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The design of neighbourhood open spaces to improve mental health: a critical review of restorative spatial characteristics and their applicability in design practice

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ABSTRACT

As urbanisation continues to increase, a rising prevalence of individuals dealing with stress-related mental health issues can be observed. Psychological restoration research can teach designers which spatial characteristics should be implemented in neighbourhood open spaces to enhance psychological restoration and improve citizens' mental health. Unfortunately, this information is scattered across different fields, and it is unclear if the research results can be applied in design practice. Therefore, this study aims to identify restorative spatial characteristics and their applicability in neighbourhood open space design to improve citizens' mental health, and critically reflect upon the current literature to guide future research and design practice. A scoping literature review ($N = 62$) resulted in 32 restorative spatial characteristics that can be applied in design practice. According to the literature, designers should focus on a variety of vegetation, consider the position of design elements, and optimise the design of adjacent buildings to enhance restorative potential. Although more research is needed into the applicability of the currently available information in real-life settings and for a variety of participant groups, this study is a first step in bringing together research of different fields on the design of neighbourhood open spaces that improve mental health of all citizens.

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Introduction

Compared to rural living, urban living is associated with worse physical and psychological health (Peen *et al.* 2010). As urbanisation continues to increase, a rising prevalence of individuals dealing with stress-related mental health issues can be seen (Collado *et al.* 2017, Zhao *et al.* 2020, Roe and McCay 2021). Urban environments can harm citizens' mental health, over-exposing them to environmental stressors by presenting them with information overload, social stress, or low exposure to nature (Evans 2003, Subiza-Pérez *et al.* 2020, Zhao *et al.* 2020). The WHO estimates that globally, 1 in 4 people will be impacted by poor mental health or mental illness (WHO 2022). It is not without reason that governments and major global health agencies increasingly pay attention to the development of inclusive, healthy cities that ensure healthy living and promote well-being for all at all ages, for example, via the WHO Healthy Cities program (WHO 2014) or within the UN sustainable development goals (UN 2015).

The presence of well-designed public spaces supporting mental health can significantly benefit whole populations. Researchers like Bornioli and Subiza-Pérez (2022) and Roe and McCay (2021) argue that psychological restoration research can offer significant insights into designing these mental health-promoting public spaces. The field of restorative environment research is guided by two major theories: the Attention Restoration Theory (ART) (Kaplan and Kaplan 1989) and the Stress Reduction Theory (SRT) (Ulrich 1983). Both theories propose that certain environments can reduce stress and renew or recover adaptive resources, thereby promoting psychological well-being through the process of psychological restoration (Ulrich *et al.* 1991, Kaplan 1995, Staats 2012, Hartig *et al.* 2014). Both theories propose characteristics for environments so that psychological restoration can occur. The Attention Restoration Theory suggests four environmental characteristics (Kaplan and Kaplan 1989, Kaplan 1995): 1) Compatibility refers to the perceived fit between the environment and the individual's needs. 2) Fascination refers to the environment's capability to catch one's attention involuntarily and not demand mental effort. 3) Extent refers to properties of connectedness; the environment feels like a whole and

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promises to engage one's mind. 4) Being away refers to the escape from everyday routine pressures and obligations. The Stress Reduction Theory proposes seven different environmental characteristics for restorative environments: 1) Complexity – a balance between structured and unstructured elements, 2) Structural properties, 3) Depth, 4) Ground surface, 5) Deflected vista, 6) Absence of threat, and 7) Presence of water (Ulrich 1983, Ulrich *et al.* 1991, Staats 2012). Despite these differences, both theories are often used simultaneously to research the mental health effects of restorative environments (Staats 2012).

However, both theories emphasise the restorative value of natural environments, leading to a substantial research focus on these environments (Staats 2012, Berto 2014, Hartig *et al.* 2014). Urban environments (un)consciously obtained a more negative image (Lindal and Hartig 2013, Weber and Trojan 2018). If urban environments were researched, they were often part of the urban vs. nature dichotomy. Studies failed to reflect on the diversity found in both types of environments, leading to an overestimation of the restorative value of some natural environments and the underestimation of the restorative value of some urban settings (Staats 2012); for example, beautiful parks were compared with back alleys or parking lots giving a distorted image (Velarde *et al.* 2007, Korpela 2013). As a result, most research focuses on the restorative potential of natural environments, and less is known about how to design restorative urban spaces. While for citizens, visiting these restorative natural environments, like forests or large urban parks, can be challenging due to time constraints, mobility issues or monetary reasons (Weber and Trojan 2018). Especially for more vulnerable citizen groups like the rapidly ageing population or people with low socio-economic status (Boyd *et al.* 2018, Schmidt *et al.* 2019). At the same time, citizens have a need for psychological restoration. Too few possibilities for restoring resources in daily life can lead to prolonged stress reactions, eventually leading to mental illnesses like depression (Collado *et al.* 2017). This need for restoration became especially evident during the COVID-19 pandemic (Lõhmus *et al.* 2021, Pouso *et al.* 2021, Meuwese 2022). People had fewer opportunities to escape daily hassles and were resigned to their immediate home environment. In these cases, well-designed restorative neighbourhood open spaces close to people's homes become increasingly important for citizens to restore their psychological resources and maintain well-being and mental health (San-Juan *et al.* 2017, Schmidt *et al.* 2019, Subiza-Pérez *et al.* 2020).

This urgency to (re)design our rapidly growing cities to support psychological restoration and thereby improve the mental health of all citizens has fuelled interest in research into the restorative potential of neighbourhood open spaces. Subsequently, increasing research interest in the restorative potential of urban environments out of the urban vs. nature dichotomy can be seen, as Weber and colleagues (2018) showed in their extensive literature review. These upcoming studies show that urban environments, including neighbourhood open spaces such as streets and plazas, can indeed offer restoration to the urban population (e.g. San-Juan *et al.* 2017, Ríos-Rodríguez *et al.* 2021). On the one hand, these results are positive news for designers involved in inclusive, healthy city design. Research now provides evidence that neighbourhood open spaces can indeed offer restoration to citizens. Making it possible to put restorative urbanism more at the forefront of city planning and urban design (Roe and McCay 2021).

On the other hand, simply acknowledging the potential of neighbourhood open spaces for restoration is insufficient information for designers. What ignites their creativity is uncovering the unique spatial characteristics that enhance restoration in neighbourhood open spaces. However, until now, little attention has been paid to the spatial characteristics that increase the restorative potential of neighbourhood open spaces (Weber and Trojan 2018, Bornioli and Subiza-Pérez 2022). From the perspective of the Attention Restoration Theory and Stress Reduction Theory, it is known that natural spatial characteristics (e.g. trees, flowers, and water) will offer restoration (Hartig *et al.* 2014). However, neighbourhood open spaces consist of more than natural characteristics. The spaces are complex environments, including landscape, infrastructure, and architectural characteristics (Hunter and Askarinejad 2015, Bornioli and Subiza-Pérez 2022). Gradually, evidence arises that these other spatial characteristics found in neighbourhood open spaces can also offer restoration (Lindal and Hartig 2013, 2015, Weber and Trojan 2018). For example, Lindal and Hartig (2013; 2015) found that architectural variation and building height positively influence a street's restorative potential. Spatial characteristics like roofline silhouette, surface ornamentation and number of floors could explain restorative potential. Even independent of the overall amount of vegetation, suggesting that the architecture of buildings can influence the restorative potential of environments, even in urban spaces with limited vegetation (Lindal and Hartig 2015). These findings suggest that spatial characteristics of neighbourhood open spaces are even more important for psychological restoration than is often assumed. Furthermore, these findings illustrate the importance of placing research interest not only on which types of environments offer restoration but also, in more detail, which spatial characteristics of those environments promote restoration (Bornioli and Subiza-Pérez 2022). This information can guide designers in designing restorative

neighbourhood open spaces that improve the mental health of all citizens.

Due to the recent increase in interest regarding restorative neighbourhood open spaces and because of the tendency to conduct research per type of environment, information about restorative spatial characteristics of neighbourhood open spaces is spread across various disciplines, like landscape design, environmental psychology, and leisure sciences (Joye and Van Den Berg 2012, Staats 2012, Weber and Trojan 2018). This scattering of research makes it difficult to determine whether the current research available about restorative spatial characteristics of neighbourhood open spaces is sufficient and applicable for designers to apply in design practice. Therefore, this study aims to identify restorative spatial characteristics and their applicability in neighbourhood open space design to improve citizens' mental health, and critically reflect upon the current literature to guide future research and design practice. In order to facilitate this goal, a scoping literature review was performed. The scoping review method allows us to review emerging studies from various fields and construct an overview of existing research, allowing us to map out the spatial characteristics of neighbourhood open spaces that can promote psychological restoration (Arksey and O'Malley 2005, Levac *et al.* 2010) and critically reflect on the current state of literature identifying research gaps and guide future research and design practice on the design of restorative neighbourhood open spaces to promote mental health of all citizens.

Method

Study design

The scoping review was carried out according to the five-step approach defined by Arksey and O'Malley (2005) and adjusted by Levac *et al.* (2010). The first step, identifying the research question, is presented in the introduction. The four sequential steps are described below. All authors discussed procedures to ensure consistent search methodology, and the PRISMA-ScR checklist was followed to ensure clarity of reporting (Tricco *et al.* 2018).

Study identification

A comprehensive search of literature was conducted in January 2023 to understand and critically reflect upon the current state of the literature on restorative spatial characteristics of neighbourhood open spaces. Studies were identified via different search engines: Scopus, PubMed, Google Scholar, Web of Science and Psynet. The search range of papers was set for studies published in the last decade to control search results. Search terms were arranged according to three key themes of the research question: psychological restoration, neighbourhood open space, and mental health (Table 1). The terms were used to make several search strings. Each string used at least one of the key themes' search terms, for example ('perceived restoration') AND ('pocket park') AND ('attention fatigue'). Furthermore, we tried to find additional papers or book chapters by scanning publication lists of well-known authors to prevent publication bias. Additionally, we looked at the backlog of essential journals in the field, such as Landscape and Urban Planning, Landscape Research, Journal of Environmental Psychology, and Cities and Health.

Screening and study selection

In total, 5968 records were identified by the first author (Figure 1). After removing duplicates, 5336 papers were nominated for title selection. First, removing non-English titles and non-original works, theses, not-peer-reviewed works, and reports resulting in 3045 titles for further selection. Hereafter, iterative selection cycles were performed with all three authors. In the first selection cycle, titles were selected based on two inclusion criteria: mental health and neighbourhood open spaces. 1448 titles remained; therefore, an extra selection cycle was performed. Titles were selected on the more specific inclusion criteria of psychological restoration (including attention restoration and stress reduction). Hereafter, the abstract selection was performed on 233 abstracts. At the start of the abstract selection, the first author used a random number generator to select 30 titles. Then, inclusion/exclusion decisions were discussed and agreed upon among all authors. After that, abstracts were selected based on three inclusion criteria: 1) psychological restoration needed to be discussed following the Attention Restoration Theory or Stress Reduction Theory theory. Therefore, other forms of restoration were excluded from the study (e.g. building, dental, and nature area restoration). 2) The studied environment is a neighbourhood open space, a publicly accessible outdoor urban space. 3) We

Table 1. Search items used in the search per key theme.

Psychological restoration	*Restoration likelihood; Restorative experiences; Restorative potential; Perceived restoration; Restorative environment*
Neighbourhood open space	*Street, Pocket park, Small Urban Green Space; Urban park, Neighbourhood open space, Public open space, Public space, Square, Plaza, Recreational area, Architecture, Design, Urban environment, Built environment, Urban, Landscape design, Landscape*
Mental health	*Stress, Well-being, Attention fatigue*

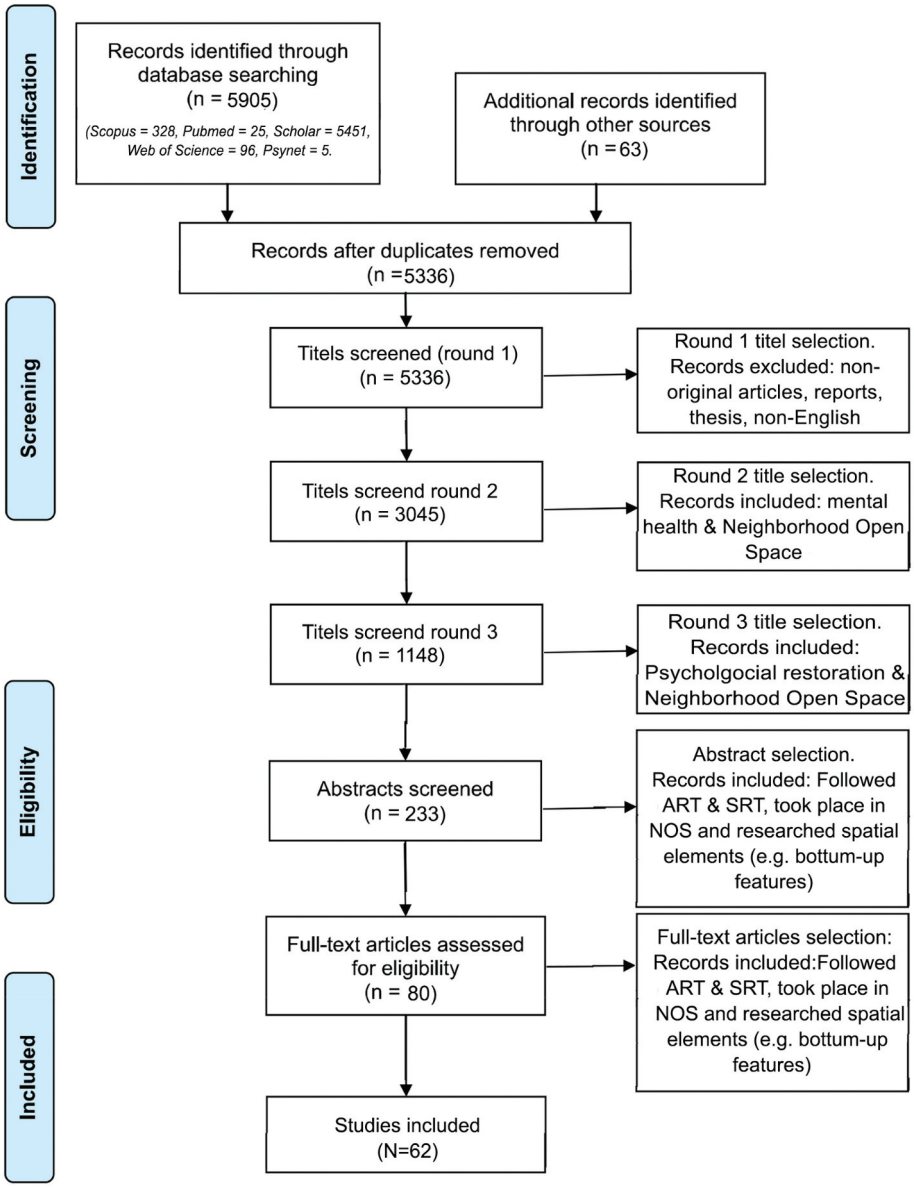

Figure 1. Flow chart of the paper selection process. Based on PRISMA (2020) flow diagram for scoping reviews.

selected studies researching spatial characteristics that can be used in design and promote restoration, also called bottom-up elements (Bornioli and Subiza-Pérez 2022). These are elements whose restorative potential resides in the perceptual characteristics of the object itself. Studies only researching the urban vs. nature dichotomy or focusing only on top-down features (e.g. personal experiences and perceptions) were excluded from this study. Eventually, 80 papers were included for full paper analyses. During the full paper analyses, the previously described selection criteria were also considered, resulting in a total of 62 studies included in this review (Figure 1).

Data charting

Following the scoping literature review method (Arksey and O'Malley 2005, Levac *et al.* 2010), the next step was setting up a data charting table (Appendix A, Table A1). Papers were grouped according to the data charting table: auteur, year, country, type of environment, research type, theory background, research methods, psychological restoration measures, and participants' characteristics. These data were used for descriptive and comparative paper analyses (Arksey and O'Malley 2005, Onwuegbuzie *et al.* 2012).

Analysis and description of the data

Collation, summarising and analysis

After completing the data charting table (Table A1), a qualitative content analysis was performed (Hennink *et al.* 2020). The analytic software ATLAS.ti was used to code, sort and categorise the data and to conduct the paper analyses in a structured way (Smit & Sherman, 2021). The first author read and re-read

the papers several times. While reading the data, sentences or text sections describing restorative spatial characteristics were highlighted as code in a bottom-up approach. The authors selected spatial characteristics that significantly influenced the psychological restoration process, reducing attention fatigue, stress or enhancing restoration likelihood. Multiple coding cycles were completed, resulting in 104 codes. All authors further analysed and discussed the coded data, which led to the results of this research.

Description of the data

In this section, we present the descriptive data of the 62 reviewed studies included in this review to get more insight into the current state of literature and the data leading to the results presented in Section 4.

The selected studies were published in 23 journals from various research fields. Most studies were published in Urban Forestry and Urban Greening ($N = 9$), International Journal of Environmental Research and Public Health ($N = 8$), and Frontiers in Psychology ($N = 6$). This scattering of publications indicates the broad distribution of research about restorative spatial characteristics of neighbourhood open spaces in various research fields. The scoping review method allowed us to bring this scattered research together. When analysing the publication dates of the reviewed studies, a recent increase in published studies can be seen, indicating a growing interest in restorative neighbourhood open spaces (Figure 2).

The reviewed works studied six types of neighbourhood open spaces: squares, streets, small urban green spaces, pocket parks (<0.5 Ha), play/school areas and cemeteries. The more nature-oriented environments (i.e. small urban green spaces and pocket parks) were mainly researched. The focus on these types of neighbourhood open spaces aligns with classic, nature-focused restorative environment research (Weber and Trojan 2018). However, in more recent publications, an increase in studies researching built-focused environments (e.g. streets, squares) can be seen. For example, 38% in 2022 and 58% in 2021 of the reviewed studies were non-nature-oriented built environments compared with 25% and 27% the years before.

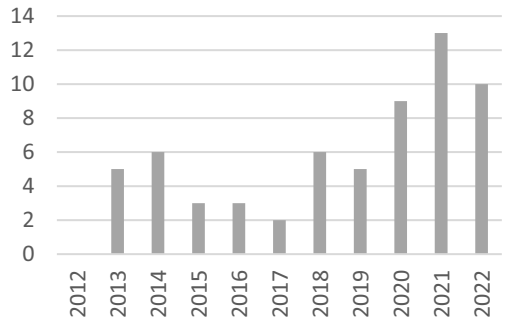

Figure 2. The number of publications per year.

Delving into the research design of the selected studies, it can be seen that most studies used quantitative methods to measure the effect of spatial characteristics on the restorative potential of neighbourhood open spaces. Only three used qualitative methods, and nine used mixed methods. Restoration can be measured using a variety of methods. Which methods are used depends on the theoretical background authors embrace. Studies adherent to the Attention Restoration Theory ($N = 43$) used attention tests (e.g. digit span backwards) or validated questionnaires (e.g. Perceived Restoration Scale and Short Version Revised Restoration Scale) to measure restoration. Studies adherent to the Stress Reduction Theory ($N = 2$) used physiological measures (e.g. skin conductance) to measure restoration. Seventeen studies used a mix and implemented attention restoration and stress reduction measures.

Moreover, a remarkable fact about the research design of the reviewed studies is that more than half were performed online or in a laboratory setting, where the measures relied on photos, videos, or VR environments for evaluation.

Another outstanding methodological choice is the homogeneity of participant samples. 32 of the 62 studies were performed with young adults as participants, of which 21 consisted wholly of university students (Figure 3). Studies were mostly often performed with highly educated and healthy participant groups. Hardly any studies were performed with potentially vulnerable population groups. Of the reviewed studies, only three focused on older adults (Fumagalli *et al.* 2020, Qiu *et al.* 2021, Lu *et al.* 2022), four were performed with children (Bagot *et al.* 2015, Paddle and Gilliland 2016, Akpınar 2021, Bai *et al.* 2022) and two focused on low socio-economic status (Bagot *et al.* 2015, Paddle and Gilliland 2016).

Thus, although the included studies come from different fields, similarities between the selected studies are noticeable. Most studies use quantitative methods to measure the restorative potential of neighbourhood open spaces ' spatial characteristics in laboratory or digital settings. Also, participant samples are similar, consisting of healthy, highly educated young adults.

Results: the restorative spatial characteristics of neighbourhood open spaces

The following section will present the restorative spatial characteristics that promote citizens' mental health when applied in neighbourhood open space designs according to the reviewed literature. The characteristics are presented in three categories: natural, landscape, and architectural characteristics. Alongside

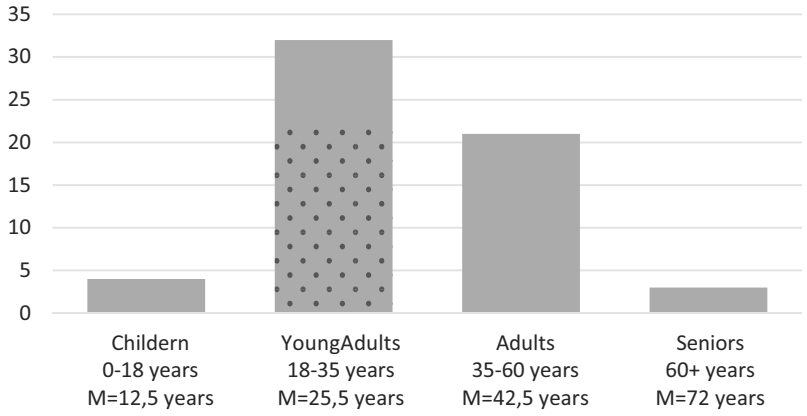

Figure 3. The number of studies performed for every age group. The dotted graph represents studies exclusively performed with university students.

listing the spatial characteristics, we try to make the literature applicable to designers by offering impressions on how to implement the restorative spatial characteristics into neighbourhood open space designs.

Natural characteristics

As is known from classic restoration literature, nature or natural spatial characteristics significantly influence the restorative likelihood of environments, which is also confirmed by the reviewed studies (e.g. Deng *et al.* 2020, Lai *et al.* 2020, Akpınar 2021). Two-thirds of the reviewed studies researched one or more natural spatial characteristics and their restorative potential. Eleven of these characteristics significantly impacted the restorative potential of neighbourhood open spaces (Table 2).

Vegetation

There is sufficient evidence in the literature that the presence of vegetation in neighbourhood open spaces significantly influences restoration and thereby improves citizens' mental health (Lindal and Hartig 2015, Zhao *et al.* 2020, Hidalgo 2021). However, designers must be cautious not to incorporate excessive vegetation in their designs, as this can negatively impact restoration potential. Lu and colleagues (2022) found that the presence of vegetation is U-shaped in relation to psychological restoration. On the one hand, vegetation can offer refuge and a place to relax (Tabrizian *et al.* 2018, Qiu *et al.* 2021). On the other

Table 2. Overview of the natural elements that were researched in the reviewed studies. Italic characteristics have no significant relation. They are only strongly associated with psychological restoration. (Source numbers see Appendix A, Table A1).

Natural characteristics	Connection to ART components	Connection to SRT components
Animals (presence) [10;17;20]	*Being-away [20]*	*Impacts feelings of safety [17]*
Animals (sound) [25; 40; 43; 55; 62]	Being-away [40]	Impacts feelings of safety [40]
Aquatic plants [62]		
Biodiversity of vegetation [15; 31; 39; 41; 53; 54; 56; 58; 61]	Fascination [20] Extent [32]	Enhance the complexity of the scene [15; 32]
Bushes [21; 26; 38; 46]	Being-away [21; 32] Compatibility [21] Scope [21]	
Flowers [18; 24; 37; 46; 59]	Being-away [24; 59] Fascination [5; 24; 59]	
Tree (general) [5; 8; 12; 16; 18; 22; 26; 39; 44; 46; 47; 49; 53; 59; 61]	Being-away [5; 24; 59] Fascination [5; 24; 59]	
Tree (density) [45; 51; 53]		*Impacts feelings of safety [45]*
Tree (positioning) [17; 24; 51]		*Impacts feelings of safety [17]*
Tree (size) [24]		
Vegetation (general) [7; 10; 14; 21; 24; 37; 38; 43; 46; 53; 57; 59; 58; 61]	Fascination [21; 43] Coherence [21] Compatibility [21]	Enhance the complexity of the scene [45] Impacts feelings of safety [20; 41; 40]
Water (general) [7; 15; 17; 21; 26; 29; 31; 34; 37; 38; 45; 46; 47; 52; 56; 62]	Fascination [17; 21; 32] Compatibility [32; 45] Extent [45] Being away [21; 45]	Presence of water [17] Structural property [17] Depth [17] Enhance the complexity of the scene [17]
Water (% land covered by water) [56; 62]		
Water (accessibility) [62]		
Water (sound) [25; 34; 37; 40; 44; 46; 55; 60; 62]		Impacts feeling of safety [25; 40]
Water (visual naturalness) [62]		

hand, too much (unmaintained) vegetation can give feelings of enclosure and reduce safety perception, negatively affecting restoration (Lai *et al.* 2020, Qiu *et al.* 2021, Yin *et al.* 2022). Not only does the mere presence of vegetation influence the restorative potential of environments, but the biodiversity in the environment has an effect. The number of species of plants (e.g. trees and evergreens) and animals (e.g. birds and insects) are significant factors in increasing the restorative quality of neighbourhood open spaces (Wood *et al.* 2018, Zhao *et al.* 2020, Luo *et al.* 2022). In addition, biodiversity can increase (visual) complexity, generate fascination, and promote exploration to restore attention (Andreucci *et al.* 2019, Lai *et al.* 2020, Huang *et al.* 2021, Luo *et al.* 2021).

Furthermore, different types of vegetation can have different effects on restorative potential. For example, researchers found that flowers significantly influence the restoration potential of neighbourhood open spaces because they increase fascination and feelings of being away (Nordh *et al.* 2013, Lindal and Hartig 2015). Also, trees can significantly influence restorative quality (Lin *et al.* 2014, Elsadek *et al.* 2019). Like flowers, trees can increase fascination and being away. Authors contribute this to the play of light generated by the foliage of trees. It enhances the mystery and fascination of a place and makes people feel like they are in another world (Hunter and Askarinejad 2015, Feizi *et al.* 2022). Some researchers even explored different tree types and found that the Metasequoia, Sakura, London Plane trees, G. Biloba and S. Japonica trees had more restorative effects than others (Elsadek *et al.* 2019, Guo *et al.* 2019).

After reviewing the literature, we recommend that designers add vegetation to their restorative neighbourhood open space designs (Figure 4). Adding various vegetation types, such as flowers and trees, enhances feelings of mystery and fascination (Nordh and Østby 2013, Elsadek *et al.* 2019). Varied vegetation can enhance exploration and stimulate feelings of being in another world, giving a break from 'ordinary' life and giving a place and time to relax. However, a balance between vegetation and built elements is needed. Too much vegetation can negatively affect a space's restorative potential because of impaired feelings of safety.

Water

According to the Stress Reduction Theory, one of the spatial characteristics that increases restorative potential is the presence of water (Ulrich 1983). The reviewed literature shows that the presence of water also enhances restoration in neighbourhood open spaces (Masullo *et al.* 2021). Water promotes the complexity of the environment (Hunter and Askarinejad 2015) and enhances fascination and extent factors (Luo *et al.* 2021, Li *et al.* 2022) (Figure 4). Not only the visual presence of water but also water sounds can enhance restoration (Zhao *et al.* 2018, F. Liu *et al.* 2022, Xie *et al.* 2022). However, it is important to take into account that the presence of water should not impair the environment's compatibility; otherwise, it reduces restorative quality (Luo *et al.* 2021, Qiu *et al.* 2021). Making water bodies easily accessible,

Figure 4. Impression of a restorative neighbourhood open space with natural characteristics that significantly enhance the environment's restorative quality. Image by the authors.

for example, by using a platform (Figure 4), can enhance compatibility and, therefore, positively affect the restorative potential of the neighbourhood open space.

Landscape characteristics

During the review, it becomes clear that not only natural but also landscape characteristics play a role in the restorative potential of neighbourhood open spaces and the positive impact on citizens' mental health. In the reviewed literature, 12 of these landscape elements were found to significantly influence the restorative potential of neighbourhood open spaces (Table 3).

Landscape terrain

According to the reviewed studies, differences in topography, for example, a slight slope in the terrain, would enhance fascination and significantly influence the restorative quality of neighbourhood open spaces (Peschardt and Stigsdotter 2014, Huang *et al.* 2021). Furthermore, a slight slope could enhance views and contribute to the environment's good prospect/refuge balance (Deng *et al.* 2020, Yin *et al.* 2020). However, the height differences should not be too major; otherwise, they will constrain accessibility and safety perception of space, negatively influencing compatibility (Zhao *et al.* 2018, Deng *et al.* 2020). Figure 5 gives an impression of how designers could use gradual slopes in neighbourhood open space designs to enhance restoration.

Another landscape characteristic that is presented in literature as restorative is ground cover. This characteristic is one of the original restorative components proposed by the Stress Reduction Theory (Ulrich 1983). Researchers also found that in neighbourhood open spaces, material and colour of the ground cover can have restorative effects (Nordh and Østby 2013, Peschardt and Stigsdotter 2014, Gu *et al.* 2021). For example, green-painted streets were more restorative than red or blue-painted surfaces (Gu *et al.* 2021). Also, grass can enhance the restorative quality of neighbourhood open spaces, although not in all cases (Nordh *et al.* 2013, Lu *et al.* 2022). Large grass areas negatively influenced restorative potential probably because people felt too exposed (L. Qiu *et al.* 2021, L. Liu *et al.* 2022). Furthermore, types of pavement can also enhance restoration, for example, wooden walkways or decorated pavement (Deng *et al.* 2020). However, the same applies here. Too many hard surfaces negatively influence restorative quality. It is, therefore, essential to balance hard and

Table 3. Overview of the landscape characteristics that were researched in the reviewed studies. Italic characteristics have no significant relation. They are only strongly associated with psychological restoration. (Source numbers see Appendix A, Table A1).

Landscape characteristics	Connection to ART components	Connection to SRT components
Art [1; 7; 17; 55; 56]	Fascination [1] Extent [1] Being away [1]	*Focal point/landmark [17; 33]*
Fountain [17; 55] *Garbage bin [17]*		
Ground cover (colour) [11]	Being away (Green, Blue) [11] Fascination (Green, Red neg. [11]	
Ground cover (material) [7; 21; 25; 30; 33; 46; 52]	Fascination [15] Coherence [21] Compatibility [21] Being away [21]	Complexity [17] Depth [17] Ground cover (SRT) [17] Impacts feelings of safety [51]
Market stall [50] *Parking space [50]*	Fascination *[50]* Compatibility *[50]* *Being away [50]* *Extent [50]*	
Paths [20; 39]	Being away [20] Compatibility [20]	Impacts feelings of safety [20]
Powerlines [61]		
Seating [1; 5; 30; 46; 56]	Compatibility [1; 5] Being away [1] Extent [1] Fascination [1]	Impacts feelings of safety [30]
Side borders [20; 57]		Impacts feeling of safety *[20; 57]*
Street lighting [14; 17; 36; 40; 53]	Compatibility [36] Being away [36] Fascination [36] Extent [36]	Impacts feelings of safety packer 2014 [17; 36]
Site facilities (general) [30; 54; 58]		
Table (neg.) [44]		
Traffic (general) [5; 6; 11; 15; 17; 19; 37; 38; 43; 44; 46; 52; 55; 57; 59; 61]	Being away (neg.) [60]	Impacts feelings of safety [5; 17; 61]
Traffic signs [61]		Impacts feelings of safety [61]
Topography [7; 15; 43; 44; 57; 62]	Fascination [43]	Complexity [7] Ground cover [7] Impacts feelings of safety [62]

Figure 5. An impression of a restorative neighbourhood open space with landscape characteristics that enhance the environment's restorative quality. Image by the authors.

soft ground covers and balance the presence of vegetation (grass), accessibility and feelings of exposure.

Infrastructure

A difference between nature and urban environments, like neighbourhood open spaces, is often the infrastructure. In urban environments, motor vehicles are much more present in the space. Roads with much motor traffic negatively influence restoration (Nordh and Østby 2013, Bornioli *et al.* 2018). This negative effect is related to noise pollution. Traffic sounds bring people back to reality, negatively affecting feelings of being away (Zhang *et al.* 2019). Traffic also can negatively impact feelings of safety, reducing the restorative quality of neighbourhood open spaces (Zhao *et al.* 2020). In the reviewed literature, it is recommended that designers design designated pedestrian paths and traffic signs that positively affect restoration (Zhao *et al.* 2020) (Figure 5). Clear paths can enhance accessibility and feelings of being away and increase safety perceptions (Lai *et al.* 2020).

Site facilities

Several researchers examined whether site facilities impact the restorative quality of neighbourhood open spaces. Seats were proven to have a positive effect, although results varied. Whether seats positively affect the restorative quality of neighbourhood open spaces is prompted by the quality, position, and number of seats available (Abdulkarim and Nasar 2014, Barros *et al.* 2021). The availability of seats can enhance compatibility and offer a moment of relaxation, promoting restoration (Barros *et al.* 2021, Lu *et al.* 2022). Additionally, well-positioned seats can close off certain 'negative' elements like the view on a traffic road and thereby enhance feelings of being away (Lu *et al.* 2022). Indirectly, seats enhance the time people spend in a space, enhancing restoration possibilities, especially for vulnerable citizen groups like older adults (Lu and Fu 2019, Lai *et al.* 2020, Lu *et al.* 2022). For designers, adding seats to increase the restorative potential of neighbourhood open spaces can be a good step. Especially if the seating areas are semi-sheltered and offer peace and quiet in busy neighbourhoods (Figure 5).

Another element designers could implement into the restorative neighbourhood open spaces design is moderate lighting levels by streetlights. Nikunen and colleagues stated that moderate lighting can add to the compatibility of the environment and generate fascination, extent and feelings of being away by generating light play (Figure 5).

Furthermore, art objects can also positively contribute to the restorative quality of neighbourhood open spaces. For example, Abdulkarim and colleagues (2014) and Xu and colleagues (2018) found that sculptures improve the restorative quality of urban plazas. Also, poetry walls and historical or cultural objects can enhance restorative quality (Deng *et al.* 2020, Martínez-Soto *et al.* 2021, Xie *et al.* 2022). Art objects can thus be incorporated into Neighbourhood Open Space design to enhance restoration (Figure 5).

Peschardt & Stigsdotter (2014) found that tables had a negative effect on the restorative quality of neighbourhood open spaces. They suggested that this is because tables enhance social interaction activities that counteract spaces' restorative potential (Peschardt and Stigsdotter 2014).

No significant restorative qualities were found on other site facilities like food stalls, garbage bins and playgrounds (Abdulkarim and Nasar 2014, Lorenzo

et al. 2016). So, for now, we cannot recommend adding these elements to neighbourhood open space designs, more research is needed to confirm if these elements influence restorative potential.

Architectural characteristics

Lastly, we present architectural spatial characteristics that, according to literature, impact the restorative quality of neighbourhood open spaces (Table 4). When architects and urban designers design spaces, they often talk about spatial characteristics in more abstract terms, for example, enclosure and spaciousness. In some reviewed studies, researchers explored whether these more conceptual but spatial architectural characteristics impact restorative potential and thereby improve mental health of citizens.

Prospect and refuge

The most researched architectural spatial characteristics are prospect and refuge (e.g. Hunter and Askarinejad 2015, Deng *et al.* 2020). Studies demonstrate that refuge can stimulate restoration by offering a certain level of privacy, safety and enclosure, which can enhance feelings of entering a whole other world (e.g. Akpınar 2021, Barros *et al.* 2021, Xie *et al.* 2022). Additionally, some authors state that the spatial characteristic prospect can offer fascination and, thereby, restorative effects by offering sightlines through permeable facades or vegetation (Tabrizian *et al.* 2018, Barros *et al.* 2021). These two spatial characteristics need to be balanced. Too much prospect in a space, for example, when standing on a large lawn or walking along an open lake without shelter, has a negative effect on the restoration potential of a space (Zhao *et al.* 2018, Qiu *et al.* 2021, L. Liu *et al.* 2022). This is probably due to compromised feelings of safety and fewer opportunities for exploration, reducing fascination and thereby negatively affecting the restoration qualities of a space (Zhao *et al.* 2018, Qiu *et al.* 2021, L. Liu *et al.* 2022). These feelings of safety also play a role in the spatial characteristic of refuge. For example, Tabrizian and colleagues (2018) found that the restorative ratings were higher in a plaza enclosed by buildings on four sides, thus offering refuge, than in plazas only enclosed by buildings on one or two sides. Conversely, restoration levels dropped significantly in a park with vegetation on four sides. While the one- and two-sided enclosed park settings did yield restorative effects (Tabrizian *et al.* 2018). Tabrizian and colleagues (2018) suggest that these differences are due to the mediator safety. High degrees of enclosure in a park can reduce safety through a lack of control and escape options, while an enclosed urban plaza can offer shelter from busy city life (Tabrizian *et al.* 2018). Thus, authors suggest that enclosure by buildings or structures can offer feelings of safety, opportunities for exploration and fascination, thereby positively affecting the restoration qualities of a space (Zhao *et al.* 2018, Qiu *et al.* 2021, L. Liu *et al.* 2022). Figure 6 gives an impression of different design options for designers to generate prospect and refuge in neighbourhood open space designs to enhance restorative potential, for example, by adding seating, sightlines, and a certain level of enclosure. Creating places to retreat in a safe and private place but with sightlines to oversee the environment can be perfect for restoring attention and reducing stress.

Table 4. Overview of the architectural characteristics that were researched in the reviewed studies. Italic characteristics have no significant relation. They are only strongly associated with psychological restoration (Source numbers see Appendix A, Table A1).

Architectural characteristics	Connection to ART components	Connection to SRT components
Biophilic materials [33]		
Building arrangement [17; 30]		*Depth cues [17]* *Deflected vistas [17]*
Building design (Aesthetics) [5; 18; 19; 20; 24; 37; 46]	Fascination [20] Compatibility [20]	
Building presence [21]	Being away [21] Compatibility [21]	
Building height [23; 60]	Being away [23; 60]	
Colour [11; 30; 41; 56]	Fascination [11; 56]	
Complexity [9; 19; 23]	Extent [19; 23]	Complexity [19; 23]
Decoration [18]		
Entropy (facade variation) [5; 17; 23]	Being away [23] Fascination [5; 23]	Complexity [23]
Horizontal line position [17]		*Depth perception [17]*
Permeability of façade [5]	*Fascination [5]*	
Physical permeability (enclosure/openness) [4; 26; 30; 31; 37; 45; 46; 49; 51; 53; 55; 58]	Extent [37]	Feelings of safety [7; 37; 51]
Place of refuge [2; 4; 5; 7; 20; 29; 37; 40; 43; 45; 51; 53; 55]	Compatibility [29]	Impacts feelings of safety [2; 29; 51]
Shadow (play of light) [17; 36]	*Coherence [17]* *Fascination [36]*	*Complexity [17]* *Depth cues [17]*
Skyview [17; 18; 30; 33]		Depth perception [17]
Visual permeability (e.g. prospect) [2; 5; 7; 29; 30; 31; 33; 37; 40; 43; 44; 45; 46; 49; 51]	Extent [29] *Fascination [5; 51]*	Impacts feelings of safety [7; 45; 49]

Figure 6. Impression of a restorative neighbourhood open space with architectural characteristics that enhance the environment's restorative quality. Image by the authors.

Building design

Alongside the design of prospect and refuge, building design and building position can also influence the restorative potential of neighbourhood open spaces (Nordh *et al.* 2013, Lindal and Hartig 2015, Barros *et al.* 2021). Lindal and Hartig (2013, 2015) found, for example, that buildings with one story, façade details, and peaked roofs had high restoration scorings. However, buildings labelled as ugly by participants, like modern urban mass-produced architecture, were found not to be restorative (Korpela 2013). This effect could be related to aesthetically pleasing buildings having higher levels of fascination and compatibility and, therefore, a positive restorative effect (Lai *et al.* 2020).

Lindal and Hartig (2013) explored different aspects of building designs to determine whether they influenced restoration potential. They found that entropy – architectural variation in the façade – significantly affects the restorative quality of neighbourhood open spaces. Adding windows, façade details, setbacks and entrances in a façade enhances the complexity and engages attention for exploration and discovery (Lindal and Hartig 2013, Barros *et al.* 2021) (Figure 6). Furthermore, entropy enhances fascination and feelings of being away, thereby increasing the space's restorative potential (Lindal and Hartig 2013). They also found that building height is significantly correlated with restoration likelihood. Higher buildings give higher feelings of enclosure and, therefore, negatively affect restoration. However, in some cases, the adverse effects of extra floors could be reduced by the increased entropy that high-rise buildings can offer (Lindal and Hartig 2013).

Potentially also other elements like biophilic materials (Martínez-Soto *et al.* 2021), horizontal line position (Hunter and Askarinejad 2015), or permeability of the façade (Barros *et al.* 2021) could also play a role in enhancing the restorative potential of urban spaces. More research is needed to confirm these hypotheses.

Discussion

Strengths and limitations of the study

A strength of the scoping review methodology is its ability to provide a comprehensive overview of the literature. The method is particularly well-suited for synthesising research from diverse fields but centring on a common theme (Arksey and O'Malley 2005, Levac *et al.* 2010). Using this methodology allowed us to bring diverse research together, identify spatial characteristics to inspire designers and find research gaps to guide future research. To bolster the credibility of this interdisciplinary study, an extensive search strategy was deployed across multiple databases, and the study identification and selection process underwent a rigorous double review.

However, it is important to acknowledge that this literature review exclusively focused on the spatial

characteristics of restorative neighbourhood open spaces. Intangible elements, also called top-down elements like place attachment and social interaction, can also affect the restorative potential of neighbourhood open spaces (Bornioli and Subiza-Pérez 2022). These top-down elements enable restorative processes dependent on the observer's inputs. They can boost the restorative experiences if individuals actively engage with cultural or social landscapes (Lai *et al.* 2020, Barros *et al.* 2021), triggering, for example, place attachment and sense of belonging (Weber and Trojan 2018, Lu and Fu 2019). Future research can be done to get more insights into these top-down elements and how they relate to more tangible elements of restorative neighbourhood open spaces (Table 5).

Furthermore, when critically evaluating the methods of the reviewed studies, certain issues arise that can compromise the usability of the research on restorative spatial characteristics in design practice.

Firstly, it is important to notice that most studies are performed in laboratory settings. 38 of 62 studies were not performed in real-life environments. Twenty-eight of these studies used a purely visual method – photo evaluation – to measure the restorative spatial characteristics of neighbourhood open spaces. The choice to use photo evaluation in laboratory settings is an understandable decision because researchers can better control variables and confounding factors in lab studies. In real-life environments, variables like lighting, sounds and people present can change (Acemyan and Kortum 2018). Furthermore, lab studies are often more economical to perform and can be carried out in any location as opposed to having to take participants to a particular space (Ellard 2017, Acemyan and Kortum 2018). However, it must be considered that an urban environment is complex. For example, walking down a street is a dynamic experience which is challenging to imitate with photos. People's spatial perception is different when looking at photos than in real-life environments (Zhao *et al.* 2020). Some researchers respond to this methodological limitation by applying new technologies such as high-performance graphical display technologies or realistic virtual reality environments (Lindal and Hartig 2013, 2015, Huang *et al.* 2020). Research shows that virtual environments can have a restorative effect; however, these effects are not always translatable to real-life environments (Ünal *et al.* 2022). That is why designers and researchers should be careful when extending the results of lab studies to real-life landscape designs without additional in situ testing.

The second methodological issue that arises is the homogeneity of participant samples. More than half of the studies were performed with young adult participant groups. Twenty-one samples even consisted wholly of university students. Understandably, university students are often recruited for these types of studies due to the facility of recruitment, lower costs and assumed lower response bias (Hanel and Vione 2016). However, generalising results from student participants to the general public can be problematic and must, therefore, be done with care (Hanel and Vione 2016). Especially because the few studies done with other participant groups show differences in restorative experiences. For example, Akpınar (2021) found that teenagers need restorative environments that more strongly portray feelings of being away than restorative environments for adults. Furthermore, Lu and colleagues (2022) found that older adults reported higher levels of psychological restoration than younger adults in similar environments. These differences probably arise because older adults are more susceptible to attention fatigue and life stressors (Jansen 1997, Fumagalli *et al.* 2020). These studies with varied participant groups show the importance of involving other target groups in restorative neighbourhood open space research. Especially more vulnerable target populations, like older adults, could benefit significantly from well-designed restorative neighbourhood open spaces close to their homes. Unfortunately, only three of the reviewed studies included older citizens in their participant samples (Fumagalli *et al.* 2020, Qiu *et al.* 2021, Lu *et al.* 2022). Also, other citizen groups, such as people with mobility issues, cognitive decline, or visual limitations, were not included in the reviewed studies, and only two studies included people with low socio-economic status (Bagot *et al.* 2015, Paddle and Gilliland 2016). While as indicated earlier, these groups probably benefit most from restorative neighbourhood open spaces that improve their mental

Table 5. Critical areas of recommendation for future research.

Restorative spatial characteristics of neighbourhood open spaces	More research is needed into different spatial characteristics of neighbourhood open spaces to explore if they enhance restorative qualities, primarily focus on non-natural elements. Research the effect of the composition of spatial characteristics on the restorative quality of the neighbourhood open spaces. Research the effect of the 17 proposed spatial characteristics that have a strong correlation with restoration.
Setting of research	Explore if lab results gathered through photo evaluation are extendable into real-life contexts.
Participant sample	Differences between different age groups, cultures, and social statuses. More focus on vulnerable target audiences like children and older adults.
Top-down characteristics	Research the relation between top-down (intangible) and bottom-up (tangible) characteristics and how they influence psychological restoration.

health.Future research should consider these methodological issues and focus more on real-life studies in varied environments, including diverse participant groups (Table 5). In this way, more insights about differences in restorative experiences can be obtained. This information can be implemented in real-life designs, creating neighbourhood open spaces that improve mental health of all citizens.

Lessons learned from literature to support design practice

The methodological issues in the reviewed studies do not mean that urban designers should not implement the listed restorative spatial characteristics into design practice. As long as the raised methodological issues are considered, implementing the findings in real-life designs can give us more insight into the restorative effects and how restorative neighbourhood open spaces affect citizens' mental health in the long term. Therefore, in this section, we will present some design directions to aid future designers in developing meaningful design solutions for the design of restorative neighbourhood open spaces that can improve mental health of all citizens.

Focus on variation in vegetation

The reviewed studies present evidence that natural spatial characteristics like trees, water, and ground cover offer restoration when implemented into neighbourhood open space designs (e.g. Lin *et al.* 2014, Elsadek *et al.* 2019, Masullo *et al.* 2021). These findings align with classical psychological restoration theories (Kaplan and Kaplan 1989, Ulrich *et al.* 1991, Staats 2012) and support the fact that green urban environments can positively contribute to citizens' mental health. Results from this study give designers an extra incentive to add green to their neighbourhood open space designs not only because it looks pretty, encourages physical activity, or improves air quality but also because it positively affects our mental health.

However, designers must be aware that simply adding greenery does not mean the job is done. Different vegetation types (e.g. trees, flowers, bushes) can have different effects on the restorative potential of neighbourhood open spaces (Elsadek et al., 2019; Zhao *et al.* 2020, Luo *et al.* 2022). Authors suggest that how the plants are positioned, offering shadow play and thereby stimulate fascination impacts restorative potential (Nikunen *et al.* 2014). A (bio)diverse design with different plants, trees, and flowers in combination with accessible water bodies can enhance the impact design has on citizens' mental health.

Optimise adjacent buildings

In addition to natural spatial characteristics, non-natural characteristics can also impact restorative potential of neighbourhood open spaces, according to the reviewed studies. For example, building height and entropy of adjacent buildings can positively influence restorative potential of neighbourhood open spaces (Lindal and Hartig 2013). Also, how you position a building, creating openness and enclosure, can influence restoration likelihood (Hunter and Askarinejad 2015, Tabrizian *et al.* 2018). These results indicate that the design of a building and the adjacent neighbourhood open space can influence the mental health of citizens. Unfortunately, only a few studies have been conducted on these non-natural spatial characteristics. For example, only two studies looked at building height (Lindal and Hartig 2013, Zhang *et al.* 2019) and one at building decoration (Jahani and Saffariha 2020). Results, therefore, should be used consciously, and future research and validating design implementations could provide more robustness to the results.

Position of design elements

When implementing these research results in neighbourhood open space designs, it must be considered that the configuration and combination of characteristics can affect the restorative quality of a space (Abdulkarim and Nasar 2014, Tabrizian *et al.* 2018). Abdulkarim and Nasar (2014), for example, showed that not only the presence of seats and sculptures but also their positioning influences the restorative qualities of neighbourhood open spaces. This more detailed information can provide designers with better guidance on how to apply restorative spatial characteristics in practice. It would be good if future research would pay more attention to these specifications (Table 5).

Conclusion

This scoping review gives an extensive overview of the current literature about restorative spatial characteristics of neighbourhood open spaces. The results provide insights to designers on how to design neighbourhood open spaces that improve mental health of citizens. Different natural, landscape and architectural characteristics were found that can enhance the restorative potential of urban environments. Literature suggests that designers can add a variety of greenery and accessible bodies of water to strengthen restoration. Furthermore, designers must pay attention to the position of design elements like seats and streetlights. Lastly, the architecture of the adjacent buildings can also impact psychological restoration in the neighbourhood open spaces. It is important to note that this is an emerging research topic and much research still needs to be done. Future research can, for example, focus on more varied participant groups and

different urban settings. Nevertheless, we hope that this study can aid designers in the design of restorative neighbourhood open spaces to improve mental health of all citizens.

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