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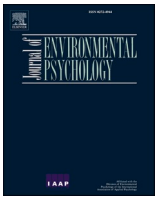

# Effects of greenspace interventions on mental disorders - a systematic review and meta-analysis

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ABSTRACT

This WHO-funded systematic review with meta-analysis summarizes the evidence of greenspace interventions on mental disorders, with patient-reported outcomes. The databases were searched through October 23, 2023: MEDLINE, Embase, PsycINFO and Cochrane Central Register of Controlled Trials. Randomized-controlled trials (RCT) for mental disorders with provider directed nature-based therapeutic interventions, or individual/group programs to improve health outcomes in nature were included. A search update was executed on Embase through November 19, 2025. The review was pre-registered in PROSPERO (CRD42023452769) and follows the PRISMA guidelines. Investigated interventions were detailed using the TIDieR Checklist. The study data were extracted, reviewed and scrutinized for risk of bias assessment by two reviewers independently. The meta-analysis was conducted with random-effects for all patient relevant outcomes. The mean differences (MD) or the standardized mean differences (SMD, Hedge's *g*) and their 95 % confidence intervals (CIs) were calculated between groups. The proportion of variability in effect estimates between studies that is not due to sampling error was categorized using $I^2$, the between-studies variance in true effects was categorized using $\tau 2$. Further, we report prediction intervals. While twenty RCTs (1299 patients) were included, only twelve studies were eligible for quantitative data syntheses. All but one had a high or unclear risk of bias. Between two and maximum six studies could be included per meta-analysis. For all psychiatric indications, meta-analysis revealed a significant effect on depressive symptoms (SMD -0.52, $p = .006$, 95 %CI [-0.89;-0.15]), anxiety (SMD -0.65, $p = .005$, 95 % CI [-1.10;-0.20]) and positive affect (MD -1.70, $p < .001$, 95 %CI [-2.66;-0.74]). Declines in positive affects may indicate a normalization of dysregulated or psychosis-related activations rather than a loss of positive emotions. Effects on negative affect, well-being and stress were not significant (all $p \geq .05$). Among patients diagnosed with depression, significant improvement on depressive symptoms was evident (SMD -0.39, $p = .049$, 95 %CI [-0.77;-0.001]). Among patients diagnosed with schizophrenia, significant improvements on positive affect (MD -1.75, $p < .001$, 95 %CI [-2.73;-0.77]), negative affect (MD -1.39, $p = .01$, 95 %CI [-2.38; −0.40]), and general

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psychopathology (MD -1.21, $p < .001$, 95 %CI [-1.90;-0.53]) were evident. Heterogeneity differed and prediction intervals crossed zero. Overall, the current evidence is insufficient to establish efficacy. Future trials require larger samples, standardized interventions, longer follow-up, and improved methodological rigor to enable robust conclusions.

## 1. Introduction

### 1.1. Greenspace interventions for mental health

Globally, only 2 % of health budgets are spent on mental health, while one in eight people are affected by mental disorders and over 70 % of the most severely affected, such as those suffering from psychosis, receive no mental health services at all (World Health Organization (WHO), 2021; Pan American Health Organization (PAHO), 2022; World Health Organization (WHO), 2021). Without adequate support or treatment options, a patient's chances of recovery are negatively impacted (Sun et al., 2023; van Dijk et al., 2023). Mitigating these circumstances underscores the need for evidence-based, (cost-) effective, low-threshold ways to address mental health disorders. Greenspace interventions, defined as planned activities with direct exposure to nature in areas permitted for recreational purpose (Annerstedt van den Bosch et al., 2015), have been recognized for their therapeutic value (Taylor et al., 2017) and show promising evidence for mental health (Nguyen et al., 2023). Generally, therapeutic measures such as horticulture and gardening therapy (Lu et al., 2021; Panțiru et al., 2024; Whelden et al., 2023), or green exercise (Coventry et al., 2021) are addressing a wide range of mental disorders from depression, schizophrenia, attention deficit hyperactive disorder (ADHD), or others.

### 1.2. Importance of nature on human health

Humankind's deep connection to nature is reflected in two main theoretical frameworks that explain how natural environments impact human psycho-physiological well-being. The *biophilia hypothesis* suggests that humans have an innate preference for natural environments, potentially rooted in our genome and shaped by biocultural and adaptive evolution (Gaekwad et al., 2022; Hand et al., 2017). *Attention Restoration Theory* (ART), builds on a concept from early cognitive psychology developed by William James at the end of the 19th century with the core idea that voluntary attention, or cognitive activities requiring directed attention, cause fatigue in humans (Kaplan, 1995; Kaplan et al., 1989). ART maintains that by redirecting attention back to natural settings, human seek restorative effects and stress reduction (Kaplan, 1995). The underlying human preference for natural environments is underscored by Stress Reduction Theory (SRT) emphasizing the instinctual safety provided by these environments (Ulrich, 1983; Ulrich et al., 1991). Conditioned Restoration Theory (CRT), furthermore, highlights how repeated exposure to nature is conditioned not only by evolutionary survival, but also through learned individual behavior and cultural practices that shape preferences to particular environments (Hartig et al., 1991; Staats et al., 2016). This provides the theoretical underpinning for how greenspace interventions may be able to alleviate symptoms of mental distress.

This knowledge and dependence on nature has been embedded in indigenous cultures worldwide and has been well documented through research in fields such as ethnobiology (Fernández-Llamazares et al., 2024), postcolonial, and international studies (Danto et al., 2022) as well as (trans)cultural psychiatry (Fernando et al., 2018). The traditional practices of nature immersion have been integral to health and well-being for ages and have deep historical roots, for example in Korea, China, and Japan (Kotte et al., 2021). In many European countries spending time in nature has been coupled with holistic healing traditions from the 18th century onwards (Schuh et al., 2022). Internationally, the World Health Organization (WHO) has prioritized agendas that emphasize the connection between health and the environment supporting the United Nations Sustainable Development Goals (SDGs) (United Nations et al., 2023). Greater acknowledgment and visibility of the mutual benefits of spending time in nature to sustain these environments and improve human health is evident for instance with the SDG for Good Health and Wellbeing (goal 3) and Climate Action (goal 13) that are inextricably and conceptually linked with the social determinants of health and well-being (Lund et al., 2018; World Health Organization (WHO), 2023). These agendas promote low-cost and potentially environmentally protective ways to effectively and simultaneously address both mental health and planetary ecological and environmental concerns (World Health Organization (WHO) and R.O.f.E., 2016).

### 1.3. Evidence of greenspace intervention effects on health

Multiple systematic reviews have demonstrated health benefits of spending time in nature. Next to improvements seen in physical health to longevity (Gascon et al., 2016; van den Berg et al., 2015) and cardiovascular health (Nguyen et al., 2023; Coventry et al., 2021; Gascon et al., 2016; Bettmann et al., 2025; van den Bosch et al., 2017), greenspaces have been shown to be beneficial to the mental wellbeing such as reducing stress (Bettmann et al., 2025; van den Bosch et al., 2017; Djernis et al., 2019; McCormick, 2017) and reducing loneliness (Moll et al., 2022; Tong et al., 2025). Next to wellbeing in adults, greenspace interventions seem to have modulating effects across age groups, promoting a self-regulatory effect in children (McCormick, 2017; Moll et al., 2022; Weeland et al., 2019) and reducing agitation in older adults (Murroni et al., 2021). In addition, some systematic reviews have examined blue spaces, suggesting potential benefits for restoration and mental wellbeing while living near blue spaces (Britton et al., 2020; Gascon et al., 2017; Georgiou et al., 2021) particularly for adults over 50 (Wang et al., 2024). Evidence for young people remains underexplored (Bray et al., 2022). More generally, across both diagnosed and not-diagnosed populations, time spent in nature has been associated with reductions in depression and anxiety symptoms.

However, a comprehensive summary of the evidence on whether interventions to spend time in nature can improve clinical outcomes for individuals diagnosed with mental disorders has not yet been conducted. Nature exposure interventions, for the purpose of our review were defined further as planned exposure to nature-based green areas permitted for recreational use for the explicit purpose of conducting a mental health intervention with individuals with a diagnosed mental disorder. This definition expanded an existing greenspace definition to include water areas used for recreation (World Health Organization (WHO) and R.O.f.E., 2016). This systematic review and meta-analysis provides a clearer understanding of the therapeutic benefits of healthy natural environments for individuals with mental health diagnoses.

## 2. Methods

The protocol for this systematic review was registered with the PROSPERO registry (CRD42023452769) prior to commencing the review. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009; Page et al., 2021).

### 2.1. Search strategy and selection criteria

This systematic review and meta-analysis included randomized-controlled or cluster-randomized trials with individuals without age restrictions diagnosed with a mental disorder according to DSM-5, ICD-10 or ICD-11. Interventions included guided and unguided nature-based therapeutic activities, health care professional-given directives, or programs for individuals, or a group to improve health outcomes by spending time in nature, such as in a park, having contact with the natural environment, including green and blue spaces, and/or horticultural therapy activities. To ensure a certain level of standardization, replicability and intervention consistency, studies were excluded if they had designs other than an randomized controlled trial (RCT), included patients without a mental disorder diagnosis or had no control group, aimed their interventions or measures towards special skills or where mental health activities and outcomes were not the focus, or practiced simulation without nature exposure. All patient-reported outcomes were included. An entire inclusion and exclusion strategy is found in Table 1. We searched Ovid MEDLINE and Embase via Ovid, PsycINFO via EBSCOhost and Cochrane Central Register of Controlled Trials (CENTRAL, The Cochrane Library) from inception to October 23, 2023. A manual search of reference lists from systematic reviews of similar nature-based interventions was also undertaken and did not yield further results. A search update was executed on Embase through November 19, 2025. A complete search strategy was tailored for each database (see supplement). For searching greenspace interventions, we used the search strategy from the systemic review by Nguyen and colleagues (Nguyen et al., 2023) with permission granted by the corresponding author. For mental disorders, we adapted the strategy by Wilczynski and Haynes (Wilczynski et al., 2006) (see supplement). The extraction was conducted as follows to minimize extraction errors and enhance methodological transparency. The search results were extracted from each database by two reviewers independently, then compared for consistency and data were added into the open-source software rayyan.ai (Ouzzani et al., 2016) and detected duplicates were checked. After deleting duplicates, abstracts and full text of articles were screened independently in rayyan.ai by two authors (SB and MS) for eligibility. When disagreements arose, these were discussed and resolved by consensus together with a third and fourth author (AK and MJ). Data was extracted independently by two authors (SB and MS) from the full texts for the following: Author, year, study design, country, funding, sample population, mental health disorder diagnosis, age, participant gender, intervention and control activity, reported outcomes, and adverse events. Details on the greenspace intervention characteristics were extracted using the Template for Intervention Description and Replication (TIDieR) Checklist (Hoffmann et al., 2014). Data for meta-analysis were extracted by two authors as well (MJ and SS).

**Table 1**
Inclusion and exclusion criteria.

| | Inclusion | Exclusion |
|---|---|---|
| **Design of primary studies** | Randomized controlled, randomized crossover and cluster randomized trials | Other quantitative or qualitative study design beyond RCT. |
| **Population** | Patients diagnosed with a mental disorder according to DSM-5 or ICD-11 (F-diagnoses). The respective disease conditions are considered separately. No restrictions on age will be applied. | Animal studies. Patient studies without a mental disorder diagnosis. |
| **Interventions** | A directive from a health care professional to spend time in nature, such as in a park, or a program offered by health care, social service agencies to their patients, or clients that includes nature-based interventions; these are defined as interventions that use nature therapy to improve health outcomes and contact with the natural environment, including green and blue spaces; eligible activities include both guided and unguided experiences in nature in individual or group settings. | Interventions aimed at only changing the environment in which people live (e.g., building new greenspaces, changing design, or providing facilities within greenspaces, or the provision of gardens, indoor vegetation, community allotments, outdoor gyms, without organizing any activity); programs requiring high levels of safety and skilled organizers (e.g., wilderness adventure programs, animal-assisted therapies, mountain hiking); simulation of nature spaces (e.g., virtual reality, photos, audio records) without actual nature exposure; school and after-school curricular activities, or any interventions aimed at increasing play time without a clear nature focus. |
| **Control interventions** | (1) No treatment/waitlist, (2) treatment as usual (TAU), or (3) any other active treatments. Studies that investigated nature therapy in combination with other procedures were included only if concurrent procedures were comparable between all groups. | No control group |
| **Outcomes** | All outcomes directly relevant to the patient (e.g. symptoms, quality of life). | Studies that only measure social, economic, and financial outcomes or diet. |
| **Other** | No time restriction. Studies in English or German Language. | |

Note: The rationale for the inclusion and exclusion criteria was to focus on patient-reported outcomes of formal nature programs under controlled conditions of a randomized controlled trial and with individuals who have been diagnosed with a mental disorder.

### 2.2. Data analysis

We planned to conduct meta-analyses for all patient-reported outcomes. Mean differences (MD) were used when the outcomes were measured using the same instrument across studies. The standardized mean differences (SMD, Hedge's *g*), using the conventional reporting for group differences interpreted as small vs. moderate vs. large effects, were applied when studies used different instruments to assess the same latent construct. Standardization was performed using the pooled standard deviation of the two groups, and Hedges' g was calculated to correct for small sample bias to ensure comparability across different measurement tools. This aligns with current recommendations for meta-analytic effect size computation, using the following formula: Hedges' $g = J \times [(M_1 - M_2)/SD\_pooled]$, where $J = [1 - (3/(4df - 1))]$, and $SD\_pooled = \sqrt{[(SD_1^2 + SD_2^2)/2}$. Confidence intervals of 95 % (CIs) between the groups were calculated for continuous variables. Binary variables were not present. When both mean changes from baseline and post-intervention mean values were reported, the post-intervention mean values were used, as these offer reasonable statistical power in the absence of baseline adjustment particularly when pre-post correlations are unknown or vary across studies (Vickers, 2001). If the required information was not available, the standard deviations (SDs) were calculated from standard errors (SEs) or 95 % CI of the mean. If this was also not possible, the authors were contacted and asked to provide the missing values. If an outcome was measured at more than one time point, we selected the time point that was reported most frequently in all studies. If an outcome was measured with multiple scales, we selected the scale that was most frequently reported in all studies. The proportion of variability in effect estimates between studies that is not due to sampling error was categorized using $I^2$ with $I^2 > 25$ % representing moderate, $I^2 > 50$ % representing substantial, and $I^2 > 75$ % representing considerable heterogeneity (Higgins et al., 2003). The between-studies variance in true effects was categorized using $\tau^2$.

Further, we report the ranges of the predicted effects in comparable future studies using prediction intervals. Subgroup analyses were planned beforehand on mental health diagnosis, intervention type and age. The risk of bias was assessed independently by two authors (SS and SB) using the Cochrane risk of bias tool version 1 (Higgins et al., 2011). Any disagreements that arose from insufficient or unclear methodological details were resolved with a third author (AK/MS) and discussed until consensus was reached. In the cases where at least two studies assessed the specific effect outcome of greenspaces, a meta-analysis was conducted with inverse-variance weighting under a random-effects model to pool study estimates for all patient-reported outcomes. For analysis of less than 10 studies, we refrained from conducting statistical tests such as Egger's regression or presenting funnel plots, as both have been shown to yield misleading results (Sterne et al., 2011). Non-significant outcomes were described descriptively regardless of confidence interval. Although formal tests for publication bias were not conducted due to the small number of studies, we considered the risk of publication bias when interpreting the findings. Analyses were performed using the Statistical Package for Social Sciences software (IBM SPSS Statistics for Windows, release 29.0; IBM Corporation, Armonk, NY).

## 3. Results

The literature search yielded an initial 2461 records and 632 further records via the search update (Fig. 1). After removing duplicates, we screened 1690 titles and abstracts, 1650 were excluded. Hence, 40 records were included in the full text screening: 22 records were excluded after full text screening for being the wrong study design (n = 8), not having a mental disorder diagnosis (n = 9), or no greenspace focus (n = 5, see supplement). Thirteen records were included in the full text screening via the search update: Ten records were excluded after full text screening for not having a mental disorder diagnosis (n = 5), being the wrong study design (n = 1), abstracts only available (n = 2) or no greenspace focus (n = 2). In three cases (Corazon et al., 2018a; Oh et al., 2018; Park et al., 2010) studies were only included after the authors were contacted via email to verify details about the randomization procedure, population, and study design respectively. In total, 21 reports were included for review, based on 20 separate studies (Atta et al., 2025; Chen et al., 2025; Corazon et al., 2018a; Detweiler et al., 2015; Hyvönen et al., 2023; Jarrott et al., 2010; Joubert et al., 2024; Kam et al., 2010; Luk et al., 2011; Oh et al., 2018; Shin et al., 2012; Siu et al., 2020; Stigsdotter et al., 2018; Taylor et al., 2009; Voola et al., 2022; Vujcic et al., 2017; Watkins-Martin et al., 2022; Wheeler et al., 2020; Yang et al., 2022; Yeon et al., 2023; Zhu et al., 2016). One study had two reports included (Corazon et al., 2018b; Stigsdotter et al., 2018). No included studies focused exclusively on blue spaces.

### 3.1. Characteristics of included studies and interventions

The 20 trials included in the review encompassed 1299 patients. 601 (46 %) were female, 364 (28 %) were male, one patient chose the gender option 'other', and 311 (24 %) were not documented (Table 2). Thirteen of the included studies had 50 participants or less. Mental health disorders were depression (Chen et al., 2025; Hyvönen et al., 2023; Watkins-Martin et al., 2022; Yeon et al., 2023), dementia (Jarrott et al., 2010; Luk et al., 2011; Yang et al., 2022), substance abuse disorder (Detweiler et al., 2015; Shin et al., 2012), schizophrenia (Oh et al., 2018; Zhu et al., 2016), attention deficit hyperactivity disorder (Taylor et al.,

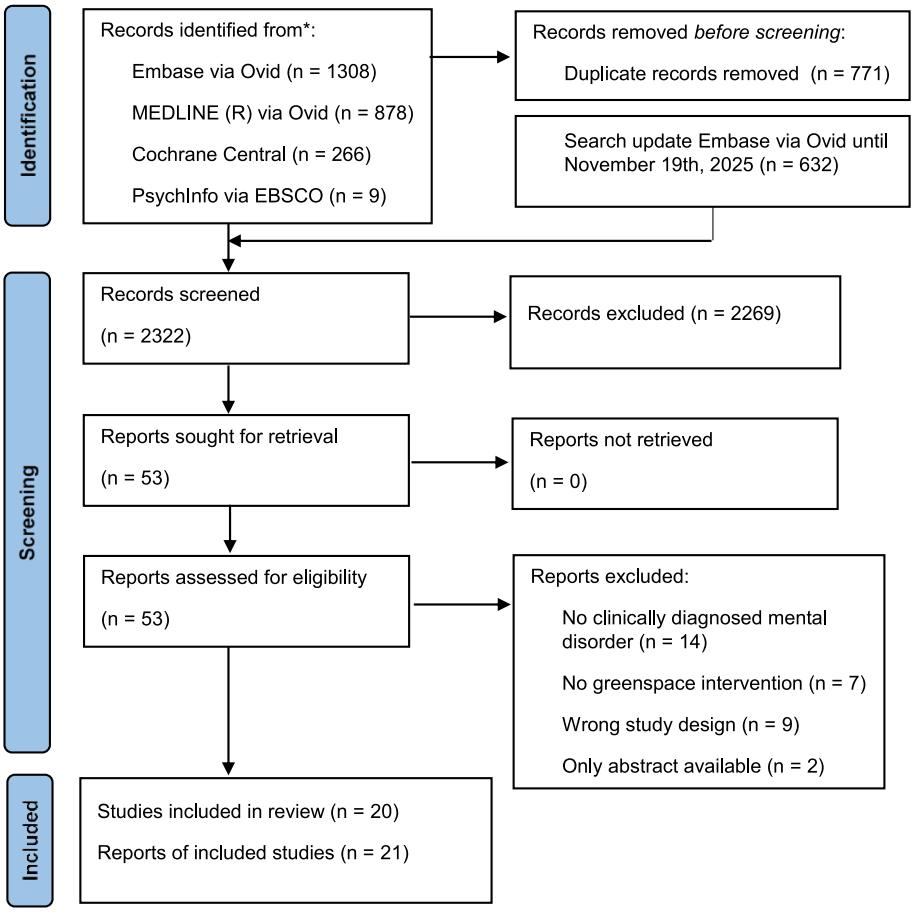


**Fig. 1.** Title: Flow chart, adapted from PRISMA guidelines (Page et al., 2021). The flow chart depicts the number of records identified, screened, assessed for eligibility and included in the review, as well as reasons for exclusion.

**Table 2**
Characteristics of included studies.

| | Study design, country, funding | Sample Population (sample size, ITT, PP) | Mental health disorder (DSM-5 or ICD-11 F-diagnoses coding) | Age group, Mean age years (SD), Gender: female %, male %, other % | Intervention | Control | Reported outcomes, measure between group, adverse events |
|---|---|---|---|---|---|---|---|
| Depression | | | | | | | |
| Hyvönen et al. (2023) | RCT, Finland, Kela (The Social Insurance Institution of Finland) | Adults treated for depression (N = 136, ITT/PP unclear) | diagnosis of depression (ICD -diagnostic system, code not specified) and a Beck Depression Inventory-I score of 10 or above (cutoff score for mild depression) | Adults, 45.2 (19–64), 82 %, 17 %, 1 % | Nature-based treatment | TAU | Non-significant group differences in depression (Beck Depression Inventory-I; BDI-I), sign. group differences for psychological distress (Clinical Outcomes in Routine Evaluation; CORE-10), restorative experiences (Restoration Outcome Scale; ROS), and self-reported ability to work or study (adopted from the Work Ability Index; WAI; only at post)<br>Adverse events: n.r. |
| Yeon et al. (2023) | RCT, South Korea, R&D program for Forest Science Technology funded by the Korea Forest Service (Korea Forestry Promotion Institute) | Adult patients with mild depression (N = 50, PP: n = 47) | Mild depressive disorder diagnosed by psychiatrists according to DSM-5 and confirmed through the Korean version of Structured Clinical Interview for DSM Disorders (SCID) (code not specified) | Adults, 37.31 (±10.27), 85 %, 15 %, 0 % | Urban forest therapy | TAU | Significant decrease in Beck Depression Inventory (BDI), Hamilton Rating Scale for Depression (HRSD), Pittsburgh Sleep Quality Index (PSQI), and Patient Health Questionnaire-15 (PHQ-15) scores for the urban forest therapy program group compared to TAU<br>Adverse events: n.r. |
| Watkins-Martin et al. (2022) | RCT, Canada, Social Sciences and Humanities Research Council, Fonds de recherche du Quebec en Sante, Canada Research Chair, Tier 2 | Adult psychiatric outpatients diagnosed with major depressive disorder (N = 47, PP: n = 37) | Primary diagnosis of mild depressive disorder (as per their medical chart according to the Structured Clinical Interview for Axis I DSM-IV, SCID I) | Adults, 49.27 (±10.95), 32 %, 68 %, 0 % | Single nature walk | Single urban walk | Participants who walked in nature reported overall lower levels of negative affect compared to those who walked in urban settings measured by the Positive and Negative Affect Schedule (PANAS)<br>Adverse events: n.r. |
| Chen et al. (2025) | Four-arm RCT, China, Guangxi Medical and Health Appropriate Technology Development, Promotion, and Application Project | Adults diagnosed with post stroke depression (N = 80, PP: n = 77) | Diagnosis with Post-Stroke Depression according to the Chinese Expert Consensus on Clinical Practice of Post-Stroke Depression | Adults, Intervention 65.2 (±5.5), 9 %, n.r., n.r. Control 64.1 (±5.6), 9 %, n. r., n.r. | Antidepressant and Horticultural therapy (HT) | Antidepressant | Hamilton Depression Scale (HAMD) Hamilton Anxiety Scale (HAMA) Significant reductions in HAMD and HAMA scores were observed in all groups post-treatment compared to baseline ($p < .01$).<br>Adverse events: n.r. |
| Dementia | | | | | | | |
| Jarrott et al. (2010) | Cluster RCT, USA, Alzheimer's and Related Diseases Research Award Fund | 8 nursing care programs for dementia patients (N = 129, IPP/PP: n.r.) | Diagnosis of dementia (code not specified) | Elderly, 80.09 (±8.05), 53 %, 47 %, 0 % | Horticultural therapy-based activities | Traditional activities | Menorah Park Engagement Scale (MPES) Apparent Affect Rating Scale (AARS) Significant differences between the treatment and comparison groups were found in four of the five engagement |

(*continued on next page*)

**Table 2** (*continued*)

| | Study design, country, funding | Sample Population (sample size, ITT, PP) | Mental health disorder (DSM-5 or ICD-11 F-diagnoses coding) | Age group, Mean age years (SD), Gender: female %, male %, other % | Intervention | Control | Reported outcomes, measure between group, adverse events |
|---|---|---|---|---|---|---|---|
| | | | | | | | categories coded from the Menorah Park Engagement Scale (MPES).<br>No group differences on affective domains.<br>Adverse events: n.r. |
| Yang et al. (2022) | RCT, China, no funding received | Nursing home residents with Alzheimer's (N = 32, ITT: n = 32) | Diagnosis of Alzheimer's type dementia under the criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Association | Elderly, 84.5 (IQR = 9.5), 94 %, 6 %, 0 % | Horticulture therapy | TAU | Apathy Evaluation Scale-informant version (AES-I)<br>Mini-Mental State Examination (MMSE)<br>Quality of Life in Alzheimer's disease (QoL-AD) scale<br>Barthel index (BI)<br>Apathy was significantly lower, cognitive function significantly higher in the experimental group than that in the control group at T1. Other outcomes were not significant |
| Luk et al. (2011) | RCT, Hong Kong, no funding mentioned | Nursing home residence with dementia (N = 14, ITT: n.r., PP: n = 13) | Diagnosed with dementia (code not specified) | Elderly, 84.9 (±8.3), 93 %, 7 %, 0 % | Horticulture therapy | Sensory stimulation and social interaction | Non-significant group differences on Mini-Mental State Examination scores (C-MMSE)<br>Adverse events: n.r. |
| Substance abuse disorder | | | | | | | |
| Detweiler et al. (2015) | Pilot RCT, USA, supported with resources from and by the use of facilities at the VA Medical Center in Salem, Virginia | Veterans in treatment for substance abuse disorder (N = 38, PP: n = 24) | Alcohol and/or substance dependence or abuse (code not specified) | Adults, 46.4 (±11.9), 4 %; 96 %, 0 % | Horticulture therapy | Occupational therapy | Quality of Life Enjoyment and Satisfaction Questionnaire-Short Form (Q-LES-Q-SF), the Alcohol Craving Questionnaire (ACQ-NOW), the Posttraumatic Stress Disorder Checklist Civilian Version (PCLC), and the Center for Epidemiologic Studies Depression Scale (CES-D).; no sig. Group differences.<br>Adverse events: n.r. |
| Shin et al. (2012) | RCT, South Korea, none mentioned | Adults with alcoholism (N = 92<br>ITT/PP: n.r.) | Alcohol abuse disorder (code not specified) | Adults, 45.26 (±3.89), 91 %, 9 %, 0 % | Forest therapy | TAU | Non-significant decrease in Beck Depression Inventory (BDI); between group differences n.r.<br>Adverse events: n.r. |
| Schizophrenia | | | | | | | |
| Zhu et al. (2016) | RCT, China, Minhang District Science and Technology Committee | Patients at psychiatric hospital (N = 110, ITT/PP n.r.) | Patients who met the ICD-10 diagnostic criteria for schizophrenia (code not specified) | Adults, 46.5 (±9.0), 56 %: 44 %, 0 % | Horticulture therapy | TAU | Positive and Negative Syndrome Scale (PANSS)<br>The PANSS score in the intervention group was statistically significantly lower than in the control group both at the end of the fourth week, and at the end of the 12th week.<br>Adverse events: n.r. |
| Oh et al. (2018) | RCT, South Korea, KU Research Professor Program | Adults with schizophrenia (N | Patients with schizophrenia (code not specified) | Adults, Horticulture (n = 15): 42.1 | Horticulture therapy | TAU | Korean version of the Positive and Negative Syndrome Scale |

(*continued on next page*)

**Table 2** (*continued*)

| | Study design, country, funding | Sample Population (sample size, ITT, PP) | Mental health disorder (DSM-5 or ICD-11 F-diagnoses coding) | Age group, Mean age years (SD), Gender: female %, male %, other % | Intervention | Control | Reported outcomes, measure between group, adverse events |
|---|---|---|---|---|---|---|---|
| | of Konkuk University | = 28, ITT/PP n. r.) | | (±13.0) 7 %, 93 %, 0 % Control (n = 13): 33.4 (±9.4), 54 %, 46 %, 0 % | | | (PANSS) Brief Psychiatric Rating Scale (BPRS) No group differences calculated Adverse events: n.r. |
| Attention deficit hyperactive disorder (ADHD) | | | | | | | |
| Taylor and Kuo (2009) | Randomized crossover trial, USA, the National Urban and Community Forestry Advisory Council, U.S. Forest Service | Children Diagnosed with ADHD or ADD (N = 17, ITT/PP: n. r.) | Children professionally diagnosed with ADHD by a physician, psychologist, or psychiatrist (code not specified) | Children 7–12 yrs old, 9.23 (SD: n.r.), 12 %, 88 %, 0 % | Walk in an urban park | (1) Walk in a downtown area (2) Walk in a residential area | Digit Span Backwards (DSB) Children with ADHD concentrated better after the walk in the park than after the downtown walk or the neighborhood walk Adverse events: n.r. |
| Voola et al. (2022) | Pilot RCT, India, self-funded | Children diagnosed with attention deficit disorder (N = 10, ITT/PP: n.r.) | Children with ADHD fulfilling the DSM-IV criteria (code not specified) | Children, 6–12yrs, 10 %, 90 %, 0 % | Outdoor sensory garden (SG) + indoor sensory integration (SI) | Indoor Sensory Integration (SI) therapy | Weiss Functional Impairment Rating Scale (WFIRS) increased significantly after the intervention compared to the controls. Adverse events: n.r. |
| Adjustment disorder | | | | | | | |
| Stigsdotter et al. (2018) | RCT, Denmark, TRYG Foundation | Stress patients with doctor referral (N = 84, PP: 76) | Psychiatric diagnosis of adjustment disorder and reaction to severe stress (ICD-10 codes F43.0, 2–9) | Adults, 47.9 (±7.8) in intervention group, 44.9 (±8.8) in control group, 82 %, 18 %, 0 % | Nature-based therapy | Cognitive behavioral therapy | Psychological General Well-Being Index (PGWBI), Shirom-Melamed Burnout Questionnaire (SMBQ) No sig. Group differences Adverse events: n.r. |
| Corazon et al. (2018) (long-term follow-up of Stigsdotter et al. (2018)) | | | | | | | Sick leave Healthcare consumption (number of contacts with a general practitioner) No group differences calculated Adverse events: n.r. |
| Post-traumatic stress disorder (PTSD) | | | | | | | |
| Wheeler et al. (2020) | Pilot RCT, UK, no specific funding | Veterans in treatment for PTSD (N = 25, PP: n = 18) | Diagnosis of PTSD by a National Health Service or Ministry of Defense psychiatrist (code not specified) | Adults, 40.0 (±12.7), 6 %, 94 %, 0 % | Outdoor activities (angling) | Waitlist | PTSD Checklist (PCL-5) Patient Health Questionnaire (PHQ-9) to assess depression General Anxiety disorder (GAD-7) Perceived stress scale (PSS) Work and social Adjustment (WSAS) Posttraumatic-wellbeing (PWB-PTCQ) Participants in the intervention group had significantly lower PTSD symptomology, depression, anxiety, and perceived stress relative to controls, and also reported post-traumatic growth relative to controls Adverse events: n.r. |
| Combined mental disorders | | | | | | | |

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**Table 2** (*continued*)

| | Study design, country, funding | Sample Population (sample size, ITT, PP) | Mental health disorder (DSM-5 or ICD-11 F-diagnoses coding) | Age group, Mean age years (SD), Gender: female %, male %, other % | Intervention | Control | Reported outcomes, measure between group, adverse events |
|---|---|---|---|---|---|---|---|
| Vujcic et al. (2017) | RCT, Serbia, Ministry of Education and Science of the Republic of Serbia | Psychiatric patients (N = 30, ITT/PP: n.r.) | Primary psychiatric diagnosis of an adjustment disorder, anxiety, or depression disorders (codes ICD-F43 codes, ICD-F41, or ICD-F32) | Adults, 45.35 (±10.16), 70 %; 30 %, 0 % | Horticulture therapy, including occupational and art therapy | Occupational and art therapy + conventional therapy | Depression Anxiety Stress Scale (DASS-21) Larger change in the stress subscale of the DASS-21 in the study group compared to the control group; no effect on other two subscales. Adverse events: n.r. |
| Siu et al. (2020) | RCT, Hong Kong, no external funding | Vocational rehabilitation services (N = 82, PP: n = 73) | Schizophrenia or other psychiatric illness (code not specified) | Adults, 50.3 (±9.6), 55 %; 45 %, 0 % | Horticulture therapy | TAU | Depression Anxiety Stress Scale (DASS21 subscales), Chinese version of the Short Warwick-Edinburgh mental well-being measure (C-SWEMWBS) Engagement in Meaningful Activities Survey (EMAS), and social exchange measured by the Social Exchange and Support Measure (SESM) The treatment group participants had significantly higher levels of mental well-being, showed more engagement in therapeutic horticultural activities, and found the activities more meaningful than did the comparison group Adverse events: n.r. |
| Kam and Siu (2010) | RCT, Hong Kong, no funding listed | Participants of faming rehabilitation workshop (N = 24, PP: n = 22) | Adults diagnosed with schizophrenia spectrum disorder (schizophrenia, schizoaffective disorder, schizophreniform disorder, psychosis not otherwise specified), bipolar disorder, or major depression (code not specified) | Adults, 44.3 (±11.6), 29 %, 71 %, 0 % | Horticulture therapy | TAU | Depression Anxiety Stress Scale (DASS21); work behavior on the subscales of Work Habit, General Work Behavior and Work-related Social and Emotional Behavior using the Work Behavior Assessment (WBA); Personal Well-being Index-Chinese Version (PWI-C) Significant differences in the DASS-21 total and the Depression, Anxiety and Stress subscales. However, there were no significant differences in the WBA and its subscales as well as the PWI between groups. Fatigue described as adverse effect, no adverse events reported |
| Atta et al. (2025) | RCT, Egypt, Study supported via funding from Prince Sattam bin | Adults with schizophrenia or bi-polar disorder (N = 130, PP: n = 120) | Adults with a diagnosis of schizophrenia or bi-polar disorder in treatment at the hospital | Adults Study Group 27.28 (±7.19), sex/gender n.r. Control (27.68 | Horticultural therapy program | Standard psychiatric care | Herth Hope Index (HHI), Ryff Psychological Wellbeing Scale (PWBS) and modified |

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**Table 2** (*continued*)

| | Study design, country, funding | Sample Population (sample size, ITT, PP) | Mental health disorder (DSM-5 or ICD-11 F-diagnoses coding) | Age group, Mean age years (SD), Gender: female %, male %, other % | Intervention | Control | Reported outcomes, measure between group, adverse events |
|---|---|---|---|---|---|---|---|
| | Abdulaziz University project | | for psychiatric medicine (code non-specified) | (±7.55), sex/ gender n.r. | | | version of the Social Adjustment Scale Self-Report (SAS-SR) Significantly higher HHI scores were seen in the intervention group compared to the control. The intervention scored significantly higher on the Psychological Wellbeing Scale (PWBS) than the control, indicating enhanced autonomy in the intervention group. The Modified Social Adjustment Scale (MSAS) scored significantly higher, indicating superior social adjustment in various domains of life for the intervention group. Adverse events: n.r. |
| Joubert et al. (2024) | RCT, France, French Ministry of Health and Prevention (Programme Hospitalier de Recherche Infirmière et Paramédicale) | Adults in treatment at an adult psychiatric unit (N = 211, PP: n = 191) | Adults with personality disorders, anxiety disorders, schizophrenia, or other mental disorder in psychiatric treatment for at least 1 month (code non-specified) | Adults, 42.9 Intervention Group 41.1 (31.1–51.3), n. r., 50.5 %, n.r. Standard of care 44.4 (35.3–53.9), n. r., 49.5 %, n.r. | Horticultural therapy | TAU | Hospital anxiety and depression scale (HADS) using the anxiety subscales HADS-A Horticultural therapy significantly reduced HADS-A compared to standard care Adverse events: n.r. |

Note. N = Number, RCT = randomized controlled trial; ITT = intention to treat; n.r. = not reported; PP = per protocol; SD = Standard Deviation; TAU = Treatment As Usual; DSM-5 = Diagnostic and Statistical.
Manual of Mental Disorders, Fifth Edition; ICD-11 F = International Classification of Diseases 11th Revision; F diagnoses.

2009; Voola et al., 2022), adjustment disorder (Corazon et al., 2018a; Stigsdotter et al., 2018), post-traumatic stress disorder (Wheeler et al., 2020), and combined mental health disorders (Atta et al., 2025; Joubert et al., 2024; Kam et al., 2010; Siu et al., 2020; Vujcic et al., 2017). The studies were conducted in twelve countries: Egypt, France, Hong Kong, South Korea, the United States of America, China, Denmark, Canada, Finland, India, Serbia and the United Kingdom (see supplement). Publications ranged between 2009 and 2025 (see supplement). Participants included children (Taylor et al., 2009; Voola et al., 2022), adults (Atta et al., 2025; Chen et al., 2025; Detweiler et al., 2015; Hyvönen et al., 2023; Joubert et al., 2024; Kam et al., 2010; Oh et al., 2018; Shin et al., 2012; Siu et al., 2020; Stigsdotter et al., 2018; Vujcic et al., 2017; Watkins-Martin et al., 2022; Wheeler et al., 2020; Yeon et al., 2023; Zhu et al., 2016), and elderly (Jarrott et al., 2010; Luk et al., 2011; Yang et al., 2022). Six studies were designed as pilot RCTs and had between 10 and 49 participants (Detweiler et al., 2015; Kam et al., 2010; Luk et al., 2011; Voola et al., 2022; Wheeler et al., 2020; Yang et al., 2022). Eleven studies compared a greenspace intervention to treatment as usual (TAU) (Atta et al., 2025; Chen et al., 2025; Hyvönen et al., 2023; Joubert et al., 2024; Kam et al., 2010; Oh et al., 2018; Shin et al., 2012; Siu et al., 2020; Yang et al., 2022; Yeon et al., 2023; Zhu et al., 2016), seven compared it to other active interventions (Detweiler et al., 2015; Jarrott et al., 2010; Luk et al., 2011; Stigsdotter et al., 2018; Voola et al., 2022; Vujcic et al., 2017; Watkins-Martin et al., 2022) whereas a waitlisted control was conducted by one study (Wheeler et al., 2020). One study used a within subject crossover design (Taylor et al., 2009). Another study (Corazon et al., 2018a) presented the long-term data results of a previous RCT (Stigsdotter et al., 2018).

Most interventions had a horticultural therapy approach (Atta et al., 2025; Chen et al., 2025; Detweiler et al., 2015; Jarrott et al., 2010; Joubert et al., 2024; Kam et al., 2010; Luk et al., 2011; Oh et al., 2018; Siu et al., 2020; Yang et al., 2022; Zhu et al., 2016) or focused on activities that exposed participants to nature and greenspaces, termed forest or nature therapy (Corazon et al., 2018a; Hyvönen et al., 2023; Shin et al., 2012; Stigsdotter et al., 2018; Taylor et al., 2009; Vujcic et al., 2017; Watkins-Martin et al., 2022; Yeon et al., 2023). The two other types of interventions were a built sensory garden environment (Voola et al., 2022) and a mixed activity outdoor intervention (Wheeler et al., 2020). Table 3 provides a detailed intervention description based on the TIDieR Checklist (Hoffmann et al., 2014).

### 3.2. Meta-analysis

Of the 20 included studies, 16 reported relevant outcomes for potential inclusion in the meta-analysis. However, four of these studies did not report sufficient data and did not respond to our data request and were therefore excluded from the meta-analysis (Detweiler et al., 2015; Jarrott et al., 2010; Kam et al., 2010; Siu et al., 2020; Yang et al., 2022). Three authors provided the missing information of which two could be included for meta-analysis (Luk et al., 2011; Vujcic et al., 2017; Watkins-Martin et al., 2022). This left twelve studies with analyzable data that could be included in the quantitative synthesis (Atta et al., 2025;

**Table 3**
Intervention Characteristics based on the Template for Intervention Description and Replication Checklist (Hoffmann et al., 2014).

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| Depression | | | | | | | | |
| Hyvönen et al. (2023) | Flow with Nature (FWN) treatment | Attention Restoration Theory (ART; Kaplan & Kaplan, 1989) and Stress Recovery Theory (SRT; Ulrich et al., 1991); Comprehensive Nature Experience (Salonen et al., 2020, 2022); FWN treatment is informed by psychotherapy research (e.g., group cohesion, empathy, feedback; Norcross & Wampold, 2018), the transtheoretical model of behavior change (Prochaska et al., 2020), and theories of cognitive behavioral therapy (e.g., Hayes et al., 2012) and creative arts therapies (e.g., Zubala & Karkou, 2018) | General principles are characteristic to FWN[43]: regular social support (e.g., weekly meetings), psychological and physical safety (e.g., support from the facilitator and group, safe environment), respect for other group members as well as nature (i.e. everyone's experiences and favorite places are respected), flexibility (e.g., the FWN exercises are optional and the participants' acute needs are primary) and responsibility (i.e., for rehabilitation and towards the environment). In addition to social support, FWN participants are encouraged to recognize nature environments' significance for one's own well-being, and they receive support for psychological and environmental self-regulation. The FWN treatment has separate stages (Horizon, Growth and Path) that emphasize nature, group (social support) and FWN exercises differently. At each stage, there are four different FWN exercises with similar structures: first, experiencing nature individually and then sharing the nature place experiences in pairs or with the group | Eight licensed healthcare professionals (e.g., psychologist, occupational health nurse) who attended the 12-day intervention training and were provided supervision during the intervention period | Mainly group based; some group meetings were in-person or conducted as hybrid meetings | Five towns across the Pirkanmaa, Häme, and Central Finland Regions; nature environments near the health and rehabilitation centers such as parks, urban and rural forests, and water areas In hybrid meetings, some members met together, and some participants joined the group online. During online and hybrid meetings, those participants who joined the group meeting via video call chose their own favorite place in nearby nature and shared their experiences and received support via video call to the whole group | 12 nature-based intervention sessions once a week for 90min | Adapted to COVID-19 pandemic conditions (see mode of delivery) |
| Yeon et al. (2022) | Forest therapy | To investigate the effects of a forest therapy program using urban forests on depression disorders. In addition, we investigated sleep quality and somatization symptoms closely related to depression in patients with depression | The first step ("Recognition") is to explore and clarify emotions. The second step ("Action") is to stop negative thinking through forest therapy activities. The last step ("Change") is to break the chain of ruminant thinking and improve lifestyle habits | Forest therapy curriculum developed and distributed according to each appropriate session's theme based on researchers in forest therapy and forest therapists | Outdoor, guided groups | Seoul forest in Seongdong-gu, Seoul Metropolitan City, South Korea | Three stage healing modules over 6 sessions, once a week for 2 h. | |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | through the daily life of forest therapy. The main activities of this program were "relax the body and mind through stretching", "walking on the five senses", "playing emotional card game", and "breathing and meditation" | | | | | |
| Watkins-Martin et al. (2022) | Single walk in nature | Not stated | One scheduled walk, for approximately 60 min at a pace of 3–5 km/h and were instructed to refrain from engaging in conversation to minimize social stimulation and maximize their focus on the surrounding environment | Two research assistants (psychology undergraduate/ graduate students) | Individually or in groups of two, outdoor, guided | 97-ha biodiverse urban park near the Douglas Mental Health University Institute (DMHUI) in the province of Quebec, Canada. The total distance of the nature walk was 4.41 km with a cumulative elevation of 13 m. The walk included a stretch of 3.5 km within the park far from urban sounds (e.g., automobile noise) and sights (e.g., buildings and parked automobiles). The park consists of a forest of with over 20,000 trees as well as a pond, and no automobiles are permitted within the vicinity of the park | Single 60-min walk | Not stated |
| Chen et al. (2025) | Horticultural Therapy (HT) | Aims to combine HT with anti-depressant medication and also transcranial magnetic stimulation (rTMS) to develop a non-invasive, cost-effective, and replicable treatment approach for post-stroke depression | Over 28 days the patients participated in HT group activities for 5 days a week for 45 min per session. | Occupational therapists and social workers | Group of 3–4 people | Therapist and social worker assisted sessions in a rehabilitation hall with activities such as pruning plants, teaching how to use tools, gardening knowledge and self-recognition of the intervention. | HT sessions lasted 45 min, 5 days/week. HT sessions lasted 45 min, 5 days a week over 28 days. | Tasks were based on the patient's functional ability and fine motor ability or support required. |
| **Dementia** | | | | | | | | |
| Jarrott and Gigliotti (2023) | Horticultural therapy-based (HT-based) programming | Theory of environmental press | Activities ranged from sowing seeds and training topiaries to craft activities that incorporated horticultural therapy materials or themes. Activities were designed to support both | Two facilitators; all activity plans were reviewed by the second author, a horticulture therapist and gerontologist, to insure use of a person-centered approach across sites. | Partly outdoor, depending on study site; group-based | 4 treatment sites (care programs in rural southwest Virginia); the physical environment varied across facilities; each group participated in a | Twice weekly for 6 weeks; 30-min activities | Adaptations for activities (i.e., to simplify, make more complex, or extend an activity with different materials) were preplanned to ensure |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | individual and collective engagement. Facilitators encouraged social interaction and reminiscence by asking questions about participants' social histories and experience gardening, farming, and cooking | | | designated area, and several sites had outdoor spaces that were accessible in good weather. | | inclusion of all participants wishing to join the horticulture therapy sessions. |
| Yang et al. (2022) | Horticulture therapy (HT) | To examine the effects of horticulture therapy on apathy, cognitive ability, quality of life, and functional capacity | HT activities were categorized into planting, handicraft, and diet. Planting activities included planting, growing, and harvesting. Handicraft activities consisted of the use of natural materials to make handicrafts. Dietetic activities involved eating, drinking, and cooking plants. There were ten sessions in total, including four planting sessions, four handicraft sessions, and two dietetic sessions | The research team employed an activity leader who was a registered nurse with a master's degree, whose role was to introduce and host the activities. A nurse was employed to conduct the HT activities. The activity leader completed a professional skill workshop organized by the HT Association of China. The activity assistants were four registered nurses and four social workers, who worked in the nursing homes and were familiar with the participants. | Indoor, face-to-face in groups of 6, guided | sessions were administered in a large well-lit classroom in the morning hours in a nursing home in Guangzhou | Once a week for 10 Weeks for a 60 min session | Minor adjustments were made depending on the participants' levels of dependence during the activity. |
| Luk et al. (2011) | Horticulture therapy | Horticultural therapy as an unique and therapies to foster reciprocal relationships between nature and people. | Each session had a different theme such as fertilizing, seeding, flower arranging, and planting. | No specific person mentioned | Fertilizing, seeding, flower arranging, and planting group | An outdoor garden, Hong Kong | The intervention was a 30-min twice-weekly horticultural activity conducted in an outdoor garden for 6 weeks. | Not stated |
| **Substance Abuse Disorder** | | | | | | | | |
| Detweiler et al. (2015) | Horticulture Therapy | To promote neuroendocrine and affective restoration from stress in veterans | Daily education about gardening activities; activities: (1) adding soil to garden boxes; (2) planning the types of seeds to plant (e.g., flowers, vegetables, and herbs); (3) planting the seeds; and (4) watering, weeding, and harvesting the vegetables and flowers | Horticulturalist | Outdoor supervised group | Salem Veterans Affairs Medical Center (SVAMC), U.S. A box garden area included two adjacent, small courtyards immediately in back of the facility in which the veterans were housed during the program. The area had gardens 0.46 m wide along 1 side of each courtyard. One courtyard had five box gardens that were 0.61 m | 1 h per day, 5 days per week for 3 weeks during a 28-day treatment program for substance use disorder | Not stated |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | | | | high, 1.22 m wide, and 2.44 m long; two window boxes; and nine large flowerpots 0.61 m in diameter. The second courtyard contained two window boxes; four large flowerpots that were 0.61 m in diameter; and a small hut for garden tools. Both courtyards had one circular table with three benches | | |
| Shin et al. (2012) | Forest therapy | Kaplan's theory indicating that exposure to a forest environment can effectively reduce stress ( Kaplan, 1995) | The 9-day forest healing camp in Summer of 2009: The forest healing program was designed to meet the following objectives: (1) to provide exercises representative of the forest therapy programs described in the literature, specifically those exercises prescribed to aid in psychological development; (2) to be representative of Kaplan's theory denoting the mechanisms of psychological benefits from forest experiences; (3) to accompany the application of other therapies, such as meditation, exercise, and counseling. Three treatment sessions were developed for the treatment (experimental) group. Each session of the camp was designed to achieve different goals to interact with nature, be challenged and be introspective | None mentioned | Outdoor supervised group | The study area (Saneum Recreational Forest) is located in Kyungggi Province, about 80 km away from Seoul, the capital of South Korea. Saneum Recreational Forest has 2140 ha of forest area mainly composed of oaks and pine. The number of visitors was 76,559 in 2007. | 9 days, 3 different sessions à 3 days | |
| **Schizophrenia** | | | | | | | | |
| Zhu et al. (2016) | Horticultural therapy | to further test its potential application in psychiatric hospitals | Specific contents included ridging, planting, watering, fertilizing and pruning of flowers; plowing, sowing, watering, fertilizing, weeding and catching pests for gardens; appreciating, | Rehabilitation therapist with level II (Chinese standard) psychological counselor qualification and another rehabilitation therapist | Both indoor (when weather was unfavorable) and outdoor activities, group-based | Two rehabilitation wards in the Minhang District Mental Health Center, China; 0.5 $m^2$ of land for planting in a 2-m times 15 m outdoor garden. Indoor pot | 12 weeks, 3 times a week, à 90min | Adapted for indoors due to weather |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | collecting vegetables, cooking and tasting for flowers and grasses. During the final 10 min of every session, patients mutually expressed their thoughts and experiences, and the rehabilitation therapist concluded the session | | | planting was adopted for floral gardening due to convenience in planting, management and maintenance | | |
| Oh et al. (2018) | Horticultural therapy | An ancient and modern documented tradition of using time in gardens as a prescription for mental illness | Once a week, 10-session horticultural group therapy from April–June 2017. The participants received explanations and demonstrations of the gardening activities in each session from the instructors. Then, a list of work that needed to be done in the garden was provided, and each participant performed the work in every session. The participants took a lesson how to make garden bed and plant crops such as potato and lettuce by instructors. Moreover, demonstrations were provided to help their understanding of the activities. And then, each participant made a garden bed and planted the crops by themselves. The divided garden plot into eight sections according to the type of crop, was cultivated by the participants together. | The horticultural therapy program was run by two horticultural therapists certified by the Korean Horticultural Therapy Association, and one volunteer. Three individuals who were in charge of the mental health rehabilitation centers supervised each session. | Guided weekly horticultural group therapy sessions over 10 wks. | A 991.7 m2 garden plot on a farm located in Suwon, South Korea | Single weekly sessions over 10 sessions with a 120 min duration | Not stated |
| **Attention deficit hyperactive disorder** | | | | | | | | |
| Taylor and Kuo (2009) | Walk in urban park | Attention Restoration Theory (ART) | Children and their guides walked a route designed to be completed in 20 min at a relaxed pace. The guides kept the walk on schedule and discouraged conversation | Walking guide | Individual, guided, outdoor | Urban park | One 20min session | Not stated |
| Voola and Kumari (2022) | Combined outdoor sensory garden and indoor sensory integration therapy | Sensory Garden in 2017 was conceptualized, designed and implemented by three research team members of SRM College of Occupational Therapy in SRM | Designed with sensory stimulation therapeutic program to convert an open underused fringe area attached to an occupational Therapy clinic to a small, user friendly, low cost, well | Conceptualized, designed and implemented by 3 research team members of SRM College of Occupational Therapy in SRM Hospital & | Indoor and outdoor activities | The grounds of an occupational therapy clinic, Chennai, India | The intervention lasted for 3 months (12 weeks) with intervals of 3 times a week (45 min/ session) for a | Not stated. |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | Hospital & Research Centre, Chennai after formal approval. | protected and delimited space which made it easily accessible and safe to explore by the special needs children attending the treatment. It is composed of various natural elements which provide opportunity to respond to various senses such as water (hearing and touch), loose materials on the surface of textured paths such as gravel and sand separated by wood edgings (tactile), natural grass on plain surface and ramp (tactile, vestibular, proprioceptive), aromatic and edible herbs (smell, taste), colorful plants and flowers and unused cycle rim (sight), low concrete wall with wired fence (proprioceptive, vestibular) tree swing and hammock (vestibular). | Research Centre, Chennai | | | total of 46 sessions. | |
| **Adjustment disorder** | | | | | | | | |
| Stigsdotter et al. (2018) | Nacadia® nature-based therapy (NNBT) | Builds upon elements from mindfulness-based stress reduction (MBSR) and Cognitive-based Therapy (CBT), integrated with theories from environmental psychology, especially attention restoration theory, which emphasizes sensory stimulation from natural environments as a means of restoring fatigued cognitive resources. | 5 Components: (a) Therapeutic conversations: individual conversations based on CBT and psychoeducation based on MBSR. (b) Awareness exercises: individual and group physical and mental awareness exercises in accordance with MBSR and related to nature experiences, such as mindful walking in the garden. (c) Nature-based activities: individual gardening activities, dependent on the season. Before each session, the gardener, who also maintains the therapy garden, makes a list of possible activities from which the patients choose together with the therapist. The choice of activity is guided by what is comprehensible, | Two therapists (licensed clinical psychologists with formal training in CBT) and a gardener | Outdoor, hybrid between a group-based and an individual treatment, mostly individual | At the University of Copenhagen's therapy garden called Nacadia. This garden has been designed as a 1.4-ha wild forest garden and is located within an arboretum containing the largest collection of trees and shrubs in the country. The design of the garden follows the model for evidence-based health design, and the design process has been transparently described and documented. | 10 weeks, 3 days per week for 3hrs | Not stated |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | manageable and meaningful for the individual. Mindful awareness is integrated into the activities. That is, participants are trained to notice non-beneficial behavioral patterns that could lead to stress. (d) Reflection and relaxation time: individual time for reflection and relaxation in the garden. (e) Homework: individual homework to practice the different techniques and methods. | | | | | |
| **Post-traumatic stress disorder** | | | | | | | | |
| Wheeler et al. (2020) | Outdoor activity: experiment 2 | Formal evaluation of the potential impact of brief outdoor activity experiences with military veterans with diagnosed PTSD who were not receiving any form of psychological therapy. | The intervention involved a day-long outdoor recreational experience (angling) in a peer group context. In addition to the angling coaches and a mental health practitioner, three military veteran participants from experiment one also attended in the role of 'mentor'. | Fully trained professional coaches and a high intensity psychological therapist | A day-long outdoor recreational experience | Developed and tested intervention near veterans' homes and limiting access difficulties. Tents and tackle provided for angling context near a lake. Collaborative food and hot drink preparation by the veterans. | One day-long outdoor intervention | |
| **Combined disorders** | | | | | | | | |
| Vujcic et al. (2017) | Horticulture therapy program | Based on Stress Recovery Theory and Attention Restoration Theory (Ulrich et al., 1991; Kaplan & Kaplan, 1989) | Week 1: day 1: Presentation of the HT program. Tour of the Botanical Garden (Introduction and Orientation) day 2: Visit the Greenhouse and relax on the grass lawn outside (Sunbathing and Meditation) day 3: Work activity (Collecting chestnuts; Social support in a group); week 2 day 1: Visit the Japanese garden (Relaxing; Stress-coping strategies) day 2: Work activity (Collecting acorns and hazelnuts; Social support in a group) day 3: Organized garden walk through and learning about the species (Develop interest in plants); week 3, day1:Work activity (Plot weeding; Social support in a group), | Collaboration between psychiatrists, doctors and therapists from the Institute of Mental Health | Outdoor, in a group | Jevremovac Botanical Garden in Belgrade, Serbia; area of about 5 ha, with an open space containing 350 species of trees and shrubs and domestic, European and exotic plants. The total plant population now comprises over 1500 trees, shrubs and herbaceous plants. The Jevremovac Botanical Garden includes the addition of an open space, a greenhouse, a Japanese garden, systematic plots, a central fountain and offices of the Institute of Botany, such as the administrative | 12 sessions: three days a week for 1 h for four weeks | Adjusted to the conditions and the environment of the Jevremovac Botanical Garden in Belgrade |

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**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | day2: Art therapy in Japanese Garden (Draw a favorite element; Awaken creative mood), day3: Work activity (Potting collected autumn fruits; Social support in a group), week 4: day 1: A therapy garden walk through and rest by the central fountain (Relaxing; Stress-coping strategies), day2: Work activity (Potting collected autumn fruits; Social support in a group) Day3: Visit favorite parts of the garden and reflection. | | | building, the herbarium, the library, a lecture hall and laboratories. | | |
| Siu et al. (2020) | Horticulture therapy (HT) Program designed by New Life Psychiatric Rehabilitation Association (NLPRA) | Key objectives: (1) To reduce perceived stress and anxiety and promote mental well-being; (2) to increase engagement and achievement in meaningful activities through horticulture therapy; and (3) to increase social exchange, peer interaction, and social support, while working in a non-competitive environment. | During each horticultural therapy session with three phases: (1) Opening and review (5 min); (2) horticulture therapy activity (50 min); and (3) closing and debriefing (20 min). The first three sessions focused on basic horticulture knowledge and skills. In Sessions four and five, the therapist guided participants to use plants, fruits, and herbs as media in mindfulness and relaxation activities. In Sessions six and seven, the therapist conducted horticultural therapy projects that use plants in decorations and other products, and re-visited the mindfulness techniques, and promoted reflection on the participants' experiences. In the final session (Session 8), the therapist wrapped up the experiences with horticulture therapy by harvesting vegetables that were planted and then cooked some of the produce and enjoyed a meal together. Throughout the sessions, therapists guided participants to take care of their own plants and | Conducted by accredited horticultural therapists and are assisted by rehabilitation worker | In a group | Hong Kong, not specified | Once a week for eight weeks | Standardized |

(*continued on next page*)

**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | observed the growth process of the plants. | | | | | |
| Kam and Siu (2010) | Horticultural activity program | Objectives: (a) to teach basic horticultural knowledge and skills, and to develop interests in working with plants, (b) to share relaxing experience and coping strategies through working with plans, (c) to promote sharing and social support among participations. | Each session of the standardized horticultural program has a specific theme and objectives, and all the main activities were related to work with living plants. In each session, there is an introduction and warm-up, followed by horticulture activities and group sharing. | Registered occupational therapist | In a group, outdoor | New Life Farm (NLF)- Sheltered workshop in Hong Kong for persons with psychiatric disability and/or mental handicap; five outdoor theme gardens of the Farm, namely the Sensory Garden, Activity Garden, Farm Garden, Display Garden and Practical Garden. | 10 consecutive days within 2 wks for 1 h | Not stated |
| Atta et al. (2025) | Horticultural therapy | Objectives: (1) To empower participants with self-competency in plant care and introduce them to horticultural therapy, including the therapeutic benefits such as relaxation, improved mood, cognitive enhancement, and accomplishment. (2) To guide participants through practical planting and propagation activities, foster emotional expression and mindfulness, ensure safety, and encourage reflection, gratitude, and social interaction throughout the eight-session program. | The program consisted of eight weekly group sessions, each lasting 30 min, where participants engaged in activities like sowing, watering, monitoring, and harvesting plants. The first session focused on participants' past horticultural experiences, followed by individually scheduled plans for each patient, and sessions were organized into separate male and female groups. | The horticultural therapy program was developed by a researcher in psychiatric nursing and a botanist and facilitated by a therapist. | In a group, women and men in separate groups | Horticultural activities across eight weekly sessions, including sowing, watering, monitoring, propagating, and harvesting plants. Additional activities involved sharing experiences, practicing mindfulness with plants, learning emergency plant care, creating a group exhibition garden, and reflecting on their progress and the therapeutic benefits of gardening of an aromatic flower bud crop (Cloves; Syzygium et al.) and aromatic and floral (*Lavandula multifida*). | Eight weekly sessions, 30 min sessions once a week for 8 wks | Individually written and scheduled plan specifying the time, duration and setting for each session |
| Joubert et al. (2024) | Horticultural therapy | Aim to effect the anxiety state of patients hospitalized in adult psychiatry with horticultural therapy, compared with the effect of usual care after four weeks of mediation or usual care. | Each session had the same structure: welcome (arrival of patients), reminder of what previous session accomplishments, warm-up (performing a few movements related to gardening gestures), mediation with a theme (weeding, planting, mulching, cuttings, watering, ikebana, etc.), clean-up and tidying up of tools, followed by an assessment of the session (tasks performed, patients' | Supervision by two nurses | Group of 6 patients | Gardening at the Melisses Garden with 6 patients in a group two times a week for 1.5hrs with a focus on weeding, planting, mulching, cuttings, watering, ikebana, tool maintenance and reflection. | Four wks of bi-weekly 1.5hr horticultural sessions | Schedule for the next session was discussed at the end of each session |

(*continued on next page*)

**Table 3** (*continued*)

| | Intervention Name | Rationale/Theory/ Goal | Materials/ Procedures | Providers | Mode of delivery | Location and infrastructure | Time Frame | Tailoring |
|---|---|---|---|---|---|---|---|---|
| | | | feelings, schedule for the next session). | | | | | |

*Note.* Attention Restoration Theory (ART), Cognitive-based Therapy (CBT), Flow with Nature (FWN), Horticultural therapy (HT), mindfulness-based stress reduction (MBSR), Nacadia® nature-based therapy (NNBT), Stress Recovery Theory (SRT). Measurements: kilometers (km), hectare (ha), meters (m), meters squared ($m^2$), weeks (wks), hours (hrs), minutes (min).

**Table 4**
Efficacy of greenspace intervention for patient-reported outcomes after the intervention.

| | Type of effect measure | k | Effect estimates (95 % CI) | *p* | $I^2$ | $\tau^2$ | 95 % prediction intervals |
|---|---|---|---|---|---|---|---|
| All indications | | | | | | | |
| Depressive symptoms (across various mental health conditions) | SMD | 6 | −0.52 (−0.89 to −0.15) | 0.006 | 53 | 0.11 | −1.56 to 0.53 |
| Anxiety | SMD | 5 | −0.65 (−1.10 to −0.20) | 0.005 | 67 | 0.16 | −2.12 to 0.82 |
| Stress | SMD | 3 | −0.73 (−1.60 to 0.14) | 0.10 | 76 | 0.43 | −10.80 to 9.33 |
| Well-being | SMD | 3 | 0.94 (0.66 to −0.35) | 0.16 | 96 | 1.26 | −15.61 to 17.49 |
| Positive affect | MD | 3 | −1.70 (−2.66 to −0.74) | <0.001 | 0 | 0 | −7.92 to 4.52 |
| Negative affect | MD | 3 | −2.61 (−5.87 to 0.66) | 0.12 | 52 | 4.63 | −37.18 to 31.97 |
| **Depression** | | | | | | | |
| Depressive symptoms (related to a formal diagnosis of depression) | SMD | 4 | −0.39 (−0.77 to −0.001) | 0.049 | 50 | 0.08 | −1.84 to 1.07 |
| **Schizophrenia** | | | | | | | |
| Positive affect | MD | 2 | −1.75 (−2.73 to −0.77) | <0.001 | 0 | 0 | n.a. |
| Negative affect | MD | 2 | −1.39 (−2.38 to −0.40) | 0.01 | 0 | 0 | n.a. |
| General Psychopathology | MD | 2 | −1.21 (−1.90 to −0.53) | <0.001 | 0 | 0 | n.a. |

*Note.* CI = confidence interval; MD = mean difference; SMD = standardized mean difference reported based on small vs. moderate vs. large differences, k = number of studies included, $I^2$ = the proportion of observed variance that reflects real differences in effect sizes rather than sampling error with units presented in percent (%).

Chen et al., 2025; Hyvönen et al., 2023; Joubert et al., 2024; Oh et al., 2018; Siu et al., 2020; Stigsdotter et al., 2018; Vujcic et al., 2017; Watkins-Martin et al., 2022; Wheeler et al., 2020; Yeon et al., 2023; Zhu et al., 2016) (Table 4). Between two and maximum six studies could be included per meta-analysis thereby limiting the interpretability of the effect sizes given the limited data.

For all indications, meta-analysis revealed a significant effect on depressive symptoms (SMD -0.52, $p = .006$, 95 %CI [−0.89;-0.15]), anxiety (SMD -0.65, $p = .005$, 95 %CI [−1.10;-0.20]) and positive affect (MD -1.70, $p < .001$, 95 %CI [−2.66;-0.74]). Effects on negative affect, well-being and stress were not significant (all $p \geq .05$). Regarding substance abuse disorder, one study focused on horticulture therapy through gardening compared to occupational therapy (Detweiler et al., 2015). The other study compared forest therapy to normal daily routines in the treatment of alcoholism (Shin et al., 2012). No meta-analysis could be performed. The four RCTs that addressed depression compared nature-based intervention treatment (Hyvönen et al., 2023) or urban forest therapy (Yeon et al., 2023) against TAU (Chen et al., 2025), or nature walk versus urban walk (Watkins-Martin et al., 2022). Meta-analysis revealed significant effects of greenspace interventions on depressive symptoms in people with diagnosed depression (SMD -0.39, $p = .049$, 95 %CI [−0.77;-0.001]). Regarding adjustment disorder, one RCT compared individual intervention of nature therapy vs. cognitive-based therapy with mindfulness-based stress reduction (MBSR) aspects (Stigsdotter et al., 2018). A further paper reported on follow-up measures of the same study (Corazon et al., 2018a). No meta-analysis could be performed. One RCT for PTSD included veterans with post-traumatic stress disorder and compared a nature camp with a fishing intervention versus waitlist control (Wheeler et al., 2020). No meta-analysis could be performed. Two RCTs on schizophrenia were included (Oh et al., 2018; Zhu et al., 2016). Both studies compared a therapeutic horticultural intervention versus TAU. Compared with control conditions, greenspace interventions had a significant effect on positive affect (post-intervention values MD -1.75, $p < .001$, 95 % CI [−2.73 to −0.77]), negative affect (post-intervention values MD -1.39, $p = .01$, 95 % CI [−2.38 to −0.40]), and general psychopathology (post-intervention values MD -1.21, $p < .001$, 95 % CI [−1.90 to −0.53]) scores in patients diagnosed with schizophrenia. Regarding ADHD, one RCT compared a walk in an urban park with a walk in a downtown area or a walk in a residential area (Taylor et al., 2009) and one RCT compared an outdoor sensory garden plus indoor sensory integration with indoor sensory integration only (Voola et al., 2022). Both studies were on ADHD in children. No meta-analysis could be performed. Three RCTs were identified for dementia. One compared horticultural therapy-based activities versus traditional activities (Jarrott et al., 2010), one compared horticulture therapy versus TAU (Yang et al., 2022) and one compared horticulture therapy versus sensory stimulation and social interaction (Luk et al., 2011). All studies were conducted with elderly nursing home residents. Given the vastly different interventions and corresponding outcome measures, no meta-analysis could be performed. Five RCT evaluated horticultural therapy for a combination of mental diagnoses against TAU (Atta et al., 2025; Joubert et al., 2024; Kam et al., 2010; Siu et al., 2020) or horticulture therapy, including occupational and art therapy versus occupational and art therapy plus conventional therapy (Vujcic et al., 2017). A forest plot displaying the summary effect were generated for all meta-analyses (see supplement). Subgroup analyses despite mental health indication were not possible. Heterogeneity regarding significant effects varied between meta-analyses with moderate heterogeneity regarding symptoms of depression in all indications and low heterogeneity regarding positive affect in all indications. Due to the low number of included studies for schizophrenia, no heterogeneity could be assessed.

### 3.3. Risk of bias

Risk of bias was categorized as unclear or high risk for all but one included publication (see Figs. 2 and 3). The open-label nature of most studies resulted in only two studies effectively blinding interventions to participants (Watkins-Martin et al., 2022; Zhu et al., 2016) or assessors (Kam et al., 2010; Luk et al., 2011; Taylor et al., 2009; Wheeler et al., 2020; Yang et al., 2022; Zhu et al., 2016). Consequently, there were notably high levels of performance and detection biases across studies.

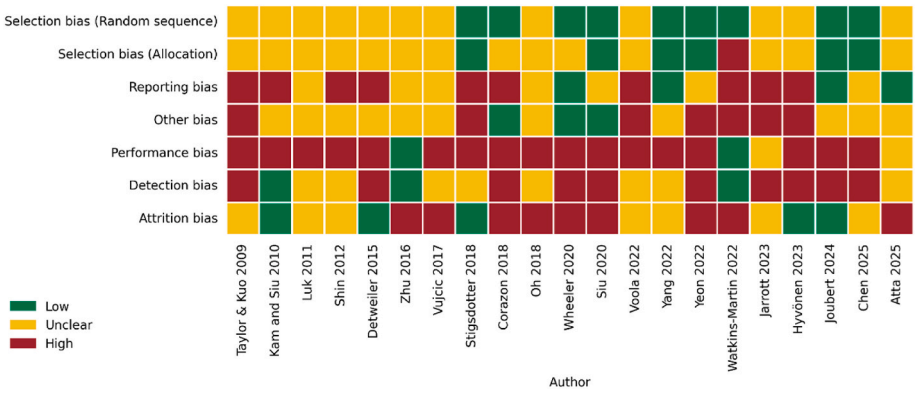


**Fig. 2.** Risk of bias of individual studies based on the Cochorane risk of bias tool, version 1 (Higgins et al., 2011), showing the low (green), unclear (yellow), or high (red) risk of bias for each included studie across each bias category. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

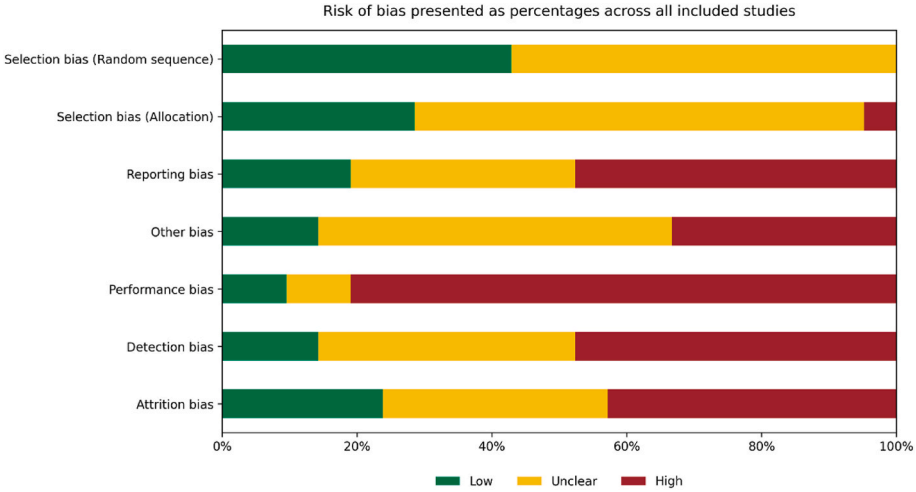


**Fig. 3.** Based on the Cochrane risk of bias tool, version 1 (Higgins et al., 2011), percentage is used to determine the low (green), unclear (yellow), or high (red) risk of bias for all included studies. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Less than half of the studies described robust practices for randomization (Chen et al., 2025; Corazon et al., 2018a; Joubert et al., 2024; Kam et al., 2010; Stigsdotter et al., 2018; Watkins-Martin et al., 2022; Wheeler et al., 2020; Yang et al., 2022; Yeon et al., 2023) or intervention allocation (Chen et al., 2025; Corazon et al., 2018a; Joubert et al., 2024; Kam et al., 2010; Yang et al., 2022; Yeon et al., 2023) and could be described as having a low risk of bias. Furthermore, the studies had insufficient reporting of data and had methodological limitations, with only three studies (Joubert et al., 2024; Wheeler et al., 2020; Yang et al., 2022) providing comprehensive and clear data. Incongruent or insufficient reporting led to difficulties in verifying reported measures against clinical trial registries, thereby increasing the risk of bias. As most studies were categorized as unclear or high risk of bias, no sensitivity analyses could be performed.

## 4. Discussion

The 20 studies included in this systematic review focused on therapeutic greenspace interventions ranging from forest therapy to horticulture therapy addressing clinically diagnosed mental health disorders. Greenspace interventions addressed either combined or seven specified mental disorders: dementia, depression, schizophrenia, attention deficit hyperactivity disorder, adjustment disorder, post-traumatic stress disorder, or substance abuse disorder. All but one showed a high or unclear risk of bias, which due to the methodological limitations and insufficient reporting, publication bias cannot be ruled out, thus limiting the strength of the meta-analysis. Of the twelve studies that were included into meta-analysis (Atta et al., 2025; Chen et al., 2025; Hyvönen et al., 2023; Joubert et al., 2024; Oh et al., 2018; Siu et al., 2020; Stigsdotter et al., 2018; Vujcic et al., 2017; Watkins-Martin et al., 2022; Wheeler et al., 2020; Yeon et al., 2023; Zhu et al., 2016), data suggested that greenspace interventions lead to moderate improvements in depressive symptoms, anxiety and in positive affect regarding all included mental disorders. For patients diagnosed with depression, greenspace interventions had a significant effect on depressive symptoms. For patients diagnosed with schizophrenia, greenspace interventions had a significant effect on positive affect, negative affect, and general psychopathology – a scale that includes positive and negative symptoms –. In schizophrenia, positive symptoms refer to the presence of excesses or distortions of normal functions, such as hallucinations, delusions, disorganized thinking, or inappropriate emotional expression. Negative symptoms, by contrast, involve reductions or losses of normal functions, such as blunted affect, social withdrawal, or diminished motivation. Data indicated a positive effect of greenspace interventions on general psychopathology reflecting a normalization of emotional expression, consistent with the broader clinical improvements seen in this group. This observed reduction in positive and negative symptoms may be understood in light of theoretical frameworks that explain how natural environments impact mental health. Stress Reduction Theory suggests that greenspaces lower physiological arousal, potentially buffering

against psychotic exacerbation. Attention Restoration Theory highlights the role of natural settings in reducing attentional fatigue, which could support cognitive control and thereby mitigate intrusive thoughts or disorganized thinking. From a biophilia or conditioned restoration perspective, repeated exposure to calming natural environments may provide safety cues and culturally conditioned associations of tranquility, which could lessen hallucinatory or delusional experiences. The reduction in both positive and negative affect probably reflects a decrease in general emotional arousal rather than a deterioration in emotional well-being. The PANAS primarily captures affective states with high arousal; therefore, declines in positive affects may indicate a normalization of dysregulated or psychosis-related activations rather than a loss of positive emotions. However, since these schizophrenia-related findings are based on only two studies, they should be viewed with due caution. The significant effect for depressive symptoms in the overall sample reflected a pooled estimate across various mental health conditions, including, but not limited to, depression diagnoses. In contrast, the subgroup analysis focusing exclusively on studies with a formal diagnosis of depression included only three trials, which substantially reduced statistical power.

Moreover, some of the studies in the broader group of mental health conditions reported depressive symptoms as a secondary outcome, and in some cases, these interventions (e.g., in schizophrenia or adjustment disorder) may have yielded relatively large effects on mood symptoms, thereby contributing to the pooled significance. The meta-analysis found no further significant clinical outcomes of greenspace interventions.

### 4.1. Gaps in research and evidence

Studies provide a heterogeneous and non-cohesive picture of analyzed mental disorders and greenspace interventions in terms of intervention types, duration, and population targeted. Heterogeneity across study settings may account for differing effects seen and variation across several outcomes such as depressive symptoms, anxiety, stress, and negative affect (as seen in Table 4 with the measure of heterogeneity $I^2$ ranging from 0 % to 76 %). Interventions were often planned near the health care facilities and adapted to the type of disorder to be addressed. For instance, where cognitive function limited mobility such as with dementia, nature therapies were chosen that enabled proximity to health care facilities such as with horticulture therapy activities (Jarrott et al., 2010; Kam et al., 2010; Luk et al., 2011; Yang et al., 2022). Exploring innovative ways to implement low-threshold and potentially cost-effective greenspace interventions has encouraging potential to bridge some existent gaps in current mental health care provision, especially in populations that are underserved by the existing mental health systems (Hajna et al., 2023; Park et al., 2024). However, these studies took place in countries with well developed mental health provision, perhaps limiting their global application. At the same time, immense caution in general should be taken about conclusions reached on the efficacy of greenspace interventions because more rigorous studies of sufficient quality and robust designs are still needed. Another glaring gap in the evidence base is the effect of blue spaces: no RCTs conducted with individuals diagnosed with mental disorders were found, despite potential seen in other study designs (Bray et al., 2022; Britton et al., 2020; Gascon et al., 2017; Geneshka et al., 2021; Georgiou et al., 2021; Overbury et al., 2023; Vitale et al., 2022; Wang et al., 2024).

### 4.2. Implications for policy and practice

Insufficient mental health coverage is a burden particularly carried by countries with the least economic and geopolitical resources, and with the most precarious societal circumstances (World Health Organization (WHO), 2021). As climate-related stress factors increasingly affect mental and physical health, the role of greenspaces as a buffer against environmental stress and health emergencies is also becoming increasingly important (Garrett et al., 2021; Hajna et al., 2023; Obradovich et al., 2018). Establishing local, community-based solutions that use existing traditional health-related knowledge of natural areas can contribute to the diversified and affordable solutions necessary for mental health provision (World Health Organization (WHO), 2023; World Health Organization (WHO), 2022). Particularly regarding the observed improvements in positive affect and depressive symptoms, greenspace interventions with structured activities, such as nature-based walks, horticultural therapy, or outdoor group activities appeared to yield benefits that may serve as low-cost, accessible adjuncts to conventional mental health care. These measures could be recommended as practical interventions to be implemented within clinical guidelines for mental health clinics and primary care providers especially as formalized social prescriptions are gaining traction (de Bell et al., 2024) although small sample sizes limit firm conclusions. Duration and frequency of interventions varied from 20 min to 12 weeks. Correlations of dose-response go beyond the scope of this review but were recently examined by Bettmann and colleagues (Bettmann et al., 2025). Focused on quantifying optimal exposure durations and frequencies of greenspace interventions through the dose-response relationship, they found significant positive effects on adults with mental illness (Bettmann et al., 2025). This study also found that short exposure of only 10 min in nature had a significant impact on those diagnosed with mental illness, however longer exposures did not see a significant effect. In a recent review about schizophrenia spectrum disorders by Mercham and Ellett, greenspace exposure was found to be associated with reduced risk of schizophrenia (Marcham et al., 2024). First indications demonstrating the protective effects of greater exposure to nature may explain why greenspace interventions appear clinically beneficial to this patient group. This may signal that a potentially important aspect of greenspace intervention efficacy is reliant on how they are conducted, a point that is detailed in the included interventions and warrants greater scrutiny. The largest and most consistent effects were seen in included studies targeting individuals with depressive symptoms or mood disorders, particularly in young to middle-aged adults. In contrast, findings for individuals with schizophrenia spectrum disorders were more variable and less robust. While longitudinal studies have demonstrated long-term benefits to child mental health with greenspace exposure (Bolanis et al., 2024; Naya et al., 2022), greater scrutiny about the dose-response and efficacy of specific greenspace interventions on children diagnosed with mental disorders is equally deserving of attention.

Broad improvement in symptoms with greenspace interventions are consistent with the premise of theoretical construct of Attention Restoration Theory (ART) to restore depleted cognitive and emotional resources (Kaplan, 1995) at the same time that the moderate reductions in distress-related symptoms potentially supports Stress Reduction Theory (SRT) through the recuperative influence of nature (Ulrich et al., 1991). Exploration about how the cognition of repeated exposure of greenspace interventions may relate to a sense of safety in therapeutic settings as posited by Conditioned Restoration Theory (CRT) should be explored in future studies (Staats et al., 2016).

### 4.3. Strengths and limitations

This systematic review meta-analysis has several strengths. It has provided an overview of efficacy of greenspace interventions on patient-reported symptoms of mental disorders and has given a detailed overview of the existing interventions. The focus on greenspace interventions for individuals with a mental disorder has honed in on specific effects on mental health, while highlighting the need for carefully designed, rigorous studies with larger populations, a finding mirrored in a recent systematic review of studies with individuals diagnosed with depression, anxiety or stress (Jessen et al., 2025). A gap between public and policy-level enthusiasm for greenspace interventions to address mental health and continued challenges to demonstrated evidence. Possible impediments exist due to difficulties in

standardizing and operationalizing greenspace interventions across contexts, given limited funding for non-pharmacological or non-clinical interventions and due to insufficient collaboration between mental health and environmental science. Acknowledging this deficit may help explain the scarcity of high-quality trials and the methodological limitation of available evidence base.

This work was not without limitations, principally our limited ability to compare effects in the meta-analysis given the diversity of disorders, their reported outcomes and limited number of studies. Formal methods to assess publication bias were not conducted due to the limitations of the evidence base: as only twelve studies were available for meta-analysis with a maximum of six per individual meta-analysis, we chose to avoid the unreliability of analysis with fewer than 10 studies (Sterne et al., 2011). Furthermore, the studies included in the meta-analysis also have a high or unclear risk of bias, and therefore the robustness of the meta-analysis should be viewed with caution. On a broader scale, our inclusion stipulated an established mental disorder for the study sample population, which likely excluded many parts of the world without expansive mental health service coverage or greenspace interventions tailored to community populations who are experiencing symptoms of a mental health disorder outside of clinical settings, without a diagnosis (Kim & Park, 2018; Kotozaki, 2014). Regions where individuals endure significant stressors beyond individual and psychological factors such as poverty, violence, inequality, and environmental degradation—dramatically increases the risk of mental health conditions (Saraceno et al., 2002). Examining studies with such populations is outside the scope of this study but may contribute importantly to the effects that greenspace interventions in community settings have. Indeed, we may posit that limiting our study to those diagnosed with mental disorders could have had an effect on the current synthesis. Excluded studies investigating psychopathological symptoms without formal diagnoses may have led to an underestimation or 'camouflaging' of effects. Nonetheless, problematic gaps exist in the reporting of the included studies in our review that demonstrated an overwhelmingly high or unclear risk of bias (for instance omitting how randomization was implemented) and made the analysis particularly challenging while limiting available findings. Precise classification of disorders and terminology inhibited detailed comparison of studies. Studies often did not report the ICD codes used for inclusion. This specification would enable comparability across studies. The inconsistency in terminology used for greenspace interventions and therapies presented a distinctive challenge to compare activities (Nejade et al., 2022; Nguyen et al., 2023). A next step could be to clearly define terms for greenspace interventions e.g. through a Delphi process (Dalkey et al., 1969; Jorm, 2015). Further, effects of blue spaces on mental disorders should be investigated in more detail (Britton et al., 2020; Gascon et al., 2017; Georgiou et al., 2021). The risk of bias results indicated that only a few studies could be accurately assessed due to incomplete reporting of information and lack of listing in clinical trial registries. For instance, some studies did not report deviation measures. Due to the limited number of included studies, we were not able to stratify mental disorders for an age, a limitation also highlighted by Jessen and colleagues regarding their inability to pool effects (Jessen et al., 2025). Also, due to the limited amount of included studies, subgroup analyses regarding indications were possible only for depression and schizophrenia. High-quality RCTs remain difficult to conduct for these interventions. Nature-based interventions often involve complex interventions that combine social, physical movement and environmental activities that are difficult to standardize. Blinding is also difficult or unfeasible raising questions about performance bias. Despite growing popularity, institutional and cultural biases still exist, that perceive nature-based strategies as too unscientific. While our inclusion criteria that specified the stringent study form of RCTs permitted a methodologically-controlled perspective, future reviews would benefit from looking into a wider methodological application of such interventions. Additionally, the experiential side of patient-reported outcomes could demonstrate how greenspace interventions affect the subjective mental health and well-being of participants. The continuation of this work is planned with a meta-synthesis to summarize and analyze qualitative findings (Czakert et al., 2025), that may expand current findings of this work to the community setting with a wider methodological scope.

### 4.4. Conclusion

The findings of this work on greenspace interventions underscore the complexity of understanding the effects of spending time in nature on the mental well-being of individuals diagnosed with mental disorders. Facing multiple crises in health care and environment, the greenspace interventions show promise as a supportive tool in mental health care. In a time where social prescriptions are gaining favor within health systems, greenspace interventions may be a particularly helpful means for health care practitioners to help patients. Despite this, more rigorous evidence is required to determine their broader epidemiological impact.

## CRediT authorship contribution statement

**Sarah B. Blakeslee:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation. **Anna Katharina Koch:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Marleen Schröter:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Michael Jeitler:** Writing – review & editing, Formal analysis, Data curation. **Steven Ngandeu Schepanski:** Writing – review & editing, Methodology. **Hiba Boujnah:** Writing – review & editing. **Stefan Brunnhuber:** Writing – review & editing. **Pierpaolo Mudu:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Francesco Forastiere:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Andreas Michalsen:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Georg Seifert:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Christian S. Kessler:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

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## Declaration of competing interest

We declare no competing interests.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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