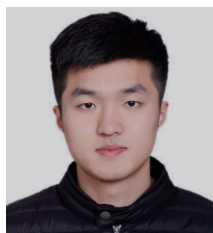


## 城市绿地促进人群健康的作用途径： 理论框架与实践启示

# IMPACT MECHANISM OF URBAN GREEN SPACES IN PROMOTING PUBLIC HEALTH: THEORETICAL FRAMEWORK AND INSPIRATION FOR PRACTICAL EXPERIENCES



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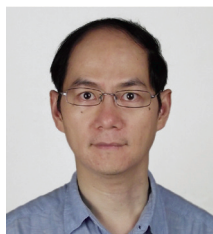


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### 摘要

城市绿地不仅可以提供广泛的生态系统服务，也能提升人群健康。当前，已有大量研究论述了城市绿地与人群健康的关系并取得了诸多进展，但尚缺少对两者复杂潜在作用途径的探讨。本文首先论述了城市绿地对人群健康的积极与消极影响，其次从鼓励体力活动、缓解精神压力、提高社会凝聚力和提供生态系统调节 / 支持服务4个方面构建了城市绿地促进人群健康的作用途径理论框架。在此框架研究基础上初步提出了健康导向下的城市绿地系统规划应对策略，具体包括：1) 提升城市绿地的可获得性；2) 提高城市绿地的可达性；3) 增强城市绿地的可视性；4) 优化城市绿地的空间要素组成；5) 构建网络状城市绿地空间格局；6) 降低城市绿地对人群健康的消极影响。研究成果可为人群健康和城市可持续发展提供有效的理论基础和经验启示，让有限的城市绿地发挥更大的健康效益。

### 关键词

人群健康；城市绿地；基于自然的解决方案；生态系统服务；城市绿地系统规划

### ABSTRACT

Urban green spaces can not only offer a wide range of ecosystem services, but also promote public health. Most of existing studies have effectually explored the correlation between urban green spaces and public health, but failed to dig the complex impact mechanism behind. This article firstly goes into the positive and negative impacts of urban green spaces on public health, and proposes a theoretical framework of the impact mechanism from perspectives of physical activity encouragement, stress management, social cohesion enhancement, and regulating / supporting services provision by ecosystems. On this basis, 6 health-oriented urban green space system planning strategies are proposed, including promoting the availability, improving the accessibility, enhancing the visibility, optimizing the spatial composition, constructing a network pattern of urban green spaces, and reducing the negative impacts of urban green spaces on public health. The research results can provide theoretical grounding and reference for public health promotion and sustainable urban development to exert more health benefits with limited urban green spaces.

### KEYWORDS

Public Health; Urban Green Spaces; Nature-Based Solutions; Ecosystem Services; Urban Green Space System Planning

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## 1 引言

随着城市化的不断发展,人口从乡村流向城市,城市已成为人类最主要的栖息地。然而,快速的城市化进程也带来了严峻的环境和人群健康问题。快速的生活节奏、日益加大的社会竞争压力、多坐少动等缺乏体力活动的生活方式,以及城市高密度发展所导致的绿色空间的不断减少,成为引发各类精神疾病和慢性疾病的重要因素<sup>[1]-[3]</sup>。“基于自然的解决方案”(NBS)正是科学家为应对复杂的城市生态环境问题和人群健康问题所提出的一项重要行动策略,旨在高效利用自然资源,以有效且强适应的方式来应对一系列环境挑战,同时带来经济、社会和环境效益<sup>[4]</sup>。作为一种创新的可持续设计理念,NBS强调从设计实践层面实现理论价值,以达到城市韧性提升、人与自然和谐共处和资源可持续利用的目的<sup>[5]</sup>。城市绿地作为城市中重要的自然资源,是NBS的重要组成部分。城市绿地不仅为城市提供了广泛的生态系统服务<sup>[6]</sup>,也是居民亲近和感受自然的重要场所,能够缓解居民的生活和工作压力、改善人群健康<sup>[7]-[9]</sup>。玛娅·武伊契等人<sup>[10]</sup>通过跨学科方法研究了城市自然环境与人群心理健康的关系,发现NBS能有效帮助改善实验参与者的压力过大、抑郁和焦虑等状况;马蒂尔达·范·登·波什等人<sup>[11]</sup>则引入“NBS框架”综述了城市自然环境对人群健康的各类积极效益。然而,当前的NBS研究多集中于探讨生态环境问题的缓解,仅有少量研究将其与人类健康和福祉相互关联。因此,如何将城市绿地与人群健康研究和NBS理论研究相结合仍有待深入探索。此外,现有研究虽然在城市绿地与健康效益关系的探索上取得了诸多进展,但是,关于系统构建城市绿地与人群健康之间复杂潜在作用途径的相关研究仍显欠缺<sup>[12]-[14]</sup>,这直接阻碍了城市绿地系统在规划设计层面的策略实施<sup>[15]</sup>。

鉴于此,本文通过论述城市绿地对人群健康的积极与消极影响,构建了城市绿地促进人群健康的作用途径理论框架,最后从实践视角提出了相应的城市绿地系统规划应对策略和启示,以期推动实现自然解决方案的价值。

## 2 城市绿地对人群健康的影响

《世界卫生组织组织法》将“健康”定义为“不仅为疾病或羸弱之消除,而系体格、精神与社会之完全健康状态”<sup>[16]</sup>。据此可将“健

## 1 Introduction

The rapid urbanization has caused people to migrate from rural to urban areas, where have become the primary habitat for human beings. In the meantime, the living environments and health status of people are heavily challenged. For instance, mental disorders and chronic diseases are prone to happen either due to fast pace of living, increasing competitive pressure, sedentary lifestyles without physical activity, or the shrinking of green spaces<sup>[1]-[3]</sup>. Under such circumstances, “Nature-Based Solutions” (NBS), aiming at using natural resources to effectively and adaptively address a range of environmental challenges while bringing economic, social, and environmental benefits, have become a key course of action<sup>[4]</sup>. With its innovative response, NBS emphasizes the theoretical value via design practices to achieve urban resilience, harmonious human-nature relationship, and sustainable resource utilization<sup>[5]</sup>. In this regard, urban green spaces could act as a crucial NBS because it provides not only extensive ecosystem services<sup>[6]</sup>, but also opportunities for people to get close to and enjoy the nature with benefits such as stress relief and health improvement<sup>[7]-[9]</sup>. Specifically, Maja Vujcic et al.<sup>[10]</sup> found that NBS can effectively relieve participants’ feelings of stress, depression, and anxiety in an interdisciplinary research on the linkage between urban natural environments and human psychological health. Matilda van den Bosch et al.<sup>[11]</sup> further introduced an NBS framework to summarize positive effects of urban natural environments on public health. However, such studies on how urban green spaces may impact public health and human well-being are insufficient as most of the current NBS-related research focus mainly on mitigating ecological and environmental problems. Moreover, although considerable studies have explored the links between urban green spaces and public health, there is still a gap in identifying and structuring their complex mechanism of action<sup>[12]-[14]</sup>, which directly impedes the implementation of relevant strategies in urban green space system planning and design<sup>[15]</sup>.

In response, this study explores the positive and negative impacts of urban green spaces on public health, constructs a theoretical framework for the mechanism of urban green spaces in promoting public health, and finally proposes potential strategies and inspirations for health-oriented urban green space system planning to realize the value of NBS.

## 2 Impacts of Urban Green Spaces on Public Health

The Constitution of the World Health Organization defines that health is a state of complete physical, mental, and social

康”分为生理健康、心理健康和社会健康。目前已有大量文献通过实验研究、典型案例研究或追踪调查等方法探索了城市绿地与人群健康的关系。

在生理健康层面，城市绿地能够降低人群罹患慢性疾病和临床疾病的风险，进而降低人群死亡率。如米雷娅·加斯康等学者综述了12篇研究绿地与死亡率相关性的文献，发现在绿化覆盖率较高的居住区，居民的死亡率相对较低——其中患心血管疾病人群的死亡风险显著降低<sup>[17]</sup>。现有研究也表明绿地与心脏病、呼吸系统疾病、肝癌、慢性乙肝等临床疾病的发病率有很大关系<sup>[11]</sup>。此外，城市绿地能够降低人群罹患代谢性疾病的风险，如肥胖症、糖尿病等<sup>[18]</sup>。

在心理健康层面，居住区周边的绿地面积（或可达性）与居民的心理健康程度有着密切联系。现有文献讨论了城市绿地对特定精神疾病的缓解效应，主要包括焦虑症<sup>[19]</sup>、多动症<sup>[20]</sup>、精神分裂症和抑郁症等<sup>[21]</sup>。同时，大量文献通过实验设计和自我报告等方法表明绿地体验（活动）能够提升情绪积极性。这些研究主要围绕由罗杰·乌尔里希提出的压力缓解理论<sup>[22]</sup>和史蒂芬·卡普兰提出的注意力恢复理论展开<sup>[23]</sup>，包括对人群与城市绿地接触情况进行的单次或连续多次的跟踪调研。如相关研究证实了城市绿地不仅能够提升人群的积极情绪和幸福感知指数<sup>[24]</sup>，而且对记忆力和注意力<sup>[25]</sup>，儿童的认知功能<sup>[26]</sup>、学习行为<sup>[27]</sup>，以及想象力和创造力等方面都有着积极影响<sup>[28]</sup>。

在社会健康层面，城市绿地提供了社区居民社交活动的空间，能够促进社会互动，进而增强居民归属感、支持感和参与感<sup>[29]</sup>，促使居民感悟生活意义<sup>[30]</sup>，增加场所依恋性<sup>[31]</sup>，进而增强社会凝聚力和社会资本，促进人群的社会健康。

然而，相关研究表明城市绿地偶尔也会对人群健康产生负面影响，主要包括三个方面：1) 城市绿地中某些植物的花粉传播会导致过敏性疾病<sup>[32]</sup>；2) 城市绿地（尤其是水体周边）中的蚊子会加速疟疾等传染性疾病的传播<sup>[33]</sup>；3) 因城市绿地的维护工作而造成的伤害<sup>[34]</sup>。

### 3 城市绿地促进人群健康的作用途径

#### 3.1 城市绿地暴露度与人群健康

绿地能够充分地“暴露”（exposure）于城市居民之中，是其实现各类健康效益的基本前提和必要途径。“暴露”是一个较为宽泛的学术用语，指的是基于一定的绿地特征（如面积、类型、设施品质）的城市绿地暴露度<sup>[35]</sup>，可以通过多种指标进行评估，如城市绿地的可获得性、可达性和可视性<sup>[36]</sup>。可获得性是一种数量指标，通常表示为一定范围内的绿地总量（主要指绿地总面积或面积占比）或一定范围内的平均归一化植被指数（NDVI）<sup>[37]</sup>。可达性是一种距离/时间指标，通常指到达公园绿地的距离或所耗用的旅行时间，往往通过ArcGIS来估测居

well-being and not merely the absence of disease or infirmity<sup>[16]</sup>，according to which it may cover physical health, mental health, and social health. A large collection of papers have studied the link between urban green spaces and public health via experimental research, case study, and longitudinal research.

Regarding the physical health, urban green spaces are proved effective in reducing people's risks of suffering from chronic and clinical diseases, thus lowering the mortality rate. For example, Mireia Gascon et al. systematically reviewed 12 papers and found that the mortality rate is relatively lower in residential areas with higher greenery coverage—especially for mortality caused by cardiovascular diseases<sup>[17]</sup>. Studies have also indicated a close relation between urban green spaces and the incidence of clinical diseases such as heart disease, respiratory diseases, liver cancer, and chronic hepatitis B<sup>[11]</sup>. Furthermore, urban green spaces can help decrease the morbidity of metabolic diseases, such as obesity and diabetes<sup>[18]</sup>.

The area (or accessibility) of surrounding green spaces is closely associated to residents' mental health. Recent reviews have pointed out that some mental illnesses, such as anxiety disorder<sup>[19]</sup>, attention deficit hyperactivity disorder (ADHD)<sup>[20]</sup>, schizophrenia, and depression<sup>[21]</sup>, can be ameliorated with urban green spaces. Additionally, a large amount of research with experimental data and self-reports showed that experience and physical activities in green spaces may catalyze positive moods. These studies were normally conducted on the basis of two main theories, i.e. the Stress Reduction Theory proposed by Roger Ulrich<sup>[22]</sup> and the Attention Restoration Theory by Stephen Kaplan<sup>[23]</sup>, and developed by the investigations of single as well as cumulative occasions of nature contact. Relevant research confirmed that urban green spaces improve not only the positive moods and happiness of the public<sup>[24]</sup>, but also children's memory and attention<sup>[25]</sup>, cognitive functioning<sup>[26]</sup>, learning behavior<sup>[27]</sup>, imagination, and creativity<sup>[28]</sup>.

On the level of social health, urban green spaces provide opportunities for residents to interact, which enhances their sense of coherence, support, and participation<sup>[29]</sup> with a better understanding of the worthwhile or good life<sup>[30]</sup>. In the meantime, place attachment<sup>[31]</sup> would also come into being with increased social cohesion and social capital, and finally the social health.

However, studies have shown that urban green spaces may also have negative impacts on public health: 1) pollen allergy caused by pollen emission<sup>[32]</sup>; 2) the spread of infectious diseases (such as malaria) accelerated by mosquitoes flying in urban green spaces (especially around water bodies)<sup>[33]</sup>; and 3) injuries caused by urban green spaces management activities<sup>[34]</sup>.

1. 城市绿地暴露度与人群健康的关系
1. The relationship between exposure of urban green spaces and public health

住地和公园绿地之间的欧氏距离或网络距离<sup>[38]</sup>，或通过网络地图的API接口获取出行时间值。可视性指的是居民通勤出行时或者其住宅附近绿地的可视情况，通常借助调研问卷的自我报告形式或Google地球街景模式等方式获取<sup>[36]</sup>。

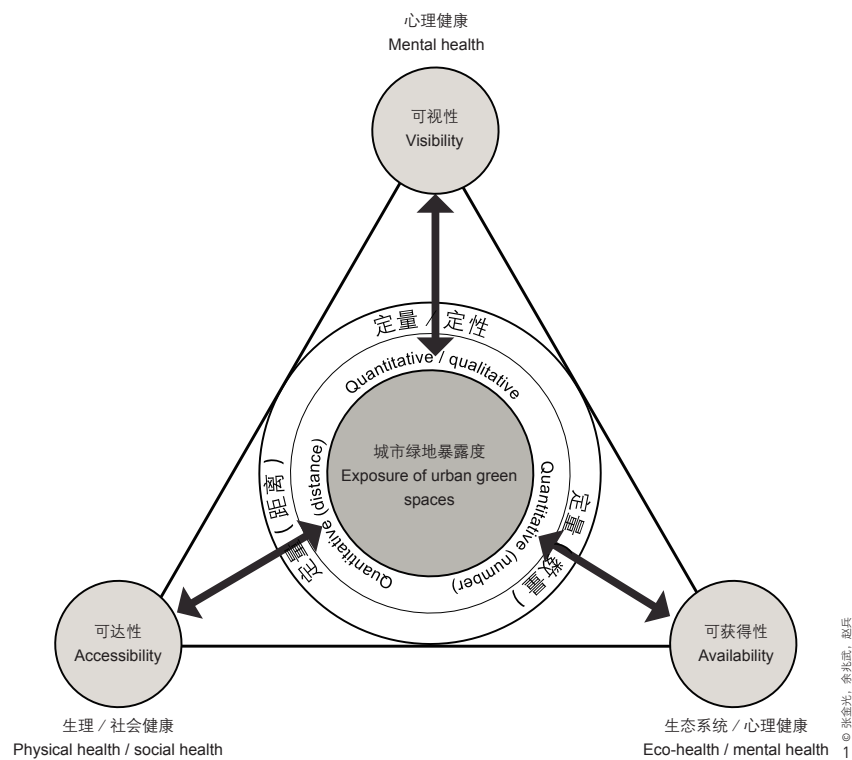
不同的“暴露”指标的选取，一定程度上依赖于城市绿地对人群健康的作用途径<sup>[7]</sup>。例如，可获得性适用于描述城市绿地所能提供的生态系统服务的能力，尤其是生态系统的调节服务所带来的健康效益；可达性指标更多被用于评估与人类活动相关的健康效益——如促进体力活动；可视性指标则更适用于城市绿地对心理健康的影响作用，常被应用于以注意力恢复理论和压力缓解理论为基础的科学问题上（图1）。

### 3.2 作用途径的理论框架建构

城市绿地促进人群健康的作用途径理论框架主要包含鼓励体力活动、缓解精神压力、提高社会凝聚力和提供生态系统调节/支持服务4个方面（图2）。

#### 3.2.1 鼓励体力活动

居住在（或易于到达）有一定活动设施的城市绿地附近，有利于人群的生理和心理健康，其中最重要的作用途径就是鼓励居民开展散步、慢跑等体力活动<sup>[39]</sup>。在城市居民三大活动领域（工作、交通和休闲）中，城市绿地主要通过交通（步行或骑自行车）和休闲（运动或游憩）促进体力活动。例如，伊娃·海宁等人指出在前往目的地途



## 3 Impact Mechanism of Urban Green Spaces in Promoting Public Health

### 3.1 Exposure of Urban Green Spaces and Public Health

In realizing the health promotion benefits, urban green spaces should be able to have full “exposure” to residents. “Exposure,” as a broad term, here means the exposure degree of urban green spaces based on their natural features (size, type, and qualities such as configuration)<sup>[35]</sup>, which is often assessed by various indicators including the availability, accessibility, and visibility<sup>[36]</sup>. Availability refers to the total area or proportion of the green spaces, or the average NDVI within a defined spatial distance<sup>[37]</sup>. Accessibility is the distance or time spent from residence to parks, which can be estimated by the Euclidean Distance or network distance by ArcGIS or travel times via API data from digital maps<sup>[38]</sup>. Visibility represents the green spaces that can be seen visually when residents commute or move around the residential communities, which are usually accessed from self-reports or Google Earth Street View<sup>[36]</sup>.

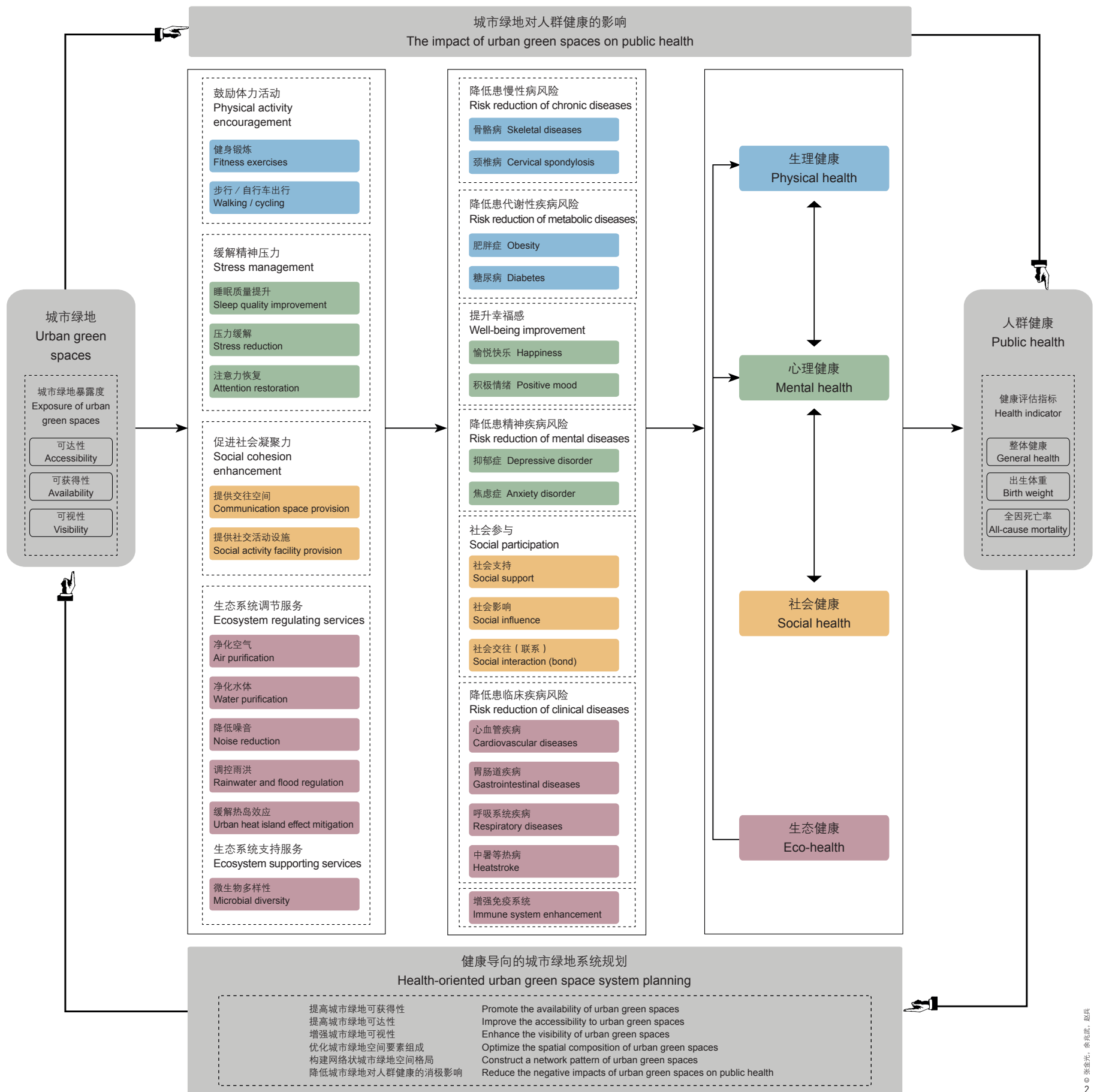
The selection of different “exposure” indicators, to a certain extent, depends on the mechanism of urban green spaces impacting public health<sup>[7]</sup>. For example, when emphasizing the ecosystem services provided by urban green spaces, especially the health benefits as regulating services, the indicator of availability is preferable; accessibility is usually used to assess the health benefits associated with human activities, such as the promotion of physical activity; visibility is more applicable in evaluating the effect of urban green spaces on mental health—especially concerning questions based on Attention Restoration Theory and Stress Reduction Theory (Fig. 1).

### 3.2 Theoretical Framework Construction of the Impact Mechanism

In this study, the impact mechanism of urban green spaces in promoting the public health was summarized to 4 approaches: 1) physical activity encouragement; 2) stress management; 3) social cohesion enhancement; and 4) ecosystem regulating / supporting services provision (Fig. 2).

#### 3.2.1 Physical Activity Encouragement

Easily accessible urban green spaces with certain recreational facilities is significant to human physical and mental health, as it could encourage residents to carry out physical activities such as walking and jogging<sup>[39]</sup>. For citizens, physical activities are usually realized via commuting (walking or cycling) and recreation (sports or touring). For example, Eva Heinen et al. pointed out that people prefer walking or cycling in paths with beautiful and greenery-covered scenes<sup>[40]</sup>. Studies also confirmed that physical activities in green spaces bring about more health benefits than activities



2. 城市绿地对人群健康作用途径的理论框架
2. The theoretical framework of urban green spaces' impact mechanism on public health<sup>[11]</sup>

中, 风景优美、绿地覆盖率较高的路径会促使人们选择步行或骑自行车出行<sup>[40]</sup>。多项研究证实, 在绿地上开展的体力活动比在其他环境(如室内)中的活动更具健康效益<sup>[1]</sup>。体力活动能够降低罹患慢性疾病和代谢性疾病的风险, 如预防和治疗业已成为“全球头号杀手”的心血管疾病<sup>[11]</sup>。

### 3.2.2 缓解精神压力

在城市绿地进行体验(活动)后, 人群能更好地消除疲劳、缓解压力, 产生更多的积极情绪。实证表明, 居住在绿地周边的人群所承受的心理压力普遍较低, 恢复能力更强, 且更能集中注意力。大量研究通过参与者自我报告, 统计绿地暴露度与各类健康指标之间的相关性, 证实了绿地体验(活动)能够改善睡眠和减轻压力<sup>[41][42]</sup>——二者是人群罹患精神疾病(尤其是抑郁症)的主要因素<sup>[35][43]</sup>。格雷戈里·N·布拉特曼等人的研究表明, 实验对象在进行绿地体验(活动)后, 大脑内的前扣带回皮层、背外侧前额叶皮层和背内侧前额叶皮层的活跃度会增强, 这将有效降低罹患精神疾病的风险<sup>[44]</sup>。

### 3.2.3 提高社会凝聚力

社会关系可以通过以下机制影响健康: 社会参与、社会支持、社会影响, 以及社会交往(联系)<sup>[31]</sup>。城市绿地(尤其是社区公园)能够提供居民社会交往所需的公共空间, 促进人群或邻里之间频繁的社会接触和联系, 提升群众参与感, 进而为其带来自我认同感和幸福感<sup>[45]</sup>。例如, 一项聚焦于伦敦东部区域的研究案例表明, 城市绿色空间中的社交互动空间可以提高参与者与他人建立联系的机会, 发展其社区意识, 并从日常生活需求中重组人际关系<sup>[46]</sup>。芝加哥的研究人员发现, 在树木和草地等植被覆盖率较高的公共空间中, 邻里之间的非正式社交更加频繁<sup>[47]</sup>。

### 3.2.4 提供生态系统调节/支持服务

近年来, 有学者提出了“生态系统健康”概念<sup>[48][49]</sup>, 即城市绿地通过广泛的生态系统服务(尤其是调节服务和支持服务)促进人群的心理和生理健康。从这一层面而言, “生态系统健康”能够相应地促进人群健康。以调节服务为例, 城市绿地能够通过净化空气和水体、降低噪音、调控雨洪、缓解热岛效应等方式降低人群感受到的环境压力, 在一定程度上促进人群健康。比如, 有研究表明, 城市绿地通过

happened in other (such as indoor) environments<sup>[1]</sup>。Moreover, along with physical activities, risks of chronic and metabolic diseases, e.g., cardiovascular diseases known as the “No.1 killer worldwide,” could be decreased<sup>[11]</sup>。

### 3.2.2 Stress Management

For the public, more positive emotions with less fatigue and stress will generate after urban green spaces experience or outdoor physical activities. Empirical evidence showed that people living adjacent to green spaces are much more emotionally resilient with less mental stress and better attention focusing. With self-reports by participants and analytical analysis of the correlation between each indicator of exposure and health, a great deal of research proved that experience or activities in green spaces could help improve sleep quality and relieve stress<sup>[41][42]</sup>, which are two main causes of mental illness, especially depression<sup>[35][43]</sup>. The study of Gregory N. Bratman et al. suggested that the activation of anterior cingulate cortex, dorsolateral prefrontal cortex, and dorsomedial prefrontal cortex increased after the interaction between human and nature, thereby enhancing people's resistance to mental illness<sup>[44]</sup>.

### 3.2.3 Social Cohesion Enhancement

Public health can be affected by social relations through the avenues of social participation, support, influence, and interaction (bond)<sup>[31]</sup>. Urban green spaces (especially community parks) can provide public spaces for people to constantly interact with neighbors, during which process their sense of participation, self-identity, and happiness will be enhanced<sup>[45]</sup>. For example, a case study in East London showed that social interaction happened in urban green spaces catalyzed relationship building between participants and others, while encouraging their sense of community and desire of reorganizing relationships to meet daily needs<sup>[46]</sup>. Researchers in Chicago have found that public spaces with higher vegetation coverage, such as trees and grass, see more informal social interactions between neighbors<sup>[47]</sup>.

### 3.2.4 Ecosystem Regulating / Supporting Services Provision

In recent years, many scholars have put forward the concept of “Eco-health”<sup>[48][49]</sup>, and defined it as an exporter of extensive ecosystem services—especially regulating and supporting services—to promote the mental and physical health, i.e. public health. In terms of ecosystem regulating services, urban green spaces can play a key role in reducing people's pressure from the environment by air and water purification, noise reduction, rainwater and flood regulation, urban heat island effect mitigation, etc. to promote public health to some extent. For instance, studies have evinced that

净化水体、改善空气质量等调节服务可减少胃肠道疾病、呼吸道疾病等临床疾病的发生<sup>[49]</sup>。就支持服务而言，研究人员主要关注丰富的微生物组（微生物多样性）所带来的健康效益：城市绿地中丰富的微生物组能够增强使用者的免疫系统，进而减少过敏性城市疾病的发生<sup>[50]</sup>。

## 4 健康导向下的城市绿地系统规划设计启示

### 4.1 提升城市绿地的可获得性

城市绿地可获得性是健康导向下城市绿地系统规划的基础指标之一。规划设计师和决策者在城市规划初期，尤其是新城规划建设阶段，应设定合理的绿地评估指标，提升城市绿地的可获得性，满足人与自然的交互需求。中国现行的对城市绿地数量的评估指标主要包括“城市绿地率”“城市绿化覆盖率”和“人均公园绿地面积”，而此类指标主要应用于城市或街道尺度。未来应继续细化评估模式和尺度，以社区或居住小区为基本单元，精准识别因缺乏可获得的城市绿地而具有潜在健康问题的居住小区。另外，在建筑高度密集的城市建成区，由于很难大范围开展绿地建设，研究学者应深入探索城市绿地可获得性与人群健康之间的阈值关系。比如，杰洛·科佩尔等学者<sup>[51]</sup>探讨了绿地可获得性（住址周围250m缓冲区内的绿化覆盖率）与人群健康之间的关联，发现绿化覆盖率低于2.5%的住区对居民的（自评）健康有显著的负面影响。

### 4.2 提高城市绿地的可达性

良好的城市绿地可达性不仅可以提高居民到访频次，增加居民与自然接触的机会，还能促使居民开展各项体力活动，进而带来更多健康效益<sup>[52][53]</sup>。研究表明，客观情况下（即居民没有明确的绿地接触意图时），300~400m是绿地布置的距离阈值区间<sup>[54][55]</sup>，超过这一阈值区间，居民的到访意愿将会大幅下降。玛格丽塔·特里盖罗—马斯等人的研究表明，300m距离以内的自然环境与心理健康指标呈正相关<sup>[56]</sup>。雷吉纳·格拉祖列维等人<sup>[57]</sup>的研究表明，与城市绿地的距离每增加300m，正常血压值就会增加9%，中高血压值增加14%。因此，规划设计师和决策者应当增加居民与绿地的接触机会，确保居民在300~400m的出行距离内“见绿”。此外，随着城市的高度集约化发展，新建大

urban green spaces can reduce the risk of clinical diseases such as gastrointestinal and respiratory diseases through some of the above regulating services<sup>[49]</sup>. Regarding the ecosystem supporting services, researchers mainly focus on the health benefits brought by the rich microbiome (microbial diversity) in urban green spaces as it can strengthen the immune system of users and reduce allergic diseases<sup>[50]</sup>.

## 4 Health-Oriented Urban Green Space System Planning

### 4.1 Promote the Availability of Urban Green Spaces

The indicator of availability is basic for health-oriented urban green space system planning. Urban planners and policy makers are responsible to set reasonable urban green space assessment indicators at the early stage of urban planning, especially regarding new urban areas, aiming at increasing the interaction between human and nature. Existing indicators, e.g. urban green rate, urban green coverage rate, and the per capita green area of the park, are primarily used to assess the quantity of urban green spaces at city or sub-district scales. Given this condition, future research should refine the mode and scale of urban green spaces assessment, better at the community level, to help accurately identify communities suffering from the potential health problems caused by limited urban green spaces. For built-up areas in a high-rise city with less availability to urban green spaces, studies should focus on examining the threshold relationship between urban green spaces and public health. For example, Gero Coppel et al.<sup>[51]</sup> found that spatial coverages of urban green spaces of less than 2.5% (within a 250-meter-long buffer around the residence) would negatively impact the self-reported health.

### 4.2 Improve the Accessibility to Urban Green Spaces

Reasonable accessibility to urban green spaces can encourage citizens to not only contact with the nature more frequently, but also participate in various physical activities that bring about more health benefits<sup>[52][53]</sup>. Research suggested that the use frequency of urban green spaces steeply declined once the distance exceeded the interval of 300~400 meters for citizens without definite trip plans<sup>[54][55]</sup>. Margarita Triguero-Mas et al. found a positive association between natural outdoor environments and mental health indicators within the distance of 300 meters<sup>[56]</sup>. Regina Grazuleviciene et al.<sup>[57]</sup> pointed out that the probability of normal blood pressure increased by 9%, and that of high-normal blood pressure by 14% for every 300 meters increase in the distance to urban green spaces. On these findings, urban planners and policy makers should take into consideration the distance threshold of 300~400 meters to urban green spaces for citizens. In addition,

型绿地难度加大，未来以社区公园和街旁游园为代表的小型绿地将成为提升绿地可达性、改善城市居民健康的关键因素<sup>[58]</sup>。

#### 4.3 增强城市绿地的可视性

城市绿地的可视性是缓解人群精神压力的关键因素。因此，在城市绿地系统规划中应充分考虑绿地对周边环境的视觉呼应，明确绿色景观的视觉焦点与人群活动的主要观赏面。特别是在居住区、办公区及商业区等人群活动密集的空间中，户外环境设计应充分考虑与室内观赏面（如窗户）的融合与呼应，增加人们在室内活动时外界“绿色”的可视性。另外，城市绿地可以作为城市标志性景观（如观光塔等）的背景，其设计形态应与城市标志性景观的视觉焦点相融合，使人们在观赏标志性景观的同时能够最大程度地获得绿色视野<sup>[59]</sup>。最后，应加强人行道两侧的绿色环境营造，鼓励采用以攀缘型绿植为主的垂直绿化模式来装饰两侧围墙和建筑立面，提升“绿色”可视性。

#### 4.4 优化城市绿地的空间要素组成

既有研究表明，城市绿地的空间特征会对人群健康产生一定影响。黄秋韵等人<sup>[60]</sup>通过虚拟现实技术探究了草地、林地及硬质铺装在缓解人群压力方面的作用，发现草地的积极效应最高。帕亚姆·塔布里赞等人<sup>[61]</sup>基于沉浸式虚拟环境评估不同绿地组成环境对人群的注意力恢复能力，发现混交林、疏林草地和落叶树种对人群注意力恢复能力的影响最大，而建筑物及硬质铺装则存在负面影响。邓莉等人<sup>[62]</sup>的研究表明，具有天然森林形态和水景特征的地貌景观可能是最佳的生理和心理恢复环境。因此，规划设计师应合理配置城市绿地内部的空间要素组成，协调“硬质”与“软质”空间的配比——既要建造满足人群体力活动、社交活动的“硬质”空间，也要兼顾“软质”空间在缓解精神压力方面的功效。

#### 4.5 构建网络状城市绿地空间格局

规划设计师和决策者应考虑构建网络状的城市绿地空间格局和公园系统。一方面，“翡翠项链”式的网络状结构可达性高，有利于促进居民开展户外活动；且其以线性游憩型绿色开放空间（如绿道等）

by embracing the strategies of constructing small green spaces such as community parks and street gardens, both the accessibility to green spaces and public health will get promoted effectively in the trend of highly intensive urban development<sup>[58]</sup>.

#### 4.3 Enhance the Visibility of Urban Green Spaces

Viewing urban green spaces may significantly relieve stress. In view of this, the visual contact in urban green space system planning, including the visual focus of the landscape and the main viewing interface during daily activities of the public, should echo with the surroundings. For instance, outdoor spaces that support intensive activities, e.g. residential areas, offices, and commercial zones, should fully consider the integration and echo with the indoor viewing interface (such as windows) for more visible urban green spaces. Furthermore, urban green spaces may also act as the background of landmarks, e.g. the sightseeing tower, for which its designed form should match up with visual focuses of these landmarks to provide a wider green vision for visitors<sup>[59]</sup>. Finally, the visibility of urban green spaces could also be realized by increasing vertical greening (introducing climbing plants) on fences and façades of building along sidewalks.

#### 4.4 Optimize the Spatial Composition of Urban Green Spaces

Recent findings also showed that spatial characteristics of urban green spaces may affect public health. Huang Qiuyun et al.<sup>[60]</sup> examined the impact of grasslands, woodlands, and impervious paved areas with virtual reality, pointing out that grasslands relieve stress more efficiently. Payam Tabrizian et al.<sup>[61]</sup> assessed the restoration potential of different landscape compositions and configurations through the immersive virtual technology and found that mixed forests, sparse forests and grasslands, and deciduous tree species performed the best, while buildings and impervious paved areas showed negative impacts. Recent empirical research by Deng Li et al.<sup>[62]</sup> suggested that landscapes with natural forest morphology and water features may be the best physical and psychological recovery environment. In response, urban planners should figure out the rational configuration of “grey” and “green” spaces—the “grey” ones for physical and social activities and “green” ones to relieve stress.

#### 4.5 Construct a Network Pattern of Urban Green Spaces

A network pattern of urban green spaces and park systems is suggested for urban planning and design. For one thing, the network featured like the “Emerald Necklace” holds high accessibility which encourages outdoor activities; linear recreational green spaces (e.g. greenways) connecting various green spaces attract citizens to travel on foot or by bicycle, which means

作为纽带连接各个绿地斑块，能够在最大程度上鼓励居民选择步行、骑行等慢行交通出行方式，从而提升体力活动水平。另一方面，网络状的绿地结构有利于城市生态系统的稳定性<sup>[63]</sup>，从而促进城市绿地生态系统调节功能的充分发挥。例如，余兆武等人<sup>[64]</sup>指出理想状态下多等级的正六边形网络状绿地空间格局能够最大程度地降低城市热岛效应，进而减少中暑等病状的发生。

#### 4.6 降低城市绿地对人群健康的消极影响

健康导向下的实践研究还应密切关注对城市绿地所产生的消极影响的回应，如城市绿地植被传粉所导致的过敏性疾病等。据统计，全球有30%~40%的人口正在遭受过敏性疾病的困扰，其中很大一部分病因即源自植物花粉过敏<sup>[65]</sup>。因此，城市规划设计中应明确城市树种的选择标准，以控制使用某些会大量传播花粉的物种数量。

## 5 结论

本文以城市绿地促进人群健康的作用途径为切入点，从鼓励体力活动、缓解精神压力、促进社会凝聚力和提供生态调节/支持服务4个层面构建了理论研究框架，并借此提出健康导向下的城市绿地系统规划应对策略。未来研究在进一步深入探索城市绿地对人群健康影响的潜在途径的同时，还应注重城市绿地的健康实践，提出更多面向提升人群生理、心理和社会健康的规划设计应对策略。如通过绿地的组成（绿地植被种类、绿地中的水体、活动设施等）与配置（绿地的类型、大小、形状等）对人群健康实施“主动式”干预，让有限的城市绿地发挥更大的健康效益。LAF

more physical activities. For another thing, the network pattern is conducive to the stability of the urban ecosystem<sup>[63]</sup> that could give full play to regulating services. For instance, Yu Zhaowu et al.<sup>[64]</sup> suggested that the urban green spaces spatial pattern in a hierarchical hexagonal structure can ideally mitigate the urban thermal environment, and thus reduce the incidence of heat-related illnesses.

#### 4.6 Reduce the Negative Impacts of Urban Green Spaces on Public Health

Strategies respond to urban green spaces' negative impacts on public health also need more discussion. For instance, 30% to 40% of the world's population are suffering from allergic diseases, most of which are caused by pollen allergies<sup>[65]</sup>. Therefore, in urban planning and design, criteria should be set for urban tree species selection to minimize species that produce lots of pollen.

## 5 Conclusion

Based on the impact mechanism of urban green spaces in promoting public health, this article builds a theoretical research framework from 4 aspects: physical activity encouragement, stress management, social cohesion enhancement, ecosystem regulating / supporting services provision, and further proposes a new pathway to health-oriented urban green space system planning. Future discussion should make further efforts in exploring the potential impact mechanism and focus on planning practices that employ more strategies to improve the physical, psychological, and social health of citizens. For instance, “proactive” interventions should be implemented to exert more health benefits with limited urban green spaces by optimizing its composition (e.g. vegetation types, water bodies, and activity facilities) and configuration (e.g. types, size, and shape). LAF

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