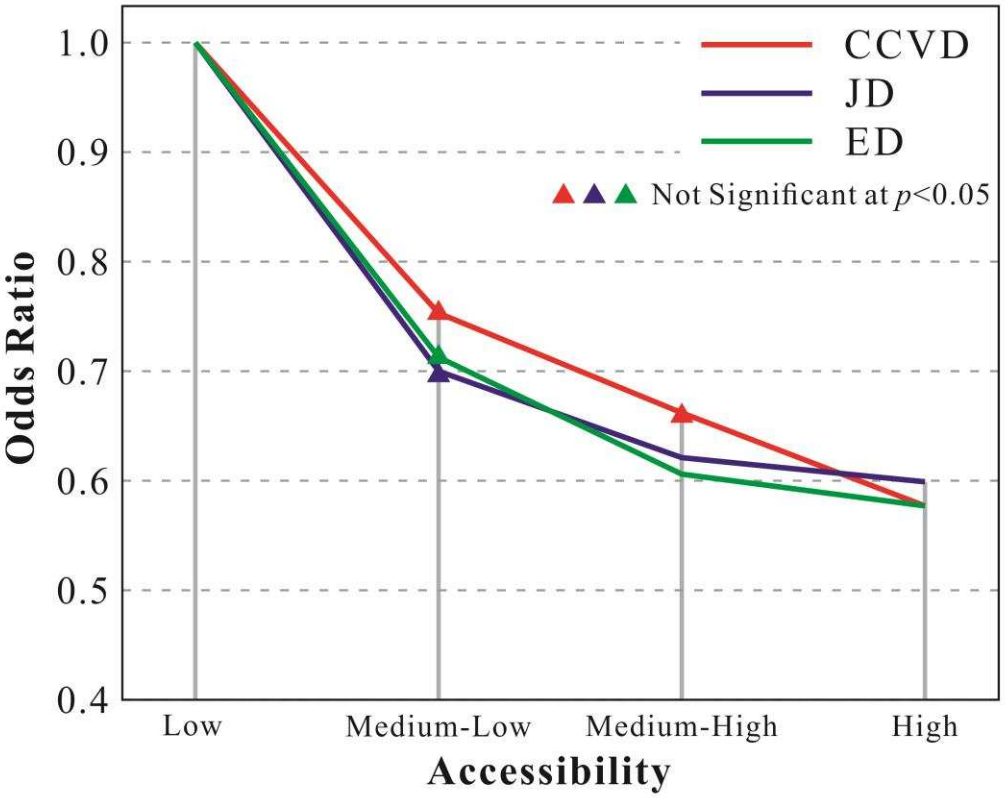

Figure 10 The ORs for CCVD/JD/ED for different accessibility zones.

Table 6 The relationship between the risks of diseases and the accessibility of parks

	Medium-low		**Medium-high**		**High**	
Diseases	ORs	95% CI	ORs	95% CI	ORs	95% CI
CD	0.788	0.491-1.265	0.998	0.625-1.568	0.742	0.456-1.208
CCVD	0.753	0.494-1.256	0.662	0.435-1.007	0.577 *	0.366-0.910
JD	0.704	0.456-1.085	0.618 *	0.396-0.966	0.599 *	0.376-0.952
DD	0.934	0.522-1.673	1.059	0.612-1.834	0.745	0.496-1.206
RD	0.966	0.540-1.714	0.875	0.509-1.501	0.576	0.307-1.080
NSD	1.034	0.197-5.443	1.918	0.439-8.381	0.939	0.151-5.859
ED	0.707	0.447-1.118	0.606 *	0.357-0.980	0.580 *	0.350-0.962
UD	0.724	0.209-2.489	0.845	0.248-2.873	NA	

Abbreviations: chronic diseases (CD), cardio-cerebral vascular diseases (CCVD), joint diseases (JD), digestive diseases (DD), endocrine diseases (ED), urological diseases (UD), nervous system diseases (NSD) and respiratory diseases (RD).

Note: Regression analyses were adjusted for age, gender, monthly income, education, occupation, and household structure. NA indicates that no older adults in the investigation suffered from urogenital diseases in the high accessibility zone.

*P<0.05.

5. Discussion

Based on the findings from the present study, older adults who reside in a high ACS zone tend to have lower risks of developing CCVD, JD, and ED compared with their counterparts in low ACS zones after controlling for individual sociopersonal characteristics. The accessibility of parks might reflect the potential availability of parks, and it is jointly associated with physical environments and the sociopersonal context. Under the simultaneous influence of these two crucial dimensions, differences in the choice of parks and participation in park-based activities among older adults are generated, thereby resulting in potential health inequalities.

5.1. Role of the physical environment in the association between park accessibility and healthy aging

The physical characteristics of parks and the surrounding physical environment, namely, the distribution, proximity, size and quality of parks, as well as the local road networks, affect the accessibility of parks. In low ACS zones, the availability of parks to older adults is limited by combinations of these factors, which in turn exposes this group to greater health risks.

Specifically, a long travel distance to parks and insufficient road networks are not conducive to regular visits by older adults, who generally suffer from limited mobility and cognitive deficits and thus rely more on local environments (Yen, Michael & Perdue 2009). Accordingly, these transportation barriers potentially restrict the alternatives available to older adults, and in the worst cases, they would even have no parks to visit. The size and quality of parks also influence the ability of older adults to experience park-based activities, including participation in both physical and social activities, and thereby their health status. The usage of parks by older adults is strongly correlated with the park size, the organization of activities, and the availability of equipment and amenities (Cohen et al. 2010; Kaczynski et al. 2016). Within a specific distance threshold, such as the service catchments of UOPs identified in this research, high-quality and large parks are more attractive to older adults. Under these circumstances, parks are not simply a travel destination, as regular park-based activities might be promoted. An ample park area and ideal facilities encourage participation in outdoor activities (Kaczynski et al. 2016), which has positive effects on CCVD and diabetes (Hillsdon, Foster & Thorogood 2005; Hu et al. 2001) and might also improve the muscle strength of older adults and reduce the risk of JD (Omori et al. 2013). Sufficient support facilities, such as benches and pavilions, potentially encourage socialization and enhance social capital though longer park visits (Baur & Tynon 2013; Mowen & Rung 2016), which help improve self-management and prevent chronic diseases (Farajzadegan, Jafari, Nazer, Keyvanara & Zamani 2013).

5.2. The sociopersonal context correlates with park accessibility and healthy aging

In addition to the physical environment, the sociopersonal context also plays a crucial role in shaping park accessibility and subsequently affects the health status of older adults. First, a large population, particularly a large aging population, will have negative effects on the supply-demand balance between parks and park visitors. Park congestion might limit the opportunities to use facilities, particularly necessary rest facilities (Sister et al. 2010), and this conflict can be further exacerbated by the increasing number of older adults who are prone to fatigue. Moreover, a high visitor density within parks might not only interfere with the park site and recreational experiences but also weaken the motives for park visitation (Arnberger & Brandenburg 2007; Ekkel & Vries 2017). For individuals who greatly value their leisure-time activities, the crowding barrier would accordingly hinder the accessibility and availability of parks among older adults.

Second, discrepancies in mobility, which are closely associated with individual socioeconomic characteristics, might also lead to disparities in park accessibility and health status. A high level of mobility provides older adults with more alternatives when selecting a park to visit for their daily activities. Conversely, a low level of mobility limits the options of older adults, forcing them either to refrain from engaging in physical activities or to visit poor-quality parks, contributing to a higher risk of disease. Park accessibility is often stratified by individual socioeconomic variables (Wüstemann, Kalisch & Kolbe 2017). In general, marginalized groups have poor access and lower utilization of parks and, in turn, greater risks of developing health problems (Boone, Buckley, Grove & Sister 2009; Markevych et al. 2017). The present study controlled for individual sociopersonal characteristics to eliminate the effects of confounding factors. However, the internal connection between mobility and sociopersonal characteristics and the effects of mobility on park accessibility cannot be neglected. Based on the existing evidence, characteristics associated with higher SES are also associated with better functional mobility (Koster et al. 2005), which is reflected by travel behaviors and patterns among older adults (Cui, Loo & Lin 2017; Hildebrand 2003). Therefore, for older adults residing in the same community, individuals with a higher SES might have better than average access to parks due to their higher mobility. In areas with low average park accessibility where older adults have either no or limited access to parkland resources, the impact of individual SES becomes much more crucial. Therefore, a higher SES might help to offset the negative effects of access to poor-quality parks from the perspective of mobility, whereas deprived residents tend to be restricted by the spatial inequality of parks and are at higher risks of developing health problems. Thus, strategies designed to ensure the provision and quality of parks in deprived communities are particularly important to safeguard health equity.

6. Conclusions

This article presents a framework for exploring the association between the accessibility of parks and the health status of older adults in urban China. A new approach was developed based on the classic 2SFCA method to operationalize the accessibility of parks while simultaneously considering physical environments and the sociopersonal context. Using separate logistic regression models, we examined the association between the health status and the accessibility of parks for older adults. After controlling for individual sociodemographic characteristics, the highest ORs of CCVD, JD, and ED were observed in the low ACS zone, and the values decreased to varying degrees based on accessibility, eventually reaching their lowest levels in the high ACS zone.

Our research provides empirical support for the role of parks in supporting healthy aging. It also helps us to identify the unfavorable elements and areas with low park accessibility, thereby providing a scientific basis for urban planning to improve park environments and promote public health. In general, the physical environment and the sociopersonal context jointly influence the potential alternatives for parks and participation in park-based activities among older adults and in turn impact the health benefits experienced by older adults. Accordingly, strategies promoting accessibility, as reflected in these two dimensions, should be treated as the central target for park planning. Moreover, the “one-size-fits-all” park planning approach should be completely reconsidered, since the classic planning strategy to build more parks to offset the transportation barrier and spatial inequality might be untargeted, insufficient, and not cost effective.

The current research also had some limitations. First, the current research did not employ the classic door-to-door sampling method due to limited information on the home addresses of older adults. Moreover, the number of questionnaires obtained from each survey location might be inconsistent. These issues potentially impacted the randomness of the sampled groups (e.g., older adults who stayed in their homes might not go to the park on a regular basis) and could have led to biased results. In addition, physical activity and social interactions were not quantified. We have not determined how these factors mediate the association between park accessibility and the health status of older adults. Therefore, a more systematic sampling method would be helpful to ensure a robust analysis. Second, because numerous factors affect the health of older adults, additional factors such as smoking history, drinking behavior and medical insurance participation should be considered in future studies. Additionally, the mediators of the association between park accessibility and different health statuses should be quantified to better understand causality.

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