Studies in Social Science Research
ISSN 2690-0793 (Print) ISSN 2690-0785 (Online)
Vol. 6, No. 2, 2025
www.scholink.org/ojs/index.php/sssr

Original Paper

Impacts of Community Green Spaces on the Mental Health of Urban Residents: Evidence from Periods of Public Health Crisis and Non-Crisis

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Abstract

The frequent occurrence of public health emergencies highlights the importance of community public spaces in urban emergency management. While community green spaces are a key form of public space, their impact on urban residents' mental health during crises and non-crisis periods is not well understood. This study analyzes survey data from Xi'an citizens during and after the COVID-19 pandemic to explore how community green spaces affect residents' mental health. The findings reveal that: (1) Interaction with community green spaces significantly improves mental health through two mediators—connectedness to nature and neighborhood social cohesion. (2) The effect of connectedness to nature was stronger during the pandemic and in higher-risk situations, while neighborhood social cohesion had a greater impact post-pandemic and in lower-risk times. (3) Women benefit more than men from green spaces in terms of mental health improvement. (4) The impact of green space engagement on mental health decreases with age. (5) Higher educational attainment strengthens the mediating role of connectedness to nature and weakens that of neighborhood cohesion. This study suggests using community green spaces to address mental health issues during public health emergencies, enhancing urban emergency management's ability to provide humanistic care.

Keywords

Community green space, Connectedness to nature, Neighborhood social cohesion, Risk perception, Structural equation modeling

1. Introduction

Environmental changes triggered by a mix of natural and anthropogenic factors are now causing urban areas to experience an ongoing increase in health risks. The frequency of public health emergencies such as Severe Acute Respiratory Syndrome (SARS), H1N1 influenza, and Coronavirus Disease (COVID-19) is on the rise. These public health emergencies not only severely damage the physical health of urban residents but also profoundly threaten their mental health as well (Chen, 2023), which can lead to people

feeling varying degrees of loss of control, relational disconnection, and existential crises (Meng et al., 2021). In the emergency management of public health crises, both local governments and community organizations absolutely prioritize the protection of physical health, because that is the only way to effectively control infectious disease (Liu & Liu, 2021; Li, 2022). However, studies to date have shown that, compared with infectious diseases, mental health issues involving varying degrees of psychological disorders are more pervasive among urban residents (Robinson et al., 2021). Citizens and urban managers should invest more time and effort to address these issues, as the mental health problems that arise from public health crises are also a critical concern.

When a public health crisis arise, communities will typically immediately condense into "courtyard communities" (Wang & Qin, 2022), with limited public areas available to provide essential environmental support for individuals' physical and mental health. Recent studies have shown that green spaces served as "green buffers" during the COVID-19 pandemic, playing a crucial role in enhancing public health (Xie et al., 2020). Compared to other green spaces, community green spaces have unique advantages in terms of accessibility and immediate benefits, making them important venues in which urban residents can connect with nature and engage socially (Tabrizi & Lak, 2023). By relying on the natural landscapes and social functions of community green spaces, residents can recover from the continuous depletion of their resources and the capacities of their bodies and minds, thereby strengthening their emotional connections and enhancing their psychological resilience. However, despite the fact that some scholars have recognized the importance of communities during public health emergencies, studies to date have often considered community emergency governance mechanisms solely from a macro perspective (Lin & Cai, 2022; Shi et al., 2021). There has been a notable lack of analysis regarding the specific pathways through which community green spaces affect residents' mental health in the context of public health crises, particularly from a micro perspective, and there have been even fewer studies comparing their effects in crisis vs. non-crisis periods.

In light of these facts, this study constructs a moderated mediating model based on empirical observations and theoretical analysis. Using survey data from citizens of Xi'an during and after the COVID-19 pandemic, this study reveals and validates the pathways and boundary conditions through which community green spaces impact urban residents' mental health. Furthermore, it compares the changes in these effects between the two periods of the pandemic and its aftermath. Our findings can provide urban managers with insights on how best to use community green spaces to enhance the ability of emergency management to provide humanistic care during public health crises, as well as to offer references for developing high-quality urban development strategies that promote harmonious coexistence between humans, cities, and nature.

2. Literature Review and Research Hypotheses

2.1 The Impact of Engagement with Green Spaces on Residents' Mental Health

The term “green spaces” is primarily used to refer to open areas of grass and other vegetation within

residential communities and their living surroundings, which serve to fulfill community residents' needs for relaxation, nature appreciation, and social interaction. Studies to date have predominantly focused on the ecological functions and planning issues surrounding community green spaces (Xu & Wu, 2015), often neglecting their recreational functions and psychological benefits. Measurement approaches have mainly relied on objective indicators such as green space ratio, vegetation index, and spatial characteristics (Wu et al., 2021), overlooking the fact that residents' usage behaviors and the psychological effects they experience are influenced by subjective perceptions. Therefore, this study introduces the concept of "engagement with community green spaces" to emphasize user subjectivity and heterogeneity in its evaluation of residents' overall perception of community green spaces, reflecting their recognition of the importance of these spaces and the enjoyment and self-expression derived from their use (Tan et al., 2021).

High-density urban living environments subject individuals to persistent stressors such as noise pollution, environmental congestion, and relationship alienation. Moreover, the current wave of frequent public health emergencies has exacerbated the public crisis of mental health. For example, many individuals have experienced symptoms of anxiety, depression, and insomnia during the pandemic (Mazza et al., 2020), which, over time, have significantly affected their quality of life, as well as overall urban development. Prior studies have found that urban parks serve as an important option for residents to cope with the uncertainty and social isolation provoked by such crises (Venter et al., 2020). However, studies to date have primarily emphasized the positive effects of large green spaces. By contrast, community green spaces differ from large green spaces in terms of scale, function, and usage patterns (Qiu et al., 2019). This research gap is significant, in that community green spaces are the locations most frequently chosen by urban residents for their recreational activities. Therefore, it is essential to further verify the direct impacts of community green spaces on residents' mental health and the underlying mechanisms of those impacts. The following hypothesis (H1) is thus proposed:

H1: Engagement with community green spaces positively influences residents' mental health.

2.2 The Mediating Role of Connectedness to Nature

The biodiversity-carrying function of green spaces reconstructs the connection between humans and nature in urban environments — hence the term, "concrete jungles". Connectedness to nature is not merely about contact with nature; it reflects an intimate and interactive relationship between individuals and nature, emphasizing the view of humans as being an integral part of nature. This emotional bond between individuals and nature can be achieved through the recognition of the value of other forms of life and their existence (Li et al., 2018). Scholars such as Nisbet have conceptualized connectedness to nature as a construct that encompasses both cognitive and emotional dimensions (NISBET et al., 2009), thereby providing a more comprehensive assessment of human-nature interactions. Studies to date have identified numerous antecedents of connectedness to nature, such as awe (Graziosi & Yaden, 2021) and materialistic values (Wang, 2019); of these, "direct contact with nature" has been identified as a key factor enhancing this connectedness (Peng et al., 2022). Humans possess an inherent inclination towards nature,

and thus community green spaces, as complements to larger urban green spaces, extend nature's reach into residential areas, facilitating residents' innate tendencies to engage with nature and enhancing their connectedness to it. Meanwhile, restorative environment theory posits that contact with nature allows individuals to experience a sense of respite and relaxation, thereby alleviating their psychological stress (Hartig et al., 2003). Research has shown that, post-pandemic, residents now actively spend time in nature to restore their cognitive attention and mitigate their negative emotions (Venter et al., 2020). The above analysis suggests that residents' activities in community green spaces promote their connectedness to nature, resulting in mental health benefits. Therefore, the following hypothesis (H2) is proposed:

H2: Connectedness to nature mediates the relationship between engagement with community green spaces and residents' mental health.

2.3 The Mediating Role of Neighborhood Social Cohesion

The sociologist B. Wellman has stated that communities are fundamentally networks of personal relationships encompassing social connections (Wellman, 1982). However, with the acceleration of urbanization and the commodification of housing, community heterogeneity has increased, leading some scholars to propose a theory of "disappearance of community", which claims that traditional intimate relationships within communities have diminished in modern urban contexts (Feng et al., 2017). Nevertheless, China’s collective cultural traditions mean that in Chinese cities, neighborly relations remain a key factor for community existence and development. Particularly during emergencies, the return to proximity, prompted by compressed living spaces, has led to a more rapid resurgence of local relationship networks compared to the period before the pandemic (Wang & Qin, 2022). Neighborhood social cohesion, as a construct that reflects relationships among neighbors, as well as their degree of trust and shared values, norms, and resources (Holmes & Marcelli, 2020), is a social attribute of a community that also reflects the differentiated social backgrounds and life experiences within the community. Community green spaces, as public spaces with both natural and social attributes, play a crucial role in helping residents establish and enhance such neighborly relationships. According to scholar Chen Fuping, the communal use of community green spaces enables residents to collectively focus on personal and collective life issues, fostering a sense of collective feelings and mutual understanding (Chen & Li, 2008) and thereby strengthening the cohesion among community members. This cohesion not only represents a positive outcome of community green spaces as public spaces but also contributes to positive psychological benefits for residents. For example, studies have shown that strong community ties during the COVID-19 pandemic provided residents with a sense of safety and alleviated their death anxiety (LI et al., 2021). In such circumstances, even weak social ties such as smiling or greeting one another can significantly enhance residents' well-being (Helliwell & Putnam, 2004). Given that community green spaces contribute to increasing awareness of neighborhood cohesion, thereby positively impacting residents’ mental health, the following hypothesis (H3) is proposed:

H3: Neighborhood social cohesion mediates the relationship between engagement with community green spaces and residents' mental health.

2.4 The Moderating Role of Risk Perception

Risk perception consists of individuals' subjective judgments and evaluations regarding the presence of risks and potential consequences in their environment, influencing their future attitudes and behavioral choices while also predicting their mental health outcomes (Rice et al., 2020). In densely populated urban areas, residents' risk perception increases with narrowing social distance. Following the outbreak of the COVID-19 pandemic, a typical public health emergency, risks became a widespread concern and thus affected urban residents' recreational behaviors. Risk perception theory posits that individuals with high risk perception actively take measures to avoid risks, such as reducing social contact, while those with lower risk perception exhibit weaker motivation for self-protection (Rimal & Real, 2003). Studies have shown that individuals who were highly concerned about the pandemic are now more eager to engage with natural environments to reap their psychological benefits (Rice et al., 2020). Furthermore, social interaction is perceived as a high-risk motivation for accessing outdoor green spaces in Western countries (Ugolini et al., 2020). Individuals with higher risk perception are more sensitive to information regarding pandemic risks and are more likely to adhere to public health measures. Ultimately, under moral and legal constraints, many residents with high risk perception may be highly conscious of even mild symptoms or consider the risks their social interactions pose to their families, often opting to reduce their social behaviors to ensure their safety and that of others. Consequently, high risk perception may encourage residents one the one hand to enhance their connectedness to nature through activities in community green spaces to address negative psychological issues arising from the pandemic, while simultaneously diminishing neighborly interactions. In contrast, residents with low risk perception would be expected to have relatively lower expectations and needs for contact with nature during community activities but higher expectations and needs for social support. Thus, the following hypotheses (H4 and H5) are proposed:

H4: Risk perception positively moderates the mediating role of connectedness to nature. The higher the residents' risk perception, the stronger the impact of engagement with community green spaces on their mental health through connectedness to nature.

H5: Risk perception negatively moderates the mediating role of neighborhood social cohesion. The higher the residents' risk perception, the weaker the impact of engagement with community green spaces on their mental health through neighborhood social cohesion.

2.5 The Moderating Role of Time Period

Recent and frequent public health emergencies have unprecedentedly influenced the health and lifestyles of urban residents, highlighting the importance of high-quality urban green spaces in daily life. Zhao *et al.* found that during the COVID-19 pandemic, residents preferred visiting urban green spaces over entertainment venues or workplaces (Zhao et al., 2022). Cheng *et al*. conducted comparative research on people's attitudes towards urban parks before and during the pandemic, and found that residents' sensitivity to green spaces increased by one-third during the pandemic and that the positive impact of "green quality" on residents' well-being was significantly amplified (Cheng et al., 2021). However, these

studies only examined changes in green space preferences and their effects on mental health among Chinese residents before and during the pandemic. After the declaration of the pandemic's end, although social life and work ostensibly returned more or less to normal, the psychological effects of the pandemic did not completely dissipate (Tabrizi & Lak, 2023). During this period, the pathways (Connectedness to Nature & Neighborhood Social Cohesion) and positive effects of community green spaces on residents' mental health may differ from what they were before and during the pandemic. After the pandemic, residents returned to on-site work and may now have more options for outings, such as visiting other recreational venues, and this could exert a crowding-out effect on the mediating role of connectedness to nature. During the pandemic, residents demonstrated solidarity, support, and care for each other, bringing them closer together. They began to cherish emotional ties with their fellow residents and recognize the importance of mutual support during difficult times, potentially leading to stronger emotional connections among community members post-pandemic, as expressed in the maxim, "a friend in need is a friend indeed". Therefore, compared to the pandemic period, as residents return to normal life post-pandemic, the role of connectedness to nature through engagement with community green spaces would be expected to diminish. Conversely, the mediating role of neighborhood social cohesion would be expected to strengthen due to the stronger emotional connection, i.e., "a friend in need is a friend indeed." Therefore, the following hypothesis (H6) is proposed:

H6: Compared to the pandemic period, the role of connectedness to nature has lessened after the pandemic, while the role of neighborhood social cohesion has increased.

2.6 Differences in Demographic Characteristics

Residents acquire different recreational experiences and values from urban green spaces depending on their life stage and socioeconomic status. A longitudinal study in the UK found that as individuals age, the health benefits derived from green spaces differ between males and females (Magill et al., 2020). Thus, the correlation between community green spaces and their health benefits not only depends on the characteristics of their built environment or levels of engagement but also on demographic factors such as gender, age, and educational attainment (Dong et al., 2020). Different groups of residents may be affected by their unique characteristics, which can influence their preferences, motivations, actual opportunities, and value orientations regarding community green spaces. These then alter their usage patterns and, in turn, impact the health benefits derived from these spaces (Huang & Lin, 2021). Exploring the differences in how community green spaces affect residents' mental health across gender, age, and educational background can provide more detailed insights into issues of environmental justice in the context of public health crises. Therefore, the following hypothesis (H7) is proposed:

H7: The impact of community green spaces on residents' positive mental health will exhibit variations based on demographic characteristics (gender, age, and educational attainment).

In summary, the comprehensive theoretical model of this study is illustrated in Figure 1.

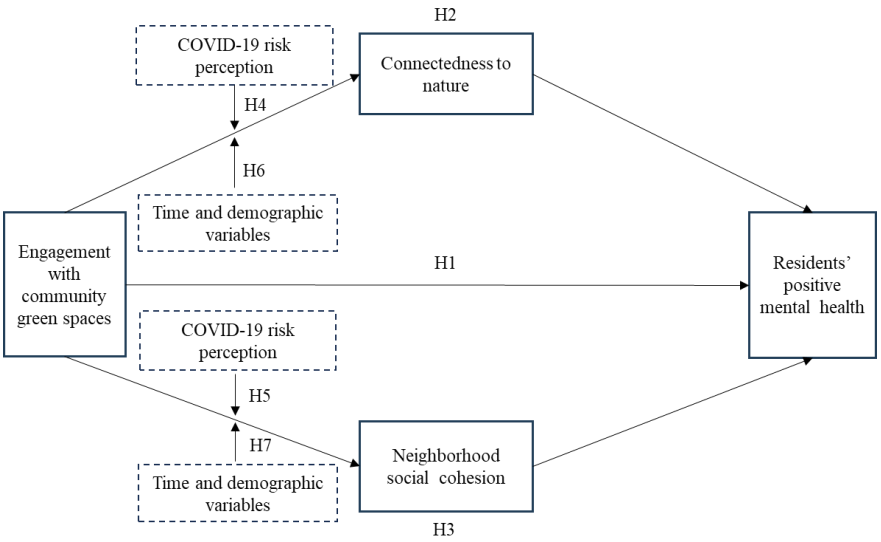

Figure 1. Theoretical Model

3. Research Methods and Data Sources

3.1 Variable Measurement

In this study, the measurement of variables was primarily based on the use of established scales from related fields. The measurement of engagement with community green spaces was adapted from McIntyre's leisure involvement scale (Mcintyre, 1989), with items modified to fit the research context. The measurement of connectedness to nature was based on the studies of Nisbet (Nisbet et al., 2009) and Wang Jianming (Wang et al., 2021). Neighborhood social cohesion was measured using the scale developed by Sampson *et al.* (Sampson et al., 1997). The positive mental health scale (PMH-Scale) used here was developed by Lutz *et al.* (Lukat et al., 2016). The measurement of risk perception was informed by the COVID-19 risk perception scale developed by O'Connor and Assaker (O'Connor and Assaker, 2021). All scales used a 7-point Likert scoring system.

3.2 Collection and Overview of Data

In December 2021, Xi'an, China experienced its largest local outbreak of COVID-19 since the pandemic originated in Wuhan, resulting in the implementation of a month of closed-off management and several months of semi-closed-off management (including nucleic acid testing, mask mandates, and community access restrictions) to control the spread of the pandemic. By January 2023, with new measures in place, the domestic outbreak was declared largely over. To study urban residents' activities in green spaces and their psychological states during the outbreak, and to compare the psychological health effects of community green spaces before and after the end of the pandemic, surveys were conducted on residents of Xi'an, China in February 2022 and December 2023, respectively. A total of 634 valid questionnaires were collected, comprising 320 in the first survey and 314 in the second, with a relatively balanced data volume across both surveys.

Of the participants, females constituted a larger proportion than males, accounting for 65%. The age

distribution predominantly featured young and middle-aged individuals, with 26.8% aged 18-25 and 28.4% aged 31-40. In terms of educational attainment, a majority held higher education degrees, with 45.4% holding a bachelor's degree. Income levels varied, with 43.2% earning below 4,000 yuan and 38.2% earning above 6,000 yuan. In terms of community type, the sample primarily consisted of commodity housing communities (58.7%), followed by institution-based communities (20.2%). Traditional neighborhood communities and public rental housing communities represented the smallest proportions, at 12.1% and 5.2%, respectively.

4. Analysis of Results

4.1 Reliability and Validity Analysis

Confirmatory factor analysis was conducted using Amos 24.0 and SPSS 23.0. The results indicated that the Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) all exceeded 0.9; however, other absolute and parsimonious fit indices did not necessarily meet the ideal values. Based on modification indices (M.I.), the error terms of the measurement items for engagement with community green spaces (CG) and risk perception (RP) (i.e., CG_A1, CG_A3, CG_C1, and RP7) were found to co-vary with other residual and error terms. Thus, these four measurement items were sequentially removed (Wu and Zhang, 2021), resulting in an improved fit of the revised measurement model (CMIN/DF = 2.892, RMSEA = 0.055, GFI = 0.869, CFI = 0.948, NFI = 0.923, TLI = 0.943). As shown in Table 1, the Cronbach's α coefficients for the five constructs were all greater than 0.7, and the composite reliability (CR) coefficients exceeded 0.6, indicating that the measurement model and data had high reliability. In addition, the average variance extracted (AVE) and the standardized factor loading for the items of the five constructs were all above 0.5, demonstrating good convergent validity among the measurement items for the same variable.

Table 1. Composite Reliability and Convergent Validity Test Results After Removal of Items

Latent Variable	Observed Variable	Standardized Factor	*Cronbach's α*	*CR*	*AVE*
Engagement with community green space (CG)	CG_A2	0.562	0.914	0.916	0.582
	CG_A4	0.656			
	CG_A5	0.818			
	CG_S1	0.860			
	CG_S2	0.861			
	CG_S3	0.834			
	CG_C2	0.793			
	CG_C3	0.662			
	CN1	0.871	0.926	0.927	0.717

Connectedness to nature (CN)	CN2	0.892			
	CN3	0.840			
	CN4	0.797			
	CN5	0.831			
Neighborhood social cohesion (NSC)	NSC1	0.851	0.945	0.946	0.777
	NSC2	0.898			
	NSC3	0.899			
	NSC4	0.902			
	NSC5	0.856			
Positive mental health (PMH)	PMH1	0.819	0.952	0.952	0.690
	PMH2	0.822			
	PMH3	0.848			
	PMH4	0.833			
	PMH5	0.835			
	PMH6	0.821			
	PMH7	0.803			
	PMH8	0.857			
	PMH9	0.834			
Risk perception (RP)	RP1	0.749	0.887	0.88	0.514
	RP2	0.742			
	RP3	0.811			
	RP4	0.736			
	RP5	0.679			
	RP6	0.642			
	RP8	0.641			

To verify the discriminant validity among the factors, the fit of the five-factor, four-factor, three-factor, and single-factor models were compared. As shown in Table 2, the five-factor model (engagement with green spaces, connectedness to nature, neighborhood social cohesion, positive psychological health, and risk perception) demonstrated the best fit to the actual data compared to the other eleven models. This suggests that the five scales used in this study possess good discriminant validity.

Table 2. Results of Discriminant Validity Testing

	Model	Fit indices						Model comparison test		
		χ^2	*df*	χ2/df	NFI	CFI	RMSEA	Model comparison	$\Delta\chi^2$	Δ*df*
1	Baseline model (five-factor)	1480.84	512	2.89	0.92	0.95	0.06			
2	Four-factor model one	1980.63	516	3.84	0.90	0.92	0.07	2 vs 1	499.79***	4
3	Four-factor model two	2548.24	516	4.94	0.87	0.89	0.08	3 vs 1	1067.4***	4
4	Four-factor model three	2152.25	516	4.17	0.89	0.91	0.07	4 vs 1	671.41***	4
5	Four-factor model four	2713.46	516	5.26	0.86	0.88	0.08	5 vs 1	1232.62***	4
6	Three-factor model one	3171.60	519	6.11	0.84	0.86	0.09	6 vs 1	1690.76***	7
7	Three-factor model two	2586.83	519	4.98	0.87	0.89	0.08	7 vs 1	1105.99***	7
8	Three-factor model three	3148.98	519	6.07	0.84	0.86	0.09	8 vs 1	1668.14***	7
9	Three-factor model four	3325.98	519	6.41	0.83	0.85	0.09	9 vs 1	1845.14***	7
10	Three-factor model five	3745.31	519	7.22	0.81	0.83	0.10	10 vs 1	2264.47***	7
11	Three-factor model six	3336.18	519	6.43	0.83	0.85	0.09	11 vs 1	1855.34***	7
12	Single-factor model	4963.33	522	9.51	0.74	0.76	0.12	12 vs 1	3482.49***	10

4.2 Hypothesis Testing

(1) Main Effect Testing

To test the research hypotheses, structural equation modeling was conducted in Amos 24.0 (see Table 3). The results show that engagement with community green spaces significantly and positively affected connectedness to nature ($\beta = 0.835$, $p < 0.001$), neighborhood social cohesion ($\beta = 0.449$, $p < 0.001$), and positive mental health ($\beta = 0.259$, $p < 0.001$), thus supporting Hypothesis 1. In addition, connectedness to nature had a significant positive effect on positive mental health ($\beta = 0.465$, $p < 0.001$). Neighborhood

social cohesion also had a significant positive impact on positive mental health ($\beta = 0.234$, $p < 0.001$). Meanwhile, the results show that connectedness to nature significantly and positively influenced neighborhood social cohesion ($\beta = 0.347$, $p < 0.001$), suggesting the potential presence of a chain mediating effect, warranting further examination.

Table 3. Hypothesis Testing Results

Hypothesis path	Path coefficient	*t* value	Results
CG→CN	0.835***	16.695	Positive
CG→NSC	0.449***	6.857	Positive
CG→PMH	0.259***	5.001	Positive
CN→NSC	0.347***	5.591	Positive
CN→PMH	0.465***	9.137	Positive
NSC→PMH	0.234***	6.302	Positive

Note. CG, engagement with community green space; CN, connectedness to nature; NSC, neighborhood social cohesion; PMH, positive mental health; RP, risk perception. 95% confidence interval; *** indicates $p < 0.001$.

(2) Testing of the Mediating Effects of Connectedness to Nature and Neighborhood Social Cohesion

To further investigate the hypotheses regarding the mediating effects, the PROCESS macro (Model 6) in SPSS was used to test the mediating roles of connectedness to nature and neighborhood social cohesion (see Table 4). The confidence intervals for both the total effect and the direct effect of "Engagement with community green spaces → Positive mental health" did not include zero, indicating the presence of a direct effect. The confidence intervals for the indirect effects of "Engagement with community green spaces → Connectedness to nature → Positive mental health" and "Engagement with community green spaces → Neighborhood social cohesion → Positive mental health" similarly did not include zero, demonstrating that connectedness to nature and neighborhood social cohesion each played a partial mediating role in the relationship between engagement with community green spaces and positive mental health. Hypotheses H2 and H3 are thus supported, with the mediating effect of connectedness to nature being greater than that of neighborhood social cohesion ($\beta_{\text{connectedness to nature}} = 0.306$; $\beta_{\text{neighborhood social cohesion}} = 0.107$). Furthermore, the confidence interval for the chain mediating effect "Engagement with community green spaces → Connectedness to nature → Neighborhood social cohesion → Positive mental health" did not include zero, indicating that connectedness to nature and neighborhood social cohesion acted as chain mediators in the impact of engagement with community green spaces on positive mental health.

Table 4. Mediating Effects Testing

Effect	Path	*β*	95%*CI*		*Effect ratio*
			LLCI	*ULCI*	*(%)*
Direct effect	CG→PMH	0.266	0.201	0.332	36.19%
Indirect effect	CG→CN→PMH	0.306	0.221	0.401	41.63%
	CG→NSC→PMH	0.107	0.064	0.156	14.56%
	CG→CN→NSC→PMH	0.056	0.028	0.092	7.62%
Total effect		0.735	0.688	0.782	100%

Note. CG, engagement with community green space; CN, connectedness to nature; NSC, neighborhood social cohesion; PMH, positive mental health; RP, risk perception.

(3) Examination of the Moderating Effect of Risk Perception

Model 59 of the PROCESS macro was used to test the moderating effect. The results (see Table 5), indicate that after adding risk perception to the model, the interaction term between engagement with community green spaces and risk perception did not have a significant predictive effect on connectedness to nature (β=0.014, t=0.734, p>0.05). Similarly, the interaction term between engagement with community green spaces and risk perception did not significantly predict neighborhood social cohesion (β=-0.002, t=-0.088, p>0.05). Further analysis revealed the presence of a moderated mediating effect. As shown in Table 5, as risk perception increased from low to high, the mediating effect of connectedness to nature in the link between engagement with community green spaces and positive mental health exhibited an increasing trend. This suggests that as individuals' risk perception increases, engagement with community green spaces more effectively promotes positive mental health through enhanced connectedness to nature, supporting H4. Conversely, as risk perception increased from low to high, the mediating effect of neighborhood social cohesion in the link between engagement with community green spaces and positive mental health showed a decreasing trend. This indicates that as individuals' risk perception increases, their engagement with community green spaces becomes less effective in improving their mental health through neighborhood social cohesion, thus supporting H5.

Table 5. Direct Effects and Mediating Effects at Different Levels of Risk Perception

Effect	Risk perception level	Effect	Boot *S.E.*	Boot *LLCI*	Boot *ULCI*
Direct effect	M-1SD	0.296	0.042	0.214	0.378
	M	0.249	0.033	0.184	0.315
	M+1SD	0.203	0.043	0.118	0.288
Mediating Effect of Connectedness to Nature	M-1SD	0.239	0.054	0.173	0.377
	M	0.301	0.037	0.235	0.378
	M+1SD	0.364	0.052	0.250	0.456

Mediating Effect of Neighborhood Social Cohesion	M-1SD	0.178	0.038	0.097	0.249
	M	0.150	0.029	0.095	0.209
	M+1SD	0.123	0.041	0.054	0.213

(4) Moderating Effect of Time Period

Time, specifically the periods classified as "during the pandemic" (assigned a value of 0, n=320) and "post-pandemic" (assigned a value of 1, n=314), was examined as a potential moderating variable. As shown in Table 6, the mediating effect of connectedness to nature in the link between engagement with community green spaces and positive mental health was greater during the pandemic than post pandemic; conversely, the mediating effect of neighborhood social cohesion was found to show an increasing trend. This indicates that as the domestic pandemic was declared over and residents returned to normal work and life, the significant advantage of connectedness to nature was relatively diminished. By contrast, the various forms of solidarity and mutual assistance of residents during the pandemic, such as exchanging essential supplies and spontaneously forming community volunteer teams, may have strengthened the bonds among community members. Consequently, the positive role of neighborhood social cohesion in the pathway through which engagement with community green spaces affects residents' mental health has been enhanced.

Table 6. Mediating Effects at Different Time Stages

Effect	Time	Effect	Boot *S.E.*	Boot *LLCI*	Boot *ULCI*
Mediating Effect of Connectedness to Nature	During the pandemic (assigned a value of 0)	0.350	0.053	0.248	0.460
	Post-pandemic (assigned a value of 1)	0.246	0.073	0.132	0.405
Mediating Effect of Neighborhood Social Cohesion	During the pandemic (assigned a value of 0)	0.142	0.040	0.074	0.228
	Post-pandemic (assigned a value of 1)	0.184	0.053	0.073	0.282

(5) Moderating Effects of Demographic Characteristics

Gender. Gender was incorporated into the model as a binary moderating variable. As shown in Table 7, comparative analysis across the two genders shows that engagement with community green spaces significantly enhanced the positive psychological well-being of both male and female residents through connectedness to nature. However, the effect of connectedness to nature was notably stronger for females, due to their generally higher levels of green space engagement. In contrast, the mediating effect of neighborhood social cohesion exhibited marked heterogeneity between the genders: for females,

engagement with green spaces positively influenced psychological well-being through neighborhood social cohesion, while this mediating effect was not significant for males. This gender difference in mediating effects can be understood from two perspectives. First, traditional gender roles suggest that females tend to demonstrate greater concern for the ecological environment, whereas males often adopt a perspective of conquest and utilization of nature (WANG and LEI, 2018). Consequently, compared with females, males tend to find it more challenging to establish a close relationship with nature. Second, during community engagement, female residents pursue the establishment of strong neighborhood relationships and seek emotional support and a sense of belonging through community interactions, making them more receptive to the psychological comfort derived from the interpersonal network values fostered by green space activities. Conversely, males typically associate community participation with issues of community rights, order, and image (Zhang and Chen, 2022), typically acquiring less psychological benefits from the social cohesion associated with green space activities.

Age. The model included age as a quantitative moderating variable. As seen in Table 7, as age increased, the mediating roles of connectedness to nature and neighborhood social cohesion both decreased. Prior studies have generally assumed that green spaces provide opportunities for physical exercise and social interaction for elder adults, who may be more inclined than younger individuals to seek health and social engagement in these settings (Zhang et al., 2022). However, during the pandemic, outdoor spaces like community green areas instead became hazardous. Despite the pandemic's end, risks still persist, and elder adults, given their vulnerability, may struggle to overcome their fears associated with pandemic risks. In addition, studies have shown that many urban communities in China are characterized by stranger relations, such that elderly residents, particularly those who are migrants, face social integration challenges and develop a defensive attitude towards others in their community (Shi, 2019). Consequently, this limits the health benefits that elder adults can gain from engagement with community green spaces.

Educational Attainment. Educational attainment was quantified and incorporated as a moderating variable in the model. As shown in Table 7, with increasing educational levels, the mediating role of connectedness to nature intensified, while the mediating role of neighborhood social cohesion diminished. Individuals with higher education levels tend to be more attentive to the built environment and greening levels of their communities, because they possess greater environmental knowledge. When faced with social stress, they may consciously seek nature to achieve positive thinking and a calm mindset. However, social individuals have limited time and energy, and higher educational attainment often correlates with more substantial social capital within the family and social relationships, reducing reliance on community relational capital. This phenomenon can lead to lower levels of community participation among the more highly educated, inhibiting the development of close interactions and robust neighborhood relationships. Conversely, individuals with lower educational levels typically live in residential communities with lower greening rates, and neighborhood relations occupy a more significant position in their social networks, thereby enhancing the role of neighborhood social cohesion relative to that of connectedness to nature.

Table 7. Moderating Mediating Effects of Demographic Variables

Moderating Variable	Variable Level	Connectedness to nature			Neighborhood social cohesion		
		Effect	Boot *S.E.*	*LLCI, ULCI*	Effect	Boot *S.E.*	*LLCI, ULCI*
Gender	Male	0.268	0.090	[0.125, 0.459]	0.071	0.052	[-0.016, 0.188]
	Female	0.340	0.046	[0.249, 0.430]	0.214	0.037	[0.141, 0.289]
Age	M-1SD	0.335	0.060	[0.221, 0.454]	0.171	0.049	[0.078, 0.271]
	M	0.304	0.049	[0.210, 0.399]	0.159	0.035	[0.095, 0.229]
	M+1SD	0.274	0.060	[0.156, 0.388]	0.147	0.041	[0.073, 0.233]
Educationa l Attainment	M-1SD	0.225	0.055	[0.115, 0.333]	0.256	0.051	[0.156, 0.360]
	M	0.288	0.048	[0.197, 0.382]	0.176	0.032	[0.117, 0.238]
	M+1SD	0.346	0.060	[0.233, 0.467]	0.107	0.041	[0.035, 0.196]

5. Research Conclusions and Insights

5.1 Research Conclusions

Studies to date have had only a limited focus on the unique value of community green spaces and subjective experiences of green spaces for improving urban residents' mental health. Moreover, relevant research during public health crises has been scarce. This study thus empirically analyzed the mechanisms and boundary conditions of the effects of community green spaces on urban residents' mental health based on data from both public health crisis and non-crisis periods. Its main conclusions are as follows.

First, engagement with community green spaces is a significant factor affecting residents' mental health. Our results indicate that residents' engagement with community green spaces positively impacted their mental well-being, i.e., a higher level of engagement was correlated with improved mental health. This agrees with conclusions from earlier studies during non-crisis periods but contrasts with studies conducted during the pandemic. For instance, Pearson *et al*. suggested that community green environments did not alleviate the stress resulting from the pandemic (Pearson et al., 2021). However, their study focused on low-income African American communities, which typically have lower quality green spaces with a limited buffering capacity for mental health. Our study, which encompasses a diverse range of communities and age groups, provides stronger evidence for the positive effects of community green spaces on the mental health of the general population during the pandemic. This contrast with earlier findings also highlights the importance of addressing environmental justice issues in urban areas impacted by public health emergencies.

Second, community green spaces were found to improve residents' mental health through two pathways: connectedness to nature and neighborhood social cohesion, both individually and through a chain mediating effect. Studies to date have focused on the individual mediating roles of connectedness to

nature and neighborhood social cohesion in the relationship between environmental factors and individual psychological benefits (Zelenski et al., 2015; Liu et al., 2020). This study incorporates both perspectives to provide a more comprehensive explanation of the complex mediating mechanisms through which residents can promote their positive mental health via engagement with green spaces. Our findings indicate that both connectedness to nature and neighborhood social cohesion partially mediated the impact of engagement with community green spaces on positive mental health. Contemporary urbanization has led to the fragmentation of geographical spaces, resulting in a decline in the ecological quality of many public recreational areas and a weakening of social network relationships. However, community green spaces are necessary because they facilitate residents' interactions with natural elements, such as plants and trees, and foster connections with neighbors through activities like chess and dance. These interactions provide psychological support for residents and alleviate their feelings of loneliness and depression. However, the nature of contemporary urban communities often resembles that of a stranger society, and increased social distancing during the pandemic has led to a weaker mediating effect of neighborhood social cohesion compared to connectedness to nature. In addition, this study validated the chain mediating effect of connectedness to nature and neighborhood social cohesion, by which both sequentially transmit the influence of engagement with green spaces on residents' positive mental health. Activities in community green spaces enhance residents' awareness of nature and their emotional connections to it. This then promotes collective sentiments and understanding among neighbors through shared interests and emotional exchanges regarding these spaces. This process also enhances individual openness and inclusiveness, fostering interactions between residents and neighbors, and ultimately improving their psychological well-being. This underscores the restorative environmental and social connection functions that community green spaces fulfill in risk-intensive urban environments. Moreover, the mediating effect of connectedness to nature in the link between engagement with green spaces and positive mental health was stronger during the pandemic and at high levels of risk perception, while the mediating effect of neighborhood social cohesion was more pronounced post-pandemic and at low levels of risk perception. Our results indicated that risk perception positively moderated the mediating role of connectedness to nature in the relationship between engagement with community green spaces and positive mental health, while negatively moderated the mediating role of neighborhood social cohesion in that relationship. On the one hand, the outbreak of the COVID-19 pandemic prompted a reassessment of humanity's relationship with nature and changes in individuals’ emotional perceptions of nature. The psychological stress induced by the desire for outdoor activities intensifies as risk perception increases, which can be alleviated through activities in community green spaces. On the other hand, as residents' risk perception increases, their sensitivity to social distancing also increases. Thus, open green spaces and close interactions with neighbors may exacerbate their psychological stress, weakening the positive mediating effect of neighborhood social cohesion in the relationship between community green spaces and mental health. At the pandemic’s end, the return to normal life, along with the positive role of neighborhood social cohesion, will gradually enhance the health benefits derived

from green spaces. Conversely, the positive effects of connectedness to nature diminished, although the strength of its impact remained greater than that of neighborhood social cohesion. The findings of this study confirmed the influence of risk perception on the psychological mechanisms associated with community green spaces and their differences during and post-pandemic, revealing how external circumstances (such as public health emergencies) can either amplify or diminish the internal functioning of community green spaces. Therefore, community development and management should be focused on strategically adjusting community service provision in line with social dynamics, emphasizing the inclusion of natural landscape elements in community green spaces, while balancing it with the need for interaction among community residents and neighbors.

Finally, the impact of community green spaces on residents' mental health in the context of COVID-19 exhibited demographic variations. Compared with male residents, female residents were more likely to alleviate psychological stress and negative emotions by engaging with nature in community green spaces and interacting with their neighbors. Elder residents, being a vulnerable population, tended to consciously reduce their opportunities for physical socialization and thus often engaged with green spaces in a more limited manner, which restricted their ability to effectively mitigate the negative emotions induced by the pandemic. The health benefits from engagement with green spaces were consequently constrained; similarly, Corley *et al*. found that community gardening activities during the pandemic did not yield significant improvements in the physical and mental health of elder adults in Scotland (Corley et al., 2021). In addition, higher educational attainment strengthened the mediating effect of connectedness to nature while weakening the mediating role of neighborhood social cohesion. This suggests that residents with higher levels of education were more inclined to improve their mental well-being through their connectedness to nature in community green spaces, rather than relying on their relationships with neighbors. These findings underscore the necessity of understanding the relationship between community green spaces and residents' well-being in terms of the varying needs of different demographic groups. It is essential to consider factors such as gender, age, and educational level in relation to accessibility, intimacy needs, and avoidance needs. Consequently, a multidimensional evaluation framework for community green spaces should be established, encompassing physical, physiological, and psychological indicators.

5.2 Research Insights

(1) Emphasizing Environmental Justice and Rationalizing the Distribution of Green Spaces

Community green spaces and the justice of their allocation are closely related to issues of health equity among residents. The current wave of large-scale urbanization and dense spatial planning policies has led to a saturation of urban spatial environments, resulting in the capitalization of urban spaces and stratification of residential areas. Increasingly, green environments are being integrated into spaces that adhere to specific segregation criteria, causing structural imbalances and differentiation in the accessibility of green spaces for urban populations. This situation is particularly detrimental to lower socioeconomic groups, creating “green poverty" that adversely affects their health. The outbreak of the

COVID-19 pandemic has further exacerbated this issue, as disparities in access to community green spaces and outdoor environments have become a significant factor contributing to variations in the mental health of urban residents under activity restrictions. Therefore, it is essential to prioritize the rational distribution of community green spaces to promote environmental justice among communities.

(2) Promoting Community Gardens to Foster a Sense of Community

In addition to enhancing greenery and incorporating natural landscape elements into community green spaces to ensure that they serve their foundational function of connectedness to nature, it is vital to strengthen their role in facilitating multi-layered social interactions among residents. Although modern cities are characterized as stranger societies, the collectivist values deeply rooted in Chinese culture can be leveraged to remedy this problem. Increasing community public activities and fostering a sense of community can enhance the capacities of both the individual and the collective to respond to public health crises. Community gardens, as multifunctional landscape spaces, enable residents to share the cultural aspects of public spaces through collaborative construction and governance, helping to stimulate community cohesion and reduce vulnerability. Community gardens can be established by defining residents' rights and responsibilities through a division of labor based on household units. Residents can spontaneously organize special cultural activities, such as regular gardening workshops and aesthetic sharing sessions, to strengthen the emotional connections within their community. Additionally, collaboration with schools, welfare institutions, and nursing homes can enhance social benefits through mutually beneficial practice-sharing activities, thereby consolidating the governance of diverse stakeholders.

(3) Activating Community Environments and Members to Enhance Community Resilience

Although the COVID-19 pandemic has been declared over, modern society still faces numerous environmental risks and may encounter more in the future. The renovation and enhancement of community green spaces should be regarded as a long-term goal of urban development that must be persistently implemented. This includes the effective reclaiming of "lost spaces" to create restorative environments that ensure that community green spaces will provide connectedness to nature during crises. In addition, communities should provide and improve online interaction channels for residents to meet their basic needs for social interaction during crises. In non-crisis periods, communities should promote the regularization of social activities, particularly targeted toward older adults, men, and individuals with higher education levels. Opportunities for these groups to contribute ideas and participate in public affairs should be provided based on their physical and intellectual characteristics and hobbies, allowing their social capabilities to continuously manifest within the community. This approach can increase neighborly interactions and strengthen community resilience.

5.3 Limitations and Future Directions

This study, supported by the relevant theories, examines the impact of community green spaces on residents' mental health through the two pathways of nature and society. It introduces risk perception as a moderating variable within the context of the COVID-19 pandemic, confirming the significant role and

development potential of community green spaces during public health emergencies. However, the data collection process was influenced by the study's objectives and the unique timing of the investigation, due to the pandemic and related policies. This has resulted in an imbalance in community types in the data sample. Although the proportions of community types are in approximate agreement with the housing reality in Xi'an, the sample sizes for traditional neighborhoods and public rental housing communities were relatively low. Future research should expand this segment of the sample and further explore the differences in outcomes between the various community types, which will provide empirical evidence for issues of environmental justice and enrich the related research findings.

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