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Assessing the impact of blue and green spaces on mental health of disabled children: A scoping review

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ABSTRACT

During recent decades, there has been a growing consideration of the role of blue and green spaces on mental health of children, but there is insufficient attention in the literature to the mental health of children with disabilities. This paper presents an overview of the evidence on how blue and green spaces affect the mental health of children with various disabilities. A database search found twenty studies eligible for the review, after several consecutive screening stages. Most studies used a cross-sectional design and were carried out in Europe. The results consistently indicate that blue and green space can reduce emotional, behavioral, and social problems in disabled children. A protective association was found between the level of blue or greenness and depressive and anxiety symptoms. Moreover, in most of the studies there were no significant changes in the result after adjusting for socioeconomic confounders. Generally, there is an identified need for more short-term exposure studies in this area, focusing on the impact of landscape design elements on mental health of disabled children. The findings of this scoping review call on urban planners, health care workers and decision makers to consider appropriate measures and interventions providing more blue and green space exposure to disabled children.

1. Introduction

Approximately 50% of the global population currently resides in urban areas, and according to the World Health Organization, this figure is projected to rise to around 68% by 2050 (United Nations 'World Urbanization Prospects: The 2018 Revision',). Living in dense and crowded cities, can cause stressful experiences for various demographic groups. Many researchers believe that such stressors increase the risk of mental illnesses in both children and adults (Peen et al., 2010; van Os et al., 2010). Contemporary modern and crowded cities can adversely impact people's lives and jeopardize their physical and mental health, partly by limiting their access to natural blue and green spaces (Cox et al., 2017; Liu et al., 2019; Wong et al., 2015). Consequently, 15% of the world population grapples with mental health problems like depression and anxiety (Dattani et al., 2021). Furthermore, the Covid-19 pandemic has also had a negative impact on mental health globally (Fiorillo and Gorwood 2020; Shigemura et al., 2020; Usher et al., 2020). It is worth noting that the prevalence of disabilities and mental disorders is notably higher among individuals residing in economically disadvantaged areas characterized by chronic low employment rates (Sarah Curtis et al., 2019; S. Curtis et al., 2021; Tieges et al., 2022). This can have a significant impact on individuals' health, social engagement, participation, mobility, and other aspects of their lives (Vornholt et al., 2018). More recently, it has become evident that in deprived areas, exposure to blue and green spaces is linked to a decreased risk of various types of disabilities and mental disorders (Georgiou et al., 2022; Nutsford et al., 2016; Tieges et al., 2022).

Blue spaces encompass recreational spaces such as lakes, rivers, and shorelines (White et al., 2020), and green spaces include national and urban parks, as well as various types of urban vegetation (Hunter et al., 2019). Natural blue and green spaces offer a restorative and healing environment with mental and psychophysiological benefits for individuals (Carreño et al., 2023; McCormick 2017; Olszewska-Guizzo et al., 2020; Parmes et al., 2020; Pasanen et al., 2023). Numerous studies have reported the positive effect of high greenery in landscape on mental health, whether through short-term and long-term exposure (Beyer et al., 2014; Liu et al., 2019; Martensson et al., 2009; Pun et al., 2018; Sturm and Cohen 2014; Ward Thompson et al., 2016). Furthermore, various indirect pathways have been proposed to explain how spending time in blue and green spaces contributes to mental health benefits. These pathways include providing opportunities for leisure activities and social interactions, which, in turn, promote physical activity and

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foster social connections (Dadvand et al., 2016; De Vries et al., 2013; Oswald et al., 2020). Additionally, spending time in both blue and green spaces has been linked to improved cognitive function, regulation of blood pressure, brain activity, and overall mental well-being (Twohig-Bennett and Jones 2018). The health benefits associated with these spaces can be attributed to their capacity to mitigate exposure to factors such as noise, air pollution, and contribute to the recovery of psychophysiological stress (Houlden et al., 2018; Markevych et al., 2017; McDougall et al., 2021; Mishra et al., 2023; White et al., 2020).

Children's mental disorders can be defined as considerable changes in their cognitive, social, and behavioral functioning, leading to distress and impacting the way they think, learn, or behave (Centers for Disease Control and Prevention, 2020; Okwori 2022). Whilst the evidence concerning the link between blue and green space and children's mental health is rapidly increasing, there has been a lack of consideration for disabled children as a specific subgroup (Larson et al., 2018). In addition, we could not find a scoping review focusing on the impact of blue or green spaces on mental health of children with disabilities. According to the World Health Organization (WHO), a mental disorder is characterized by clinical disturbances in behavior, emotion, or cognition, significantly associated with impairment or distress, affecting people's functioning. These disorders encompass anxiety disorders, schizophrenia, depression, post-traumatic stress disorder, eating disorders, behavioral and dissocial disorders, and neurodevelopmental disorders (World Health Organization). The mental and psychological conditions of disabled children and non-disabled children may not always be the same (Fauth et al., 2017), justifying a separate scoping review for disabled children. Based on WHO's definition and classification of disability (2001), various types of disabilities can affect a person's life, including hearing, vision, thinking, remembering, learning, communicating, movement, mental health, and social relationships (WHO 2001). This study aims to review the literature on blue and green spaces and mental health of disabled children (aged 0–18). We will also assess the methodologies, the exposure data, and outcomes of the reviewed studies in order to gain a clear understanding of the subject and to identify the remaining gaps. Moreover, we will examine existing evidence, explore the consistency of the findings, and identify critical directions for future research. We aim to address three key questions.

1. What is the relationship between blue and green spaces exposure and different aspects of mental health among disabled children, and how strong are these associations?
2. Which aspects of mental health among disabled children are influenced by blue and green space exposure?
3. Which mental disorders and disabilities are not assessed and should be considered in future studies?

2. Methods

2.1. Search strategy

We performed a scoping review of the existing literature with the aim of identifying all original published studies regarding how blue and green spaces affect disabled children's mental health. This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-extension for scoping reviews statement (PRISMA-ScR) (Tricco et al., 2018). Consistent with this approach, we did not assess the risk of bias or methodological limitations in the included studies. Anticipating significant variations in study designs and the data at hand, we employed a qualitative summary approach rather than a specific meta-analysis. The review was carried out in four distinct steps: identification, screening, eligibility, and inclusion. Four databases were searched for relevant research studies published up to October 2023, including Science Direct, Scopus, Web of Science and PubMed, without imposing any restrictions on publication date.

After conducting searches in four databases, we included original studies that explored the association between blue and green space and mental health outcomes for children with disabilities. To structure our search, we followed the PECO framework (Population, Exposure, Comparators, and Outcome) (Morgan et al., 2018). We incorporated the search terms on population ("disabled children" OR "children with disability"), exposure ("blue space" OR "green space"), and outcome ("mental health" OR "mental disorders"). During several consecutive rounds of screening and assessment of eligibility (Fig. 1), we reviewed the title, abstract, and full text of eligible articles. We were unable to incorporate all types of mental disorders and disabilities in the search because of the high number of possible types and categories. For instance, in accordance with the WHO's classification of mental disorders, various kinds of mental health issues exist, including anxiety disorders, schizophrenia, depression, and so on and we considered mental health as a broader category encompassing all these various issues. During the screening and selection process of abstracts and full texts, we included all research that addressed these specific conditions.

2.2. Study selection

We included only original empirical articles and generally considered green space as exposure, regardless of the location (neighborhood, urban landscape or school green spaces). Both quantitative and qualitative analyses were considered eligible in this scoping review. Moreover, each included study had to examine at least one aspect of mental health, including stress, emotional well-being, psychological health, social functioning, behavioral outcomes, cognitive functioning, and more, as the main focus. To ensure comprehensiveness, we performed a search through the reference lists of the identified and screened original articles and review studies (Islam et al., 2020; Putra et al., 2020; Vanaken and Danckaerts 2018). These studies underwent a separate assessment, and their abstract and full text were reviewed for eligibility in the scoping review. It should be noted that one researcher performed the screening and selection based on inclusion criteria and the other three researchers verified the process to ensure the reliability and consistency.

Following the completion of the study selection process, we provided information on characteristics of studies (the location of the research, time of conducting), study population (age, type of disability and sex), study design (cross-sectional, longitudinal, or mixed-method), exposure (nature exposure, source of exposure measure of exposure), outcome (mental health outcome, method of measurement), statistical methods (type of statistical analysis and model, covariates of the models) and results (the coefficient, main findings, size and level of effect and significance). We synthesized the data through descriptive analysis, cross categorization, and graphical presentation. To ensure the cumulative evidence was rigorously assessed, we considered the number of research papers reporting certain findings; the consensus in research results; the quality of evaluations for studies reaching such conclusions; and the target population. Criteria for exclusion were established prior to the review of search results and are outlined in Table 1.

2.3. Quality assessment

After removing duplicates, one researcher conducted an initial review of the remaining abstracts to assess relevance, accessibility to full-text articles, and study type. Following this, both abstracts and full texts underwent screening based on predefined inclusion criteria by the reviewer. The outcomes of this stage were then discussed and verified by the three other reviewers to ensure accuracy and consistency. We utilized reference management software (EndNote) to facilitate the organization of titles and abstracts. The lead author conducted an initial assessment of the abstracts and titles of all retrieved records to identify which studies would advance to a full-text assessment, consulting the co-authors in the process.

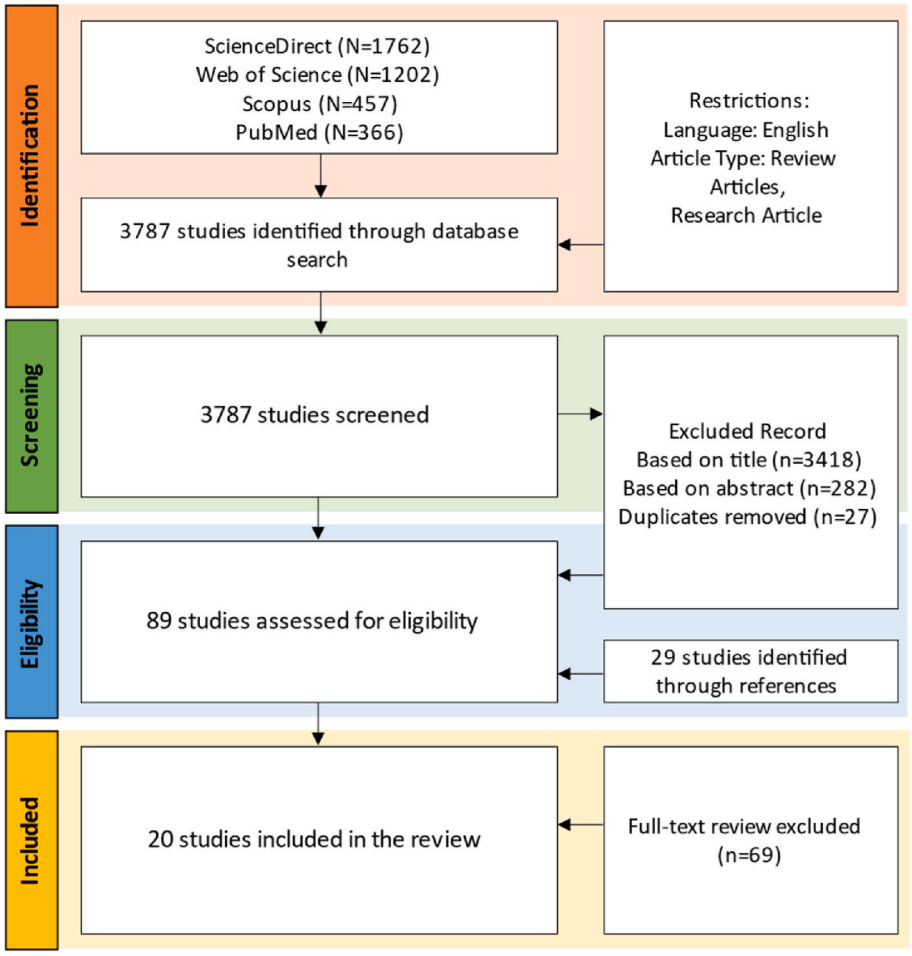

Fig. 1. PRISMA flow diagram for the scoping review.

Table 1
Exclusion criteria for the scoping literature review of how blue and green spaces affect the mental wellbeing of disabled children.

Category	Exclusion criteria
Exposures	Exclusive focus on grey spaces and/or buildings
Outcomes	No mental health measure
	Not focused on disabled children
Design	Case reports
	Review articles
	Encyclopedia articles
	Book chapters
	Conference papers
	Book reviews
Logistics	Duplicates
	Full texts unavailable
	In other languages with no English translation

2.4. Data abstraction

Data extraction from relevant studies was carried out in two phases using predefined templates. In the initial phase, we focused on key elements to provide a broad categorization of the available data. These key elements encompassed details such as the study's country or geographic region, study design, and the year of publication. Additionally, we extracted key information such as mental disorder, type of disability, sample size, age range, etc. Into a summary table (Table 2), to develop an overview of the literature. In the second phase, we carried out in-depth, narrative data abstraction for each mental health category. This is presented through summary graphs and detailed descriptions of the study outcomes and findings. In the discussion, we interpret the data within three major themes, which directly align with the research questions of this scoping review.

3. Results

3.1. Studies identified

We initially identified 3787 studies through a comprehensive database search (Fig. 1), following the application of search restrictions. The review consisted of a three-step screening process, involving the evaluation of titles, abstracts, and full texts. During the initial screening of the titles in the first step and abstracts in the second step, 89 studies remained eligible after the removal of duplicates. An additional 29 research papers, meeting the predefined criteria, were discovered through reference searching (following initial screening based on title and abstract). After retrieving full texts and conducting a thorough assessment, a total of 20 primary research papers were deemed eligible for inclusion based on alignment with the research objectives and search terms.

3.1.1. Study characteristics

As shown in Table 2, following the selection process and screening stages, 20 articles were eligible for the review, covering the period from 2010 to 2022. Most of these articles were carried out in 2018 or later (n = 14), with the remaining six studies published in 2010, 2014 and 2017. In terms of study design, most of the studies (n = 10) had a cross-sectional design and nine studies (n = 9) adopted a longitudinal

Table 2
Study characteristics of the included studies by mental Disorder category.

	Authors/Year/Country	Study Design	Population/Sample size/Age range	Type of Disability	Exposure Data source	Exposure Area/Concept	Analytical Instrument	Outcome(s)
Behavioral and cognitive	Amoly et al., (2014)/Spain	Cross-sectional	Children/2111/7–10	ADHD	NDVI, SDQ	Urban Green and Blue Spaces/Availability	SDQ, EOSDIS	A beneficial and positive effect of green and blue spaces on emotional, social problems and behavioral development
	Barger et al., 2022/The United States	Cross-sectional	Children/All children in the US/6-17	ASD	NLCD	Residential green space/Availability	R 'survey' package	There is no relationship between green space and behavioral problems
	Barger et al., 2020)/The United States	Cross-sectional	Children/1501/6-17	ASD	NLCD	Residential green space/Availability	R 'survey' package	Green areas with tree canopy coverage decreased the risk of severe behavioral problems
	Dockx et al., 2022b/Belgium	Longitudinal	Children/411/4–6	Behavior disorders	Land cover	Residential green space/Availability	CANTAB	Increasing the level of green space is related to a 38% reduction in behavioral and hyperactivity problems
	Lee et al., (2019)/South Korea	Cross-sectional	Children/1817/7-17	Behavior disorders	NDVI	neighborhood green space/Availability	ArcGIS Desktop 10.5	Green space can effectively decrease behavioral and behavior problems
	Markevych et al., (2014)/Germany	Longitudinal	Children/1932/6-11	ADHD	Land use data	urban green spaces/ Accessibility	GINIplus and LISAplus	Living further than 500 m from urban green spaces causes more overall emotional and behavioral problems compared to living within 500 m of urban greenness
	Pérez-Del-Pulgar et al., 2021/Spain	Cross-sectional	Children/151,110/ 0–12	Behavior disorders	Data from the Urban Ecology Department	Residential green space/Accessibility	SPSS 26	Proximity to green play is linked to a 4% lower prevalence rates of mental or behavioral problems
	van den Berg et al. 2010 /Netherlands	Mixed method	Children/12/9-17	ADHD	Observations, Mood and Concentration test, questionnaire	Natural landscape and urban built environment/Use	SPSS 17.0	Children with ADHD visiting natural and green areas have more positive behavior, feelings, and emotional functioning
Emotional and social	Balseviciene et al., (2014)/Lithuania	Cross-sectional	Children/1468/4-6	Emotional and behavioral problems	NDVI, SDQ questionnaire	City parks, Residential green spaces/ Accessibility	ArcGIS 10, ETM+, SPSS	
	Flouri et al., (2014)/UK	Longitudinal	Children/6384/3, 5, and 7 years old	Emotional problems	GLUD	Urban neighborhood green space/ Availability	SPSS 20	
	Li et al., (2019)/China	Longitudinal	Children/22/4-17	ASD	Interview	Urban green neighborhood and parks/Use	MAXQDA Analytics Pro 12	
	McCrorie et al., (2021)/UK	Cross-sectional	Children/774/10-11	Emotional problems	Ordnance Survey (OS) MasterMap Topography Layer®	Natural and private garden/Accessibility	Stata software v.14.2, GUS	
Anxiety and depression	Bezold et al., (2018)/The United States	Longitudinal	Children/13,346 born from 1999 to 2013	Depression	NDVI	Urban green space/ Availability	MRFS, CES-D 10	
	Larson et al., (2018)/United States	Cross-sectional	Children/1651/6-17	ASD	NLCD	Urban green space, grey space/ Accessibility	R 'survey' package	
ADHD	de Vries and Verheij (2022)/Netherlands	Cross-sectional	Children/248,270/5-12	ADHD	Land-use data, NDVI	Residential green space/Availability	MLwiN, SPSS 22	The level of greenness is inversely linked to the incidence of ADHD
	Donovan et al., (2019)/New Zealand	Longitudinal	Children/49,956/7-18	ADHD	NDVI, land-use data	Natural urban environment/ Availability	Stata software v. 15	Living in rural and green area decreases ADHD incidence
	Thygesen et al., (2020)/Denmark	Longitudinal	individuals/814,689 born between 1992 and 2007	ADHD	NDVI	Residential green space/Availability	SAS version 9.4	Living in regions with less vegetation) caused a higher risk of ADHD in comparison with areas with more vegetation
	Yang et al., (2019)/China	Cross-sectional	Children/59,754/2-17	ADHD	NDVI, SAVI	School green space/ Availability	SAS version 9.4	A greater level of greenness is linked to lower risk of ADHD
ASD	Wu and Jackson (2017)/The United States	Longitudinal	Children/543/5-12	ASD	NLCD	Urban and residential green space/ Accessibility	ArcGIS 10.3	A 10% rise in forest, grassland, average tree canopy and near-road tree canopy are accompanied with a reduction in incidence of autism by 10%–19%
Psychiatric	Engemann et al., (2019)/Denmark	Longitudinal	individuals/943,027 born from 1989 to 2013	Psychiatric disorders	NDVI	Residential green space/Availability	R 'survey' package, ENVI software	The incidence of mental disorders in areas with less greenness is 55% higher than areas with more greenness

Acronyms: ADHD: Attention Deficit and Hyperactivity Disorder; ASD: Autism spectrum disorder; CANTAB: the Cambridge Neuropsychological Test Automated Battery; CES-D: the Center for Epidemiologic Studies ten-item depression scale; DNPR: Danish National Patient Register; DPCR: Danish Psychiatric Central Research Register; EOSDIS: Earth Observing System Data and Information System; ETM+: Enhanced Thematic Mapper Plus; GLUD: Generalized Land Use Database; IDI: Integrated Data Infrastructure; MRSF: McKnight Risk Factor Survey; NDVI, Normalized Difference Vegetation Index; NLCD: National Land Cover Database; SAVI: Soil-Adjusted Vegetation Index; SDQ: Strengths and Difficulties Questionnaire.

design (Fig. 2). There was only one mixed methods paper (van den Berg and van den Berg 2011).

Out of the 20 studies, five were carried out in the United States, with two studies each from Denmark, China, the United Kingdom, Spain, and Netherlands. Additionally, there was one study each from New Zealand, Lithuania, Germany, South Korea, and Belgium (Fig. 3). Regarding data sources, nearly half of the articles (44%) relied on medical records and diagnoses; 39% involved assessments of children's mental health by parents or teachers, while 17% of the studies utilized self-reported data.

The sample size and proportion of examined population in the included studies exhibited a broad range, from as few as 12 to approximately 945,000 participants. As shown in Fig. 4, three studies included children along with young adults (age range: 5–29 years). It's worth noting that we excluded studies focusing on adult population, but these three studies were included because they examined mental health in individuals within an age range that encompassed both children and young adults.

3.2. Exposure data assessment

The type and area of exposure to blue and green spaces were generally consistent across most studies. The Normalized Difference Vegetation Index (NDVI) was the most frequently used exposure data source in included studies, featured in nine of the included studies. Other measures of green space include land cover and vegetation density, questionnaire, interviews, SAVI, SDQ, Generalized Land Use Database (GLUD) and NLCD. In studies which utilized NDVI, surrounding greenness was typically assessed using buffers, with distances such as 100 m or 500 m around specific residential addresses. Similarly, studies using a land cover database, similarly, calculated data based on various buffers (50 m or 1000 m) near the residence. Regarding the types of blue and green spaces, most articles (n = 16) considered natural and residential green spaces. The remaining studies explored school green space and natural and private gardens. Notably, ten studies focused on the availability of green space, six studies aimed to measure green space accessibility and two articles examined the use of green spaces.

3.3. Mental health outcomes

The results generally indicate a noteworthy positive association between green space and mental health, or a protective association with mental disorders. Fig. 5 shows the distribution of studies examining various aspects of mental health and the percentage of articles establishing an association. Of the 20 studies, 17 (89%) indicated a beneficial association between green spaces and mental health outcome, and just two articles found potential detrimental effects: one related to the risk of anxiety in autistic children (Larson et al., 2018) and another establishing a negative impact on social and behavioral issues in children (Balseviciene et al., 2014). Only two papers reported a non-effective association between green space and mental health (behavioral and Emotional problems).

3.4. Incidence of ADHD

As illustrated above, four studies evaluated the association between green space and the incidence of ADHD, all of which found a protective association. Children living in areas with higher levels of urban greenness had a reduced risk of ADHD, based on diagnoses and medical records. However, one study in New Zealand concluded that green space exposure was linked to a lower incidence of ADHD in children aged 2 to 18, but this protective effect did not extend to children under 2 (Donovan et al., 2019). Another study (de Vries and Verheij 2022) which evaluated the level of greenness within 250–500 m of the home addresses in Netherlands, found an inverse association with the use of ADHD medication. Similarly, one study indicated that higher greenness within 500 m from a kindergarten or school was linked to lower odds of ADHD disorders (Yang et al., 2019). Furthermore, Thygesen and colleagues reported that individuals living in areas with lowest decile of NDVI had considerably more ADHD symptoms in comparison with those living in areas with higher greenness (Thygesen et al., 2020).

3.5. Emotional, cognitive and social problems

We found nine articles assessing green space effects on emotional, cognitive, and social problems in disabled children. The majority indicated a beneficial relationship between green space and these three aspects of mental health. One study carried out in the UK (McCrorie et al., 2021) showed that a 10% increase in neighborhood greenness was linked to a 0.08 decrease in emotional problems, similar to another study (Flouri et al., 2014) that reported an improved emotional well-being. Li et al. (2019) interviewed caregivers and parents of children with autism in China, concluding that exposure to green spaces has social and emotional benefits (Li et al., 2019). However, Balseviciene and others (2014) assessed green space within a 300-m buffer around home addresses, found a non-significant association in children's emotional health (Balseviciene et al., 2014).

Another comparative study evaluated the emotional condition of 12 children with ADHD in green spaces and urban built settings, concluding that contact with nature can positively affect emotional and cognitive functioning (van den Berg and van den Berg 2011). Dockx et al., (2022a, b), assessed the land cover within 50–1000 m buffer around home addresses, indicating a positive effect of exposure to green space on cognitive condition of children (Y. Dockx et al., 2022a). In contrast, one study (Balseviciene et al., 2014) showed that higher greenness in residential areas was linked to less prosocial behavior in children, while another study (McCrorie et al., 2021) reported a beneficial effect of green spaces on prosocial behaviors.

3.6. Behavioral problems

Seven studies investigated the impact of green space on behavioral

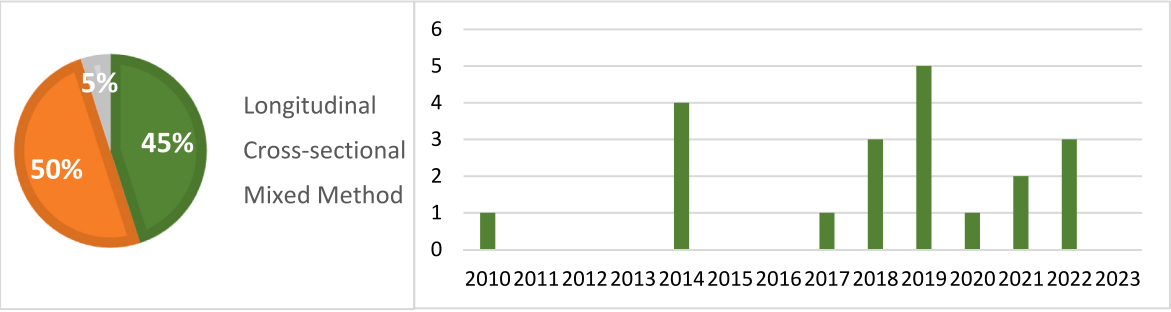

Fig. 2. Study design and the year of publication of included studies.

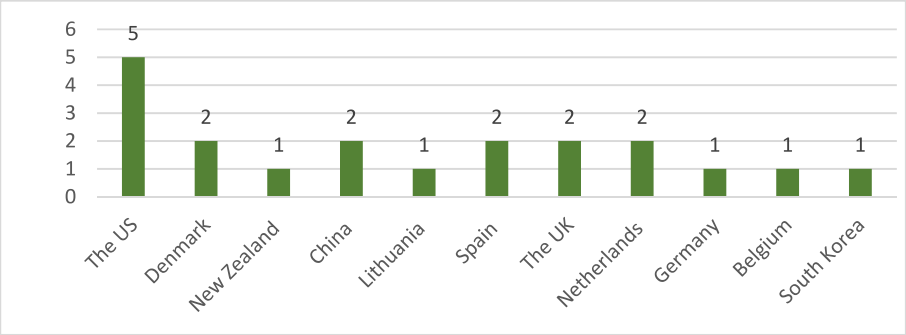

Fig. 3. Geographical distribution of the studies.

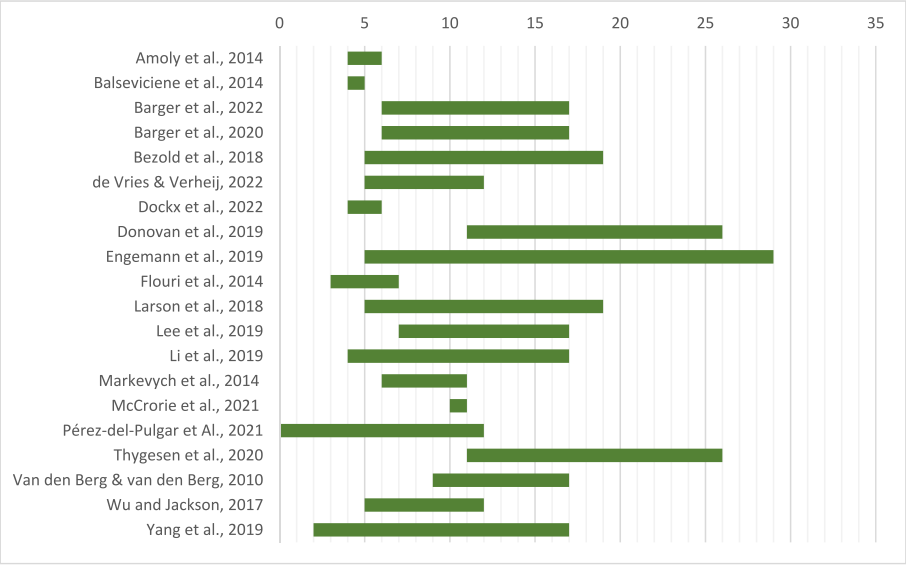

Fig. 4. The age ranges of participants in the reviewed articles.

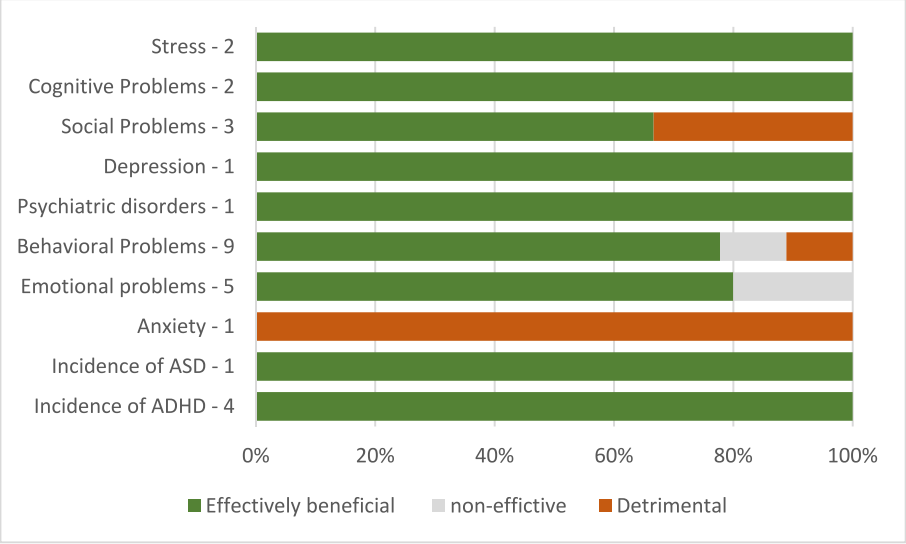

Fig. 5. The number of studies focusing on different mental health issues.

problems in such children. One study reported more overall behavioral problems in children living further than 500 m from green areas. (Markevych et al., 2014). Another study (Amoly et al., 2014) concluded that longer time spent in blue spaces and higher greenness in neighborhoods were associated with improved behavioral indicators. Lee et al. (2019) utilized the Child Behavior Checklist (CBCL) and found that

higher level of greenness in residential areas was linked to a lower problematic behavioral score in children (Lee et al., 2019). Similarly, another study (Pérez-Del-Pulgar et al., 2021), discovered that outdoor green playgrounds within 300 m of a child's home were linked to a roughly 5% lower risk of behavioral disorders. Three other studies also reported a positive effect of green spaces on the behavioral condition of children with disabilities (Brian Barger et al., 2020; Yinthe Dockx et al., 2022b; van den Berg and van den Berg 2011). However, one study (Balseviciene et al., 2014) reported a detrimental effect of higher greenness in residential areas on behavioral problems, while another article (B. Barger et al., 2022) confirmed no association among children with ASD.

3.7. Anxiety and depression

Two studies explored the connections between urban green spaces and anxiety and depression among children with disabilities. The first article used land cover and zip code data to evaluate the effect of green space proximity on children's mental health. It found that these spaces increased the odds of severe anxiety in children with ASD but reduced their stress level (Larson et al., 2018). The second study (Bezold et al., 2018) explored the impact of living in green areas over childhood on depressive symptoms in early adulthood. The findings demonstrated that green spaces could reduce depression rates by 6%, particularly in city center areas (8% reduction).

3.8. Psychiatric disorders

Regarding the role of green space and the prevalence of psychiatric disorders, one article from Denmark was identified. The article assessed land cover and greenness within a 210 × 210 m square around the home address. The study found that an increase in natural landscapes and higher greenness in residential area reduces the incidence of psychiatric disorders (Engemann et al., 2019).

3.9. Autism spectrum symptoms (ASD)

In a study by Wu and Jackson (2017), the effect of green spaces on the rate of autism in children was assessed. The research study evaluated the level of greenness and presence of grassland, forest, and tree canopy around school districts. It concluded that a 10% increase in these three types of landscape considerably reduces the prevalence of autism.

3.10. Effect of mediations and moderators

As shown in Table 3, the effect of blue and green spaces on different aspects of mental health was moderated and mediated by several factors categorized into three domains: sociodemographic, personal/parental health, and environmental/contextual. Most of the moderators were non-significant, however some studies indicated significant effects of variables such as age, sex, parental income, and education. To instance, one article found that the relationship between green space and behavioral problems was significant only among boys when adjusting for sex (Markevych et al., 2014). Another study indicated that household income moderated the association between natural spaces, private gardens and social and behavioral problems (McCrorie et al., 2021).

There was a positive relationship between natural spaces and social/behavioral problems in children from low-income households, while the relationship was negative for those from high-income households (McCrorie et al., 2021). However, the association between private gardens and social/behavioral problems was completely reversed for these two groups, indicating the effect of sociocultural factors. Moreover, four studies concluded that parental education moderated the correlation between green space and mental problems in children with disabilities. One study found that the relationship was positive in children with mothers of lower education levels, whereas green spaces were linked to more mental and social problems in children with more educated mothers (Balseviciene et al., 2014).

In addition, the included studies considered mediators to explore the underlying mechanisms to realize how or why an effect takes place. In most studies, no significant changes were identified after considering the adjusted models. However, in some studies, effective mediations were reported. For example, air pollution mediated the association between green space and mental health of children with disabilities in three studies, (Lee et al., 2019; Thygesen et al., 2020; Wu and Jackson 2017). Other identified mediators included antibiotic use (Donovan et al., 2019), parental mental health history (Bezold et al., 2018), and physical activity (Amoly et al., 2014; Lee et al., 2019).

Table 3
Mediators and moderators assessed in the included studies.

Domain	Mediators/Moderators		
	Variables	No. of Studies Considered	No. of Studies with Significant Moderation/ Mediation
Sociodemographic	Age	10	4
	Gender	13	5
	Ethnicity	8	3
	Birth order	1	1
	School level	1	0
	Calendar time	1	0
	Household income	10	6
	Parental education	10	4
	Parental marital status	2	0
	Number of siblings	1	0
	Neighborhood socioeconomic status	6	2
	Social cohesion	1	0
	Parental age	4	1
Personal/Parental health	Antibiotic use	1	1
	Maternal general health	1	0
	Parental mental health history	3	1
	Child general health	1	0
	Birthweight	2	0
	Body mass index (BMI)	2	0
	Preterm birth	2	0
	Breastfeeding	2	0
	Maternal alcohol consumption	2	0
	Mother's smoking	3	0
	Physical activity	8	2
	Blood lead level	1	0
	Leisure time	1	0
Environmental and contextual	Natural environment/ built setting	1	1
	Air pollution	5	3
	Road density	1	1
	Urbanicity	4	0
	Population density	1	1
	Exposure to environmental smoke	1	0

4. Discussion

4.1. Q1: what is the relationship between blue and green space exposure and different aspects of mental health among disabled children, and how strong are these associations?

The primary objective of this scoping review was to provide a comprehensive overview of research studies that investigate the connection between blue and green spaces and various mental health outcomes in children with disabilities. Although the number of papers on this topic is limited, the evidence generally supports a positive relationship. Most of the included studies primarily focused on investigating the effect of green space exposure on the mental health of children with disabilities. They notably demonstrated a positive association, aligning with studies centered on non-disabled children (Camerini et al., 2022; Fernandes et al., 2023; Oswald et al., 2020).

In contrast, we found only one study that assessed the effect of urban blue space on the mental health of children with disabilities, which showed a beneficial and positive association. Several studies have demonstrated the significant effect of blue space on mental health of children without disabilities (Bray et al., 2022; Subiza-Pérez et al., 2023; Vitale et al., 2022). Although there may be some similarities in the mental and psychological characteristics of children with and without disabilities, as disabled children contend with mental or physical challenges, some significant differences may exist (Fauth et al., 2017). Therefore, it is useful to comprehend how blue space may affect the mental health of children, with considering the fact that the findings of such studies may not necessarily be applicable to disabled children, and these effects are expected to be assessed separately in future research.

4.2. Q2: which aspects of mental health among disabled children are influenced by blue and green space exposure?

There is strong evidence to support a protective correlation between green space and the risk of ADHD for children, as suggested by five papers assessing this domain. It is likely that any intervention to increase green space exposure in urban areas could be a valuable strategy for preventing ADHD in children. Exposure to green spaces appears to bring about positive effects on the social and emotional functioning of autistic children (Li et al., 2019). This underscores the potential salutogenic benefits of natural environments for this population. Fewer studies explored the effect of green space in anxiety, depressive and psychiatric problems in children. Two articles, which assessed depression reports and psychiatric diagnoses, confirmed inverse relationships with exposure to green spaces. The findings of these studies were consistent with research that focused on Australian adults and suggested that increasing childhood contact with green spaces was mildly linked to lower risk of depression in adulthood (Tristan et al., 2016). However, one study related to anxiety symptoms in autistic children failed to establish a positive impact, instead finding that green spaces and tree canopy presence were associated with an increased risk of severe anxiety. However, the authors explained that the practical significance of the association for such children was minimal, as the odds associated with green space were low, and the comprehensive model did not explain the variations in reported anxiety. This is in contrast to the study that reported milder symptoms for hyperactive children who played in green spaces in comparison with non-green environments (Faber Taylor and Kuo, 2011). Emotional problems in children were assessed in one cross-sectional study, but it did not report an effective association. This may be influenced by the quality of green space exposure or the design characteristics (Balseviciene et al., 2014). The authors of this research assessed land cover data with a 300 m buffer and parent's reports. In contrast, in four other studies that used observation, interview and questionnaire and assessed green space within a smaller area, a positive relationship between green space and emotional wellbeing was established. Moreover, the findings of these studies are in line with the study that focused on adults with mood disorders, showing positive emotional effects when exposed to green space (Lengen 2015).

Of the nine studies focusing on behavioral problems in children, one paper concluded that residential greenness can increase mental problems, especially behavioral problems. The authors explained that this result is specific to children whose mothers were more educated (Balseviciene et al., 2014). Another study that investigated the correlation between canopy cover and behavioral problems in autistic children, found no significant association (B. Barger et al., 2022). The other seven articles reported a protective association which align with several previous research articles reporting better behavioral condition (Mårtensson et al., 2009; Taylor and Kuo 2011). Regarding social and cognitive problems in children, four studies observed a positive impact of green space on social and cognitive functioning of children with disabilities. However, one study (Balseviciene et al., 2014) reported more social problems for children exposed to green space, particularly those with higher maternal education. This finding contrasts with previous studies (Richardson et al., 2017; Tillmann et al., 2018) which reported that children who live near natural areas and spending time in green spaces had fewer social, emotional and behavioral problems.

4.3. Q3: which mental disorders and disabilities are not assessed and should be considered in future studies?

Seven different domains of mental health have been assessed by the included studies, which include: anxiety, depression, stress, psychiatric, behavioral, and social problems, neurodevelopmental, emotional and cognitive problems. We categorized the mental health category into five different types of disabilities covered by these studies: ADHD, autism, social, cognitive, and behavioral problems. It's worth noting that certain disability types (vision, hearing, physical, intellectual, and learning) and mental health problems (eating disorder and schizophrenia) were not assessed in any of the included studies. Fig. 6 illustrates the number of articles that focused on various aspects of disability types and mental health. It should be mentioned that there were some studies reported multiple mental health outcomes.

As shown in Fig. 6, behavioral, social, emotional, and cognitive dimensions of mental health received substantial attention, according to the outcomes and reports in the included studies. However, certain dimensions of mental health such as anxiety, depression, eating, schizophrenia, and neurodevelopmental disorders were not assessed as expected. Thus, there is a crucial need for further research to gain a better understanding of the relationship between these issues and green spaces. Moreover, although the researchers of the included articles examined the mental health outcomes accompanying green space exposure in children with ADHD, ASD, and behavioral problems, there is a lack of evidence confirming an association with mental health effects in children with other types of disabilities, particularly vision, hearing, physical and learning types of disability. Even though some of these disabilities and mental disorders may not appear to be directly correlated with green space in the expected way, several studies assessing mental and psychological aspects of children, reported higher risk of emotional, anxiety and depression in children with learning and physical disabilities (de Ruiter et al., 2007; Richards et al., 2001; Wallander et al., 2006).

4.4. Strengths, limitations and future directions

In this review, we adhered to the PRISMA-ScR protocol, and we conducted several consecutive searches to improve the rigor of the review. It's important to note that certain studies may have been overlooked either because they were not published due to non-significant outcomes or because they were in other languages. This may cause geographical bias and may, to some extent, account for the limited number of research papers outside of Europe and the US. This limitation affects the generalizability of the outcomes, as we could not find any

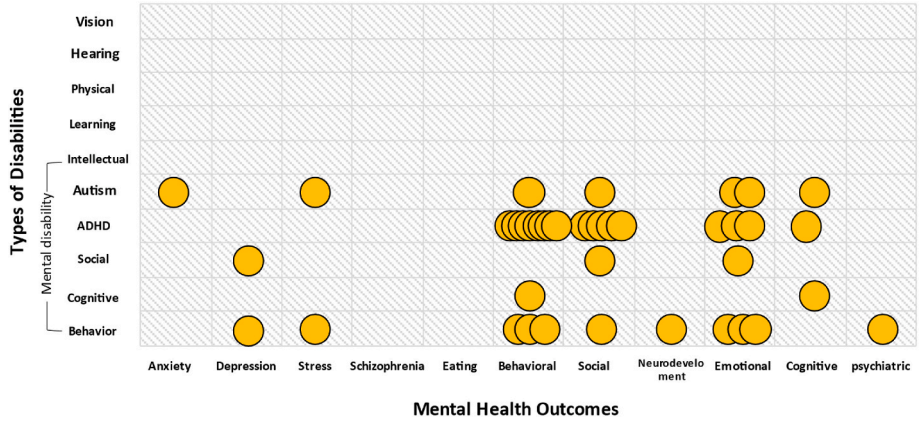

Fig. 6. The Mental health outcomes and disability types.

studies from low and middle-income countries. Additionally, we directed our attention to various dimensions of mental health among disabled children, a vulnerable group for which there is a lack of evidence. Moreover, it proved challenging to compare outcomes across studies with varying levels of green space exposure, especially within specific geographic areas. Specifying and analyzing the optimal and appropriate amount of green space exposure was complex. Lastly, there was a significant lack of evidence on the effect of short-term exposure of green space on mental health of disabled children. Changes in outcomes of mental health cannot always be evaluated over a long period and it is essential to assess immediate effects. There are several research papers focusing on the mental health of adults which evaluated the effect of short walks in nature or spending time in green spaces (Grigoletto et al., 2023; Jenny Roe and Aspinall, 2011; J. Roe et al., 2020).

We identified only one study that assessed the impact of blue spaces on the mental health of disabled children, despite several studies highlighting the potential benefits of such spaces (Bell et al., 2021; White et al., 2020). It is of great importance that future research directs its focus towards evaluating the relationship between blue spaces and the mental health of these children. We recommend examining the association between green space exposure and disabled children's mental health in less developed nations and low socioeconomic and ethnic minorities to enhance the generalizability of the outcomes. In addition to this, we did not come across any articles assessing the quality of green space, diversity of vegetation, aesthetic dimensions, design elements, visual and non-visual aspects, or the impact on five senses of landscape. Some research studies assessed design characteristics like vegetation and biodiversity (Wood et al., 2018), and the quality and design elements of green spaces (Nordh and Østby 2013), which are known factors influencing mental health in adults. Future research should prioritize the examination of the effect of these crucial aspects of landscape on mental health of children with disabilities. Moreover, there is a need for more precise tools and assessment instruments to measure green space exposure, particularly for short-term experiments and to assess the impact of different types of exposure such as proximity and quality of green space on mental health outcomes for this vulnerable group. Softer and more qualitative methods, such as behavioral observation and interviews with caregivers or parents, can be highly effective.

5. Conclusions

The findings of this scoping review not only demonstrate the clear benefits of green space exposure on the mental health of disabled children but also emphasize the significance of conducting short-term exposure studies in future research. Additionally, it highlights an important research gap regarding the impact of blue spaces on the mental health of disabled children, which could make a significant contribution to the broader literature. This review also revealed that some types of mental disorders, including emotional, behavioral, cognitive, stress, and social problems, were predominantly negatively associated with green space exposure. However, there is limited research on other aspects such as schizophrenia, eating disorders, anxiety, neurodevelopmental conditions, and psychiatric problems. Surprisingly, only one study delved into the impact of blue spaces on the mental health of disabled children. On balance, the findings significantly support a positive relationship between long term exposure to green space and mental health and a protective association with mental disorders in children with different types of disabilities. It is crucially expected more research focus on the potential effects of short-term blue and green space exposure on mental health of children with disabilities. We also observed a lack of attention to the relationship between the quality and design characteristics of landscapes and the mental health of children with disabilities. Moreover, the findings might not be generalizable to regions in the Global South. We believe it is vital to strategically increase the availability of green spaces in residential areas and implement design interventions to enhance and strengthen the association between green spaces and the mental health of such children.

Conflicts of interest

The authors declare they have no actual or potential competing financial interests.

Data availability

Data will be made available on request.

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