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Impacts of the COVID-19 Pandemic on Health-Related Behaviours in Community Gardens in China: An Evaluation of a Natural Experiment

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Abstract: There is little robust quantitative evidence on how community gardens impact on physical activity and other health-related behaviours. This natural experiment study aimed to examine the effects of a community garden within a Chinese neighbourhood on health-related behaviours during the COVID-19 epidemic. The study design was a repeat cross-sectional pre–post study, assessing differences between the non-epidemic period and epidemic period. Camera-based systematic observations were conducted at two locations within a community garden. A total of 180 h of video recordings were collected and coded by two researchers during a "non-epidemic" period when there were no COVID-19 restrictions (120 h) and the "epidemic" when COVID-19 restrictions were implemented (60 h). Observations of these video recordings assessed the total number of users, physical activities (Sedentary, Walking, Vigorous), social interactions (Connect), and people taking notice of the environment (Take Notice), followed by a breakdown of observed gender and age group. Data were analysed using paired *t*-tests and Wilcoxon signed-rank tests, comparing outcomes during the epidemic period and non-epidemic period. Results showed a significant increase in total number of users during the epidemic, particularly in females, older adults and children. Sedentary and moderate physical activities were significantly higher during the epidemic period. The increase in the total number of users of the community garden during the 2022 epidemic outbreak in Suzhou shows the importance of community gardens as a primary space for outdoor activities. This robust natural experiment study demonstrated that the community garden contributed more to physical activity, such as walking, but less to interactions between people (connecting) or people–place interactions (taking notice of the environment). More natural experiment research on community gardens like this is needed to better understand how the health and well-being benefits of community gardens can be maximized.

Keywords: community gardens; health behaviours; pandemic

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1. Introduction

The COVID-19 pandemic has had a profound impact on people's lives [1–4]. During the pandemic lockdown period, public spaces such as schools, squares, and parks were closed, restricting residents of opportunities to connect with nature and conduct social activities, potentially affecting their physical and mental health [2,5,6].

Research indicates that green spaces were crucial for maintaining overall well-being during the COVID-19 pandemic [7,8]. Despite travel restrictions during the initial months of the outbreak, there was an increase in people accessing parks and gardens globally [2,9,10].

Recent studies highlight that nearby public and private green spaces have become essential health resources for health-related activities during this period, particularly due to the temporary closure of certain public health spaces (e.g., parks, gyms and sports fields) and imposed behavioural restrictions (e.g., increased stay-at-home, social distancing and reduced in-person social contact) [3,8,11–13].

One type of green space that is particularly promising as a health promotion strategy is community gardens. The American Community Gardening Association (ACGA) defines community gardens as plots or multiple individual plots in urban, suburban, or rural areas where flowers and vegetables can be grown [14,15]. Although different scholars have varying definitions of community gardens, there is a consistent emphasis on aspects such as sharing and community management, gardening cultivation, and promoting well-being.

A recent systematic review suggests that community gardens may provide multiple health-related benefits, including physiological (e.g., improving dietary intake, micronutrient status and physical activity), social (e.g., enhancing sense of community, social support and social participation) and psychological benefits (e.g., relieving depression and anxiety) [16]. Evidence indicates a noticeable increase in the utilization of community gardens during the COVID-19 pandemic [5,10,17,18]. While green space played a positive role during the pandemic globally, community gardens were particularly valuable for promoting health behaviours. Even with social distancing measures, community gardens allowed people to engage with their neighbours in a safe, outdoor environment. This is in addition to other potential benefits for physical health by helping people to stay active, and for mental health [19,20].

However, recent systematic reviews on the health benefits of community gardens show that the most of the existing evidence consists of qualitative studies [16,21,22]. Crucially, there is a lack of quantitative evidence on the impacts of community garden interventions. As randomisation is rarely feasible when evaluating environmental interventions, studies of natural experiments ('real-world' interventions not controlled by researchers) are the optimal study design for assessing the impacts of real-world community garden interventions [23].Natural experiment studies can therefore help demonstrate the intervention effects of community gardens on health-related behaviours, filling the research gap in understanding how to design new or improve existing community gardens to promote health and well-being in communities.

Importantly, there is limited natural experiment evidence on the impact of urban green space interventions in developing countries, including China [24]. Mainland China's social and economic landscapes and the governance of those landscapes differ from those of other countries and regions. Most neighbourhoods in China are designed and built with clear physical boundaries for security and property ownership purposes, and local residents have more access and ownership of the green space within their neighbourhoods [25]. While community gardens have been reported to have positive effects on mental health, mutual support and neighbourhood resilience [26,27], there is a lack of quantitative evidence showing the changes of residents' health-related behaviours in community gardens during the pandemic period in domestic China.

1.1. Literature Review

Despite the inspiring early research and extensive academic studies on the social and environmental impacts of community gardens, the scope of the therapeutic landscape of community gardens remains largely underexplored [28]. Edward O. Wilson's Biophilia Hypothesis [29] suggests that contact with plants and nature improves an individual's physical, psychological, and emotional well-being. Sanchez and Liamputtong [20,30] categorise therapeutic landscapes as places that promote sustained health and well-being, distinguishing between extraordinary landscapes and everyday landscapes. In contrast to extraordinary therapeutic landscapes such as resorts, summer camps, or national parks, some therapeutic landscapes dispersed around communities tend to be more commonplace. These can become places where residents escape daily stress or meet up to obtain long-term

therapeutic benefits [20]. In the long term, the indirect impact of "nature nearby" also includes increasing people's overall satisfaction with family, work, and life [31,32].

Community gardens are particularly useful spaces for facilitating daily opportunities for social interaction. For instance, Milligan et al. [33] conducted a study in northern England, revealing that older individuals in community gardens experienced a sense of security, aesthetics, enhanced social networks, and a sense of achievement through gardening activities. Marsh et al. [28] explored how community gardens serve as places offering end-of-life and mourning support. This research supports the idea that community gardens are multifaceted spaces meeting diverse needs, including social support, emotional comfort, and spiritual solace.

Kingsley et al. [34] argued that community gardens represent a "third place" environment outside of home and work. These third places are accessible, socially neutral, and offer opportunities for people to meet, interact, and cultivate a sense of belonging, enhancing social life across cultures and ages [35–37]. Community gardens also function as "contact zones" [38] or "micro publics", [39] forming a "cross-cultural third Space" contributing to social well-being [37]. Evidence suggests that community gardens can enhance trust among neighbours and foster a willingness to intervene collectively for mutual neighbourhood interests, known as "collective efficacy", including social cohesion, neighbourhood attachment, and informal social control [14,40,41]. Gardening activities, as collective endeavours, bring together the collective resources of neighbours to achieve common goals, creating an environment for shared actions and connections [20,40,42].

Research on the health promotion of community gardens has primarily focused on gardening, which has been classified as a medium- to high-intensity physical activity (PA). Community gardens can serve as a "green gym", providing regular exercise and thereby associated physical health benefits (e.g., positively impacting gardeners' blood pressure [43,44]). This is supported by evidence highlighting a substantial rise in physical activity resulting from tasks like harvesting, planting, and daily maintenance [21]. These activities can yield mental health benefits as well, such as reducing stress and anxiety, boosting self-esteem, and enhancing satisfaction [16]. However, it should be noted that community gardening may have unintended negative impacts on health and well-being. For instance, community gardening has the potential to exacerbate or increase local health inequalities [15,45], result in injuries or overexertion [15], and may increase stress associated with managing projects [21].

During the COVID-19 pandemic, lockdowns hindered access to larger public green spaces, leading to an increased use of small-scale residential green spaces including community gardens [8]. Marsh et al. [17] found that the rise in gardening activities during the pandemic was not solely driven by food production needs, similar to "victory gardens" during war or economic downturns, but was more about obtaining intangible elements of "refuge garden spaces", seeking mental tranquillity, joy, respite, or relaxation. During lockdowns, increased frequency and duration of access to community gardens contributed to positive mental health outcomes [19]. Research indicates increased interest in gardening as lockdowns became more widespread, with the benefits of improving physical health, life satisfaction levels and creating a social support network that strengthens local communities [5,10,43].

Community gardens have been shown to have numerous benefits both during the pandemic and non-pandemic period, yet the prioritization of these benefits varies across different locations, cultures, and socioeconomic groups [46]. A recent systematic review found that countries with different socioeconomic contexts have different expectations for the benefits of community gardens. Developed countries' community gardens often provide social, health-related, and nature education-related benefits, while developing countries emphasize local economic benefits and ecological needs [47]. Providing more evidence on the promotion of health-related benefits of community gardens in developing countries during pandemic is crucial, as it can enhance the local government's attention to community gardens as a health-promoting tool.

1.2. Aim and Objectives

The overall aim of this natural experiment study was to examine the effects of the COVID-19 pandemic on users and health-related behaviours in one community garden in China. Specific objectives were to assess observed differences in:

1. Total number of people using the community garden;
2. Total number of people engaging in physical activity (moderate, vigorous PA, sedentary), social interactions, and people taking notice of the environment;
3. Demographic profile of community garden users.

2. Materials and Methods

2.1. Study Design

This was a repeat cross-sectional pre–post quasi-experimental design [48], comparing outcomes in the non-epidemic period (defined as "pre-intervention") and the epidemic period (defined as "post-intervention"). All data were proceeded in SPSS 14 (28.0.1.1).

2.2. The Neighbourhood and Residents

The study was set in the Luxiangercun (LX) community in Wujiang district, Suzhou, China (Figure 1). It was built in 1993 and represents a typical old residential quarter in China, facing issues such as deteriorating walls, damaged pipelines, inadequate drainage, outdated facilities, and various deficiencies in public amenities. In 2019, the neighbourhood was selected as the national-level demonstration of upgrading of a dilapidated neighbourhood. Following preliminary surveys and resident consultation meetings, the renovation commenced in June 2020. Alongside facade improvements, roof waterproofing repairment, technological advancements, replacement of unit doors and security upgrading were implemented.

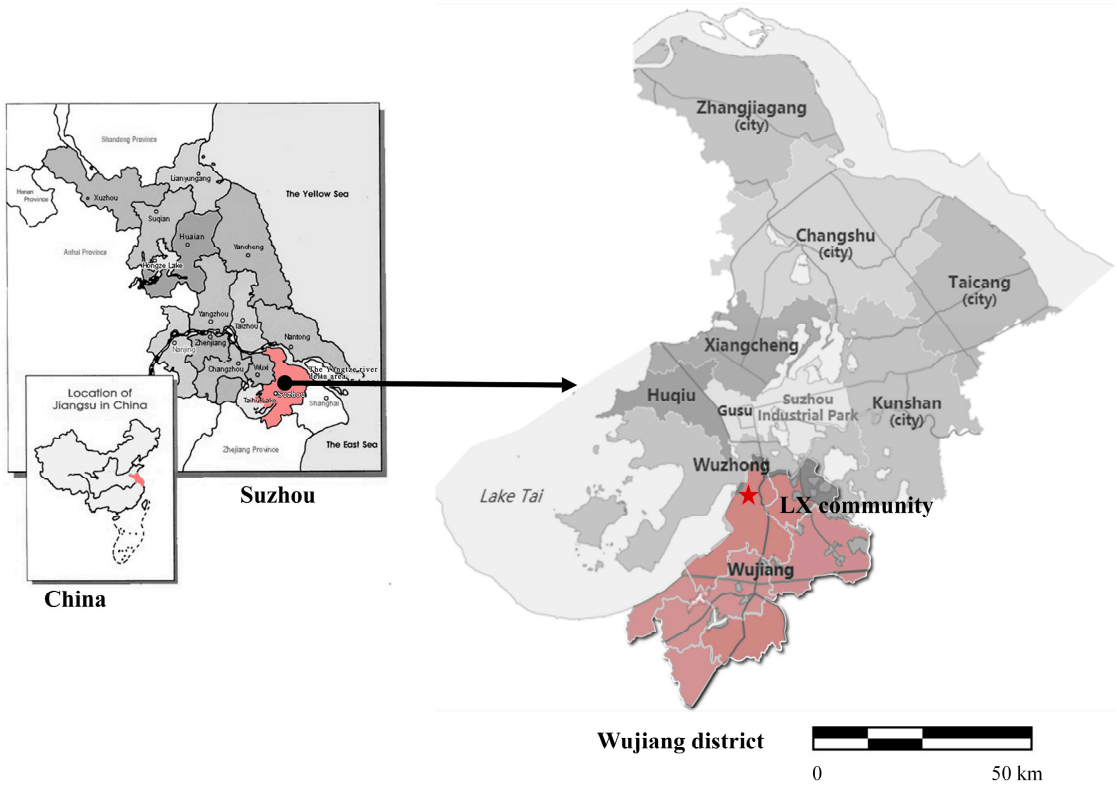


Figure 1. Location of LX community (compiled by author).

As of 2020, there are about 1340 households in total, and 60% are migrant worker families who have settled down. In order to demonstrate public participation as the novel

approach in neighbourhood upgrading, the community garden project was introduced and led by a research team of Xi'an Jiaotong-Liverpool University, in collaboration with Tongji University and Clove School (an NGO on nature education for the youth in Shanghai). Since its inception, a series of place-making activities with a participatory approach have been organised, and more than 300 families have participated [49]. A volunteer team was established for daily maintenance and has approximately 30 core members from the local community [50].

2.3. The Study Area

The physical construction of the community garden was completed by the end of 2020. The community garden has a total area of approximately 500 square meters, including five keyhole-shaped planting beds at the north, a herb garden at the south, and a sand pitch play area near the central square (Figure 2). This study focuses on the garden area at the north and south. The North Garden is structured as a "keyhole garden", offering a multifunctional space for residents to engage in gardening, appreciate flowers, socialise, and unwind. Its layout comprises five keyhole-shaped flower beds, resembling a flower's structure. The South Garden is designed as a therapeutic garden, primarily catering to residents for walking, socialising, relaxation, and contemplation. It comprises three flower beds of varying heights and a lengthy bench. The high-desk and low-desk planting areas are designed for the convenience of the elderly or people with disabilities.

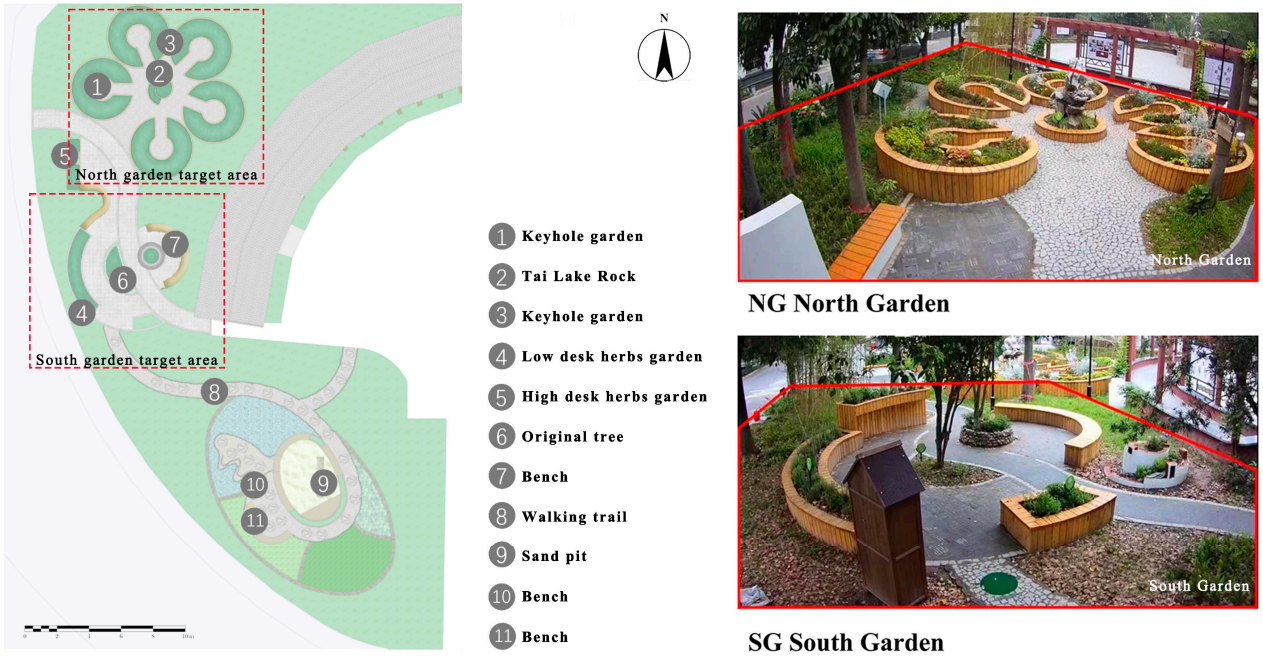


Figure 2. Location and observation boundaries of NG and SG.

2.4. Natural Experiment (COVID-19 Epidemic)

This study focussed on the LX community garden in Wujiang district during the 2022 COVID-19 epidemic outbreak in Suzhou. On 13 February 2022, there was a new wave of COVID-19 in Suzhou. From 15 February 2022, the Suzhou municipal government closed some highway entries and stopped travel across Jiangsu province. After 16 April 2022, more stringent epidemic prevention and control measures were implemented in Wujiang District, including social distancing, studying and working from home, close management of all neighbourhoods and inspection of all external visitors. These countermeasures were then relaxed after 5 May 2022.

During this epidemic period (i.e., from February to May 2022), the research team stopped all changes of the site, such as planting and organized voluntary activities. The

research team also followed the social distancing policy and did not travel to the site except for one short visit in early March 2022. All live information about the site was obtained through an online instant chatting platform (WeChat).

2.5. Data Collection Method (Camera-Based Systematic Observation)

Systematic observation (i.e., direct observations of behaviour using pre-determined criteria) is a promising objective method of unobtrusively assessing health behaviours in small-scale public open spaces [51]. This method offers numerous advantages by minimising errors and subjectivity in self-report measures [52]. Commonly used observation tools for this type of research include behaviour mapping [53], Public Life and Public Space (PLPS) [54], and the System for Observing Play and Recreation in Communities (SOPARC) [55].

Benton et al. [56] recently developed a new systematic observation tool: Method for Observing Physical Activity and Well-being (MOHAWk). MOHAWk was designed explicitly for smaller public spaces with lower numbers of users, such as pocket parks, amenity green spaces, canal waterways, or residential streets [56]. It is therefore the most suitable validated observation tool relevant to meet the objectives of the present study. MOHAWk assesses three levels of PA (Sedentary, Moderate, Vigorous), social interactions (Connect) and people taking notice of the environment (Take Notice) in urban spaces. MOHAWk also assesses demographic categories, including age group, gender, and ethnic group. There is evidence of high inter-rater reliability when using MOHAWk, and there is evidence of validity (Benton et al., 2020) [56]. MOHAWk has been used in multiple natural experiment studies [57–61].

Traditional in-person observation methods can be resource-intensive. Emerging technologies have led to researchers using camera-based methods to assess the use of small public spaces. Specifically, video cameras can be used to collect video recordings in public spaces, which can then be manually coded. By removing the need for on-site observers to conduct "live" observations, use of camera-based observation methods can reduce observer errors, enhance scalability, and increase cost-effectiveness compared to traditional observation. It has been shown that using video cameras as an observation tool in research can be carried out in a reliable manner and in line with ethical and information governance regulation [62,63]. Therefore, the present study utilised the collection of monitoring videos to conduct manual observations of video recordings collected in the community garden by trained observers.

2.6. Chinese MOHAWk Adaptation

Given that the behaviours assessed by MOHAWk are culturally sensitive, a simplified Chinese version of MOHAWk was developed to adapt the age group code and activity types, and for a wider use of the manual in China. Due to the characteristics of Chinese elderly women dyeing their hair, it is difficult to determine whether individuals aged 55–65 are adults or elderly based on hair colour. There is also difficulty in distinguishing between children and teenagers in China, based on school uniforms (junior high and elementary school uniforms are different) and whether they wear a red scarf (Chinese elementary school students are required to wear a red scarf). Therefore, the protocol was adapted so that if it is still difficult to distinguish between children and adolescents, the observed person is generally coded as a child (many local children may purchase junior high school uniforms or habitually not wear a red scarf). Finally, in response to unique activities observed in Chinese contexts—particularly the care of children by older adults in Chinese communities, gardening in public spaces, and the presence of vendors selling goods—additional types of activities were included. These additional activity types included purchasing and selling goods, household tasks, and engaging in recreational activities with children. The adapted simplified Chinese MOHAWk materials are provided in the Supplementary File.

2.7. Health-Related Behaviour Outcomes

In this study, PA levels are based on the 2011 Compendium of Physical Activities [64]. Sedentary activities (i.e., <3 METs) involve prolonged periods of lying, sitting, or standing, including low-intensity activities in place, stepping, very slow walking, stretching, traditional yoga, etc. Moderate activities (i.e., ≥3 METs and <6 METs) include relaxed walking or equivalent activities [65]. Vigorous activities (i.e., ≥6.0 METs) exceed normal walking intensity (e.g., sweating from increased heart rate, running, brisk walking, wheelchair pushing, skipping rope).

"Connect" behaviours involve social interactions between the observed individual and other people, which include talking and listening or using body language to communicate, physical contact with others (e.g., shaking hands, patting on the shoulder, hugging), smiling and making eye contact, or participating in group activities.

"Take Notice" behaviours focus on being aware of the external environment. Behaviours such as stopping or slowing down to consciously appreciate the surroundings, observing for an extended period, pausing to observe or take photos, or turning to observe an object or person, are considered Take Notice behaviours.

Figure 3 shows examples of health-related behaviours in the LX community garden.



Figure 3. Examples of health-related behaviours observed in LX community garden (photos taken by author).

2.8. Observation Schedule and Procedures

Videos were obtained from two surveillance cameras facing the north and south gardens. Before video collection, researchers visited each space to ensure the video monitoring equipment could comprehensively record the environment and behaviours. During the site visit, the researchers also agreed on the boundaries of the target area in the monitored videos (shown in Figure 2).

The collected video data were categorised into two periods: non-epidemic and epidemic periods. It has previously been found that conducting systematic observations on at least two days per week can provide a reliable estimation of activity in urban spaces [66]. The data collected therefore included four days during the non-epidemic period and two

randomly selected days during the epidemic (Table 1). Weekdays (Tuesday, Wednesday, or Thursday) were chosen for video collection to mitigate potential influences on the health-related behaviours of the residents from weekend factors, such as increased outdoor activities. The non-epidemic period dates were 21 May 2021, 21 September 2021, 7 September 2022, and 18 October 2022, while the epidemic period dates were 7 April 2022 and 31 May 2022.

Table 1. The dates and weather of video collection during the non-epidemic and epidemic period.

Time Period	Date	Days of the Week	Temperature (Celsius)	Weather	Wind Direction and Speed
Non-epidemic period	21/05/2021	Friday	18–26	cloudy	southeast wind, force 3–4
	21/09/2021	Tuesday	22–31	sunny to cloudy	southwest wind, force 3–4
	07/09/2022	Wednesday	22–32	cloudy	southeast wind, force 3–4
	18/10/2022	Tuesday	10–19	sunny	northeast wind, force 3–4
Epidemic period	07/04/2022	Thursday	12–26	sunny	southeast wind, force 3–4
	31/05/2022	Tuesday	20–28	cloudy	southeast wind, force 4–5

As the videos were being recorded continuously, each site captured a full day's observation from early morning to late evening (5:00 to 23:00). However, due to the impact of nucleic acid testing policies during the epidemic, abnormal activities were noted before 8:00. As a result, the study focused on the period from 8:00 to 23:00, totalling 15 h. In total, 120 h during the non-epidemic period and 60 h of video during the epidemic were analysed.

Observers used our adapted simplified Chinese MOHAWk to record the characteristics and behaviours of each person entering a pre-determined boundary ('target area') during hour-long observation periods. While watching the video, observers used the MOHAWk observation form to record the following data for each person that entered the target area during each observation period: age group (Child, Teen, Adult or Older Adult), gender (Female or Male), PA level (Sedentary, Moderate, Vigorous), social interaction (Connect), and taking notice of the environment (Take Notice). Since the same individual may exhibit multiple behaviours, each behaviour is recorded, so the total level of behaviours will exceed the number of individuals. In the same observation period (one hour), the behaviour of the same individual will only be recorded once. However, if this individual disappears from the boundary of the monitoring video for a time and reappears, this individual will be coded again to reduce errors. When a large group (>10 people) appears, the total number of people is recorded in the "Group" column. Each time a person appears within the target area, the video can be paused if required.

Age groups were determined based on overall appearance and movement. For example, children (3–12 years old) are usually accompanied by parents and typically wear elementary school uniforms; teens (13–19 years old) are independent and personalized, and wearing middle or high school uniforms; adults (20–64 years old) dress formally and maturely; and the elderly group (65 years and older) can be distinguished from adults based on appearance (such as grey or white hair, wrinkles, balding) and movement (slow, stiffness, or having mobility issues).

Agreement between a pair of observers (i.e., inter-rater reliability) was analysed using two-way mixed, single measure, and consistency intraclass correlation coefficients (ICC). The inter-rater reliability of observers was tested by selecting a randomly sampled one-hour monitoring video divided into 5 min units (12 observation units). ICC values can be interpreted as follows: <0.5 = poor; 0.5–0.75 = moderate; 0.76–0.9 = good; and >0.9 = excellent [67]. Inter-rater reliability was mostly 'good' or 'excellent', with only one 'moderate' ICC (see Table 2).

Table 2. Inter-rater reliability result of a pair of observers.

Inter-Rater Reliability Test	Intraclass Correlation	Lower Bound	Upper Bound
Infant	1	1	1
Child	0.98	0.932	0.994
Teen	0.889	0.614	0.968
Adult	0.928	0.75	0.979
Older adult	0.959	0.857	0.988
Female	0.983	0.942	0.995
Male	0.988	0.959	0.997
Overall count	1	1	1
Sedentary	0.98	0.92	0.99
Moderate	0.96	0.861	0.988
Vigorous	0.72	0.01	0.92
Connect	0.784	0.251	0.938
Take Notice	1.00	1.00	1.00

2.9. Analysis

The analysis unit is the observation period, representing the count for each location during each observation period.

We assessed differences between the non-epidemic and epidemic periods in total number of users, behaviours, gender and age groups using paired-sample difference tests.

In this study, we initially employed the Shapiro–Wilk test to verify if the differences in the paired samples conformed to a normal distribution. For paired groups exhibiting a normal distribution, a paired *t*-test was used. Conversely, if the differences in the paired samples did not follow a normal distribution, a non-parametric test method was used (the Wilcoxon signed-rank test). The significance level was set at $\alpha = 0.05$. All analyses were conducted using SPSS version 28.0.1.1(14).

This study underwent an ethical review, and ethics approval was granted by the XJTLU University Ethics Committee (21-02-19).

3. Results

Table 3 presents a descriptive summary of data from both epidemic and non-epidemic periods in the North and South Gardens.

Table 3. Descriptive statistics of NG and SG during the non-epidemic and epidemic period.

Paired Samples Statistics			Non-Epidemic Period				Epidemic Period			
			Total Count	Median	IQR	Mean	Total Count	Median	IQR	Mean
North Garden	Total	Total number of people	116.50	6.75	9.00	7.77	225.50	14.00	17.50	15.03
	Gender	Male	58.25	3.50	4.00	3.88	106.00	6.00	7.50	7.07
		Female	58.25	3.25	5.50	3.88	119.50	8.00	9.50	7.97
	Age	Child	51.25	2.25	6.75	3.42	123.00	7.50	10.50	8.20
		Teen	0.75	0.00	0.00	0.05	1.00	0.00	0.00	0.07
		Adult	28.00	1.75	2.00	1.87	40.00	2.50	1.00	2.67
		Older adult	36.50	2.75	3.50	2.43	61.50	4.50	4.00	4.10
	Behaviour	Sedentary	62.00	3.25	5.50	4.13	95.00	6.00	6.50	6.33
		Moderate PA	108.00	6.75	9.25	7.20	202.00	12.00	16.00	13.47
		Vigorous PA	34.00	1.00	4.25	2.27	55.50	2.50	4.50	3.70
		Connect	12.50	0.75	1.25	0.83	7.00	0.00	1.00	0.47
		Take Notice	22.25	1.50	2.00	1.48	9.50	0.50	1.00	0.63

Table 3. *Cont.*

Paired Samples Statistics			Non-Epidemic Period				Epidemic Period			
			Total Count	Median	IQR	Mean	Total Count	Median	IQR	Mean
South Garden	Total	Total number of people	121.50	8.75	9.25	8.10	208.50	11.50	14.00	13.90
	Gender	Male	60.25	4.25	4.25	4.02	91.50	7.00	5.50	6.10
		Female	61.25	4.25	6.25	4.08	117.00	7.00	9.00	7.80
	Age	Child	52.50	2.50	6.25	3.50	108.50	5.50	11.00	7.23
		Teen	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.07
		Adult	32.25	2.00	3.00	2.15	45.00	3.00	2.50	3.00
		Older adult	36.75	3.25	2.75	2.45	54.00	2.50	4.00	3.60
	Behaviour	Sedentary	58.50	3.50	6.00	3.90	109.00	6.50	6.50	7.27
		Moderate PA	112.00	8.75	8.50	7.47	188.50	11.00	13.50	12.57
		Vigorous PA	28.25	1.25	3.00	1.88	57.00	3.50	6.00	3.80
		Connect	13.50	1.00	1.00	0.90	27.00	1.00	3.00	1.80
		Take Notice	18.25	1.00	1.75	1.22	8.00	0.50	1.00	0.53

3.1. Normality Test

The results of the normality test for differences in paired samples, conducted using the Shapiro–Wilk test and displayed in Table 4, revealed that the *p*-values for Female (0.536), Child (0.054), Adult (0.087), Sedentary (0.196), Moderate PA (0.165), Connect (0.188), and Take Notice (0.566) in the North Garden, as well as Total number of people (0.076), Female (0.809), Child (0.116), Adult (0.138), Older adult (0.728), and Vigorous PA (0.881) in the South Garden, were all significantly above 0.05. This suggests that the data conform to a normal distribution, meeting the criteria for a paired sample *t*-test. The result of the test is shown in Table 5.

Table 4. The Shapiro–Wilk test of the differences in the paired samples.

Tests of Normality			Shapiro–Wilk Statistic	d.f.	Sig.
North Garden	Total	Total number of people	0.877	15	0.042
	Gender	Male	0.806	15	0.004
		Female	0.951	15	0.536 *
	Age	Child	0.884	15	0.054 *
		Teen	0.64	15	<0.001
		Adult	0.897	15	0.087 *
		Older adult	0.828	15	0.009
	Behaviour	Sedentary	0.92	15	0.196 *
		Moderate PA	0.916	15	0.165 *
		Vigorous PA	0.799	15	0.004
		Connect	0.919	15	0.188 *
		Take Notice	0.953	15	0.566 *
South Garden	Total	Total number of people	0.894	15	0.076 *
	Gender	Male	0.876	15	0.041
		Female	0.967	15	0.809 *
	Age	Child	0.906	15	0.116 *
		Teen	0.413	15	<0.001
		Adult	0.91	15	0.138 *
		Older adult	0.962	15	0.728 *
	Behaviour	Sedentary	0.84	15	0.012
		Moderate PA	0.878	15	0.044
		Vigorous PA	0.972	15	0.881 *
		Connect	0.809	15	0.005
		Take Notice	0.869	15	0.033

* Since *p*-value is >0.05, do not reject H0, Distribution can be assumed to be normal.

Table 5. Paired-sample *t*-test results of the difference of NG and SG during the non-epidemic and epidemic period.

Outcome		Paired Differences						t	d.f.	Sig. (2-Tailed)
		Mean	Median	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
North Garden	Female	4.08	4.75	3.15	0.81	2.34	5.83	5.02	14	<0.001 **
	Child	4.78	5.25	4.95	1.28	2.04	7.52	3.745	14	0.002 **
	Adult	0.80	0.75	1.76	0.45	−0.17	1.77	1.762	14	0.1
	Sedentary	2.20	2.75	3.66	0.94	0.18	4.22	2.33	14	0.035 *
	Moderate PA	6.27	5.25	5.78	1.49	3.06	9.47	4.197	14	<0.001 **
	Connect	−0.37	−0.75	1.15	0.30	−1.00	0.27	−1.236	14	0.237
	Take Notice	−0.85	−1.00	1.19	0.31	−1.51	−0.19	−2.756	14	0.015 *
South Garden	Total number of people	5.80	2.75	4.77	1.23	3.16	8.44	4.712	14	<0.001 **
	Female	3.72	2.75	3.14	0.81	1.98	5.46	4.585	14	<0.001 **
	Child	3.73	3.00	3.37	0.87	1.87	5.60	4.295	14	<0.001 **
	Adult	0.85	1.00	1.62	0.42	−0.05	1.75	2.029	14	0.062
	Older adult	1.15	−0.75	1.95	0.50	0.07	2.23	2.287	14	0.038 *
	Vigorous PA	1.92	2.25	2.40	0.62	0.59	3.24	3.096	14	0.008 **

** Statistically highly significant at $p < 0.01$ (2-tailed); * Statistically moderately significant at $p < 0.05$ (2-tailed).

Conversely, *p*-values for other outcomes, including Total number of people (0.042), Male (0.004), Teen (<0.001), Older adult (0.009), and Vigorous PA (0.004) in the North Garden, as well as Male (0.041), Teen (<0.001), Sedentary (0.012), Moderate PA (0.044), Connect (0.005), and Take Notice (0.033) in the South Garden, were all below 0.05. This indicates a non-normal distribution, therefore requiring non-parametric testing methods (the Wilcoxon signed-rank test), and result of the test is shown in Table 6.

Table 6. Wilcoxon signed-rank test results of NG and SG during the non-epidemic and epidemic period.

Outcome		Paired Differences		Z	Sig. (2-Tailed)
		Mean	Median		
North Garden	Total number of people	7.27	7.25	−3.240 [b]	0.001 **
	Male	3.18	2.50	−2.587 [b]	0.01 *
	Teen	0.02	0.00	−0.272 [b]	0.785
	Older adult	1.67	1.75	−3.015 [b]	0.003 **
	Vigorous PA	1.43	1.50	−1.414 [b]	0.157
South Garden	Male	2.75	2.08	−2.787 [b]	0.005 **
	Teen	0.00	0.07	−1.414 [b]	0.157
	Sedentary	3.00	3.37	−3.012 [b]	0.003 **
	Moderate PA	2.25	5.10	−3.352 [b]	<0.001 **
	Connect	0.00	0.90	−1.430 [b]	0.153
	Take Notice	−0.50	−0.68	−2.294 [c]	0.022 **

** Statistically highly significant at $p < 0.01$ (2-tailed); * Statistically moderately significant at $p < 0.05$ (2-tailed); [b] Based on negative ranks; [c] Based on positive ranks.

3.2. Total Number of People

There was a significantly higher total number of people observed during the epidemic period compared to the non-epidemic period in both gardens. The North Garden exhibited a significant difference in total numbers (mean difference = 7.27, z = −3.24, $p = 0.001 < 0.01$).

Similarly, the South Garden showed a significant increase in total number of people observed during the epidemic period compared to the non-epidemic period (mean difference = 5.8, t = 4.712, $p < 0.001$).

3.3. Health-Related Behaviours

3.3.1. Physical Activity

Moderate PA in the North Garden during the epidemic period was significantly higher than in the non-epidemic period (mean difference = 6.27, t = 4.197, $p < 0.001$). Similarly, in the South Garden, moderate PA showed a significant increase during the epidemic period compared to the non-epidemic period (mean difference = 2.25, z = −3.352, $p < 0.001$).

Sedentary activities in the North Garden were moderately significantly higher during the epidemic period compared to the non-epidemic period (mean difference = 2.2, t = 2.33, $p = 0.035 < 0.05$). Likewise, in the South Garden, sedentary activities were significantly higher during the epidemic period compared to the non-epidemic period (mean difference = 3, z = −3.012, $p = 0.003 < 0.01$).

Vigorous PA during the epidemic period was moderately significantly higher in the South Garden compared to the non-epidemic period (mean difference = 1.92, t = 3.096, $p = 0.008 < 0.05$). However, there were no significant changes observed in the North Garden between the non-epidemic and epidemic periods (mean difference = 1.43, z = −1.414, $p = 0.157 > 0.05$).

3.3.2. Connect

In the North Garden, there was a decrease in people connecting with others during the epidemic compared to the non-epidemic period, but this difference was not statistically significant (mean difference = −0.37, t = −1.236, $p = 0.237 > 0.05$). Meanwhile, in the South Garden, the level of people connecting with others remained largely unchanged between the non-epidemic and epidemic periods (mean difference = 0, t = −1.43, $p = 0.153 > 0.05$).

3.3.3. Take Notice

People taking notice of the environment during the epidemic period was significantly lower compared to the non-epidemic period in the North Garden (mean difference = −0.85, t = −2.756, $p = 0.015 < 0.05$). Similarly, there was a significant decrease in people taking notice of the environment during the epidemic period compared to the non-epidemic period in the South Garden (mean difference = −0.5, z = −2.294, $p = 0.022 < 0.01$).

3.4. Demographic Profile of Garden Users

3.4.1. Gender

There was a significant increase in the number of females during the epidemic period compared to the non-epidemic period in both the North Garden (mean difference = 4.08, t = 5.02, $p < 0.001$) and in the South Garden (mean difference = 3.72, t = 4.585, $p < 0.001$), indicating a higher female presence during the epidemic period in both locations.

The number of males also saw a moderate increase during the epidemic period compared to the non-epidemic period in the North Garden (mean difference = 3.18, z = −2.587, $p = 0.01 < 0.05$) and a highly significant increase in the South Garden (mean difference = 2.75, z = −2.787, $p = 0.005 < 0.01$).

3.4.2. Age Groups

There was a highly significant increase in the number of children in both the North Garden (mean difference = 4.78, t = 3.745, $p = 0.002 < 0.01$) and the South Garden (mean difference = 3.73, t = 4.295, $p < 0.001$) during the epidemic period, indicating a higher presence of children during this time. Additionally, there were no significant changes in the number of teenagers during the epidemic period in both the North Garden (mean difference = 0.02, z = −0.272, $p = 0.785 > 0.05$) and South Garden (mean difference = 0, z = −1.414, $p = 0.157 > 0.05$).

However, the adult group showed a slightly higher number during the epidemic period compared to the non-epidemic period in both the North Garden (mean difference = 0.8, t = 1.762, $p = 0.1 > 0.05$) and the South Garden (mean difference = 0.85, t = 2.029, $p = 0.062 > 0.05$), although the difference was not statistically significant.

There was a moderate increase in the number of older adults during the epidemic period compared to the non-epidemic period (mean difference = 1.15, t = 2.287, $p = 0.038 < 0.05$). Specifically, there was a highly significant increase in the number of older adults in the North Garden during the epidemic period compared to the non-epidemic period (mean difference = 1.67, z = −3.015, $p = 0.003 < 0.01$).

4. Discussion

This study found a significantly higher number of visitors during the epidemic period compared to the non-epidemic period in both community gardens. Sedentary behaviours and moderate physical activity increased significantly in both gardens, while vigorous physical activity only increased significantly in the South Garden. Social interactions remained largely unchanged, but fewer people took notice of their environment during the epidemic period. Demographically, there were significant increases in both male and female visitors, as well as children and older adults, with adults showing a slight, non-significant increase, and no significant changes in teenagers.

The video recording observation analysis results are consistent with information from other sources. From the Wechat group history during the epidemic period, elderly volunteers visited the garden in turn and shared the photos in the Wechat group. The Wechat chat history also recorded resident's donations to the garden, cleaning of the pond, guarding and more children's visits to the garden.

4.1. How This Study Compares to Existing Literature

Similarly to what is found in international literature, community gardens may have been the most accessible green spaces for outdoor activities during the COVID-19 lockdown [5]. Due to the temporary closing of day care centres for the elderly, the elderly moved some activities to the South community garden, such as instrument practice and other physical exercises (e.g., dancing, Tai qi, etc.) which can partly explain the increase in vigorous physical activity. Additionally, differently from what is mentioned in some international literature, i.e., that children's PA levels were lower and outdoor time was shorter during the COVID-19 pandemic [68,69], the number of children in community gardens appeared to significantly increase during COVID-19. This is mainly because neighbourhood spaces replaced school for off-class time after online studying at home. The increase in child users to some extent explains the increasing demand for stress relief and anxiety relief among children during the COVID-19 pandemic due to the loss of peer interaction, social isolation, and reduced contact with teachers [69]. Based on the Attention Restoration Theory (ART) and Stress Reduction Theory (SRT), the natural environment in community gardens encompasses necessary elements for their attention restoration experiences and stress relief [70–72].

Based on current literature, community gardens are recognized for emphasizing health and well-being through therapeutic landscapes, fostering community connections, and promoting physical and leisure activities as integral components of health-related behaviours [14]. Most studies during pandemics focus on the community garden's role in enhancing social resilience [19,73,74]. However, the present study suggests that community gardens may be more effective in promoting physical activity, such as walking, and less on facilitating people–place interactions (e.g., taking notice of the environment) or interpersonal connections among people. Therefore, community gardens during pandemics may serve less as spaces for social interactions, but instead may function more as a "nature nearby" [31,32] space, offering a therapeutic environment rich for mental tranquillity, joy, respite, and relaxation. The observed increase in sedentary activities supports the idea that participants spent more time in the garden, therefore likely experiencing greater benefits

from its therapeutic environment. However, it is noteworthy that during the epidemic period there was a significant decrease in people taking notice of the environment compared to non-epidemic periods. One potential explanation could be that the primary purpose of visiting the garden shifted from appreciating the landscape to activities like walking or supervising grandchildren. Additionally, while the garden benefitted from good voluntary monitoring to prevent damage or loss, there was a lack of maintenance for the plants. Consequently, the overall quality of the landscape deteriorated, and excessive consumption, especially by children, resulted in damage to the garden. The gender and age differences are consistent with a previous study in China that found that females and the elderly are more willing to conduct community garden activities [75].

4.2. Implications for Policy and Practice

At present, community gardens in China are not part of regulatory planning and are not covered by public expenditure. There is no system or regulatory framework to safeguard the financing, use rights, planning, design, implementation, and maintenance of community gardens in China. In contrast, in many developed countries, for example, in New Zealand, in the Reserves Act 1977 [76] the local government formulated policies to regulate the establishment and management of community gardens, including land use rights and permits, funding, benefits and services, economic activities, and maintenance, which can be a good reference. A study from researchers in Perth, Western Australia proposed strategies to integrate formal green space planning with the development of community gardens, providing an approach for community gardens to become formal green spaces [77]. The present study has provided important robust evidence that community gardens are a promising urban intervention for health promotion during urban crises in China. The natural experiment method used in this study provides important practice-based evidence to better inform preventive public health policy specifically in a Chinese context [23].

Differently from traditional well-designed small-scale parks, community gardens reflect a sense of place and agency of local residence [78,79]. In this sense, community gardens are public green spaces created by local residents. For example, in Adelaide, Australia, many underutilized lands have been spontaneously transformed into community gardens, contributing to the restoration of local vitality and promoting well-being [80]. Additionally, the maintenance teams and cultural activities behind community gardens promoted community sense, cultural diversity, social capital, and social cohesion [80,81]. Similarly, in Poland, community gardens are seen as a new method to develop interactive green spaces in residential areas, enhancing residents' sense of community, unity, and shared responsibility [82].

4.3. Strengths and Limitations

To the authors' knowledge, this study is the first to systematically observe health-related behaviours in community gardens in China. Nevertheless, it is important to highlight that community gardens in China are generally different from those reported in international literature [83] in three aspects. First, most neighbourhoods in mainland China are gated neighbourhoods with clear physical boundaries, such as walls, fences and exits with security services. The land use right is therefore more secured than vacant land outside of a neighbourhood. Second, in contrast to other countries, most community gardens in mainland China are not predominantly used for growing vegetables or food, but mainly for appreciation of flowers and nature. Thirdly, although access to community gardens in China is available without strict security screening [84], during the pandemic period in 2022, the access was greatly restricted to local residents living in the neighbourhood only. These differences must be considered when interpreting and generalising the study findings.

We have provided a new framework and methodology that can be applied in future community garden research, including an adapted version of the MOHAWk observation tool that will facilitate improved systematic observation of physical activity and other health-related behaviours in Chinese contexts. Furthermore, this study has made a novel

contribution by utilizing video cameras as the original data source, rather than relying on traditional in-person observations, which has the potential to improve the accuracy, scalability and cost-effectiveness of natural experiment research [85]. However, challenges in video data collection persist due to differences in ethical norms and data protection regulation [63].

It is important to acknowledge that the present study was a repeat cross-sectional pre–post design, comparing the difference in the outcomes when pandemic restrictions were not in place (defined as pre-intervention) compared to outcomes during COVID-19 restrictions (defined as post-intervention). While this study design is not as robust with respect to internal validity as longitudinal experimental designs (i.e., collecting data in the same individuals over time), due to potential unmeasured changes in the composition of the samples over time, they can still provide valuable insights [86]. Furthermore, we relied on quantitative data using systematic observations and thus did not triangulate these outcome measures with other methods (e.g., surveys and qualitative methods). These data collection limitations were a result of constraints associated with COVID-19 and the opportunistic nature of this study. Nonetheless, this study still provides rare, robust natural experiment evidence on how community gardens served communities during the COVID-19 pandemic.

4.4. Future Research

Community gardens have great potential as a public health resource, and COVID-19 has emphasized this. However, there is currently very limited natural experiment research on how community gardens can be planned and designed to maximize the health and well-being benefits. This study has provided a new method that can be used to produce quantitative evidence on the effects of community gardens from the perspective of health-related behaviours. More research like this is needed to accumulate natural experiment evidence of effects of community gardens on health and well-being. It would also be particularly valuable to use this method to assess how health-related behaviours correlate with different garden design configurations, and model the most utilized spatial, function and landscape configuration of gardens. Finally, more qualitative research is needed to develop a deeper understanding of the motivations, perceptions, and needs of different age groups for community gardens to maximize their benefits.

5. Conclusions

This natural experiment study found that a neighbourhood community garden played a vital role in enabling access to green space during the COVID-19 epidemic. The increase in the total number of users of the community garden during the 2022 epidemic outbreak in Suzhou shows the importance of community gardens as a primary space for outdoor activities. The community garden contributed more to physical activity, such as walking, during COVID-19, but less on interactions between people (connecting) or people–place interactions (taking notice of the environment). More natural experiment research on community gardens like this is needed to better understand how the health and well-being benefits of community gardens can be maximized.

Supplementary Materials: The following supporting information can be downloaded at: https://doi.org/10.17605/OSF.IO/PJHAV, Ying Chang, Siyu Chen and Jing Lu (2024) MOHAWk (Method for Observing physical Activity and Wellbeing) Instruction Manual (Simplified Chinese version). Open Science Framework.

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