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Review article

Mental health benefits of specific blue space types and characteristics: A systematic evidence map

F. Beute [a,b,1,*], M.R. Marselle [c,d,1], A. Olszewska-Guizzo [e,f], M.B. Andreucci [g], A. Lammel [h], Z.G. Davies [i], J. Glanville [j], H. Keune [k], L. O'Brien [l], R. Remmen [k], A. Russo [m], S. de Vries [n]

[a] Faculty for Health and Social Sciences, University of South-Eastern Norway, Norway
[b] Psychology Department, Inland Norway University of Applied Sciences, Norway
[c] Environmental Psychology Research Group, School of Psychology, University of Surrey, United Kingdom
[d] Biodiversity & People Department, Helmholtz Centre for Environmental Research (UFZ), Germany
[e] Neurolandscape Foundation, Warsaw, Poland
[f] Yong Loo Lin School of Medicine, National University of Singapore, Singapore
[g] Department of Planning, Design, Technology of Architecture, Sapienza University of Rome, Rome, Italy
[h] Laboratoire Paragraph, Université de Vincennes, Paris 8, France
[i] Durrell Institute of Conservation and Ecology (DICE), School of Anthropology and Conservation, University of Kent, United Kingdom
[j] York Health Economics Consortium, University of York, United Kingdom
[k] Faculty of Medicine and Health Sciences, Department Family Medicine and Population Health, University of Antwerp, Belgium
[l] Forest Research, Society and Environment Research Group, Alice Holt Lodge, United Kingdom
[m] School of Architecture and Built Environment, Faculty of Engineering, Queensland University of Technology, Australia
[n] Wageningen Environmental Research/Cultural Geography, Wageningen University & Research, the Netherlands

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ABSTRACT

Natural environments support mental health and wellbeing, yet limited evidence exists about which types or characteristics are most beneficial. This is particularly true for blue spaces (natural or manmade outdoor environments featuring water). This evidence map investigates the mental health and wellbeing benefits associated with specific blue space types (e.g. coast, river) and characteristics (e.g. sounds). Following PRISMA guidelines, specific keywords were used to search for articles published from inception to March 2025. A total of 139 papers were included, examining the relationships between specific blue space types or characteristics and mental health. Coastal environments were the most frequently studied blue space (94 studies). Affect was the most assessed mental health outcome (74 studies). Most studies were conducted in European and Asian countries. Most studies compared blue spaces to urban or a green space environments, rather than other blue spaces. Only six studies directly compared different blue space types within the same study. Overall, the current evidence base does not allow for comparisons between different blue space types or characteristics, due to the limited number of direct comparisons and substantial heterogeneity across study designs, outcome measures, geographical contexts, blue space descriptions, and study populations. Future research should prioritize direct comparisons between different blue spaces, preferably including the detailed descriptions and analyses of specific characteristics, and examine the role of amount and type of exposure to better inform evidence-based recommendations for blue spaces and mental health.

1. Introduction

Living in a dense urban environment is a threat to mental health and well-being (van der Wal et al., 2021; Xu et al., 2023). As the characteristics of cities—their natural and built environment and the different features of neighbourhoods—can affect mental health (WHO, 2016), it is important to understand which specific environmental factors prevent mental health problems. A large body of literature suggests that contact with natural environments in cities might prevent mental ill health by reducing stress and exposure to environmental stressors, while also

* Corresponding author. Faculty for Health and Social Sciences, University of South-Eastern Norway, Norway.
E-mail address: Femke.Beute@usn.no (F. Beute).
[1] Joint first author.

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restoring attention, promoting physical activity and social cohesion (Frumkin et al., 2017; Hartig et al., 2014; Markevych et al., 2017; Wood et al., 2017). However, natural environments are not all the same; these spaces are diverse in both their typology (e.g. forest, park, coast) and defining characteristics (e.g. parks can differ in their level of biodiversity) (WHO, 2021). As such, future studies should understand which specific types and distinguishing characteristics of nature positively influence mental health (WHO, 2021). The literature often distinguishes a macro classification of nature into green and blue spaces. Green spaces being outdoor areas partially or entirely covered by 'green' vegetation (e.g. urban parks) or isolated elements of vegetation (e.g. street trees) (Taylor and Hochuli, 2017). Blue spaces are natural or manmade outdoor environments that prominently feature water (Grellier et al., 2017). Most studies focus on the mental health benefits of green spaces (Gascon et al., 2015; Houlden et al., 2018; Meredith et al., 2020; Tillmann et al., 2018; Van den Berg et al., 2015; Vanaken and Danckaerts, 2018). Consequently, less is known about the mental health benefits of blue spaces (Bell et al., 2021; White et al., 2020). As urban planners and decision makers need to know which types of nature are worth investing in for health promotion, future studies should differentiate between specific types and characteristics of blue spaces (Smith et al., 2021). The purpose of this study is to systematically map the literature to examine which specific blue space types and blue space characteristics provide mental health benefits.

Despite the widespread research on green space and health, there have been only three reviews of the mental health benefits from contact with specific types and characteristics of green space. Nguyen et al. (2021) conducted a systematic review of 59 quantitative studies, finding positive associations between mental health and most green space types, and the green space qualities 'natural features', 'shape and connectivity' and 'objective quality scores'. Reyes-Riveros et al. (2021) undertook a systematic review of 153 quantitative studies to look at three specific green space characteristics—biodiversity, naturalness and structure—on four dimensions of human wellbeing (i.e. health, security, good social relations, freedom of choice). They found that biodiversity and naturalness of green spaces were beneficial for human health. Beute et al. (2023) investigated the mental health benefits from seven different green space types and five distinct green space characteristics. Their scoping review of 215 qualitative and quantitative studies found almost all green space types and characteristics were associated with positive mental health. This evidence map draws inspiration from Beute et al. (2023) by specifically examining the mental health and wellbeing benefits associated with specific types (e.g. coast, river) and characteristics (e.g. sounds) of blue spaces.

While there is a limited, but growing, volume of systematic reviews examining the potential health benefits of blue spaces, very few provide insight into which specific types or characteristics of blue space are beneficial for human health. Existing systematic reviews typically focus on proximity to, and availability of, blue space within residential contexts, and report beneficial associations for physical and mental health (Gascon et al., 2015; Geneshka et al., 2021; Smith et al., 2021). However, these existing systematic reviews do not disaggregate findings by blue space types or characteristics. Velarde et al. (2007) were among the first to review health effects across different landscape types, finding that environments featuring water were associated with greater health benefits, compared to environments without water. Similarly, Völker and Kistemann (2011) reviewed 36 articles on the health impacts of freshwater blue spaces, identifying psychological restoration, recreation, landscape design and preference as mediating factors. Yet, their analysis did not differentiate outcomes by freshwater types (e.g. lake, river). Britton et al. (2020) undertook a systematic review focused on 'blue care'—therapeutic mental health interventions that occurred in blue space—and found these interventions to be beneficial for mental health. However, Britton et al. (2020) did not report the mental health outcomes by the specific type of blue space in which the 'blue care' interventions occurred (e.g. sea, lake, wetland). In their scoping review of five studies (Hermanski et al., 2022), found mental health benefits from blue space exposure, although the small number of included articles preclude any firm conclusions. Wang et al. (2024) conducted a systematic review of 34 quantitative studies, finding positive associations between exposure to freshwater blue spaces and mental disorders, and subjective wellbeing. However, as their primary focus was on freshwater blue space exposure assessment methods (e.g. availability, visibility), the mental health outcomes were not analysed by specific freshwater types (e.g. lakes, rivers) (Gascon et al., 2017). conducted a systematic review of 35 quantitative studies found positive associations between blue space exposure, physical activity, and mental health and wellbeing. Importantly, their review investigates three different blue space types: coast, freshwater, and a combination of both fresh and salt waters. A greater number of studies reported positive associations for exposure to coastal environments and mental health, than for freshwater and combination of fresh and salt water blue spaces (Gascon et al., 2017). Given the growth in research on blue spaces (Bell et al., 2021; K. Wang et al., 2022), there is a clear need to update and extend previous reviews by systematically examining the mental health benefits associated with specific types and characteristics of blue spaces.

We conducted a systematic evidence map of studies to investigate the mental health benefits from contact with specific blue space types and characteristics. In line with established definitions of mental health (Keyes, 2006; WHO, 2014), we investigate both mental illness (e.g., prevalence and severity of mental and psychiatric disorders) and mental wellbeing (e.g., happiness, stress). We define blue space types as a specific kind of outdoor environment that features water (e.g. coast, river, wetland), and blue space characteristics as a distinguishing aspect of a blue space (e.g. soundscape) (Beute et al., 2020). By focusing on specific blue spaces types and characteristics, our evidence map provides new insights, expanding upon previous systematic reviews on blue space and human health that have focussed on either generic blue space types (Smith et al., 2021) Velarde et al. (2007); Völker and Kistemann (2011); Wang et al. (2024), or a combination of blue/green spaces (Gascon et al., 2015; Geneshka et al., 2021; Smith et al., 2021). Where past systematic reviews have examined a specific blue space type, they have been largely coastal (Gascon et al., 2017; Smith et al., 2021), meaning other specific blue space types and characteristics are under-explored (Smith et al., 2021). Our current systematic evidence map advances the field by going beyond these vague, general categories, mapping the existing literature according to mental health outcomes associated with specific blue space types and characteristics, identifying gaps in the current evidence base and making suggestions for future research.

This systematic evidence map aims to.

(a) Identify studies that investigate specific blue space types or blue space characteristics in terms of impact on mental health and wellbeing
(b) Systematically map these studies in terms of their type(s) and/or characteristic(s) of blue space studied, study design, geographical spread, types of mental health outcomes investigated, population types, assessment context, exposure characteristics, and direction of outcomes
(c) Identify potential gaps in the current evidence base.

1.1. Conceptual framework for the systematic evidence map

Distinguishing between the mental health benefits of different blue space types and characteristics calls for studies looking at separate and measurable features of blue spaces and their characteristics. Building on conceptual models by White et al. (2020) and others (Bratman et al., 2019; Hartig et al., 2014; Markevych et al., 2017; Marselle et al., 2021), we developed a four-step conceptual framework detailing how blue spaces influence mental health outcomes (Fig. 1). The first step defines

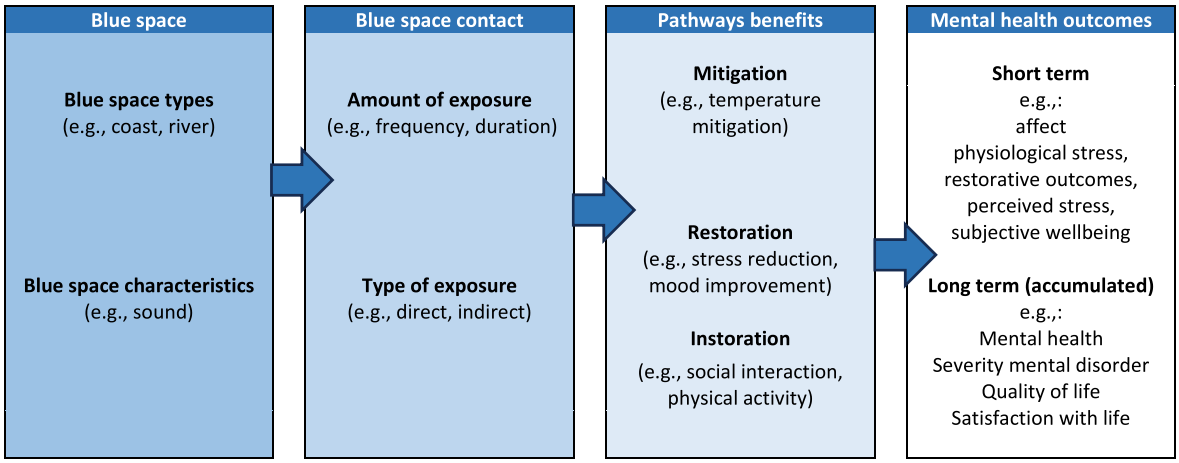

Fig. 1. Conceptual framework for the systematic evidence mapping, adapted from (Bratman et al., 2019; de Vries, 2022; Markevych et al., 2017; Marselle et al., 2021; White et al., 2020).

blue spaces by its specific type (e.g., coast, river, waterfall) and/or characteristics (e.g., produced sounds). The second step focuses on contact with these blue spaces, which is defined by two different aspects: the amount and type of exposure. The amount of exposure that an individual or population has with a type or characteristic of blue space can be measured in a variety of ways: actual measures such as duration (how long) and frequency (how often) (Bratman et al., 2019; De Vries, 2022); or proxy measures such as availability (the total amount of blue space surrounding a person's location, e.g., residence, workplace, neighbourhood); or proximity (the distance from one's location (i.e., home/work) to the nearest blue space type; Bratman et al., 2019; Ekkel and de Vries, 2017; Frumkin et al., 2017; Wang et al., 2024). Type of exposure can, for instance, be assessed as to whether an individual or population has direct or indirect exposure to a blue space. Direct exposure is when people are physically present in the blue space (e.g. sitting by a lake) (Marselle et al., 2021). Indirect exposure is when people have contact with a blue space without being physically present to it (e.g. watching Blue Planet TV programme, looking at the ocean through a window, experiencing Niagara Falls in virtual reality) (Marselle et al., 2021). The third step involves the three domains of pathways linking blue spaces to mental health and wellbeing: mitigation (i.e. reducing harm, e.g. reduced urban heat island), restoration (i.e. restoring depleted capacities, e.g. attention restoration, stress recovery), and instoration (i.e. building capacities for meeting everyday demands, e.g. physical activity, positive social relationships) (Markevych et al., 2017; White et al., 2020). The final step details the particular short- and long-term mental health outcomes from contact with specific types and characteristics of blue spaces.

2. Method

A systematic evidence map literature review was performed to investigate the mental health benefits from contact with specific blue space types and characteristics. Systematic maps are a form of systematic evidence synthesis, designed to map out and categorize existing literature, and explore trends and identify gaps for use in future reviews and primary research (Grant and Booth, 2009; Miake-Lye et al., 2016). This study was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines for scoping reviews (Moher et al., 2010; Tricco et al., 2018). This systematic evidence map was not registered in a protocol database, but a protocol was published separately (Andreucci et al., 2019). This systematic mapping review consisted of six consecutive steps: protocol development, literature search, study selection, metadata extraction, a descriptive and narrative synthesis, and the development of two searchable Excel tables.

2.1. Search strategy

Searches were conducted by a qualified information specialist on November 29, 2018 in Web of Science and MEDLINE (Ovid) and on February 7, 2019 in Scopus only, supplemented with searches on March 29, 2021, August 29, 2023, and March 19, 2025 in Scopus, Web of Science and MEDLINE (Ovid) to include more recent studies.Fig. 2 and Section 3.1 detail the number of studies identified and excluded.

To identify relevant literature on mental health, we employed both generic (e.g., mental health, wellness, relaxation) and specific (e.g. anxiety, depressive disorder, quality of life) search terms. Similarly, for blue space types and characteristics, we also used both generic (e.g., blue space, aquatic, waterscape) and specific (e.g., lake, wetland, beach, canal) search terms. The full search strategy is available in the supplementary materials (S1).

2.2. Study selection

We included all studies meeting the following PICO/PECO criteria (Morgan et al., 2018, see Supplementary Table 1).

(a) Population: Human beings of all ages and genders.
(b) Intervention: Environmental interventions that manipulated or changed exposure to a specific outdoor blue space type (e.g., lake river) or characteristic of a blue space (e.g., water sounds). Table 2 lists the outdoor blue space types and characteristics included in this evidence map. Interventions that changed the amenities and/or facilities in a specific blue space type were also included. Excluded were compound measures of blue space (e.g., amount of water without specification of its type or characteristics; normalised difference water index), and studies that examined green-blue space (e.g., amount of all green and blue spaces together). Studies of therapeutic interventions in a blue space were also excluded when the intervention focused on humans.
(c) Exposure: Any amount or type of exposure to an outdoor blue space type or blue space characteristic is eligible. Regarding type of exposure, both direct (being physically exposed to the environment) and indirect (e.g., viewing videos or through a window) interactions with a specific outdoor blue space type or characteristic were eligible. Indoor blue space exposure was excluded to keep the focus on outdoor blue space types and their characteristics.

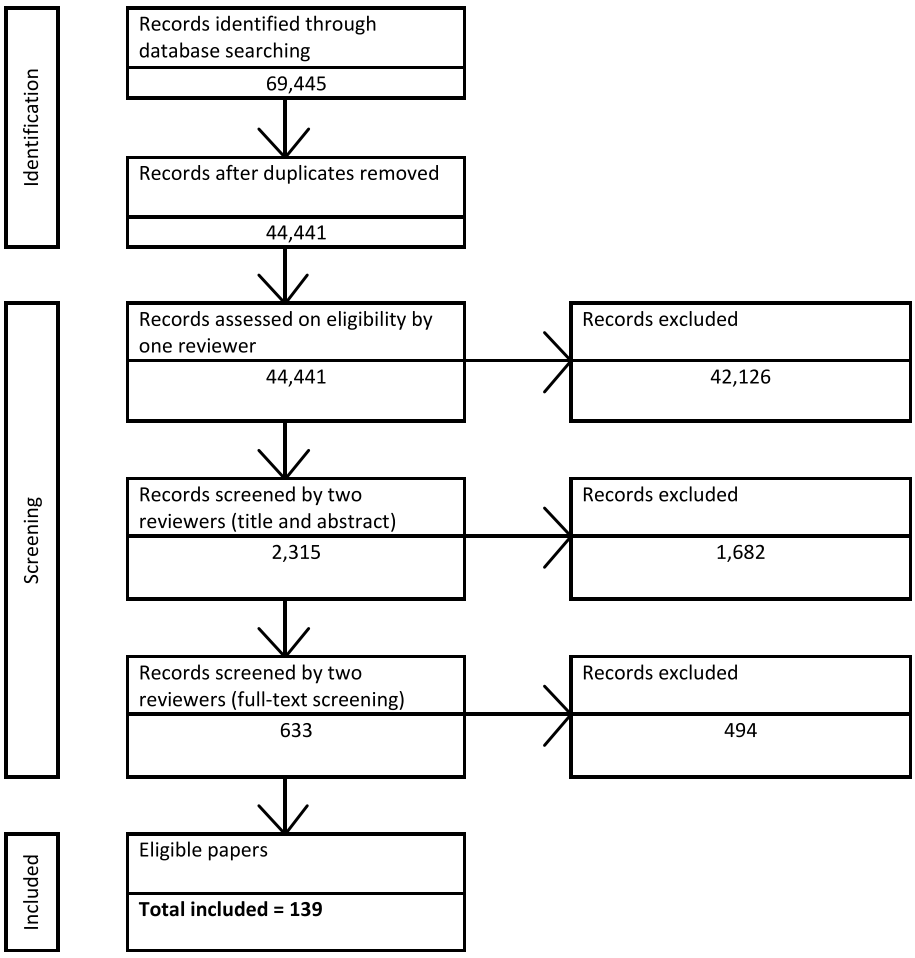

Fig. 2. PRISMA flow chart.

(d) Comparison: The comparison environment was a different type(s) or characteristic(s) of outdoor blue space, green space, or the built environment. Comparisons with indoor environments or compound measures of blue space were excluded.
(e) Outcomes: Studies that investigated mental ill health (e.g., depression, anxiety) according to the ICD-10 (WHO, 1992), mental wellbeing (e.g. life satisfaction, quality of life), momentary mood, and stress were eligible. Table 3 lists the mental health and wellbeing outcomes included in this evidence map. Studies that only measured preference, perceived restorativeness, cognitive performance, or physical activity were excluded.

Regarding study design, all experimental, observational (cross-sectional and longitudinal), and qualitative designs were eligible. Peer-reviewed empirical articles, published in English, from any date were eligible. Case studies with only one participant were excluded.

Obviously ineligible records were first excluded by a single reviewer (JG). Records were then loaded into Covidence (Veritas Health Innovation, Australia), where two reviewers independently screened titles and abstracts against the eligibility criteria. Full-text screening of eligible studies following the title/abstract screening was undertaken by two reviewers (FB and MM) independently to determine the final set of included studies for the evidence map. Any disagreements were resolved through discussion between the two reviewers. Fig. 2 and Section 3.1 detail the number of articles rejected and included at each stage.

2.3. Metadata extraction

Metadata were extracted from all eligible records, using a predetermined codebook. Two reviewers independently charted the data (FB & MM). Consistency checks were done by one reviewer (FB). Data were extracted within four general themes: general study information, study methodology, blue space, and mental health. On one occasion an article contained more than one eligible study (Tanja-Dijkstra et al., 2018); both studies were treated as separate records.

The resulting meta-dataset was subsequently used to create two searchable Excel tables, summarizing the elementary characteristics and results of each study (Appendix S2) as well as an overview of the studies organised by blue space category and mental health outcome (Appendix S3). In both searchable tables, each row represents a unique combination of blue space type or characteristic and mental health outcome. Hence, one study can have multiple rows in the table.

2.4. Descriptive and narrative synthesis

For the descriptive and narrative synthesis, overviews were made for blue space categories (Table 2). In addition, there were also two miscellaneous categories, one for blue space types ('other blue space types') and one for the blue space characteristics ('other blue space characteristics'). Categorization of the blue space type(s) or characteristic(s) for each paper was based on the terms that were used in the papers themselves. Tables 2 and 3 provide an overview and description of the blue space categories and mental health outcomes, respectively.

To systematically map studies (aim b) by geographical spread, types of mental health outcomes investigated, population types, assessment context, exposure characteristics, and direction of outcomes, we used meta-data extraction tables. Descriptions are made for all studies, in

Table 1
Main characteristics of the 139 papers.

Author	CAT	Type/characteristic of blue space	Mental health outcome
Afentou et al. (2024)	Q	River/Canal	Social contact
Alcock et al. (2015)	O	Coast/sea/beach	Mental health
Aliyas (2021)	O	Coast/sea/beach	Mental health
Amoly et al. (2014)	O	Coast/sea/beach	Problem behaviour
Angradi et al. (2022)	O	Other Char. (Flood/Percentage artificial shores)	Mental health
Arnberger et al. (2024)	O	Inland/Other (outdoor swimming location)	Affect
Ashbullby et al. (2013)	Q	Coast/sea/beach	Subjective wellbeing
Ballesteros-Olza et al. (2024)	Q	Coast/sea/beach	Restorative outcomes, Social contact
Bell et al. (2015)	Q	Coast/sea/beach	Restorative outcomes, Subjective wellbeing
Benvegnu et al. (2024)	E	Wetland	Affect, Subjective wellbeing
Bergou et al. (2022)	O	River/Canal, Other Char. (Qualities)	Subjective wellbeing
Bryce et al. (2016)	O	Other Type (Marine)	Subjective wellbeing
Cao et al. (2024)	E	River/Canal	Affect, Physiological stress
Cao et al. (2023)	E	Inland	Affect, Physiological stress
Chen et al. (2023)	O	River/Canal, Sound, Other Char. (biodiversity, visual attractiveness, air freshness)	Affect
Chen and Yuan (2020)	O	Inland (rivers and lakes), Other Char. (Qualities)	Mental health, Perceived stress, Social contacts
Chen et al. (2024)	E	Inland	Affect, Physiological stress
Coleman and Kearns (2015)	Q	Coast/sea/beach	Restorative outcomes
Corney and Neave (2019)	Q	River/canal, Other Char. (Biodiversity)	Restorative outcomes
De Vries et al. (2021)	O	River/Canal, Coast/sea/beach, Other Type (Planar: water, sea)	Affect
Dempsey et al. (2018)	O	Coast/sea/beach	Severity mental disorder
Diamond et al. (2024)	Q	Coast/sea/beach	Restorative outcomes, Social contact
Elliott et al. (2023)	O	Coast/sea/beach, Inland	Social contacts, Subjective wellbeing
Elsadek et al. (2024)	E	Inland	Affect, Brain activity, Physiological stress
Emfield and Neider (2014)	E	Coast/sea/beach	Affect, Perceived stress
Fang et al. (2021)	O	Inland	Mental health
Faulkner (2023)	Q	Coast/Sea/beach, River/canal	Restorative outcomes
(Fisher, et al., 2021a)	O	Inland	Affect
(Fisher, et al., 2021b)	Q	Coast/sea/beach	Subjective wellbeing
Fu et al. (2024)	O	Inland	Affect
Gao et al. (2019)	E	Lake	Affect, Brain activity
Garrett et al. (2023)	O	Coast/sea/beach, Lake, River/canal, Waterfall, Other Type (Marine, Water feature/fountain, Outdoor pool/spa, Ice rink, Fen/bog/marsh)	Affect, Satisfaction with life
Garrett et al. (2019)	O	Coast/sea/beach, Inland	Mental health, Severity mental disorder
George et al. (2025)	O	Coast/sea/beach, River/Canal, Lake (and swamp)	Problem behaviour
Gernow et al. (2024)	Q	Coast/sea/beach, Inland	Subjective wellbeing
Gidlow et al. (2016)	E	River/canal	Affect, Physiological stress, Restorative outcomes
Gong et al. (2024)	O	River/Canal	Subjective wellbeing
Grace et al. (2024a)	O, Q	Inland	Restorative outcomes
Grace et al. (2024b)	Q	Inland	Subjective wellbeing
Greco et al. (2024)	E	Coast/Sea/Beach	Physiological stress
Helbich et al. (2018)	O	Coast/sea/beach	Other (suicide rate)
Hepburn et al. (2021)	O	Inland	Satisfaction with life
Hooyberg et al. (2020)	O	Coast/sea/beach	Mental health
Hooyberg et al. (2023)	E	Coast/Sea/Beach	Affect, Perceived stress, Physiological stress
Hsieh et al. (2023)	E	Sound	Affect, Mental health, Physiological stress
Huang et al. (2024b)	E	River/Canal. Other Char. (% artificial elements, industrial remains, pavements, natural elements, ground-covering plants, flowering shrubs, trees)	Physiological stress
Huang et al. (2024a)	E	Inland, Other Char. (waterfront)	Physiological stress
Hung et al. (2022)	E	River/canal, Other (ponds)	Affect, Brain activity, Physiological stress
Jewkes et al. (2020)	Q	Coast/sea/beach	Affect
Jin et al. (2022)	E	Lake	Affect
Jin et al. (2024a)	O	Wetland	Affect
Jin et al. (2024b)	E	Inland	Brain activity, physiological stress
Jo et al. (2022)	E	Waterfall	Affect, Brain activity, Physiological stress
Korpilo et al. (2024)	E	Coast/Sea/Beach, Sound	Physiological stress, Restorative outcomes
Lan et al., 2024	E	Inland	Affect, Physiological stress, perceived stress

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Table 1 (*continued*)

Author	CAT	Type/characteristic of blue space	Mental health outcome
Lan et al. (2025)	O	Coast/Sea/Beach, Lake, River/Canal	Mental health, Perceived stress, Social contact
Li et al. (2023)	O	Coast/sea/beach, Inland	Mental health
Li and Managi (2024)	O	Wetland	Mental health
Li and Liu (2024)	O	Inland, Sound	Affect, Brain activity
Li et al., 2024	E	Sound	Brain activity
Lin et al. (2024a)	O	Coast/Sea/Beach	Mental health, Subjective wellbeing
Lin et al. (2024b)	E	Other Char. (speed of water flow)	Affect, physiological stress
Liu et al. (2021)	O	Inland	Affect, mental health, Subjective wellbeing
Liu et al. (2020)	O	River/canal, Waterfall	Mental health
Liu and Liao (2024)	O	Inland	Subjective wellbeing
Liu et al. (2024)	E	Sound	Affect
Liu et al. (2025)	E	Other type (Pool), Waterfall	Restorative outcomes
Luo et al. (2023a)	E	Waterfall	Brain activity
Luo et al. (2023b)	E	River/Canal, Lake	Affect, Restorative outcomes,
Ma et al. (2023)	O	River/Canal	Sleep, Social contacts
MacKerron and Mourato (2013)	O	Coast/sea/beach, Inland	Affect
Maes et al. (2021)	O	Inland	Problem behaviour, Quality of life
Martin et al. (2024)	O	Coast/Sea/Beach	Sleep, Subjective wellbeing
Mavoa et al. (2019)	O	Coast/sea/beach, Lake, River/canal	Severity mental disorder, Subjective wellbeing
McDougall et al. (2024)	O	Coast/Sea/Beach, Inland	Subjective wellbeing
McDougall et al. (2021)	O	Coast/sea/beach, Inland, Lake, River/canal	Prevalence mental disorder, Subjective wellbeing
McNamara et al. (2020)	Q	Coast/Sea/beach, River/canal	Restorative outcomes, Subjective wellbeing
Michels and Hamers (2023)	E	Sound	Affect, physiological stress
Murrin et al. (2023)	O	Coast/sea/beach, Inland	Severity mental disorder, Subjective wellbeing
Nicolosi et al. (2021)	E	Coast/sea/beach	Restorative outcomes
Ning et al. (2023)	E	Lake	Physiological stress
Paraskevopoulou et al. (2022)	E	Coast/sea/beach	Physiological stress
Park et al. (2020)	E	River/canal	Physiological stress
Pearson et al. (2019)	O	Lake	Prevalence mental disorder
Pedersen et al. (2019)	O	Wetland	Affect, quality of life
Pitt (2018)	Q	River/canal	Mental health
Qiang et al. (2019)	O	Coast/sea/beach	Severity mental disorder
Reece et al. (2022)	E	Lake	Affect, Mental health, Physiological stress
Reeves et al. (2019)	E	Wetland	Affect, Brain activity, Physiological stress
Reeves et al. (2021)	Q	Wetland	Restorative outcomes
Rickard and White (2021)	E	Coast/sea/beach	Restorative outcomes
Rouse and Wishart (2025)	Q	Coast/sea/beach	Subjective wellbeing
Sandifer et al. (2021)	O	Coast/sea/beach	Mental health
Satariano (2019)	Q	Coast/sea/beach	Social contacts, Subjective wellbeing
Severin et al. (2022)	Q	Coast/sea/beach	Restorative outcomes
Shi et al. (2024)	E	Inland	Affect, Perceived stress, Physiological stress
Subiza-Pérez et al. (2020)	O	Coast/Sea/beach	Restorative outcomes
Sun et al. (2024)	O	River/Canal	Affect
Tang et al. (2024)	E	Inland	Physiological stress
(Tanja-Dijkstra et al., 2018) S1	E	Coast/Sea/beach	Other (Pain)
(Tanja-Dijkstra et al., 2018) S2	E	Coast/Sea/beach	Perceived stress, Other (Pain)
Tashiro et al. (2021a)	O	Coast/Sea/beach	Mental health
Tashiro et al. (2021b)	O	Coast/Sea/beach	Mental health
Triguero-Mas et al. (2017)	E	Coast/Sea/beach	Affect, Physiological stress
Tsai et al. (2023)	Q	Coast/Sea/Beach	Restorative outcomes
Tsutsumi et al. (2017)	E	Coast/Sea/beach	Affect, Physiological stress
van den Bogerd et al. (2021)	E	Coast/Sea/beach	Satisfaction with life, Subjective wellbeing
Vasco et al. (2024)	Q	Other type (Pond)	Quality of life
Vert et al. (2020)	E	Coast/Sea/beach	Affect, Mental health, Physiological stress, Satisfaction with life, Subjective wellbeing, Vitality
Völker and Kistemann (2015)	Q	River/canal	Restorative outcomes
Wade et al. (2023)	O	Lake, River/canal, Wetland. Other Type (Tributary)	Affect, Restorative outcomes
Wang et al. (2021)	E	Other Char. (naturalness)	Restorative outcomes
Wang et al. (2022)	E	Sound	Physiological stress
Weng et al. (2024)	E	River/Canal, sound	Affect, physiological stress
White et al. (2013a)	O	Coast/Sea/beach, inland	Mental health, Satisfaction with life

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Table 1 (*continued*)

Author	CAT	Type/characteristic of blue space	Mental health outcome
White et al. (2013b)	O	Coast/Sea/beach, inland	Restorative outcomes
White et al. (2017a)	O	Coast/Sea/beach	Affect, Satisfaction with life
White et al. (2017b)	E	Coast/Sea/beach, Other Char. (Biodiversity)	Restorative outcomes
White et al. (2021)	O	Coast/Sea/beach, inland	Prevalence mental disorder, Subjective wellbeing
Willis (2015)	Q	Coast/sea/beach	Subjective wellbeing
Wilson et al. (2024)	O	Coast/sea/beach, Inland	Mental health, Prevalence mental disorder, Subjective wellbeing, Other (Suicide)
Wyles et al. (2019)	O	Coast/Sea/beach, Other Type (protected vs unprotected)	Restorative outcomes
Yan et al. (2024a)	E	River/Canal, Other type (Waterfront), Other Char. (green & blue visibility, openness, cleanliness, naturalness, water-friendliness)	Affect, Physiological stress
Yan et al. (2024b)	O	Coast/Sea/Beach	Perceived stress, Social contacts
Yang et al. (2024)	O	Inland	Perceived stress, Social contacts, Subjective wellbeing
Yin et al. (2023a)	E	Inland	Affect, Physiological stress
Yin et al. (2023b)	E	Lake	Affect
Yinan et al. (2024)	E	Inland	Affect, Mental health, Physiological stress
Yuan et al. (2023)	E	Lake	Affect, Brain activity
Zhang et al. (2021)	E	Other type (Waterscape)	Physiological stress
Zhang et al. (2022)	E	Lake	Physiological stress
Zhang and Chen (2023)	E	Sound	Affect
Zhang et al. (2023)	E	Lake	Affect, Brain activity
Zhang et al. (2025b)	E	Lake, Sound, Waterfall	Brain activity
Zhang et al. (2025a)	E	Sound	Affect, Brain activity, Physiological stress, Restorative outcomes
Zhu et al. (2021)	E	Waterfall	Severity mental disorder
Zhu et al. (2023b)	E	Sound	Restorative outcomes
Zhu et al. (2023a)	E	Sound, Other Type (Waterfront)	Physiological stress
Zhu et al. (2024)	E	Other type (Waterfront)	Affect, Physiological stress

Note. CAT = Research Design Category. E = Experimental, O = Observational. Q = Qualitative. Other char. = other characteristic.

Table 2
Overview of the blue space categories present in the systematic evidence map.

Blue space category	Description	Examples
Blue Space Types		
Coast/Sea/Beach	Sea and the part of land adjacent to it	A rocky beach
Inland water	Combination of inland waters, sometimes also referred to as freshwater, including different categories such as lakes and rivers.	Freshwater
Canal/River	A stream of water flowing in a naturally formed river or an artificial canal.	A river
Lake	A large body of water that is surrounded on all sides by land	Lake
Wetland	Waterlogged soil, with water at or near the surface.	Marsh, swamp, bog
Waterfall	A stream of water falling down from a height	Waterfall
Other blue space type	Miscellaneous	Waterscape, Waterfront, Fountain, Outdoor pool
Blue Space Characteristics		
Sound	Sounds of water	Sound of a waterfall
Other blue space characteristic	Miscellaneous	Quality, Biodiversity, Naturalness

total, and for specific study design types (i.e., experimental, observational, qualitative).

To understand the differential effects between different blue space types and characteristics on mental health outcomes (aim c), studies were categorized into three different comparison types, based on previous research (Beute et al., 2023).

1. 'Direct within study' - different environments were directly compared in the same study (e.g. the effects of a visit to the river vs. visit to a lake on perceived stress).
2. 'Indirect within study' - different types and characteristics were analysed separately within the same study (e.g. a study looking at the effects of proximity to the coast and proximity to inland waters on subjective wellbeing separately). For experimental study designs, the different types or characteristics of blue space investigated in the same study often constitute different conditions within the same experiment but are not directly compared. For observational study designs, the different types or characteristics of blue space investigated in the same study may be included in the same analysis as separate variables (e.g. regression model).
3. 'Indirect between studies' - studies reporting outcomes of a single blue space type or characteristic. In these studies, comparisons need to be made with other studies.

For the purposes of this evidence map, we decided that 'direct within study' comparisons were the most reliable, because these comparisons were made within a single study, and with the same study design. Indirect comparisons could only be made by looking at the direction of the effects – either within the same study or between studies. Between the two types of indirect comparisons, we considered that 'indirect within study' comparisons would have more reliable results, because at least the study design, population type and methodology would be similar. We considered that 'indirect between studies' comparisons were the least reliable way of comparing the effects of blue space types and characteristics, because the comparison would be made between two

Table 3
Overview of the mental health outcomes present in the systematic evidence map (adapted from Beute et al. 2023).

Mental health category	Description	Example objective and self-report measurement
Long-term mental health and wellbeing		
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 and Hillier, 1979)
Severity mental disorder	Severity of a specific mental disorder, expressed in level of symptoms or use of medication	CES-D (depression) (Radloff, 1977)
Prevalence mental disorder	How often a specific mental disorder occurs within the general population	Prevalence of ADHD
Satisfaction with life	Global life satisfaction	Satisfaction With Life Scale (Diener et al., 1985)
Short-term mental health and wellbeing		
Subjective wellbeing	Subjective ratings of wellbeing, encompassing different aspects of wellbeing such as happiness, life satisfaction, and psychological functioning	Warwick-Edinburgh Mental Well-being Scale (Tennant et al., 2007)
Affect	Momentary measurements of mood and affective state, including for instance positive and negative affect but also state anxiety, including vitality	Positive And Negative Affect Schedule (Watson, 1994)
Restorative outcomes	Measures focused on the restorative effects following contact with blue space, including psychological benefits such as relaxation and forgetting worries. Does not include perceived restorativeness, or anticipated/expected restoration	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 et al., 1983)
Physiological stress	Physiological responses to stress, or activity of the autonomic nervous system as an 'objective' measure of stress.	Heart Rate Variability
Brain activity	Brain activity associated with emotional states, relaxation, etc. measured with e.g., mobile EEG or fNIRS device.	EEG (Davidson et al., 2009)
Social Interaction	The amount of social interaction a person has with other people and/or the quality of these social interactions.	Number of social contacts (Chen, 2020)
Other	Miscellaneous: Problem behaviour, quality of life, sleep, pain, and suicide rate	E.g., sleep duration (Ma et al., 2023)

Note. ADHD = Attention deficit hyperactivity disorder. CES-D = Centre for Epidemiologic Studies Depression Scale. EEG = Electroencephalogram. fNIRS = Functional near-infrared spectroscopy.

different studies, which could vary on study design, population type, and methodology.

3. Results

3.1. Search outcomes

The combined search—including all records up until March 19, 2025—retrieved a total of 69,445 records. After removing duplicates, 44,441 records remained (Fig. 2). A single reviewer assessed the records on eligibility based on title alone, and at this stage 42,126 records were removed. After that, 2315 records were assessed for eligibility based on title and abstract by two reviewers (Fig. 2), where 1682 records were removed. Full-text screening further removed 494 records. A total of 139 papers were included in the systematic evidence map (59 experimental, 58 observational, 23 qualitative). The key characteristics of the 139 included studies are summarised in Table 1.

3.2. Description of the studies included in the systematic evidence map

The first studies investigating the effects of different blue space types and characteristics were published in 2013. The number of observational and experimental studies slowly increased over the years, with a leap in the number of publications in 2024 (Fig. 3). Details on the number of publications by year and study design can be found in the Supplementary Table 3.

The 139 papers included in this evidence map were categorized into 6 specific blue space types (46 coast/sea/beach, 22 inland water, 18 canal/river, 13 lake, 5 wetland, and 3 waterfall), and one miscellaneous blue space type category.[2] In addition, there was one blue space characteristic (sound) and one miscellaneous category looking at blue space characteristics (e.g., biodiversity, quality). See Table 2 for the descriptions of the different categories. The inland water blue space category was a combination category of studies investigating inland (or fresh) waters in general, without specifying the specific type of inland water. Studies that could be categorized into the specific inland water category 'river/canal', 'lake', or 'waterfall' were categorized as such and were not included in the inland water category. All blue space categories were represented in the experimental and observational study categories. For qualitative studies, all categories were represented except for lake, waterfall, and sound.

The studies will be discussed in terms of their blue space categorization(s) and their relationship with the mental health outcomes, as well as the direction of the effect of/association with these mental health outcomes (positive, negative, neutral). In addition, the results will focus on the geographical spread, population type used in the study, the assessment area (e.g., residential or school environment), and the exposure characteristics. Results will be split between the three research design categories: experimental, observational, and qualitative studies.

3.2.1. Mental health outcomes

In line with a previous review on green space types and categories (Beute et al., 2023), we defined 11 different categories for the mental health outcomes, plus a miscellaneous category 'other' (Table 3). All mental health outcomes that were investigated 5 times or more were included as a category.

Experimental studies focused mostly on affect and physiological stress, both as short-term mental health outcomes (Table 4). Observational studies focused on both short-term and long-term mental health outcomes—namely affect, subjective wellbeing, and overall mental health (Table 4). Qualitative studies focused mostly on restorative outcomes and subjective wellbeing.

The mental health outcomes studied were represented across all blue space types and research design categories (Table 4). Affect was the most often studied mental health outcome overall (74, 24%), and most often investigated in both experimental (40, 31%) and observational research designs (33, 21%). Affect was most often studied in the 'other blue space types' category (16, 22%), followed by inland (13, 18%) and river/canal environments (11, 15%).

After affect, the mental health outcomes that received the most research attention were: restorative outcomes (42, 13%), subjective wellbeing (41, 13%), physiological stress (39, 12%), and overall mental health (33, 10%) (Table 4). Restorative outcomes were most often studied in coast environments (16, 38%) and in the qualitative studies

[2] Categories were created if there were 5 or more papers investigating the specific blue space type or characteristic. Otherwise, papers were included into the 'miscellaneous blue space type' or 'other blue space characteristic' categories.

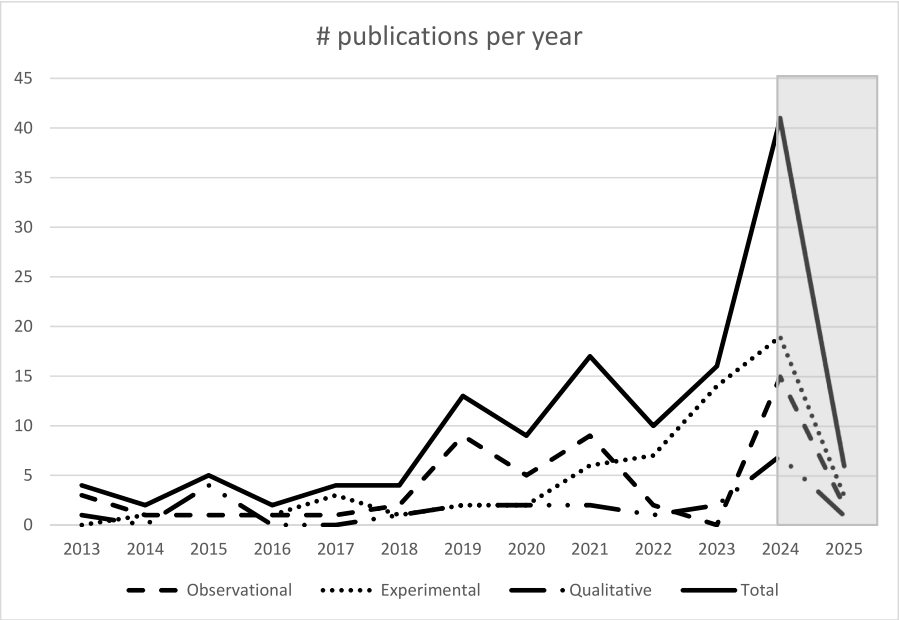

Fig. 3. Number of publications per year and study design. Please note that the search was conducted on March 19, 2025 and therefore the number of publications for 2025 are not complete.

(17, 50%). Subjective wellbeing was most often explored in observational studies (28, 68%). For subjective wellbeing and overall mental health, most studies looked at the coast (respectively: 10, 24%; 13, 39%). Physiological stress was only investigated in experimental studies (39, 100 %), and mostly for inland water categories (10, 26%). Overall mental health was further studied relatively often with exposure to the coast (14, 42%) and was most often explored in observational studies (29, 88%).

In general, Table 4 indicates that studies of different blue space types are highly scattered across the mental health outcomes. The coast was most often studied in relation to subjective wellbeing (18, 19%), closely followed by restorative outcomes (16, 17%), overall mental health (14, 15%) and affect (10, 11%) (Table 4). Inland waters were mostly investigated in relation to affect (13, 20%), physiological stress and subjective wellbeing (both 10, 15%), and overall mental health (9, 14%). Rivers/canals were most often investigated in relation to affect (11, 26%), subjective wellbeing (7, 16%), restorative outcomes (7, 16%), and physiological stress (6, 14 %). For lake, most studies looked at affect (9, 29%). Sound was investigated most often in experimental studies (21, 91%), and mostly in relation to affect (9, 39%), and physiological stress (6, 23%). The remaining studies were scattered across the mental health outcomes (Table 4). Absence of studies were found mostly for the blue space characteristics (Table 4). Overall, there were fewer studies for 'other blue space types' and waterfalls and 'other blue space characteristics'. This indicates how, to date, the mental health impacts of these blue space categories have received little scientific attention.

3.2.2. Geographical spread

Most studies in this evidence map were conducted in European and Asian countries[3] (both 62, 40%), see also Fig. 4.; The older publications were mostly conducted in Europe, and particularly in the United Kingdom, but in more recent years the studies were often performed in Asia, particularly in China. Experimental studies conducted in Europe focused on the blue space types coast, whereas the observational studies focused on the coast, inland water spaces, and 'other blue space types'. Experimental studies were most often conducted in Asia (38, 63%), with a focus scattered across blue space types lakes, river/canals and waterfalls, as well as on the blue space characteristic sounds. The other continents contributed less to the review: North America (17, 11%), Oceania (10, 6%), South America (3, 2%), and one observational study included data from Africa (1%). These data can be found in Supplementary Tables 4 and 5

3.2.3. Type of population

Most of the studies in this evidence map looked at the influence of blue space types or characteristics on the mental health of healthy populations (55 experimental, 58 observational, all 23 qualitative). Only four studies (3 experimental, 1 observational) included a clinical population. No studies were conducted using a population at-risk for mental illness.

Nine different types of populations,[4] and one miscellaneous 'other' category were identified (Table 5, see also Supplementary Table 3 for more information). About a quarter of the studies used national residents (52, 25%), most of which were observational studies (48, 92%). The second most often studied population type were students (42, 20%), followed by blue space visitors (30, 15%). Only experimental studies included students as a population (42, 100%). Local residents and the 'other' population type were each used in 21 studies (21, 10%). Urban residents (6), school children (4), and adolescents (3) were least investigated in all studies (Table 5).

The coast was mostly investigated using national residents (24, 36%) and to a lesser extent using local residents (9, 14%) and blue space visitors (8, 12%). Inland waters were also mostly investigated using national residents (12, 32%), and students (8, 21%). Both the lake (7, 35%) and sound (9, 64%) were investigated relatively often in experimental designs with students. For the other categories, the populations used were widely scattered (Table 5).

3.2.4. Type of assessment context

Type of assessment context refers to the context in which the studies

[3] There were 6 papers that were conducted in 17-167 countries. For these six papers, the contribution per continent was counted as 1. Otherwise, the proportion of studies would be highly skewed towards these 6 papers.

[4] All types of populations that were investigated in three or more studies were included as a category.

Table 4
Overview of studied mental health outcomes per blue space category.

Mental health outcome	Coast/Sea/ Beach			Inland			River/Canal			Lake		Waterfall		Wetland			OBST		
	E	O	Q	E	O	Q	E	O	Q	E	O	E	O	E	O	Q	E	O	Q
Affect	5	4	1	7	6	0	6	5	0	7	2	1	1	2	3	0	3	8	0
Rest. outc.	4	3	9	0	2	2	2	1	4	1	1	1	1	0	1	0	1	2	1
Subj. wellb.	2	10	6	0	8	2	0	5	2	0	3	0	0	1	0	0	0	1	0
Phys. Stress	5	0	0	10	0	0	6	0	0	2	0	1	0	1	0	0	5	0	0
Overall m. health	1	13	0	1	8	0	0	2	0	1	2	0	0	0	1	0	0	0	0
Brain act.	0	0	0	2	0	0	2	0	0	5	0	3	0	1	0	0	1	0	0
Other	2	5	1	0	3	0	0	2	0	0	1	0	0	0	1	0	0	0	1
Social Int	0	4	2	0	3	1		2	1	0	1	0	0	0	0	0	0	1	0
Satisf. w. life	2	3	0	0	2	0	0	1	0	0	1	0	1	0	0	0	0	5	0
Perc. Stress	3	2	0	2	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Sev. m. d.	0	5	0	0	2	0	0	1	0	0	1	1	0	0	0	0	0	0	0
Prev. m. d.	0	3	0	0	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Total	**24**	**51**	**19**	**22**	**39**	**5**	**16**	**20**	**7**	**16**	**15**	**7**	**3**	**5**	**6**	**0**	**10**	**16**	**0**
	94			**66**			**43**			**31**		**11**		**11**			**28**		

Mental health outcome	Snd		OBSC			**Total**			**Overall total**
	E	O	E	O	Q	**E**	**O**	**Q**	
Affect	7	2	2	2	0	**40**	**33**	**1**	**74**
Rest. outc.	3	0	2	0	1	**14**	**11**	**17**	**42**
Subj. wellb.	0	0	0	1	0	**3**	**28**	**10**	**41**
Phys. Stress	6	0	3	0	0	**39**	**0**	**0**	**39**
Overall m. health	1	0	0	3	0	**4**	**29**	**0**	**33**
Brain act.	4	0	0	0	0	**18**	**0**	**0**	**18**
Other	0	0	0	0	0	**2**	**12**	**2**	**16**
Social Int	0	0	0	1	0	**0**	**12**	**4**	**16**
Satisf. w. life	0	0	0	0	0	**2**	**13**	**0**	**15**
Perc. Stress	0	0	0	1	0	**5**	**7**	**0**	**12**
Sev. m. d.	0	0	0	0	0	**1**	**9**	**0**	**10**
Prev. m. d.	0	0	0	0	0	**0**	**8**	**0**	**8**
Total	**21**	**2**	**7**	**8**	**1**	**128**	**162**	**34**	
	23			**16**			**324**		

Note. E = Experimental, O = Observational. Q = Qualitative. Snd = Sound as a characteristic of blue space. Overall m. health = Overall mental health. OBST = other blue space type, OBSC = other blue space characteristic. Perc. stress = perceived stress, Phys. Stress = Physiological stress. Prevalence. m. d. = prev. m. d., Rest. Outc. = restorative outcomes, Satisf. w. life = satisfaction with life, sev. m. d. = severity mental disorder, Subj. Wellb. = subjective well-being, Social Int = Social Interaction. The table includes all unique combinations; if one study looked at different mental health outcomes and/or blue space categories, the sample will be counted in all relevant cells (e.g., 'coast' and 'river' categories for affect). However, if a study measured a mental health outcome in more than one way (e.g., physiological stress measured using blood pressure and heart rate variability), this study would only be counted once. Many studies included multiple mental health outcomes and are therefore included multiple times in the table.

Legend:

Individual scores	Total scores
1-3	1-10
4-6	11-20
7-9	21-30
10-12	31-40
13-14	> 41

were conducted (e.g., visiting blue space or proximity to the participants' home), which tells us something about the applicability of the results. In the present review, four different types of assessment contexts[5] were identified (Table 6).

Half of all the studies were conducted with participant's visiting blue spaces (i.e., including blue space contact in various ways such as recent visits or momentary contact; 105, 50%), followed by exposure in a residential context (60, 28%). A blue space visit was relatively frequently used in all research design categories (experimental: 32, 32%, observational: 47, 42%, qualitative: 26, 96%). In addition, river/canal (17, 65%), wetland (5, 83%) and 'other blue space types' (20, 80%) were investigated relatively often for blue space visits (Table 6).

Only observational studies used residential exposure as an assessment context—most often to investigate effects of the coast (28, 47%) and inland blue space types (18, 30%). Only experimental studies used an indirect assessment context (40, 55%), and most often for the coast and sound (both 8, 20%).

3.2.5. *Exposure characteristics*

As effects of blue space types and characteristics on mental health depend on when and how the effects of the exposure is measured, an overview was made of the amount (e.g., momentary, frequency, proximity) and type of exposure (direct: while being in the real environment, or indirect: viewing representations of blue spaces, e.g. images, videos, Virtual Reality) (Table 7).

Most studies measured effects of the blue space momentarily, while participants were in the actual environment or viewing representations of the blue space (87, 42%). Momentary exposure was the main exposure type for studies using indirect exposure (35, 90%), although it was often used in studies of direct exposure as well (52, 31%) (Table 7). Momentary exposures were mostly studied with regards to the coast (18,

[5] All types of assessment context that were investigated in three or more studies were included as a category.

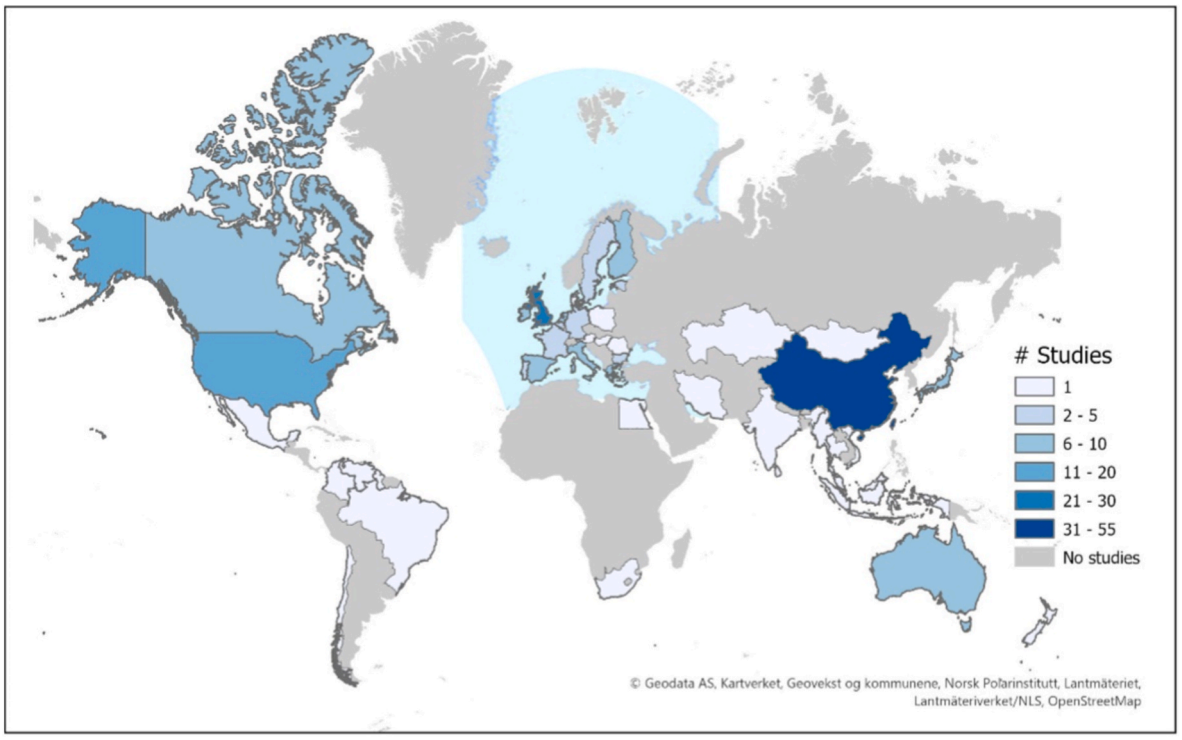

Fig. 4. Worldmap of the included experimental and observational studies.

21%), inland waters (16, 18%), river/canal (12, 14%), and sound (11, 13%). The next most often studied exposure types were availability (39, 19%) and proximity (29, 14%) as proxies for actual exposure[6] (Bratman et al., 2019) (Table 7). Proximity was the most often used exposure characteristic for the coast (17, 29%), whereas inland waters were most frequently approximated with availability of blue space around the residence (14, 37%), followed by the coast (12, 31%) (Table 7). Recent visits represented the fourth most often investigated exposure characteristic (26, 13%). For recent visits, exposure was measured in terms of having been at a site during a given period (of up to 1 year ago, e.g., Bryce et al., 2016). Availability, proximity, and recent visits were all used for direct exposure only (Table 7).

3.2.6. *Direction of the outcomes per blue space category*

For all quantitative studies, the direction of outcomes (positive, negative, or neutral) reported per combination of mental health outcome and blue space category were synthesised in Table 8.

At least one positive effect or association was reported on 184 occasions (48%; experimental: 105, 55%; observational: 79, 41%). At least one neutral effect (no difference) was reported on 177 occasions (46%; experimental: 74, 39%; observational: 103, 53%). At least one negative effect was reported on 25 occasions (6%; experimental: 12, 6%; observational: 13, 7%).

Looking at the coast, over half of the quantitative studies reported at least one positive effect (53%; experimental: 19, 61%; observational: 39, 49%), and this proportion was larger than for the studies reporting at least one neutral (43%, experimental: 11, 35%; observational: 36, 46%) or negative effect (5%; experimental: 1, 3%; observational: 4, 5%). More positive than neutral outcomes for the coast environments were found for affect, restorative outcomes, subjective wellbeing, physiological stress, and overall mental health (Table 8). The negative outcomes were highly scattered and were found on overall mental health (observational), social interactions (observational), physiological stress (experimental), and severity and prevalence of mental disorder (observational) (Table 8).

For inland waters, the results were slightly less pronounced, with more studies reporting at least one neutral outcome (50%) than studies reporting a positive outcome (45%), with four studies reporting a negative outcome (5%). Subjective wellbeing rendered many neutral outcomes for inland waters (Table 8). The negative outcomes were reported for affect (observational), physiological stress (experimental), and brain activity (experimental).

The river/canal category rendered an equal amount of positive and neutral responses (49/49%, positive: experimental:11, 55%, observational: 11, 44%; neutral: experimental: 8, 40%, observational:14, 56%), and one negative effect for affect (experimental). The lake category had more studies reporting a neutral effect (59%, experimental: 10, 50%; observational: 13, 68%) than studies reporting at least one positive effect (36%, experimental: 8, 40%; observational: 6, 32%), with two studies reporting a negative outcome (5%, experimental: 2, 10%). Wetland environments had more positive outcomes (73%) than neutral outcomes (27%) and no negative outcomes (Table 8).

Waterfalls elicited equally often positive outcomes as neutral outcomes (both 39%) and relatively many negative outcomes (22 %). These negative outcomes for waterfalls were found mostly for the observational studies (3, 50 %) for affect, satisfaction with life, and severity and prevalence of mental disorders—with one experimental study reported a negative outcome (1, 8%) of waterfalls on brain activity.

More studies of the 'other blue space type' category reported neutral outcomes (45%, experimental: 6, 43%; observational: 7, 47%), than studies reporting at least one positive outcome (31%, experimental: 7, 50%; observational: 2, 13%). Here, there were some differences between the observational and experimental studies, with experimental studies reporting more positive and fewer negative outcomes for 'other blue space types' (Table 8). The 'other blue space type' category had the most studies reporting at least one negative outcome (24%, experimental: 1,

[6] The exposure characteristics of proximity and availability are classified as direct exposure because these metrics estimate blue space exposure based on geography of natural features that exist in the real world around an individuals' location (Bratman et al., 2019).

Table 5
Overview of the population types used per blue space category.

Population type	Coast/Sea/Beach			Inland			River/Canal			Lake		Waterfall		Wetland		OBST		
	E	O	Q	E	O	Q	E	O	Q	E	O	E	O	E	O	E	O	Q
National residents	1	22	1	0	11	1	0	4	0	0	3	0	2	0	1	0	2	0
Students	4	0	0	8	0	0	3	0	0	7	0	4	0	0	0	4	0	0
Blue space visitors	2	2	4	1	4	1	1	3	2	0	1	0	0	0	1	1	2	2
Local residents	1	2	6	0	4	2	1	2	1	0	0	0	0	0	1	0	0	0
Other	4	2	1	0	0	0	0	1	2	1	2	2	0	2	1	1	1	0
Convenience sample	3	0	0	1	0	0	3	0	1	2	0	0	0	0	0	1	0	0
Elderly	0	4	1	0	4	0	0	1	0	1	0	0	0	0	0	0	0	0
Urban residents	1	1	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0
School children	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Adolescents	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Total	**16**	**35**	**15**	**10**	**24**	**4**	**8**	**14**	**6**	**11**	**9**	**6**	**2**	**2**	**4**	**7**	**5**	**2**
	66			**38**			**28**			**20**		**8**		**6**		**14**		

Population type	Snd		OBSC			**Total**			**Overall total**
	E	O	E	O	Q	**E**	**O**	**Q**	
National residents	0	0	1	3	0	**2**	**48**	**2**	**52**
Students	9	0	3	0	0	**42**	**0**	**0**	**42**
Blue space visitors	0	2	0	1	0	**5**	**16**	**9**	**30**
Local residents	0	0	0	1	0	**2**	**10**	**9**	**21**
Other	0	0	1	0	0	**11**	**7**	**3**	**21**
Convenience sample	2	0	0	0	1	**12**	**0**	**2**	**14**
Elderly	0	0	0	1	0	**1**	**10**	**1**	**12**
Urban residents	1	0	0	0	0	**1**	**5**	**0**	**6**
School children	0	0	0	0	0	**0**	**2**	**2**	**4**
Adolescents	0	0	0	0	0	**0**	**3**	**0**	**3**
Total	**12**	**2**	**5**	**6**	**1**	**74**	**101**	**28**	**206**
	14		**12**			**206**			

Note. E = Experimental, O = Observational. Q = Qualitative. Snd = Sound as a characteristic of blue space. OBST = other blue space type, OBSC = other blue space characteristic. The table includes all unique combinations; if one study looked at different samples and/or blue space categories, the sample will be counted in all relevant cells.

Legend:

Individual scores	Total scores
1-3	1-10
4-6	11-20
7-9	21-30
10-12	31-40
13-15	41-50
> 16	> 51

8%; observational: 6, 40%). These negative outcomes were mostly found for the observational studies and for affect, satisfaction with life, and restorative outcomes.

For water sounds, more positive (67%) than neutral (29%) and negative outcomes (4%) were reported. The one negative outcome for sound was found on affect (experimental). The 'other blue space characteristics' category yielded slightly more positive outcomes (50%, experimental: 5, 45%; observational: 8: 53%) than neutral outcomes (46%, experimental: 5, 45%; observational: 7, 47%), and one negative outcome (4%). The negative outcome was found on affect (experimental).

In sum, the studies included in the evidence map reported an almost equal amount of positive as neutral outcomes, and only very little negative effects for blue space on mental health. Slightly over half of the outcomes were positive for the coast, whereas half or less of the outcomes were positive for inland waters, river/canal, waterfalls, and other blue space types. Water sounds, on the other hand had a more pronounced larger component of positive than neutral outcomes.

3.2.7. Comparison between different blue space types and characteristics

Comparisons between different blue space types and characteristics were divided into three different categories: directly within a study, indirectly within a study, and indirectly between studies (see Supplementary Table 7).

An equal number of studies compared a blue space type or characteristic directly within or indirectly within studies (both 50, 34%), and slightly less studies enabled comparisons indirectly between studies (46, 32%). Most studies allowing for 'direct within study' comparisons had an experimental research design (38, 76%), whereas most studies allowing for 'indirect within study' comparisons where observational research designs (33, 66%).

Even though around a third of the included studies allowed for 'direct within study' comparisons, only few studies allowed for direct comparisons between blue space types. This is because the largest proportion of 'direct within study' comparisons were made between blue space types and urban environments (36, 49%), or between a blue space and a green space type (31, 42%, Supplementary Table 8). Only six studies (9%) directly compared between different blue space types (3 observational, 1 experimental, 2 qualitative). Four of the 'direct within study' comparisons were between the river/canal category with another blue space type: a lake (2), and an 'other blue space type' (2). Two qualitative studies directly compared the coast with inland waters. Only one study directly compared different blue space characteristics within the same study; this experimental study compared different 'other blue space characteristics' within the same study.

'Indirect within study' comparisons were made between different

Table 6
Overview of the different types of assessment context per blue space category.

Assessment context	Coast/Sea/Beach			Inland			River/Canal			Lake		Waterfall		Wetland		OBST		
	E	O	Q	E	O	Q	E	O	Q	E	O	E	O	E	O	E	O	Q
Visiting blue space	7	10	15	6	10	2	4	7	6	5	3	1	1	2	3	3	11	2
Residential exposure	0	28	0	0	18	0	0	4	0	0	6	0	0	0	1	0	1	0
Indirect (lab/online)	8	0	0	4	0	0	5	0	0	5	0	3	0	0	0	3	0	0
Other	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**16**	**40**	**15**	**10**	**29**	**2**	**9**	**11**	**6**	**10**	**9**	**4**	**1**	**2**	**4**	**6**	**12**	**2**
	71			**41**			**16**			**16**		**4**		**6**		**20**		

Assessment context	Sound		OBSC			Total			**Overall total**
	E	O	E	O	Q	E	O	Q	
Visiting blue space	3	1	1	1	1	32	47	26	**105**
Residential exposure	0	0	0	1	1	0	59	1	**60**
Indirect (lab/online)	8	0	4	0	0	40	0	0	**40**
Other	0	0	0	2	0	1	5	0	**6**
Total	**11**	**1**	**5**	**4**	**2**	**73**	**111**	**27**	**211**
	12		**6**			**211**			

Note. E = Experimental, O = Observational. Q = Qualitative. Snd = Sound as a characteristic of blue space. OBST = other blue space type, OBSC = other blue space characteristic. The table includes all unique combinations; if one study looked at different types of assessment context and/or blue space categories, the sample will be counted in all relevant cells.

Legend:

Individual scores	Total scores
1-3	1-10
4-6	11-20
7-9	21-30
10-12	31-40
13-15	41-50
> 16	> 51

Table 7
Overview of the exposure characteristics for the quantitative studies, divided by direct and indirect (e.g., Virtual Reality, videos, images) exposure.

Exposure characteristics	Coast/Sea/Beach		Inland		River/Canal		Lake		Waterfall		Wetland		OBST		Sound		OBSC		**Total**		**Overall total**
	D	I	D	I	D	I	D	I	D	I	D	I	D	I	D	I	D	I	**D**	**I**	
Momentary	11	7	13	3	9	3	5	4	1	4	4	0	5	3	3	8	1	3	**52**	**35**	**87**
Availability	12	0	14	0	5	0	5	0	0	0	1	0	1	0	0	0	1	0	39	**0**	**39**
Proximity	17	0	7	0	1	0	3	0	0	0	0	0	0	0	0	0	1	0	**29**	**0**	**29**
Recent visits	8	0	2	0	4	0	1	0	1	0	1	0	7	0	1	0	1	0	**26**	**0**	**26**
Visit frequency	7	0	2	0	2	0	1	0	0	0	0	0	0	0	0	0	1	0	**13**	**0**	**13**
Not reported	1	1	0	0	1	1	2	0	0	0	0	0	1	1	1	1	0	0	**6**	**4**	**10**
Visibility	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	**4**	**0**	**4**
Total	**68**	**8**	**38**	**3**	**23**	**4**	**17**	**4**	**2**	**4**	**6**	**0**	**14**	**4**	**5**	**9**	**6**	**3**	**169**	**39**	**208**

Note. D = Direct exposure. I = Indirect exposure. OBST = other blue space type. Sound = Sound as a characteristic of blue space. OBSC = other blue space characteristic. The table includes all unique combinations; if one study looked at different types of assessment context and/or blue space categories, the sample will be counted in all relevant cells.

Legend:

Individual scores	Total scores
1-3	1-10
4-6	11-20
7-9	21-30
10-12	31-40
13-15	> 41
> 16	> 51

blue space types (68, 59%), but also with green (44, 38%) and, occasionally, urban (4, 3%) environments. 'Indirect within study' comparisons were found across most blue space types, with a few exceptions (Supplementary Table 8). Relatively many 'indirect within study' comparisons between blue space types were between the coast and inland waters with an observational design (12, all observational). For 'indirect within study' comparisons with green environments, most comparisons were made with the coast and in observational designs (15, 44%).

In sum, most studies used a direct or indirect within comparisons, with direct within studies often being experimental and indirect within studies often were observational research and most of these focused on the comparison between the coast and inland water. Around a third of the studies used a direct within comparison. However, most of these comparisons were with urban settings, followed by green space, and only very few studies compared blue space types or characteristics.

3.2.8. *Comparison between the coast and inland waters*

For illustrative purposes, we discuss the studies that compare the coast and inland waters, as these were the two most studied categories for the quantitative studies. All comparison categories are included

Table 8
Overview of the direction of the outcomes per blue space category and per mental health outcome (quantitative studies only).

	Coast/Sea/Beach	Inland	River/Canal	Lake	Wetland	Waterfall	OBST	Sound	OBSC
Affect	++++++++++ Ooooo	++++++++++ ooooo -	++++++++++ ooooooo -	+++++++ oooooooo -	++++ oo	++ -	++++ ooooooo - - -	++++++ ooo -	++++ oooo -
Restorative Outcomes	+++++ oo	+ Oo	+++	+ O	+	o	+ -	++	++ oo
Subjective Wellbeing	++++++ Ooooo	+++++ Oooooooooo	++ ooo	oooo	+		o		+
Physiological Stress	++++ ooo -	++++++++ oooooo --	++++ ooo	+ O	+ o	+ o	++++ oo -	+++++ oo	++ o
Overall Mental Health	++++++++++ ooooo -	+++++ Oooo	+	+	+			o	+ o
Brain Activity		+ o -	o	+ ooo -	+ o	++ oooo -	o	+++ o	+ o
Other	++++ Oooooooo	++ ooooo	oo	O	+				+ o
Satisfaction with Life	+++++ ooooo	Oo	+ o	O		o -	ooo - -		
Perceived stress	+++ oo	+++ Oo	o	O					oo
Social interaction	++++ ooooo -	+ Oo	+ o	+ O					
Severity & Prevalence mental disorder	+++++ ooooooo - -	+++ Oooo	oo	++ oo		++ -			

Note. Each dot represents *at least one* effect reported per combination, and per study. If a study measured affect after a visit to the coast with the Profile of Mood States (POMS) scale and reported positive results on all 6 subscales (i.e. tension-anxiety, depression, anger-hostility, vigour, fatigue, and confusion), this would be represented by a single solid dot. This was necessary to keep the contribution of each study to the table similar, as some studies only report outcomes of a total score of a questionnaire, whereas others report all subscales or even outcomes on single items.

Legend:

+ = positive experimental	+ = positive observational
○ = neutral experimental	○ = neutral observational
- = negative experimental	- = negative observational

(except 'indirect between study' comparisons); this includes the direct and indirect within study comparisons of blue space types with urban and/or green environments. The three different comparison categories are reported in separate tables, namely: investigations of 'direct within study' comparisons between coast or inland water types with green or urban environments (Supplementary Tables 9 and 10, respectively), 'indirect within study' comparisons between coast and inland water types (Supplementary Table 11), 'indirect within study' comparisons between the coast or inland water types and green or urban environments (Supplementary Tables 12 and 13, respectively).

'Direct within study' comparisons between the coast or inland waters blue space types and green environments were investigated in 23 studies. Most of these 'direct within study' comparisons had an experimental design (17, 74%) and were largely conducted in Asia (10, 59%). The observational studies in this 'direct within study' comparison, however, were mostly conducted in (or included) Europe (5, 71%). Students or another convenience sample (11, 48%) were the most investigated population type in these 'direct within study' comparisons between coast or inland waters and green space. Most studies were conducted while visiting blue spaces (12, 52%) or indirect (lab/online) (9, 39%) as the assessment contexts, and investigated momentary exposure as the exposure characteristic (17, 74%). In the 'direct within study' comparisons with green spaces, either the coast or inland water produced better outcomes on 16 occasions (31%, 6 coast: 40%, 10 inland: 27%), similar outcomes on 31 occasions (60%, 7 coast: 47%, 24 inland: 65%), and worse outcomes on five occasions (10%, 2 coast: 13%, 3 inland: 8%).

A total of 27 studies investigated a 'direct within study' comparison between the coast or inland waters blue space types and urban environments. Most of these studies had experimental designs (21, 78%), and were conducted in Europe (12, 44%) or Asia (8, 29%). Most studies used students or another convenience sample as population type (12, 44%), visiting a blue space as assessment context (18, 67%) and investigated momentary effects as the exposure characteristic (24, 89%). The two types of blue spaces produced better outcomes than urban space on 36 occasions (60%, coast: 15, 63%, inland: 21, 58%), an equal outcome on 20 occasions (33%, coast: 7, 29%, inland: 13, 36%), or a worse outcome on 4 occasions (7%, coast: 2, 6%, inland: 2, 6%).

'Indirect within study' comparisons between the coast and inland water types were investigated in 18 studies. All these studies were observational designs and the majority stemmed from (or included) Europe (14, 78%) with a particular focus on the UK (12, 67%). Five studies were conducted in multiple countries (28%). The remaining four studies all stemmed from Oceania (22%). Many studies in this comparison category included national residents as the population type (14, 78%) and looked at effects of residential exposure as the assessment context (12, 67%). In studies that indirectly compared the coast with inland waters, the coast produced better outcomes than inland waters on 19 occasions (19, 37%), an equal outcome on 26 occasions (26, 51%), and a worse outcome on six occasions (6, 12%).

'Indirect within study' comparisons were also made between the coast or inland water types with green or urban spaces. 'Indirect within study' comparisons between the coast or inland water types and green environments were conducted in 28 studies, of which the majority had an observational design (24, 86%). Again, the studies mostly included national residents as the population type (14, 50%) and looked mostly at residential exposure (15, 54%) and visiting blue space (10, 36%) as the assessment contexts. Exposure characteristics were mostly availability (16, 57%), recent visits (7, 25 %), or momentary exposure (6, 21%). However, in this comparison category, the geographical spread of the studies was more diverse, with five observational studies conducted in multiple countries (18%), 10 studies conducted in Asia (all in China, 36%), eight studies conducted in Europe (29%), and three studies conducted in Oceania (11%). The two types of blue spaces produced better

outcomes than green spaces on 19 occasions (20%, 7 coast: 19%, 12 inland waters: 20%), had similar outcomes with green spaces on 42 occasions (44%, 18 coast: 50%, 24 inland waters: 41%), and green space outperformed the two blue space types on 34 occasions (36%, 11 coast: 31%, 23 inland waters: 39%). When comparing the coast with inland water types and how they related to green space, we see that the coast had slightly more equal results to green space and less worse effects than green space (Supplementary Table 12).

Only three studies indirectly compared either the coast or inland waters with urban spaces: one experimental and two observational studies. The experimental study was conducted in the USA, one observational study included 37 countries and the other observational study was conducted in China. The coast and inland water blue spaces scored either better or equal to urban space in these comparisons.

In sum, large variety of study types and designs were used to compare the coast or inland water blue space types. All 'direct within study' comparisons were with either green or urban space. Most 'direct within study' comparisons were conducted with an experimental design. In these 'direct within study' comparisons, the two blue space types often produced better outcomes than urban space, but often similar outcomes when compared with green space. The 'indirect within study' comparisons of the coast and inland water types with green and urban space were mostly observational. The coast and inland water were only compared indirectly within studies, all of which had an observational design. In these 'indirect within study' comparisons, the coast most often had similar outcomes as inland waters.

4. Discussion

Our systematic evidence map partly corroborates the potential benefits of blue spaces for mental health (Gascon et al., 2017; Geneshka et al., 2021; Smith et al., 2021). Positive outcomes were reported for all included blue space types and characteristics, but a rather similar number of neutral outcomes was reported as well. Only very few negative results of blue space types or characteristics were found.

Our evidence map further signals that the current evidence base does not yet make it possible to indicate which blue space type or characteristic is most beneficial for mental health. This is mainly due to the large heterogeneity in investigated mental health outcomes, geographical spread, measurement of the amount and type of exposure with blue space, and type of comparators. Most importantly, the evidence map points to a need for more studies that allow for comparisons between different blue space types/characteristics, and preferably direct comparisons within the same study. Overall, the coast appeared to have slightly better mental health outcomes than inland waters, except for the 'indirect within study' comparisons with green spaces, but these outcomes need to be treated with great caution given the large heterogeneity within the different studies and the different types of comparisons.

In parallel with this present evidence map, a scoping review with systematic evidence map has been published looking at the effects of different green space types and characteristics on mental health, using the same methodology (Beute et al., 2023). Even though the evidence base for the mental health benefits of green space types/characteristics is larger (Beute et al., 2023), the conclusions of that scoping review were very similar in nature to what has been found here with blue spaces types/characteristics: in order to be able to conclude whether there are differences in mental health outcomes between different types of blue and green spaces, the heterogeneity in research designs, geographical location, sample populations, types of assessment context, and exposure characteristics needs to be addressed.

4.1. Comparisons of blue space types and characteristics in terms of mental health benefits: challenges and gaps in the current evidence base

The most reliable comparisons are studies that directly compare two or more blue space types or (levels of) characteristics. However, only seven studies (around 5% of the included studies) directly compared different blue space types/characteristics within the same study. Four quantitative studies directly compared a river/canal with either a lake or 'other blue space type' (S.-H. Hung et al., 2022; Lan et al., 2024; Luo et al., 2023a; Wade et al., 2023a,b). Two qualitative studies directly compared the coast with inland waters (Ballesteros-Olza et al., 2024; Gernow et al., 2024). Only one experimental study directly compared different 'other blue space characteristics' within the same study (Lin et al., 2024b). Given that too few studies directly compared different blue space types and characteristics, the present systematic map also looked at studies comparing green spaces with coast or inland waters as these were the two most investigated blue space types. However, as the number of direct within study comparisons were limited, we also needed to look at indirect within study comparisons between the coast or inland waters with green spaces. In 'direct within study' comparisons with green spaces, the coast and inland waters blue spaces more often performed better than green spaces, than that they performed worse than green spaces. This pattern was mostly pronounced for coastal blue space. However, the exact opposite pattern was found for the indirect within study comparisons; coast and inland waters blue space types performed worse than green spaces more often than these two types of blue spaces performed better than green spaces.

These differences in outcomes by type of comparison present a serious complication for drawing conclusions on which type of blue space is better for mental health. As the results of this evidence map demonstrate, comparisons between different blue space types/characteristics are substantially hampered due to the types of comparisons (i.e. direct or indirect within study), and at least four areas of heterogeneity across the studies: geographical spread, differences in definitions of blue space types, comparators used, and study population and assessment context.

4.2. Heterogeneity in research design and characteristics

4.2.1. Geographic distribution

Both Europe (particularly the UK) and Asia (particularly China) contributed equally and mostly to the current evidence base, with the majority of the experimental studies stemming from Asia and Europe contributing mostly to the observational and qualitative studies. The other continents, and especially South America and Africa, only had a relatively small contribution to the current evidence base. This already introduces potential issues when comparing across different research designs, for example due to cultural, geographical, and climatic differences. In addition, studies investigating the effects of the blue space characteristic sound were relatively frequently conducted in Asia (and with an experimental design), whereas studies looking at the coast and inland waters often originated from Europe (and with an observational design). Interestingly, a few of the included studies were observational studies conducted in multiple countries, thereby potentially overcoming geographical heterogeneity. However, some of these studies analysed the differences between the included countries and did report differences in outcomes, signalling that differences are likely to occur between geographical locations.

Of course, some blue space types are more geographically restricted than others. With geographical differences, one can also expect that the blue space environment varies with other characteristics such as seasons, climate, and culture. Benefits of certain blue space types/characteristics may be cooling down in warm weather or easing your mind when walking on a stormy beach (e.g., Bell et al., 2015; Severin et al., 2022) and these benefits may differ between geographical locations. Indeed, several studies already indicated considerable differences in blue space benefits between countries (Elliott et al., 2023; Garrett et al., 2023; McDougall et al., 2024; Sandifer et al., 2021; White et al., 2021); this variability in results even occurred within the same continent (Europe) and therefore highlights a difficulty in comparing the effectiveness of blue space types and characteristics from studies conducted

across different countries and continents. Part of the explanation here may also be that even though blue spaces can be categorized into one particular type, such as lake, they may differ substantially in characteristics.

4.2.2. Blue space types and descriptions

The successful comparisons of different blue space types and characteristics highly depend on the inclusion of an adequate description of the blue space in research studies. However, this was often not the case. There was sometimes ambivalence in the categorization of the blue spaces. One important issue is that some studies used a composite of various freshwater bodies (e.g. rivers and lakes combined) without specification of the specific type of freshwater blue space, resulting in the inland water category included in this evidence map. Whereas other studies were explicit about the specific types of inland waters investigated (e.g., only lakes or only waterfalls). Composite measures of inland waters make it difficult to assess the impact of blue space types on mental health as the composition of inland water according to type may differ between locations, and even more so between studies, making comparison of outcomes even more problematic. Importantly, these categories were mutually exclusive in the present review and evidence map (categorized either as inland water or as river/canal or lake) ensuring studies were never double counted.

Blue space is often surrounded by green space. This surrounding green space may have an additional or separate beneficial effect on mental health. Adjacent green space also influences the appearance of the blue spaces. The coast, for instance may be surrounded by naturally formed dunes, or by man-made dikes or docks. Not all studies report, analyse and/or consider the amount and type of green space surrounding the blue spaces. Whereas, other studies included and even focused on the amount of green space or its naturalness as a characteristic of the blue space (see, e.g., Arnberger et al., 2024; Elsadek et al., 2024; Fisher et al., 2021a,b; Korpilo et al., 2024; Wang et al., 2021; Yan et al., 2024a).

Studies looking at blue space characteristics further emphasise the need for future studies to look beyond typology, as specific blue space characteristics may produce differential mental health outcomes. Thus, we recommend that future studies detail and describe both the type *and* the characteristics of the particular blue space under study (e.g. rocky beach, lake with varying levels of naturalness). This may be difficult to achieve, especially in cross-sectional studies. Possible options could be to include the characteristics that are most relevant, provide information on each of those characteristics for each location, and include the characteristics in the analyses. This can, for instance, also include more temporal aspects such as season, climate, or weather as discussed in the previous section.

4.2.3. Sample and mental health

People with mental health challenges may especially benefit most from exposure to nature (Beute and De Kort, 2018; Garrett et al., 2019; Ottosson and Grahn, 2008; Roe and Aspinall, 2011). In addition, the benefits may depend on the type of use or the reason of using natural environments which, in turn, may also depend on mental health status (McCartan et al., 2023). The studies included in the present evidence map almost exclusively focused on healthy individuals. Less than three percent of the included studies involved a clinical population. A similar finding regarding the study population has also found in a scoping review of green space types and characteristics (Beute et al., 2023).

The type of mental health outcome differed between study type. In line with previous findings for green space types/characteristics (Beute et al., 2023), our analysis on blue space types/characteristics found the experimental studies mostly focused on affect and physiological stress responses, whereas the observational studies examined more long-term mental health outcomes. This heterogeneity confounds comparisons between different study design types as momentary (short-term) responses are expected to wash out sooner after the blue space contact and fluctuate more than long-term health outcomes. The accumulation of short-term effects into long-term effects may be expected to depend to some extent on the frequency of experiencing such short-term effects in daily life.

The observational studies often included national residents (often panels comprising members of the general population), whereas the experimental studies often included students or another convenience sample as participants. This hampers especially the generalizability of the experimental studies.

4.3. Explaining heterogeneity: type of assessment context

The studies included in the present systematic map further differed in the type of assessment context in which blue space benefits were researched. Whereas most studies looked at blue space visits (in all three study design categories), only observational studies investigated residential exposure and only experimental studies used indirect (lab/online) as an assessment context. This introduces considerable heterogeneity in the type of assessment context in which the studies were conducted with blue space visits often thought to produce more intense mental health outcomes compared to indirect assessment contexts involving representations of blue spaces (de Vries, 2022), partly because of the involvement of other senses besides vision.

These considerations are important when comparing different blue space types and characteristics, especially since the different types of comparisons differed in dominant assessment context, with for instance the 'indirect within study' comparisons between the coast and inland waters mostly looked at residential exposure, whereas the 'indirect within study' comparisons with green spaces most often looked at either recent blue space visits or indirect (lab/online) assessment contexts. These assessment contexts, in turn, may have an impact on the absorbed dose (Bratman et al., 2019) and may be an explanation for the heterogeneity in the results (Beute et al., 2023).

4.4. Explaining heterogeneity: amount and type of exposure

Judgments about dose-response relations for beneficial mental health outcomes (Bratman et al., 2019; Shanahan et al., 2015, 2016) appear difficult based on the current evidence base for the benefits of blue spaces types/characteristics. This is largely due to the variation in exposure characteristics—the amount (e.g., momentary, frequency, proximity) and type of exposure (direct or indirect).

Exposure characteristics varied in the amount of exposure. Most of the studies included here examined momentary exposure, availability, or proximity, and very few studies examining visit frequency or visibility. From this current evidence, it is difficult to determine what amount of exposure to blue space types or characteristics is beneficial due to the lack of variability. This is because many studies used proximity to and availability of blue spaces as a measure of amount of exposure. These studies estimate the amount of blue space exposure using proxy measures based on geography but are unable to inform about frequency and duration of exposure (Bratman et al., 2019). While the conceptual model proposed by White et al. (2020), gives a special focus to proximity as a measure of contact, studies have shown that living close to blue space environments does not automatically mean that this environment is visited (Schipperijn, 2010), and usage and visit frequency to blue spaces may be more important for mental health than availability (Lan et al., 2025). Future studies should examine the frequency and duration of exposure to specific types and characteristics of blue spaces, to determine the amount of exposure required for particular mental health benefits. As especially long-term health outcomes are thought to be related to accumulated exposure over time (Pearce et al., 2016), there is a need for longitudinal studies to look at blue space exposure over time; a similar outcome we found for green space types/characteristics (Beute et al., 2023).

Exposure characteristics also differed substantially with regards to type of exposure—here assessed as either direct (while being in the real

environment) or indirect (viewing representations of blue spaces, e.g. images, videos, Virtual Reality). While, availability, proximity, and visit frequency were all used for direct exposure only, momentary exposure could be measured with both direct and indirect exposures. This variation in the measurement of exposure characteristics further compounds investigation of dose-response for specific types of blue spaces and comparisons between blue space types—as one must also consider the differences in how amount *and* type of exposure are assessed.

The role of experience—experiential characteristics resulting from the exposure and engagement with the blue space environment—further complicates the study on the beneficial effects of blue space types/characteristics on mental health (Bratman et al., 2019; de Vries, 2022). A recent review on blue space care interventions reported that type of activity (active or passive) may be a more important indicator for mental health benefits than the actual blue space type or characteristics, at least for blue care interventions (Britton et al., 2020). However, in our systematic map, we found information about the type of activity performed in the blue spaces was often unreported, especially in the observational studies. As the type of exposure with blue spaces, or natural environments in general, is thought to influence the effect of this environment on mental health (Bratman et al., 2019; Marselle et al., 2021; de Vries, 2022) there is a general gap in knowledge about the experiences with blue spaces and mental health outcomes, which again was also found for green spaces (Beute et al., 2023).

4.5. Explaining heterogeneity: intra- and interindividual differences

Another potential source of heterogeneity in the outcomes, which was not directly addressed in this review, is that besides the above-mentioned complicating factors, the effects of blue space on mental health may also depend on intra- and inter-individual differences. Indeed, several studies included in the review have reported that effects were dependent on gender (George et al., 2025; Liu et al., 2021), age (Yang et al., 2024), socioeconomic status (Garrett et al., 2019; Yang et al., 2024), and mental health status (Reeves et al., 2019). Benefits of blue spaces on mental health may thus differ between different individuals, but also within a single individual based on for instance life stage or mental health status. In addition, other studies reported temporal differences irrespective of the individual, such as seasonal and weather differences, indicating that timing of the study may also have an influence on the mental health outcomes found (Cao et al., 2023; White et al., 2021). These studies further corroborate the importance of looking at the characteristics of the blue space, including in which season the blue space is in.

4.6. Explaining heterogeneity: blue space characteristics

Even though not many studies included in the review investigated blue space characteristics, the few studies did indicate importance of a number of these characteristics, such as naturalness, speed of flow, sound, quality of the blue space, air freshness, biodiversity, and visual attractiveness (Arnberger et al., 2024; Chen et al., 2023; Fisher et al., 2021a,b; Korpilo et al., 2024; Lin et al., 2024b; Wang et al., 2021; Weng et al., 2024; White et al., 2017a; Yan et al., 2024a). Including these characteristics in the description and analyses may help reveal what makes some blue space types more restorative than others and may also allow to at least partly overcoming geographical differences. In addition, it will help answer additional research questions such as how blue and green space interact, or whether the speed of water flow matters and thereby potentially enabling a more thorough comparison blue space characteristics.

4.7. Recommendations for future research

As the current evidence base does not yet enable conducting reliable comparisons of different blue space types or characteristics, a number of recommendations can be formulated based on the outcomes of the present evidence map. First, direct comparisons within the same study are required to perform reliable comparisons. Second, an increased focus on exposure characteristics—particularly actual exposure and type of exposure like type of activity—is necessary to understand dose-response relationships. Longitudinal studies that explicitly capture actual exposure, for example studies employing Ecological Momentary Assessment (see, e.g., Beute et al., 2016; De Vries et al., 2021; MacKerron and Mourato, 2013), or more (quasi-) experimental interventions that last for a longer period of time (e.g., with multiple visits over a period of several weeks) could especially help advance the current evidence base. More experiential accounts (e.g., qualitative studies) can further detail the type of experiences people have in these blue spaces. Third, a more thorough description of the blue space in terms of, for example, dynamics of water flow, season, weather, surrounding green space (amount, type, characteristics), blue space size, type of enclosure, ground cover (rocks or sand), or number of other people present could further help understand which elements of blue space are beneficial and under what conditions. Future research should also pay special attention to other sources of heterogeneity, including but not limited to, cultural differences, geographical differences, inter-and intra individual differences, and climatic and seasonal differences. Studies targeting these differences, for example by comparing results between different countries or age groups are highly encouraged. These recommendations are very similar as those we posed for the comparison of green spaces (Beute et al., 2023).

4.8. Limitations of the systematic evidence map

There are limitations in the present evidence map that may have influenced our conclusions. First, we may not have captured all publications relevant to the topic under study. Second, the exclusion of non-English language studies may have introduced language, cultural, and/or publication bias. The geographic distribution of studies in our English review suggests the need for future reviews to incorporate multilingual searches. Third, judgements made when categorising the studies into various groupings for blue space category and mental health outcome depended on the clarity and reporting detail within the included studies. Inappropriate categorization is therefore possible as not all papers used clear descriptions of the blue space. Finally, the present study did not include a risk of bias assessment, as this was outside of the scope of the present overview which focussed on mapping the current evidence base available for the comparison of different blue space types and characteristics rather than on answering which type or characteristic is best. When the evidence base is ready for such a review, we recommend adding a risk of bias assessment as well as performing a formal meta-analysis.

5. Conclusion

This review highlights the potential mental health and wellbeing benefits of blue spaces. Positive outcomes were reported across all blue space types and characteristics, though a similar number of neutral findings and very few negative outcomes were also observed. However, the current evidence base is too heterogeneous to support robust comparisons between specific blue space types or characteristics. A considerable research gap needs to be addressed to advance the research domain and to allow for more practical and landscape design-oriented recommendations. Importantly, most of the research gaps identified for blue space types/characteristics were also found in a similar review looking at green space (Beute et al., 2023), signalling a more general gap in the research field. We recommend future research to focus more on direct comparisons between different blue space types and characteristics within the same study, with a good measure of actual exposure (preferably longitudinally measured and including the activity performed within the blue space), and a thorough description of the blue

space environment. This description should include important characteristics of the blue space. Looking at characteristics rather than types of blue spaces may, in addition, help overcome geographical restrictions in blue space categories (e.g., for the coast). Preferably, studies will also focus on the effects of different blue space characteristics and thereby further our understanding of what makes blue spaces mental health-promoting places (or not). Important characteristics may be, but are not limited to, the biodiversity, dynamics of the water, quality of the environment, and presence and type of green space surrounding the blue space.

CRediT authorship contribution statement

F. Beute: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **M.R. Marselle:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **A. Olszewska-Guizzo:** Writing – review & editing, Methodology, Conceptualization. **M.B. Andreucci:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **A. Lammel:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Z.G. Davies:** Writing – review & editing, Methodology, Conceptualization. **J. Glanville:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **H. Keune:** Writing – review & editing, Methodology, Conceptualization. **L. O'Brien:** Writing – review & editing, Methodology, Conceptualization. **R. Remmen:** Writing – review & editing, Methodology, Conceptualization. **A. Russo:** Writing – review & editing, Methodology, Conceptualization. **S. de Vries:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envres.2026.124054.

Data availability

The data is included in the submission (two excel tables)

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