Study on the Development Strategies of Park Green Spaces in Hohhot in the Post-Pandemic Era

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Abstract: The health benefits and disaster prevention and mitigation functions of urban park green spaces are of significant importance for normalized epidemic prevention. This study first analyzes the challenges faced in the post-pandemic era and the corresponding responses of urban park green spaces, clarifying their positive role in addressing normalized epidemic prevention. Taking Hohhot as the research subject, the current status of epidemic prevention in urban park green spaces was investigated using methods such as GIS network analysis and field surveys. Finally, integrating the characteristics of epidemic prevention in the post-pandemic era, development strategies are proposed across three aspects: constructing an epidemic prevention system for urban park green spaces, optimizing their spatial layout, and enhancing their operational management. These strategies aim to improve the epidemic prevention capacity of park green spaces in Hohhot and provide a reference for the safe development of urban park green spaces in the post-pandemic era.

Keywords: Urban Park green space; Post-pandemic era; Public health; Development strategy; Hohhot

1. Introduction

The COVID-19 pandemic has evolved into a global public health crisis, posing a substantial threat to human life, health, production, and daily living. As China's epidemic prevention focus shifts from comprehensive emergency response to a combination of proactive prevention and emergency management [1], it marks the country's entry into the post-pandemic era characterized by normalized prevention. Cities will face long-term challenges from normalized epidemic prevention and its associated secondary risks. As a crucial component of urban comprehensive disaster prevention systems, urban park green spaces possess a theoretical and practical foundation for improving public health and responding to epidemic outbreaks. However, there is a lack of consideration for normalized prevention in the post-pandemic context. Therefore, based on an in-depth analysis of the mechanisms through which urban park green spaces improve public health and their spatial responses in the post-pandemic era, and combined with the current epidemic prevention status of park green spaces in Hohhot, this study aims to develop a tailored epidemic prevention system for

urban park green spaces, providing a basis for the layout planning of urban park green spaces in response to epidemic prevention and control in China.

2. Analysis of Challenges in the Post-Pandemic Era and Responses of Urban Park Green Spaces

2.1 Challenges in Epidemic Prevention Work in the Post-Pandemic Era

According to World Health Organization statistics, as of April 28, 2022, over 509 million confirmed cases and more than 6.2 million deaths have been reported globally [5]. While China has achieved phased success in controlling the COVID-19 pandemic, it continues to face dual risks of imported cases and domestic resurgence. The post-pandemic era presents enduring challenges related to the complexity, timeliness, and spatial aspects of epidemic prevention.

2.1.1 Challenge of Complexity in Epidemic Prevention

Against the backdrop of the global COVID-19 pandemic, pressure from imported cases in China continues to rise. Data from the National Health Commission indicate that since March 2022, the frequency and scope of local outbreaks triggered by imported cases have significantly increased [6]. COVID-19 spreads through multiple channels including human-to-human, object-borne, and environmental transmission. Not only can infected individuals directly carry the virus, but risks also exist throughout the processing, transportation, and storage of imported goods, increasing the complexity of epidemic detection and contact tracing [7].

2.1.2 Challenge of Timeliness in Epidemic Prevention

Nadhim Zahawi, UK Minister for COVID Vaccine Deployment, stated that there are approximately 4,000 variants of the SARS-CoV-2 virus globally, including recent widespread variants such as Delta and Omicron [8]. WHO research indicates that the Delta variant has approximately double the transmissibility of the original strain, with shorter incubation and serial intervals, concealed early symptoms, and a higher rate of severe illness [9]. The Omicron variant spreads even faster with greater stealth, and infected individuals often exhibit milder symptoms similar to the common cold [10]. The enhanced transmissibility and stealth of currently circulating variants pose a greater threat to vulnerable groups such as the elderly and children, while also presenting significant challenges to the timeliness of epidemic detection and tracing.

2.1.3 Challenge of Spatiality in Epidemic Prevention

A primary issue faced during Wuhan's epidemic response was the shortage of medical spaces, resources, and personnel [11]. Although the lack of medical treatment space remains a difficulty, the challenge has shifted from insufficient treatment space to insufficient space for testing and isolation. The Design Standards for Medical Isolation and Observation Facilities stipulate that such facilities should be located away from densely populated areas and sensitive locations such as kindergartens, schools, and elderly care facilities. However, studies have found that most Chinese cities primarily utilize specific hotels as medical isolation facilities, some located within urban areas, posing potential pollution risks such as water backflow, wastewater discharge, and lack of safety barriers between the facilities and surrounding environments [12]. During testing, sampling sites are often set up in hospital dispersal plazas [12], leading to mixed flows of testing personnel and general patients. During peak testing periods, large crowds can form, and hospital plazas may be inadequate for screening needs, increasing the risk of virus transmission.

2.2 Public Health Risks in the Post-Pandemic Era

Currently, isolation and quarantine are the most effective measures to control epidemic spread. However, prolonged confinement in isolated spaces, with restrictions on outdoor recreation, social interaction, travel, and healthcare, causes significant physical and psychological harm to quarantined individuals. Research by Chen Xiaoshuang et al. during the pandemic showed that quarantined individuals experienced mental health issues including somatization (mild to moderate symptoms like headaches, dizziness, or back pain), anxiety, depression, and fear, with negative emotions worsening over time [13]. Wang Mengyu et al. found prominent mental health issues among the elderly during the pandemic, particularly those in poor physical health [14]. Furthermore, public healthcare-seeking behavior has been impacted. Zhao Ting et al. reported a 37% decrease in stroke patient visits to Zhejiang Hospital compared to the same period pre-pandemic [15]. Zhang Yunqiu et al. found that perceived risk of infection was a key factor influencing healthcare-seeking behavior and choice of medical institutions during the pandemic, with people tending to seek care only for more severe conditions [16].

2.3 Response of Urban Park Green Spaces in the Post-Pandemic Era

2.3.1 Mechanisms of Urban Park Green Spaces in Improving Public Health

Urban Park green spaces improve public health primarily through physiological, psychological, social, and ecological pathways, which can be assessed using indicators such as availability, accessibility, and visibility [17].

By providing open, airy, and visually rich environments, urban park green spaces encourage health-promoting behaviors among residents, thereby reducing risks of certain chronic diseases and obesity [18]. Environmental epidemiology research indicates that the accessibility of park green spaces is a key factor in evaluating their health benefits, with the strongest effects within a straight-line distance of 500m, gradually weakening within 500–1500m [19].

Environments with higher greenery levels can effectively alleviate negative emotions such as depression, anxiety, and stress [20]. Sun Sijie et al. found that viewing photographs of park green space landscapes could alleviate psychological stress among residents under home quarantine during the pandemic, with the stress-relief effect initially increasing then decreasing as stress levels rose [21].

As important urban public spaces, park green spaces provide opportunities and venues for social interaction, promoting social cohesion and neighborhood relationships [22].

Park green spaces can improve public health by mitigating the urban heat island effect, purifying air, and reducing noise. Wang Lan et al., in their study on the impact of the urban built environment on lung cancer incidence, found that centrally located open spaces and green spaces had better dust-retention effects, effectively reducing airborne particulate matter concentrations [23].

2.3.2 Epidemic Response of Urban Park Green Spaces

Although COVID-19 has undergone several mutations, its transmission routes remain unchanged, primarily through respiratory droplets, aerosols, and contact. In the absence of breakthrough therapeutics, interrupting transmission routes is the most effective way to curb virus spread. Research by Yin Lihua et al. found that residential communities with higher green space ratios and lower building densities had lower average COVID-19 infection rates [24]. Thus, as primary carriers of urban ecological functions, urban park green spaces, through scientifically planned systematic layouts, can effectively disperse urban population and building density,

establishing buffer zones for epidemic isolation. Simultaneously, as key response spaces within urban comprehensive disaster prevention systems, park green spaces offer advantages such as open land and good ventilation, providing spatial support for testing, treatment, isolation, and material storage during epidemics [25-27].

3. Research on the Current Epidemic Prevention Status of Urban Park Green Spaces in Hohhot

3.1 Study Area Overview

This study focuses on the administrative area of Hohhot City, specifically defined as: east to Talidong Road and the southern section of Ke'erqin Expressway, south to the Third Ring Road, west to the southern section of West Second Ring Expressway and Wusutu Gully, and north to 2 km beyond the Jingqing Line, encompassing areas such as Daqingshan Wildlife Park and Halagin Ecological Park (Figure 1). As of 2020, the coverage area of park green spaces in Hohhot's central urban area was approximately 4335 hm2, comprising 73 parks of various types. With a total population of about 2.546 million, the per capita park green space area was approximately 17.03 m2, meeting Hohhot's green space planning target of 16.8 m2 per capita.

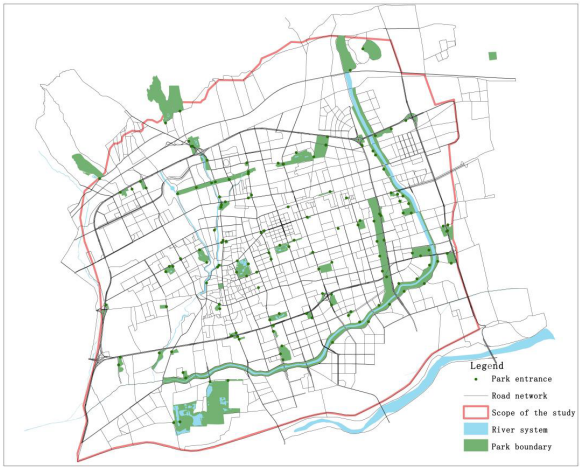


Figure 1: Indoor Open Ditch Test Soil Mass Water Content Profile Change Curve Diagram.

3.2 Data Sources

Park green space data for Hohhot were obtained from the *Hohhot Urban Park Green Space System Plan (2010-2020)*. Road network data were acquired from OpenStreetMap and revised based on Google Satellite high-definition imagery and field surveys.

3.3 Classification and Service Radii of Park Green Spaces in Hohhot

Considering the epidemic prevention function of urban park green spaces in the post-pandemic era, this study reclassifies Hohhot's park green spaces based on comprehensive factors including scale, type, and service range. Referring to the Urban Green Space Classification Standard (CJJ/T85-2017) and the Hohhot Green Space System Plan (2010-2020), park green spaces in Hohhot are categorized into four types: Forest/Country Parks, Municipal Parks, Regional Parks, and Neighborhood Green Spaces. Their respective service radii are: Forest/Country Parks 5000m, Municipal Parks 3000m, Regional Parks 2000m, and Neighborhood Green Spaces 500m (Table 1).

Table1: Service Radius of Park Green Space in Hohhot.

Type of Park Green Space	Service Radius
Forest/Country Parks	5000m
Municipal Parks	3000m
Regional Parks	2000m
Neighborhood Green Spaces	800m

3.4 Research Methods

3.4.1 GIS Network Analysis

The convenience for residents to reach park green spaces with epidemic prevention functions directly impacts time loss and secondary transmission risks during travel, significantly influencing epidemic prevention efficiency and safety. To understand the health benefits and epidemic prevention timeliness of Hohhot's park green spaces, service area analysis within GIS network analysis was employed, using distance cost to study their spatial layout.

3.4.2 Field Survey

In the post-pandemic era, establishing an epidemic prevention system combining infrastructure and management in urban park green spaces is crucial for ensuring healthy activities for urban residents by enhancing spatial isolation and visitor awareness. To understand the epidemic prevention functions and the status of facilities and management in park green spaces, this study referenced regulations from the Guidelines for Urban Park Operation and Management during Major Pandemics (Trial). Four quantitative indicators each were selected from four aspects: visitor management, environmental hygiene, key area management, and epidemic prevention publicity. Data on operation and management were collected and recorded through photography and on-site observation at 15 parks including Qingcheng Park, Nanhu Wetland Park, Gongzhufu Park, and A'ertai Amusement Park (Table 2).

Table 2: Quantification Table of Operation and Management Measures of Park Green Space in Hohhot.

Operational Management	Quantitative Indicators
Visitor Management	1) Real-name Registration 2) Visitor Capacity Control 3) "Health Code" Verification 4) Body Temperature Checkpoint Setup
Environmental Hygiene	1) Hand Hygiene Supplies Setup 2) Public Area Disinfection 3) Used Mask Collection 4) Trash Bins
Key Area Control	1) Indoor Space Ventilation 2) One-way Flow Guidance 3) Crowd-gathering Activity Management 4) Crowd Spacing Indicators
Epidemic Prevention Publicity	1) Presence of Safety and Epidemic Prevention Notice Boards 2) Presence of Epidemic Prevention Publicity Slogans 3) Location and Scale of Publicity Materials 4) Park Epidemic Prevention Management Notices

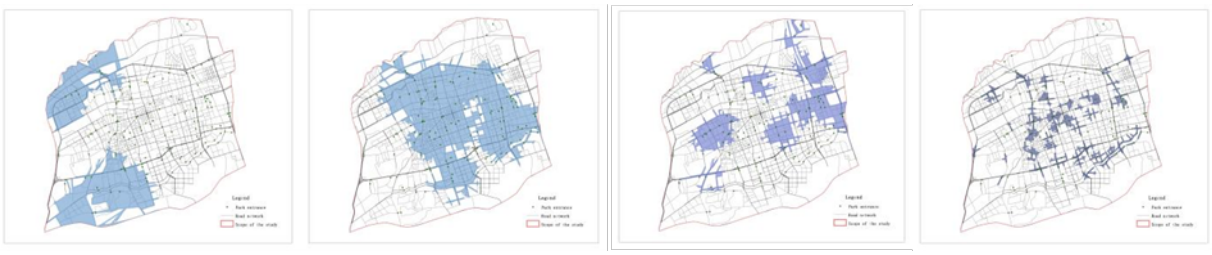
3.5 Analysis of Spatial Layout of Park Green Spaces in Hohhot

Analysis of service area ranges for various park types revealed good coverage in Hohhot's central urban area, with overlapping coverage from multiple park types (Municipal, Regional, Neighborhood

Green Spaces). However, larger green spaces such as Nanhu Wetland Park, Daqingshan Wildlife Park, and Wusutu National Forest Park are located in peri-urban areas, while the central urban area has relatively smaller park green space coverage and per capita green space area.

Furthermore, significant coverage gaps and large service blind spots exist in Yuquan District and some peri-urban areas. Most coverage in Yuquan District comes from inward radiation of Nanhu Wetland Park located at the urban fringe, while other park types within the district are severely lacking. This is attributed to Yuquan District's historical development as Hohhot's old city, which lacked scientific planning, resulting in high density of low-rise buildings and increasing the risk of aerosol transmission of COVID-19.

The large service blind spots in peri-urban areas are due not only to insufficient park green space construction but also to a lack of supporting infrastructure such as roads. For example, parks like Halagin Ecological Park and Shakeng Park have large theoretical service radii, but their actual service ranges are limited by road network constraints (Figures 2-3).



Figures 2: Service Scope of Various Types of Park Green Space in Hohhot. (From left to right, it is a forest country park, municipal park, regional park and amusement park).

Figures 3: Overlay Analysis on the Scope of Park Green Space Service Area in Hohhot.

3.6 Analysis of Operation and Management of Park Green Spaces in Hohhot

Field surveys of 15 urban park green spaces in Hohhot revealed that certain epidemic prevention measures have been implemented in the post-pandemic era, but their enforcement varies depending on the openness of the parks. Specific findings are as follows:

Among the 15 parks, Daqingshan Wildlife Park, being a gated park with defined entrances/exits, implemented measures like staggered visiting hours, visitor registration, and temperature checks.

Approximately 43% of other open parks adopted semi-closed management for easier control, such as closing facilities prone to crowds or blocking minor entrances/paths while keeping main entrances open. However, management measures were relatively weaker in smaller parks like Regional Parks and Neighborhood Green Spaces.

Regarding environmental hygiene, all parks performed routine cleaning and enhanced ventilation and disinfection of indoor spaces. However, surveys indicated that most parks lacked sufficient epidemic prevention facilities, such as hand sanitizer dispensers and designated disposal bins for used masks and gloves.

Surveys found that although large parks like Nanhu Wetland Park and Qingcheng Park did not host group events, small-scale gathering activities like square dancing and futsal still occurred within them. Furthermore, 86% of parks lacked crowd control and guidance measures at locations prone to gatherings, such as entrances, plazas, and path junctions, where visitor flow was often chaotic.

Enhancing visitors' self-protection awareness is an effective approach for normalized prevention. Surveys showed that only 40% of the 15 parks had installed safety notice boards or publicity slogans, mostly at entrances, with few such displays in high-density areas inside the parks.

4. Development Strategies for Park Green Spaces in Hohhot

4.1 Constructing an Epidemic Prevention Spatial System for Urban Park Green Spaces

Before constructing such a system, an assessment should be conducted on each park's type, scale, location, transportation, and infrastructure to systematically analyze its epidemic prevention capacity. Specific functions for epidemic prevention spaces should be defined, including: treatment spaces, testing spaces, isolation spaces, and material storage spaces. The municipal epidemic prevention headquarters should coordinate with departments like parks and urban management to establish a unified command structure. Based on the overall city's and individual prevention units' needs, tiered deployment plans and emergency response protocols should be formulated.

Functional Division for Epidemic Prevention: Forest/Country Parks and Municipal Parks, with their large open spaces, good ventilation, and comprehensive supporting facilities, can provide spatial support for isolation, treatment, and material storage. Compared to conventional medical facilities, healthcare facilities integrated with park green spaces offer advantages for patient recovery and convalescence. Normalized testing is a key focus in the post-pandemic era, requiring substantial space for temporary testing and isolation facilities. Regional Parks and Neighborhood Green Spaces, being numerous, flexibly located, and close to residential areas, offer advantages in pedestrian accessibility. Aligned with Hohhot's zoned and graded prevention policies, where control zones are often delineated by communities, these smaller parks can serve as sites for temporary testing, material transfer, and distribution within controlled areas, facilitating local screening for residents (details in Table 3).

Table 3: Division of Epidemic Prevention Function of Park Green Space in Hohhot.

	Name	Total Area (hm^2)	Green Area (hm^2)	Characteristics	Epidemic Prevention Space Conversion	Detailed Epidemic Prevention Functions	Epidemic Prevention Space Type
1	Daqingshan Wildlife	542	459	Spacious; Well-ventilated;	Temporary Infectious	Treat confirmed patients; Isolate	Treatment Space; Isolation Space

	Park			Far from densely	Disease Hospital;	and observe	
2	Nanhu Wetland Park	667	537	populated urban areas; Good transportation conditions	Makeshift Hospital; Temporary Isolation Facilities	suspected patients, close contacts, and secondary close contacts	
3	Qingcheng Park	46.4	24.3				
4	Genghis Khan Park	44.3	31				
5	Zadagai Park	29.8	19.8	Spacious; Good transportation conditions; Parks with disaster prevention functions possess good material storage space	Epidemic Testing; Material Storage and Transfer; Emergency Command Center	Epidemic testing management; Emergency command; Material storage	Testing Space; Municipal Park
6	A'ertai Amusement Park	80	64.3				
7	Gongzhufu Park	13.4	8.04				
8	Xingang Park	13.9	7.5				
9	Manduhai Park	22	16				
10	Xilin Park	20	15				
11	Chandu Integrity Culture Park	12	9	Spacious; Good transportation conditions;	Epidemic Testing; Material Transfer and Distribution	Epidemic testing management; Material transfer, etc.	Testing Space; Regional Park
12	Yuquan Haoren Park	5.8	3.7				
13	Environmental Protection Garden	2.12	1.37	Numerous; Flexible layout; Located near residential areas; Relatively good accessibility	Epidemic Testing; Material Distribution	Epidemic testing management; Material distribution, etc.	Testing Space; Neighborhood Green Space
14	Guangming Garden	1.13	1.04				
15	Qiaotou Garden	2.98	2.28				

Planning of Epidemic Prevention Spaces: When setting up testing, treatment, and isolation facilities within park green spaces designated for epidemic prevention, the principle of "dual-use in peace and disaster, conversion during disaster" should be followed. In Forest/Country Parks and Municipal Parks with epidemic prevention functions, sites for temporary infectious disease hospitals or makeshift hospitals should be pre-allocated, equipped with necessary transportation and municipal infrastructure. Pre-design should address functional zoning, organization of people and logistics flows, pollutant treatment, and isolation between facilities and surrounding environments, considering post-use environmental restoration to ensure rapid deployment during public health emergencies. Testing spaces have lower site requirements. By controlling entrances/exits of Regional Parks and Neighborhood Green Spaces and utilizing internal walkways and vegetation for isolation,

orderly testing can be guided, reducing cross-infection risks during testing and material distribution.

4.2 Optimizing the Spatial Layout of Urban Park Green Spaces

City Level: Hohhot possesses excellent natural resources, with the Zadaga River and Wulisha River intersecting in a T-shape north-south within the city, and the Halagin Gully, Xiaohe River, and Wusutu River forming a U-shape around the urban fringe. The city's park green space system planning should leverage the connectivity of linear spaces like urban rivers and protective greenbelts to construct a point-line-plane integrated system. Utilizing the virus-inhibiting and air-purifying functions of green plants can optimize the immune isolation effect of the urban built environment and urban wind environment, while effectively addressing service blind spots in peri-urban areas.

Community Level: Communities are the basic units of epidemic prevention, closely related to residents' daily lives. Aligning with Hohhot's "Ten-Minute Living Circle" Construction Plan, it is recommended to adopt a combination of linear and nodal park green space development. Linear green spaces can provide physical separation between living circle clusters, while nodal parks like Regional Parks and Neighborhood Green Spaces within clusters can offer spatial dispersal [28]. Considering the high population density and intensive land use in Hohhot's old city, creating large new park green spaces is challenging. It is suggested that urban renewal planning incorporate the flexible placement of Neighborhood Green Spaces on vacant lots or land cleared from illegal structures in old communities. This can effectively reduce service blind spots and enhance the accessibility and visibility of park green spaces.

4.3 Enhancing the Operation and Management Level of Urban Park Green Spaces

In the post-pandemic era, normalized prevention has increased residents' demand for outdoor activities. It is recommended to implement scientifically effective management measures tailored to each park's type, scale, location, and openness, balancing the need for outdoor activities with reducing transmission risks.

Strengthen Smart Park Development: Utilize high-tech information systems to integrate dynamic data on environmental hygiene monitoring, facility management, staff health safety, and visitor volume/behavior. Establish an integrated supervision and management system across departments. A contactless "reservation-ticketing-registration entry" model is recommended, along with real-time announcements of visitor distribution and capacity within parks to guide staggered visits and reduce cross-infection risks.

Create "Social Distancing" Spaces: Drawing inspiration from spatial redesigns during the pandemic in places like New York's Hudson Yards and High Line Park [29], it is suggested to implement safety designs promoting "social distancing" in areas prone to crowding. This can include marking safe-distance social units and flow interval indicators on the ground to guide safe interaction.

Enhance Epidemic Prevention Infrastructure: Strengthen the construction of epidemic prevention facilities within park green spaces, emphasizing the collection and disposal of hazardous waste like used masks and gloves, and ensuring regular environmental disinfection.

Prioritize Epidemic Prevention Publicity: Place safety notice boards and publicity slogans inp rominent locations such as main entrances and high-traffic areas within park green spaces to improve visibility. Fully utilize the educational function of Regional Parks and Neighborhood Green Spaces within communities to pre-announce local emergency plans and prevention measures, ensuring

preparedness and improving prevention efficiency when needed.

Author Contributions

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Data Availability

The data presented in this study are available on request from the corresponding author.

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