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Negative Associations between Quality of Urban Green Spaces and Health Expenditures in Downtown Shanghai

Liqing Zhang * and **Yue Wu**

Department of Landscape Architecture, School of Design, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, China
* Correspondence: liqingzh@sjtu.edu.cn; Tel.: +86-021-34205743

Abstract: The health–beneficial value of urban green spaces (UGS) is increasingly accepted by scholars. However, compared to the large number of studies focused on UGS–health associations, whether UGS in high-density cities could reduce public health expenditures remains less investigated. In particular, few studies have examined the association of UGS quality with health expenditures. Therefore, we conducted a cross-sectional study in downtown Shanghai to examine such associations. A population-based household survey (n = 1000) was conducted to collect relevant information about different aspects of health expenditure and the characteristics of UGS. Specifically, a new method was proposed to measure UGS quality based on the supply–demand of 20 types of UGS activities. We also measured the perceived quality of different types of UGS and quantified the amount of UGS using GIS based on remote sensing data. Regression models were applied for statistical analysis. The results showed that both UGS quality based on user needs and perceived UGS quality have a significant negative association with total health expenditures. This study provides insights for UGS quality measurement, contributes to the understanding of the health-related economic benefits of UGS, and also highlights the importance of UGS optimization in high-density urban areas.

Keywords: urban green spaces (UGS); health expenditure; quality of UGS; supply–demand of UGS activities; Shanghai

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1. Introduction

Rapid urbanization has led to an increasing disconnection between urban dwellers and nature, and simultaneously, urban life poses global health challenges as the Sustainable Development Goals call for the construction of healthy cities. Promoting health and controlling rising health care costs are major concerns for urban areas, so the health benefits of urban green space (UGS) are now receiving increasing attention. In the past three decades, various scholars have explored the association between UGS and different health outcomes through cross-sectional studies, longitudinal studies, or field experiments [1–5]. It was found that most of the relevant studies were concentrated in Europe and North America [5]. Numerous studies have proved that UGS can provide a wide range of short- or long-term health benefits, such as physical and mental health [6–8], self-reported health [9], reduced morbidity [10], and improved mortality [10,11]. In addition, evidence has also been produced showing the positive association of UGS with specific diseases, including diabetes [12], cardiovascular health [13], respiratory diseases [14], and the risk of overweight or obesity [15]. Moreover, UGS has been studied for its ability to enhance population well-being and social welfare [16].

Therefore, it can be expected that the health benefits provided by UGS can lead to a reduction in health expenditures, and recently scholars have begun to explore the associations of UGS with health expenditures. Becker, et al. [17] examined the association between land cover and health care spending in more than 3000 counties in the United States, and found that forest and shrub covers were inversely related to the median Medicare fee-for-service spending. Similarly, Kabaya [18] found mixed forest coverage and urban–forest proximity have a significantly inverse long-run association on per capita health expenditure at the prefectural level in Japan. Van Den Eeden, et al. [19] investigated the members of Kaiser Permanente Northern California (KPNC), and observed a significant negative relationship between higher residential green cover and lower direct health care costs. Becker and Browning [20] found a statistically significant and largely negative association between greenness and per capita geographically standardized Medicare spending at the county level in the US. Opposite results were also observed, and Astell-Burt, et al. [21] reported a positive association between tree canopy, grassland, and mental health expenditures by analyzing the relevant records in a large sample of individuals from three Australian cities.

However, in high-density cities, there is still very limited research focusing on the impact of UGS on health expenditures. Furthermore, most of the existing research has focused on exploring the association between the quantity of UGS and health expenditures based on administrative statistics rather than surveys of individuals [20]. Few studies have been conducted to examine the association between green space quality and health expenditures in high-density cities in China. If it can be demonstrated through empirical research that there is indeed some association between UGS and health expenditures, this research will help to enrich the literature on the economic value of UGS in providing health-related benefits to residents.

Currently, plentiful research works on UGS focus on the assessment of their quantity and accessibility [22]. For instance, Gupta, et al. [23] and Kuang and Dou [24] developed new algorithms to assess the quantity and distribution of UGS based on remote sensing techniques. Chen, et al. [25], Zheng, et al. [26], and Rao, et al. [27], on the other hand, explored the spatial patterns and differences in green space accessibility in terms of equity. Furthermore, research on UGS and health also has mainly focused on the association between the quantity of UGS and health outcomes [3]. Mitchell, et al. [10] reported that larger green spaces may be more important for health than smaller spaces through different indicators of UGS quantity. Wood, et al. [28] and Feng and Astell-Burt [29] both reported that the number of green spaces was closely associated with greater mental wellbeing. In recent years, the assessment of UGS quality has undergone exploration and development. Many studies developed assessment tools based on particular research focus and available resources, while other studies either adapted existing tools or created one-off tools that met the specific research needs [30]. For instance, Hugheya, et al. [31], and Gidlow, et al. [32] measured the quality of individual UGS by developing a site audit tool. In addition, Vidal, et al. [33] and Stessens, et al. [34] assessed the quality of green space based on the ecosystem services they provide. Kraemer and Kabisch [35] incorporated spatial context as a key dimension in determining green space quality. Moreover, the association between UGS quality and health is also gradually being explored more; De Vries, et al. [36] found that even though both quantity and quality of streetscape greenery were related to perceived general health, relationships were generally stronger for UGS quality than for quantity. Zhang, et al. [37] similarly reported that perceived usage quality was more important to mental health than objective quantity and visual greenness.

Many audit tools have been developed to objectively examine green space quality from different perspectives [30,38,39]. However, existing assessment methods rarely consider whether the quality of UGS meets the specific demand of users from a user's perspective. In fact, measuring the quality of UGS from a supply–demand perspective is more in line with the concept of sustainable development because this allows for a more rational and efficient layout of UGS to maximize their benefits within a tight urban land supply [40]. In high-density cities, the situation of a vast population living on limited land requires space construction to be transited from simply increasing the number and amount of UGS to optimizing the quality of existing UGS. Populations with different demographic characteristics may also have different demands for specific functions of UGS [41]. Measuring green space quality based on users' needs can deepen our understanding of the actual characteristics of

UGS from the social perspective and help to identify the specific qualitative aspects of UGS that need to be optimized.

Therefore, this research aims to assess the quality of UGS based on users' demand and its association with health expenditures, using downtown Shanghai as a case study. As a high-density urban area, all types of land use in Shanghai are tight, and how UGS can be more efficient in promoting health needs more profound thinking. Assessing the quality of UGS and its association with residents' health expenditure in downtown Shanghai has important implications for guiding the optimization of UGS in high-density cities and urban medical management. In particular, this study aims to answer the main research question: to what extent could UGS quality help to reduce the health expenditures of Shanghai residents?

2. Research Methods

2.1. Study Area

As one of the largest cities in China, Shanghai is a typical high-density city with a large and compact population. It is located between 120°52′ and 122°12′ East longitude and 30°40′ and 31°53′ North latitude. The region has a subtropical monsoon climate with an average annual temperature of about 15 °C and average annual precipitation of 1000–1200 mm. In 2020, the population density of downtown Shanghai area had reached 23,092 people/km^2 (Shanghai Bureau of Statistics, 2020). In this study, we identified Huangpu District, Jing'an District, Hongkou District, Yangpu District, Xuhui District, Changning District, and Putuo District as downtown Shanghai (Figure 1).

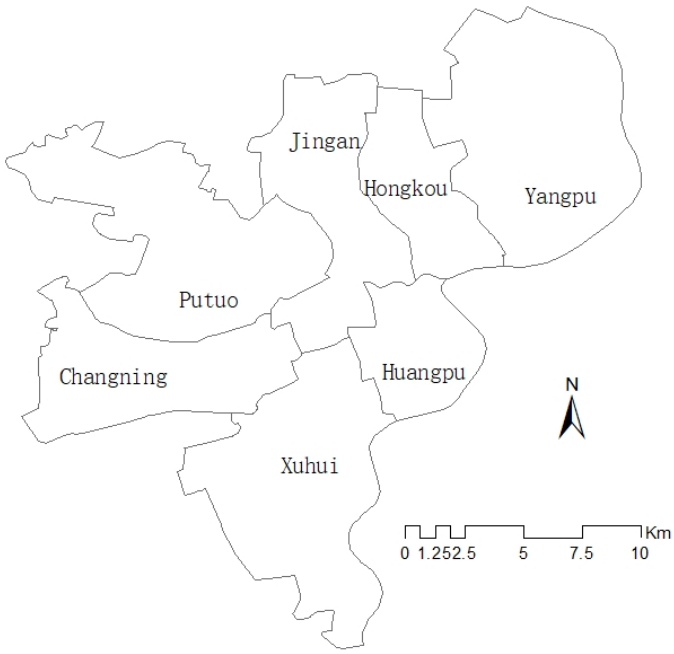


Figure 1. The boundaries of the downtown Shanghai area and the administrative districts included in this study.

2.2. Research Methodology

2.2.1. Household Survey

We selected a representative sample of 1000 respondents in downtown Shanghai, with the spatial distribution and demographic structure similar to the overall population, to conduct a household questionnaire survey in February and March, 2021. Only permanent residents of Shanghai (not younger than 18 years old) who have lived in the same residence for more than one year were included as eligible respondents. They were asked to answer about their health expenditures over the past half year by referring to their medical records. Specifically, six items about different aspects of health expenditures were asked: medical treatment expenses; medical insurance expenses; health care product expenses; expenses for health-related books and courses total health expenditures; and frequency of medical visits. Respondents were asked to rate each health expenditure item. Individual health expenditures were divided into seven intervals ("no expenditure", "less than CNY 100", "CNY 100–1000", "CNY 1000–2000", "CNY 2000–5000", "CNY 5000–10,000", and "more than CNY 10,000"), while total health expenditures were divided into eight intervals ("no expenditure", "less than CNY 100", "CNY 100–1000", "CNY 1000–2000", "CNY 2000–5000", "CNY 5000–10,000", "CNY 10,000–20,000", and "more than CNY 20,000"). Similarly, they were asked to describe the frequency of medical visits based on the following answers: "0 visits", "1–2 visits", "3–5 visits", "once a month" and "twice or more per month". Two self-reported health outcomes were also included in our questionnaire. General health was measured by a single General Self-Rated Health (GSRH) question [42] and mental health was measured by GHQ-12 [43]. The questionnaire also included possible confounding factors such as respondents' demographic, socioeconomic, and risk factors (alcohol consumption and smoking habits) that may impact the health expenditure. In addition, questions about UGS perception were included in the questionnaire.

2.2.2. UGS Assessment

Objective Quantity of UGS

The amount of UGS was determined according to different types of vegetation cover based on remote sensing data mapped by Gong, et. al. [44]. As the Euclidean distance for a five-minute walk is generally accepted as 400 m [45], the percentage of cropland, forest land, and grassland was calculated within the 400 m buffer surrounding the respondents' residential places. The sum of these three types was also calculated as an indicator of UGS quantity.

Quality of UGS Based on User Needs

Users' demands for UGS can be reflected by their demands for the various activities taking place in the UGS [46]. Therefore, we divided the activities performed in UGS into 20 categories based on previous literature and local conditions; these details are presented in Table 1. In the questionnaire survey, respondents were asked to rate their demand for each type of UGS activity (the higher the score, the higher the demand) and how well the current state of nearby UGS surrounding their residence met their demand for that activity (the higher the score, the better the satisfaction). Their satisfaction reflects the supply of UGS for each type of activity, so a higher satisfaction level indicates a higher UGS supply level. Respondents were asked to rate each of the two components on a scale of 1 to 5. Based on these two items, we calculated the supply–demand variance (supply minus demand), for each activity type separately, which represented the UGS quality based on users' needs, while the average variance represents comprehensive UGS quality.

Perception of UGS

Three indicators were used to measure the quantity of nearby UGS. Here, nearby UGS refers to the green spaces within a 20 min walk of their residence, approximately 1.6 km off the residence. First, we asked respondents about the total number of UGS (Total UGS) near their residence ("1–2", "3–4", "5–6", "7–8", "more than 9", coded as 1, 2, 3, 4, 5). We also investigated the amount of nearby UGS ("Very inadequate", "Inadequate", "General", "Adequate", "Very adequate") to indicate respondents' perceived quantity of UGS. Respondents' perception of the greenery coverage (1. 0–10%, 2. 10–20%, 3. 20–30%, 4. 30–40%, 5. 40–50%, 6. 50–60%, 7. 60–70%, 8. 70–80%, 9. 80–90%, 10. more than 90%) was also asked in the questionnaire. Furthermore, we examined the quality of several sub-categories of UGS, including nearby UGS, most frequently visited UGS, favorite UGS, community UGS, and workplace UGS. For each type of UGS, respondents were asked to rate the perceived quality ("very bad", "bad", "general", "good", "very good", coded as 1, 2, 3, 4, 5).

Table 1. UGS categories.

Category	Activity	Reference
Social activities	1. Chatting and other daily social interaction 2. Make friends, date 3. Picnics, camping, and other group activities 4. Parent-child activities	Kelly, et al. [47], Lay-Yee, et al. [48], Min, et al. [49]
Physical activities	5. Walking 6. Gardening 7. Cycling 8. Dog walking 9. Running, hiking, climbing 10. Ball activities (e.g., badminton and basketball) 11. Square dancing, martial arts, Tai Chi, yoga 12. Using fitness equipment	Akpinar [50], Ali, et al. [51], Mao, et al. [52], Mytton, et al. [53]
Activities related to nature	13. Viewing plants, animals, and other natural landscapes 14. Enjoying water features (lakes, streams, fountains, etc.) 15. Water-friendly activities (fishing, boating, etc.)	Baceviciene, et al. [54], Puhakka [55]
Cultural activities	16. Meditation, contemplation, reading 17. Playing chess, mahjong 18. Singing, playing instruments, writing brush calligraphy 19. Using amusement facilities 20. Festivals, history and cultural activities, public welfare activities, science exhibitions	Cuypers, et al. [56], Theorell and Nyberg [57], Yamaoka, et al. [58]

2.2.3. Statistical Analyses

The statistical analyses were performed in IBM SPSS Statistics 26 (IBM Corp., Armonk, NY, USA), and all 1000 responses were included in the statistical analyses. We first analyzed the overall social demographic characteristics of the sample, self-reported health outcomes, and health expenditures using descriptive analysis. The socio–demographic and other risk variables were then checked for whether they are confounders by bivariate correlation analysis. The identified confounders were included in the regression models for adjustment. Multiple logistic regression models were developed to examine the association of each UGS variable with health outcomes and health expenditure variables, controlling for confounding factors. For each model, the odds ratio (OR), significance (p-value), standard error, and 95% confidence interval (CI) were calculated to demonstrate the size and significance of the association.

3. Results

3.1. Study Population Characteristics

The main characteristics of the sample population are shown in Table 2, where 51.4% of the respondents were male and 48.6% were female. Shanghai locals accounted for 94.4% of the respondents, 93% of the respondents own their own residence and only 7% live in rented housing.

Tables 3 and 4 present the health status and health expenditures of the respondents. 31.9% reported their general health as "very good" and 48.8% were in "good" condition. The results of the GHQ-12 questionnaire showed a similar pattern, with a percentage of 84.9 in a "good" situation. In terms of health expenditures, more people do not spend on health insurance (72.4%), equipment and health products (62.2%), and books and courses (84.2%). However, the expenses on medical treatment (under CNY 100: 21.1%, CNY 100–1000: 31.2%, CNY 1000–2000: 14.8%) are more common. Total health expenditures were more concentrated in the CNY 100–1000 (25.1%) and CNY 1000–2000 (35.9%) ranges. In addition, 41.9% of respondents reported 0 visits to the doctor and 31.7% reported 1–2 visits. Only 5.6% of the respondents visited the doctor twice or more per month.

3.2. UGS Assessment

3.2.1. UGS Quantity

As shown in Table S3, among all the respondents, under half of them reported an adequate (44.2%) or very adequate (2%) perceived quantity of nearby UGS. A small total amount of UGS (1–2: 47.6%, 3–4: 46.8%) was commonly reported. The greenery coverage (20–30%: 47.1, 30–40%: 39.3%) performs in line with this. For the quantity of UGS within the 400 m buffer zone, we counted the average values of area percentage (cropland: 7.51%, forest: 0.85%, grass: 0.10%, sum: 8.45%), and maximum values (cropland: 49.13%, forest: 21.62%, grass: 1.19%, sum: 52.08%), respectively.

Table 2. Respondents' socio–demographic characteristics.

Variables		Sample Size (Proportion)	Variables		Sample Size (Proportion)
Residence status	Owned	930 (93.0)	Occupation	Full-time	264 (26.4)
	Lease	70 (70.0)		Part-time	6 (0.6)
Housing size	Less than 15 m^2	1 (0.1)		Free job	35 (3.5)
	15–30 m^2	36 (36.0)		Retirement	415 (41.5)
	30–80 m^2	739 (73.9)		Student/Military	123 (12.3)
	80–100 m^2	129 (12.9)		Housewife	157 (15.7)
	Over 100 m^2	95 (9.5)	Number of children	No child	801 (80.1)
Domicile Location	Shanghai	944 (94.4)		1	193 (19.3)
	Outland	56 (5.6)		2	6 (0.6)
Gender	Male	514 (51.4)		3 or more	0 (0)
	Female	486 (48.6)	Monthly income per capita	No income	147 (14.7)
Age	18–24	80 (0.8)		Less than CNY 1500	1 (0.1)
	25–34	100 (10.0)		CNY 1500–2488	3 (0.3)
	35–44	190 (19.0)		CNY 2500–3499	7 (0.7)
	45–54	170 (17.0)		CNY 3500–4999	337 (33.7)
	55–64	160 (16.0)		CNY 5000–6999	306 (30.6)
	65–74	269 (26.9)		CNY 7000–9999	156 (15.6)
	75–84	31 (3.1)		CNY 10,000–15,000	24 (2.4)
Marriage Status	Unmarried	241 (24.1)		CNY 15,000–20,000	14 (1.4)
	Married	679 (67.9)		Over CNY 20,000	5 (0.5)
	Widowed and bereaved	53 (5.3)	Monthly household income	No income	0 (0)
	Divorce/Separation	27 (2.7)		Less than CNY 1500	0 (0)
Academic Qualifications	Primary and below	0 (0.0)		CNY 1500–2499	0 (0)
	Junior High School	17 (1.7)		CNY 2500–3499	0 (0)
	High School and Technical Secondary School	163 (16.3)		CNY 3500–4999	6 (0.6)
	Junior College	498 (49.8)		CNY 5000–6999	25 (2.5)
	Undergraduate	257 (25.7)		CNY 7000–9999	200 (20)
	Master	50 (5.0)		CNY 10,000–15,000	267 (26.7)
	PhD	15 (1.5)		CNY 15,000–20,000	234 (23.4)
				Over CNY 20,000	268 (26.8)

Table 3. Respondents' health outcomes.

Variables		Sample Size (Proportion)
General health	Very good	319 (31.9)
	Good	488 (48.8)
	General	185 (18.5)
	Bad	8 (0.8)
	Very bad	0 (0)
Mental health (GHQ-12)	Poor	151 (15.1)
	Good	849 (84.9)

Table 4. Health expenditures.

Variables		Sample Size (Proportion)	Variables		Sample Size (Proportion)
Total expenses on health	None	221 (22.1%)	Expenses on devices and health products	None	622 (62.2%)
	Less than 100	74 (7.4%)		Less than 100	101 (10.1%)
	100–1000	251 (25.1%)		100–1000	225 (22.5%)
	1000–2000	359 (35.9%		1000–2000	52 (5.2%)
	2000–5000	91 (9.1%)		2000–5000	0 (0%)
	5000–10,000	4 (0.4%)		5000–10,000	0 (0%)
	10,000–20,000	0 (0%)		More than 10,000	0 (0%)
	More than 20,000	0 (0%)			
Expenses for medical treatment	None	320 (32.0%)	Medical insurance expenses	None	724 (72.4%)
	Less than 100	211 (21.1%)		Less than 100	52 (5.2%)
	100–1000	312 (31.2%)		100–1000	112 (11.2%)
	1000–2000	148 (14.8%)		1000–2000	107 (10.7%)
	2000–5000	9 (0.9%)		2000–5000	4 (0.4%)
	5000–10,000	0 (0%)		5000–10,000	1 (0.1%)
	More than 10,000	0 (0%)		More than 10,000	0 (0%)
Number of medical visits	0	419 (41.9%)	Health-related books and course expenses	None	842 (84.2%)
	1–2 times	317 (31.7%)		Less than 100	143 (14.3%)
	3–5 times	109 (10.9%)		100–1000	15 (1.5%)
	Once a month	99 (9.9%)		1000–2000	0 (0%)
	Two or more times a month	56 (5.6%)		2000–5000	0 (0%)
				5000–10,000	0 (0%)
				More than 10,000	0 (0%)

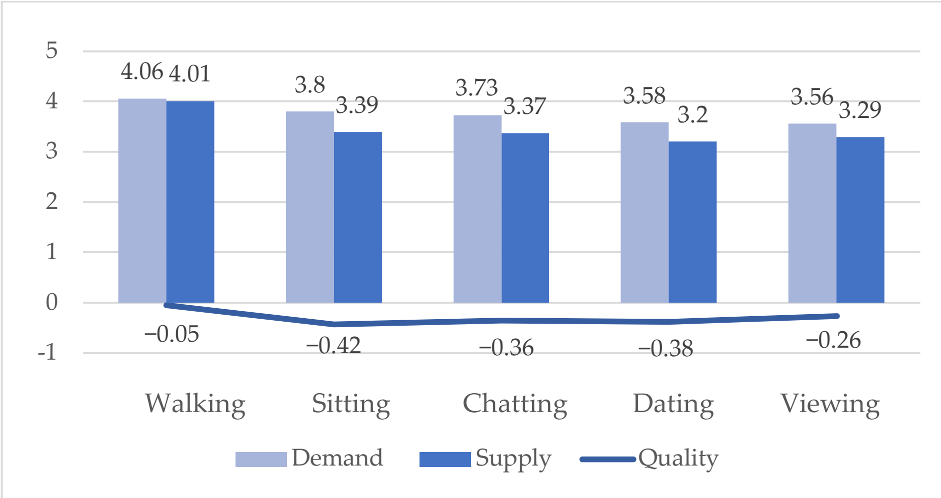
3.2.2. Perceived UGS Quality

Table S4 in the Supplementary Material shows the overall picture of the perceived quality variables for different types of UGS. The overall quality of the nearby UGS was rated as "good" (62.4%) centralized by the respondents. For the most frequently visited UGS, the vast majority of quality was rated as good (61.1%) and very good (20.5%). The percentage of respondents who rated the most preferred UGS quality as good and very good reached 68.2% and 27.9%, respectively. However, regarding community UGS, more than 60% (average quality: 46.8%, bad quality: 15.3%) of the respondents considered the quality to be at and below the average.

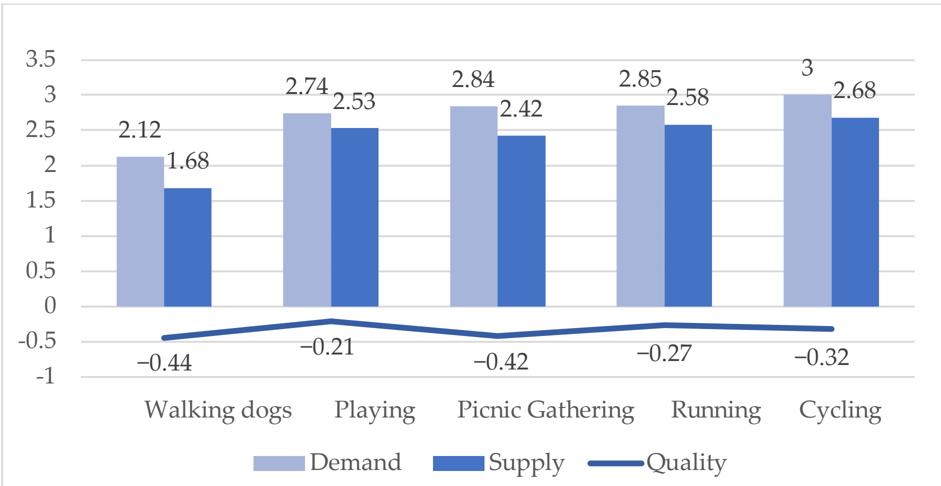
3.2.3. UGS Quality Based on User Needs

First, we examined the reliability and validity of the questions for UGS activities. We found that Cronbach's α = 0.952, and all the questions passed the validity test. These implied a very good internal consistency of our questionnaire for UGS assessment based on user needs.

Table S5 in the Supplementary Material reported the respondents' evaluation for each type of UGS activity. Among the 20 activities, Walking is the activity for which people have the highest demand, and also the activity for which the current status of UGS supply is most adequate. In addition, all quality indicators are negative. This meant that the current status of UGS supply is generally unable to meet the demands of people for various activities. At the same time, we identified the five activities with the highest demand (walking, sitting, chatting, dating, viewing) and the five activities with the lowest demand (dog walking, playing, picnic and gathering, running, cycling) from the respondents (Figure 2). We also discovered the five activities with the best quality (walking, playing chess and mahjong, using fitness equipment, singing, dancing) and the five activities with the worst quality (gardening, dog walking, science, picnic, sitting). In addition, we examined the correlation between the perceived quality of different types of UGS and the quality based on user needs assessment (Table S6). We found that UGS quality for the walking function was significantly and positively correlated with the perceived quality of the most frequently visited UGS ($r = 0.089$, $p < 0.01$), community UGS ($r = 0.065$, $p < 0.05$), and nearby UGS ($r = 0.068$, $p < 0.05$).



(**a**)



(**b**)

Figure 2. (**a**) The quality assessment for the five types of UGS activities with the highest demand; (**b**) The quality assessment for the five types of UGS activities with the lowest demand.

3.3. Associations between UGS Indicators and Health Status

First, we examined the association between indicators of UGS quantity and general health ("very bad", "bad", "average", "good", "very good", coded as 1, 2, 3, 4, 5) using linear regression (Table 5). Total UGS (OR = 0.856, $p = 0.000$) had a significant negative association with general health outcomes, while greenery coverage (OR = 1.100, $p = 0.015$) showed a significant positive association. That is, general health would decrease 14.4%, if the total UGS was increased by one level. If the greenery coverage was increased by one level, the odds of having good general health outcomes would increase by 10.0%. However, no significant association with general health was reported for the objective quantity of UGS within the 400 m buffer.

Table 5. Partial linear regression results.

Dependent Variable	Independent Variable		B	p	OR	95.0% C.I. for OR		Covariance Statistics	
						Lower	Upper	Tolerance	VIF
General health	Quantity	Total amount	−0.155	0.000	0.856	0.791	0.927	0.601	1.664
		Greenery coverage	0.095	0.015	1.100	1.019	1.186	0.482	2.073
	Quality	Average of variance	0.099	0.045	1.104	1.002	1.217	0.910	1.099
		Satisfaction mean value	−0.237	0.000	0.789	0.733	0.849	0.732	1.366
		Supply–demand variance of gardening activities	0.087	0.008	1.091	1.023	1.162	0.457	2.188
		Supply–demand variance of walking dog activities	0.042	0.044	1.043	1.001	1.088	0.684	1.462

As for the associations between metrics of UGS quality and general health, we found a significant negative association for the mean supply indicator (OR = 0.789, p = 0.000) and a significant positive association for comprehensive UGS quality based on supply–demand variance (OR = 1.104, p = 0.045) (Table S3). If the average variance was increased by one percent, the odds of having good general health would increase by 10.4%. In particular, the supply–demand variance of gardening (OR = 1.091, p = 0.008) and dog walking (OR = 1.043, p = 0.044) showed a significant positive association with general health. However, no significant association was observed for the quality variables for the other 18 types of UGS activities. Additionally, for the indicators of perceived quality of different types of UGS, no significant association with general health was found.

In conclusion, the total number of UGS and the supply indicator were significantly and negatively correlated with general health. The greenery coverage and the mean value of supply–demand variance, as well as the supply–demand variance of gardening and dog walking activities, were significantly positively correlated with general health. In contrast, neither the quantity of UGS within the 400 m buffer nor the perceived quality of different types of UGS was significantly associated with general health.

Surprisingly, after controlling for confounders, all independent variables had no significant association with the mental health variable.

3.4. Associations between UGS Indicators and Health Expenditures

Multiple logistic regressions were used to examine the association between indicators of UGS quantity and health expenditure variables (Tables 6 and 7). We found that total health expenditures, health insurance expenditures, medical product expenditures, and health-related book and course expenditures were all more likely to be low when the total number of UGS was less. However, we did not observe an association between objective quantity indicators of UGS and health expenditures.

We found that both total health expenditures and health insurance expenditures are more likely to be high when the perceived quality of the most frequently visited UGS is poor. Similar findings were revealed for the number of medical visits, with fewer visits likely to occur when the perceived quality of the nearby UGS was better.

Table 6. Partial multiple logistic regression results for total health expenditures.

Dependent Variable	Independent Variable		Value (*p*, B)			
Total Expenditures	**Category**	**Detailed Items**				
None	Quantity	Total number of nearby UGS	1 (0.000, 126.959)	2(0.000, 126.673)		
	Quality	Perceived quality of most frequently visited UGS	2 (0.000, −244.198)			
		Perceived quality of nearby UGS	3 (0.000, 5.321)	4 (0.000, 6.733)		
		Quality (supply–demand variance) of ball activities	−3 (0.000, −586.504)	−2 (0.000, −459.263)	−1 (0.000, −345.759)	0 (0.000, −229.919)
		Quality (supply–demand variance) of dance activities	1 (0.046, −53.100)			
Less than CNY 100	Quantity	Total number of nearby UGS	1 (0.000, 126.371)	2 (0.000, 126.020)		
	Quality	Perceived quality of most frequently visited UGS	2 (0.000, −244.571)			
		Perceived quality of nearby UGS	3 (0.000, 6.427)	4 (0.000, 7.118)		
CNY 100–1000	Quantity	Perceived quantity	2 (0.015, 13.019)	3 (0.017, 12.576)	4 (0.022, 11.753)	
		Total number of nearby UGS	1 (0.000, 127.900)	2 (0.000, 127.632)		
	Quality	Perceived quality of most frequently visited UGS	2 (0.000, −244.298)			
		Perceived quality of nearby UGS	3 (0.000, 5.110)	4 (0.000, 6.776)		
		Quality (supply–demand variance) of ball activities	−3 (0.000, −585.102)	−2 (0.000, −458.406)	−1 (0.000, −344.980)	0 (0.000, −229.156)
CNY 1000–2000	Quantity	Perceived quantity	2 (0.023, 14.046)	3 (0.027, 13.536)	4 (0.038, 12.462)	
		Total number of nearby UGS	1 (0.000, 126.977)	2 (0.000, 126.938)		
	Quality	Perceived quality of most frequently visited UGS	2 (0.000, −245.902)			
		Perceived quality of nearby UGS	3 (0.000, 5.771)	4 (0.000, 7.066)		
CNY 2000–5000	Quantity	Total number of nearby UGS	1 (0.000, 125.926)	2 (0.000, 126.041)		
	Quality	Perceived quality of most frequently visited UGS	2 (0.000, −247.815)			
		Perceived quality of nearby UGS	3 (0.001, 4.825)	4 (0.000, 6.316)		
		Quality (supply–demand variance) of ball activities	−3 (0.000, −587.770)	−2 (0.000, −459.385)	−1 (0.000, −346.182)	0 (0.000, −229.812)
		Quality (supply–demand variance) of dance activities	−3 (0.044, −237.728)	−2 (0.038, −196.291)	−1 (0.030, −156.485)	0 (0.019, −116.528)
		Quality (supply–demand variance) of viewing activities	−3 (0.000, 182.102)	−2 (0.000, 148.824)	−1 (0.000, 116.471)	0 (0.000, 76.088)

Table 7. Partial multiple logistic regression results for other health expenditures.

Dependent Variable		Independent Variable	Value (p, B)	
Medical treatment expenses	None Less than CNY 100 CNY 100–1000 CNY 1000–2000	Total number of nearby UGS	1 (0.000, 117.281) 1 (0.000, 116.991) 1 (0.000, 118.820) 1 (0.000, 119.016)	2 (0.000, 116.564) 2 (0.000, 116.632) 2 (0.000, 118.473) 2 (0.000, 118.740)
Medical insurance expenses	None Less than CNY 100 CNY 100–1000 CNY 1000–2000 CNY 2000–5000	Quality of most frequently visited UGS	2 (0.000, −490.789) 2 (0.000, −489.568) 2 (0.000, −491.976) 2 (0.000, −492.096) 2 (0.000, −490.628)	
Health care product expenses	None Less than CNY 100 CNY 100–1000	Total number of nearby UGS	1 (0.000, 20.748) 1 (0.000, 19.549) 1 (0.000, 19.844)	2 (0.000, 20.049) 2 (0.000, 19.310) 2 (0.000, 19.138)
Book and course expenses	Less than CNY 100	Total number of nearby UGS	1 (0.004, 6.433)	2 (0.000, 8.567)
Medical visits	1–2 visits	Quality of nearby UGS	4 (0.034, 2.045)	

In addition, total health expenditures were statistically more likely to be high when UGS quality for both ball and dance activities was worse. When the quality for viewing is poor, health expenditures were also more likely to be in the 2000–5000 range rather than in the range of below 2000. However, we did not observe a significant association between quality indicators and health expenditures for the other 17 activities. Somewhat surprisingly, the means of all three indicators of demand, supply, and quality for these twenty activities had no significant results with the health expenditure indicators. In addition, there were no significant results for the quality indicators representing the four categories of activities and the health expenditures.

4. Discussion

4.1. UGS Quality Assessment Based on User Needs

Among the limited studies on the relationship between green space and health expenditures, few have thoroughly investigated the association between various indicators of UGS and different health expenditures, perhaps because they are often limited to only one aspect of UGS or one branch of health expenditure. The number of studies related to the quality of UGS based on user needs is also very limited. Thus, our study has new implications for a comprehensive exploration of the association between UGS and health expenditures.

Our survey found that the current supply of UGS is generally inadequate to meet the demand for activities. In addition, there is less variation among the demands of the 20 activities, which implies that people's activity demands are homogeneous. Walking has the highest satisfaction alongside the highest demand, so it is also the best quality indicator of UGS.

The advantages of our established user needs-based quality assessment of UGS are significant. The health benefits of UGS are closely related to people's use [59], and our examination of user needs for UGS can partially explain why people use UGS. This method provides a new direction for thinking about UGS design from a humanistic perspective. In addition, the significant positive correlations found for UGS quality for walking and perceived quality of most frequently visited UGS, community UGS and nearby UGS may indicate that the respondents' walking activities usually occur in the most frequently visited UGS, and the most frequently visited UGS are most likely to be community UGS. Similarly, the perceived quality of nearby UGS also significantly and positively correlated with UGS quality for sitting and dating. Meanwhile, walking and sitting were the two activities with the highest demand from respondents in our survey. We can assume that the walking, sitting, and dating features offered by UGS significantly affect people's subjective perceptions of UGS quality.

For the three activities (ball, dance, and viewing) significantly associated with total health expenditures, two of them belong to physical activities. In previous studies, it has been established that those physical activities play an important mediating role between UGS and health [60,61]. Our study provides a new possibility that physical activities may also be an important mediator linking UGS and health expenditures, and the results of some existing studies lend credence to our findings. Krustrup, et al. [62] found recreational football appears to effectively stimulate musculoskeletal, metabolic, and cardiovascular adaptations of importance for health. Williams, et al. [63] reported a better working memory through football activity. Similarly, many health benefits from dance activities have been reported [64–66]. As for the activity of viewing, Velarde, et al. [67] reported three types of health benefits of viewing greenery: short-term recovery from stress or mental fatigue; faster physical recovery from illness; and long-term overall improvement in people's health and well-being. Ball activities can be enjoyed by a wide range of ages, dancing is unrestricted and easily accessible, and viewing satisfies the desire to be close to nature. Therefore, we suggest that the design of UGS should pay attention to enhancing the attractiveness of the venue, and in particular, special consideration should be given to setting up places for physical activities especially ball activities and dance activities.

4.2. Associations of UGS Indicators with Health Outcomes

The results showed that more UGS indicated that worse general health was not in line with expectations. Many recent findings on green space and health reported a significant positive association between UGS quantity and general health [28,68,69]. We speculate that the possible reason is the fragmentation of UGS due to land constraints in a high-density city like Shanghai. More green spaces may mean a smaller individual area of UGS in this area, and smaller UGS tend to be of lower quality and provide limited functions. Wood, et al. [28] found a stronger association of larger park areas with positive mental health compared to an increased number of smaller green spaces. In contrast, we obtained a significant positive association between greenery coverage and general health. Therefore, we suggest giving priority to designing UGS with more complete form and functions that would provide wider general health benefits.

The finding that UGS supply based on user needs has a significant positive association with general health is consistent with our expectations. This complements and corroborates the existing studies on the association between UGS quality and residents' health, which mainly evaluate UGS quality from objective indicators [70–72]. In particular, we noticed a significant positive association between UGS quality in terms of gardening, dog walking, and general health. The results are consistent with many existing studies. Soga, et al. [73], Shiue [74], and Wakefield, et al. [75] all reported the health benefits of gardening, while Christian (Nee Cutt), et al. [76] and Westgarth, et al. [77] obtained results that dog walking was positively associated with health through increasing physical activities as a mediating factor. Therefore, we recommend that special consideration should be given to the UGS design to provide scenarios for gardening and dog walking to occur. An interesting point is that the average supply (satisfaction) of UGS activities provided by UGS was significantly and negatively associated with general health. We think this can be explained by the fact that people who are more concerned about their health will have higher requirements and evaluation criteria for UGS activity features.

Zhang, et al. [78] and Putra, et al. [79] reported that better general health of respondents was recognized when the perceived quality of UGS is better. However, we actually found no significant association between UGS perceived quality and general health. The reason may be that we examined the perceived quality of different types of UGS separately, while in the daily life of the respondents, different UGS are interrelated to deliver their health benefits.

The results of not finding an association between UGS indicators and mental health were acceptable. Astell-Burt, et al. [80] have reported that the relationship between UGS and mental health can vary across people's life courses. Similarly, Nutsford, et al. [81] also failed to find an association between the proportion of UGS within the 300 m buffer zone and mental health. We believe that this may be related to the fact that green environments often have an impact on mental health as a whole. A categorical investigation of UGS weakens the significance of its association with mental health.

4.3. Associations of UGS Indicators with Health Expenditure Outcomes

First, although some significant correlations were obtained for each of the health expenditure indicators, a noticeably larger number of UGS indicators were significantly correlated with total health expenditure. We believe this is because the respective variables tend to be associated with more than one type of health expenditure, but their associations are not yet significant enough. When all types of health expenditure are considered as a whole, the association becomes adequately significant. In addition, no significant results were observed for the objective UGS quantity indicators, which implies that UGS quality has a stronger association with health expenditures compared to UGS quantity.

GS has a significant positive association with several health expenditure indicators including medical treatment expenditures, medical insurance expenditures, health care product expenditures, and total health expenditures. This was not as expected but is consistent with the results of the association between total UGS and general health outcomes above. Studies have confirmed that the health risks have been an important factor that makes household health care consumption rise [82]. When the total UGS-general health-total health expenditure path is achieved, an increase in total UGS has a significant positive association with health expenditures. Another possible explanation is that respondents who choose to live in areas with more total UGS tend to be more concerned about the quality of their living environment. This implies that they are more concerned about living a healthy life and are more willing to spend on health; consequently, the associated health expenditures may be larger.

We observed a significant negative association between the perceived quality of the most frequently visited UGS as well as nearby UGS and total health expenditures. The association between the perceived quality of nearby UGS and medical visits showed similar results. In studies of the association between UGS and health expenditures, existing studies have mostly used the quantity of UGS as indicators [17,19], and our study adds to this research area in qualitative terms. Although not tested in our results, we suspect that these associations are achieved with health as a significant mediator. Initially, Fongar, et al. [83] found a significant positive association between UGS perceived quality and green space visits. Through a systematic review, Nguyen, et al. [84] pointed out that all the "perceived quality" related studies that have been examined show a positive correlation between the UGS perceived quality and health. These results all provide some reasonability to our speculations. In contrast to the most frequently visited UGS and nearby UGS, other UGS types did not report significant associations between UGS quality and health expenditures. This may suggest that whether UGS can exert their health benefits is related to users' usage behavior for such types of UGS. Yessoufou, et al. [85] pointed out that among the mechanisms linking UGS to human health improvement, how people use UGS, including frequency of visits, length of stay, and type of activity, matters. These illustrated the importance of access to green spaces, also known as green space exposure. Only with active use can users take full advantage of health benefits from the UGS, as indicated in previous studies [59,86].

In addition, we consider air quality as another mediating factor. Sun, et al. [87] reported that air pollution is the main factor that promotes the increase in residents' health expenditures. Das and Ivaldi [88] similarly pointed to environmental pollution, including air pollution, as a cause of health expenditures in many developed countries. Therefore, it is reasonable to infer that UGS can mitigate air pollution to achieve lower health expenditures.

4.4. Limitations and Future Directions

There are still some limitations. First, our assessment of UGS quality is primarily based on users' needs. The supply and demand for each UGS activity were identified through a questionnaire and the exploration of objective UGS quality assessment was absent. Additionally, the health status and health expenditure are based on respondents' self-reported indicators. Such a survey method is somewhat subjective and may suffer from self-reported response bias. Another limitation of the study is that although we delineated a 400 m buffer zone to discuss the association between the UGS quantity and health expenditures in the region, we did not consider the relationship in other buffer sizes. This may cause us to miss some of the findings between UGS quantity and health expenditures. In addition, the results on activities significantly associated with health and significantly associated with health expenditures are inconsistent, but we do not have a very plausible explanation currently. More follow-up research is needed on this developmental pathway of UGS quality–health–health expenditures.

In future studies, more attention should be paid to the exploration of the association between objective evaluation indicators related to UGS quality and health expenditures. Alternatively, a more complete framework for UGS functionality can be developed to measure UGS quality more accurately. In addition, even if we still focus on subjective measures of UGS quality, more research methods can be introduced like in-depth interviews. In addition, we suggest further exploring more buffer distances to comprehensively study the association between the UGS quantity and health expenditures within different buffer zones.

Based on the study results, we propose corresponding UGS optimization recommendations to better obtain the benefits of UGS in reducing health expenditures:

1. First, enrich UGS types to meet residents' different needs for UGS use;
2. Then optimize UGS quality, like providing sufficient activity facilities and infrastructure, to create a high-quality outdoor environment with sufficient open space and visible greenery;
3. Finally, we suggest that future studies can focus on a specific type of UGS activity and examine its association with health and health expenditures separately. Perhaps this will yield different and more informative results than the broader classification of activities such as physical activities.

5. Conclusions

This study developed a method to measure UGS quality based on user needs and evaluated various UGS indicators and their associations with different types of health expenditures. We found that the highest demand for the activities in UGS was for walking and sitting, and we obtained quite high health expenditures when the UGS quality for viewing, ball, and dance activity was poor. Our findings also suggest that the perceived quality of nearby UGS and the most frequently visited UGS has a significant negative association with the health expenditures of urban residents. All of the results illustrate a close association between UGS quality and health expenditures, which is found to be stronger than such association for UGS quantity. This provides evidence for the need to optimize the quality of UGS, thus facilitating healthcare management in high-density urban areas, such as Shanghai. Based on the findings from this study, we recommended several suggestions including enriching UGS types, optimizing UGS quality, and paying attention to the location of UGS. In conclusion, our study contributes to the understanding of the indirect economic benefits of UGS through health promotion, and also fills some of the gaps in the research on the association between UGS, residents' health, and health expenditures.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11081261/s1, Table S1: Correlation check of perceived UGS quantity variables; Table S2: Correlation check of the UGS quantity in the 400m-buffer zone; Table S3: Indicators of UGS quantity of nearby UGS; Table S4: Perceived quality of different types of UGS.

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