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Europe

Green and Blue Spaces and Mental Health

New Evidence
and Perspectives for Action



Abstract

The WHO European Centre for Environment and Health has been closely following the research on green and blue spaces because of their importance in addressing human and ecosystem health in urban planning, especially in the context of climate change. Particular attention has been paid to the mental health effects of such spaces. The EKLIPSE Expert Working Group on Biodiversity and Mental Health conducted two systematic reviews on the types and characteristics of green and blue spaces, in relation to a broad set of mental health aspects. The reviews demonstrated the overall positive relationship between green and blue spaces and mental health. This report summarizes the key findings of the systematic reviews, briefly looks at the relevant WHO tools and strategies, and reflects on future needs for research and action. The comparisons of the different green space types and characteristics produced mixed results, indicating that there is no one single space type or characteristic that is a “gold standard” that works best for everyone, everywhere and at any time. For blue spaces, few high-quality papers were available, with little systematic variation in the type of blue space exposure. This prevented the formulation of firm conclusions and recommendations. Finally, the role of access to green and blue spaces, as a refuge for people to relax and socially interact, in the context of the COVID-19 pandemic is discussed.

Keywords

MENTAL HEALTH
URBAN HEALTH
CITIES
ENVIRONMENT
GREEN SPACE
BLUE SPACE

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Foreword

Natural environments and accessible green and blue spaces play a direct and indirect role in health and well-being. They can mitigate climate change impacts and lower the risks of disasters, as well as support active recreation; they provide a place to relax and leave daily stress behind for a while. Recent studies have shown that being able to spend time in nature is something that communities experiencing COVID-19 lockdowns have particularly missed.

Although it has long been understood that green and blue spaces play an important role in addressing both human and ecosystem health, it has only been in recent times that these relationships have been specifically investigated. This has become even more important within the context of needing to adapt planning and land use to several social and environmental challenges, such as urban deprivation, biodiversity loss, pollution and climate change.

The WHO European Centre for Environment and Health (ECEH) has been following these developments in scientific research, while paying particular attention to mental health. Mental health is fundamental to our ability to think, express ourselves, interact with each other, make a living and enjoy life. The natural and built environment of cities and their neighbourhoods can affect our mental health. To further understanding in this area, the EKLIPSE (Establishing a European Knowledge and Learning Mechanism to Improve the Policy-Science-Society Interface on Biodiversity and Ecosystem Services) project was established in 2016, funded by the European Commission, with the goal of supporting better-informed decision-making in relation to biodiversity. Within this unique project, the WHO ECEH supported and cooperated with experts from academia across Europe, who formed the EKLIPSE Expert Working Group on Biodiversity and Mental Health to conduct two systematic reviews on green and blue spaces and their impact on a broad set of mental health aspects.

I am happy to present this report summarizing the evidence of the effects of different types and characteristics of urban green and blue spaces on mental health and providing an overview of the relevant WHO strategies and activities carried out over recent years in this area. Mental health also features prominently in the European Programme of Work 2020–2025 – “United Action for Better Health in Europe”, which sets out to enhance mental health promotion, protection and care across the European Region by transforming attitudes about mental health, expediting mental health service reforms and accelerating progress towards universal health coverage for people with mental health conditions. Through an improved understanding of the positive impacts of green and blue spaces, we can support the development of better policies that both create healthy communities and reduce the burden on health systems – a goal that has been embraced more than ever during the current COVID-19 pandemic.

Looking beyond the health sector, we hope this work will support policy-makers responsible for planning, maintenance and protection of green and blue spaces, both at national and local levels. United Nations Secretary-General António Guterres recently noted that COVID-19 has presented us with an opportunity “to use the recovery to build back better”. Following this call, the *WHO manifesto for a healthy recovery from COVID-19* was published; two relevant goals prescribed within the manifesto are: to protect nature as the source of human health and to build healthy, liveable

cities. Through further research and disseminating better understanding of this topic, we may encourage taking a holistic path, acknowledging the role that nature plays in providing a wide range of health and well-being benefits.

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Acknowledgments

This report summarizes the evidence of health effects of urban green and blue spaces, in particular on mental health, and it is based on a collaboration with the EKLIPSE Expert Working Group (EWG) on Biodiversity and Mental Health, which conducted two systematic reviews. The report also offers a short summary of the relevant WHO strategies and activities carried out over the years in this area.

The report was planned, supervised and developed by Matthias Braubach, Vladimir Kendrovski, Dorota Jarosinska and Pierpaolo Mudu of the WHO European Centre for Environment and Health (ECEH), in collaboration with the EKLIPSE EWG, which is comprised of the following experts:

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Abbreviations

EEG	electroencephalogram
EKLIPSE	Establishing a European Knowledge and Learning Mechanism to Improve the Policy-Science-Society Interface on Biodiversity and Ecosystem Services
EPW	European Programme of Work
EWG	Expert Working Group on Biodiversity and Mental Health
NCD	noncommunicable disease
SDG	Sustainable Development Goal
WHO ECEH	WHO European Centre for Environment and Health

Executive summary

The growing recognition of the importance of the natural environment, and in particular of green and blue spaces, for mental and physical health has led to numerous scientific studies that provide evidence on a wide range of health outcomes. Among the health effects of green and blue spaces, mental health is one of the most investigated outcomes. WHO recognizes the substantial importance of the benefits related to green and blue spaces, and the critical need to support these spaces to protect and promote health and well-being. This report presents the main results of two systematic reviews on types and characteristics of green and blue spaces and mental health, conducted by the Expert Working Group (EWG) on Biodiversity and Mental Health of the EKLIPSE project. By focusing on mental health, and how various kinds of mental disorders are impacted by green and blue spaces, the analysis synthesizes evidence in an understanding of the interactions between environment and health. Information from earlier WHO reports and activities has also been provided so that the results of the EKLIPSE systematic reviews presented here can be put into the context of the general public health framework of which they are part.

The COVID-19 pandemic has highlighted the importance of contact with green and blue spaces in fostering the ability of communities to cope with the stress of the threat of the virus and the physical restrictions imposed in response to it, and also the role of such spaces as alternative places for physical activity and social interaction.

The results and conclusions of the EKLIPSE reviews are of relevance to the health sector, where policies and programmes generally target specific health issues. Besides direct or immediate health and well-being benefits, interventions on green and blue spaces can generate other benefits, related to ecosystem services such as climate adaptation and reduction of air pollution, and can improve opportunities for social interaction. A deeper understanding of the beneficial and restorative impacts of various types and characteristics of green and blue spaces can help guide policy-makers in designing cities that not only support mental health, but also reduce costs to the health-care system. The findings are also relevant to non-health sectors, whose activities influence the planning, design and maintenance of green and blue spaces and, thereby, indirectly affect health and well-being.

The key findings from the two systematic reviews presented in the report can be summarized as follows:

- In general, most green space types yielded positive effects on both short-term and long-term mental health outcomes.
- For all green space types, there were positive effects on affect.¹
- With few exceptions, most green space types also yielded beneficial effects on perceived stress, restorative outcomes and severity of mental disorders.

¹ In psychology, "affect" refers to underlying mood or emotion.

- For long-term mental health, most green space types yielded positive effects on overall mental health, quality of life and subjective well-being.
- Dense vegetation and shrublands were the only green space type that appeared to have no or even negative effects on mental health.
- Neutral reported outcomes (i.e. no effect of the green space type found) came from about one third of the experimental studies, and slightly over a third of the cross-sectional and longitudinal studies.
- Negative effects were reported in 5% of the outcomes in the experimental studies, and in 8% of the outcomes in the cross-sectional and longitudinal studies.
- Characteristics of green spaces have received less attention than types of green spaces in terms of their effect on mental health.
- The comparison between different green space types yielded mixed results, indicating that there is not one single green space type or characteristic that appears best, or is a “gold standard” that works best for everyone, everywhere and at every time.
- Among blue spaces, benefits of the coast were found across all studies.
- Studies looking at direct effects of coastal exposure, as opposed to just coastal availability or proximity, showed in general more consistent positive results on mental health.
- Positive associations with mental health appeared less clear for inland waters than for coastal blue space.
- Across blue space categories, the most pronounced effects were found for affect and affective disorders.

A range of policies and tools is already available to orient and support decisions on urban green and blue spaces. In the urban development context, several actions deserve attention:

- taking a holistic approach that encompasses the role of nature to provide ecosystem services, including a wide range of health and well-being benefits;
- assessing green and blue space benefits and trade-offs in planning and managing city transformations because of their important role in addressing urban health;
- considering that evidence on positive benefits from well-designed and managed green and blue spaces is sufficient for action and is increasing through newly published scientific observations and studies;
- focusing on mental health and well-being as an approach to address interrelated issues (e.g. climate adaptation, social inclusiveness and socioeconomic crisis) that emerged during the COVID-19 pandemic, and work towards a post-pandemic recovery.

1. Introduction



According to the WHO constitution, health is "... a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2006); and mental health is a state of well-being in which a person realizes their abilities, can cope with the normal stresses of life, work productively and is able to contribute to their community (WHO, 2004).

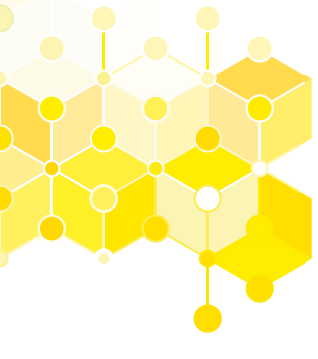
The multiple benefits to health and well-being, including to mental health, of the natural environment in cities through contact with green and blue spaces are increasingly recognized (Keniger et al., 2013; Hartig et al., 2014; Dzhambov et al., 2018; Bratman et al., 2019; Filipova et al., 2020; Labib, Lindley & Huck, 2020). However, the type of nature may differ significantly depending on the type of vegetation and level of biodiversity, among many other characteristics.

Nature, biodiversity and green and blue spaces represent significant elements and systems to be investigated in the context of improving public health through "nature-based solutions". If exposure of people to nature is recognized as positive, the research focus should be not only on its mere presence or absence, but should also look into the relevance of the type and the characteristics of nature in generating health benefits. This is the focus of this report: the effect of types and characteristics of urban green and blue spaces on mental health.

The WHO Regional Office for Europe, through the WHO European Centre for Environment and Health (ECEH), has been active in the area of the health effects of green and blue spaces. Working in close cooperation with experts and stakeholders, WHO activities have included reviews of evidence, development of tools and production of several publications and reports to support policy-making and interventions, including a briefing for urban policy-makers and practitioners (WHO Regional Office for Europe, 2017a); the key products are briefly introduced in this document.

At the core of this publication, are the key findings of the work conducted by the EKLIPSE Expert Working Group (EWG) on Biodiversity and Mental Health in their recently completed systematic reviews of evidence (Beute et al., 2020a; 2020b). The first review focused on identifying the evidence for effects of both distinct types of green spaces and their characteristics on mental health, as well as on collecting studies comparing types and characteristics of green spaces directly with each other. The other EKLIPSE systematic review focused on the effects of different blue space types. These works not only provide useful insights into the new scientific evidence, but also offer support for the conservation, planning, design and management of urban green and blue infrastructure with the aim of optimizing its health benefits.

In addition, the current publication provides some reflection on the future needs for research and action, and touches upon the current challenges of the COVID-19 pandemic and their implications for mental health and the role of green and blue spaces.



2. Mental health – the public health challenge

Mental health is fundamental to the individual and collective ability of people to think, express their emotions, interact with each other, make a living and enjoy life. It can be affected by a range of socioeconomic, biological and environmental factors, such as violence and persistent socioeconomic pressures, rapid social change, stressful work conditions, gender discrimination, social exclusion, unhealthy lifestyles, physical ill-health and human rights violations (WHO, 2018). The characteristics of cities, their natural and built environment and the different features of neighbourhoods can affect mental health. Studies have established an association not only with socioeconomic neighbourhood characteristics, but also with population density and access to public transportation, local services and public spaces (WHO Regional Office for Europe, 2018).

Mental disorders are a major public health challenge in the WHO European Region and globally. Depression is one of the leading causes of illness and disability among adolescents and adults (WHO, 2020b). In the European Region, the prevalence of mental disorders increased by approximately 16% between 2005 and 2015, and can be expected to rise further. In 2015 mental disorders affected some 110 million people in the Region, equivalent to 12% of the entire population (WHO Regional Office for Europe, 2018; 2019a). They are the leading cause of disability and the third leading cause of overall disease burden, measured as disability-adjusted life years, after cardiovascular disease and cancers (WHO Regional Office for Europe, 2019a). The most common disorders in the Region are depression and anxiety, with a prevalence of 5.1% and 4.3%, respectively (WHO Regional Office for Europe, 2018).

There are well-established links between mental disorders and other major noncommunicable diseases (NCDs); such disorders can be a precursor or a consequence of chronic somatic conditions, such as cardiovascular disease, diabetes mellitus or cancer, and share several risk factors, such as stress, sedentary behaviour and harmful use of alcohol (WHO Regional Office for Europe, 2018; 2019a). Several actions, such as outdoor sports and recreation, can offer mutually reinforcing benefits, reduce the risk of depression and contribute to preventing NCDs, like cardiovascular diseases or diabetes (WHO Regional Office for Europe, 2018).

Given the crucial role of good mental health for individuals and for society, the promotion, protection and restoration of mental health should be of vital concern, and be mainstreamed into governmental and nongovernmental policies and programmes. A strategic vision for integrating mental and physical health care and prevention must be linked to and engage many constituencies in and beyond the government and the health sector, including social care, education, environment, transport, housing, spatial planning and labour (WHO, 2018; WHO Regional office for Europe, 2019a).

Box 1. The COVID-19 pandemic – contact with nature and mental health

The ongoing COVID-19 pandemic, with the related societal measures and socioeconomic implications also affects mental health (Probst, Budimir & Pieh, 2020; van der Velden et al., 2020). In terms of public mental health, the main impact is elevated rates of stress and anxiety. However, with the introduced measures, such as quarantine and isolation, elevated levels of loneliness, depression, harmful substance use, self-harm and suicidal behaviour can be expected (WHO, 2020a; 2021a), adding to the already substantial burden of mental disorders in the population. Many tools to mitigate feelings of anxiety or depression exist, which may help in coping with mental distress. Getting out into nature, where and when permitted, and keeping active is one of these tools. That makes the role of access to nature, to green and blue spaces, even more significant for mental health, as a refuge for people to relax and socially interact, while adhering to COVID-19 restrictions (physical distancing, being outdoors) (Dzhambov et al., 2020; Ugolini et al., 2020; Venter et al., 2020; Pouso et al., 2021; Stieger, Lewetz & Swami, 2021).





3. The main WHO policy frames relevant for the work on green and blue spaces and health

It is increasingly understood that there is a complex interplay of proximal and distal (including environmental) determinants of health in the development of NCDs. That implies not only the need for the identification of risk factors, but also highlights the opportunity to identify domains of interventions, among them providing access to green and blue spaces.

Reducing the substantial burden of NCDs in the WHO European Region and globally is a priority for public health. Mental health features prominently in that context. In 2018, at the third United Nations General Assembly High-level Meeting on NCDs, efforts to promote mental health and well-being were placed alongside the work to tackle other priority NCDs, including cancers, heart and lung diseases, stroke, and diabetes (United Nations & WHO, 2018). “Creating healthy cities and environments” is one of the programmes that governments can adopt to promote health, and good quality and accessible green and blue spaces are integral components of healthy cities and environments.

While there are no specific policies that address green and blue spaces and health in a comprehensive manner, several global and regional WHO policy frameworks cover the issues of nature and sustainable, more liveable cities.

In the WHO European Region, efforts to support “...European cities and regions to become healthier, more inclusive, safer, resilient and sustainable,” including actions to “provide equitable access to the natural and built environments, including green spaces, healthy housing and basic services,” were among the regional priorities agreed by Member States at the Sixth Ministerial Conference on Environment and Health (WHO Regional Office for Europe, 2017b). In the follow-up, at the ninth meeting of the European Environment and Health Task Force, held in December 2019, the latest available knowledge on nature and biodiversity linkages to health and well-being was presented, at the request of Member States, reflecting a growing interest in the topic. Further, in an informal working group, Member State representatives discussed national challenges related to biodiversity and health, including collaboration across sectors and the difficulty in linking health outcomes directly with biodiversity aspects, and emphasized the role of biodiversity in building resilience.

Mental health features prominently in the European Programme of Work 2020–2025 (EPW) – “United Action for Better Health in Europe”, which sets the priorities for Member States of the WHO European Region. Recognizing the relevance of mental health as a vital element of individual and collective well-being, and the challenges posed by mental health conditions touching all ages and social groups, the EPW focuses on this topic as one of four flagship initiatives for the coming years. This initiative sets out to enhance mental health promotion, protection and care across the European Region by transforming attitudes about mental health, expediting mental health service reforms and accelerating progress towards universal health coverage for people with mental health conditions.

At the global level, a strategy on health, environment and climate change has been developed and was broadly supported by countries during the seventy-second World Health Assembly in 2019 (WHO, 2020c). It aims at transforming the way we tackle environmental risks to health by

accounting for health in all policies and scaling up disease prevention and health promotion. Cities have been identified as one of the settings for action to improve the health and well-being of populations.

Improving access to good-quality green and public open spaces for people of all ages and abilities, including accessible and safe play areas and recreational spaces for children and young people, is among the actionable measures of building healthy and liveable cities; this, in turn, is one of the six pillars of the healthy post-COVID-19 recovery, as defined in the WHO Manifesto “for building forward better” (WHO, 2020d).

Several other WHO policy documents, such as resolutions of the World Health Assembly on climate change, or those related to urban development are also relevant for this topic, though they do not address green and blue spaces explicitly. In a wider United Nations context, Sustainable Development Goal (SDG) 11, target 7, explicitly mentions: “By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities”. The efforts to protect biodiversity and well-functioning ecosystems, with a view to human well-being and health are the subject of numerous initiatives led by different United Nations agencies; for example, UN-Habitat (UN-Habitat & WHO, 2020), or the new United Nations Decade on Ecosystem Restoration (2021–2030), including the work on restoring urban ecosystems.

Although a lot of research has been done, especially on green space, it is not clear what type of green space, with which characteristics, is most beneficial for health, including mental health. The health benefits of contact with nature, and especially the mental health benefits, are generally considered less tangible than many other environmental benefits (e.g. carbon dioxide fixation), and thereby more difficult to study. This type of knowledge is relevant for practitioners who would like to know how much and what kind of green space is needed or can be considered most effective, and for which population segment, and how relevant the health benefits are, in order to make better informed allocations of space and budgets, and to incentivize more efficient uses of the available space. Additionally, stakeholders need to assess trade-offs which have to be made, or synergies implied in decision-making on green and blue open space, holistically considering the comprehensive needs of the population and the environment.



4. Building an actionable evidence framework on the health benefits of urban green and blue spaces

The WHO Regional Office for Europe, through the ECEH, has carried out various activities to scrutinize the evidence on the health effects of green and blue spaces (WHO Regional Office for Europe, 1997; 2016). WHO has been following the development of research on green and blue spaces and has played an active role in convening meetings and discussions among experts on the available evidence and its use to promote best practices and policies.

An important aspect of research is the organization of the evidence from different studies and systematic reviews (Rojas-Rueda et al., 2019); the WHO ECEH has been active in gathering and evaluating the evidence through a regular work stream that has benefitted from several scientific collaborations (WHO Regional Office for Europe, 2016; 2017c; Braubach et al., 2017).

A parallel ECEH work stream has focused on the production of practical information and tools to support urban planning interventions and practices on green and blue spaces. This resulted in the publication of several useful resources, including *Urban green spaces: a brief for action* (WHO Regional Office for Europe, 2017a), the BlueHealth Decision Support Tool (BlueHealth, 2020a), and a prototype of the GreenUR tool on urban green space quantification with regard to health impacts (currently in finalization, see WHO Regional Office for Europe, 2021). This work offers assistance and actionable evidence not only for the public, but also for urban practitioners and decision-makers (examples of practical tools are briefly presented in Section 7).

Since the 1980s, the innovative work on “healthy cities” has included the development of evidence and support tools for sustainable and healthy urban development, and the current vision of the WHO European Healthy Cities Network explicitly includes the need to create accessible social, physical and cultural urban environments that facilitate the pursuit of health and well-being. A focus for such approaches is human-centred urban development and planning, and the integration of equity aspects into urban policies (WHO, 2021b). In order to provide practical support for sustainable urban planning, the Healthy Cities Network has recently published an overview of various tools and resources aiming to guide local decision-making, with many of the listed approaches focusing on environmental dimensions (WHO Regional Office for Europe, 2020a).

Evidence frameworks

In the last decade, a number of conceptual frameworks and better study designs have been produced (among others, see for green spaces: Bratman et al. 2019; and for blue spaces: White et al., 2020). Though exact mechanisms of interactions remain to be elucidated (Kondo et al., 2018), several studies suggest positive associations between species diversity and well-being, psychological and physical (Marselle et al., 2021), and between ecosystem diversity and immune system regulation (Aerts, Honnay & van Nieuwenhuysse, 2018). Three domains of pathways have been proposed for the beneficial effects of nature on health: (1) mitigation (reducing harm), (2) restoration (restoring capacities), and (3) instoration (building capacities) (Markevych et al., 2017). Examples of pathways include reducing air pollution (mitigation), reducing stress levels (restoration), and increasing social

interactions (instoration) in green spaces. Contacts with nature offer multiple benefits, especially to those living in urban areas, for physical and mental health, and also for the opportunities to improve social relations and cohesion, for various age groups (Andreucci, Russo & Olszewska-Guizzo, 2020). Other studies focused on the relevance of green elements and systems for urban temperature regulation, and on their influence on air quality (Vieira et al., 2018).

Progress in our knowledge of the benefits provided by nature is partly due to the outcomes of numerous studies on the mental health effects of exposure to the natural world (Kaplan, 1983; Ulrich, 1984), and partly due to advances in understanding of the role of ecosystems and the services they provide in supporting and sustaining human health and well-being (MEA, 2005). In fact, the concept of ecosystem services links human health and well-being to biodiversity and the functioning of natural environments (WHO, 2005). In order to generate evidence-based knowledge, there is an explicit need to identify measurable outcomes of the various mental health effects provided by different green spaces, and to identify key characteristics of those spaces (see Frumkin et al., 2017). A recent conceptual model – aimed at translating outcomes of research on the restorative effects of nature on mental health into policies and practices – also included specific features of the natural environment as directly and indirectly influencing the mental health benefits derived from that environment (Bratman et al., 2019). The features of the natural environment may influence the amount of “exposure” to be expected, operationalized as actual time spent in the green space, and may also affect the “experience” of people when interacting with the environment. Beneficial effects can be gained from green spaces even by just looking at nature (see for example, Ulrich, 1984; Brown, Barton & Gladwell, 2013).² Both exposure and experience are deemed relevant for the dimension and the type of mental health benefits derived from the natural environment.

The evidence on public health benefits of exposure to natural environments has been contextualized in particular for cities, taking into consideration different socioeconomic groups and health inequalities (Mitchell & Popham, 2008; Hartig et al., 2014; Hunter et al., 2019; WHO Regional Office for Europe, 2019b). The number of studies on green spaces has boomed in the last 10 years (Zhang et al., 2020) and a range of systematic reviews are already available, while blue spaces have received less research attention and systematic review (see for example, Gascon et al., 2017).

Focusing on mental health, the benefits of green space can follow several distinct pathways. What is missing in the current evidence base, though, is an understanding of how specific types and characteristics of green spaces differ in their beneficial effects on mental health.

The EKLIPSE EWG, when developing the two systematic reviews on types and characteristics of green and blue spaces, considered the above mentioned pathways. The main findings are presented in sections 5 and 6.

² This aspect should not be underestimated because of the implications for the design and management of hospitals, for example (Gesler et al., 2004; Beukeboom, Langeveld & Tanja-Dijkstra, 2012; Weerasuriya, Henderson-Wilson & Townsend, 2019). Moreover, the implications are not just limited to the design of hospitals, but are relevant also for indoor environments in general, since many people spend most of their time indoors. Consequently, working environments (offices) and residential indoor environments deserve more attention, especially during particularly prolonged stressful times, such as the COVID-19 pandemic.



5. Green space in urban and peri-urban areas and mental health: which green space types and characteristics are most beneficial?

Urban green space plays an important role in the mental and physical health of urbanites, as well as of people working in or visiting urban areas (WHO Regional Office for Europe, 2016). But green space can be very diverse in its typology, including for instance urban forests, parks, playgrounds, allotments and urban farming locations. These green space types can also differ greatly in their defining characteristics; for instance, parks can differ in scenic beauty, vegetative composition or openness. Globally, continuing urbanization, as well as climate change, is increasingly putting pressure on the existence of green spaces within urban areas (e.g. Dallimer et al., 2011; Richards & Belcher, 2020). The scarcity of urban green space and the desire to create liveable cities requires in-depth knowledge on how different green space types and characteristics influence mental health, to facilitate well-informed design and planning choices.

The systematic review

A systematic review was conducted according to the PRISMA guidelines for systematic reviews (Moher et al., 2009), and incorporated three different categories of studies: experimental studies, cross-sectional and longitudinal studies, and qualitative studies. The literature search was conducted in two different databases: Scopus and Medline (Ovid). For paper selection, inclusion and exclusion criteria were formulated using the PICO/PECO approach (population, intervention or exposure, comparison and outcomes), with PICO mainly for the experimental papers, and PECO mainly for the cross-sectional and longitudinal papers (Higgins & Green, 2011).

Eligibility criteria

The search focused on all available population types (e.g. children, elderly people, students, employees, the general population or clinical samples) and on experimental studies that introduced a green space intervention either with regards to a specific green space type or its defining characteristics. Cross-sectional and longitudinal studies often do not introduce an intervention but instead look at exposure, which is also relevant for studying effects of green space on mental health. Therefore, studies measuring effects of exposure to specific green spaces were also included in the review. Many studies, however, used a compound measure of green space, for instance by combining effects of parks with forests. These studies were excluded from this review as they did not inform about the specific effects of one particular green space type or characteristic. The amenities and facilities present in green space types were also of interest. Studies investigating only the efficacy of therapeutic interventions in green environments were excluded from the systematic review, unless the effect of the physical environment could be separated from the therapeutic intervention. The comparison, or reference, environment was ideally another type of green space, or the same type with different characteristics, for example a comparison between different tree species. However, other comparisons with, for instance, a specific type of green space with a built environment, or a blue space, were also included. Studies investigating a single environment but with pre-post measurements were also considered.

A wide range of mental health outcomes were included as potential outcome variables, ranging from momentary mood to suicide rates. The WHO ICD-10 mental health classification system (WHO, 1992) was adhered to for psychological disorders: affective disorders, stress-related diseases, schizophrenia, psychosis, paranoia, personality disorders, disorders of psychological development, cognitive dysfunction, neurodegenerative disease and problem behaviour. Studies looking only at individuals' preference ratings, perceived restorativeness and expected restorative effects of physical health correlates to mental health (such as physical activity without looking directly at mental health outcomes) were excluded.

Qualitative studies were searched for using the same inclusion and exclusion criteria. Qualitative studies were included to identify in-depth insights from people's experiences of engaging with green spaces and the meanings people attributed to these experiences.

Search outcomes

The search yielded a total of 16 581 unique (deduplicated) papers published. After three rounds of eligibility screening, a total of 134 studies were categorized as eligible: 55 cross-sectional papers, 67 experimental papers (68 studies), and 12 qualitative papers. Meta-data were extracted from these 134 papers in four categories: general information, methodology, green space manipulation and mental health outcomes, and all included papers were systematically assessed on their potential for systematic bias (introduced, for instance, by the study design, method of selection of participants or selection of green space manipulations) during the critical appraisal phase. Studies with low scores in the critical appraisal phase were excluded from the next step, the synthesis. Further details on the search method, critical appraisal and included studies can be found in Beute et al. (2020a).

Synthesis of the included studies

Both a descriptive synthesis and a narrative synthesis were performed for each group of papers, according to the study design (experimental, cross-sectional and qualitative).

Green space categories

Before starting the syntheses, the studies were organized into seven different categories (see Table 1). In addition, a miscellaneous category captured studies that could not be included in one of the other categories; these included, for instance, agricultural land or saline dryland. A study could be included in more than one category (e.g. forest and grassland). As the main purpose of the review was to look at differential effects between green space types and characteristics, all studies comparing different green space types or characteristics were gathered for each category, and given priority in the analysis.

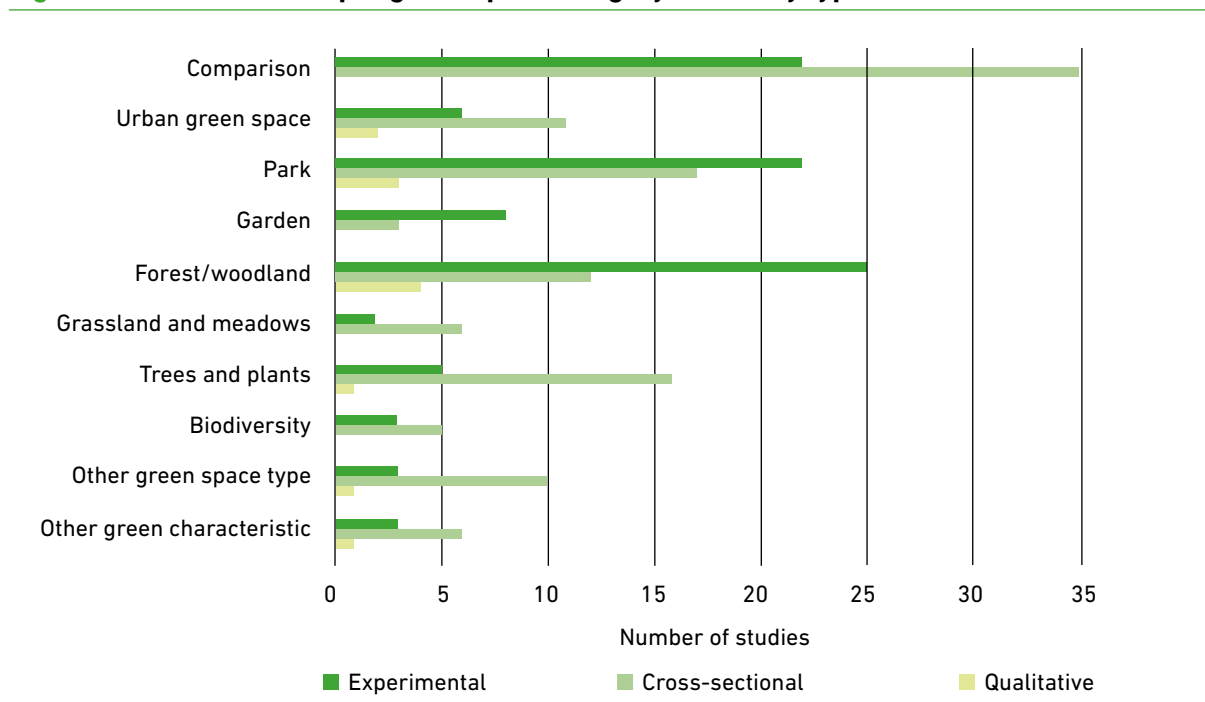


Table 1. Overview of the included green space types and characteristics

Green space category	Description	Examples
Urban green space	Urban land covered by vegetation, which does not fall (solely) into one of the other categories such as parks or gardens	Urban forest, street trees, green vegetation cover in the city, informal green spaces
Park	A large area of land with grass and trees, usually surrounded by fences or walls, and specially arranged so that people can walk in it for pleasure	Urban park, district park, neighbourhood park
Garden	An area where plants and flowers are cultivated; this can be either a private garden (adjacent to the house) or a public garden	Backyard, botanical garden
Forest and woodland	An area mainly covered with trees and undergrowth cover	Deciduous, coniferous, mixed forest
Grassland and meadows	An area mainly covered with grass	Mowed lawn, improved grassland (used for grazing), semi-natural grassland
Trees and other plants	Plants, shrubs or vegetation cover	Tree canopy cover, vegetation cover, shrubs
Biodiversity	Diversity in plants and animals	Flora richness, fauna richness

Fig. 1 displays the distribution of the green space categories across the different study types. The cross-sectional and longitudinal studies had the most examples that enabled comparison, followed by the experimental category, whereas none of the qualitative studies enabled comparison. All three study types had a strong focus on the park and the forest, while the cross-sectional and longitudinal studies also included a relatively high number of studies on trees and other plants, and on urban green space.

Fig. 1. Number of studies per green space category and study type





Mental health outcomes

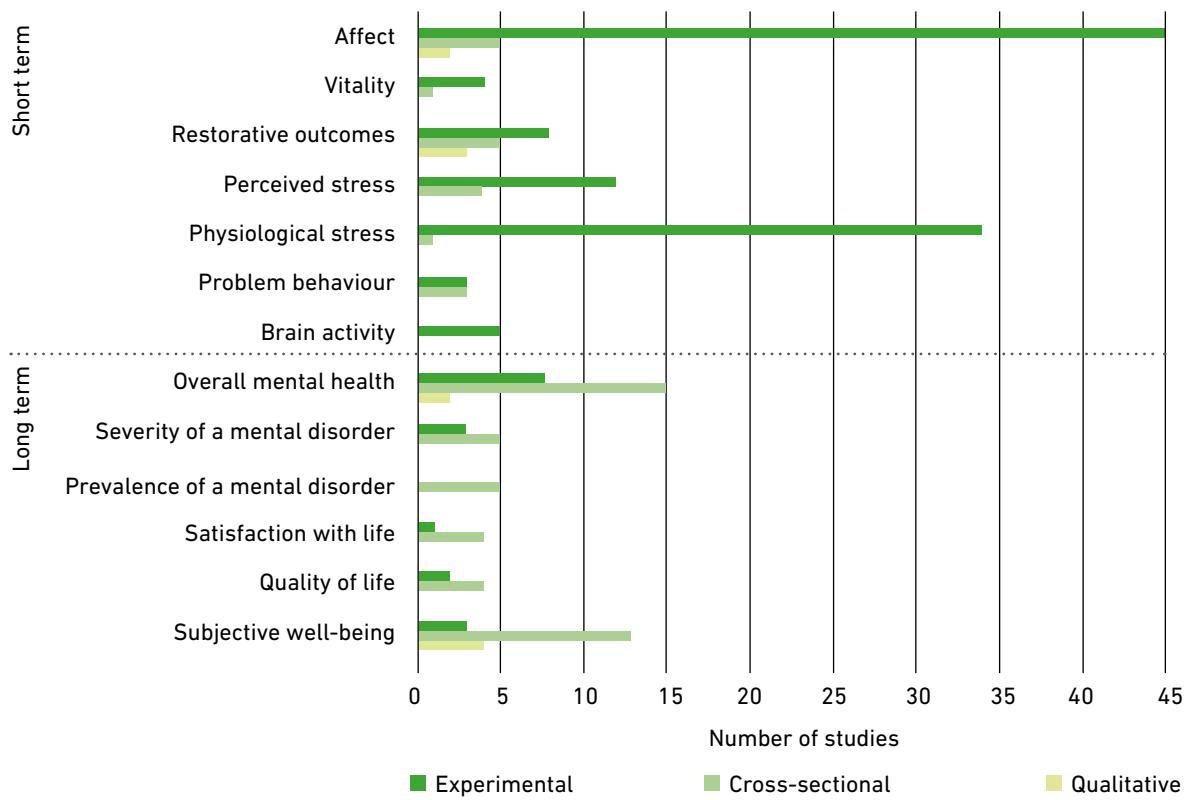
Groupings and tabulations were also made per health outcome measure, divided into 14 categories. Categories focusing on short-term mental health were: affect, vitality, restorative outcomes, perceived stress, physiological stress, problem behaviour and brain activity. For long-term mental health, the categories were: self-reported overall mental health, severity of a mental disorder, prevalence of a mental disorder, satisfaction with life, quality of life and subjective well-being. The 14th category was miscellaneous. See Table 2 for an overview of the mental health categories.

With regards to the mental health outcomes that were studied, there was a clear focus among the experimental studies on affect and physiological stress. The cross-sectional and longitudinal studies were more heterogeneous in terms of mental health outcome, but most studies focused on overall mental health and subjective well-being. Logically, the experimental studies focused most on momentary measures of mental health, whereas the cross-sectional and longitudinal studies included more long-term effects of exposure to green spaces (see Fig. 2). The qualitative studies focused more on subjective well-being followed by restorative effect, affect and overall mental health.

Table 2. Overview of mental health outcomes

Mental health category	Description	Example measurement	Reference
Short-term health			
Affect	Momentary measurements of mood and affective state, including for instance positive and negative affect but also momentary anxiety	Positive and Negative Affect Schedule (PANAS)	Watson & Clark, 1999
Vitality	Positive energy available to the self	Vitality subscale of the Short Form-36	Ware Jr & Sherbourne, 1992
Restorative outcomes	Measures focused on the restorative effects of nature, including psychological benefits such as relaxation and forgetting worries; does not include perceived restorativeness	Restorative Outcomes Scale	Korpela et al., 2008
Perceived stress	The amount of stress a person perceives they are under either right now or over a period of time	Perceived Stress Scale	Cohen, Kamarck & Mermelstein, 1983
Physiological stress	Physiological responses to stress, or activity of the autonomic nervous system	Heart rate variability	
Problem behaviour	Disruptive behaviour such as hyperactivity or agitation	Strengths and difficulties questionnaire	Goodman, 1997
Brain activity	Brain activity measured with (mobile) electroencephalogram (EEG) or functional magnetic resonance imaging	(mobile) EEG	
Long-term health			
Overall mental health	Overall score for mental health, encompassing multiple aspects of mental health (e.g. depression and anxiety) and not specifically focusing on one mental disorder	General Health Questionnaire	Goldberg & Hillier, 1979
Severity of a mental disorder	Severity of a specific mental disorder, expressed in level of symptoms or use of medication	CES-D scale (depression)	Radloff, 1977
Prevalence of a mental disorder	How often a specific mental disorder occurs within the general population	Prevalence of attention deficit hyperactivity disorder (ADHD)	
Satisfaction with life	Global life satisfaction	Satisfaction with Life Scale	Diener et al., 1985
Quality of life	Quality of life is the general well-being of an individual and can encompass multiple factors such as mental health, physical health and social health	WHO Quality-of-life assessment (short version)	Group, 1995
Subjective well-being	Subjective ratings of well-being, encompassing different aspects of well-being such as happiness, life satisfaction and psychological functioning	Warwick-Edinburgh Mental Wellbeing Scale	Tennant et al., 2007
Miscellaneous	Sleep quality, self-image, social contacts and suicide rate	E.g. national suicide rate data	

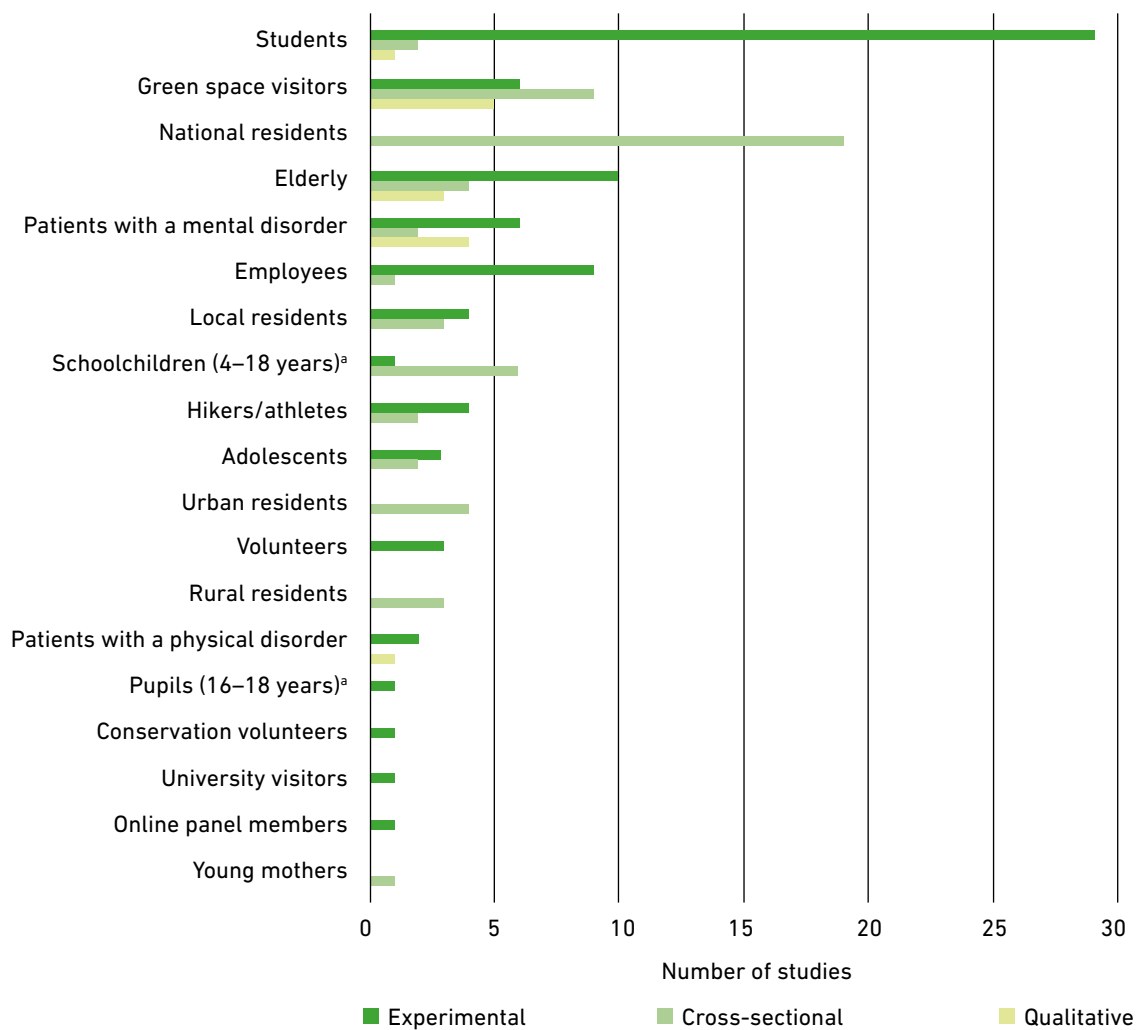
Fig. 2. Number of studies per mental health outcome and per study type



Population types

A large variety of population types were included in the review. The majority of the experimental studies included a convenience sample of students, whereas many of the cross-sectional and longitudinal studies included nationwide sampling of respondents. The qualitative studies, on the other hand focused mainly on green space visitors. Green space visitors were also sampled frequently in the quantitative study types. Additional population types examined included the elderly and employees, most frequently for the experimental studies, and schoolchildren in the cross-sectional and longitudinal studies (see Fig. 3). The majority of studies focused on healthy participants (114), whereas relatively few studies looked at clinical populations (17) or at-risk populations (2).

Fig. 3. Number of studies per population type and per study type



^a The terms "schoolchildren" and "pupils" are the ones used in the original studies, or are considered a fitting description. Exact definitions may vary from study to study. For example, for "schoolchildren" definitions may vary from 4–5 years to 7–18 years old.

Key findings on the mental health effects of specific green space types and characteristics

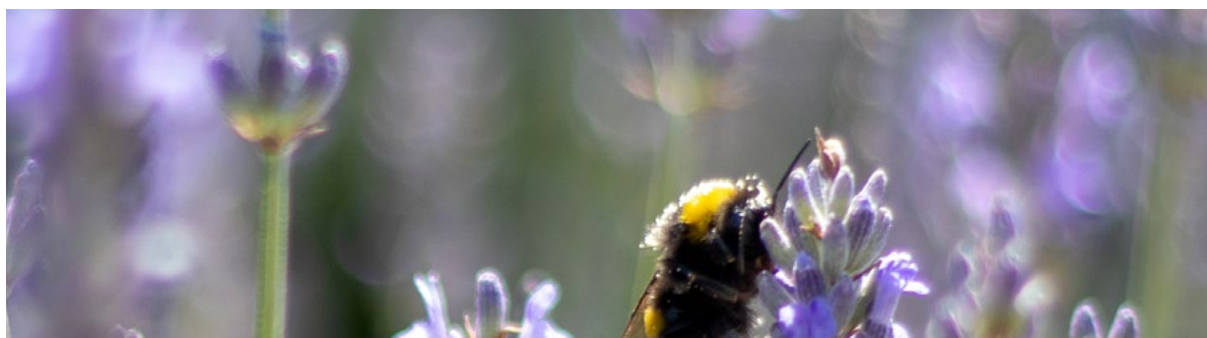
Not all studies enabled a direct comparison between different green space types or different green space characteristics. Therefore, outcomes were also based on indirect comparisons, looking at effects reported in studies including only one specific green space type, and by comparing the effects on, and associations with, mental health between different studies.

Mental health effects of green space types – long term and short term

In general, most green space types yielded positive effects on both short-term and long-term health. Tables 3 and 4 present an overview of the effects reported in the included studies on short- and long-term health. The studies included in the review sometimes employed multiple parameters to measure the same mental health outcome and these different metrics were not always consistent in their outcomes. One study could for instance include both heart rate and blood pressure measures to capture physiological stress, with a positive effect of the green space type on heart rate but not on blood pressure. In that case, both outcomes (a positive and a neutral outcome) are reported in the tables. For more details, please consult Beute et al. (2020a).

For all green space types, beneficial effects were found on affect. Furthermore, positive effects were reported for all green space types on perceived stress, except for trees and other plants for which no studies were included measuring effects on perceived stress. Mental health and subjective well-being were also positively associated with all green space types, except for gardens, which only had neutral outcomes. Likewise, quality of life was also positively associated with all green space types except grassland (no study was available). Restorative outcomes and severity of a mental disorder were studied relatively often (i.e. for 4 of the 6 green space types) and yielded positive effects for all green space types; although no studies reported on restorative outcomes for gardens and grassland, and none reported on severity of a mental disorder for urban green space and grassland. The other mental health outcomes had received less attention and therefore did not cover the majority of green space types. The least consistent results were reported for gardens (both private and public) and grassland.

For the experimental studies, about a third of the reported outcomes (32.4%) were neutral (no effect of the green space type was found). Relatively many of these neutral outcomes were found for measurements of physiological stress. Similarly, slightly over a third (36.3%) of the outcomes for the cross-sectional and longitudinal studies were also neutral. Some negative effects were also reported: 5.0% of the outcomes reported for the experimental studies were negative, as were 7.7% of the outcomes reported for the cross-sectional and longitudinal studies. Whereas positive effects were found scattered across green space types and health outcomes, neutral or negative effects were found for shrubland and more dense vegetation. This was the only green space type that was relatively consistently related to detrimental mental health outcomes.



Key findings on green space types

- Not all studies enabled a direct comparison between different green space types and different green space characteristics.
- For all green space types, beneficial effects were found on affect.
- Positive effects were reported for all green space types on perceived stress, except for trees and other plants (no studies were available).
- Mental health and subjective well-being were positively associated with all green space types, except for gardens (only neutral outcomes).
- Quality of life was positively associated with all green space types except grassland (no studies were available).
- Restorative outcomes yielded positive effects for all green space types, except for gardens and grassland (no studies were available).
- Severity of a mental disorder was positively associated with all green space types, except for urban green space and grassland (no studies were available).
- The least consistent results were reported for gardens (both private and public) and grassland.
- Neutral outcomes were found for 32.4% (experimental) and 36.3% (cross-sectional and longitudinal) of the studies.
- Negative outcomes were found for 5.0% (experimental) and 7.7% (cross-sectional and longitudinal) of the studies.

Mental health effects of green space characteristics

Most studies focused on green space types, and fewer on green space characteristics. Only one green space characteristic was studied sufficiently to form a separate category, namely biodiversity. Still, the outcomes for biodiversity were rather scattered across the different mental health outcomes, though generally pointing at beneficial effects. Other characteristics included several different features of a specific green space type, such as quality, openness, sky visibility, acoustic qualities or amount of light pollution. Unfortunately, studies on characteristics were very scarce and often unique in their focus on a specific characteristic, thereby not allowing firm conclusions for these characteristics.

Main conclusions, specific green space types and characteristics

Parks, forests, grassland and other urban green spaces (such as green community squares or greenways) can improve mental health. Not only designated urban green spaces, such as urban parks or forests, appeared to matter, but also informal street greenery and tree canopy. Outcomes indicated, in particular, a clear relationship between more trees, as well as higher biodiversity levels, and better mental health. Participants also seemed to prefer a certain level of human involvement in green areas. Managed meadows or grassland appear to provide better outcomes, whereas mixed results on this aspect were found for forests. Shrubland, on the other hand, especially in the presence of highly connected patches, produced mainly negative associations with mental health. Such outcomes would be worth avoiding.

Table 3. Summary of mental health outcomes per green space category – experimental studies

	Short-term health							Long-term health						
	Affect	Vitality	Restorative outcomes	Perceived stress	Physiological stress	Problem behaviour	Brain activity	Mental health	Severity of a mental disorder	Prevalence of a mental disorder	Satisfaction with life	Quality of life	Subjective well-being	
Urban GS	+ □ 4	+ □ 2	+ □ 1	+ □ 2	+ □ 8	+ □ 1	+ □ 1	+ □ 1	+ □ 4	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Park	+ □ 13	+ □ 2	+ □ 4	+ □ 3	+ □ 11	+ □ 1	+ □ 1	+ □ 1	+ □ 4	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Garden	+ □ 2	+ □ 2	+ □ 1	+ □ 1	+ □ 3	+ □ 1	+ □ 1	+ □ 1	+ □ 4	+ □ 2	+ □ 1	+ □ 1	+ □ 1	
Forest	+ □ 18	+ □ 3	+ □ 4	+ □ 2	+ □ 12	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Grassland	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Trees & plants	+ □ 3	+ □ 1	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Biodiversity	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	

GS = green space

Note: numbers in cells reflect numbers of studies.

Table 4. Summary of mental health outcomes per green space category – cross-sectional and longitudinal studies

	Short-term health							Long-term health						
	Affect	Vitality	Restorative outcomes	Perceived stress	Physiological stress	Problem behaviour	Brain activity	Mental health	Severity of a mental disorder	Prevalence of a mental disorder	Satisfaction with life	Quality of life	Subjective well-being	
Urban GS	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Park	+ □ 1	+ □ 1	+ □ 1	+ □ 2	+ □ 1	+ □ 2	+ □ 1	+ □ 3	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 5	
Garden	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 3	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 2	
Forest	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 3	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 2	
Grassland	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Trees & plants	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 2	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	
Biodiversity	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 1	+ □ 2	+ □ 1	+ □ 3	+ □ 1	+ □ 1	+ □ 1	

GS = green space

Note: numbers in cells reflect numbers of studies.

+ Positive outcomes □ Neutral outcomes - Negative outcomes 1–5 studies 6–10 studies 11–15 studies >15 studies 1–5 studies 6–10 studies 1–5 studies 1–5 studies

Key findings for the comparison between different green space types and characteristics

Indirect comparisons between effects of distinct green space types on mental health enabled a rather coarse comparison in terms of types of effect (positive, neutral, negative). In a study in which two green space types both showed significantly positive outcomes, those space types were rated as having similar effects in the indirect comparison. However, there may still exist differences between these green space types in effect size. Studies enabling direct comparisons were analysed separately to shed additional light on which types or characteristics of green spaces could be more beneficial than others.

These direct comparisons of the different green space types and characteristics yielded very mixed results. Table 5 illustrates these comparisons per mental health outcome. No comparisons were retrieved for problem behaviour, brain activity, severity of a mental disorder or satisfaction with life. In addition, no comparisons with other green space types were found for the trees and other plants category for the long-term mental health outcomes.

Not only were results of the comparisons rather mixed, but they were also highly scattered across mental health outcomes and different green space types. Two clusters of comparisons did surface, though, for: (1) urban green versus rural green, and (2) the park versus the forest.

Exposure to the countryside or rural green was compared a number of times with urban green space exposure. Urban green space scored better than visits to the countryside on affect in one study, but predominantly visits to the countryside scored better than urban green space, or had similar outcomes.

Key findings of the direct comparisons between green space types and characteristics

- The direct comparisons of the different green space types and characteristics yielded mixed results.
- Not only were results of the comparisons rather mixed, but they were also highly scattered across mental health outcomes and different green space types.
- There is not one single green space type or characteristic that appears best, or is a “gold standard” that works best for everyone, everywhere and at every time.



Table 5. Comparisons between green space types and characteristics per mental health outcome

Green space	Comparison outcome	Comparison green space	Health outcome
Urban green space	Better than	Countryside	Affect
		Forest	Subjective well-being
	Worse than	Farmland/green corridor	Affect, perceived stress
		Rural green	Restorative outcomes
		Coast	Restorative outcomes (3)
		Countryside	Restorative outcomes
		Farmland	Restorative outcomes
		Forest	Restorative outcomes
		Hill/moor/mountain	Restorative outcomes
	Similar to	Countryside	Restorative outcomes (2), quality of life
Park		Restorative outcomes	
Park	Better than	Garden	Mental health, subjective well-being
		Beach	Mental health, subjective well-being
		Sports pitch	Mental health
		Grass, shrubland	Quality of life
		Forest	Subjective well-being (2)
	Worse than	Forest	Affect (3), restorative outcomes (3), physiological stress (2), subjective well-being, vitality
		Farmland	Restorative outcomes
		Hill/moor/mountain	Restorative outcomes
		Coast	Restorative outcomes
		Wilderness	Perceived stress, physiological stress
	Similar to	Grassland	Affect, perceived stress
		Beach	Affect, perceived stress
		Riverside	Affect, perceived stress
		Canal	Affect
		Forest	Vitality, restorative outcomes, perceived stress (2), mental health, subjective well-being
		Countryside	Restorative outcomes
		Urban green space	Restorative outcomes
		River/canal	Restorative outcomes
		Sports pitch	Subjective well-being
Garden	Worse than	Park	Mental health, subjective well-being
		Forest	Mental health
		Sports pitch	Subjective well-being
	Similar to	Sports pitch	Mental health
		Beach	Mental health, subjective well-being
		Forest	Subjective well-being



Table 5. continued

Green space	Comparison outcome	Comparison green space	Health outcome		
Forest	Better than	Park	Affect (3), vitality, restorative outcomes (3), physiological stress (2), subjective well-being		
		Urban green space	Restorative outcomes		
		River/canal	Restorative outcomes		
		Rock outcrop	Physiological stress		
		Garden	Mental health		
		Sports pitch	Mental health		
		Beach	Mental health		
		Herbaceous vegetation	Mental health		
		Shrubland	Mental health		
		Grassland	Prevalence of mental disorder		
		Meadows/rough grass	Subjective well-being		
		Countryside	Subjective well-being		
	Worse than	Mountain/heath/bog	Mental health		
		Improved grassland	Mental health		
		Grassland	Prevalence of mental disorder		
		Park	Subjective well-being (2)		
		Urban green space	Subjective well-being		
		Sports pitch	Subjective well-being		
	Similar to	Park	Vitality, restorative outcomes, perceived stress (2), mental health, subjective well-being		
		Farmland	Restorative outcomes		
		Coast	Restorative outcomes		
		Hill/moor/mountain	Restorative outcomes		
		Grassland	Mental health, subjective well-being (2)		
		Arable land	Mental health		
		Garden	Subjective well-being		
		Beach	Subjective well-being		
		Flowering bushes	Subjective well-being		
		Heathland	Subjective well-being		
		Grassland	Better than	Forest	Mental health, prevalence of mental disorder
				Mountain/heath/bog	Mental health
Countryside	Subjective well-being				
Worse than	Park		Quality of life		
	Forest		Subjective well-being		
Similar to	Park		Affect, perceived stress		
	Beach		Affect, perceived stress		
	Riverside		Affect, perceived stress		
	Forest		Mental health, subjective well-being		
	Mountain/heath/bog		Mental health		
Trees and other plants	Better than		Sunny areas	Affect	

Note: if more than one study has the same comparison outcome, the number of studies is represented by a number in brackets.

Comparing the park with the forest

The largest group of studies enabling comparison focused on either the park (and the urban green space) or the forest. Contradictory effects were found in direct comparisons between the two, with more superior effects for the forest than the park on short-term mental health outcomes reported in most experimental studies and the exact opposite in three cross-sectional studies on long-term mental health outcomes. At least three explanations can be provided for the heterogeneity in these comparison results: (1) diversity in user characteristics and needs, (2) differences in microclimatic conditions and cultural representations, and (3) uncertainty in the measurements concerning actual exposure.

First, the heterogeneity in outcomes for the comparisons between different green space types and characteristics may suggest that there is not one single green space type or characteristic that is best, or a “gold standard” that works best for everyone, everywhere and at any time. Instead, there may be a need for variety in green space types to suit different users with different needs and also undertaking different activities. What adds complexity is that these variations not only occur between individuals, but also within a single person. On a bad day, a person may benefit more from a specific green space or characteristic than on a good day.

Secondly, factors such as geographical location, cultural perspectives and climatic conditions may also influence how a specific green space type and/or characteristic influences mental health. For instance, trees provide shade, which may have a different effect in hot climates versus colder climates. Here also lies a potential challenge as climate change is not only affecting biodiversity in cities, but also the microclimate of different urban areas within a city.

Third, contradictory findings may be due to outcomes depending on the amount of exposure (actual and accumulated). Total exposure over time is assumed to be important for long-term well-being benefits. Most experimental and cross-sectional studies did not fully capture actual exposure though. In the majority of the experimental studies, participants were taken to a certain green space environment – rather than choosing an environment themselves – which may thus not reflect their actual exposure in daily life. In the cross-sectional and longitudinal category, on the other hand, many studies investigated the effects of proximity or availability of green space types as a proxy for actual exposure. Having a park nearby does not automatically imply that an individual will actually use it. In addition, studies looking at proxies for actual exposure may overestimate exposure for green space located further away, but still included in the proxy as equal to green space more nearby (especially if the distance range or buffer size is large, e.g. 3 km). Certain types may on average be located more nearby (within the criterion distance used) than other types (e.g. parks versus forests). Since parks are more common than forests in urban residential environments, even those people who have access to forests may have more frequent access to parks. Consequently, there is a need for more research looking at actual exposure.³

Qualitative studies further pointed to the importance of experience for the beneficial effects of green space on mental health, with both the type of experience and preferences differing between life stage (for instance having small children or not), mobility, affective state or season.

³ A number of studies that were published after this systematic review was finalized confirm the results presented (for example for green spaces: Andrusaityte et al., 2020; Cameron et al., 2020; Gritzka et al., 2020; Olszewska-Guizzo et al., 2020; Yigitcanlar et al., 2020, and for green and blue spaces also: Subiza-Pérez, Vozmediano & San Juan, 2020). Fewer studies found no associations, for example for the elderly (Noordzij et al., 2021).

Implications for the design of urban green space

Even though most urban green space types had a positive relationship with mental health, the comparisons between the different green space types produced highly heterogeneous results. It thus appears that there is not one specific green space type or quality that stands out over the others in terms of the beneficial effects on mental health. This may signal that most green space types can contribute to improved mental health in urban and peri-urban environments. At the same time, some evidence was found that there may also be differences in effect between different target groups, geographical locations and contexts. From that point of view, a variety of green spaces, rather than a standard configuration of a single type of green space and/or higher concentrations of a certain green space type or quality, may meet the needs of various types of green space users, especially in highly diverse and dynamic urban and peri-urban settings, and while facing the consequences of climate change. There needs to be a more thorough understanding, though, of who needs which type of green space, and at what time, before firm design recommendations can be formulated. Evidence-based design would benefit from a more thorough mapping of the actual exposure of individuals to specific green space types and from a better understanding of the experiences people have in these green spaces and the benefits they get from them.

It is not only designated urban green spaces, such as urban parks or forests, that appeared to matter, but also street greenery, trees and general urban green space. This also points to the complexity of the relationship between green space exposure and mental health, as for such types of green space it is difficult to distinguish between, for instance, purposeful and incidental exposure.

Selecting green space type and characteristics

There will never be an exact formula for the choice of, for instance, vegetation or the density of planting, as effects of single elements will always depend on the environment they are placed in and on the community that animates and experiences it. However, it is important to think carefully about the choice of vegetation and the level of biodiversity. Flowering plants can be seen as too stimulating for some, but not for others. Seasonal changes matter in how open spaces are perceived, and the benefits of nature may differ between seasons. Green areas are not only beneficial in spring and summer but can also be valuable in the autumn and winter. Here also lies a considerable challenge for future research, as the appearance of green spaces not only changes substantially between seasons but also in relation to differences in weather conditions and daylight exposure, which may in turn result in changed activity patterns, which are also related to mental health outcomes, such as seasonal affective disorder (see for example, Beute & de Kort, 2014).

It is also important to not look only at a specific green space and what it offers but to begin with looking at the residents at hand and their needs, since there is also the issue of what else is on offer in the nearby environment; that is, for people that only have access to one park, this park is likely to be more important for their mental well-being than when several other parks are also reasonably accessible to them.

Gaps and future research directions

A number of gaps in the research on urban green space and mental health exist. The studies included in the review were highly heterogeneous in terms of objectives, theoretical frameworks, covariate data, target population and research methods. Previous reviews, including systematic ones, have indicated that this diversity makes drawing solid conclusions difficult (Bowler et al.,

2010; Bratman, Hamilton & Daily, 2012; Hartig et al. 2014; van den Berg et al., 2015; Gascon et al., 2016; Frumkin et al., 2017; Houlden et al., 2018; Tillmann, Clark & Gilliland, 2018; Twohig-Bennett & Jones, 2018; Moens et al., 2019). This was also the case for the present review, as it was not possible to draw firm conclusions on how exactly exposure and experience influence mental health benefits of urban green spaces. More homogeneous research designs are necessary to allow, for instance, for conducting meta-analysis.

At the same time, the present review has indicated that when trying to identify benefits of specific green space types and characteristics for mental health, this diversity in outcomes and user characteristics may not necessarily be a weakness but, instead, a prerequisite for gaining a better understanding of how exactly different green space types and characteristics influence mental health and well-being. However, there needs to be a more systematic way to study this, with for instance a larger contribution from longitudinal studies. Another way to go about this is to purposefully address this heterogeneity in the research methodology by enabling, for instance, a direct comparison not only between different green space types and characteristics, but also between different users (e.g. age, mental health status), different activities (e.g. active versus passive activities), different locations (geographical locations, or in areas with different population densities) or different seasons.

Conclusion

This systematic review (see for more details Beute et al., 2020a) confirmed a general beneficial relationship between green space and mental health, an association that seems to hold for most green space types. Comparisons, however, did not reveal a particular green space type or characteristic as being superior to others. Factors such as access and exposure, as well as individual and geographical differences, may be at the core of the heterogeneity in outcomes. On the other hand, it may also signal that, to a certain extent, most green space types can contribute to helping vulnerable urban communities in facing not only increased urbanization but also climate change.



6. Blue space in urban and peri-urban areas and mental health: which blue space types and characteristics are most beneficial?

There is an increasing awareness that besides green spaces, blue spaces can also positively influence mental as well as physical health (see for example, Völker & Kistemann, 2011; Gascon et al., 2017). Blue spaces are: “outdoor environments – either natural or manmade – that prominently feature water and are accessible to humans either proximally (being in, on or near water) or distally/virtually (being able to see, hear or otherwise sense water)” (Grellier et al., 2017, p. 3). Examples include coasts, lakes, ponds and pond systems, wadis systems, artificial buffer basins and water courses. Together with green spaces they form the green-blue infrastructure. Therefore, a second systematic review focused on effects of blue spaces on mental health.

The systematic review

The systematic review (Beute et al., 2020b) followed the same guidelines and process as the green space review (Beute et al., 2020a).

Search outcomes

A total of 25 papers were selected, with 7 experimental papers (8 studies), 12 cross-sectional and longitudinal papers, and 6 qualitative papers. There were thus substantially fewer papers included in the blue space review than in the green space review. This is a relatively young research field, which is also illustrated by the fact that the “oldest” paper included in the review was from 2013.

Synthesis of the included studies

Both a descriptive synthesis and a narrative synthesis were performed for each group of papers by study design (experimental, cross-sectional and longitudinal, and qualitative).

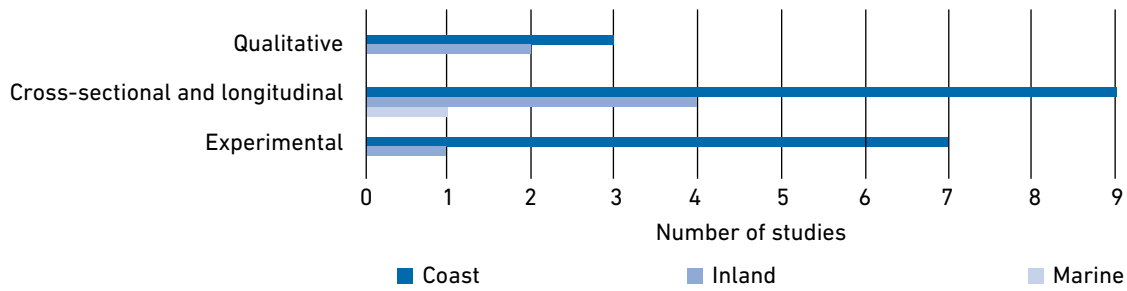
Blue space categories

Only three main categories of blue spaces emerged: the coast, inland waters and marine environments (see Table 6). Most studies, by far, focused on the coast as blue space type and the few studies included on inland waters were mostly within the cross-sectional and longitudinal category (see Fig. 4). Blue space characteristics received too little attention to form a category.

Table 6. Overview of the included blue space types and characteristics

Blue space type	Description	Examples
Coast	The part of the land directly adjacent to the sea	Rocky coast, sandy coast
Inland water	Aquatic environments located within land boundaries	River, lake, canal, ponds, fountain
Marine	Aquatic environments located within the sea	Coral reef

Fig. 4. Number of studies per blue space type and per study type

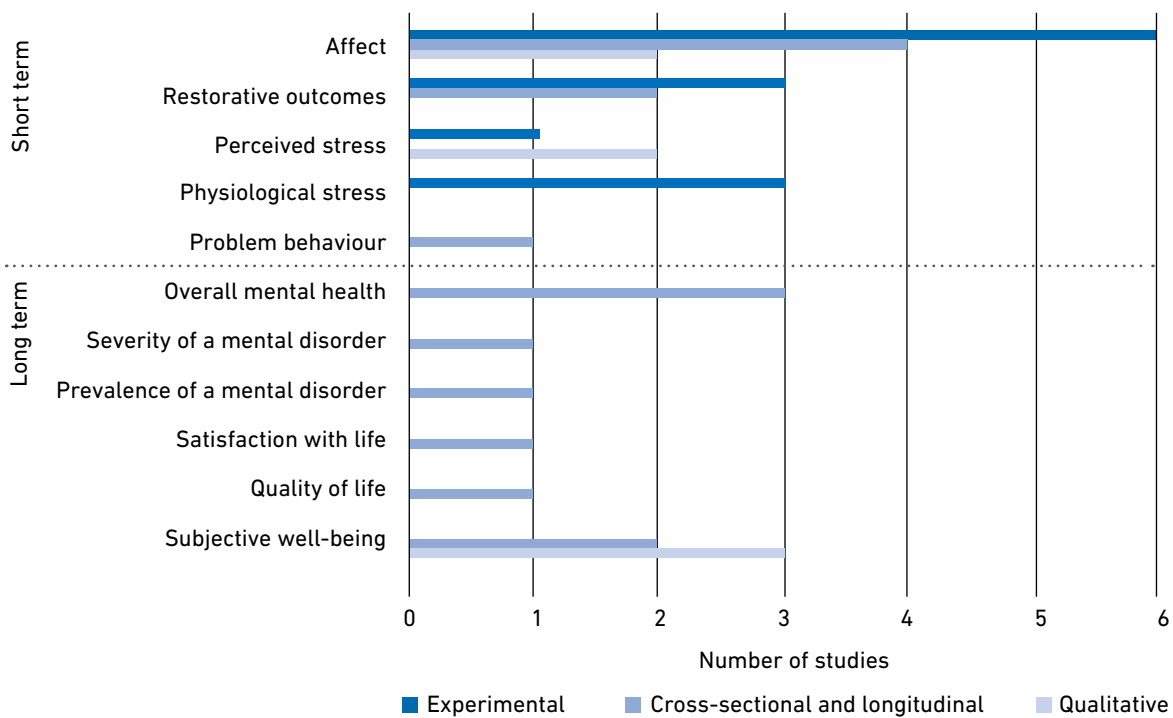


Mental health outcomes

Groupings and tabulations were also made per health outcome measure, divided into the same categories as with the green space review (see Table 2), except for brain activity and vitality, which were not studied for the blue space categories (the miscellaneous category was not used). See Fig. 5 for the distribution of mental health outcomes per study type.

As with the green space papers, the experimental studies mostly focused on affect, as well as restorative outcomes and stress. Affect also received most attention in the cross-sectional and longitudinal studies. In addition, health outcomes were highly scattered mostly across the cross-sectional and longitudinal studies, with most health outcomes only addressed in one study.

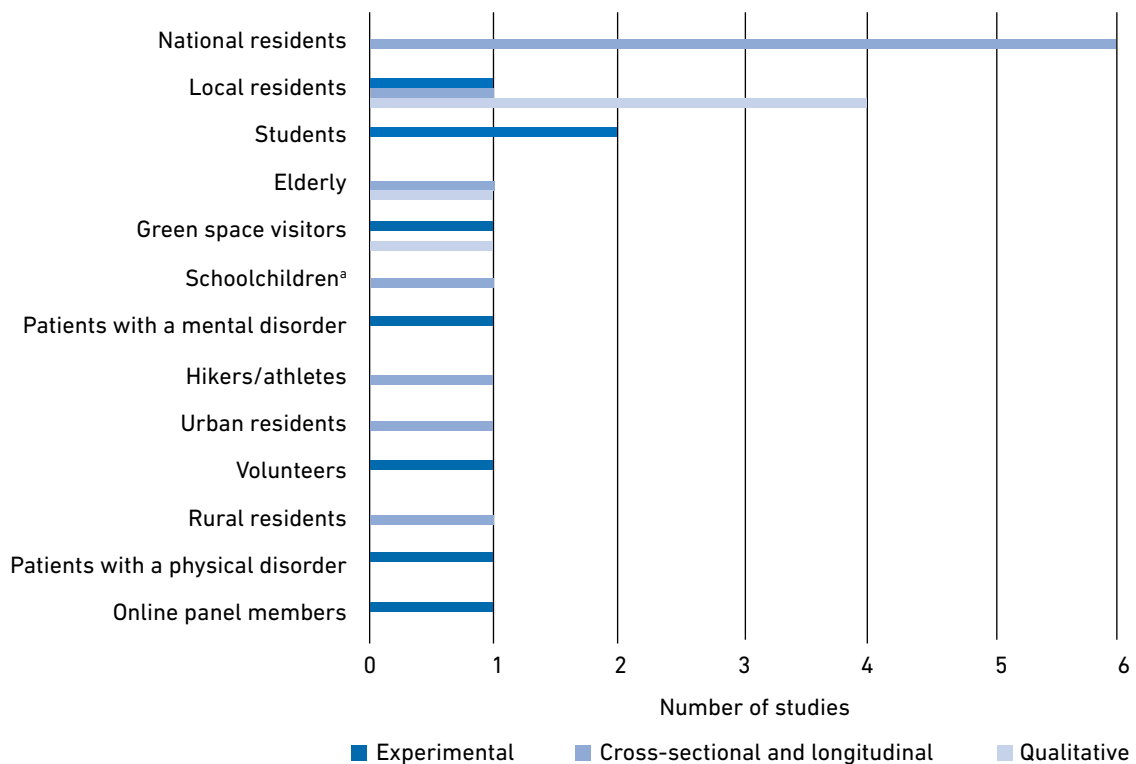
Fig. 5. Number of studies per mental health outcome and per study type



Population types

Even though fewer different population types were included in the blue space review than in the green space review, there was a large variety between the studies, with most population types included in one study only (see Fig. 6). Just over half of the studies in the cross-sectional and longitudinal category used national residents (national databases) as the participants, whereas qualitative studies focused most on local residents. Two experimental studies looked at students, and the elderly were studied in one cross-sectional and one qualitative study. All remaining population types were only included once. Two studies looked at a clinical sample, whereas all other studies looked at healthy participants.

Fig. 6. Number of studies per population type and per study type



^a The term "schoolchildren" is the one used in the original studies, or is considered a fitting description. Exact definitions (age ranges) may vary from study to study.

Key findings on the mental health effects of specific blue space types

Benefits of the coast were found across all three study categories (i.e. experimental, cross-sectional and longitudinal, and qualitative). Studies looking at actual coastal exposure, as opposed to just coastal availability or proximity, in general showed more consistent positive results on mental health. Only a few studies investigated inland water exposure, looking at either a river, a canal, a wetland or at the percentage of freshwater around the residence. It appeared that positive associations with mental health were less clear for inland waters than coastal blue space. Across blue space categories, the most pronounced effects were found for affect and affective disorders. Qualitative studies pointed towards unique and beneficial characteristics of blue spaces, including the visual openness of the space and fluidity of the water. In addition, they also pointed to the importance of safety perception (e.g. with regard to drowning or slipping).

Key findings of the blue space review

- Benefits of the coast were reported across all three study designs.
- Actual coastal exposure, rather than coastal proximity or availability, had the most pronounced beneficial effects.
- Only a few studies investigated effects of inland waters, but for those studies that did include both the coast and inland waters, the coast generally scored better.
- Qualitative studies pointed towards unique and beneficial characteristics of blue spaces, including the visual openness of the space and fluidity of the water and the importance of safety perceptions.

Gaps and future research directions

Too few studies in each category were present to allow for firm conclusions and recommendations. Research on inland water was limited to wetlands, freshwater, rivers and canals, and was not representative of the wide range of inland blue spaces that are accessible to people. Furthermore, only a few studies investigated the characteristics of blue space. There was a high level of heterogeneity in outcome variables, study designs and population types. Another issue is that a relatively large percentage of the studies were conducted within the United Kingdom (14), introducing a geographical bias to the review. The outcomes of the systematic review signal the need to look beyond mere availability and proximity of blue spaces, to actual exposure and the experiences people have in blue spaces. Moreover, this review was aimed at urban and peri-urban exposure to blue space. The majority of studies reported effects of the coast and since this type of blue space is geographically bound it will not be relevant for all urban and peri-urban areas.

Conclusion

The systematic review (Beute et al., 2020b) has once again established a general beneficial relationship between blue space and mental health. The studies that were included generally showed benefits of the coast and less pronounced effects of inland waters. The review pointed at a strong need for more research on the benefits of blue space, including a larger diversity of blue spaces and especially including more inland water types, such as lakes, ponds or streams. Blue space characteristics also require more attention, for instance by comparing different types of coastlines (e.g. rocky versus sandy beaches). Qualitative studies have already pointed at a number of interesting research avenues, including openness, dynamics and safety.



7. Tools supporting the work on green and blue spaces and health

A number of tools to facilitate comprehension and quantification of the impact of insertion or modification of green spaces have been developed and made available for users. Such tools include models and frameworks, interactive websites, toolkits and quantification software. However, tools determining health outcomes are still very limited (Oosterbroek et al., 2016). Within a long tradition of development of tools on environment and health,⁴ the WHO ECEH is working on a number of tools to encourage policy action to utilize the potential of green and blue urban spaces to promote health and well-being. These tools are of different types and formats, are aimed at different targets (see Table 7) and differ from already existing tools that are used, for example, in planning,⁵ in that they focus on health impacts.⁶

Urban green spaces: a brief for action (WHO Regional Office for Europe, 2017a) aims to provide information on how to ensure adequate integration of green spaces in the planning and design of urban settings. This practical document can represent a primer on the different dimensions and implications of planning from a health perspective. The action brief has evolved from a review of evidence on health impacts of urban green spaces (WHO Regional Office for Europe, 2016), and a review of the effectiveness of urban green space interventions in this regard, looking at both published intervention studies and a collection of practical case studies (WHO Regional Office for Europe, 2017c). The action brief summarizes the key messages of these reviews and presents practical information on the planning process itself and on approaches for involving local communities. Furthermore, it addresses the potential conflicts (for example gentrification issues) arising from green spaces in urban settings and what health risks need to be managed. Finally, the action brief provides suggestions on how to monitor the environmental, social and health impacts of urban green spaces in order to collect arguments for their relevance in urban design.

Building on the rapid advancements in the work on green and blue spaces, there is a growing need to equip planners and public health specialists with tools capable of providing evaluations and estimates of different scenarios related to green and blue spaces, using the health lens.

⁴ Other WHO tools may be of interest for the readers of this report: for example, HEAT, an online tool to estimate the value of reduced mortality that results from regular walking or cycling; AirQ+ that quantifies the health impacts of air pollution; and CarbonH that quantifies the health and economic consequences achieved through improvements in country-level air quality from domestic carbon reductions (WHO Regional Office for Europe, 2020b). Studies are still limited, but there is plausibility of potential etiological pathways between air pollution exposure and depression outcomes, and some evidence that short-term exposure to nitrogen dioxide is associated with increased odds of depression (Braithwaite et al., 2019; Fan et al., 2020).

⁵ The existing software used in urban planning provides analysis on transport and land use, and at building, district or city scale on the use of energy sources as well as the associated emissions of greenhouse gases, but it lacks health components (Allegrini et al., 2015).

⁶ Digital techniques can help designers to explore the ideas and concerns core to landscape architecture in the Anthropocene, such as designing with social ecological systems, working with landscapes in flux or adapting to the extreme weather events caused by climate change. Combining this shift with the increased attention on nature-based technologies and increased accessibility of digital tools, such as CitySym, EnviMet, Ecotect, LIM and multiparametric workflows based on the Grasshopper visual programming tool, supports a new approach for challenging static design solutions towards healthy environments (Andreucci, 2020).

In this sense, the GreenUr tool, which is currently in the final stages of development, could represent an entry point for a user, serving as an introduction to the complexity of modelling green spaces data, which can then be tackled with more sophisticated and specialized software, for example i-Tree (USDA Forest Service, 2020). However, these tools do not yet include mental health pathways. i-Tree, for example, is a model that uses tree measurements and other data to estimate ecosystem services and structural characteristics of urban or rural forest. It estimates the mortality incidence reduction and the resulting economic benefit based on the effect of trees on air quality. WHO has started the development of a module on mental health within GreenUr, which is currently based on an analysis carried out in Catalonia, Spain, using the association between surrounding greenness and the mental health of adults aged over 20 years (Triguero-Mas et al., 2015).

A range of academic works has been published in recent years on the emerging topic of the health relevance of blue spaces (see for example, Gascon et al., 2017). The recently finished Horizon 2020 project BlueHealth has developed several tools to support planning, assessment and management of blue spaces, with a focus on their integration in urban settings (BlueHealth, 2020b). Being a partner to the project, the WHO Regional Office for Europe has taken the lead in developing the BlueHealth Decision Support Tool (BlueHealth, 2020a) to help local planners to make decisions on blue space sites and assure adequate integration of health considerations into the decision-making process. As a first step, the tool provides evidence on health risks and benefits related to different local blue spaces (coastlines, rivers and lakes, but also smaller blue spaces in green settings such as parks, or ornamental blue space installations in urban settings, such as fountains) to describe how the blue spaces can have an impact on health and well-being. As a second step, the tool offers suggestions and reflections on blue space interventions and measures to maximize health benefits and reduce potential health risks. Depending on the selection of topics by a user, a checklist for on-site visits to blue spaces is provided. The tool can facilitate ensuring the integration of health aspects in the planning and development of new blue spaces, identifying and better understanding the health impacts of existing blue spaces, and improving management and maintenance schemes from a health perspective.

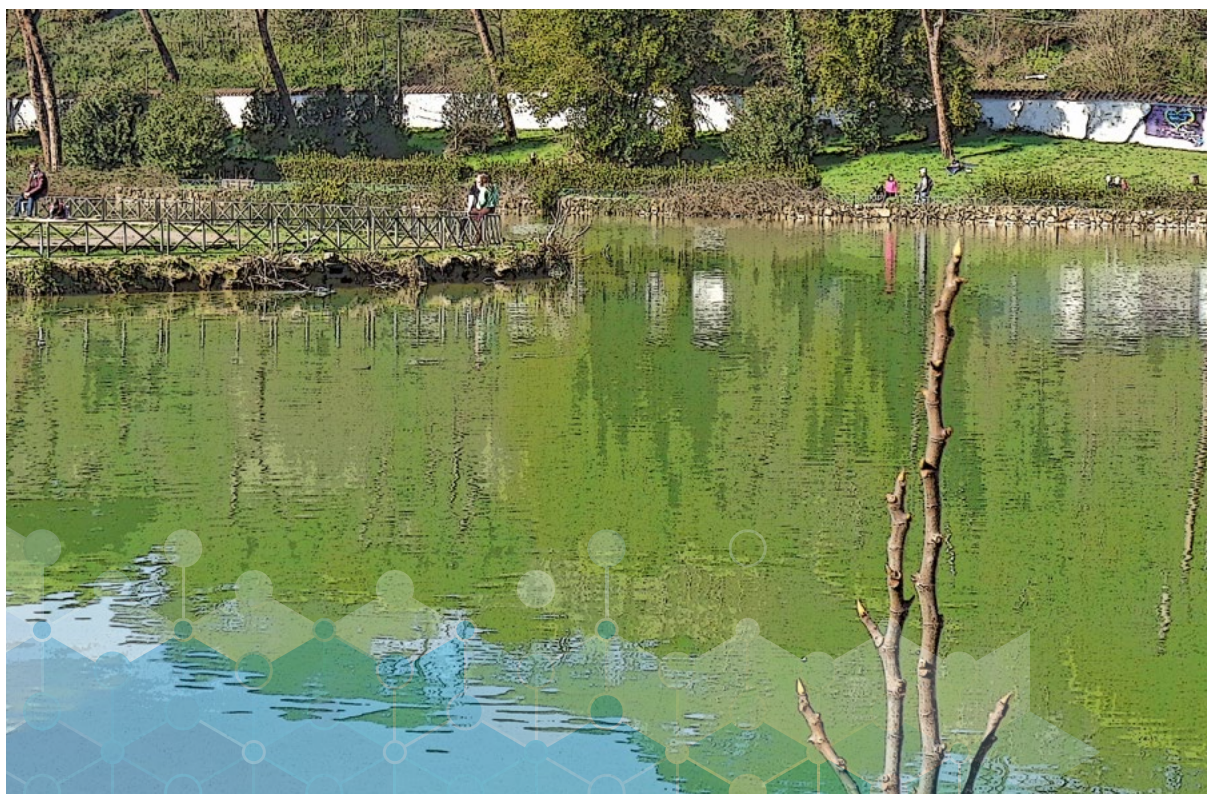


Table 7 presents some examples of tools that WHO has been involved in the development of, which help make the best use of available evidence regarding the health benefits of contact with nature, be it green or blue space. The available tools should also be considered and evaluated for their importance and applicability among the instruments useful for health impact assessment (Fischer et al., 2018).

Table 7. Examples of tools on green and blue spaces that have health outcomes included

Name	Format	Aims	Target groups	Website
Urban green spaces: a brief for action	Booklet (available in English, Finnish, French, German, Italian, Portuguese and Russian)	Translating the key findings of a review of research evidence and practical case studies on urban green space interventions into implications for practice	Practitioners at the local level, local decision-makers, politicians and public authorities, civil society organizations, local initiatives and citizens	https://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2017/urban-green-spaces-a-brief-for-action-2017
GreenUr	Software, plug-in for QGIS	Introducing the relationship between green spaces and health, by providing, for example, simple ways to measure green space availability, ecosystem services (effects on temperature, on air pollution (particulate matter), on noise), green space attractiveness for active transport, health impacts on mortality, and depression and stress	Different stakeholders, land-use planners and in particular public health or environmental specialists with some knowledge of statistical methods, epidemiology or Geographical Information System	https://www.euro.who.int/en/health-topics/environment-and-health/urban-health/activities/greenur-the-green-urban-spaces-and-health-tool
BlueHealth toolbox	Web-based tool including among others a Decision Support Tool and Behavioural Assessment Tool	The Decision Support Tool helps users to make an assessment of any given blue space through (a) identifying risks to be mitigated, and (b) assessing public health and environmental benefits to be enhanced by planning and management of blue spaces	Urban planners, landscape architects, local decision-makers, researchers, and stakeholders involved in planning, maintaining and designing blue spaces	https://bluehealth2020.eu/resources/toolbox/

Considering the systematic reviews presented in this report, there is a clear need to produce studies that investigate in more detail the actual exposure of individuals, not only based on proximity or availability, and not just field visits during experimental studies. This need should be reflected in the next generation of tools. Overall, most of the tools available for green and blue spaces do not consider health outcomes, except mortality, and mental health is particularly missing (Oosterbroek et al., 2016).

8. Looking ahead



This final section summarizes some particular results and considerations originating from the systematic reviews; it also raises some questions and makes some suggestions related to the current situation.

The EKLIPSE reviews: main results and gaps

The systematic reviews presented in this report have reinforced the evidence of a general beneficial relationship between green and blue spaces and mental health, an association that seems to hold for most green and blue space types. Comparisons, however, did not reveal a particular green or blue space type or characteristic that was more beneficial than others.

The main conclusions of the systematic reviews indicate the following:

- In general, positive effects and associations have been observed, also for small green elements, such as street trees.
- There was a large heterogeneity of outcomes.
- There is a need for a large variety of types of green (and blue) spaces to be considered in urban planning and design, and these should be made available and accessible.
- Decisions based on the local context should be encouraged.

Knowledge gaps remain, in particular in the following areas:

- There is a need for more direct comparisons of types, looking at the same key health outcomes, and considering effect sizes and strength of associations.
- Actual exposure is often not measured (whereas it is assumed to be a mediator of mental health benefits).
- There is the need to understand better the role of individual experiences during contact with specific green and blue spaces.
- Many studies looking at a specific type of green or blue space focus on areas that people usually purposefully visit. However, incidental contacts with nature, for example streetscape greenery (e.g. street trees) have also been shown to be associated with favourable health outcomes.
- Research on blue spaces is limited, especially on inland waters.
- There is a bias in the geographic distribution of research and there are many regions in which no studies have been conducted.

Future developments in urbanization and behavioural changes

Future developments may affect the type and amount of green and blue space provided, the types and characteristics of the nearby green and blue spaces that are available, and/or the contribution that these spaces may make to human health and well-being.

Current trends point towards the following:

- Ongoing urbanization (expansion and densification) is likely to lead to fewer opportunities for contact with nature in the residential environment, or at least to reduce the greenery per capita, which, in turn, could potentially result in the green space offering less peace and quiet. This may have, in general, negative health consequences.
- Climate change may affect mental health and also physical health. Green and blue space could play an important role in heat stress reduction. But the types of green and blue space that are most likely to beneficially affect mental health may not be the same type as those that are able to efficiently reduce heat stress.
- More tele-working from home, also after the pandemic, is making the residential environment more important for more people.

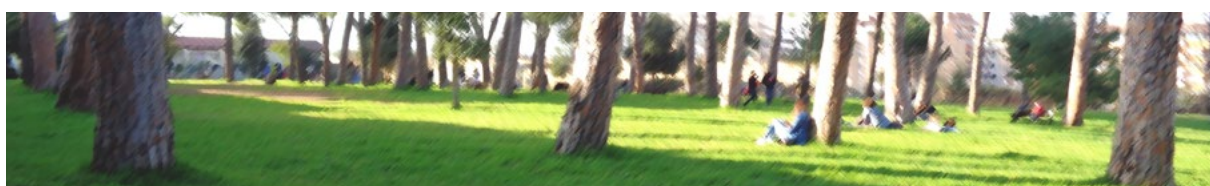
The ongoing COVID-19 pandemic significantly affects mental health. From anxieties around virus transmission and the psychological impact of lockdowns and self-isolation, to the effects of unemployment, financial worries and social exclusion – the mental health impact of the pandemic will be long-term and far-reaching. National surveys undertaken during the initial stages of the pandemic revealed that a third or more of the adult population were distressed (Rodríguez-Rey, Garrido-Hernansaiz & Collado, 2020; Pouso et al., 2021).

Already ongoing negative developments, such as social isolation and health inequalities, have been accelerated by the COVID-19 pandemic, especially where people have no easy access to nature. For some people, increased contact with nature is a partial compensation for reduced social contacts.

Reducing health disparities

Reducing health disparities is a major goal of public health in every social and environmental context. There is an urgent need to address such inequalities, which have been amplified by the pandemic. Inequalities in access to green and blue spaces represent an indicator not to be underestimated for a number of reasons. The following issues must be considered:

- Social inequity in the distribution of green and blue spaces in cities must always be considered because of the many poor urban neighbourhoods with no access to green and blue spaces (see for example, Anguelovski, Connolly & Brand, 2018). This is important in achieving progress towards the SDGs (e.g. SDG 11.7), which also emphasize vulnerable populations.
- Inequitable access to green and blue spaces can be associated with health disparities or inequalities, and it is important to think about solutions. Interventions should be promoted that provide better access to green and blue spaces, designed with local communities, placing emphasis on the health and well-being benefits.



Co-benefits of green and blue spaces

It is important to consider the synergies between the green city projects focused on the fight against climate change and pollution, and the projects on green and blue spaces focusing on mental health and well-being. The integration of green and blue spaces for nature-based climate change adaptation should work in synergy with mental health research outcomes, such as those presented in these systematic reviews, to help foster interdisciplinary work (Bibri, 2018). In addition to health effects, when well designed, green and blue solutions can produce social and environmental co-benefits, although they may also pose risks, related to ecosystem disservices, such as disseminating allergens or risk of physical injuries.

Making cities climate-resilient will help in facing various challenges, including the following:

- Besides heat stress reduction, cities face issues related to water management, for example in relation to water availability due to variations in rainfall frequency and intensity. Various green and blue solutions have a demonstrated capacity to reduce heat stress and foster water retention.
- Green and blue solutions have to take into account not only water retention capacity but also the risk of zoonotic diseases.

Biodiversity in the city exhibits an importance that is often underrated. There are some indications that biodiverse nature is better for mental health. Consequently, decision-makers should consider how biodiversity might be increased in a safe and beneficial way.

Putting knowledge into practice

Some tools are already available (for example, for ecosystem services analysis and microclimatic conditions simulation), but there is a need for more specific and better tools able to integrate health (including mental health) impacts when considering green and blue spaces.

There is a specific need for tools that include mental health benefits, and which can:

- complement assessment tools dedicated to the benefits of nature-based solutions
- consider well-being, looking beyond economic valuation.

The analysis of green and blue spaces and mental health issues is part of a larger picture that also considers climate change, loss of ecosystems and biodiversity, and increasing social inequalities.

Key issues to consider in using green and blue space to promote good mental health

Despite the gaps in our understanding of the complex relationships involved, the available evidence justifies green and blue space related actions and interventions to protect and promote mental health – with the caveat that, as highlighted in the EKLIPSE systematic reviews, there are no standard solutions.

The EKLIPSE systematic reviews have once again established a general beneficial relationship between green and blue space and mental health, an association that seems to hold for most green and blue space types. Comparisons, however, did not reveal a particular green or blue space type or characteristic that was more beneficial than others.

Many tools to mitigate feelings of anxiety or depression exist, which may help individuals in coping with mental distress. Getting out into nature, where and when permitted, and keeping active is one of them. That makes access to nature, green and blue space, even more important, as a refuge for people to relax and socially interact in, in particular while adhering to restrictions enforced because of the spread of aggressive viruses.

There is a need to strengthen capacities in the health sector so that public health and health-care professionals are aware of the current evidence on green and blue spaces and mental health, and are capable of making use of it. They also need to be better prepared to discuss with other professionals (urban planners, architects, etc.) the different options and scenarios that can be implemented in cities. The work presented here on mental health can inform WHO activities to strengthen the capacity of the public health sector to monitor progress towards goals set in international commitments, and national and local policies. Strengthening the capacity of the public health sector goes together with the creation, availability and use of new tools and the ability to develop coherent policies and integrated approaches based on scientific evidence.

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