Healthy Spaces in Transition: From Global Context to Local Evidence and BIT-UoE Research Contributions

《转型中的健康空间：从全球背景到本土证据及北京理工大学与爱丁堡大学联合研究贡献》

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Abstract

In recent years, the relationship between the urban built environment and public health has attracted growing scholarly attention, yet most existing studies rely heavily on Western contexts. In China, pioneering studies from universities such as Tsinghua University and Tongji University have laid an important foundation for understanding healthy spaces in a local setting. Against this background, we —the Joint Laboratory of Healthy Space established by Prof. Simon Bell and Dr Ziwen Sun, a collaborative initiative between the University of Edinburgh (UoE) and the Beijing Institute of Technology (BIT)— conducted a series of theoretical and empirical studies examining how the built environment influences health and well-being in China. This article will introduce a series of our latest research findings from the past ten years in the following three key areas. First, we reconceptualise walkable spaces and walking behaviour in the context of low-tier Chinese cities, highlighting the different impacts of spatial form, cultural practices, and everyday lives. This provides new theoretical and methodological directions for health behaviour research. Secondly, we identify distinct mental restoration effects associated with specific neighbourhood environments, such as wild and artificial urban parks, as well as informal green spaces. Thirdly, we compare the differential mental health benefits provided by green spaces within enclosed neighbourhoods during the pandemic lockdown. We also reveal how high-density built environments significantly moderated COVID-19 transmission risks, providing insights for future emergencies. Together, these findings contribute context-specific evidence on the health implications of urban environments, expand the global comparative literature, and inform intervention strategies aligned with the Healthy China Initiative. The article, therefore, contributes to the scientific basis for healthier human settlements and advocates for design and policy adaptations that are responsive to local contexts.

摘要：近年来，城市建成环境与公共卫生之间的关联愈发受到学界关注，但现有研究多以西方语境为基础。在中国，清华大学与同济大学等已开展开创性研究，为本土场景下的健康空间认知奠定了基础。在此背景下，由西蒙·贝尔教授与孙子文副教授牵头、英国爱丁堡大学（UoE）与中国北京理工大学（BIT）合作成立的健康空间联合实验室，开展了一系列理论与实证研究，探究中国城市建成环境对健康与福祉的影响。本文将介绍过去十年在以下三个核心领域的最新研究成果：第一，重新阐释中国低线城市的可步行空间与步行行为，揭示空间形态、文化实践与日常生活对健康行为的差异影响，为健康行为研究提供新的理论与方法方向；第二，识别特定社区环境（如城市荒野公园、人工公园及非正式绿地）对应的独特心理恢复效应；第三，对比疫情期间，

封闭社区中绿地带来的差异化心理健康效益，同时揭示了高密度封闭社区能显著降低病毒传播风险，为未来应急场景提供参考。这些研究成果既补充了城市环境健康影响的本土语境证据，拓展了全球比较研究文献，也为“健康中国”战略落地提供了依据。由此，本文为更健康人居环境的构建奠定了科学基础，倡导适配本土语境的设计与政策调整。

Keywords:Healthy space; Urban neighbourhood environment; Walking behaviour; Physical activity; Mental stress

关键词：健康空间；城市社区环境；步行行为；体力活动；心理压力

Funding:This research is supported by The Key Open Research Funding of the Laboratory of Intelligent Processing Technology for Digital Music (Zhejiang Conservatory of Music), Ministry of Culture and Tourism with a grant number of 2024DMKLB001.

1 Introduction

The development of modern urban spaces rests on the vision of 19th-century social reformers, who advocated systemic interventions to reduce illness and mortality in industrialised cities plagued by overcrowding, poor sanitation, and pollution (Giles-Corti et al., 2023; Lei et al., 2025). In the period, urban planning and design prioritised efficiency, functionality, order, and hygiene, often ignoring human scale and quality of life (Gehl, 2010). This contributed to widespread declines in physical activity and mental well-being in cities worldwide (Giles-Corti et al., 2016).

In response to these challenges, scholarly interest in healthy urban environments began to emerge in China in the early 21st century. With rapid economic transformation and urban expansion, questions about how spatial form and social life shape physical and mental well-being have become increasingly salient (Hu et al., 2018; Park et al., 2020). This growing academic focus from several leading Chinese institutes and universities has laid the groundwork for a new generation of health-oriented urban research. These studies have not only localized global concepts such as “healthy cities” but have also generated context-specific frameworks that reflect China’s socio-cultural realities and urban morphologies.

Against this background, the leading author, Dr Ziwen Sun, completed his doctoral studies at the University of Edinburgh with a focus on Chinese walking urbanism and is now working at the Beijing Institute of Technology. Building on this foundation, and in collaboration with his supervisor, Prof Simon Bell, the Joint Laboratory of Healthy Space—a partnership between the University of Edinburgh (UoE) and the Beijing Institute of Technology (BIT)—was established to advance both theoretical and empirical investigations into how the built environment shapes health and well-being in China. Drawing on cross-disciplinary expertise spanning architecture, urban planning, landscape design, public health, and medical geography, this has produced a decade of scholarship examining the reciprocal relationship between urban form and human well-being. These efforts underscore the importance of context-specific evidence, moving beyond imported frameworks toward design and policy models that resonate with China’s distinctive social rhythms, cultural practices, and spatial systems.

Based on this decade of work, the current article integrates insights from three interrelated domains of inquiry for urban neighbourhood environments: (1) Walkability and Walking Behaviours; (2) the Impact of Green and Blue Spaces on Mental Health; and (3) Health and Well-being During Pandemic Lockdowns. These studies extend global urban health debates through locally grounded evidence, informing strategies aligned with the “Healthy China 2030 Initiative” and contributing to a comparative understanding of healthy urbanism in the Global South. Beyond these three areas of inquiry, the paper further proposes a forward-looking research agenda that outlines emerging directions for integrating environmental design, behavioural science, and public health to guide the next generation of healthy space studies.

2 Literature Review

2.1 Promoting physical activity and walkability

The promotion of physical activity represents a foundational goal within healthy city planning. Modern understandings of the built environment's role in shaping movement behaviour emerged from post-industrial critiques of urban form, particularly in Western contexts where automobile dependence eroded opportunities for active transport (Cerin et al., 2022; Sallis et al., 2016). It was not until the post-modern era of urban development that enhancing walkability, pedestrian, and cycling infrastructure gained recognition as essential strategies for promoting physical activity (Lo, 2009; Althoff et al., 2025). This historical context sets the stage for understanding China's unique trajectory with the remarkable speed and dramatic transformation. Within a matter of decades, Chinese cities shifted from a bicycle-dominated landscape prior to the 1980s to an era of explosive growth in private car ownership, which brought attendant challenges, such as traffic congestion and air pollution. This rapid shift mirrored Western urban issues but on a significantly compressed timeline. Consequently, research into walkability and health in China has evolved both in dialogue with, and as a critique of, established Western frameworks.

Globally, measures such as the Walkability Index, Walk Scale, and Neighbourhood Environment Walkability Scale have been developed to quantify urban form in relation to mobility and health. These are grounded in the "5 Ds" framework-Density, Diversity, Design, Destination Accessibility, and Distance to Transit (Cervero & Kockelman, 1997). For example, higher density concentrates people, homes, jobs, and amenities, enabling convenient daily travel by foot and bicycle, while diversity describes a mix of different land uses (e.g., residential, commercial, and recreational amenities). A land-use mixed neighbourhood allows residents to meet daily needs on foot or by bicycle without relying on private vehicles. These principles provide a foundational guide for designing walkable and cyclable cities that promote physical activity and enhance urban liveability.

In China, these international methods have been localized through a growing body of context-specific scholarship. Tsinghua University, through its Center for Healthy Cities, launched the City Health Index—a big-data framework evaluating urban health performance nationwide (Li et al., 2023; Yang et al., 2018). Meanwhile, an emerging group of geographers has extended spatial analyses of walking patterns from a spatiotemporal-behavioural dynamic approach, demonstrating that canonical built environment (e.g., mixed land use, density) in high-density metropolitan cities show weaker associations with walking than in Western contexts (Liu et al., 2020; Zhang et al., 2021). This vein constitutes the first research area in this article, which aims to reconceptualise walkable spaces and walking behaviour within the context of low-tier Chinese cities.

2.2 Mental Health and Nature-based Interventions

Apart from physical activity, mental health has emerged as a critical global challenge in urban settings. It is estimated that approximately 970 million people worldwide live with a mental disorder (World Health Organization, 2025). The economic burden associated with these conditions has risen dramatically, increasing from US$2.5 trillion in 2010 to nearly US$5 trillion in 2019, accounting for 3.8% of global GDP at the time (Arias et al., 2022). These global trends highlight the importance of urban design that not only facilitates movement but also fosters psychological restoration.

During this transition, the role of natural environments in promoting mental well-being is gaining increasing recognition, particularly in high-stress, high-density urban areas. Several theoretical frameworks provide scientific grounding for this role, including Attention Restoration Theory (ART) (Kaplan & Kaplan, 1989), which suggests that natural settings can replenish cognitive resources; Stress Reduction Theory (SRT) (Ulrich et al., 1991), which emphasizes the physiological and emotional benefits of exposure to nature; and Biophilia Hypothesis (Wilson, 2010), which proposes an innate human affinity for the natural world. These perspectives collectively highlight the potential of nature-based interventions as part of holistic public health strategies in urban development.

In the Chinese context, the significance of natural environments is shaped by distinctive ecological philosophies and high-density urban conditions.

Research by Tongji University has demonstrated that urban biodiversity and ecological quality substantially enhance residents' psychological restoration, emphasizing the integration of multi-sensory natural elements in city design to promote mental well-being (Yin et al., 2023). This expanding evidence base situates natural environments not merely as amenities but as essential urban infrastructures for mental health. This line of inquiry naturally leads to the second area of our research: an understanding of wild versus artificially designed urban parks and informal green spaces in the context of China, as introduced in this article.

2.3 Built Environment, Epidemics, and Public Health Resilience

Beyond the above studies on non-communicable diseases, the COVID-19 pandemic reignited long-standing concerns within health geography and environmental health about the spatial determinants of aerosol infectious diseases. Since the 1990s, foundational works in health geography—such as Kearns & Moon (2002), Meade & Emch (2010), and Cromley & McLafferty (2012)—have emphasized how environmental exposure, population density, and social structure interact to influence health outcomes. Subsequent studies extended these perspectives to incorporate spatial modelling, GIS-based analysis, and environmental risk assessment, forming the methodological basis for modern epidemiological mapping.

In China, rapid urbanization has intensified both communicable and non-communicable health challenges. Research from Peking University, Wuhan University, and Harbin Institute of Technology has developed spatial life course and time-geography methods to examine physical and social environmental exposures, noise pollution, and their cumulative mental health impacts (Zhou et al., 2024). These approaches echo global advances in understanding how environmental contexts affect health trajectories across time and space. These insights align with broader work in Chinese health geography (Yang et al., 2010; Gong et al., 2022), which emphasizes the spatial determinants of health, the role of environmental exposure, and the importance of spatial modelling in assessing public health risks. This literature also highlights emerging concerns such as urbanization and environmental health, global environmental change, and aging and longevity, thereby situating COVID-19 research within a broader spatial health framework. The third area offers insights for public health emergency preparedness from urban planning and design perspectives. Together, these three research areas on healthy urban neighbourhoods underscore the importance of context-specific evidence and highlight the need for urban policies and development strategies to adapt to local cultures, everyday lives, and socio-spatial practices.

3 Re-conceptualising Walkable Space and Walking Behaviour

Health behaviours closely related to the built environment mainly include dietary behaviour and physical activity (Giles-Corti et al., 2016; Sun, 2020; Althoff et al., 2025). As the most common form of physical activity, walking has been widely demonstrated to contribute positively to health. Among attributes of the built environment, most of the existing studies indicate features such as high population density, mixed land use, and high-quality design have been confirmed to positively influence residents' walking behaviour, becoming key considerations when designing healthy neighbourhoods (Speck, 2012; Sun et al., 2015; Sallis et al., 2016; Cerin et al., 2022). However, a growing body of evidence suggests that built environment features traditionally assumed to promote walking may be weak or even negative correlations in certain developing contexts, including Chinese cities (Lu et al., 2017; Sun et al., 2019). This finding presents new challenges for both theory and practice, underscoring the need to re-evaluate how healthy spaces are conceived and implemented across diverse local contexts.

3.1 Deconstructing Mixed Land Use

China's urban system is predominantly composed of what are domestically classified as low-tier cities—typically prefecture-level and county-level cities with populations ranging from 1 to 5 million (State Council of the People's Republic of China, 2014). Despite their demographic significance—which would qualify them as major regional cities in many Western contexts (Yin et al., 2019)—they have been largely overlooked in

health-focused urban studies, even though they host a population of approximately 890 million people (National Bureau of Statistics, 2021). In practice, their planning paradigms are often uncritically transplanted from domestic megacities, creating a fundamental mismatch between imported design standards and local socio-spatial realities, such as shorter commuting patterns and stronger local cultural identities (Sun et al., 2019). It is precisely this contextual gap that motivates our critical examination of how the canonical concept of mixed land use—a cornerstone of Western and megacity-derived walkability models—operates in these distinctive urban settings.

In practice, urban planning paradigms and built environment interventions in these cities are often modelled after those designed for megacities such as Beijing and Shanghai. This approach overlooks the distinct socio-spatial realities of lower-tier contexts, which are typically characterised by shorter commuting patterns, stronger local cultural identities, and different rhythms of daily life (Sun et al., 2019). The direct transplantation of planning models from first-tier cities has led to a mismatch between imported design standards and local health behaviour outcomes. It is precisely this gap that motivates the present study. In the sections that follow, we deconstruct the concept of mixed land use—a cornerstone of Western and megacity-derived walkability models—and examine its nuanced relationship with walking behaviour in the context of Chinese low-tier cities.

Given the distinct everyday lives and local cultures in these contexts, we found that although mixed land use is widely recognised as a key factor influencing walking behaviour, its impact appears to be weaker in lower-tier Chinese cities (Sun et al., 2019). To investigate this phenomenon, we deconstructed the mixed land use dimension into 25–27 types of amenities, based on the Neighbourhood Environment Walkability Scale (NEWS). This approach allowed for a nuanced analysis of the relationship between the accessibility of various amenities and walking behaviour, and also enabled an in-depth exploration of the social meanings that specific types of amenities hold for local residents.

Empirical findings revealed that the accessibility of food-related amenities such as restaurants and fruit stores was positively correlated with the walking duration of nearby residents (Sun et al., 2021). Conversely, the accessibility of entertainment amenities like KTVs and bars showed a negative correlation with walking duration (Sun et al., 2024). These conclusions reveal the differential impact of various amenity types within mixed land use on walking behaviour, clarifying why traditional built environment features show insignificant relationships with walking behaviour among Chinese residents. Building on this, the relationship between walking behaviour of different age groups and the same built environment features was further constructed (Sun et al., 2019; Sun et al., 2024). For example, in China, compared to younger people, older adults use amenities such as cinemas and cafes less frequently, thus showing a weaker association with their walking behaviour.

This series of ongoing research aims to propose context-specific strategies for mixed land use, centred on the spatial distribution of different amenity types, thereby creating a built environment more conducive to walking and effectively promoting residents' health behaviours in low-tier Chinese cities. Simultaneously, it also focuses on behavioural differences among different groups, aiming to enhance the overall health level of residents through inclusive design.

3.2 Transient Walking Spaces

By conducting the studies above, we observed that in China, the transient presence of street vendors significantly shapes the nature and function of public spaces where many pedestrians occur. This phenomenon contrasts sharply with the traditional dualistic framework commonly used in walkability studies, which often juxtaposes a static built environment against dynamic walking behaviour. Therefore, we proposed to re-examine the unique characteristics of walking behaviour and the production mechanisms of walkable space in China through the dynamic changes of street vendors (Sun et al., 2016; Sun et al., 2020a; Sun et al., 2022; Sun, 2022). This approach integrates local cultural, social, political, and economic dimensions into the study of the built environment and health behaviours, offering a novel perspective to explore the complexity and diversity of walkable spaces and walking behaviours through the

innovative lens of the street vending phenomenon.

Drawing on Lefebvre's concept of rhythm analysis, three non-objective time dimensions (i.e., Arrhythmia, Eurhythmia, and Polyrhythmia) were introduced to re-examine the complex interactive relationship between vendor activities and resident walking behaviour in Chinese street spaces (Sun, 2022). Arrhythmia represents the disordered state of vendors' transient appearance and disappearance, which breaks the stability and homogeneity of traditional walkable spaces, injecting vitality and diversity into the streets. Eurhythmia embodies the coordination and synergy between residents' walking behaviour and vending activities, creating order and harmony in the street space. Polyrhythmia emphasizes the diversity and coexistence of different actors in the temporal dimension, showcasing the complexity and richness of street space. This theoretical framework provides a new perspective and explanatory approach for deeply understanding activities and behaviours in Chinese street spaces. By studying the dynamic vending-walking relationship, the impact of the built environment on walking behaviour is more comprehensively revealed.

Moreover, numerous Western theorists advocate fostering heterogeneities within urban contexts. For instance, de Certeau (1984) argue that everyday practices may sacrifice stability in favour of efficiency, functionality, and flexibility—a notion that resonates with the study of vendors' heterogeneous rhythms. Yet, based on this rhythm analysis study (Sun, 2022), we found that what is at stake here is not merely to affirm such heterogeneities, but rather to critically examine the social and spatial "consequences" of being the heterogeneities (e.g., street vendors). As marginalised urban actors, street vendors experience and influence urban life through rhythms shaped by their peripheral status; examining their everyday realities offers a novel perspective for understanding how urban environments impact health behaviours and well-being.

Building on the time-related concept above, an innovative Spatio-Temporal Behaviour Mapping (STBM) method was further developed to deeply explore, at a micro-scale, the spatio-temporal behaviour patterns of street vendors and pedestrians (Sun et al., 2020a; Liu et al., 2024). Unlike traditional behavioural mapping, the STBM method is particularly effective in highly dynamic environments, such as public markets and stations. It can meticulously track and record over 20 types of behaviours and activities of street vendors and pedestrians in time and space. Combined with Geographic Information Systems (GIS), large amounts of spatio-temporal data are visualized, revealing the subtle relationships and mechanisms between street vendors and pedestrians, as well as environmental factors (Han & Sun, 2023; Han et al., 2023b). It can also elucidate patterns of street vitality changes, such as peak hours during the day and weekdays/weekends. Furthermore, by integrating additional datasets (e.g., microclimate measurements and spatial narratives) and conducting quantitative comparative analyses of spatio-temporal data, it provides practical guidance for urban design and landscape and non-motorized traffic optimization. This research method enables a deep understanding of healthy walking behaviour, daily supply and demand, and spatial vitality, laying the foundation for creating more humanized healthy street spaces.

During the development of the STBM method, female researchers on our team identified notable gender differences in informal occupations, high-liquidity spatial characteristics, and patterns of space use (Han et al., 2023a; Han & Sun, 2023; Wang et al., 2024). These observations help uncover nuanced health behaviours and their underlying causes. This is particularly significant, for instance, existing studies highlight the importance of flexible occupations for women, often due to caregiving family responsibilities. However, we recognize informal vending as one such form of flexible work, and female vendors show distinct spatial practices, often utilizing different tools to transport/sell goods and occupy street space. These nuanced findings provide critical evidence to inform gender-responsive urban design and the development of equitable and inclusive policies for health and well-being.

4 The Impact of Biophilic Neighbourhood Environments on Mental Health

Beyond the widely recognized challenge of declining physical activity, the accelerating pace of modern social

life has exacerbated various psychological pressures, leading to a growing prevalence of mental health issues such as anxiety and depression. It is estimated that approximately 970 million people worldwide live with a mental disorder (World Health Organization, 2025), underscoring the scale and urgency of this public health crisis. This situation is compounded by a widespread lack of exposure to biophilic neighbourhood environments. Although existing studies suggest that the frequency and duration of contact with urban blue and green spaces can directly affect mental health, context-specific and nuanced evidence within urban neighbourhood settings remains limited (Kang et al., 2022; Gao et al., 2024).

The relationship between cemeteries and the city has long captivated scholars. Thinkers like Aldo Rossi, who conceptualised the cemetery as the "city of the dead" (Rossi, 2007), and Italo Calvino, who portrayed it as a repository of urban memory (Calvino, 1974), highlight its profound spatial and symbolic significance. In China, however, urban cemeteries present a striking contrast. While they are vital infrastructures for burial and ancestral rites, deep-seated cultural beliefs associate them with ghosts and the taboo (Deng & Li, 2023), often casting them as "Not-In-My-Backyard" (NIMBY) facilities (Dear, 1992). This perception has largely excluded them from the everyday urban fabric.

By contrasting the Chinese context with Western contexts, we observed that in many Western cities, historical cemeteries have evolved into multifunctional public green spaces, seamlessly integrated into daily life for recreation and mental restoration (Lai et al., 2019; Lai et al., 2020). Motivated by this distinction, we conducted an international collaborative study in Edinburgh, Scotland, to refine methodologies for assessing restorative environments. The research compared two urban cemeteries and two parks, revealing that both usage frequency and aesthetic quality in cemeteries were significantly and positively associated with key restorative qualities—including "being away," "extent," "fascination," and "compatibility" (Lai et al., 2019). Pleasantness and aesthetic quality emerged as consistent predictors of perceived restorativeness in both parks and cemeteries. However, safety was a significant factor only in the parks, whereas the presence of well-maintained paths contributed to restorativeness exclusively in the cemeteries. Notably, the influence of greenspace attributes on restorative perception was significant only among participants who did not have a deceased relative interred in the cemeteries and those living beyond an 800-meter radius (Lai et al., 2020). These findings highlight the need to integrate cemetery management into municipal green space planning and policies, so as to optimize the use of these underutilized yet potentially valuable green resources.

In the evolution of Chinese urban park design, a discernible shift has occurred from an anthropocentric to an eco-centric approach, a transition greatly influenced by late Professor Kongjian Yu. His pioneering vision contributed significantly to the emergence of wilderness parks, which are characterized by an emphasis on wildness, natural processes, and ecological integrity. These spaces stand in sharp contrast to the neatly manicured landscapes of traditional parks, reflecting a fundamental rethinking of the relationship between urban nature and human intervention (Hu et al., 2022; Yang et al., 2024; Hu & Sun, 2025). For instance, using conjoint analysis, the different preferences of professionals and the general public for wilderness parks and traditional parks were revealed. Most professionals considered biodiversity the most important attribute, supporting the construction of wilderness parks; while for the general public, facilities and biodiversity were equally important, showing a preference for traditional parks (Hu et al., 2022). Furthermore, public preference for wilderness parks increased when their maintenance level was improved and corresponding recreational facilities were provided (Hu & Sun, 2025). This type of wild green space is closely related to the "Being Away" aspect of mental restoration benefits, and long-term exposure to it can effectively improve mental health levels.

China's unprecedented rate of urbanization has triggered drastic environmental changes, and the problems arising from this process have been correspondingly amplified. Existing studies often overlook detailed consideration of the degree of

environmental change between childhood and adult locations across the life course. To address this gap, we explored the relationship between childhood place attachment and the naturalness of childhood residential environments, investigating how attachment to childhood places affects adult well-being depending on the degree of environmental change (Wang et al., 2022). We found that higher naturalness in childhood residences helps individuals form stronger place attachment. This sense of attachment is positively correlated with adult well-being. The degree of difference between childhood places and the current environment moderates adult well-being. These findings provide a deeper, more nuanced comprehension of the interplay between natural environments and human well-being under conditions of rapid urban change in China.

The research agenda for healthy spaces has progressively shifted from ensuring basic survival to enhancing quality of life, positioning blue-green spaces (natural areas with woodlands, grasslands, and water bodies) as a key research topic. Many studies have focused on the visual qualities, to the neglect of the critical dimension of soundscapes. Namely, the acoustic environment as perceived by individuals, which exerts a profound influence on restorativeness and emotion in everyday contexts (Sun et al., 2025). Based on this idea, we conducted a review regarding virtual reality (VR) technology to address this gap, demonstrating that VR-simulated soundscapes can produce restorative mental health benefits similar to actual natural environments (Zhong et al., 2024). VR enables a key methodological advance: the precise manipulation of acoustic parameters for a more immersive and controlled experimental setting than previously possible. Our review also highlights the necessity of incorporating individual differences (e.g., gender, age, socioeconomic background) into soundscape studies. We further identify VR and AI as transformative tools for pioneering healthy space design. Their applications broaden the scope of the field, spanning from immersive digital media (e.g., game spaces, short videos) to sophisticated analytical methods (e.g., Large Language Models, XGBoost), thereby demonstrating significant innovation potential (Zhang et al., 2025).

Building on the studies above, we further employed a multi-physiological and experimental approach, including electroencephalogram (EEG), heart rate variability (HRV), and electrodermal activity (EDA), to objectively investigate the nuanced restorative effects of wild/artificial and blue/green spaces (Yang et al., 2024). The selection of these physiological measures was deliberate, as they offer objective data sources that complement traditional self-report questionnaires. While questionnaires are well-validated and provide valuable insights into perceived mental states (Slimmen et al., 2025), they are subject to inherent limitations such as response bias and limited self-awareness (Gao et al., 2024). The present multi-modal approach thereby integrates complementary physiological indicators to capture different aspects of psychophysiological states (Kwon et al., 2025): EEG captures cortical brain activity and is highly sensitive to emotional valence and cognitive engagement (Sander et al., 2025); EDA reflects sympathetic nervous system arousal, serving as a reliable indicator of general psychophysiological activation (Li et al., 2022; Kim et al., 2025); and HRV—particularly its high-frequency component—serves as a non-invasive index of parasympathetic activity and self-regulatory capacity (Baigutanova et al., 2025), with higher HRV being consistently associated with better emotional regulation and stress resilience (Määttänen et al., 2021). Together, these measures provide a more comprehensive and robust understanding of the mechanisms underlying restorative environmental exposures for healthy urban neighbourhoods.

5 Health and Well-being During Pandemic Lockdowns

Beyond its role in promoting physical activity and mental well-being, urban planning and landscape also proved critical during global public health emergencies, such as during the COVID-19 pandemic (Zhang et al., 2020). For instance, living in compact urban neighbourhoods is considered to have a positive impact on residents' health behaviours. However, the outbreak of the COVID-19 pandemic raised public concerns that high population density might increase the risk of virus transmission and questioned the rationality of

high-density community or 15-minute/20-minute city policies. To address this specific question, we conducted a systematic review in collaboration with experts from the field of public health (Zhang et al., 2022). It aimed to identify, evaluate, and synthesize evidence on the association between the transmission of respiratory viruses (including COVID-19) and population density or other neighbourhood design features. We found that indoor population density is positively correlated with virus transmission. However, published studies vary in their measures of neighbourhood design, leading to inconsistent results for other factors. Therefore, no definitive conclusion could be drawn regarding the association between high population density and virus transmission (Zhang et al., 2022). These findings further strengthen the confidence and determination of governments and the public in implementing compact city and neighbourhood policies.

Furthermore, during pandemic lockdowns, residents' stress levels and various psychological problems increased significantly. During this special period, green spaces within enclosed neighbourhoods became the only accessible green spaces for the general public in China, potentially playing a positive role in alleviating mental stress and maintaining psychological well-being. We found no significant association between exposure to community green spaces and stress levels. Notably, most respondents reduced their outdoor activities and frequency of community green space use during the lockdown. Compared to younger people, older adults generally had lower stress levels, used community green spaces more frequently, and maintained higher participation in outdoor activities (Kang et al., 2022). This study provides a scientific basis for responding to future emergencies. Regarding the management and planning of community green spaces, focusing on the needs and usage characteristics during special periods, optimizing the community environment can provide residents with effective ways to relieve stress.

6 Conclusions

This article combines a diverse body of our studies on the relationship between neighbourhood environments and human health, mainly in Chinese cities, offering both theoretical advancements and practical design recommendations. Our work demonstrates that urban health is inherently shaped by local cultures and societies in relation to everyday life and spatial practices. Incorporating street vending rhythms, informal landscapes, and multi-generational experiences into planning theory creates a holistic framework for urban health promotion. These findings hold global relevance, particularly for rapidly urbanising regions seeking context-sensitive approaches to health and well-being.

Based on our ten-year studies, we propose a sophisticated and timely research agenda to advance the research field of healthy urban neighbourhoods. By synthesizing insights from walkability research, the mental health benefits of green and blue spaces, and lessons learned from pandemic lockdowns, it identifies five mutually reinforcing directions that collectively mark a paradigm shift—from correlational evidence toward causal, multisensory, and life-course understandings of the urban health nexus.

- First, the call to deepen causal mechanisms through longitudinal and intervention studies is both necessary and visionary. Integrating Spatio-Temporal Behaviour Mapping (STBM) with physiological monitoring and Ecological Momentary Assessment (EMA) can capture the immediate psychophysiological signatures of environmental exposure—an approach that promises to move the field beyond static, self-reported correlates. In addition, a life-course perspective introduces temporal depth, enabling scholars to trace how cumulative exposures and life transitions shape long-term health trajectories.
- Second, the emphasis on theoretical integration and cross-context comparison rightly situates healthy urbanism within a socio-ecological framework that connects built form, everyday practices, and emotional well-being. Comparative studies across Chinese and Global South cities can meaningfully diversify a literature still dominated by Western urban models.
- Third, the proposed focus on health equity, scale bridging, and technological innovation is particularly forward-looking. AI-driven diagnostics and large language models open scalable, cost-effective avenues

for understanding environmental quality and public perception, yet must be accompanied by ethical safeguards and interpretive transparency.

•Fourth, the inclusion of multi-sensory experience is an underexplored but crucial step toward a more complete science of environmental perception and restorative design. The use of VR/AR to simulate urban soundscapes, scents, and tactile qualities could redefine evidence-based design for mental health.

•Finally, integrating climate resilience grounds the agenda in global urgency—by linking blue–green infrastructure, thermal comfort, and psychological adaptation to climate stress.

Taken together, these directions establish a compelling vision for twenty-first-century urban health research: one that is empirically rigorous, technologically empowered, and socially equitable. Future studies should integrate mixed-method approaches—including spatial data analytics, physiological monitoring, ethnography, and participatory design—to generate locally grounded, evidence-based planning and design solutions. By aligning walkable urban form, accessible green–blue networks, and community well-being needs, cities can evolve into inclusive, resilient, and psychologically restorative environments, fostering health and well-being in the Anthropocene.

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Acknowledgements

Comments and suggestions from the anonymous reviewers helped improve the scholarly quality of this paper. This work was supported by the Hebei Natural Science Foundation [Grant E2024105062] and the 2024 Open Project of the Key Laboratory of Digital Music Intelligent Processing Technology, Ministry of Culture and Tourism [Grant 2024DMKLB001].

Author Contributions

Ziwen Sun: Conceptualization, Methodology, Writing—Original Draft, Writing—Review & Editing. Zhiyue Zheng: Writing – Review & Editing, Validation. Peiling Zhou: Writing – Review & Editing, Validation.

Use of AI and AI-assisted technologies

During the preparation of this work, the authors used ChatGPT and DeepSeek for language polishing and improvement of readability. After using these tools, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Competing interests

The authors declare no competing interests.