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Evaluating Policy Shifts on Perceived Greenspace Quality: Applying Regression Discontinuity During the COVID-19 Reopening Period

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Abstract: Urban greenspaces have been essential in supporting residents' well-being during the COVID-19 pandemic, particularly under strict lockdown measures. However, the impact of changing containment policies on residents' perceived greenspace quality remains insufficiently explored. This study utilized online survey data collected between 11 October and 29 December 2022, in Shanghai, coinciding with the major policy shift on 5 December 2022. A probability proportionate to size sampling was adopted to survey residents aged 18 and above who had lived in the city for at least six months, yielding a total of 577 valid responses. We assessed residents' perceived greenspace quality using 20 park- and community-level variables, focusing on both overall quality and specific features of greenspaces. A regression discontinuity design (RDD) was applied to evaluate how the lifting of the COVID-19 policies influenced residents' perceptions of parks and community greenspaces. Our RDD estimation indicates no statistically significant change in residents' overall perceived quality of parks after the policy shift, except for increased satisfaction with specific features such as plant diversity, maintenance, seating areas, trails, and large open spaces. In contrast, residents who responded after the policy shift reported a significantly higher perceived quality of community greenspaces compared to those who completed the survey before the shift (0.609 score difference, $p < 0.01$), with notable increases in satisfaction regarding plant diversity, maintenance, and seating areas. Perception of plant quantity remained unchanged in both types of greenspaces. Residents expressed greater satisfaction with sports facilities in parks, while community greenspaces were preferred for their water features and esthetic qualities. By adopting an RDD with a unique dataset, this study contributes empirical evidence to the current ongoing debate on the role of urban greenspace during the later stages of COVID-19. Specifically, it examines how changes in public health policy and the resulting increase in mobility might affect residents' perceived greenspace quality. The findings can assist decision-makers and urban planners in developing more adaptive strategies to address the diverse needs of residents for greenspaces during the transitional period of a public health crisis.

Keywords: perceived quality; park; community greenspace; regression discontinuity design; COVID-19 policy change

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1. Introduction

Urban greenspaces, such as forests, residential gardens, parks, lawns, green roofs, and gardens, provide numerous benefits to urban residents [1] including regulating urban climates [2], preserving urban ecological diversity [3], maintaining urban environmental quality [4], and promoting residents' mental well-being [5], ultimately enhancing overall life satisfaction and happiness [6]. These benefits derived from urban greenspaces are highly contingent on their quality, which reflects both objective and subjective dimensions of these spaces' multifaceted aspects [7]. Objective quality is predominantly related to vegetation characteristics, such as biodiversity, richness or diversity of vegetation, and climate regulation capacity [8,9]. Beyond vegetation, other factors contributing to perceived quality include the accessibility of greenspaces [10], the presence of amenities, and the safety of the environment within or around the greenspaces [7,11].

However, despite the objectively high quality of greenspaces, urban residents often perceive their quality differently [12]. Perceived quality of greenspaces refers to how residents assess certain attributes of these spaces, including their esthetic attractiveness and the ecosystem services they offered [13]. Understanding the perceived quality is crucial, as it influences residents' usage of greenspaces and strongly relates to greenspaces planning, provision, and maintenance in local communities [14], and consequently, the range of benefits they receive [15]. Although perceptions may vary across different cultural and geographical regions [16], several attributes including greenspace sizes, types, accessibility, vegetation characteristics, facilities, maintenance, and landscape design are consistently appreciated by urban residents [9]. Studies in well-developed cities confirmed that factors like vegetation diversity, accessibility, amenities, safety, and certain visual and acoustic features might contribute to perceived quality. For instance, a large-scale public participation GIS survey in Espoo, South Finland, indicated that large greenspace size, high forest diversity, proximity, being well maintained, and lower noise levels were significant predictors of positive greenspace perception [17]. In Barcelona, amenities such as seating areas and sports facilities are widely appreciated by residents and promote physical activities and greenspace use [7]. Similarly, a field study in Stockholm, Sweden, identified well-designed water features as being vital to enhancing perceived environmental acoustic quality in parks [18]. In dense urban settings such as Hong Kong and Shanghai, factors like plant quantity, landscape design, proximity, cleanliness, and maintenance are highly praised [19,20]. Certain feature of greenspaces, such as urban trees, both on streets or in private yards, are preferred by most residents in South Africa [21]. These attributes influence perception and impact both physical activity levels and mental health benefits derived from greenspaces [22].

During global health crises, urban greenspaces become vital for local residents, supporting various forms of physical and mental recovery [23]. The onset of the pandemic and subsequent lockdown measures affected people's evaluations and use of greenspaces during the early stages of COVID-19 [24]. Due to the stay-at-home policies and restricted mobility, residents had less access to these spaces than under normal circumstances [25]. As a result, people sought more frequent contact with nature in greenspaces [19], in social interactions [26], and participated in physical activities [1,27]. These heightened desires led residents to perceive greenspaces that fulfilled their demands as being of particularly high quality [28]. Additionally, residents' perceptions of certain attributes of greenspaces may have changed [19,28]. To maintain social distancing, residents preferred remote greenspaces, such as less crowded trails with tree canopies [11], or private gardens with fewer visitors [19]. Greenspaces with better facilities and diverse vegetation are also welcomed [19]. Certain features, such as waterbodies of greenspaces, are particularly popular, as they offer a sense of comfort that residents seek out more often [29].

Notwithstanding, present studies on the perceived greenspace quality have largely focused on normal periods, covering topics such as the relationship between objective attributes (e.g., size of greenspace, distance, cleanness) and perceived qualities of greenspaces (e.g., perceived accessibility) [1], evaluation approaches for perceived quality [30], and the effects of perceived quality on residents' visitation and health [7]. Limited research has examined how people value the quality of greenspaces during crisis periods, especially during the later stages of COVID-19 [19,31]. Another research gap pertains to the data and methodologies used to study the relationship between the perceived greenspace quality and changes in COVID-19 policy. Present studies largely rely on cross-sectional data, which have limited capability for establishing causal relationships [32–35]. Recently, scholars have utilized quasi-experimental designs to examine the impact of a COVID-19 containment policy on residents' visitation and their perceived accessibility to greenspaces [31,36,37]. Some of these studies, relying on social media time-series data and quasi-experiment design methods, have demonstrated the significance of accessible greenspaces for leisure activities during the pandemic [36,37]. Due to the limited information collected in social media data, few studies have investigated how residents perceive the quality of greenspaces following the end of the COVID-19 control policies [19,31]. Knowing how residents perceive the greenspace quality shift from "lock-down" to "normalcy" can deepen our understanding of the benefits of greenspaces during transitioning periods of a public crisis. Additionally, examining the effects of control policies on residents' perceptions of different greenspaces' attributes can assist decision-makers and planners more effectively in evaluating urban greenspace management strategies in conjunction with future public health policy implementation.

This study aims to address the aforementioned research gaps by focusing on how urban residents perceive the quality of greenspaces near their homes during the transition from a stringent pandemic control policy to normalcy. Using an online self-administrated survey conducted in Shanghai, we collected data spanning the adjustment of pandemic control measures at the end of year 2022. The abrupt policy adjustment created a quasi-experimental setting, enabling us to apply a regression discontinuity design (RDD). A key advantage of an RDD is its ability to establish causal relationships in non-experimental settings where random assignment is not feasible. By leveraging thresholds or policy changes, an RDD estimates the causal impact of interventions by comparing observations just above and below the policy threshold, offering more robust causal inference [38,39]. In the context of COVID-19 policy changes, an RDD allows for precise analysis of how reopening measures affect residents' perceived greenspace quality, providing clearer insights into changes in resident experiences and preferences. We focused on residents' perceived quality of two types of greenspaces—parks and internal greenspaces within residential communities—as well as the perceived evaluation of different characteristics of greenspaces. This study contributes to the existing literature by providing empirical evidence on how urban residents perceived the greenspace quality change in response to the loosening of containment measures during a public health crisis.

2. Data and Methods

2.1. Study Area and COVID-19 Adjustment Policy

This study was conducted in Shanghai, one of China's most densely populated cities with an urban area of 1242 km^2 and a population of approximately 24.75 million as of 2022 [40]. Renowned for its economic prowess and rapid urbanization, the city is now working toward becoming an ecologically sustainable and livable urban environment. Providing high-quality greenspaces for residents is one of the most prevalent approaches to promote the living quality of communities. As of 2022, Shanghai boasts 439 well-maintained urban parks, each averaging around 52.35 hectares, and park area per capita stands at 9.3 square meters, and each resident has access to more than 70 square meters of greenspaces [40].

In response to the COVID-19 outbreak originating in late 2019, China implemented a rigorous COVID-19 containment strategy aimed at preventing widespread transmission in the subsequent years. This approach included a range of interventions such as compulsory mass COVID-19 testing, isolation of positive cases, contact tracing, and quarantine for potential contacts [41], and was considered effective in controlling the outbreak in early 2020 and subsequent outbreaks in mid-2021 and entire year of 2022. However, these measures significantly limited individual mobility through social distancing protocols, the closure of public amenities, and the risks associated with being identified as a close contact or infected individual [41,42]. Effective 5 December 2022, Shanghai's pandemic control measures were substantially revised. The Office of the Leading Group for Pandemic Prevention and Control announced the cessation of mass COVID-19 testing requirements for accessing public transportation systems such as subways, buses, and ferries [43]. Similarly, proof of a negative COVID-19 test was no longer required for entry into outdoor public venues. This optimized approach alleviated the restrictions on the mobility of urban residents in public spaces, including parks, and lowered the costs associated with potential exposure to positive cases, which provides more opportunities for residents to visit greenspaces. On the other hand, the removal of testing facilities within public spaces created more usable areas for residents, restoring the landscapes of greenspaces closer to pre-pandemic conditions. These changes in greenspace characteristics plus residents' freer mobility further influence how residents perceive greenspace quality and their usage of these areas, as well as the mental and physical health benefits associated with their activities.

2.2. Survey and Regression Discontinuity Design

For data collection in our study, we administered an online survey to residents of Shanghai who had lived in the city for at least six months and were 18 years of age or older. The feasibility of conducting in-person surveys or interviews was hindered by the widespread lockdown measures and the associated risks of infection at the time. Given Shanghai's high level of internet penetration, online surveys were identified as the most efficient data collection method. We employed a probability proportionate to size sampling method with quotas based on gender, age, and highest degree earned to ensure a representative sample. According to the most recent census in Shanghai, the gender distribution was set as 50% male and 50% female, while the age distribution was 35% for individuals aged 18–29, 45% for those aged 30–49, and 20% for aged 50 and above. In terms of education level, 50% had a high school education or lower, and 50% had a college degree or higher. This probability sampling method lowers the sampling error and facilitates unbiased, valid inferences and evaluations [44,45]. Additionally, various strategies, including monetary incentives, were used to increase participation rates [46].

To ensure data quality, we implemented several verification measures, including logic checks, rapid completion checks, and the inclusion of trap questions to filter out invalid responses. By employing trap questions, we were able to conduct attention checks to identify respondents who were not answering attentively, thereby improving the reliability of the responses [47–49]. In our questionnaire, we used two attention check questions: one required the respondents to select "strongly disagree" in response to a question about their willingness to pay for outdoor landscape improvements, and the other instructed them to select "frequently" when reporting the frequency of feelings or behaviors over the past week. If respondents failed to answer these questions correctly, it indicated a lack of attention, and their data were excluded from the study due to unreliability. A pilot test involving 50 completed surveys was conducted through a professional online polling company. The finalized survey was then distributed by the same polling agency between 11 October 2022 and 29 December 2022. This period included the significant shift of the COVID-19 containment policy on 5 December 2022.

A total of 2881 valid responses were initially collected in Shanghai. Residents living in designated "control zones", who were under restrictions preventing them from leaving their communities or homes, were excluded. "Control zones" refer to areas where residents are allowed to leave their homes but are restricted from exiting their residential communities [50]. These zones are implemented to limit movement and reduce the risk of COVID-19 transmission, often as part of broader public health measures implemented during outbreaks [51,52]. We also removed the respondents who never visited a park or community greenspaces. After applying these filters, the final dataset comprised

577 respondents, with 377 responses collected prior to the evening of 5 December 2022, and 200 responses collected thereafter.

2.3. Key Variables and Covariates

To evaluate the perceived greenspace quality by urban residents, we utilized 20 indicators as dependent variables, categorized into two types: one for measuring the quality of parks and one for the internal greenspaces within residential communities. For parks, residents who had recently visited any park were asked to rate the overall quality of the parks near their homes. The quality of parks was further measured by using 10 variables, including plant coverage, plant diversity, trees and/or lawns, plant care, presence of sports facilities, seating areas, trails, presence of large open spaces, presence of high-quality waterbodies, and high esthetic value. For internal greenspaces within residential communities, residents who had recently visited these areas were asked to rate the overall quality of the community greenspaces. Also, the quality of these spaces was evaluated using 8 variables: plant coverage, plant diversity, plant care, presence of sports facilities, presence of seating areas, presence of high-quality waterbodies, trails, and high esthetic value. Overall quality ratings were obtained by asking respondents "How would you rate the overall quality of parks/outside public greenspaces near your residential area?" and the overall quality of community greenspaces was obtained by a similar question, "How would you rate the overall quality of greenspace within the residential community you live?" Responses were coded on a 5-point Likert scale, in which "1" indicated "very poor" and "5" indicated "very good". Regarding the perceived quality toward certain features, respondents were asked to indicate their satisfaction levels: features they found unsatisfied were coded as "1", satisfactory features as "3", and features they felt neutral about as "2".

We controlled for a range of standard demographics and socioeconomic covariates based on prior research [6,53–55]. Demographic variables included gender, age, and marital status, while socioeconomic factors involved employment status, highest educational attainment, and total after-tax household income for the year 2021. These covariates were included to account for potential confounding variables and to improve the accuracy of our greenspace quality assessments.

2.4. Estimation Procedures

This study utilized the temporal alignment of our survey with COVID-19 containment policy shifts to apply a regression discontinuity design (RDD) for investigating the potential impact of the policy change on urban residents' perceived greenspace quality. RDD is a well-established method for evaluating causal effects of policy interventions [56]. Compared to other methods such as difference-in-differences (DID) or propensity score matching (PSM), RDD is particularly well suited to our case due to its capability to rely on the precise timing of the policy intervention. DID requires assumptions about parallel trends, which may not hold during the dynamic changes associated with the pandemic [57]. Additionally, PSM requires matching based on observable characteristics, potentially introducing bias if key variables are unobserved [58]. In contrast, as a quasi-experimental approach, RDD approximates random assignment near the policy shift point, allowing for precise identification of causal effects under less controlled conditions [59]. This methodology is particularly relevant in our context due to the extensive implementation of containment policies in Shanghai, especially since October 2022. The abrupt shift in the COVID-19 policy aligns with RDD's basic assumption of "minimal continuity", where residents had no foresight into policy changes [60]. In other words, residents had no influence over the timing of the policy implementation, offering a credible counterfactual for assessing the effects of the policy change.

We implemented this approach using the date as a running variable and designating 5 December 2022 as the intervention point when the new policy was implemented in the city. The survey's control group consisted of residents surveyed before this date, while the treatment group included those surveyed after. Crucially, the change in COVID-19 policy was universally implemented in the city, affecting all residents of Shanghai simultaneously. Treatment conditions were uniformly applied to all residents of the treatment group, allowing for a sharp RDD application in estimation [61]. Our primary objective was to assess the policy change's impact on individuals' perceived greenspace quality. These effects could be discerned through significant changes in the dependent variable around the policy implementation dates, indicative of a discontinuity [60,61].

To estimate the effects of the COVID-19 containment policy adjustment on perceived greenspace quality, we applied a local linear analysis approach. Previous research supports the use of a local linear estimator for discrete running variables [62]. We followed standard practice for polynomial order selection, using a local polynomial order of one, a triangular kernel function, and bandwidth optimized based on mean squared error (MSE) considerations [61]. Given that not all respondents visited parks or community greenspaces despite not being quarantined at home, we conducted separate RD estimations and robustness checks for those who did visit these spaces. Five standard robustness checks were conducted to validate RDD assumptions also separated on the two subgroups regarding greenspace visitation history, with the results detailed in Section 3.3. All estimations and checks were conducted using the STATA 16 software package.

3. Results

3.1. Sample Characteristics

Table 1 presents the characteristics of the demographic and socioeconomic factors. In our sample, the majority were adults aged 18–49, with a roughly equal split between younger (18–29) and middle-aged (30–49) groups. Gender distribution was nearly balanced, with a slight male majority. Educational attainment varied, with many having completed high school or higher education. Most respondents were employed in non-agricultural jobs, reflecting the urban setting. Household income levels ranged widely, indicating economic diversity within the sample. Marital status showed a significant portion being single, with a substantial number also married and living together.

Table 1. Demographic profile of respondent.

Variables	Descriptions	Percentage/%
Age	18–29 years old	38.47
	30–49 years old	39.86
	50 years old and above	21.66
Gender	Male	50.78
	Female	49.22
Highest level of education	Primary school and below	0.17
	Junior high school	15.42
	High school	36.57
	Junior college	14.21
	Undergraduate	27.56
	Master's degree and above	6.07
Marital status	Single	46.45
	Cohabiting	5.20
	Married, living together	41.42
	Married, living separately	2.95
	Divorced	2.77
	Widowed	1.21
Employment status	Engaged in non-agricultural work	50.61
	Farming	1.73
	Unemployed or job-seeking	9.36
	Retired (not in job)	10.40
	Lost labor capacity	0.17
	Student	11.27
	Housekeeping	4.85
	Others	11.61

Table 1. *Cont.*

Variables	Descriptions	Percentage/%
Household income	Less than USD 4455.80 (3 ten thousand yuan)	10.92
	USD 4455.80–7426.32 (3–4.99 ten thousand yuan)	9.88
	USD 7426.33–14,852.65 (5–9.99 ten thousand yuan)	17.85
	USD 14,852.66–29,705.31 (10–19.99 ten thousand yuan)	28.77
	USD 29,705.32–74,263.30 (20–49.99 ten thousand yuan)	26.34
	USD 74,263.31–148,526.61 (50–99.99 ten thousand yuan)	5.55
	USD 148,526.62 (100 ten thousand yuan) and above	0.69

Tables 2 and 3 show how the residents rated the quality of greenspaces. Most respondents rated the quality of parks and community greenspaces favorably, with more than 65% giving parks a "Good" or "Very Good" rating and 56% similarly rating community greenspaces. Satisfaction with specific greenspace features, such as plant diversity and seating areas, was generally moderate, with many respondents expressing a neutral opinion. However, certain features like large open spaces and waterbodies had higher levels of neutrality, suggesting that these features might not stand out as significant aspects affecting perceived quality. The data reflect a mixed but generally positive view of the greenspaces and their specific attributes.

Table 2. Statistic summary of perceived overall greenspace quality.

Variables	Descriptions	Percentage/%
Perceived overall park quality	Very poor	0.52
	Poor	0.69
	Medium	31.20
	Good	48.01
	Very good	19.58
Perceived overall community greenspace quality	Very poor	1.44
	Poor	3.29
	Medium	38.68
	Good	41.98
	Very good	14.61

Table 3. Statistic summary of satisfaction toward greenspace quality-related features.

Variables	Descriptions	Percentage/%
Satisfaction toward park quality-related features		
Plant coverage	Dissatisfied	9.01
	Neutral	51.65
	Satisfied	39.34
Plant diversity	Dissatisfied	11.44
	Neutral	60.66
	Satisfied	27.90
Trees and/or lawns	Dissatisfied	11.27
	Neutral	52.86
	Satisfied	35.88
Plant care	Dissatisfied	8.15
	Neutral	62.39
	Satisfied	29.46
Have sport facilities	Dissatisfied	9.71
	Neutral	59.97
	Satisfied	30.33
Have seating areas	Dissatisfied	8.49
	Neutral	54.77
	Satisfied	36.74

Table 3. *Cont.*

Variables	Descriptions	Percentage/%
Have trails	Dissatisfied	6.93
	Neutral	63.26
	Satisfied	29.81
Have large open spaces	Dissatisfied	6.93
	Neutral	78.51
	Satisfied	14.56
Have high-quality waterbody	Dissatisfied	6.59
	Neutral	75.56
	Satisfied	17.85
High esthetic value	Dissatisfied	6.59
	Neutral	70.36
	Satisfied	23.05
Satisfaction toward community greenspace quality-related features		
Plant coverage	Dissatisfied	14.38
	Neutral	64.12
	Satisfied	21.49
Plant diversity	Dissatisfied	16.64
	Neutral	65.34
	Satisfied	18.02
Plant care	Dissatisfied	13.17
	Neutral	65.86
	Satisfied	20.97
Have sport facilities	Dissatisfied	7.63
	Neutral	68.11
	Satisfied	24.26
Have seating areas	Dissatisfied	7.63
	Neutral	64.82
	Satisfied	27.56
Have high-quality waterbody	Dissatisfied	10.05
	Neutral	79.90
	Satisfied	10.05
Have trails	Dissatisfied	7.28
	Neutral	76.43
	Satisfied	16.29
High esthetic value	Dissatisfied	9.19
	Neutral	78.16
	Satisfied	12.65

3.2. *Regression Discontinuity Estimation for Perceived Overall Quality*

The robust regression discontinuity (RD) estimation results revealed differential impacts of the policy change on the overall quality of parks and community greenspaces. For parks, no significant change was observed in the overall perceived quality following the policy implementation (Figure 1 and Table 4). However, community greenspaces exhibited a significant improvement in overall quality, with an estimated effect of 0.609 (95% CI: 0.218 to 1.001, $p < 0.01$) (Figure 2 and Table 5).

Table 4. RD estimation results for park quality subgroup.

VARIABLES	Overall Quality	Plant Coverage	Plant Diversity	Trees and/or Lawns	Plant Care	Have Sport Facilities	Have Seating Areas	Have Trails	Have Large Open Spaces	Have High-Quality Waterbody	High Esthetic Value
Conventional	−0.028	0.284 **	0.689 ***	1.102 ***	0.575 **	0.396 **	0.582 ***	0.354 *	0.458 ***	0.093	0.113
	(0.275)	(0.138)	(0.179)	(0.215)	(0.234)	(0.160)	(0.119)	(0.181)	(0.172)	(0.213)	(0.101)
Bias-corrected	−0.087	0.275 **	0.795 ***	1.190 ***	0.740 ***	0.481 ***	0.664 ***	0.461 **	0.516 ***	0.123	0.224 **
	(0.275)	(0.138)	(0.179)	(0.215)	(0.234)	(0.160)	(0.119)	(0.181)	(0.172)	(0.213)	(0.101)

Table 4. *Cont.*

VARIABLES	Overall Quality	Plant Coverage	Plant Diversity	Trees and/or Lawns	Plant Care	Have Sport Facilities	Have Seating Areas	Have Trails	Have Large Open Spaces	Have High-Quality Waterbody	High Esthetic Value
Robust	−0.087	0.275	0.795 ***	1.190 ***	0.740 **	0.481 ***	0.664 ***	0.461 *	0.516 **	0.123	0.224
	(0.378)	(0.185)	(0.215)	(0.232)	(0.294)	(0.178)	(0.202)	(0.252)	(0.246)	(0.319)	(0.153)
Observations	496	496	496	496	496	496	496	496	496	496	496
Robust 95% CI	[−0.827; 0.653]	[−0.087; 0.637]	[0.373; 1.217]	[0.735; 1.644]	[0.164; 1.317]	[0.132; 0.830]	[0.268; 1.059]	[−0.032; 0.955]	[0.034; 0.998]	[−0.502; 0.747]	[−0.077; 0.524]
MSE-optimal Bandwidth	5.704	9.024	6.031	2.978	3.673	4.221	4.091	3.592	3.838	4.359	3.279
Eff. N(control)	48	68	62	17	25	38	38	25	25	38	25
Eff. N(treatment)	107	158	125	39	61	77	77	61	61	77	61

Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

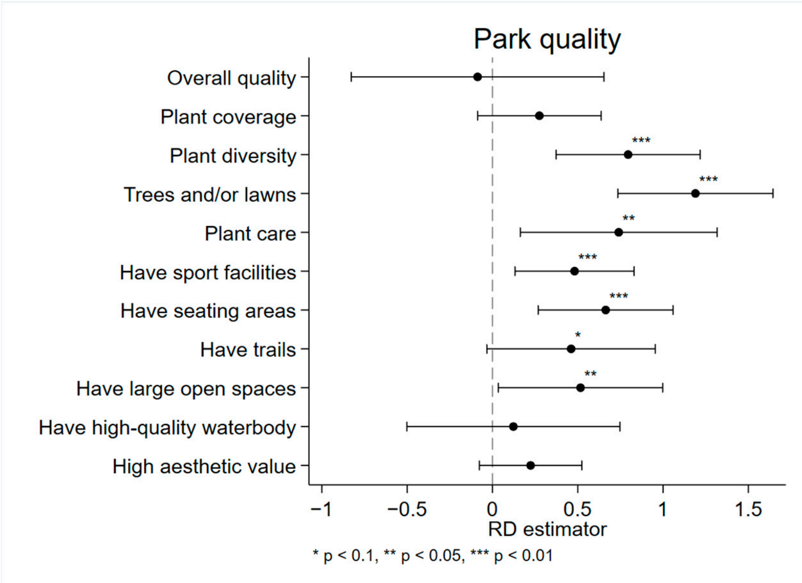

Figure 1. Plotted RD estimations for perceived quality toward parks.

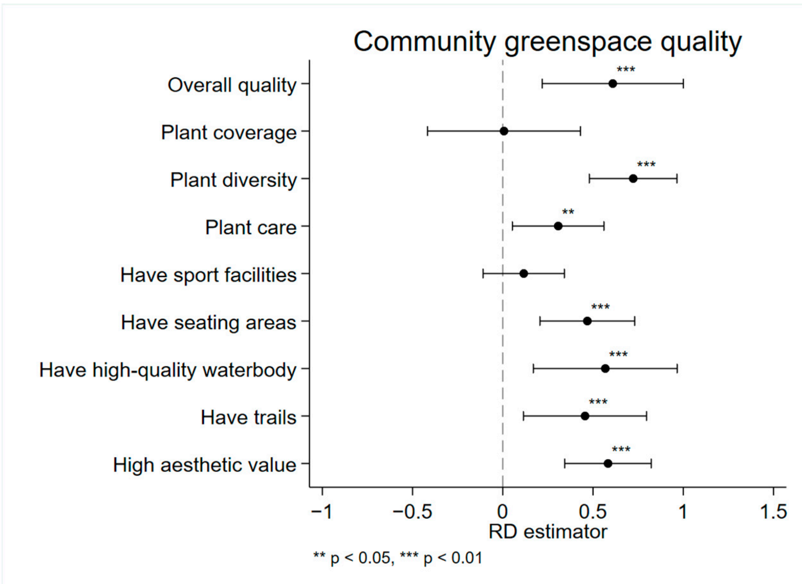

Figure 2. Plotted RD estimations for perceived quality toward greenspaces in community.

Table 5. RD estimation results for community greenspace quality subgroup.

VARIABLES	Overall Quality	Plant Coverage	Plant Diversity	Plant Care	Have Sport Facilities	Have Seating Areas	Have High-Quality Waterbody	Have Trails	High Esthetic Value
Conventional	0.401 **	0.080	0.541 ***	0.163	0.119	0.416 ***	0.280 **	0.383 ***	0.486 ***
	(0.161)	(0.197)	(0.119)	(0.132)	(0.083)	(0.094)	(0.142)	(0.119)	(0.092)
Bias-corrected	0.609 ***	0.006	0.722 ***	0.307 **	0.116	0.469 ***	0.568 ***	0.456 ***	0.583 ***
	(0.161)	(0.197)	(0.119)	(0.132)	(0.083)	(0.094)	(0.142)	(0.119)	(0.092)
Robust	0.609 ***	0.006	0.722 ***	0.307 **	0.116	0.469 ***	0.568 ***	0.456 ***	0.583 ***
	(0.200)	(0.216)	(0.124)	(0.129)	(0.115)	(0.134)	(0.203)	(0.174)	(0.122)
Observations	398	398	398	398	398	398	398	398	398
Robust 95% CI	[0.218; 1.001]	[−0.417; 0.430]	[0.480; 0.965]	[0.053; 0.561]	[−0.109; 0.341]	[0.206; 0.731]	[0.170; 0.966]	[0.115; 0.797]	[0.343; 0.823]
MSE-optimal Bandwidth	4.865	6.486	5.886	11.160	13.550	8.422	5.586	4.611	4.910
Eff. N(control)	27	46	36	65	79	52	36	27	27
Eff. N(treatment)	61	102	86	131	131	131	86	61	61

Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$.

3.3. Regression Discontinuity Estimation for Changes in Satisfaction Toward Parks and Community Greenspace Characteristics

The robust RD estimation also examined changes in satisfaction with specific greenspace characteristics. For parks (Figure 1 and Table 4), notable improvements were found in plant diversity (coefficient = 0.795, 95% CI: 0.373 to 1.217, $p < 0.01$), trees/lawns (coefficient = 1.190, 95% CI: 0.735 to 1.644, $p < 0.01$), plant care (coefficient = 0.740, 95% CI: 0.164 to 1.317, $p < 0.05$), sport facility (coefficient = 0.481, 95% CI: 0.132 to 0.830, $p < 0.01$), seating areas (coefficient = 0.664, 95% CI: 0.268 to 1.059, $p < 0.01$), and large open spaces (coefficient = 0.516, 95% CI: 0.034 to 0.998, $p < 0.01$). Having trails is weakly significant with an estimate coefficient of 0.461 (95% CI: −0.032 to 0.955, $p < 0.1$).

For community greenspaces (Figure 2 and Table 5), significant improvements were similarly observed in plant diversity (coefficient = 0.722, 95% CI: 0.480 to 0.965, $p < 0.01$), plant care (coefficient = 0.307, 95% CI: 0.053 to 0.561, $p < 0.05$), seating areas (coefficient = 0.469, 95% CI: 0.206 to 0.731, $p < 0.01$), and trails (coefficient = 0.456, 95% CI: 0.115 to 0.797, $p < 0.01$). Satisfaction toward having a high quality of water feature (coefficient = 0.568, 95% CI: 0.170 to 0.966, $p < 0.01$) and esthetic value (coefficient = 0.583, 95% CI: 0.343 to 0.823, $p < 0.01$) were also improved in community greenspaces but not in terms of having a sport facility.

3.4. Robustness Checks

We performed five robustness checks on each subsample, following the methodologies from previous studies [60,61]. Firstly, a balance test was performed to assess whether significant differences existed in resident characteristics around the policy intervention date. This involved running the same RD estimations on common predetermined variables, including gender, age, education, marital status, employment, and income. The results indicated that these predetermined variables were discontinuous around the cutoff (Figure 3). This means there was no systematic difference between the treated and control groups regarding their gender, age, education, marriage, employment, and income levels. The second test examined observation densities around the cutoff, and the results suggest no abrupt changes in the number of observations among residents that completed the survey before and after the cutoff (t = 0.781, $p = 0.435$ for parks subgroup; t = 1.534, $p = 0.125$ for community greenspaces subgroup). The third test employed placebo dates to determine whether potential events during the survey period might have influenced the estimations. Dates ranging from three to twenty days before the actual COVID-19 policy change were used as placebo dates, and the same RD estimations applied in our model were conducted on these dates. The plotted results showed no strong evidence of systematic patterns before the real policy adjustment (Figure 4). The fourth test excluded observations within one or two days from the actual cutoff to check whether the estimations were sensitive to samples very close to the cutoff. The results indicated robust estimations after such exclusions (Figure 5). Finally, we selected various bandwidths to check the sensitivity of the RD estimations, and the results were largely consistent with the original estimations (Figure 6).

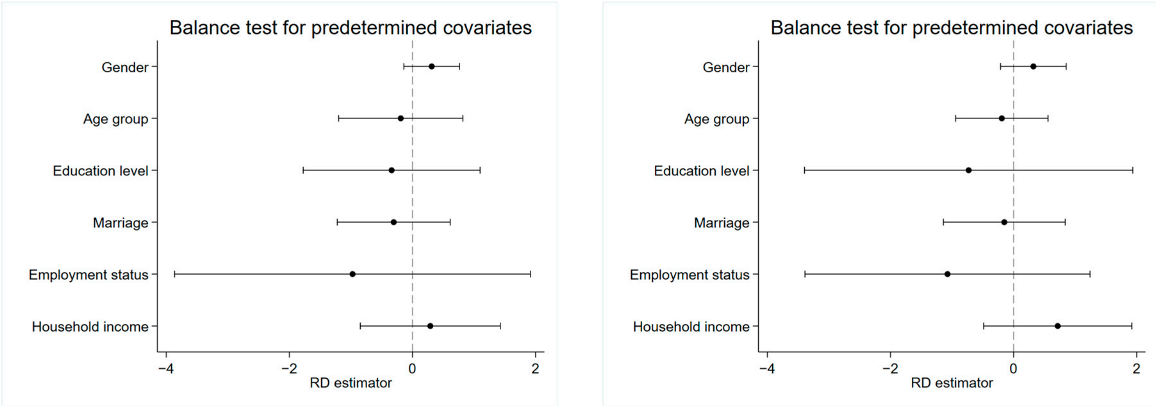

Figure 3. Balance tests for predetermined variables for park (**left**) and community greenspace (**right**) subgroups.

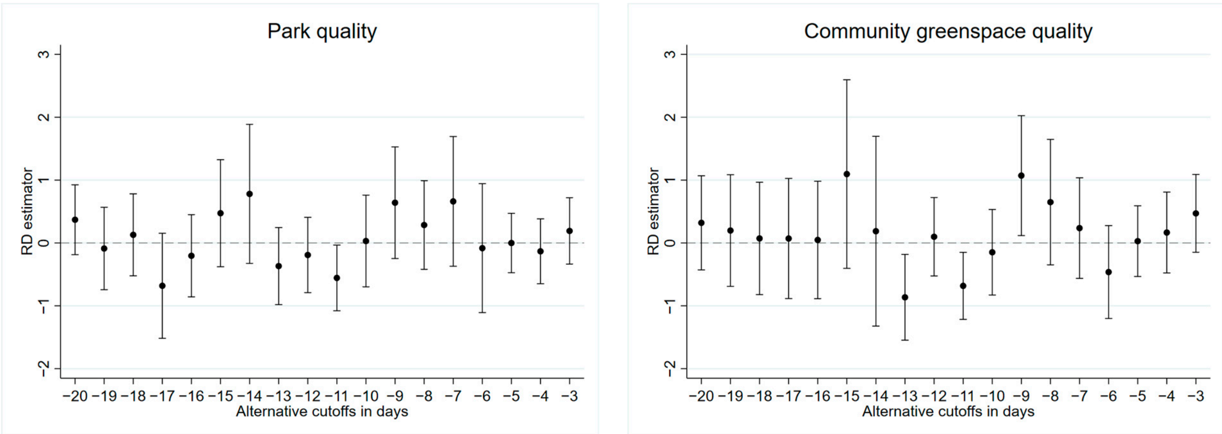

Figure 4. Analysis of placebo cutoffs' impact on survey results before cutoff (one and two days before actual cutoff were not performed due to limited number of observations).

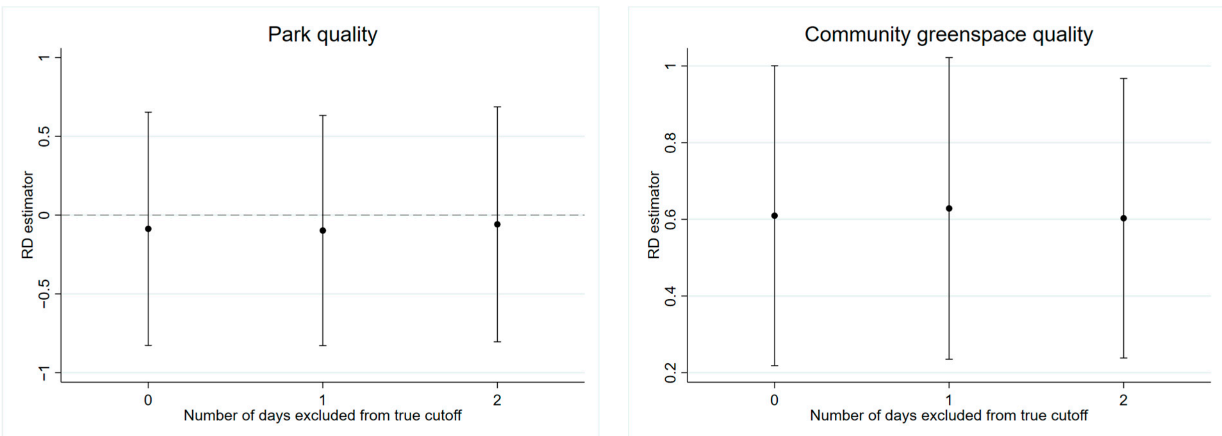

Figure 5. Sensitivity test of estimations excluding observations close to cutoff.

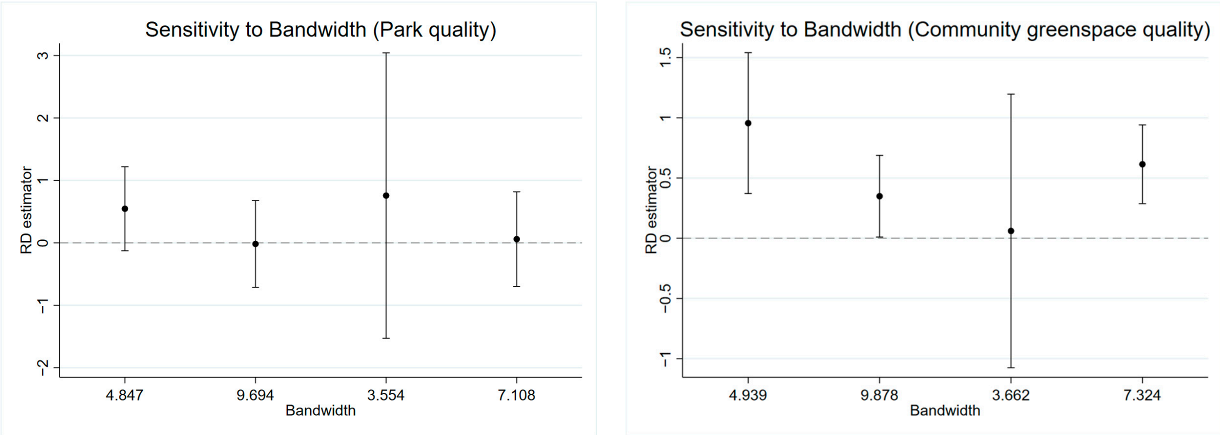

Figure 6. Bandwidth sensitivity test (bandwidths involved are MSE-optimal, doubled MSE-optimal, CER-optimal, and doubled CER-optimal values from left to right of horizontal axis in the plots below).

4. Discussions

4.1. Effects of COVID-19 Policy Change on Residents' Perceived Greenspace Quality

Based on our RD analyses, we found no significant change in residents' perceived quality of parks, but a significant improvement in the perceived greenspace quality within their residential communities. This finding suggests that, following the relaxation of pandemic restrictions, accessible community greenspaces, rather than parks, played a crucial role in shaping residents' attitudes. Greenspaces within the residential communities, being more accessible after reopening and the removal of stay-in-home mandates, became a preferred option for residents [19]. While concerns about exposure to other visitors and risks of being infected remained, the brief interactions with nature in these spaces, such as passing under trees or resting briefly in gardens, may alleviate residents' anxiety and promote their perception of greenspaces [63]. The insignificant change in perceived park quality might be attributed to the increased mobility of urban residents following the relaxation of pandemic containment policies, which heightened the risk of encountering positive COVID-19 cases, particularly in public spaces such as parks [64]. Consequently, residents may remain apprehensive about potential gatherings and social contacts in outdoor areas like parks [65]. The distance of parks from their homes and the necessity to use public transit increased the potentiality of being infected, which may have discouraged park visits [31]. Additionally, residents' perceived park quality was likely based on pre-reopening experiences, rather than recent visits [66]. Moreover, the overall condition of parks and greenspaces was not significantly altered due to limited mobility before the relaxation of containment policies. As a result, even as park visits resumed after reopening, residents may not have perceived a significant change in the overall park quality [25]. These findings suggest that urban planning should prioritize improving the quality and accessibility of residential greenspaces to better support residents' well-being in post-pandemic contexts.

4.2. Residents' Perceptions About Different Characteristics of Greenspaces

Our findings indicated that residents preferred plant diversity and maintenance quality over the quantity of vegetation in both parks and greenspaces. Typically, residents value the overall volume of vegetation less than the esthetic qualities of vegetation and landscape design according to a case study in Guangzhou, China [67], as well as cleanliness and maintenance based on an extensive analytical review on global empirical and case studies [30]. This preference persisted during the pandemic [68], which may explain why perceptions of vegetation quantity remained stable in our study. Another possible explanation is the changes made to plant diversity and maintenance quality following the policy adjustment. While the overall quantity of vegetation in urban areas did not undergo significant changes before and after the policy shift [69], the loosening of restrictions eliminated the need for COVID-19 containment infrastructures, such as mass testing facilities in the form of outdoor hubs and waiting areas within parks and community greenspaces. This modification restored landscape consistency and improved plant diversity by removing temporary visual obstructions, which residents likely noticed after the policy change.

Following the policy adjustment, residents increasingly favored seating areas and trails in both parks and community greenspaces. During the lockdown, restrictions on social interactions and mobility significantly limited residents' access to urban greenspaces, reducing the frequency of their pre-lockdown activities [28]. The inclination to gather in greenspaces was further suppressed by perceived risks of infection [66]. However, after the policy changes, the lifting of mobility restrictions led to a heightened demand for physical activities, nature observation, and social connection [66], amplifying the importance of urban greenspaces as places for direct encounters with nature [27,66]. Facilities like seating areas and trails effectively meet these needs, making greenspaces with these amenities more attractive than those without [70]. Also, the dispersed spatial distribution of seating areas and long trails have fewer visitors and might lower residents' encounters with large groups and perceived risks of being infected. Residents' increased preferences for features like trees, lawns, and large open spaces further supports this observation, as these elements facilitate social gatherings after reopening.

There were discrepancies in the perceived quality of the same features—such as sports facilities and high-quality waterscapes—between parks and community greenspaces. The perceived quality of sports facilities increased only in parks but not in community greenspaces. This difference may be attributed to the varying levels of crowdedness in these two types of greenspaces. Community greenspaces are more related to daily life and easily accessible for the community residents than large parks [66,71]. Sports facilities within community greenspaces are more frequently used than those in parks and often a critical source of spreading a virus [72]. As a result, residents in community greenspaces may have rated sports facilities lower due to the presence of larger groups and the associated fear of infection [73,74], which explains the unchanged perception of sports facilities in these areas. In contrast, the presence of high-quality waterbodies and visually appealing landscapes in parks were not as appreciated as those in community greenspaces. The easing of restrictions may have led to increased visitation at parks with high-quality waterscapes and scenic landscapes [75]. Overcrowding in these areas could have caused visitors to limit their time there to minimize the risk of infection, preventing them from fully experiencing a sense of comfort [73,74,76]. In residential communities, even though residents may have preferred to stay at home after reopening, they could still visually enjoy the esthetic landscapes and water features of their local greenspaces. Alongside the emotional relief associated with a return to normalcy, their evaluation toward esthetics and water features might be heightened [77,78].

4.3. Planning Implementations

Our findings can provide valuable insights for planners aiming to enhance urban community resilience during transition in public health crises. Priority should be given to plant diversity and maintenance quality in both parks and community greenspaces, as residents consistently value these attributes over sheer vegetation quantity, which helps sustain residents' satisfaction across different phases of the pandemic. Additionally, incorporating seating areas and well-designed trails in less crowded greenspaces can meet the heightened post-pandemic demand for physical activity, nature observation, and social connection. To address concerns about overcrowding and infection risks—particularly in community greenspaces—implementing crowd management strategies and ensuring regular sanitation of sports facilities are essential. Enhancing the visibility of esthetic features like waterbodies and visually appealing landscapes in community greenspaces allows residents to enjoy natural beauty close to home. Moreover, preventing overcrowding in parks with high-quality waterscapes and scenic spots requires thoughtful spatial configuration and management strategies, such as scheduled visitation.

4.4. Strength and Limitations

Our study demonstrates several strengths in both the estimation methods and findings related to the evaluation of urban greenspace quality, particularly during the critical transitional phase of the COVID-19 pandemic. The timing of our survey—conducted immediately following the adjustment of containment policies—enabled us to employ a quasi-experimental approach using an RDD estimation. This methodology strengthened our ability to draw causal inferences regarding the relationship between policy shifts and perceived greenspace quality. Capturing this specific timeframe is significant, as it represents a pivotal moment when communities were transitioning back to normalcy, and residents' perceptions were undergoing substantial changes. By focusing on this unique period, our study provides timely insights that can inform urban planning strategies in post-pandemic contexts. To the best of our knowledge, our research is one of the first to utilize a quasi-experimental design during the reopening phase of COVID-19. It extends the existing literature with a novel methodological perspective and advances the understanding of shifts in perceived greenspace quality during the recovery phase of a public health crisis. Additionally, our study delves into residents' perceptions of specific greenspace features during this transitional period, including plant diversity, maintenance quality, seating areas, trails, trees, lawns, large open spaces, sports facilities, and high-quality waterscapes. Highlighting these features has practical value, as discussed in detail in Section 4.3.

However, our study has several limitations, primarily related to data collection and survey methodology. Due to concerns of COVID -19 infection and ongoing containment policies during the survey distribution period, we relied on an online survey approach, which is often criticized for sample bias. Although this method facilitated the collection of a large number of responses, it may limit the generalizability of our research findings. Additionally, the timing of the study only allowed us to examine the short-term effects of policy changes on residents' perceptions of greenspaces, rather than their long-term impacts. Future research could benefit from longitudinal data to assess the sustainability and validity of our findings over time.

5. Conclusions

This study provides empirical insights into the perceived quality of urban greenspaces in Shanghai following the relaxation of COVID-19 containment policies. Utilizing a regression discontinuity design, we analyzed online survey data collected around the policy shift on 5 December 2022, to examine the causal impact of these changes on residents' perceptions. Our findings indicate that while the overall perceived quality of parks remained largely unchanged after the policy adjustment, the overall perceived quality of community greenspaces showed significant improvement. Residents reported increased satisfaction with specific features including plant diversity, maintenance quality, and the availability of seating and trails. Notably, sports facilities became more desirable in parks, while high-quality water features and esthetic value were more appreciated in community greenspaces.

These findings underscore the importance of urban greenspaces as crucial components of city planning, particularly during public health crises that alter residents' mobility patterns. The discrepancies in improved perception between parks and community greenspaces after the policy relaxation provide insights for greenspace design and management during a public crisis transitional period. Moreover, this research contributes to the existing literature by providing evidence on how public health policy changes influence residents' perceived greenspace quality. The insights gained from this study can assist urban planners and policymakers to enhance greenspace quality based on specific features, ensuring that these spaces meet the evolving needs of urban residents—particularly during times of crisis—and ultimately promote community resilience against future health challenges.

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