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Urban park use and self-reported physical, mental, and social health during the COVID-19 pandemic: An on-site survey in Beijing, China

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ABSTRACT

The COVID-19 pandemic created unprecedented challenges for people’s health. Studies have demonstrated the positive impact of urban green spaces, particularly urban parks, on physical and mental health. However, few studies have evaluated social health, which is a component of human health, and more understanding of the relationship between urban parks and human health during the COVID-19 pandemic is required. This study examined the effects of urban parks on people’s health using a canonical correlation model. Physical, mental, and social health were the dependent health variables, and five factors related to urban parks were the independent variables. This study investigated 22 urban parks inside the Forth Ring Road in Beijing, China using a questionnaire survey. The results demonstrated a positive association between urban parks and human health during the pandemic. Distance to the parks, park area, and park size were positively correlated with physical, mental, and social health. Furthermore, frequency and duration of visits to urban parks were positively associated with mental health and contact with neighbors. The health effects of urban park use varied with park types and locations’ urbanization background. These findings can provide insights for health-oriented urban park planning and construction.

1. Introduction

The COVID-19 pandemic began in 2019 and rapidly spread worldwide. As of 20 April 2022, there were over 500 million confirmed cases and over 6 million deaths globally (World Health Organization, 2022). To minimize the risk of virus transmission, the Chinese government imposed several restrictions, such as home quarantine, school closures, canceling public events, social distancing, and travel restrictions (Shi et al., 2022; Zhao et al., 2022a; Zhu and Tan, 2021). Although these actions effectively controlled the spread of the virus and reduced mortality, urban dwellers’ daily lives were greatly impacted. Restrictions reduced the chance for physical activity and resulted in sedentary lifestyles (Stival et al., 2022). In addition to the influence on physical health, economic disruption (Mueller et al., 2022), rising unemployment rates (Lee and Yang, 2022), and uncertainty regarding the disease (Szczygielski et al., 2022) created a series of psychological problems. An observational study in China showed that 16.5% of the respondents reported experienced depression, 28.8% showed symptoms of anxiety, and 8.1% had a high stress level (Wang et al., 2020). Remote learning at home for whole semester or approval management for leaving campus restrictions might aggravate the psychosocial status of young adults. A longitudinal survey from March 2020 to January 2021 analyzed 1319 students from five universities in different regions of China and found that students’ mental status significantly decreased during the pandemic peak and students majoring in medicine displayed a more negative mental health status (Zhao et al., 2022b). These mental issues may cause negative consequences, including psychosis, suicide ideation, and panic (Nicomedes and Avila, 2020; Smith et al., 2021; Rudenstine et al., 2022). Therefore, in addition to taking precautions to protect physical health, improving mental and social health conditions is crucial.

Studies have demonstrated the positive impact of urban green spaces on various dimensions of human health (Akpinar, 2017; Orban et al., 2017; Coldwell and Evans, 2018). Urban green spaces, particularly urban parks, provide multiple benefits, including environmental, recreational, and aesthetic benefits. Such places increase physical activity, reduce stress levels, provide restorative experience, and enhance social interaction, thereby contributing to improved physical and mental health (Wolch et al., 2014; Jaung et al., 2020; Liu et al., 2022). Recent studies have demonstrated the crucial role of urban green spaces in promoting human health and well-being during the COVID-19 pandemic.
The respondents received considerable attention worldwide (Macedo and Haddad, 2016; Fagerholm et al., 2021; Samuelsson et al., 2021; Pipitone and Jovin, 2021). Despite this holistic definition, the specific definition and measurement of social health remain ambiguous (Cho et al., 2020). One definition provided by the framework of the Patient Reported Outcomes Measurement Information System indicates that social health involves relationships and connections with others, including individuals, groups, and communities (DeWalt et al., 2013). Following this definition, the present study adopted frequency of contact with and trust toward community neighbors to measure social health. In addition, whether green space helped improve the overall health of residents in metropolitan areas during the COVID-19 pandemic remains unclear. Therefore, it is essential to determine the impact of urban parks on human health.

The issue of park equity, including spatial and social aspects, has received considerable attention worldwide (Macedo and Haddad, 2016; Wuestemann et al., 2017; Pipitone and Jovin, 2021). Equitable access to urban parks enables citizens, regardless of their socioeconomic status, to equally benefit from exposure to nature, and is crucial in the sustainable development of cities (Fasih and Parizadi, 2020; Wu and Kim, 2021a). Furthermore, park accessibility must be considered, as greater accessibility can prevent cardiovascular disease, enhance the health status of an aging population, reduce mortality, increase the frequency of physical activities that promote physical health, and promote social cohesion (Schipperijn et al., 2017; Xie et al., 2018; Adhikari et al., 2021). Recent studies have examined central or multiple urban parks using social media data (Zhang et al., 2019; Wang et al., 2022); however, on-site studies particularly on multiple parks distributed across the central areas of megacity with complex social and cultural backgrounds are lacking (Addas and Maghrabi, 2020).

Therefore, we selected 22 urban parks in the most heavily urbanized region of Beijing and conducted an on-site questionnaire survey during the autumn of 2021. This study aimed to identify factors related to urban park visiting behavior. The study area consists of four districts (i.e., Chaoyang, Dongcheng, Haidian, and Xicheng District). The study area contains four districts (i.e., Chaoyang, Dongcheng, Haidian, and Xicheng). We examined 22 urban parks, most of which are larger than 2 ha (Table 1). We divided the selected parks into three types: cultural relic, community, and comprehensive parks. Cultural relic parks mainly contain unique historical architecture that represents the culture and heritage of the city and are constructed for the display and protection of relics (Rong et al., 2022); Community parks are typically located within the residential area and provide basic recreational infrastructures and facilities to meet the needs of nearby residents (Zhang and Zhou, 2018); Comprehensive parks are large open green spaces containing various types of public facilities for outdoor recreation (Li and Jin, 2011).

Due to the COVID-19 pandemic, the daily lives of all groups of people were influenced (Fig. S1). Beijing experienced two waves and several small clusters from the outbreak in early 2020–2021 according to the daily number of new cases (Liu et al., 2021; Dong et al., 2022; Jiao et al., 2022) from Beijing Municipal Health Commission (http://wjw.beijing.gov.cn/wjwh/ztzl/xqzbd/). The local government continued to enforce social distancing to eliminate channels of transmission. Previously closed scenic spots gradually began to reopen in 2021. However, there were still capacity limits for large events or daily activities in public

| Name                  | Area (ha) | Administrative district | Type               | Year of building |
|-----------------------|-----------|-------------------------|--------------------|------------------|
| Within the 2nd Ring Road Park |           |                         |                    |                  |
| Beihai Park           | 69.1      | Xicheng                | Cultural relic park | 1925             |
| Jingshan Park         | 26.6      | Xicheng                | Cultural relic park | 1928             |
| Temple Heaven Park    | 273.0     | Dongcheng              | Cultural relic park | 1420             |
| Yongdingmen Park      | 17.3      | Dongcheng              | Cultural relic park | 2004             |
| Taoranting Park       | 52.1      | Xicheng                | Comprehensive park | 1952             |
| Longtan Park          | 49.2      | Dongcheng              | Comprehensive park | 1952             |
| Olympic Community Park| 1.36      | Dongcheng              | Community park     | 2004             |
| Between the 2nd and 3rd Ring Road Park |           |                         |                    |                  |
| Yuyuantan Park        | 136.7     | Haidian                | Comprehensive park | 1960             |
| Yuetan Park           | 7.0       | Xicheng                | Cultural relic park | 1955             |
| South Lishihu Park    | 2.1       | Xicheng                | Community park     | 1960             |
| Xuanwuyu Yuan Park    | 7.1       | Xicheng                | Community park     | 1984             |
| Ritan Park            | 20.6      | Chaoyang               | Cultural relic park | 1956             |
| Ditan Park            | 30.6      | Dongcheng              | Cultural relic park | 1925             |
| Youth Lake Park       | 17.6      | Dongcheng              | Comprehensive park | 1960             |
| Between 3rd and 4th Ring Road Park |           |                         |                    |                  |
| Qingfeng Park         | 9.7       | Chaoyang               | Cultural relic park | 2009             |
| Tunjiejue Park        | 11.7      | Chaoyang               | Comprehensive park | 1986             |
| Chaoyang Park         | 285.1     | Chaoyang               | Comprehensive park | 1992             |
| Madian Park           | 7.3       | Haidian                | Community park     | 2003             |
| Wukesong Olympic Park | 9.9       | Haidian                | Community park     | 2008             |
| Haidian Park          | 34.0      | Haidian                | Comprehensive park | 2003             |
| Changchun Fitness Park| 10.6      | Chaoyang               | Community park     | 2007             |
| Taoyanggong Park      | 59.0      | Chaoyang               | Community park     | 2002             |
2.2. On-site survey and data collection

In-person surveys using paper questionnaires were conducted from September to November in 2021 when there have been two major waves in Beijing during the COVID-19 pandemic (Fig. 1). In summer vacation (i.e., July and August) there are usually many tourists from other cities to visit urban parks in Beijing such as Jingshan Park. Therefore, we began the survey in September and continued until a small cluster of COVID-19 cases happened in the late November when students were not allowed to leave our campus until the end of the semester. The whole study was conducted in accordance with the ethics requirement of the College of Forestry and the procedures were reviewed and approved by the College of Forestry of Beijing Forestry University. Surveys in all sites were collected from 8 am to 5 pm during weekdays and weekends. The survey aimed to gather the recreation experience evaluation from field park visitors; thus person-to-person on-site survey was conducted with trained interviewers to ensure respondents remain focused while completing the questionnaire and detailed explanation toward questions in the questionnaire could be given to respondents. Respondents were chosen randomly (Kelfve et al., 2020). To minimize bias, paper questionnaires were distributed dispersedly within a park to avoid unrepresentative recording in concentrated locations or focusing on specific groups of visitors (Stessens et al., 2020). We collected at least 50 questionnaires (Table 2) at each park. The questionnaire included the respondents’ evaluation of satisfaction with urban park accessibility in Part 1 and self-reported health conditions in Part 2. Part 2 included a comparative question to evaluate the health effects of urban park usage before and during the COVID-19 pandemic. Evaluations used a rating scale from 0 to 10 to capture respondents’ diverse opinions (Lehberger et al., 2020). Part 3 inquired regarding respondents’ urban park usage patterns. Part 4 included personal information about age group (0–14, 15–25, 26–50, 51–64, >65), gender, and district of residence. The age category (0–14) classification was based on the national age bracket for children of China.

2.3. Accessibility mapping

To assess the accessibility of urban parks, we used Service Area Analysis (SAA) with ArcGIS 10.5 software. SAA is typically conducted based on the road network of a city (Morar et al., 2014; Stoia et al., 2022). We obtained the road database for Beijing from Open Street Map. Coordinates for each entrance were determined by referring to the high-resolution satellite images from Google Earth. We also used ArcGIS 10.5 to create the point shapefile of park entrances. Travel distance was calculated as walking time (minutes) $\times$ 5 km/h (Li et al., 2021). For transport modes, we calculated service areas at 5, 10, 20 and 30 min of walking for each park, as the on-site survey responses self-reported urban park on foot accessibility.

2.4. Data analysis

We analyzed the relationship between self-reported urban park usage and health. The independent factors were (1) number of parks accessible on foot, (2) satisfaction with distance to urban parks, (3) satisfaction with accessible park areas, (4) frequency of park visits, and (5) urban parks visit duration. The dependent factors were mental, physical, and social health conditions. We selected two aspects of social health: contact with and trust toward neighbors. We analyzed the relationship between objective urban park accessibility (i.e., service area) and health. We used the Pearson correlation coefficient to measure the strength of association for both analyses.

We further used the Canonical Correlation Analysis (CCA) to examine the relationship between two sets of variables

Table 2

| Component | Variables | Description |
|-----------|-----------|-------------|
| Usage     | Transport mode | Bicycle, e-bike, private car, public transport, walking |
|           | Visiting frequency | (Manually fill) |
|           | Visit duration | (Manually fill) |
| Personal information | Gender | Male, Female |
|           | Age | 0–14, 15–25, 26–50, 51–64, >65 |
|           | Residence district | Chaoyang, Haidian, Shijingshan, Dongcheng, Xicheng, Fengtai, Other |
| Satisfaction with urban park accessibility | Park number | 0–10 (Manually fill) |
|           | Park area | 0–10 (Manually fill) |
|           | Walking distance | 0–10 |
| Mental health evaluation | General condition | 0–10 |
|           | Activity level | 0–10 |
|           | Outdoor exercise | Days in one week (more than 15 min) |
| Physical health evaluation | General condition | 0–10 |
|           | Life satisfaction | 0–10 |
|           | Positive status | Days in one week |
| Social health evaluation (with neighbors) | Communication frequency | 0–10 |
|           | Trust level | 0–10 |
| Positive influence on mental health | During pandemic | 0–10 |
|           | Before pandemic | 0–10 |

Fig. 1. Different restrictions in Beijing during two waves (bold font for the specific outbreak month) and small clusters of COVID-19 cases.
visitors. The model with correlations were visualized in a conceptual mode.

3. Results

3.1. Respondents’ profiles

A total of 1671 respondents completed the survey (Table 3) including 749 men (44.8%) and 922 women (55.2%). The majority of the respondents were between 26 and 50 years old (42.8%). Respondents generally resided in the central area of Beijing. Approximately one-third resided in the downtown area, including Dong Cheng (15.1%) and Xi Cheng (23.2%) districts. Over half of the respondents resided in the periphery of the downtown region, with 26.4% and 26.6% in Chao Yang and Hai Dian districts, respectively. In terms of transportation modes to access to urban parks, 1034 respondents walked (55.7%) and 319 cycled (31.6%). This indicated that they actively responded to the call of the authorities encouraging the public to utilize green travel (Yang et al., 2020).

As shown in Table 4, during the pandemic, over half the respondents (50.6%) visited urban parks 1–5 times per month, and 18.7% visited parks over 20 times per month. In addition, 74.5% spent 1–2 h inside the park during one visit, and 8.6% and 16.9% spent less than 1 h and more than 2 h in parks, respectively.

3.2. Park accessibility differences in the metropolitan area of Beijing

As shown in Table 5, the surveyed parks had a total service area of 95.194 km². Ritan Park had the largest total service area (7.84 km²). The service areas of South Lishilu, Madian, Tuanjiehu, Wuksesong Olympic, and Ritan Parks were all over 0.1 km² and within a 5 min walking zone. Furthermore, Ritan Park had the largest service area.

### Table 3

Respondents’ demographic characteristics.

| Gender       | Number | Percentage (%) |
|--------------|--------|----------------|
| Men          | 749    | 44.8           |
| Women        | 922    | 55.2           |
| Total        | 1671   | 100.0          |
| Age Group    |        |                |
| 0–14         | 65     | 3.9            |
| 15–25        | 229    | 13.7           |
| 26–50        | 715    | 42.8           |
| 51–64        | 354    | 21.2           |
| ≥ 65         | 308    | 18.4           |
| Total        | 1671   | 100.0          |
| Residential District | Number | Percentage (%) |
| Chao Yang District | 441   | 26.4           |
| Hai Dian District | 444   | 26.6           |
| Shi Jingshang District | 18  | 1.1            |
| Dong Cheng District | 253   | 15.1           |
| Xi Cheng District | 387   | 23.2           |
| Feng Tai District | 84    | 5.0            |
| Others       | 44     | 2.6            |
| Total        | 1671   | 100.0          |
| Transportation | Number | Percentage (%) |
| Walk         | 1034   | 55.7           |
| Bicycle      | 190    | 10.2           |
| Bus          | 352    | 19.0           |
| Private car  | 150    | 8.1            |
| Motorized bicycle | 129  | 7.0            |
| Total        | 1855   | 100.0          |

* Some respondents chose two or more types of transportation.

### Table 4

Respondents’ pattern of urban park use.

| Pattern of usage | Category | Number | Percentage (%) |
|------------------|----------|--------|----------------|
| Frequency of visits per month |        |        |                |
| 1–5              | 845      | 50.6   |
| 6–10             | 246      | 14.7   |
| 11–15            | 107      | 6.4    |
| 16–20            | 160      | 9.6    |
| Over 20          | 313      | 18.7   |
| Visit duration   |          |        |                |
| 0–1 h            | 144      | 8.6    |
| 1–2 h            | 1245     | 74.5   |
| 2–3 h            | 186      | 11.1   |
| Over 3 h         | 96       | 5.8    |

### Table 5

Service areas of the surveyed parks.

| Name of the surveyed park | Service area (km²) | 5 min | 10 min | 20 min | 30 min | Total |
|---------------------------|--------------------|-------|--------|--------|--------|-------|
| Ritan Park                | 0.17               | 0.66  | 2.69   | 4.32   | 7.84   |
| South Lishilu Park        | 0.12               | 0.32  | 2.24   | 4.49   | 7.17   |
| Tuanjiehu Park            | 0.11               | 0.36  | 2.22   | 4.38   | 7.07   |
| Qingfeng Park             | 0.04               | 0.16  | 1.87   | 4.97   | 7.04   |
| Olympic Community Park    | 0.008              | 0.15  | 1.62   | 4.64   | 6.418  |
| Madian Park               | 0.1                | 0.30  | 1.38   | 4.54   | 6.35   |
| Wukesong Olympic Park     | 0.15               | 0.37  | 1.60   | 3.94   | 6.06   |
| Xuanwuyiyuan Park         | 0.07               | 0.23  | 1.26   | 3.79   | 5.35   |
| Youth Lake Park           | 0.02               | 0.19  | 1.14   | 3.65   | 5      |
| Yongjingmen Park          | 0.04               | 0.29  | 1.12   | 3.13   | 4.58   |
| Ditan Park                | 0.05               | 0.25  | 1.46   | 2.70   | 4.46   |
| Haidian Park              | 0.07               | 0.19  | 1.27   | 2.62   | 4.15   |
| Longtan Park              | 0.06               | 0.26  | 1.21   | 2.37   | 3.9    |
| Taiyanggong Park          | 0.08               | 0.22  | 0.88   | 2.23   | 3.41   |
| Changchun Fitness Park    | 0.09               | 0.39  | 0.89   | 2.04   | 3.41   |
| Jingshang Park            | 0.06               | 0.22  | 0.91   | 2.13   | 3.32   |
| Taoranting Park           | 0.02               | 0.04  | 0.54   | 2.19   | 2.79   |
| Temple Heaven Park        | 0.002              | 0.01  | 0.55   | 1.89   | 2.452  |
| Yuetan Park               | 0.008              | 0.02  | 0.19   | 1.97   | 2.188  |
| Chaoyang Park             | 0.03               | 0.11  | 0.47   | 1.14   | 1.75   |
| Beihai Park               | 0.002              | 0.01  | 0.04   | 0.39   | 0.442  |
| Yuyuantan Park            | 0.001              | 0.003 | 0.01   | 0.03   | 0.044  |
| Total                     | 1.331              | 4.753 | 25.56  | 63.55  | 95.194 |

within a 10 min walking zone. Changchun Fitness, South Lishilu, Madian, Tuanjiehu, and Wuksesong Olympic Parks had service areas of over 0.3 km² but were much smaller than Ritan Park. South Lishilu, Tuanjiehu, and Ritan Parks had service areas of over 2 km² and were within a 20 min walking zone. South Lishilu, Madian, Qingfeng, Tuanjiehu, Ritan, and Olympic Community Parks had service areas of over 4 km² and were within a 30 min walking zone. Fig. 2 illustrated the spatial distribution of the service area regarding the top four urban parks. It can be seen from Fig. 3 that over two third of the respondents reported one or two parks near their home. And approximately 23.2% of the respondents who said that there are at least three parks they could access to from where they live. However, there still some of the respondents (4.2%) who did not have parks around their house.

3.3. Factors influencing urban park visitors’ health

As shown in Tables 6 and 7, all the variables were positively correlated with the respondents’ physical health. The park area coefficient was the highest (0.231), followed by distance to parks (0.166). Coefficients of the number of parks, and of visits frequency, and visit duration were 0.058, 0.069, and 0.067, respectively. Similarly, all variables were positively correlated with respondents’ mental health. Distance to parks, park area, and frequency of visit had relatively high coefficients (0.236, 0.239, and 0.214, respectively). Regarding social health, number of parks, distance to parks, and frequency of visits were positively correlated with frequency of contact with and trust toward neighbors. However, there was no correlation between park area and individual’s mental health.
social health. Furthermore, visit duration was only positively correlated with frequency of contact but not correlated with trust toward neighbors.

To explore the influence of urban park accessibility on human health, this study analyzed the relationship between park service area and self-reported health conditions. The surveyed parks were reclassified into subgroups based on park type and position. Park position refers to the urbanization level of the area where the park is located. For park type, only the 30-min service area of cultural relic parks showed a positive relationship with mental health. By contrast, the 5- and 10-min service areas of community parks demonstrated negative effects in terms of social health, indicating that an increase in community park service areas within 5 or 10 min may cause a decrease in contact frequency. Comprehensive parks did not exhibit a significant influence on human health. However, park position impacted self-reported social health, and parks located in the low urbanized region (i.e., R34) negatively influenced health within the 20-min service area. Furthermore, no groups of parks exhibited a significant correlation between accessibility and physical health.

| Table 6 | Associations between selected variables and health. |
|---------|---------------------------------------------------|
| Variable | Physical health | Mental health | Social health |
|         | Coef. (P)     | Coef. (P)     | Coef. (P)     |
| Number of parks | 0.058 * (0.018) | 0.053 * (0.031) | 0.091 ** (0.000) | 0.096 ** (0.000) |
| Distance to parks | 0.166 ** (0.000) | 0.236 ** (0.000) | 0.106 ** (0.000) | 0.137 ** (0.000) |
| Park area | 0.231 ** (0.000) | 0.239 ** (0.000) | -0.026 (0.000) | -0.027 (0.287) |
| Frequency of visits | 0.069 ** (0.005) | 0.214 ** (0.000) | 0.109 ** (0.000) | 0.056 * (0.023) |
| Visit duration | 0.067 ** (0.006) | 0.093 ** (0.000) | 0.085 ** (0.000) | 0.043 (0.080) |

Note: Coef. = coefficient; P = probability; *p < 0.05; **p < 0.01.
Table 7

| Park group         | Access (min) | Physical health Coef. (P) | Mental health Coef. (P) | Social health Coef. (P) |
|--------------------|--------------|--------------------------|------------------------|------------------------|
| Cultural relic     | 30           | 0.752*                   | (0.032)                |                        |
| Community          | 5            | -0.812*                  | (0.026)                |                        |
| R2                 | 20           | -0.786*                  | (0.021)                |                        |
| Total              | 10           | -0.713*                  | (0.047)                |                        |

* R2, the area within the 2nd ring road; R23, the area between the 3rd and 2nd ring roads; R34, the area between the 4th and 3rd ring roads.

3.4. Self-evaluated influences of visiting urban parks on mental health before and during the pandemic

To examine whether visiting urban parks positively impacted health during the pandemic compared to the pre-pandemic period, we inquired about the extent to which visiting urban parks have positive influence on respondents’ mental health before and during the pandemic. As shown in Figs. 4, 5A, 52.2% of the respondents reported no change in their health status when visiting urban parks during the pandemic compared to the pre-pandemic period. However, 23.5% stated that visiting urban parks improved their mental health status, whereas approximately 24.3% reported a negative health impact of visiting urban parks.

3.5. Relationship between urban park use and human health

As shown in Fig. 5A, the number of (0.28) and distance to urban parks (−1.02) were the two main determinants of the independent canonical variate (self-reported accessibility of urban park). For the dependent variables (patterns of use), the number of visits per month (−1.01) largely determined the canonical variate. As shown in Fig. 5A, respondents who reported the presence of more urban parks near their residence and longer walking distances to parks tended to visit them less often; however, they spent more time at parks during each visit. As illustrated in Fig. 5B, the patterns of use were associated with the health of the respondents. The number of visits per month (0.96) contributed the most to the independent canonical variate (patterns of use). Mental state and frequency of contact with neighbors (0.90 and 0.68, respectively) were the two main determinants of the dependent canonical variate (health of the respondents). Moreover, the park area and distance to parks determined the first canonical variate. The physical and mental state of the respondents were the main determinants of the dependent canonical variate (health of the respondents, Fig. 5C). The results indicated that respondents who traveled to small urban parks over long distances had worse physical and mental health and fewer social interactions.

4. Discussion

4.1. Associations of accessibility and urban park use patterns with health in the metropolitan area of Beijing

In this study, distance to parks was the most important predictor of patterns of park use and self-reported health. The results demonstrated a positive correlation between self-reported urban park accessibility (i.e., park number, area, and distance) and health of the respondents during the study period (Fig. 5C). Nearest park area might demonstrate inverse association with depression in a low- and middle-income country (Mukherjee et al., 2017). Park accessibility has been found as a critical predictor of residents’ health (Dong and Qin, 2017; Xie et al., 2018; Orstad et al., 2020). However, our study revealed that people who could access to larger park area or number of parks did not show consistently positive association with park visiting frequency or duration in Beijing (Fig. 5A). In fact, besides park accessibility, park quality (e.g., amenities, safety, biodiversity) might play a critical role in urban park attraction and thus influence urban park use (Rigolon, 2016). Visiting parks more frequently could reduce the downward emotional state (Yigitcanlar, 2016). To further explore the relationship between urban park use and health, we used multivariate analysis of variance (MANOVA) and canonical correlation analysis (CCA) to examine the impact of urban park use on mental and physical health.

4.2. Variations of health effects based on urbanization background and types of urban parks

Park types have previously been proven to be associated with people’s health (Wood et al., 2017). In the present study, cultural relic parks exhibited a lower impact on people’s health compared to community and comprehensive parks, consistent with a previous study suggesting that cultural relic parks adversely affect self-rated health (Wu and Kim, 2021).
This may be attributed to fewer exercise facilities and outdoor activity spaces in cultural relics parks compared with other types of parks in Beijing (Wu and Kim, 2021b). By contrast, comprehensive parks positively impacted health, as their large areas of green space and diverse public facilities provide opportunities for people to relax and engage in recreational activities (Yin et al., 2020).

Moreover, people visiting urban parks located in less urbanized areas (between the 3rd and 4th Ring Road) reported better health conditions than those visiting urban parks in the urban core area (inside the 2nd Ring Road). A previous study constructed an assessment framework of urban park distribution in Beijing and indicated that the values of accessible park area per capita, number of parks within a certain service radius, and park quality increased from the urban center to the periphery (Yin et al., 2020). Greenery in heavily urbanized areas could mitigate the negative effect of urbanization and brought about higher self-reported health evaluations (Perez-Urrestarazu et al., 2021; He et al., 2022).

4.3. Implications for health-oriented urban park planning and management

Park visitors in developing countries have attached great importance to urban parks for improving physical and mental health during the COVID-19 (Addas and Maghrabi, 2022). This study showed that 23.5% of the respondents reported an increase of health effect during the COVID-19 pandemic. The urban residents in Beijing experienced two major waves and several small clusters of cases with various social interaction restrictions. Therefore, reasonable park provision planning and elaborate park use management for outdoor activity promotion are desired. In Singapore, 30.2% of the green space is around residential houses within a 500 m buffer, and the local government makes significant efforts to create opportunities for urban dwellers to access nature equitably (Nguyen et al., 2021). There are many different types of urban parks in the metropolitan area of Beijing and our results revealed that their service areas could vary dramatically. The dynamic and integrated analysis on local park visitors’ health status and park use characteristics should be adopted in the construction planning of different types of urban parks in Beijing. Moreover, this study found that comprehensive parks such as the Taoranting Park were positively associated with more health benefits compared with other types of urban parks. Comprehensive parks could provide numerous levels of public service facilities that satisfy visitors’ various requirements (Yin et al., 2020). Parks with diverse functions such as exercise, recreation and education might attract people from various age groups. Hong Kong encourages park users to be involved in the decision-making of urban park planning and management, as users’ dynamic expectations may provide unique perspectives on the development of urban parks (Chan et al., 2018). This on-site survey got the feedback from older people who might not know how to use smartphones. But these elderly residents are always happy to spend their time chatting with neighbors in nearby parks. They really appreciated the health effects of urban parks, especially the alleviation of deep loneliness caused by the lack of social connections during the COVID-19 pandemic (Compernolle et al., 2022). In the most heavily urbanized area of Beijing, it can never be overemphasized to pay attention to the social interaction promotion effect for older people. The COVID-19 pandemic could be a critical juncture for high-quality and multi-functionalized urban park development.

5. Conclusions

This study integrated social health into the framework of health effect study and explored the relationship between urban park use and health. Our results demonstrated that urban parks could have positive health effect during the COVID-19 pandemic in the metropolitan area of Beijing. Among various indicators related to urban park use and accessibility, distance to parks, number of parks, and park area were positively associated with human health. The frequency and duration of visits to urban parks were positively associated with mental health and...
contact frequency with neighbors. While visitors’ physical health and trust toward neighbors might be determined by many other factors apart from urban park use. These findings are expected to help urban planners in health-oriented design and inform urban park management to properly guide public usage along with various restrictions for COVID-19 pandemic prevention.

This study has several limitations. First, we did not survey respondents before the pandemic; therefore, whether urban parks induced an actual change in human health cannot be conclusively inferred. Second, the conceptual model of social health contains different elements and future studies should integrate more components to evaluate social health. Third, this was a cross-sectional survey and a longitudinal study might be reasonable to reveal the long-term effects between urban green spaces and human health, particularly during a time of crisis. Fourth, we did not collect employment, education, marriage, and income items of respondents in order to increase the probability that respondents would not reject to fill the questionnaire and answer all questions. We believe that these information from large sample size by on-site survey might be valuable for understanding the relationship questions. We believe that these information from large sample size by on-site survey might be valuable for understanding the relationship questions.

Finally, this study classified urban parks based on their types and locations; however, every park has different traits that might influence human health, such as infrastructure and landscape patterns (Petrinoff et al., 2022). Future studies based on high resolution satellite images would be helpful to understand the health effects of urban park.

CRediT authorship contribution statement

Di Lin: Data curation, Formal analysis, Visualization, Writing – original draft. Yan Sun: Conceptualization, Methodology, Investigation, Writing – original draft, review and editing, Supervision. Yi Han: Data curation, Formal analysis. Yue Yang: Data curation, Formal analysis. Chengyang Xu: Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2022.127804.

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