GeoHealth

RESEARCH ARTICLE

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Assessing Immediate and Lasting Impacts of COVID-19-Induced Isolation on Green Space Usage Patterns

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Abstract The COVID-19 pandemic has profoundly influenced urban lifestyles, particularly the utilization of green spaces. While existing studies have primarily focused on the immediate effects of COVID-19-induced isolation, less attention has been given to the enduring impacts on green space usage patterns. This study addresses this gap by conducting three comprehensive surveys in Dezhou, China—before, during, and after the first wave of social isolation (December 2019, March 2020, December 2020). These surveys assessed socioeconomic conditions, commuting habits, green space usage habits, and landscape preferences, specifically focusing on usage frequency, duration of stays, and activities undertaken. Using Mann-Whitney *U* tests and Spearman's rho correlations, we identified significant long-term changes, including an increase in the frequency of visits by previously infrequent users, a reduction in visit durations, and a rise in high-intensity activities. These trends persisted 9 months post-isolation, highlighting the pandemic's lasting impact on green space usage and its critical role in enhancing public health and pandemic preparedness through thoughtful urban environmental design. This study not only sheds light on behavioral adaptations during a public health crisis but also offers evidence-based strategies for urban planning to bolster societal resilience in the face of future pandemics.

Plain Language Summary During the COVID-19 pandemic, how people used parks and green areas changed significantly because of social distancing rules. To understand these changes, we asked people about their green space usage habits before, during, and after the first major outbreak in Dezhou, China. We were interested in how often they visited these spaces, how long they stayed, and why they went there. Our research showed that, with the pandemic's social rules, fewer people went to these spaces, and when they did, they stayed for shorter periods but were more likely to engage in intense activities. These patterns were still noticeable 9 months later. This study suggests that designing our green spaces thoughtfully can help communities better handle the challenges of pandemics, making us healthier and more prepared for future crises.

Key Points:

- Immediate and lasting effects of COVID-19-induced isolation on green space usage habits were distinguished
- Three surveys were conducted before, during, and after the first wave of the COVID-19 pandemic's social isolation
- Effects of isolation on usage habits were identified and these effects remained significant 9 months after the social isolation

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1. Introduction

Social isolation poses significant health risks and has been identified as a risk factor for morbidity and mortality (Holt-Lunstad et al., 2010; House et al., 1988). The ongoing coronavirus disease 2019 (COVID-19) pandemic has exacerbated this issue as many countries have implemented lockdowns and social isolation measures to curb the spread of infection (Banerjee & Rai, 2020; Peng & Roth, 2021). China, where the COVID-19 pandemic first emerged, has effectively contained the virus through strict quarantine and isolation measures (J. Chen et al., 2020; Kraemer et al., 2020; Niu & Xu, 2020; Tang et al., 2020). Although research on the effects of social isolation during the COVID-19 pandemic is rapidly growing, most studies have focused on physical and psychological outcomes (R. Chen et al., 2020; Suárez-González et al., 2021; Williams et al., 2020).

Existing evidence indicates that exposure to green spaces can significantly enhance both physical and mental health (Browning et al., 2022; Kondo et al., 2018; Vienneau et al., 2017). Green spaces encompass a variety of open and natural areas including parks, gardens, yards, greenways, urban forests and urban farms (Breuste et al., 2013; Johnson, 2001; Taylor & Hochuli, 2017). Translating their benefits into actionable strategies for effective green space planning and management is crucial. However, to our knowledge, no studies have directly examined the immediate and lasting effects of isolation due to the COVID-19 pandemic on urban green space usage habits. This research gap may result in missed opportunities to mitigate the social isolation risks caused by the COVID-19 pandemic. Our study aims to contribute to the development of evidence-based urban green space strategies that enhance public health during the current and future pandemics.

1.1. Multifaceted Benefits of Urban Green Spaces for Public Health and Social Well-Being

Numerous empirical studies have demonstrated the public health benefits offered by green spaces (Twohig-Bennett & Jones, 2018; J. Zhang et al., 2020). These benefits have been measured at regional (Mitchell & Popham, 2008), city-level (Lovasi et al., 2013; Ma, 2020), and neighborhood scales (Beyer et al., 2014). Urban residents can reap physical and mental health advantages, such as recreational opportunities (Cetin, 2015; H. Zhang et al., 2013), reduced mental stress (Grahn & Stigsdotter, 2010; Ward Thompson et al., 2012), and improved social cohesion through enhanced neighborhood communication (Jennings & Bamkole, 2019; Wan et al., 2021). Green spaces directly enhance urban dwellers' quality of life by providing spaces for active and passive outdoor activities (Ma et al., 2023), such as playing sports, dog walking, chess games, and sunbathing. They also offer relaxing experiences that promote restfulness, cognitive development, and mental health (Nesbitt et al., 2017). Moreover, green spaces can bolster healthcare capacity (Van den Berg, 2017), reduce aggression (Ulrich et al., 2018), lower crime and violence (Bogar & Beyer, 2016), and even elevate public perceptions of safety (Kuo et al., 1998). Additionally, they serve as meeting places for residents, thereby increasing social activities and fostering neighbor interaction (Kemperman & Timmermans, 2014). These advantages have been substantiated in various regional, cultural, and international contexts (Hunter et al., 2019; Twohig-Bennett & Jones, 2018).

These psychological and physical benefits extend across various types of green spaces, from nature reserves and urban parks to community gardens (Bowler et al., 2010; Wan et al., 2021; Wood et al., 2017). Nature reserves and larger natural areas offer immersive experiences that are crucial for enhancing mood and reducing anxiety (Hartig et al., 2014). These spaces allow individuals to engage in activities such as hiking and wildlife observation, providing a sense of escape and a deep connection with nature. Such experiences can lead to significant reductions in stress and improvements in overall well-being by offering a break from the urban environment and a chance to reconnect with the natural world (Ballew & Omoto, 2018; Passmore & Holder, 2017). Urban parks cater to more diverse uses and users, offering spaces and facilities for different age groups, thus increasing opportunities for walking and activities (McCormack et al., 2010). These parks often feature areas to explore and discover, along with amenities that provide comfort and convenience, such as seating, shade, and drinking water. Although community gardens may not offer all the amenities of urban parks due to cost and space constraints, they provide unique benefits by combining physical activity with social interaction. The proximity of multiple community gardens within residential areas enhances social cohesion by encouraging residents to spend time outdoors, thus creating ongoing opportunities for social interactions among neighbors (Veen et al., 2016; Zijlema et al., 2017). These spaces contribute to the benefits of being close to nature and offer convenient places for people to “get out of the house.” Overall, each type of green space supports public health in distinct ways, whether through promoting physical activity, facilitating social connections, or providing psychological relief.

1.2. Enhancing Resilience During Societal Crises: The Amplified Role of Green Spaces

The advantageous impacts of green spaces may be particularly pronounced during periods of societal crisis. In response to public health concerns, many governments have enacted lockdown policies, leading to changes in recreational activities. With the operational restrictions placed on indoor recreational spaces, the physical, and mental benefits offered by green spaces have been amplified in the context of isolation (Day, 2020; Ugolini et al., 2020). Moreover, additional benefits for residents have been associated with exposure to green spaces during the pandemic. In the United States, Italy, and Canada, green spaces have been negatively correlated with COVID-19 incidence and morbidity (Cascetta et al., 2021; Klompmaker et al., 2021; Stieb et al., 2020). Specifically, during the pandemic, green spaces have been shown to buffer or mitigate the detrimental impacts of social isolation on various long-term health outcomes (Berdejo-Espinola et al., 2021; Spano et al., 2021; Yang et al., 2021). The positive effects of green spaces on social equity have also been observed. For example, in the United States, communities with a larger proportion of green space have exhibited a significantly smaller black-white racial gap in COVID-19 infection rates (Lu et al., 2021). Consequently, green space management presents considerable opportunities for fostering individual resilience when development practices incorporate knowledge of usage patterns.

These usage patterns, particularly in urban parks, should be carefully analyzed to ensure they continue to serve as vital resources while minimizing public health risks. Urban parks, often more accessible for the majority of the urban population, have played a critical role in providing nearby nature experiences and opportunities for physical

activity during the pandemic (Noszczyk et al., 2022; Ugolini et al., 2020). They have adapted by offering organized, socially-distanced outdoor activities to maintain community health and well-being (Slater et al., 2020). The diversity in park amenities has allowed for varied uses, from exercise equipment to open fields for group activities, catering to the needs of different population segments under changing public health guidelines. However, the roles of nature reserves and larger natural areas, while offering the therapeutic benefits of nature and allowing for social distancing, may see limited use due to their distance from populated urban centers (Kim et al., 2023). Regarding community gardens, while their high accessibility encourages frequent visits and enhances social interactions, this could also lead to higher risks of infection during a pandemic due to potential overcrowding, which may challenge the enforcement of social distancing rules (Shoari et al., 2020).

1.3. A Critical Knowledge Gap: Immediate and Lasting Effects of COVID-19-Induced Isolation on Green Space Usage Patterns

Several studies have identified significant effects of isolation resulting from the COVID-19 pandemic on green space usage, including increased park visitation (Geng et al., 2021), heightened importance of recreation (da Schio et al., 2021), and more diverse visitor preferences (Ugolini et al., 2020). However, these studies primarily focused on the immediate effects of social isolation, with less attention given to enduring impacts over time. This oversight leaves a critical knowledge gap, particularly in light of evidence from studies like that of Venter et al. (2021), which observed sustained elevated recreational activity levels even after lockdown measures were relaxed (Venter et al., 2021). Moreover, few researchers have conducted in-site surveys among green space users who are directly affected by these conditions.

Our study addresses this gap by comparing the immediate and long-term effects of COVID-19-induced isolation on green space usage patterns. First, we provide a longitudinal analysis that evaluates how changes initiated during the height of the pandemic persist or evolve as social restrictions are lifted, offering insights into whether the observed changes in park usage patterns represent a temporary shift or a new normal in urban lifestyles. Second, we delve into detailed behavioral insights by examining the nature of activities within these green spaces —from passive to vigorous. Our objective is to reveal nuanced changes in public behavior toward green space usage in response to prolonged social stress and health anxieties, thereby contributing depth to the understanding of recreational patterns during and after the pandemic. Additionally, our findings extend beyond academic insight to practical implications, offering evidence-based recommendations for urban planning and public health policies that address both current and future public health challenges.

1.4. Research Questions

In this study, three surveys were conducted before, during, and after the social isolation of the first wave of the COVID-19 pandemic (December 2019, March 2020, and December 2020), in Dezhou, China. Emergency regulations were implemented in Dezhou city starting in January 2020, including the prohibition of gatherings, the transition from in-person classes to distance learning, the temporary suspension of public transport, and the cessation of operations for businesses such as gyms, barbershops, and restaurants. These regulations persisted until March. Notably, visiting green spaces was permitted during this period, albeit with a distance-keeping requirement.

The questionnaire survey comprised four sections: respondents' socioeconomic conditions, commuting habits, usage habits, and preferences for landscape components. The usage habits of green spaces were operationalized into three factors, including frequency of use, stay time, and visiting goals. Specifically, this study aims to address the following three research questions: (a) How did the usage habits of green spaces change during the isolation caused by the COVID-19 pandemic? (b) Were these changes sustained 9 months later? (c) How were the usage habits affected by other variables?

2. Methodology

2.1. Study Site

The present study was conducted in Changhe Park, a public green space situated in Dezhou city, China (Figure 1). Dezhou is a prefecture-level city located in Shandong province, with geographical coordinates of 36°24′25″ to 38°0′32″N and 115°45′ to 117°36′E. The city covers an area of 10,356 km^2 and had a population of

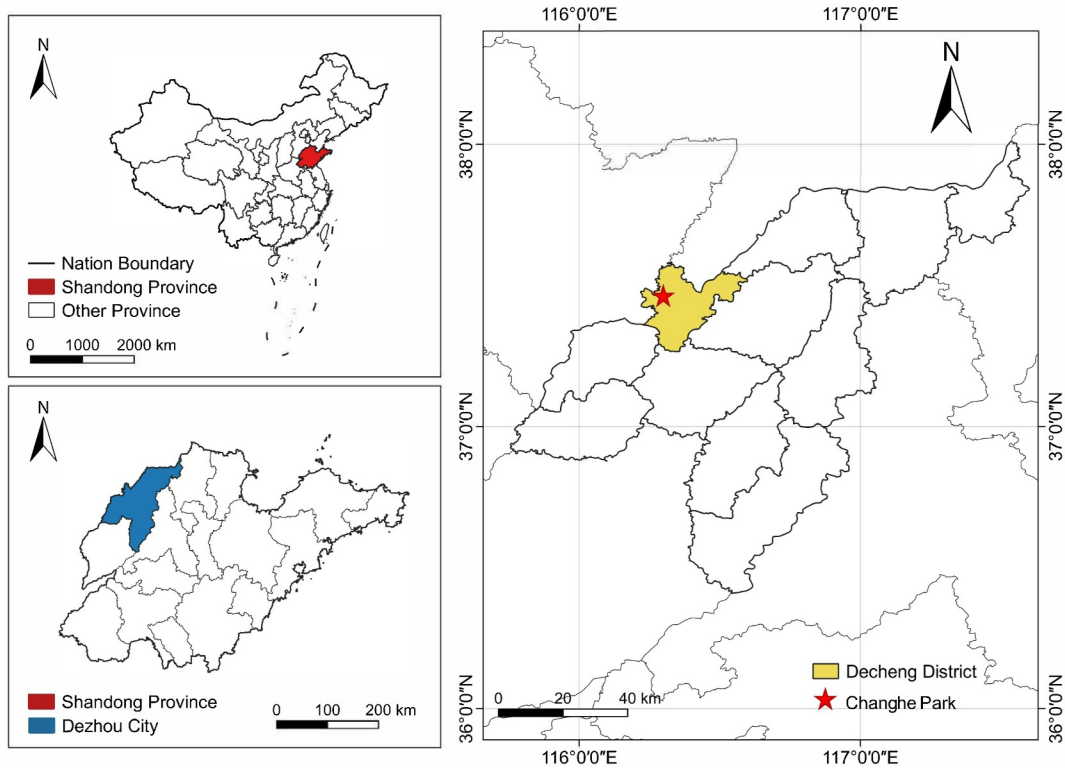

Figure 1. The location of the study site.

approximately 5.61 million as of 2020 (Shandong Provincial Bureau of Statistics, 2021). The choice of Dezhou for this study considered its representative demographics and urban layout, which closely match those of many medium-sized cities in China. This similarity makes it possible for the findings from Dezhou to potentially reflect broader green space usage patterns applicable to other urban settings with comparable demographic and geographical characteristics.

Changhe Park, the specific site selected for this study, is one of the most frequented recreational spaces by local residents and is designed in a typical Chinese urban park style, featuring a mix of blue spaces, green spaces, and squares. The park, located in the central area of the Decheng district, covers an area of 7.3 km^2 and has been relatively stable in terms of its landscape and human activities for over a decade. This stability made Changhe Park an ideal site for examining changes over time, specifically the impact of COVID-19-induced isolation on green space usage patterns.

Basic data for Changhe Park were obtained from the Dezhou Architectural Planning and Design Institute, which provided comprehensive information on the park's layout, features, and amenities. To ensure the accuracy and reliability of the data, we conducted a thorough field measurement verification process and cross-checked the data with satellite images (map.baidu.com). This allowed us to obtain a comprehensive understanding of the park's physical and social characteristics, and served as a foundation for subsequent data collection and analysis.

2.2. Questionnaire Survey

We conducted a questionnaire survey to investigate the effects of COVID-19-induced isolation on green space usage habits. The survey comprised four sections: (a) respondents' socioeconomic conditions, (b) Changhe Park visitors' commuting habits, (c) usage habits, and (d) preferences for landscape components. The questionnaire was designed based on extensive literature reviews, expert consultations, and semi-structured interviews with local residents (Rey Gozalo et al., 2018; Schetke et al., 2016; Schipperijn et al., 2010).

The survey captured detailed demographic information, including sex (male or female), age group (≤14, 15–24, 25–44, 45–64, and ≥65 years), education level (secondary school or lower, high school or technical school,

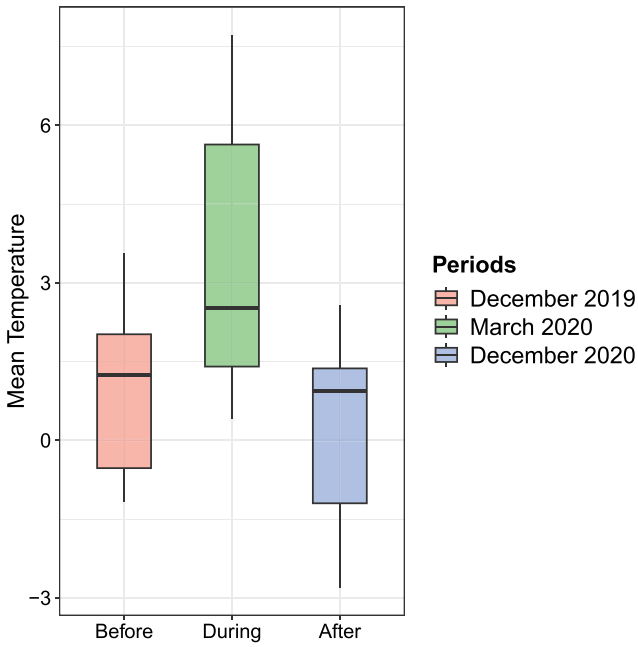

Figure 2. Mean temperatures during the study periods.

degree, master or higher), and monthly per capita income (no income, ≤2,000, 2,000–3,000, 3,000–5,000, 5,000–10,000, and ≥10,000 CNY). Commuting habits were assessed by inquiring about respondents' travel time (<5, 5–15, 15–30, and >30 min) and mode of transportation (walking, cycling, public transport, driving). Usage habits encompassed visit frequency (daily, 1–3 times per week, 1–3 times per month, 1–6 times per year, and rarely), typical visit duration (<1, 1–3, and >3 hr), and preferred activities (walking or sports, dog walking, babysitting, outings with family and friends, and recreation). Landscape components considered were plant combinations (grass, grass-shrub, grass-shrub-tree), openness-enclosure of spaces (open, half-open, closed), space size (small, medium, large), and space connection (low, medium, high). The waterfront degree was categorized as low, medium, or high, representing areas without water visibility, areas with water visible through plants, and areas directly adjacent to the water, respectively.

A stratified random sampling technique was employed, ensuring the demographic diversity of the participants. The sample size of 350 study participants was determined based on previous studies on urban park preferences (Mak & Jim, 2019; Özgüner, 2011; Özgüner & Kendle, 2006), as well as the recommendation of Krejcie and Morgan (1970) for determining sample sizes for populations of unknown size (Krejcie & Morgan, 1970). The stratification was carried out based on visit timing (weekdays vs. weekends) and hours of the day to ensure representation across different user groups. This method helped in capturing a representative cross-section of park visitors, reflecting varied socioeconomic backgrounds (Raux et al., 2016; Shan, 2020).

The surveys were conducted face-to-face in the local language (Mandarin), ensuring clarity in communication and the ability to address any respondent queries immediately. This approach also facilitated a high response rate and the accuracy of the responses (Wenz et al., 2020). Each survey session began with an explanation of the study's purpose and the survey procedure, followed by the data collection. A pilot study was initially conducted before the formal survey, where visitors were randomly selected using an intercept survey method to test the questionnaire's validity (Beatty & Willis, 2007; Groves et al., 2011). Based on the analysis of pilot responses and direct feedback from participants, modifications were made to enhance the clarity and relevance of survey items.

The initial survey was conducted in December 2019 (Ma, 2023), followed by subsequent surveys in March and December 2020 to assess both immediate and long-term changes in green space usage due to the pandemic. In selecting the timing for our surveys, we aimed to minimize the influence of seasonal weather variations. To substantiate the similarity in weather conditions during the selected periods in early March and early December in Dezhou city, we referred to temperature data visualized in Figure 2 (Shandong Meteorological Bureau, 2020). Additionally, we conducted a Kruskal-Wallis Test to compare the mean temperatures across these specific periods. This non-parametric test, chosen for its robustness with smaller data sets, confirmed that there is no statistically significant difference in temperatures, supporting our decision to compare green space usage across these times without the confounding effect of major seasonal temperature variations.

For one response, if more than 70% of the samples choose the same answer, it will be set as invalid response. Out of the 350 responses collected in each survey phase, 307, 308, and 326 responses were deemed valid for further analysis for December 2019, March 2020, and December 2020, respectively. Participants were not informed about the epidemic's relevance to the study to avoid bias.

This study is a non-interventional study. Informed consent was obtained from all individual participants included in the study.

2.3. Statistical Analysis

Upon data collection, we conducted various statistical analyses using R 4.1.2, an open-source programming language and software environment for statistical computing and graphics (R Core Team, 2016). All previously mentioned variables were considered as categorical independent variables. The initial analysis involved applying

Table 1
Participant Characteristics

	December 2019 (N = 307)		March 2020 (N = 308)		December 2020 (N = 326)	
	N	%	*N*	%	*N*	%
Sex						
Male	154	50.2%	176	57.1%	154	47.2%
Female	153	49.8%	132	42.9%	172	52.8%
Age group						
Less than 14 years	27	8.8%	30	9.7%	36	11.0%
15–24 years	16	5.2%	33	10.7%	22	6.7%
25–44 years	30	9.8%	48	15.6%	46	14.1%
45–64 years	103	33.6%	87	28.2%	100	30.7%
65 years or more	131	42.7%	110	35.7%	122	37.4%
Education						
Missing, primary or secondary school	136	44.3%	137	44.5%	167	51.2%
High school or technical school	75	24.4%	100	32.5%	99	30.4%
Degree	87	28.3%	59	19.2%	53	16.3%
Master or higher	9	2.9%	12	3.9%	7	2.1%
Monthly income per capita						
No income	35	11.4%	71	23.1%	70	21.5%
Less than 2,000 CNY	58	18.9%	61	19.8%	60	18.4%
2,000–3,000 CNY	40	13.0%	28	9.1%	46	14.1%
3,000–5,000 CNY	104	33.9%	76	24.7%	75	23.0%
5,000–10,000 CNY	66	21.5%	64	20.8%	65	19.9%
More than 10,000 CNY	4	1.3%	8	2.6%	10	3.1%

basic descriptive statistics to the information obtained through the questionnaire survey. For pairwise comparison analysis to identify differences among groups across distinct periods, we employed the non-parametric Mann-Whitney *U* test, which compares the distributions of two independent samples. This test is suitable for dealing with ordinal data, such as ours, or when the assumptions of parametric tests, like the independent samples *t*-test, cannot be met. Additionally, we performed Spearman's rho correlation analysis, a non-parametric measure of the strength and direction of the association between two ranked variables (Hauke & Kossowski, 2011). This test is often used when the data are ordinal or when the relationship between variables is not linear, as in our study. Therefore, we conducted Spearman's rho correlation analysis to determine the relationship between usage habits and respondents' demographic characteristics, commuting habits, and landscape design elements.

3. Results

3.1. Demographic Characteristics of Respondents

Table 1 presents detailed information on the demographic characteristics of survey participants across three distinct periods. The data reveal notable shifts in respondent diversity and demographic composition over these periods. Specifically, there was a significant increase in the diversity of respondents during the pandemic, a trend that persisted into the post-pandemic period. The proportions of younger respondents (below 45 years old) were 23.8% pre-pandemic, 36.0% during the pandemic, and 31.9% post-pandemic. Participants with a degree or higher constituted approximately 31.3% pre-pandemic, 23.1% during the pandemic, and 18.4% post-pandemic. Respondents with low monthly incomes (less than 2,000 CNY) accounted for 30.3%, 42.9%, and 39.9% before, during, and after the pandemic, respectively.

Table 2
Descriptive Statistics of Usage Habits

	Periods					
	December 2019 (N = 307)		March 2020 (N = 308)		December 2020 (N = 326)	
Usage habits	*N*	%	*N*	%	*N*	%
Frequency						
Daily	63	20.5	33	10.7	53	16.3
1–3 × per week	187	60.9	103	33.4	156	47.9
1–3 × per month	42	13.7	97	31.5	81	24.8
1–6 × per year	12	3.9	52	16.9	26	8.0
Not at all	3	1.0	23	7.5	10	3.1
Duration of visiting						
Less than 1 hr	16	5.2	151	49.0	126	38.7
1–3 hr	244	79.5	148	48.1	172	52.8
More than 3 hr	47	15.3	9	2.9	28	8.6
Preferred activities						
Walk or sport	81	26.4	113	36.7	107	32.8
Walk the dog	36	11.7	49	15.9	44	13.5
Babysitting	52	16.9	52	16.9	61	18.7
Trip with family and friends	61	19.9	65	21.1	68	20.9
Recreation	77	25.1	29	9.4	46	14.1

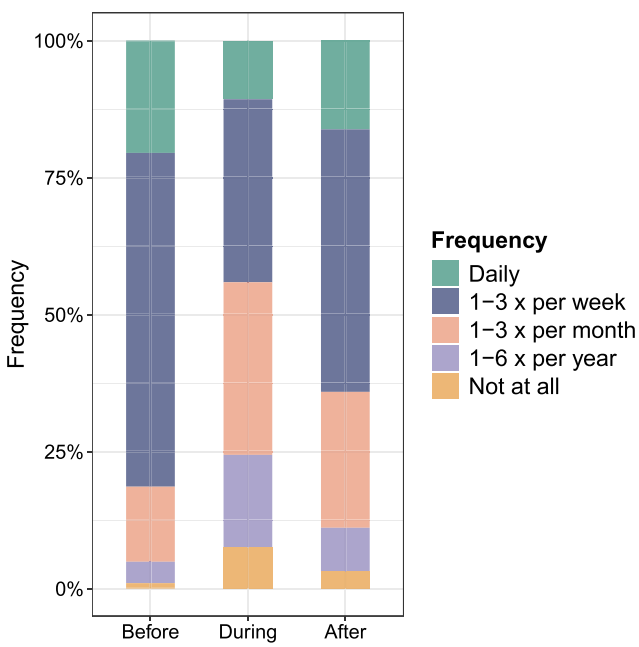

Figure 3. Percentage of visiting frequency of Changhe Park for three periods.

3.2. Results for Visiting Frequency

3.2.1. Descriptive Statistics of Visiting Frequency

Table 2 and Figure 3 detail the descriptive statistics of visiting frequency in Changhe Park across three surveyed periods. The data reveals a significant increase in the frequency of visits by individuals who previously had minimal interaction with green spaces.

Prior to the pandemic, the most frequently reported visitation rate (60.9%) was 1–3 times per week, followed by daily visits (20.5%). Less than 20% of respondents visited the park 1–3 times per month (13.7%) or 1–6 times per year (3.9%). A mere 1.0% rarely frequented the park.

In comparison to December 2019, the percentage of respondents visiting Changhe Park less frequently increased in March 2020. The most frequently reported visitation rate (33.4%) was 1–3 times per week, while the second most common response was 1–3 times per month (31.5%). The remaining options were relatively evenly distributed: 1–6 times per year (16.9%), daily visits (10.7%), and rarely (7.5%). This indicates a substantial decrease in park visitation frequency during the period of heightened social isolation.

Relative to December 2019, the visitation rates had not returned to pre-pandemic levels. In other words, most respondents visited Changhe Park either 1–3 times per week (47.9%) or 1–3 times per month (24.8%), followed by daily visitors (16.3%). Less than 10% of respondents visited the park 1–6 times per year (8.0%) or rarely (3.1%). This suggests that the effects of social isolation on park visitation frequency were not merely short-term but persisted beyond the peak of the pandemic.

3.2.2. Visitation Frequency Variations Across Periods

Mann-Whitney U test results, presented in Table 3 and Figure 4, further reinforce this observation, revealing significant differences in visitation frequency across the three time periods. The null hypothesis posits that visiting frequencies remained consistent over these periods. The results demonstrate that the visiting frequency during the pandemic differed significantly from that prior to the pandemic (U = 28,588, $p < 0.001$). Similarly, the post-pandemic visiting frequency showed a significant difference from the pre-pandemic frequency (U = 41,245, $p < 0.001$). Additionally, significant effects were observed between the during- and post-pandemic periods (U = 61,780, $p < 0.001$). Both the during-pandemic and post-pandemic visitation frequencies differed significantly from the pre-pandemic frequency, and a significant difference was observed between the during- and post-pandemic periods. This signifies the profound and enduring impact of social isolation measures on park visitation frequency.

3.2.3. Relationship Between the Visiting Frequency and Other Variables

Table 4 and Figure 5 illustrate the relationship between visiting frequency and respondents' demographic characteristics, commuting habits, and landscape design elements across the three periods. It is noteworthy that while certain factors such as age and commuting habits consistently influenced visitation frequency across all periods, the relationship of education level and monthly income with visitation frequency varied over time, potentially reflecting the changing socio-economic dynamics induced by the pandemic. However, no significant relationship was found between visitation frequency and landscape design elements.

Table 3
Comparing Usage Habits for Three Time Periods

Usage habits	Periods	Mann-Whitney *U* test	
		Statistic	*P*-value
Frequency	Before	28,588	0.000***
	During		
	Before	41,245	0.000***
	After 3		
	During	61,708	0.000***
	After		
Duration of visiting	Before	70,373	0.000***
	During		
	Before	67,400	0.000***
	After		
	During	43,697	0.001***
	After		
Preferred activities	Before	56,939	0.000***
	During		
	Before	56,753	0.003***
	After		
	During	46,582	0.105
	After		

Note. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Age appeared to have an inverse relationship with visiting frequency, with older respondents preferring to visit Changhe Park more frequently. Commuting habits positively correlated with visiting frequency, with increased access costs resulting in decreased frequency. Furthermore, visiting frequency significantly increased when the mode of transportation shifted from driving to walking.

The relationship between education level and visiting frequency, as well as monthly income and visiting frequency, varied across different periods. In December 2019 and March 2020, increased education levels correlated with decreased visiting frequency, while no significant relationship was observed in December 2020. Monthly income showed no significant correlation with visiting frequency in December 2019; however, it exhibited a negative correlation in March 2020 and December 2020.

3.3. Results for Stay Time

3.3.1. Descriptive Statistics of Visitor Stay Time

As depicted in Table 2 and Figure 6, a notable shift toward shorter visit durations was observed.

Before the pandemic in December 2019, prior to the pandemic, most respondents (79.5%) reported spending 1–3 hr at Changhe Park per visit. Only 5.2% of respondents stayed for less than 1 hr, while 15.3% stayed for more than 3 hr.

By March 2020, during the height of the pandemic, we observed a significant decrease in reported stay time at the park. The responses were almost evenly split between those who stayed for less than 1 hr (49.0%) and those who stayed for 1–3 hr (48.1%). A mere 2.9% of respondents reported stays exceeding 3 hr.

By December 2020, as the pandemic began to ease, the reported stay time had increased in comparison to March 2020, yet it was still lower than the pre-pandemic period of December 2019. Most respondents (52.8%) reported spending 1–3 hr at the park per visit, followed by less than 1 hr (38.7%), and more than 3 hr (8.6%).

3.3.2. Visitor Stay Time Variations Across Periods

The Mann-Whitney *U* tests, as shown in Table 3 and Figure 4, reveal that these changes in stay time across the three periods were statistically significant. The tests rejected the null hypothesis of consistent stay times across these periods. The stay time during the pandemic was significantly lower than the pre-pandemic period ($U = 70{,}373$, $p < 0.001$), and while the stay time increased in the post-pandemic period, it was still significantly lower than the pre-pandemic period ($U = 67{,}400$, $p < 0.001$). Even between the peak and post-peak periods of the pandemic, a significant difference was observed ($U = 43{,}697$, $p = 0.001$). These results clearly demonstrate the lasting impact of the pandemic on visitors' stay times at Changhe Park.

3.3.3. Relationship Between the Stay Time and Other Variables

In terms of the factors affecting these changes, as shown in Table 5 and Figure 5, we found that respondents' demographic characteristics, commuting habits, and landscape design elements all played a role. However, their influences varied across the three periods.

Respondents' demographic characteristics exhibited varied associations with stay time across the three time periods. Sex was positively correlated with stay time before the pandemic, indicating that female respondents stayed significantly longer than male respondents. After the pandemic, no statistically significant relationship was observed between stay time and sex. Regarding age groups, older respondents consistently had longer stays at the park, but this effect was not statistically significant in the post-pandemic period. A decrease in stay time was associated with an increase in education level in December 2019 and December 2020 (before and after the

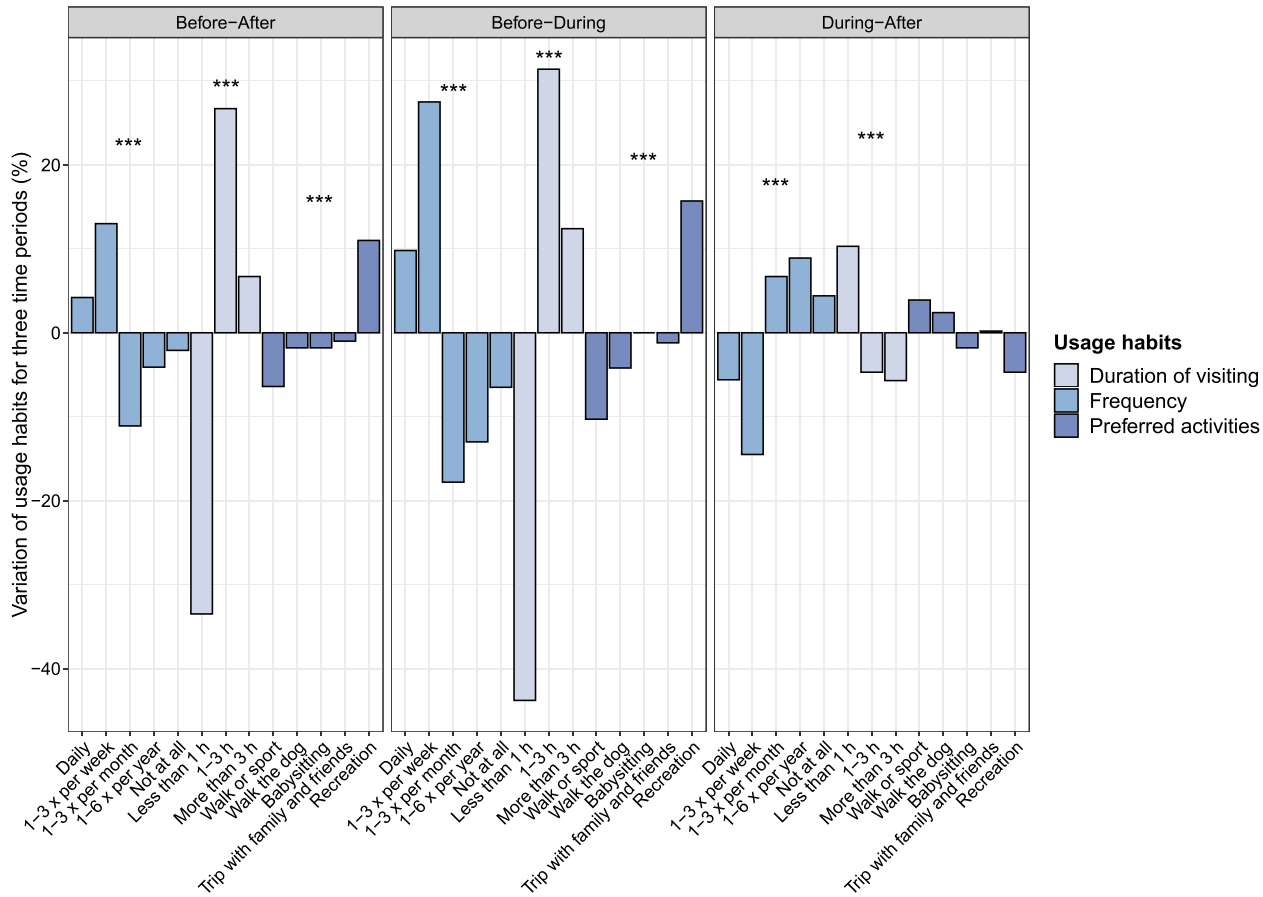

Figure 4. Percentage of variation in the usage habits of Changhe Park for three periods. Significant differences between the two situations were identified using the Mann-Whitney *U* test (***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.)

Table 4
Relationships Between the Visiting Frequency and Other Variables

	Before		During		After	
	Correlation coefficient	*P*-value	Correlation coefficient	*P*-value	Correlation coefficient	*P*-value
Sex	0.019	0.740	−0.053	0.352	0.005	0.927
Age group	−0.462***	0.000	−0.585***	0.000	−0.429***	0.000
Education	0.271***	0.000	0.347***	0.000	0.079	0.154
Monthly income per capita	0.015	0.792	−0.149***	0.009	−0.152**	0.006
Cost for access	0.315***	0.000	0.219***	0.000	0.398***	0.000
Means of transportation	0.209***	0.000	0.160***	0.005	0.398***	0.000
Compositions of plants	−0.059	0.297	0.006	0.910	−0.015	0.792
Site enclosure	−0.019	0.744	0.006	0.917	−0.057	0.306
Site size	−0.053	0.358	−0.022	0.702	0.019	0.731
Site connectivity	0.052	0.367	−0.046	0.418	0.006	0.908
Waterfront	0.085	0.135	0.016	0.776	−0.015	0.784

Note. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

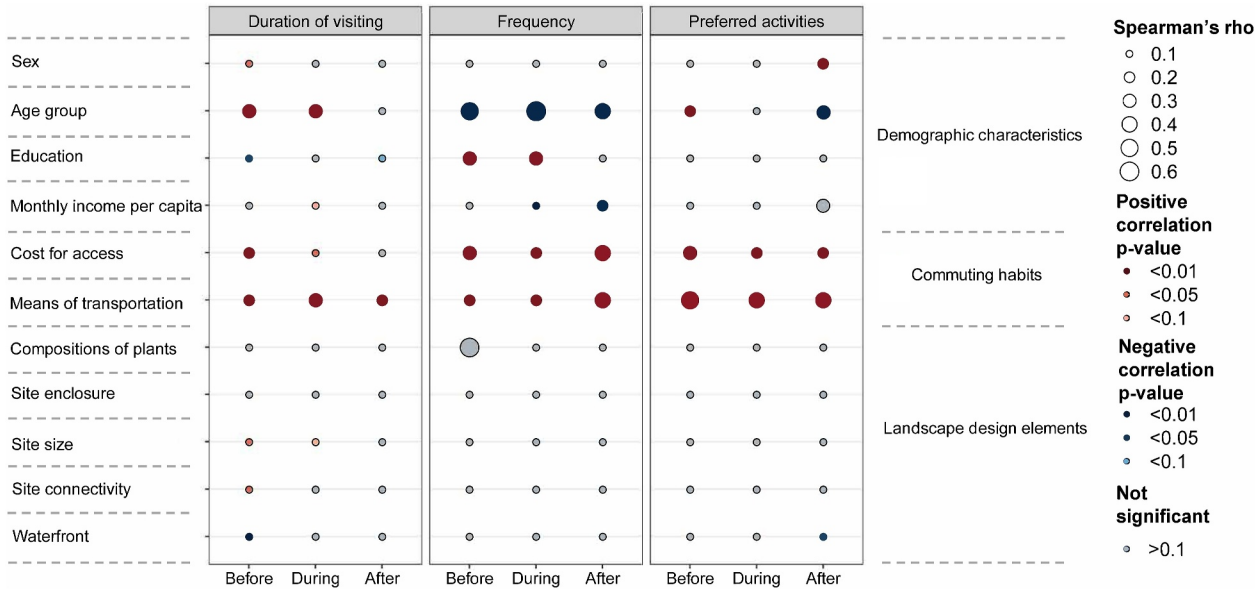

Figure 5. Relationship between the usage habits of Changhe Park and other variables for three periods. Correlation coefficient values are represented as the size of dots. Significant variables are shown in seven colors. The significant relationship between the two variables was identified using Spearman's rho correlation analysis.

pandemic). A positive relationship between stay time and monthly income was observed only during the pandemic.

In terms of commuting habits, the relationship between cost of access and stay time changed after the pandemic, while the relationship between means of transport and stay time remained consistent across all periods. A higher cost of access was positively correlated with stay time before and during the pandemic, but this relationship was not statistically significant after the pandemic. Stay time significantly increased when the means of transport shifted from walking to driving.

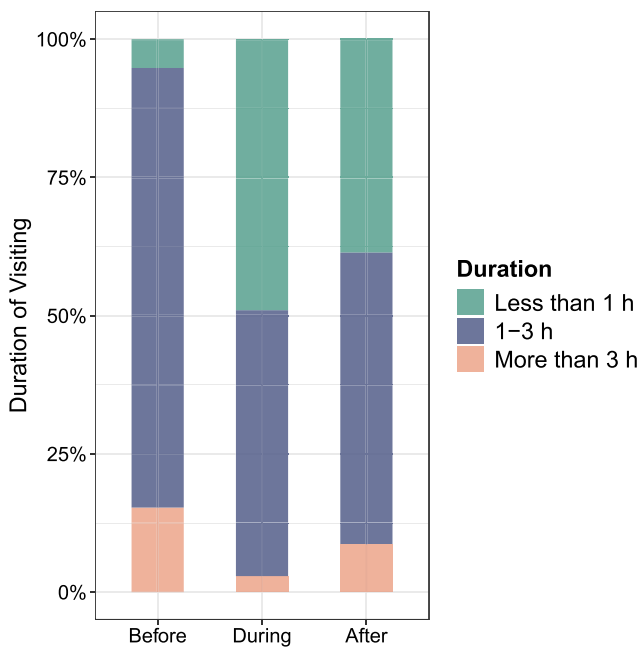

Figure 6. Percentage of visitor stay time of Changhe Park for three periods.

Table 5
Relationships Between the Stay Time and Other Variables

	Before		During		After	
	Correlation coefficient	*P*-value	Correlation coefficient	*P*-value	Correlation coefficient	*P*-value
Sex	0.127**	0.026	0.040	0.480	0.011	0.849
Age group	0.286***	0.000	0.255***	0.000	0.048	0.388
Education	−0.146**	0.011	−0.092	0.108	−0.092*	0.096
Monthly income per capita	−0.061	0.290	0.103*	0.070	−0.032	0.569
Cost for access	0.199***	0.000	0.142**	0.013	−0.024	0.668
Means of transportation	0.190***	0.000	0.272***	0.000	0.158***	0.004
Compositions of plants	0.055	0.333	0.002	0.971	0.074	0.184
Site enclosure	−0.069	0.230	−0.041	0.467	0.089	0.110
Site size	0.122**	0.032	0.107*	0.061	0.020	0.718
Site connectivity	0.113**	0.048	0.028	0.621	0.061	0.276
Waterfront	−0.103*	0.073	0.006	0.914	−0.032	0.565

Note. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The influence of landscape design elements on stay time was less pronounced during the pandemic. Before the pandemic, larger site size, and higher site connection were positively correlated with stay time, while an increased degree of waterfront access had a negative correlation with stay time. During the pandemic, only higher site connections exhibited a positive correlation with stay time. Moreover, no statistically significant relationship was observed between stay time and landscape design elements after the pandemic.

3.4. Results for Visitor Purpose

3.4.1. Descriptive Statistics of Visitor Purpose

As shown in Table 2 and Figure 7, there was a notable shift toward higher-intensity activities at Changhe Park during and after the pandemic.

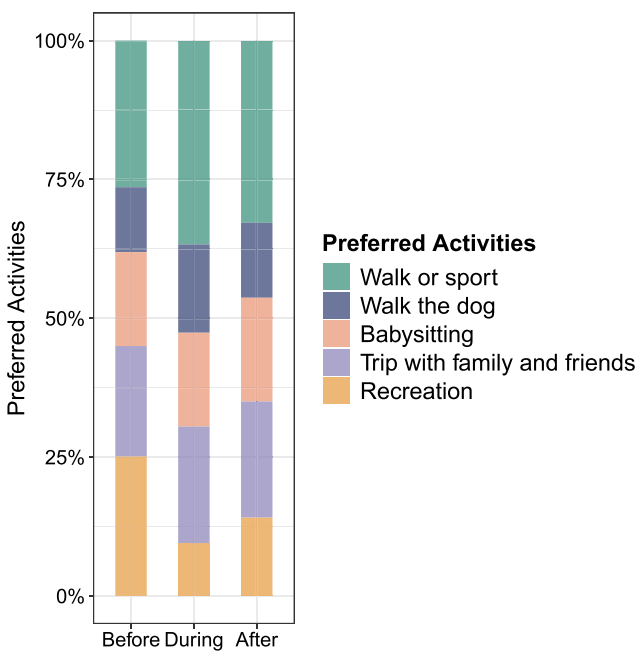

Figure 7. Percentage of visitor purpose of Changhe Park for three periods.

Prior to the pandemic in December 2019, the main purposes for visiting Changhe Park were walking or engaging in sports (26.4%) and recreation (25.1%). Fewer respondents visited for social purposes like spending time with family and friends (19.9%) or supervising children (16.9%). Dog walking was the least common purpose, with only 11.7% of respondents indicating this as their reason for visiting.

During the pandemic in March 2020, the primary reasons for visiting the park shifted. Walking or sports activities became even more prevalent (36.7%), and socializing increased to 21.1%. A significant number of visitors also reported allowing children to play outdoors (16.9%) and dog walking (15.9%). Only 9.4% of respondents cited recreation as their purpose for visiting, a marked decrease from the pre-pandemic period.

By December 2020, in the post-pandemic period, the most common purpose for visiting remained walking or engaging in sports (32.8%). However, there was a more even distribution among the remaining options: spending time with family and friends (20.9%), supervising children (18.7%), recreation (14.1%), and walking the dog (13.5%).

3.4.2. Visitor Purpose Variations Across Periods

The Mann-Whitney *U* tests, as detailed in Table 3 and Figure 4, indicate that these shifts in visiting purposes across the three periods were statistically

Table 6
Relationships Between the Purpose of Visiting and Other Variables

	Before		During		After	
	Correlation coefficient	*P*-value	Correlation coefficient	*P*-value	Correlation coefficient	*P*-value
Sex	0.054	0.346	0.037	0.523	0.212***	0.000
Age group	0.158***	0.006	0.051	0.373	−0.272***	0.000
Education	0.000	0.995	−0.060	0.293	0.007	0.905
Monthly income per capita	0.020	0.729	0.045	0.432	−0.024	0.670
Cost for access	0.278***	0.000	0.204***	0.000	0.149***	0.007
Means of transportation	0.462***	0.000	0.448***	0.000	0.367***	0.000
Compositions of plants	0.004	0.942	−0.013	0.819	0.033	0.547
Site enclosure	0.018	0.751	0.011	0.846	0.019	0.734
Site size	−0.088	0.123	0.019	0.737	−0.019	0.724
Site connectivity	−0.006	0.923	0.038	0.504	−0.023	0.677
Waterfront	0.006	0.913	−0.047	0.413	−0.108**	0.041

Note. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

significant. The tests rejected the null hypothesis of consistent visiting purposes across these periods. Both during the pandemic and post-pandemic periods showed significant differences from the pre-pandemic period ($U = 56{,}939$, $p < 0.001$ and $U = 56{,}753$, $p = 0.003$, respectively). However, no significant difference was observed between the during- and post-pandemic periods ($U = 46{,}582$, $p = 0.105$). This implies that the shifts in visiting purposes due to the pandemic persisted even after the easing of restrictions.

3.4.3. Relationship Between the Visitor Purpose and Other Variables

Table 6 and Figure 5 illustrate the relationship between visiting purposes and respondents' demographic characteristics, commuting habits, and landscape design elements. Across the three periods, these factors showed varying associations with visiting purposes.

Respondents' demographic characteristics exhibited varying relationships with the purpose of visiting Changhe Park across the three time periods. After the pandemic, a positive correlation emerged between sex and visiting purpose, with female respondents showing a preference for low-intensity activities. This trend was not observed pre- or during the pandemic. Age groups also showed an interesting shift: while older respondents preferred low-intensity activities pre-pandemic, they favored higher-intensity activities post-pandemic. No statistically significant relationships were found between visiting purpose and education level or monthly income.

The relationship between commuting habits and visiting purpose remained consistent throughout the study period. A higher cost of access positively correlated with visiting purpose, indicating that respondents with easier access to the park preferred higher-intensity activities. Means of transportation also positively correlated with visiting purpose, revealing that respondents preferred low-intensity activities when their mode of transport shifted gradually from walking to driving.

Significantly, no association was found between visiting purpose and landscape design elements pre- or during the pandemic. However, post-pandemic, a significant negative correlation emerged between visiting purpose and the degree of waterfront, suggesting a preference for higher-intensity activities among respondents who favored more waterfront areas.

4. Discussion

4.1. Key Findings

This study found significant immediate and enduring effects of COVID-19-induced social isolation on green space usage habits.

First, there was a marked increase in the frequency of visits by individuals who previously had minimal interaction with green spaces. Specifically, respondents with no prior green space visiting habits increased by 6.5 times, while those visiting rarely (1–6 times per year) increased by over four times. Nine months after the initial social isolation mandates, this increase persisted at a diminished but still significant rate: 3.1 times more for non-visitors and twice as many for rare visitors compared to pre-pandemic levels. Studies suggest that declines in physical activity and increased sedentary behavior during lockdown negatively affect mental health (Ammar et al., 2020; Chu et al., 2020). According to the Stress Reduction Theory, natural environments provide significant psychological benefits, reducing stress and enhancing mood (Ulrich et al., 1991). Thus, the increase in green space usage by individuals who previously visited infrequently suggests a coping mechanism triggered by the need for psychological relief and physical activity during prolonged home confinement. This result supports findings that people seek urban green spaces during crises (da Schio et al., 2021; Venter et al., 2020). However, our results contrast with a study in Chengdu, China, where a decrease in weekly green space visit frequency was reported (Xie et al., 2020).

Second, there was a notable shift toward shorter visit durations, with the percentage of respondents who stayed in the park for less than 1 hr increasing more than ninefold during the pandemic. This trend persisted post-social isolation, with five times as many still opting for shorter visits, indicating a lasting alteration in park usage patterns. Ongoing safety concerns about being in public green spaces potentially exposed to contagion may explain this shift (Lopez et al., 2021). Facing the conflicting needs of travel and safety, individuals may engage in self-protection behaviors, keeping essential activities brief to reduce perceived risk while satisfying their desire to be outdoors (Brewer et al., 2004). In our results, an increase in the number of visits was accompanied by shorter durations, although this variance may be influenced by regional differences in lockdown severity, public health policies, and cultural attitudes toward outdoor activities (Geng et al., 2021; Ugolini et al., 2020). Comparatively, previous studies also suggest a difference between the number of visits and time spent in green spaces as measures of usage (Burnett et al., 2021; Dass et al., 2023; Lopez et al., 2021), indicating that it is entirely possible to increase one at the expense of the other.

Third, there was a shift toward higher-intensity activities. The proportion of visitors preferring low-intensity leisure activities decreased by 15.7% during the social isolation period compared to the pre-pandemic period, with a post-isolation decrease of 11%. This shift can be interpreted through the Health Belief Model, which explains health behaviors as responses to perceived threats and benefits (Janz & Becker, 1984). A constant flow of "urgent" health warnings based on confirmed cases are carried on a daily basis by the China's media. These continuous health warnings from the media and authorities have likely heightened public anxiety (Li et al., 2020), increasing the perceived benefits of physical activity as a preventive measure against infection. With the closure of fitness facilities and other community places for recreation, open green spaces have become the ideal places for physical activity outside the home (Slater et al., 2020).

Lastly, the enduring effects observed 9 months post-isolation indicate potential long-term behavioral adjustments. This reflect the impacts of social isolation on public green space are likely as profound as in other life aspects (Corbera et al., 2020; Habib & Anik, 2021). Those who have experienced severe lockdowns may now have a renewed appreciation for parks, reflected in the sustained, although reduced, increase in park usage and the continued preference for shorter visits and more intense activities. Moreover, these behavioral shifts suggest that the pandemic may have permanently altered public perceptions and usage patterns of green spaces. Future urban planning and public space design may need to accommodate these changes, potentially increasing the availability of and access to green spaces that support a variety of activities. This aligns with hypothesis by Honey-Rosés et al. (2021), who propose that COVID-19 might fundamentally change our relationship with public spaces, influencing how they are designed and utilized in the future (Honey-Rosés et al., 2021).

4.2. Potential Mechanisms for Observed Significant Associations

The most significant variables influencing usage patterns were identified as visitor age group, education, income levels, and commuting habits. Although causal relationships cannot be determined from this work, given the extensive amount of theoretical and empirical evidence, it is appropriate to interpret the observed relationships as potential causative mechanisms. To comprehend how these factors might affect visiting habits, we discussed potential causal mechanisms.

4.2.1. How Does Age Group Affect Usage Habits?

We observed changes in participants' age demographics in response to social isolation measures and after social isolation. There was a substantial increase in the teenage (under 14 years) and young adult (15–24 years) demographics immediately following social isolation, likely due to distance learning. These changes leveled out in the young adult demographic as restrictions were lifted and schools reopened, while they remained high in the teenage group. There was also a largely positive shift in the middle-aged demographic (25–44 years) from March 2020 to December 2020, which can be attributed to the rise of remote working. Conversely, we observed an immediate and lasting negative shift in the proportion of the 45–64 and 65 years or older age groups.

These findings suggest that social isolation measures attract individuals who did not previously visit green spaces, particularly younger demographics. Social isolation encourages visits among younger groups through two pathways. First, public green spaces facilitate socialization, providing a place for personal interaction and face-to-face communication (Seeland et al., 2009). This benefit can be especially prominent during periods of social isolation when indoor public spaces frequented by young people, such as cafes and tea rooms, are closed. Meanwhile, staying outdoors makes it easier to maintain a safe social distance (Leclerc et al., 2020). Second, green spaces can help alleviate negative emotions (Pretty et al., 2007). Younger demographics are more adept at obtaining information from social media, and this information about the COVID-19 pandemic can easily trigger stress (Huang & Zhao, 2020). At the same time, activity limitations can result in a vicious cycle where fewer opportunities arise for coping with this stress (Tonello et al., 2019).

Our findings also suggest that social isolation promotes physical activity among the elderly. The pre-social isolation tendency for elderly individuals to prefer lower-intensity leisure activities shifted to higher-intensity physical activity in the post-social isolation period. This shift can be explained through the following pathways. First, previous studies have demonstrated that daily exercise may help combat disease by strengthening the immune system and counteracting some of the comorbidities that make individuals more susceptible to severe COVID-19 symptoms (Siordia, 2020). An aging immune system is more vulnerable to these threats (Akbar & Gilroy, 2020). Second, more than half of patients hospitalized due to COVID-19 experience respiratory failure (Zhou et al., 2020). The respiratory system benefits from appropriate exercise training (Woods et al., 2020). Given the significant reduction in respiratory function in the elderly, relevant exercises are particularly critical (Thomas et al., 2019). Elderly individuals can learn about these benefits and increase preventive behaviors through mass media exposure (Liu et al., 2020).

4.2.2. How Do Education and Income Level Affect Usage Habits?

Social isolation increased the frequency of visits to green spaces among highly educated and high-income individuals. Before and during social isolation, higher education levels were associated with less frequent visits to green spaces; however, this correlation disappeared 9 months after isolation. Additionally, while there was no relationship between income and visitation frequency before social isolation, higher income levels were associated with more frequent visits during and after social isolation. This suggests that 9 months after the implementation of social isolation measures, highly educated and high-income groups developed the habit of visiting green spaces.

Furthermore, social isolation measures temporarily increased the stay time of highly educated and high-income individuals in green spaces. Social isolation disrupted the relationship between education level and stay time—the higher the education level, the shorter the stay time—but this relationship was reestablished 9 months after isolation. Income only briefly impacted stay time during social isolation. This may be attributed to highly educated and high-income groups being adept at accessing useful information and thus better recognizing the positive effects of green spaces. Additionally, social isolation measures increased online activity usage and time spent watching television (Dixit et al., 2020). Highly educated and high-income groups typically spent less time on screen time (Kantomaa et al., 2007; Molina et al., 2016; Tandon et al., 2012). The less sustained impact may be due to the eventual end of remote working.

4.2.3. How Do Commuting Habits Affect Usage Habits?

Social isolation weakens the recreational attributes of green spaces. First, social isolation may lead people to choose green spaces that are easily accessible. During isolation, respondents had the shortest time to reach parks

(22.4% in less than 5 min), which decreased to 17.5% after 9 months of isolation but remained higher than the 8.8% observed before isolation. Respondents who walked to the park also experienced a brief increase during isolation. This may be attributable to the increased risk of exposure and diagnosis associated with traveling longer distances. Second, previous studies have demonstrated that people tend to walk longer distances for recreational purposes compared to other purposes (Yang & Diez-Roux, 2012). Social isolation may also lead people to use easily accessible green spaces at higher frequencies, as the correlation coefficient between the assessment time and the visitation frequency after 9 months of social isolation was higher than before and during isolation measures.

5. Conclusion

5.1. Summary of Findings

This study represents the first attempt to distinguish the immediate and lasting effects of isolation caused by the COVID-19 pandemic on the usage habits of green spaces. Through three strategically timed surveys—conducted before, during, and after the social isolation of the first wave (December 2019, March 2020, December 2020) in Dezhou, China—we utilized the Mann-Whitney *U* test and Spearman's rho correlation to identify significant shifts in usage patterns. The analysis revealed an increase in the frequency of visits by previously infrequent users, a reduction in the duration of visits, and a heightened preference for higher-intensity activities. Notably, these changes persisted 9 months post-isolation, suggesting a potential long-term shift in public behavior. These findings not only underscore the vital role of green spaces in enhancing public health and societal resilience during pandemics but also offer new insights into strategic urban space utilization to mitigate the impacts of such crises.

5.2. Contributions and Implications

5.2.1. Contributions

The findings of this study contribute to urban planning and public health in several important ways. First, by providing a longitudinal analysis of green space usage before, during, and after pandemic-induced isolation, this research offers novel insights into the persistence of changed behaviors, supporting the need for urban planning and public health strategies to consider the long-term impacts of such global events. Second, this study enhances our understanding of how urban environments can be organized to cope with current and potential future pandemics, providing evidence-based recommendations for urban design. These recommendations are crucial for creating flexible urban spaces that can accommodate increased usage during health crises and other emergencies. Lastly, this study may shed light on the long-term impacts of social isolation resulting from the COVID-19 pandemic on other urban infrastructures. Although this study focuses on green spaces, future research might explore how the use of other critical infrastructures like healthcare facilities, public markets, or transportation options is affected by similar crises.

5.2.2. Implications

The findings from this study on the changing patterns of green space usage during the pandemic provide implications for urban planning, public health, and community engagement.

Regarding urban planning and green space design, our research highlights a significant increase in the frequency of visits to green spaces by individuals who previously had minimal interaction with these areas. To support and encourage this trend, urban planners should focus on enhancing the accessibility of green spaces by expanding existing parks and converting available urban land into accessible green areas. Special attention should be given to ensuring that green spaces are equitably distributed across all neighborhoods, thereby reducing accessibility disparities particularly in underserved communities (Mayen Huerta, 2022; Rigolon et al., 2022; Spotswood et al., 2021). Additionally, considering the trend toward shorter visit durations, it is advisable to adapt green spaces to more efficiently cater to brief visits. Improvements could include adding more benches, picnic areas, and streamlined pathways that facilitate quick and fulfilling visits, enabling residents to effortlessly incorporate green space visits into their daily routines.

In terms of health promotion and public policy, echoing the perspective of Pineda and Corburn (2020), the global pandemic should be viewed by urban health advocates similarly to the urban epidemics of the nineteenth century,

which spurred significant urban health-promoting reforms (Pineda & Corburn, 2020). The observed shift toward higher-intensity activities in green spaces suggests a potential focal point for public health campaigns. Local health departments should initiate programs that promote physical activities in green spaces as part of a healthy lifestyle. This could include organized fitness games, sports leagues, and outdoor public lessons, which not only encourage physical activity but also aid in building community resilience against mental health challenges. Given the role of green spaces in providing relief from social isolation (Noszczyk et al., 2022), mental health advocates and policymakers should consider incorporating visits to green spaces into therapeutic interventions. Programs designed to mitigate isolation and stress, particularly during crises, could benefit significantly from regular structured activities in these natural settings.

5.3. Future Directions and Limitations

This study has some limitations that present opportunities for future research. This study has some limitations that present opportunities for future research. First, the data for our study were collected from park users, which may have limitations regarding the representativeness of the general population. There may be inherent biases in spatial and temporal activity patterns, potentially skewing the findings toward certain groups. Consequently, we must acknowledge that the effects of social isolation caused by the COVID-19 pandemic may have been magnified in our findings. Second, while urban parks serve as a representative type of green space, users might exhibit different usage habits in other types of green spaces. Future research should, therefore, consider exploring the effects of social isolation on various types of green spaces to comprehensively understand how usage habits evolve after social isolation induced by the COVID-19 pandemic.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

Data is available at (Ma, 2024).

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